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U.S. Law of the Sea cruise to map the foot of the slope and 2500-m isobath of the US Arctic Ocean margin, cruise report for 2009

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CRUISE REPORT

USCGC Icebreaker *Healy* (WAGB-20)

U.S. Law of the Sea cruise to map the foot of the slope and 2500-m isobath of the US Arctic Ocean margin

CRUISES HE-0905

August 7 to September 16, 2009

Barrow, AK to Barrow, AK

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INTRODUCTION and BACKGROUND

HEALY-0905 was part of a two-ship, joint U.S./Canadian expedition designed to collect multi-channel seismic and bathymetric data needed by both nations for the determination of those areas of the Arctic Ocean that may potentially qualify for an extended continental shelf under Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS). HEALY 0905 is the sixth in a series of HEALY cruises dedicated to extended continental shelf mapping. Four of these cruises (HEALY-0302, HEALY-0405, and HEALY-0703, HEALY-0805) were single-ship operations led by scientists from the University of New Hampshire and focused on the collection of multibeam echo-sounder bathymetric, and shallow, high-resolution chirp subbottom profiler data. In 2008 there was a second HEALY cruise (HEALY-0806). led by scientists from the U.S. Geological Survey that worked together with the Canadian icebreaker LOUIS S. ST. LAURENT (LSSL) to collect multi-channel seismic and multibeam echo-sounder data in the ice-covered regions. The success of the 2008 two ship operation led to a second two-ship operation, HEALY-0905, in 2009. This report focuses on the results of the HEALY component of the two-ship operation; for details of the LOUIS S. ST. LAURENT's program please see Mosher et al, 2010.

Under Article 76 of UNCLOS, coastal states may, under certain circumstances gain sovereign rights over the resources of the seafloor and subsurface of "submerged extensions of their continental margin" beyond the recognized 200 nautical mile limit of their Exclusive Economic Zone. The United States has not yet acceded to the UNCLOS. However, increasing recognition that implementation of Article 76 could confer sovereign rights over large and potentially resource-rich areas of the seabed beyond its current 200 nautical mile (nmi) limit has renewed interest in the potential for accession to the treaty.

The United Nations Convention on the Law of the Sea defines the conditions under which a coastal state may extend its continental shelf over regions beyond their current recognized 200 nmi limit (UN, 1982). These conditions involve the definition of a juridical or legal "continental shelf" that differs significantly from standard morphological descriptions of continental margins. A key element of this definition is the demonstration that the extended area is a "natural prolongation" of the nation's landmass. There are no explicit guidelines for demonstration of "natural prolongation" of a state's land territory. The determination must be based on a general knowledge and interpretation of the bathymetry, geology, and nature of the seafloor in a region.

Once a natural prolongation is demonstrated, a coastal state may extend their "continental shelf" beyond the 200 nmi limit based on either of two formulae. The distance formula allows an extension of the shelf to a line that is 60 nmi beyond the "foot of the continental slope" (defined to be the point of maximum change in gradient at its base).This line is know as the Hedberg Line. The sediment thickness formula allows the extension of the shelf to a point where the sediment thickness is 1 percent of the distance back to the foot of the slope. This line is known as the Gardiner Line. Whichever formula line is most advantageous to the coastal state may be used and they can be combined for the most advantageous extension. There are limits to the extension (limit lines) – the ECS shall not extend beyond 100 nmi from the 2500 m isobath or not beyond 350 nmi from the territorial baseline (the officially defined shoreline). Again these limit lines can be mixed in whatever way is most advantageous to the coastal state. Thus the definition of the extended continental shelf under UNCLOS Article 76 is based on a combination of bathymetric data (defining the 2500 m contour and the foot of the slope) and geophysical data (defining the thickness of sediment). When a nation accedes to the Law of the Sea Treaty, it has 10 years to submit all data and evidence supporting its submission to the

Commission on the Limits of the Continental Shelf (CLCS) who evaluate the veracity of the submission and offer recommendations on it.

The largest potential for an extended continental shelf beyond the current 200 nmi limit of the U.S. EEZ is found in the area of the Chukchi Borderland, a tightly clustered group of generally high-standing, N-S-trending bathymetric elevations that form a natural prolongation from the Chukchi Shelf north of Alaska.

The Chukchi Borderland juts out between eastern Siberia and western Alaska into the deep Amerasia Basin north of the Chukchi Sea. The borderland occupies a rectangular area about 600 by 700 km, or some 4 percent of the Arctic Ocean. This area encompasses three, approximately north-south-trending segmented topographic highs: the Northwind Ridge, the Chukchi Cap and Rise, and the western (Arlis, Sargo, and T3) plateaus (which are located beyond (westward of) the agreed boundary line with Russia). The plateau-like crests of the Chukchi Borderland rise, in some cases, as much as 3,400 m above their surroundings and they are relatively shallow (depths between 246 and 1,000 m). The ridges have steep flanks, which in some places exhibit remarkable linearity over hundreds of kilometers, especially along the east side of the Northwind Ridge. Between these ridges lie the Northwind, Chukchi, and Mendeleyev "abyssal plains". These lie at depths between 2,100 and 3,850 m

Congress (through NOAA) funded the University of New Hampshire's Center for Coastal and Ocean Mapping/Joint Hydrographic Center (CCOM/JHC) to explore the feasibility of using a multibeam sonar-equipped ice breaker to collect the data needed to make a submission for and extended continental shelf in ice-covered regions of the Arctic. This was in recognition of the fact that a submission for an ECS under Article 76 must be substantiated by high-quality bathymetric and geophysical data, and that the existing bathymetric database in the Arctic is, in many areas, inadequate. The USCGC *Healy* (WAGB-20), equipped with a SeaBeam 2112 (12 kHz, 121 beam) swath mapping system, was chosen for this task.

The multibeam echo-sounder data provided by the SeaBeam 2112 system on the HEALY provides the morphological data required to establish the "foot of the slope" (needed for the determination of the foot of the slope, the Hedberg Line, the Gardiner Line and the 2500 m contour). The seismic system on the Louis S. St. Laurent provides sediment thickness information required for establishing the Gardiner Line (once the foot of the slope is determined.

Previous Cruises: (Detailed cruise reports from each of these cruises can be found at http://www.ccom.unh.edu).

HEALY 0302 Overview:

A 10 day, 3000 km long exploratory mission (HEALY-0302, September 1-11, 2003) from Barrow, Alaska, to the Chukchi Borderland demonstrated the viability of using the multibeam echo-sounder in ice-covered waters to follow specific bathymetric targets. The 2003 cruise began at the US-Russian boundary line at 78°-30'N 168°-25'W and followed the 2500 m contour around to 78°-35'N 159°-07'W (Figure 1). The cruise collected ~3000 km of high-resolution multibeam echo-sounder data and made several significant discoveries that include:

- substantially changing the mapped position and complexity of the 2500-m isobath (a critical component of a Law of the Sea submission for an ECS),
- found further evidence for pervasive ice and current erosion in deep water (flutes and scours),
- finding evidence for gas-related features (pock-marks), and

- discovering a previously unmapped seamount that rises more than 3000 m above the surrounding seafloor. This NE-SW trending feature, some 18 km wide and 40 km long with a slightly concave and northward tilted crest, has been officially named Healy Seamount.

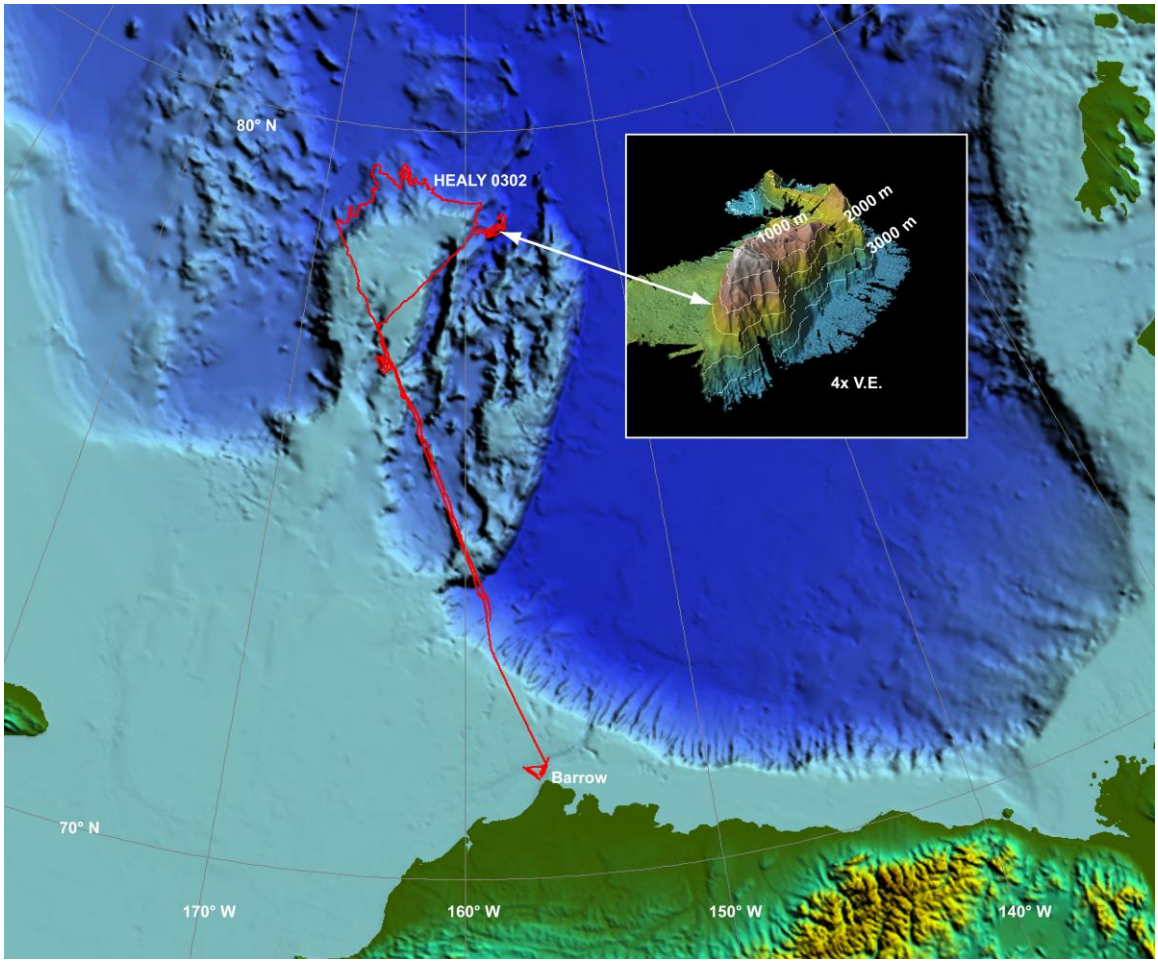

Figure 1. Track of HEALY-03002 September 2003.

HEALY-0405 Overview:

In 2004 a second, 20-day cruise, HEALY-0405 was conducted from October 6 to October 26, 2004, originating in Nome and ending in Barrow, Alaska. The cruise covered approximately 6700 km in 20 days and completed most of the mapping of the 2500-m isobath (begun on HEALY-0302) as well as a detailed survey of the "foot of the slope" over a segment of the continental margin east of Barrow, AK. The total area surveyed during HE-0405 was approximately 20,000 sq. km (5830 sq. nmi). The cruise transited northward from Nome over the Northwind Ridge until it intersected the 2500-m isobath at approximately 77° 10'N, 154° W, the point where the 350 nmi cutoff limit from the coast of northern Alaska intersects the 2500-m isobath on the eastern flank of the Northwind Ridge. Ice was first encountered ice at about 76˚N and by 77˚N the ice was very heavy (9/10 to 10/10) with many ridges and very few leads. Progress was slow and we often had to backup and ram but, nonetheless, we managed to continue mapping the 2500-m isobath up the Northwind Ridge until approximately 78° 45'N. During this time, we covered approximately 100 nmi in 4 days. Data was difficult to collect in these conditions but we were able to continuously map the 2500-m isobath to its furthest north point. About 5000 sq. km (1458 sq. nmi) of seafloor was mapped during the transect to the north and back.

At 78° 45'N, the *HEALY* had great difficulty breaking through the ridges (one ridge took more than 8 hours to break through) and the decision was made to move south to the relatively ice-free waters of the continental slope east of Barrow. This area was chosen so that we could define the foot of the slope in the central portion of the northern Alaskan margin. The foot of the slope can be used in this region as a starting point for determination of the "Gardiner Line" – one of the formula lines used for making an ECS submission under UNCLOS Article 76. The survey of the foot of the slope area began on October 18 and continued until October 24. During this time, complete overlapping multibeam-sonar data was collected over a region of approximately 15,435 sq. km (4500 sq. nmi), that ranges in water depth from 800 m to 3800 m. The survey not only delineated the foot of the slope, but it also revealed a complex margin with drift deposits, suggesting contour currents, that are cut by numerous canyons.

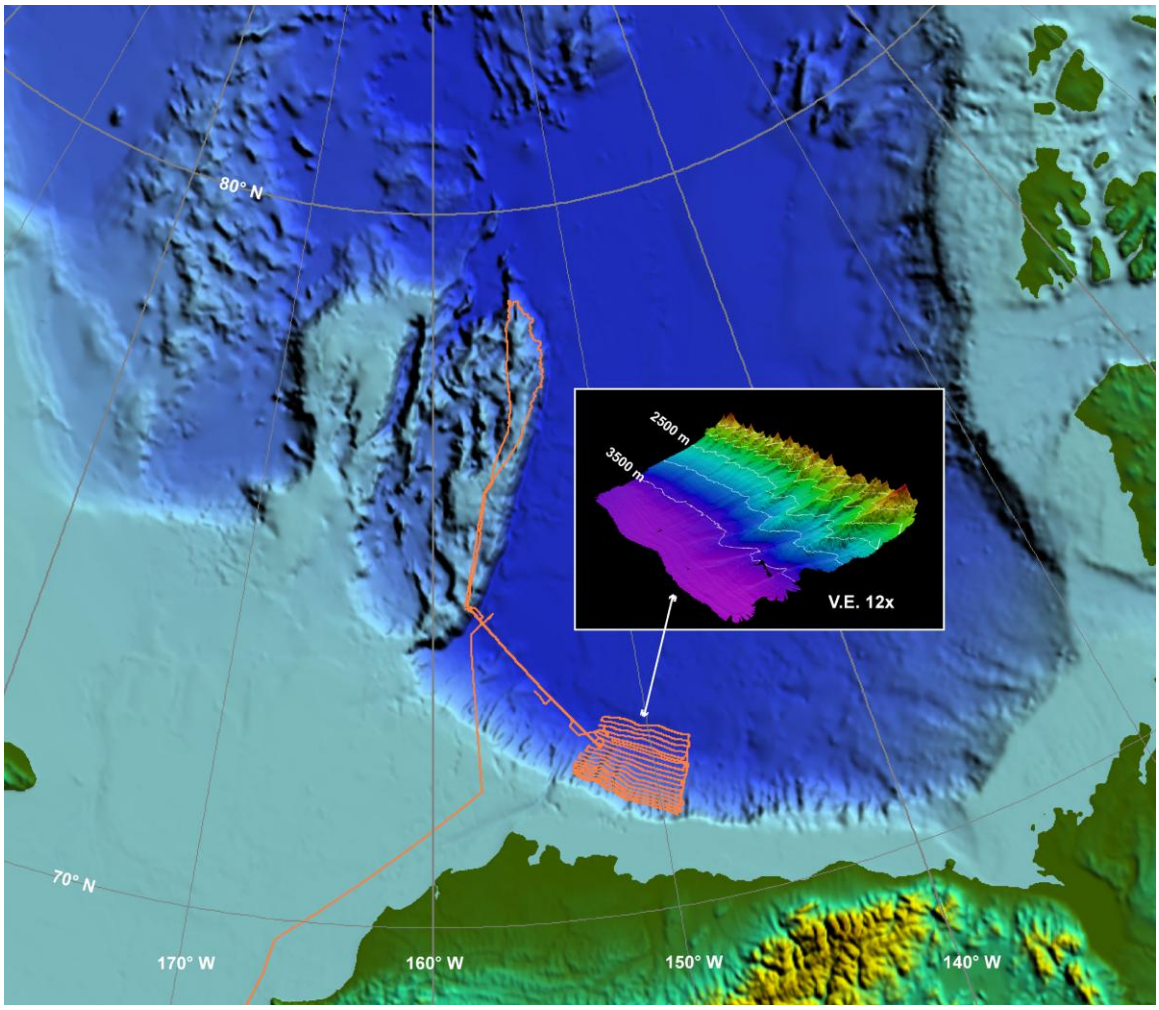

Figure 2. Cruise track for HEALY-0405

HEALY-0703 Overview:

HEALY-0703 was conducted from August 17 to September 15, 2007, with both embarkation and disembarkation via helicopter transfer from Barrow, Alaska. The cruise track covered approximately 10,000 km (5400 nm) in 30 days (Figure 3). The primary objectives of the cruise were: 1- to complete the mapping of the 2500 m isobath that began on HEALY 0302 and HEALY 0405; 2- to begin to define the "Foot of the Slope" around the the northern and eastern edges of Chukchi Cap; and; 3- to further map an area of pockmarks originally discovered on HEALY-0302. Secondary objectives

included the recovery and re-deployment of two High-Frequency Acoustic Recording Packages (HARP's), autonomous recording packages designed to record ambient noise levels at the ice margin for periods up to one year, and: the deployment of up to four ice buoys and continuous ice-observation by representatives of the National Ice Center. All objectives were achieved, far beyond expectations.

Using a nominal swath width of approximately 7 km, the total area surveyed during HE-0703 was approximately 70,000 sq. km (20,400 sq nm). The cruise departed Barrow at approximately 1800L on 17 September and steamed northward approximately 50 miles and successfully recovered the first of two HARP buoys. The second was recovered 25 miles further to the northwest. Details of this recovery as well as a description of the purpose and capabilities of the buoys can be found in the HARP Buoy Report later in the cruise report. We next conducted a patch test and a deep CTD cast at the steep southeastern edge of the Chukchi Cap. We first encountered ice at approximately 76N. It was large pieces of thick, multi-year ice but, broken up enough to allow relatively easy passage at 3- 6 knots (though we did have to back and ram occasionally). We continued northwest to the intersection of the 2500 m isobath and the U.S./Russian maritime boundary line where we then began an exploratory, zig-zag pattern to better define the foot of the slope. No definitive foot of the slope was apparent until a long excursion to the north revealed a clear transition between the slope and flat-lying abyssal plain sediments at approximately 81 15N. We made several more north – south transits and consistently found this same slope/plain transition occurring on the northern end of the cap above 81N. We continued to run a zig-zag pattern in the north-east quadrant of the cap and also found and developed several prominent topographic highs, one which shoaled above 2500 m and may allow the re-definition of the 2500 m isobath.

A well-developed foot of the slope was traced down and then back up the eastern side of Northwind Ridge, revealing a very sharp and clear slope/abyssal plain transition with the abyssal plain sediments consistently occurring at a depth of approximately 3820 m. Following this transition to the north allowed us to define a continuous foot of the slope around the northern most extreme of Chukchi Cap to the northern most point or our survey (82 17N); at this point, the slope/plain transition appears to continue to the north and east. Returning south, we mapped a seamount that rose from abyssal plain depths (3820m) to less than 2200 m at approximately 80 47N and 171 50W and then proceeded to transit southwest to carry out a detailed survey of a region in which pockmarks were discovered on a previous leg. We left the ice at about 77N but ran into occasional large packs of flows until about 75 N.

Throughout this period (17 Aug to approximately 5 August) ice conditions were variable but for the most part very light considering the latitudes we were at allowing survey speeds to average about 6 knots. Ice flows large enough to support deployment NIC ice buoys were difficult to find but three flows were found and three buoys deployed. A fourth buoy was deployed in open water at the far western extreme of our survey. Details of the ice buoy deployments and ice observations can be found in the NIC trip-report included in this document.

On HEALY-0302, several large and well-defined pockmarks (probably related to gas extrusion) were discovered in a shallow region of the Chukchi Cap at approximately 76 30N and 163 50W. NOAA's Office of Ocean Exploration asked us to further expand this survey and generate a better map of the distribution of these pockmarks. Our plan called for a survey of two areas, one where the pockmarks were already discovered and one slightly to the north and the east of the pockmark area where there is more of a depth transition and thus we might better understand the relationship of depth to pockmark formation. Our survey of the second (not previously surveyed) region revealed no pockmarks but did show a remarkable series of closely spaced, NW-SE oriented, parallel grooves in depths of approximately 400 to 500 m. Given the remarkably parallel nature of these features, they appear to be

related to ice-sheet flow rather than individual icebergs scours. Even more intriguingly, south of these grooves, as the water depths get a bit deeper, there appear to be a series of large, dune-like features that appear erosional in origin in the high-resolution subbottom profiles. We speculate that these may be related to flow under an ice-shelf that is not grounded but with near the seafloor.

When we reached the pockmark area, just a few miles south of the scoured region, the winds and seas greatly increased (50 knot winds, 15 foot seas) creating less than optimal mapping conditions but the size and stability of the HEALY allowed us to continue. An approximately 40 km x 14 km area was mapped revealing numerous pockmarks of various sizes, but typically about 300-400 m in diameter and 30 – 50 m deep. Simultaneous collection of subbottom profiles revealed an apparent relationship to subsurface faulting but the nature of this relationship will need further study. Most remarkable was a circle of pockmarks (approximately 20 of them) forming a ring that is approximately 4 km in diameter.

Upon completion of the pockmark survey, the HEALY transited south to re-deploy the two HARP buoys that were recovered at the beginning of the leg. These buoys were successfully re-deployed approximately 90 and 75 miles off Barrow, to be recovered next year. The HEALY arrived off Barrow at 0700L on the 15th of Sept with transfer of the science party by helo commencing at approximately 0900L.

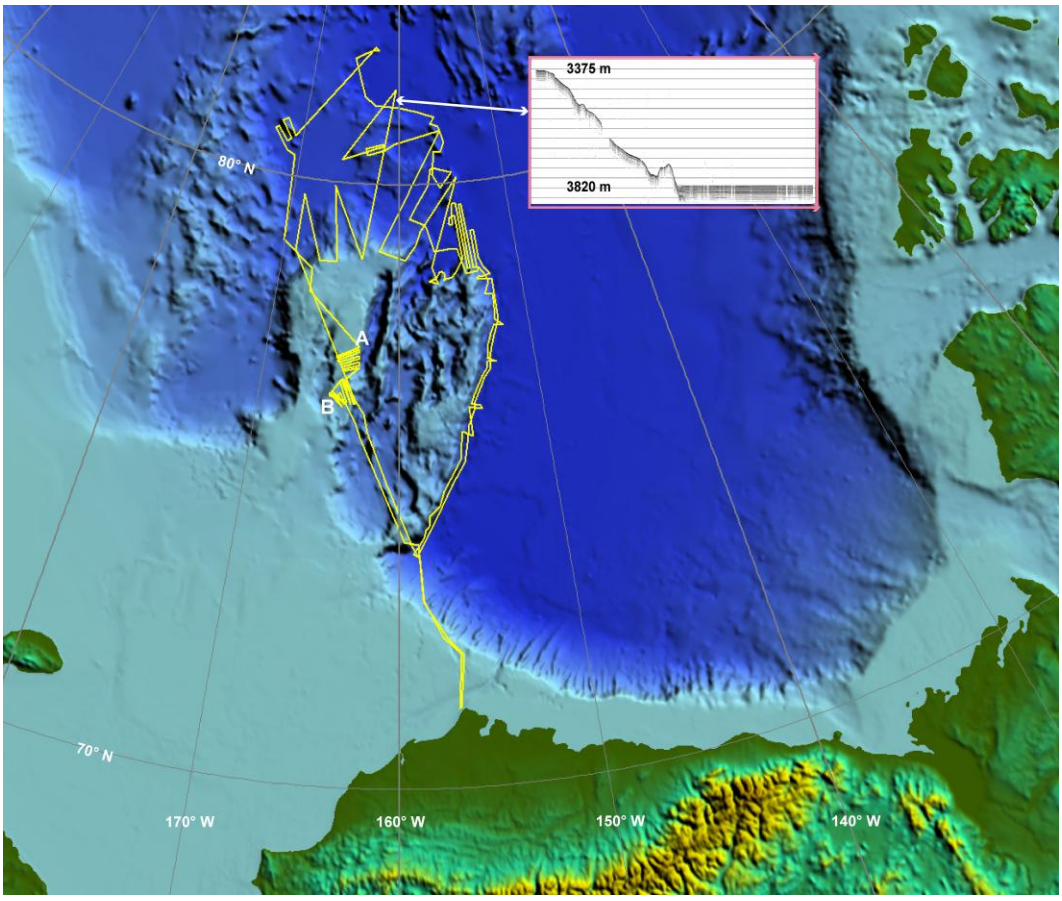

Figure 3. Ship-track for HEALY 0703

HEALY-0805 Overview:

HEALY 08-05 was the fourth in a series of cruises designed to map the seafloor on the northern Chukchi Cap in order to explore this poorly known region and better understand its morphology and its potential for an extended continental shelf under UNCLOS. The mutlibeam echo sounder on board the HEALY was the primary tool, supplemented by the Knudsen subbottom profiler and deep sea dredging operations. The primary targets for the mapping were the delineation of the 2500 m depth contour and the "foot" of the continental slope – the area where the continental margin transitions into the deep sea floor. In addition to its usefulness for Law of the Sea, the seafloor mapping data we collect is also valuable for better understanding seafloor processes, fisheries habitat, and as input into climate and circulation models that will help us predict future conditions in the Arctic. Three ancillary programs also took place during HEALY-0805: 1- the recovery of High-Frequency Acoustic Recording Packages (HARP's) that are designed to make long-term measurements of ambient noise in the Arctic and that had been deployed on HEALY-0703; 2- the deployment of several different types of ice-monitoring buoys by personnel from the National Ice Center (NIC), and; 3- the daily observation by a specialist from the Fish and Wildlife Service of both bird and marine mammal sightings. Summary reports of each of these activities are presented at below.

HEALY 08-05 departed Barrow on 14 Sept and commenced operations with both mapping and the successful recovery of two HARP hydrophones that had been deployed on HEALY 07-03. From the HARP sites we steamed north to pick up mapping of the region thought to represent the base of the slope in the vicinity of 82^0 N and 162^0W. Surveying continued east following the morphologic expression of the base of the slope until approximately 150^0W where the character of the morphological expression of the base of the slope changed and we switched to a reconnaissance mode of surveying. This mode of survey continued until we reached the easternmost extent of our survey at approximately 139^0W. From this point we traveled westward mapping several regions that we suspected shoaled above 2500 m (they did) and then began dredging operations (on 30 August). A total of 3114 linear nautical miles were surveyed (5767 km) on HLY08-05 covering an area of approximately 34,600 sq. km (assuming an average swath width of 6 km).

A total of seven dredges were taken on HEALY-0805, four on the southern portions of the Alpha/Mendeleev Ridge complex, two on ridges north of the Chukchi Borderland and one in the northwestern Northwind Ridge area. The first dredge site on the southern Alpha/Mendeleev Ridge complex yielded samples from what appeared to be an outcrop of layered sedimentary rock that appeared on shipboard examination to be non-marine in origin. The second dredge from the same vicinity contained over 200 pounds of mud and ice rafted debris. The third dredge, from another feature on the southern Alpha/Mendeleev Ridge Complex, also brought back only mud and IRD. The fourth dredge, from the same general vicinity as the third, was predominantly mud and IRD however there where interesting iron concretions and manganese crusts along with one sample of a possible altered ash deposit. The fifth dredge, from the northern extend of the Chukchi Borderland, recovered over 1000 pounds of mud with about 10 pounds of IRD of various rock types. The sixth dredge from a very steep (about 60 degree) slope on the northern Chukchi Borderland was mud free and contained over 200 pounds of what appear to be basalts. Finally, the seventh dredge from the western wall of Northwind Ridge had very little mud but over 700 pounds of rock that probably represented both outcrop and angular tallus from the foot of the steep slope from which it was dredged. Samples from this dredge represented a range of rock types including sedimentary, metamorphic, and possibly basaltic.

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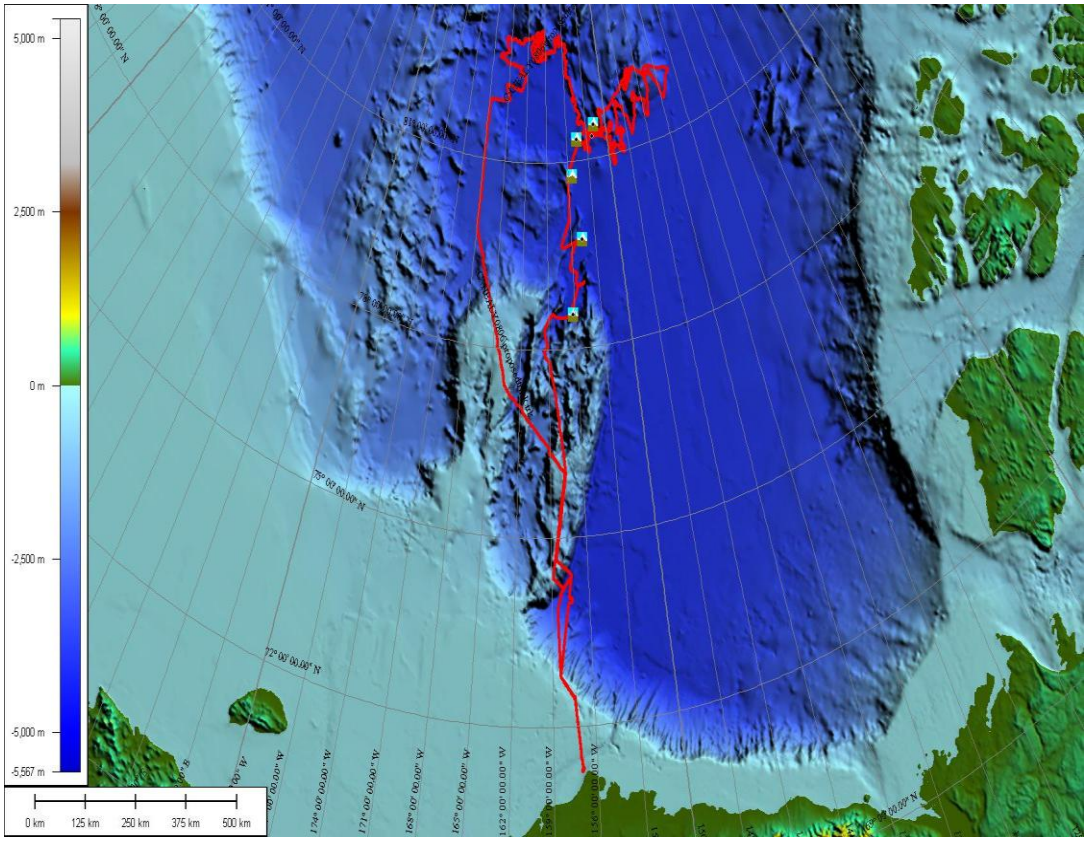


Figure 4. Healy 08-05 – Ship Track 14 Aug –5 Sept. 2008 – Dredge sites indicated by small blue icons. Dredges are numbered sequentially (1—7) from north to south, Dredge Sites 1 and 2 are at the same location and represented by a single icon; dredge sites 3 and 4 are at the same location and represented by a single icon.

HEALY-0806:

HEALY-0806 was part of a two-ship operation led by scientist from the U.S. Geological Survey and the Geological Survey of Canada (operating a seismic system on the Canadian icebreaker Louis S. St. Laurent). For details of these operations please see:
Childs et al, 2009?.

HEALY 09-05 Overview

HEALY-0905 was part of a two-ship Canadian/U.S. operation whose primary objective was to take advantage of the presence of two very capable icebreakers to collect seismic data in support of delineating the extended continental shelf for both Canada and the United States in regions where a single vessel would have difficulty due to ice-cover. In the context of the Law of the Sea, the seismic data is needed to establish the sediment thickness in order to define the "Gardiner Line" (a line denoting points where the sediment thickness is 1% of the distance back to the foot of the slope). The logistical difficulties of collecting seismic data in ice-covered regions make it much more likely that the data can be collected successfully if two icebreakers participate, one in the lead to break a path for the second following with the towed seismic acquisition system. A secondary objective of the joint program was to take advantage of the two vessels to collect high-resolution multibeam echo-sounder data in regions where it would be difficult to collect data with one vessel. In the context of the Law of the Sea, the multibeam bathymetry is used to establish the position of the foot of the slope and the location of the 2500 m depth contour, each critical components of the establishment of an extended continental shelf. In addition to the collection of seismic and bathymetric data, each vessel also carried out ancillary projects including meteorological, oceanographic and ice studies; the HEALY was also equipped to sample the seafloor with dredges.

The *LSSL* departed Kugluktuk, NWT on 6 August while the *Healy* departed Barrow Alaska on 7 August, hoping to rendezvous on the 9th or 10th of August. The *LSSL* was delayed by heavy ice and a detour to Barrow to allow a crewmember to debark. During this time the *Healy* scouted for the ice pack encountering it at approximately 75^{o} N. The vessels rendezvoused on 11 August and conducted a seismic source calibration experiment to document the source levels and source signatures of the LSSL's airgun array (see Roth Report – Appendix A). After concluding the seismic source calibrations (on 12 August), the *LSSL* deployed its hydrophone streamer, the *Healy* took the lead and the vessels stayed together in the ice until 7 September. By the 7th of September the ice had diminished to the point that the vessels were able to separate, the *LSSL* continuing to collect seismic data and the *Healy* collecting multibeam bathymetry and sampling the seafloor with dredges. Over the course of the expedition, the *LSSL* collected more than 4000 km of high-quality multichannel seismic reflection, refraction and gravity data (Fig. 5) and the *Healy* collected 9585 km (5175 nmi) of multibeam bathymetry, sub-bottom profiler and gravity data. Assuming an average swath width of 6.9 km the total area mapped was 66, 135 sq. km (19,280 sq. nmi). This report focuses on the activities of the *Healy*; for details of the *LSSL* cruise, please see Mosher et al 2010.

During the time the two ships were together the *Healy* mostly broke ice ahead of the *LSSL* during long transects across the deep Canada Basin (Fig 5). The multibeam bathymetry collected during these transects revealed a remarkably flat abyssal plain with an average depth of around 3850m and changes in depth of less than 20 m over hundreds of kms. On several occasions the mapping priorities changed and the bathymetric surveys were conducted over targets of interest. Amongst these targets of interest were the mapping of the foot of the slope in an area on the southern side of the Alpha-Mendeleev ridge complex (at approximately 81 30 N, 143 45W) and the examination of several topographic features that were implied on earlier bathymetric compilations. One such feature which appeared as a single 100 m contour (above the abyssal plain) on a Russian chart, turned out to be an 1100 m high, 26 km long, 7.5 km wide seamount. Details of these surveys can be found in the daily log below. Most remarkably, this seamount appears in a region of the abyssal plain where there are no other bathymetric features for hundreds of kms in all directions (Fig. 7).

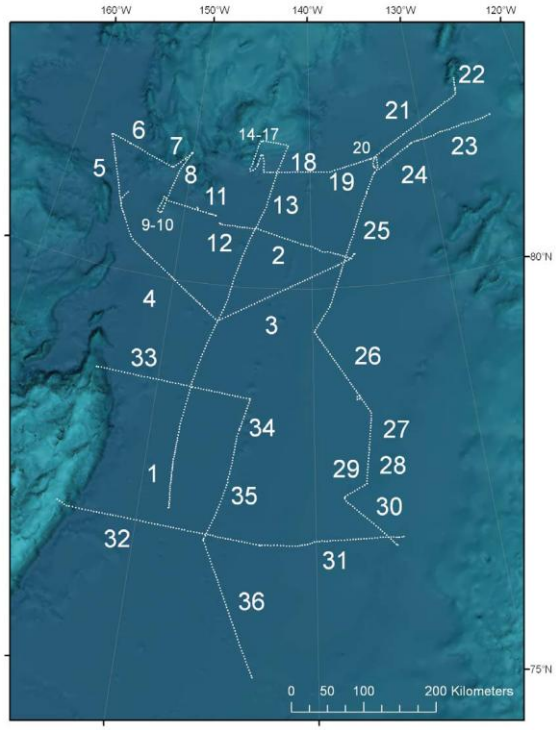


Figure 5. Seismic data collected by LSSL during joint HLY0905.

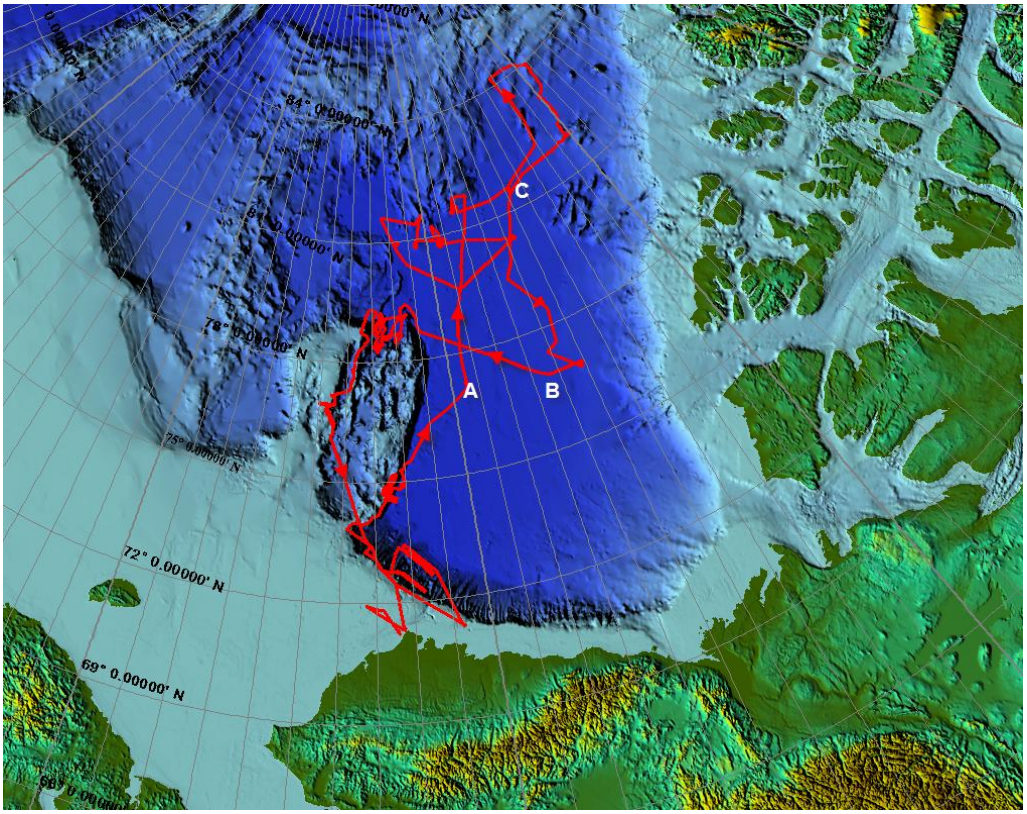


Figure 6. HLY-0905 track line. Point A is rendezvous point for LSSL and HEALY on 11 August. Point B is where the two vessels separated on 7 Sept. 2009. Point C is newly mapped seamount.

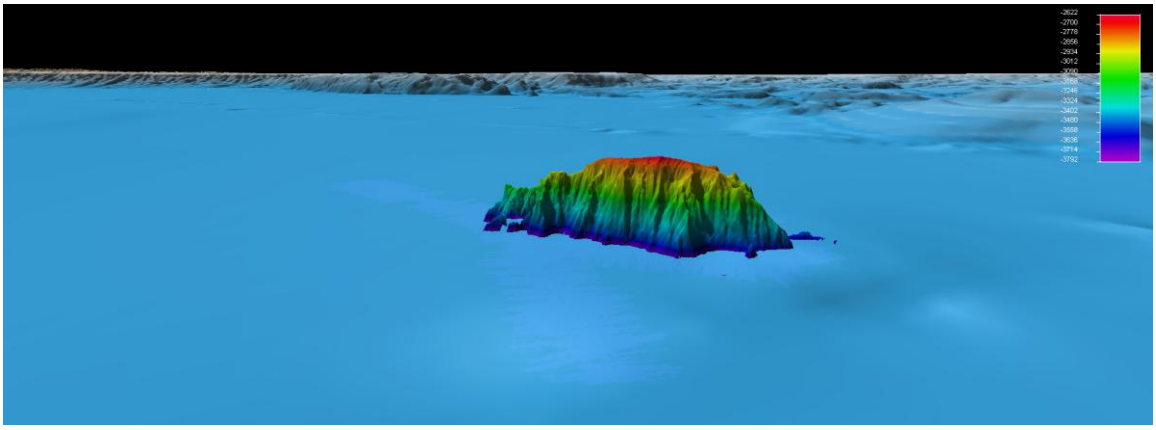


Figure 7. Newly mapped seamount (see Figure 6 for location).

On 7 September, the ice conditions had evolved to the point where the *LSSL* could continue to collect seismic data without the *Healy* breaking ice in her lead. At this point the *Healy* left the *LSSL* and started to map independently. The *Healy* transited to the northern end of Chukchi Cap and proceeded to survey and occupy 5 dredge stations (Fig. 8) located on relatively steep slopes amenable to recovery *in situ* material with a dredge. More than 800 kg (1520 lbs) of rock material was recovered from these dredge sites with much ice rafted debris but also many samples that appear to representative of the outcrop. The majority of the material recovered appeared to represent several types of basalts. There was also a large amount of manganese crust, and in the Chukchi region, numerous metamorphic rocks. These samples will be sent to the appropriate labs for full description and analyses.

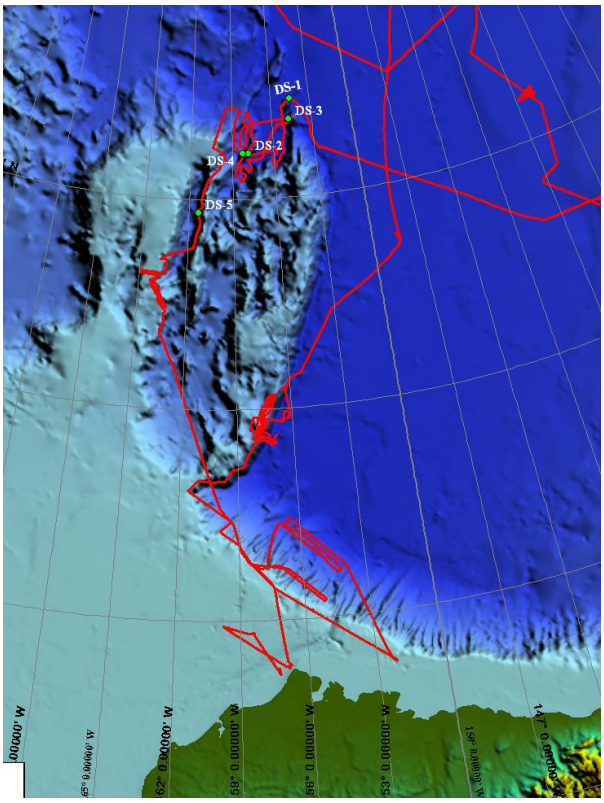


Figure 8. Location of five dredge stations on HLY0905

When dredging was completed the *Healy* proceeded south filling in gaps in coverage and extending surveys of two areas of special interest that had been identified on previous legs. The first area was an

region of numerous parallel sea floor grooves and dune-like features that had first been discovered on HLY-0703. These features are thought to be caused by a grounded ice-sheet and sub-ice flow. Details of these surveys can be found in the daily log section of this report. The second area surveyed was the pock-mark area first discovered on HLY-0302 and then surveyed again on HLY-0703. From the pockmark area the *Healy* steamed south towards Barrow, again filling gaps in coverage, deploying three HARP moorings (see below), recovering a SeaEagle glider (see below) and recovering a meteorological mooring deployed by the *Healy* on the previous leg.

Four ancillary programs also took place during HLY-0905: 1- the recovery of High-Frequency Acoustic Recording Packages (HARP's) that are designed to make long-term measurements of ambient noise in the Arctic and that had been deployed on HLY-0805; 2- the deployment of several different types of ice-monitoring buoys by personnel from the National Ice Center (NIC); 3- the launch and recovery of a SeaEagle glider by representatives of the U.S. Navy supplemented by XBT measurements and meteorological observations, and; 4- the daily observation by a NOAA marine mammal observer of both bird and marine mammal sightings.

Scientific Party

Name	Institution	Position
Larry Mayer	CCOM UNH	Ch. Scientist
Capt. Andy Armstrong	NOAA/CCOM	Co-Ch. Scient
Brian Calder	CCOM UNH	Scientist
Will Fessenden	CCOM	IT specialist
Nikki Kuenzel	CCOM/UNH	Grad Student
Rachel Soraruf	CCOM/NOAA	Grad Student
Kentaro Kaneda	CCOM	Grad Student
Christina Franco de Lacenda	CCOM	Grad Student
Barbara Moore	State Dept/NOAA	Scientist
Jennifer Henderson	NOAA/NGDC	Scientist
Tom Obrien	USGS	Scientist
Paul Henkart	SIO	Scientist
Kelley Brumley	UAF	Grad Student
Ethan Roth	UCSD	Acoustic Eng.
Betsy Baker	Vermont Law School	Professor of Law
CDR William Sommer	USN	METOC
AG1 Richard Lemkuhl	USN	METOC
John K. Hall	Geol Survey Israel	Scientist
Yoann Ladroit	Univ of Brest	Grad Student
Pablo Clemente-Colon	NIC/NOAA	Scientist
Lt. Kyle Obrock	NIC/USN	Scientist
Dale Chayes	LDEO	Snr Guru
Steve Roberts	LDEO/UAR	DB Guru
Christine Hedge	NOAA	Teacher
Jonathan Pazol	URI/ARMADA teacher	Teacher
Erin Clarke	CIS	Ice observer
Alex Andronikov	U Mich	Scientist
George Neakok	BASC	Comm Obs
Georgette Holmes	NIC/NOAA	Scientist
Justin Prudence	NOAA Contractor	MMO
NIC Steve Lilgreen	NIC/USN	Ice Analyst

SCIENCE SYSTEMS REPORT (CHAYES)

The following is a brief summary of the status of Healy science systems during HLY0905.

This cruise started on August 7 and ended on September 16, 2009.

1 Science Ice Machine

Not used during this cruise. Still making ice

2 ADCPs

Both were run during this leg using configurations provided by Frank Bahr (WHOI) during HL0904.

2.1.1 ADCP (150khz)

One beam was reported bad during shakedown and has not been fixed pending parts.

2.1.2 ADCP (75khz)

No known problems.

3 SV2000 (velocimeter in the ADCP 150 well)

Operated normally.

4 CCTV

The science controller was moved from the Main Lab to the WSWS early in the cruise but took a few days to get it working right. It is very helpful to have on the watchstanders workstation.
The controller in the Science Conference Room is not fully functional. The video to the monitors was eventually restored.

5 Ship's entertainment TV system

No known problems

6 DI/RO Pure Water Systems

No used during this cruise.

7 Fluorometer

No complaints that we are aware of.

8 Forward P-Code (Rockwell Collins)

No known issues.

9 General Purpose Science Workstations

No known issues.

10 Gyro Compasses

The gyrocompasses continue to show large variations compared with the ADU5 and POS/MV GPS-based heading references. The MK39 has also been showing some large variations,particularly Aug 13 & 14 & 28 as shown below. The MK27 continues to show large differences relative to the other heading sources as shown in the figure below.

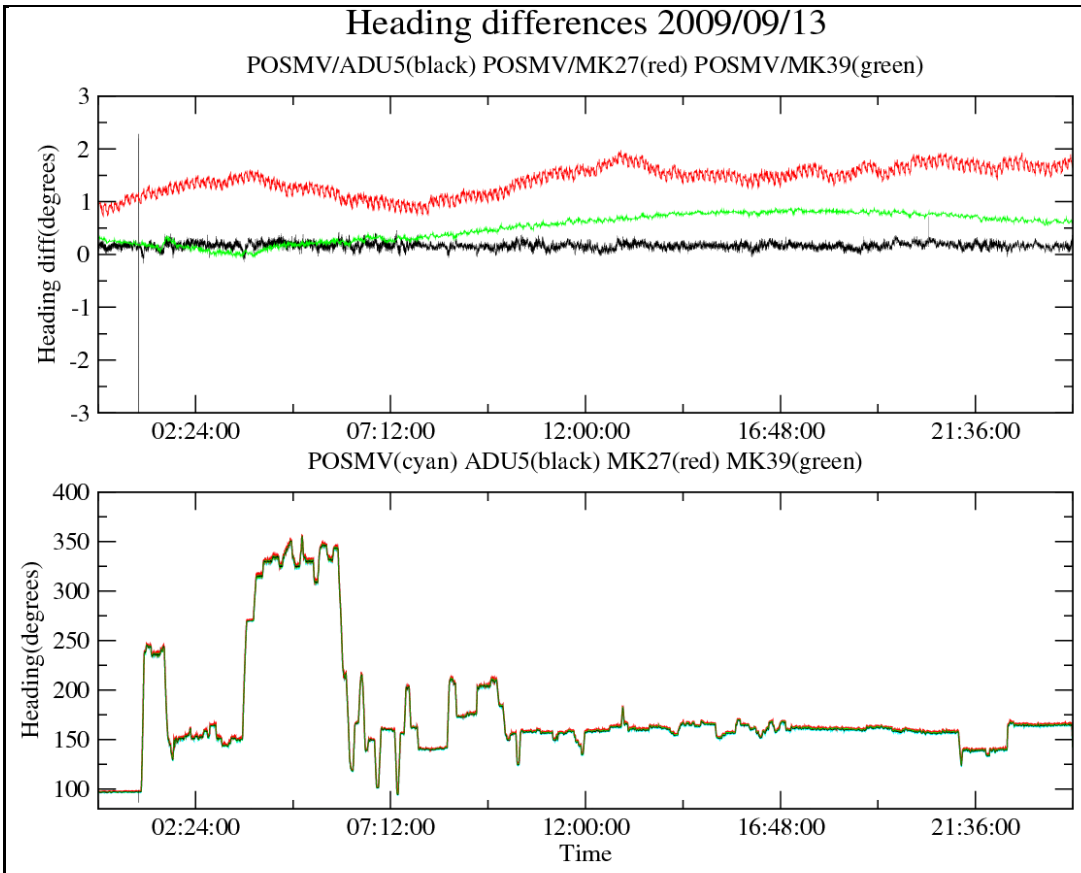


Figure X: Plot of the headings relative to the POS/MV-320. Note the wander of the MK39 and the offset of the MK27.

11 Integrated Bridge System

There were a couple of reboots and outages. One instance may have been brought on by overloading one of the workstations.

12 LDS data logging computer (posmvnav)

Working well.

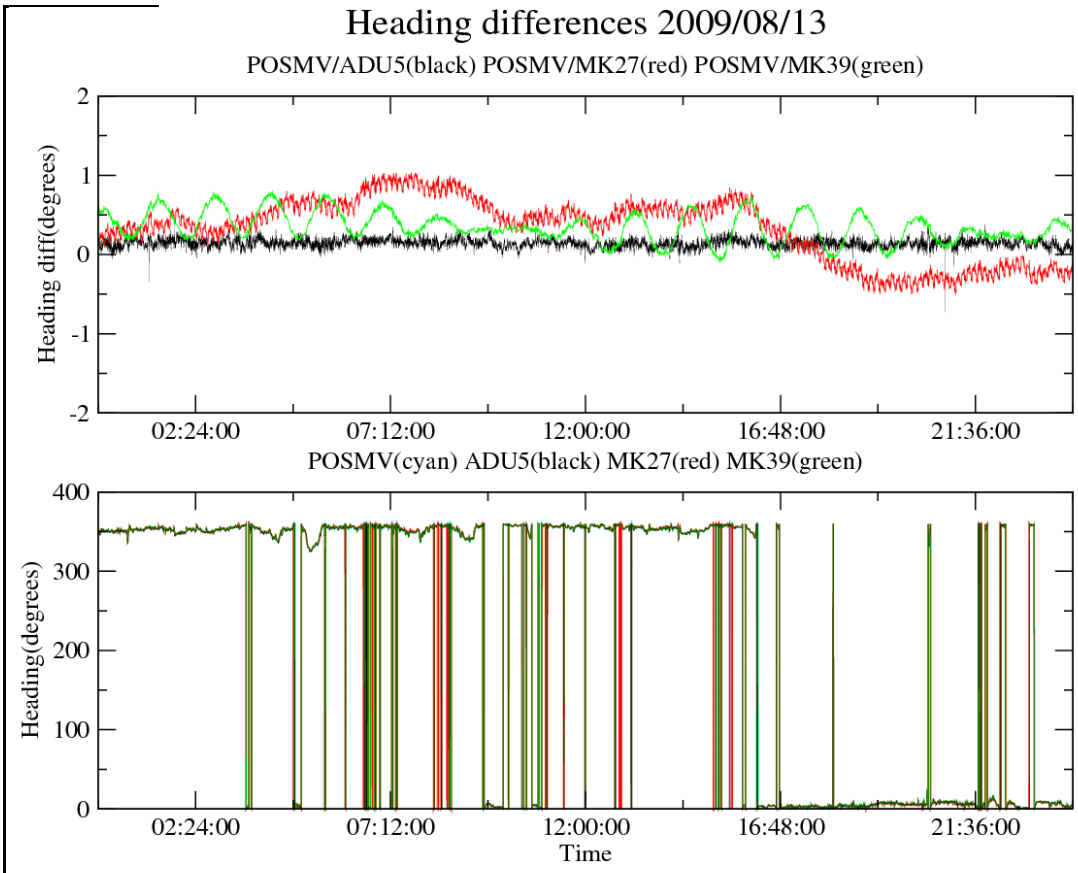


Figure X: time plot of the heading differences relative to the POS/MV-320. Note the apparently periodic variation of the MK39 (green) and the slow wander of the MK27.

13 Aft P-Code (Trimble Centurion)

Operated normally during this leg. Crypto was observed to have expired on 08/14/2009 at 21:11:27 Z and new keys were installed by OSC very shortly after it was reported.

14 Ashtech 3DGPS (ADU5)

Operated normally during this leg.
There were three instances during this leg when it lost it's ability to produce attitude data and had to be re-set. They occurred on August 15, August 27, and September 9, 2009.

15 POS/MV

The POS/MV worked well during this cruise.

16 AG132 DGPS Receiver

No known problems.
We did not seem to get the same coverage of differential GPS service around the north slope this year as we did last year.

17 Science Data Network (general)

There were several reports of problems w/ wireless access in AftCon and on the 03 deck.

18 Science Hoist/A-Frames/Capstans & Cranes

No known problems.

19 Science Uncontaminated Seawater System

No unusual problems. Noise was reported in the coupling for pump #4 but the system keep running. The system was operated in "ice" mode during this trip and output was only used for the TSG in the BioChem Lab.
One small fish appeared in the sink, apparently having made it through the intake, the pumps and the debubbler.

20 Science Reefer/Freezer/Climate Control Chambers

The chambers were not used during this cruise.

21 SCS Logging System

SCS missed writing to the second data store ("Z" drive on Seaventure) a number of times, including at:
08/17/2009 04:54:57
08/17/2009 21:35:09
08/18/2009 16:12:07
09/01/2009 00:06:37
09/15/2009 05:52:08

SCS stopped logging a few times including at:
09/01/2009 00:46:15
09/15/2009 05:52:08
09/15/2009 06:52:48

The UDP datagram broadcast of the Knudsen subbottom PKEL file data was found to be broadcasting to 255.255.255.255 instead of using the more appropriate subnet broadcast address of 192.168.10.255. It was also determined that it was rebroadcasting the same data message every second until a new ping arrived. In the absence of a new ping, e.g. when the Knudsen was not operating, it would continue broadcasting as if all was normal. This behavior caused us to terminate the broadcasts.
The reefer and climate control chamber data was not logged during this cruise.

22 SDN Time Servers

Operational with no known problems.

23 SeaBeam 2112 Multibeam Sonar

The multibeam operated as expected. Careful attention by the watchstanders was required when operating in ice in order to maximize data return by adjusting the depth of the "gates" and changing between automatic and manual gates depending on ice conditions.
A patch test was done on August 10th at longitude: 156º 58.04' W, latitude: 74º 35.86' N and a new bias of -0.10º was entered, replacing the old value of -0.11º. A pitch bias test was also performed and it confirmed the existing 0º bias.
The usual, known problems, including: inability to use correct sound speeds at the array of less than 1441 m/s; poor performance in water depths less than 250m; were observed.
The SeaSurvey workstation had to be rebooted occasionally as the result of the known memory leak that eventually causes it to misbehave.

24 Sippican Mk21 XBT System

Operational and all expendable probes were launched with it. There were some issues early in the cruise with mapping the networked files.

25 Devil XBT System

The Devil XBT system was not used during this leg because it can not support XSV probes.

26 Sperry Speed Log (SRD-500)

Because it does not have a protective window like the other sonars, the SRD-500 was retracted to prevent ice damage prior to the start of HLY0904 and was lowered on at 06:25:26Z on September 15, 2009.

27 Sub-Bottom Profiler (Knudsen)

Knudsen worked well and was stable.
It was slaved to the SB2112 transmit with a 500 millisecond delay for most of the cruise. Late in the cruise some experiments were done with a shorter (250 mS) delay.

28 Weather Decision System WDS (Terascan) satellite receiver system

The data quality is okay. The laptop which we use for processing WDS data for the mapserver locked up at least once.

29 Winches/Wires/Displays

29.1 CTD winch:

The level wind was out of adjustment on our first deep (3,800m) cast which resulted in the wire being cinched on the drum. On the next cast the wire was stopped off and the cinch was loosened. More attention to level winding and the ability of the operator to see the condition of the wire and winding on the drum by video should help prevent this problem.

Figure X: Photograph of the cinched wire on the CTD drum.

At the beginning of a CTD cast on August 18, we noticed that the wire was running over the I-beam for the new Shawbox overhead hoist. This section of the I-beam had been modified after the incident this spring when the Shawbox fell to the deck. In the new arrangement the i-beam has to be rotated athwartship in order to take a CTD from the starboard a-frame.

Figure X: CTD wire running over the modified i-beam for the new Shawbox hoist.

29.2 Trawl/Core winch:

Five dredges were taken using the 9/16" wire during this cruise. All returned rocks. The 9/16" wire is very poorly wound on the drum and should be re-wound during shakedown.

30 Coring Equipment

No coring was done during this leg.

31 CTD

Eight (8) CTDs (120-127) were taking using the CTD-only arrangement were taken for accurate sound speed profiles during this cruise. The original instrument arrangement was very light (a few hundred pounds) so we added two huge shackles to get the weight up to around 750 pounds.

Figure X: Photograph of the large shackles weights added to the CTD package to achieve a reasonable weight.

32 Thermosalinograph (TSG)

The TSG worked well during this cruise.

There was one brief glitch at shortly after midnight on September 12 (day of the year 255), when the data stopped for less than one minute. There is no known explanation at this time.

tsg_met 2009:255:00:00:42.2480 $PSSTA,-1.354,2730.800*55
tsg_met 2009:255:00:00:44.2487 $PSSTA,-1.354,2730.800*55
tsg_met 2009:255:00:01:07.0179 $PSSTA,-1.354,2730.800*55
tsg_met 2009:255:00:01:08.2497 $PSSTA,-1.354,2730.800*55

The TSG computer winch display stopped responding to remote display requests and was rebooted at --------.

33 Meteorological sensors

Operational. No known problems.

There was vastly less icing (hoar and rime) than last year during HLY0805 or HLY0806 when we were working in similar locations at about the same time of year.

34 Elog

Was used extensively by the science party and science technical support.

Science watchstanders made their entries in a separate elog table.

35 Gravimeters
Both Bell BGM3 gravity meters worked well during this cruise.

36 Map-1 server
A clean Linux install was done with the intention of using this machine (ex he-gate) to test the Science OpenPort. Due to other distractions the testing was done using a spare Mac laptop.

37 Map-2 Server
Map-2 is a general purpose Linux-based workstation in the Future Lab. No known problems.

38 Map-3 Server
The Lamont web services were run on map-3. There were some configuration problems with the experimental Drupal content management system.

39 Map-4 Server
Mapserver was run on map-4 during this leg.

40 Map-5 Server
Map-5 was used as a backup archive.

41 WebCams
No known problems.

42 Watchstander Workstation
No known problems.

43 QC plots
No known problems

44 Inmarsat Internet Connectivity
Shared use of the 128 kbps Inmarsat Internet connectivity worked much better than expected during this cruise. We retained several hours of connectivity even at 84º North. Last season, service was provided from the standard 142º West satellite and we lost all connectivity in the vicinity of 80ºN in addition to problems w/ much lower latitude service due to lease issues.
Gerry Fitzgerald of Mitre Corporation determined that the reason for the high latitude service this year was eventually determined to be the result of the service provider (Stratus) having shifted service to an older satellite I2-F1 (NORAD number 90093A) which is out of fuel and has an increasing inclination which provides service further north.

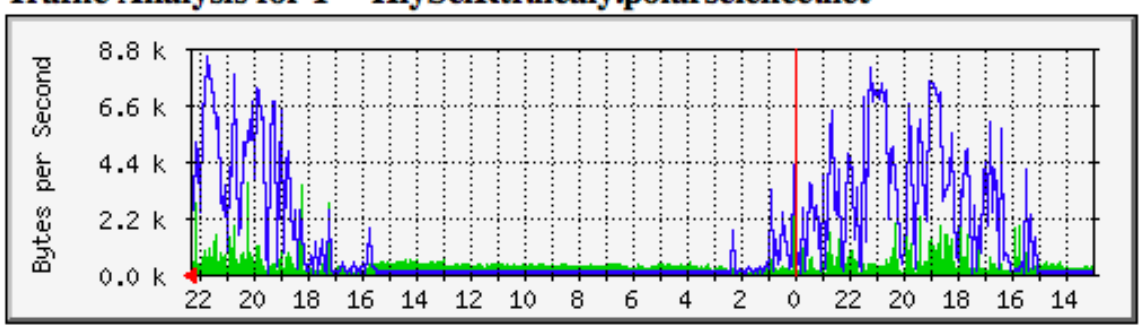


Figure X: Screen snapshot of the Multi-Router Traffic Grapher (MRTG) showing science network connectivity over the Inmarsat shared connection at 83º 54'N on August 27, 2007.

45 Iridium email system

The email system based on the General Dynamics ReachBack Vouyager system worked reasonably well. The paired Reachbacks (on ship and shore) had to be rebooted about once per week. The #2 radio is much less reliable (4x) than the others as shown in the screen snapshot below.

ReachBack™

	Channel 1	Channel 2	Channel 3	Channel 4
Connection Status	Connected	Connected	Connected	Connected
Call Up/Down Time	01:03:43	00:10:13	02:12:29	00:01:58
Total Time Up	190:19:52	164:04:21	201:28:41	174:45:08
Dropped Calls	384	1622	367	313
Local IP	169.254.85.1	169.254.85.2	169.254.85.3	169.254.85.4
Remote IP	169.254.77.4	169.254.77.2	169.254.77.3	169.254.77.1
Local Bundle IP	169.254.85.10	169.254.85.10	169.254.85.10	169.254.85.10
Remote Bundle IP	169.254.77.10	169.254.77.10	169.254.77.10	169.254.77.10

Figure X: Screen capture of the Reachback Monitor. Note the high number of dropped calls for Channel 2.

46 Cruise specific efforts

46.1 Ship to ship wireless

ESU Seattle Science installed an 802.11b mesh network connection to provide an extension of the Healy's science system onto the Canadian Coast Guard vessel Louis S. St. Laurent. This system worked fairly well but suffered from problems with duplicate ICMP reply packets which might have been the result of a configuration error in the laptop that we provided for use on the Louis.
The desired range was 8 to 12 nautical miles but the link seems to have worked to about 5 or 6. The Voice over IP (VOIP) phones worked well at ranges less than about 4 nm.

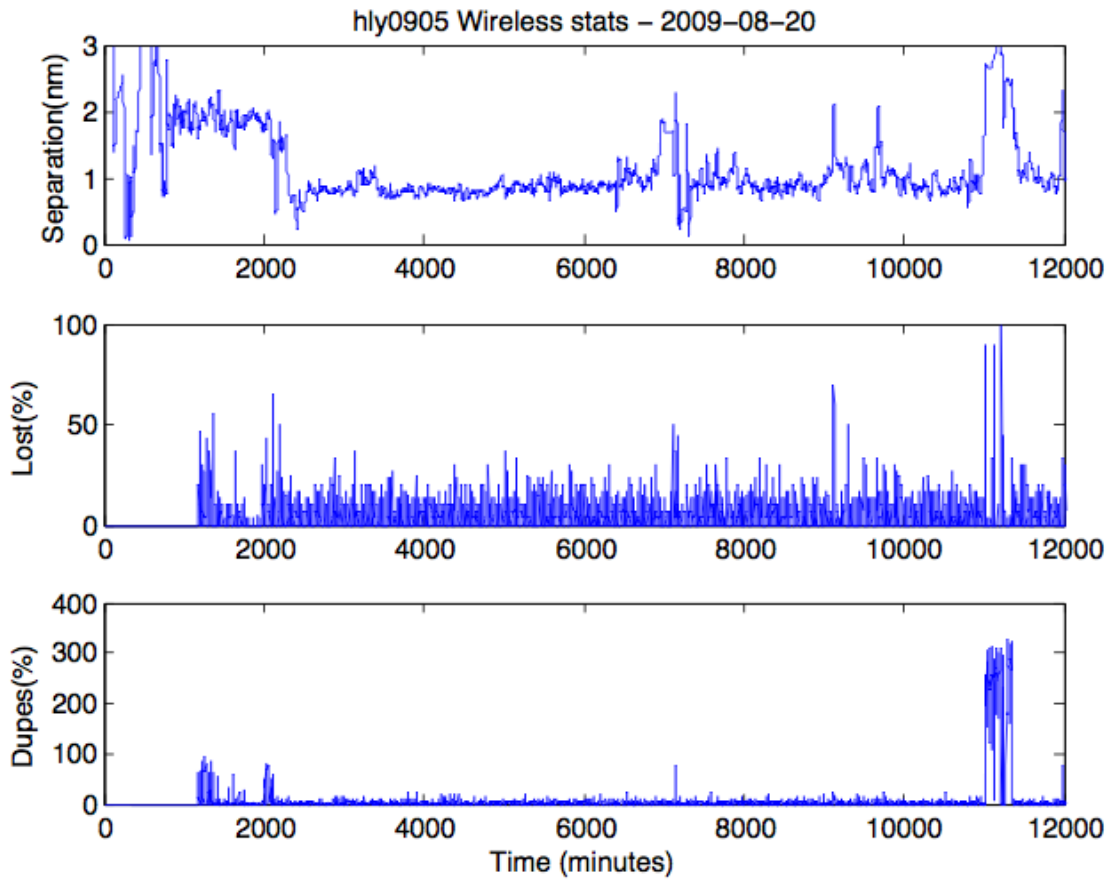


Figure X: Plot of ship to ship wireless link performance.

46.2 IceVu

Created an LDs logger to provide appropriately formatted GPS data at the right baud rate to the Canadian Ice Service "IceVU" computer system in the Future Lab.

46.3 Seismic Experiment

Provided a GPS feed and data broadcast buffer in AftCon for the seismic calibration experiment

46.4 WSWS

Provided a real-time GPS feed to the Watch Stander Work Station for the chief scientist's laptop running OzzieExplorer.

47 Experimental and development efforts:

47.1 Multibeam replacement planning

A significant amount of effort was spent during this leg doing fact checking and updating drawings and documents in support of the scheduled replacement of the SB2112 multibeam with an EM122. Specific efforts including making measurements of potential electromagnetic interference, updating drawings for cable runs and checking for mechanical interferences.

47.2 Dredging

Chayes was the lead for the five rock dredges which were attempted in water depths ranging to 3,800m during this cruise and all were successful.

47.3 Alternate real-time plot tools

We have been using LabView to prototype various kinds of real-time GUI interfaces to our real-time data system. Development is quick and relatively easy but the result is limited in a number of ways including the cost of the development package and the inability to easily cross compile for multiple platforms.

During this cruise we experimented w/ a Perl/Tk approach and a Python approach. Neither have the easy of development of Labview. The Perl/Tk approach results in complicated, awkward code. We have not found a good widget set or a way to manipulate graphics panels in real-tie for Python yet. Historically we experimented with RealBasic which cross compiles easily to Linux, Mac OS X, and Windows but does not have a clean real-time strip-chart graphics capability.

47.4 Data Watch/Tabbed Display:

Updates to our real-time LabView-based monitoring application were implemented during this cruise. These were largely based on cleaning up and reformatting the features that Chip added during HLY0902.

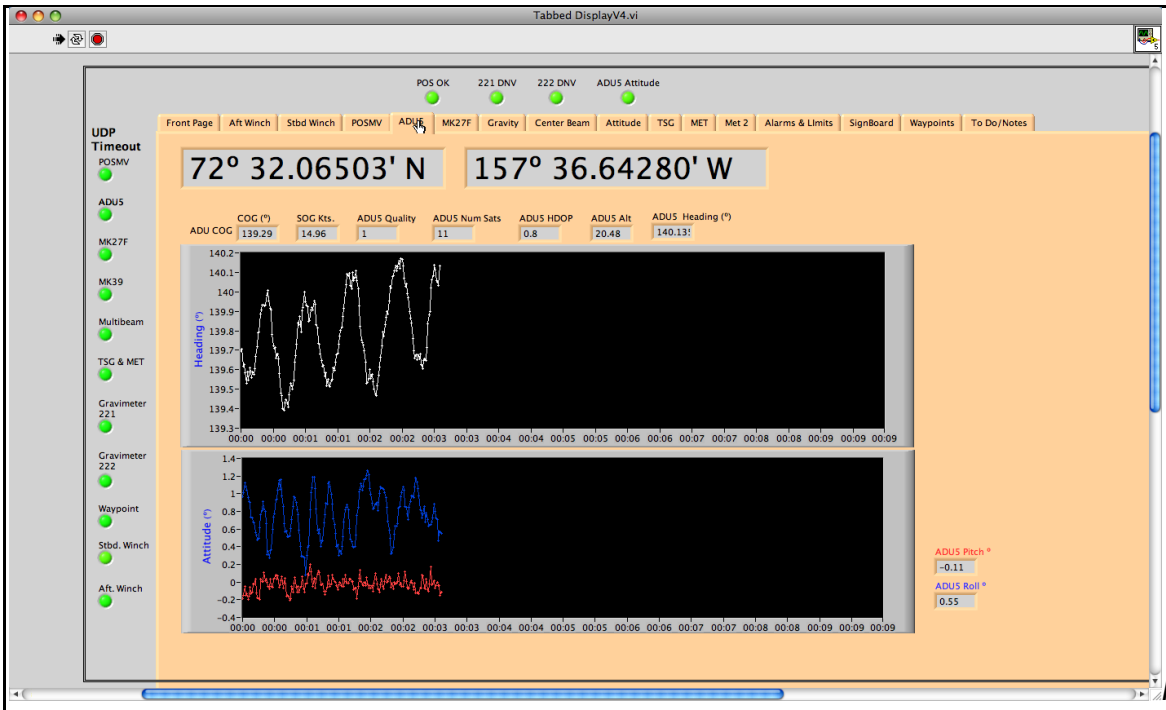


Figure X: Screen capture of the ADU5 (3D GPS) screen

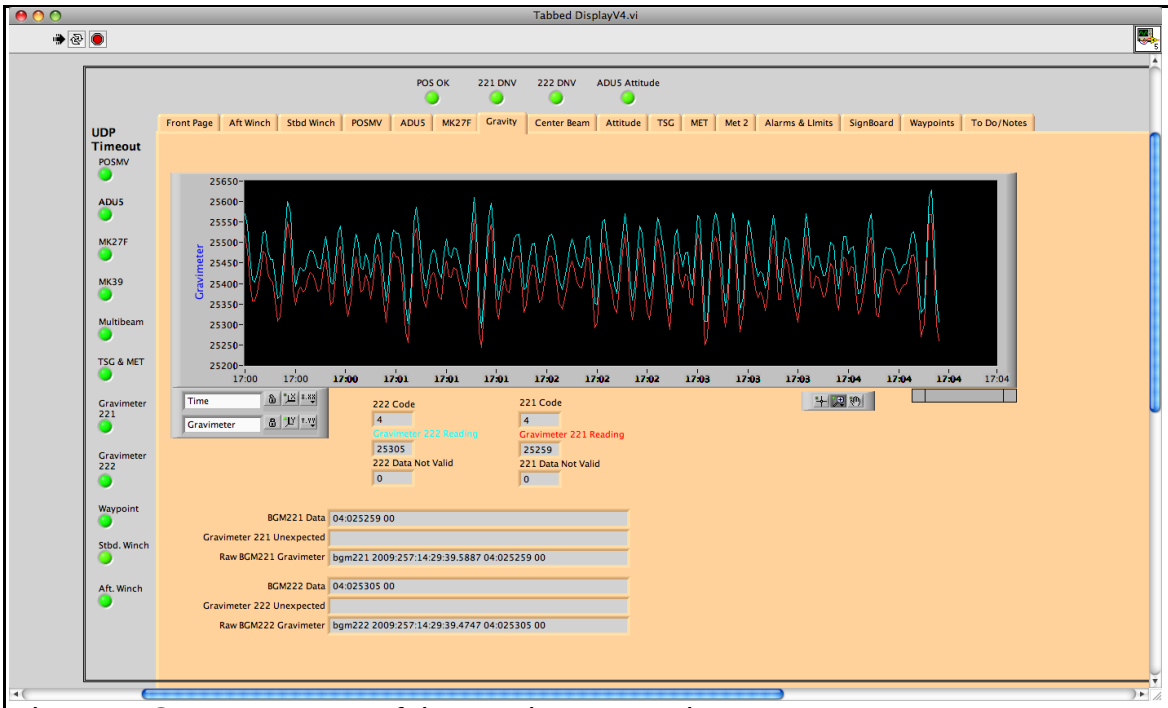
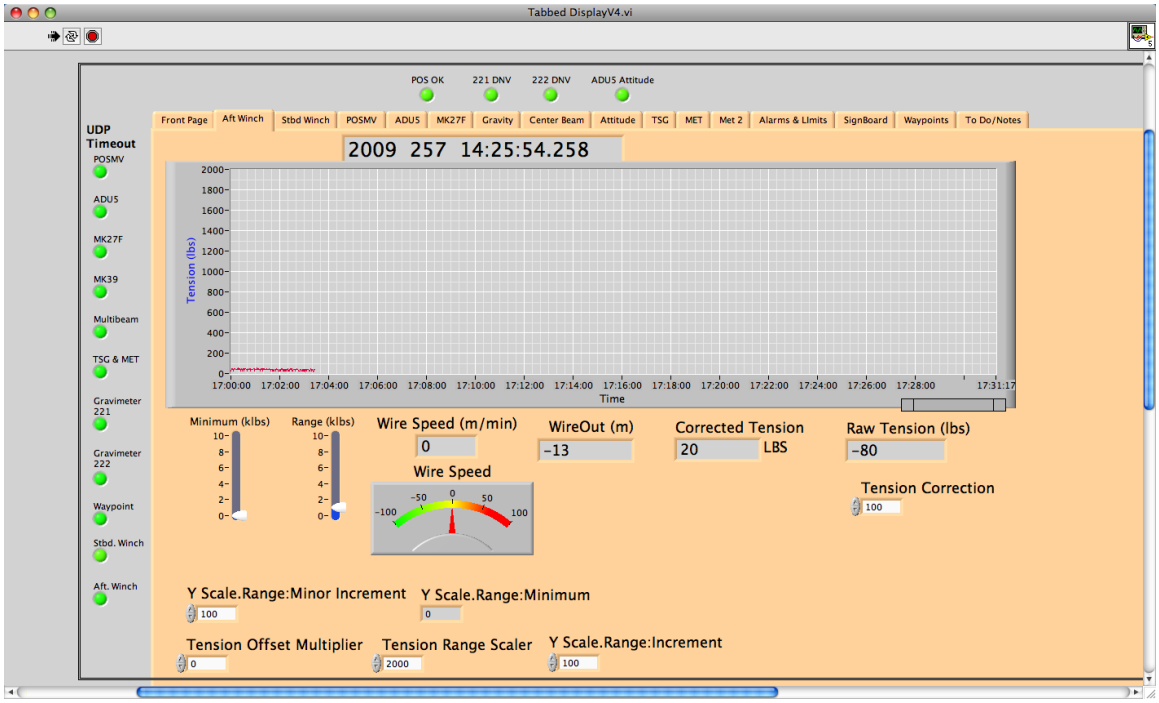
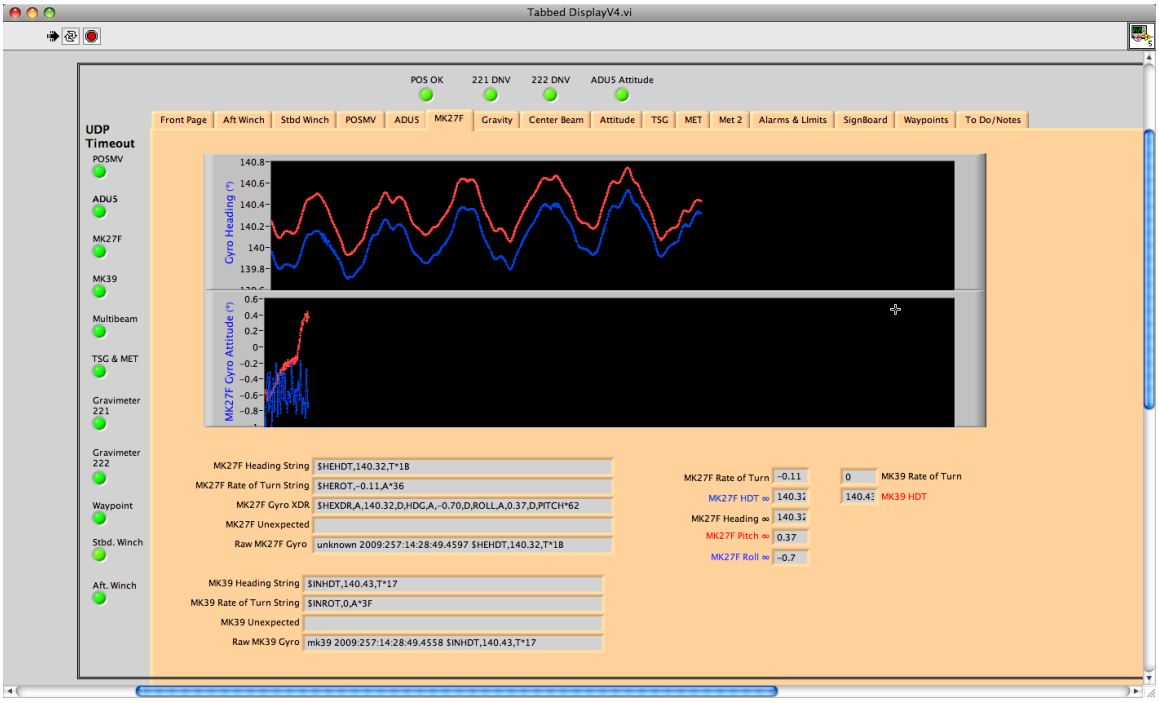


Figure X: Screen capture of the gravity meter tab.





Gyrocompass tab

47.5 Science OpenPort

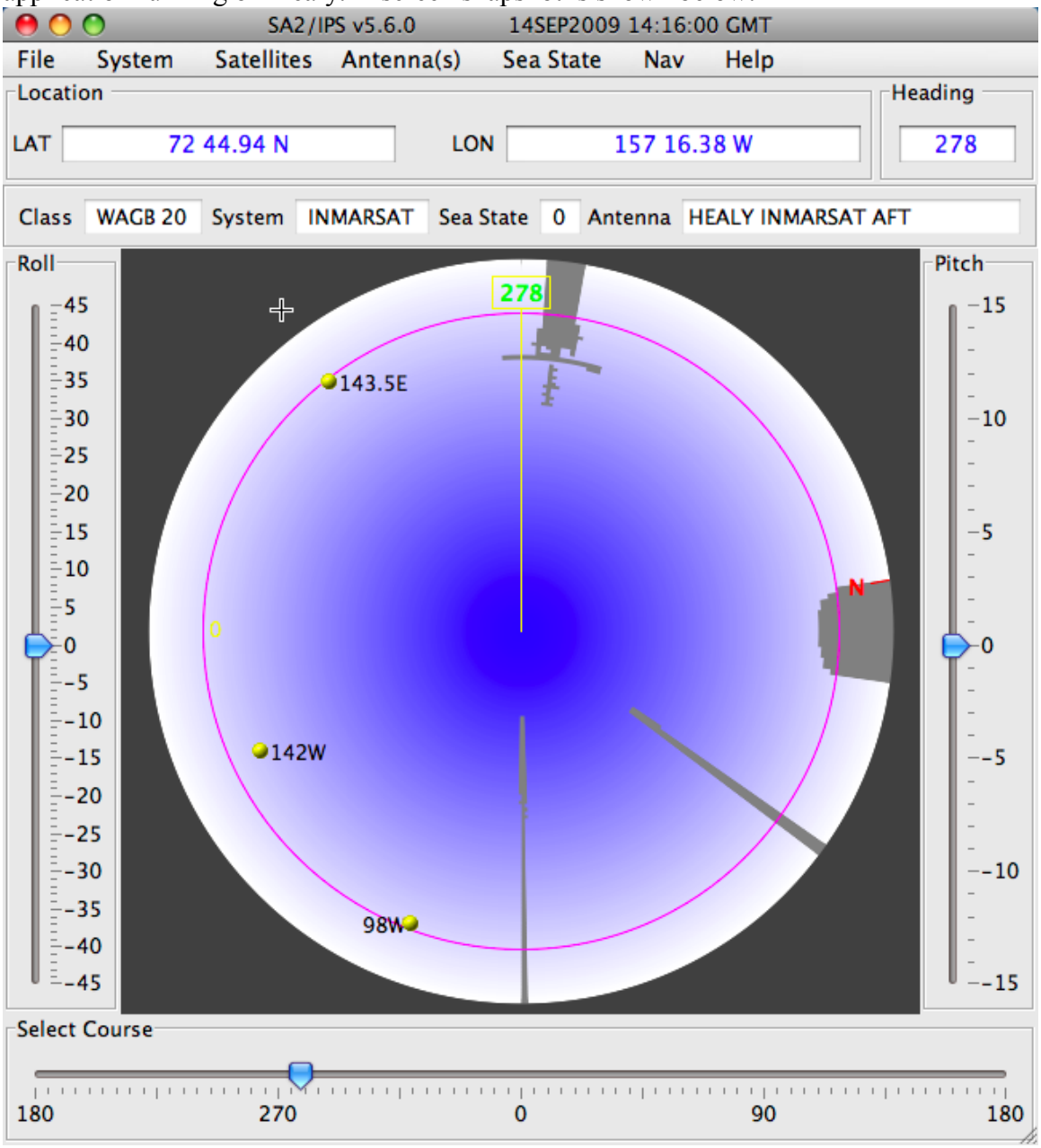
An Iridium OpenPort system was borrowed from the Greenland Traverse program for testing at high latitude and for potential use as a backup for getting satellite ice image support from NIC at high latitudes.

Due to the extended coverage afforded by the orbital instability of the satellite that was carrying the Healy's CGDN+ leased satellite service we had four to six hours per day of "regular" internet access even at 84º North so we did not use this much.

The original plan was to get the unit aboard at the beginning of HLY0904, get it installed and set up an automated test protocol. Unfortunately the unit did not arrive in Barrow until just before the mobilization of HLY0905 and the installation was significantly delayed by the need to get the cruise set up and early work done on time. The opportunity to do extensive testing was thus lost.

47.6 SA2

We worked with Gerry Fitzgerald of Miter Corp. to get an updated version of his satellite obstruction application running on Healy. A screen snapshot is shown below.



CHIEF SCIENTIST LOG
HEALY 0905
7 August 2009 – 17 Sept 2009
Barrow to Barrow

NOTE: LOG WILL BE KEPT IN GMT WITH REFERENCE OCCASSIONALLY TO ALAKSA DST TIME (ADST = GMT – 8) OR CENTRAL TIME (CT = GMT-6)

5 – 7 August 2009 = JD 217 - 219

Andy and Larry arrive in Barrow at approximately 1300ADST on the 5th of August after flight from Anchorage through a very smokey Fairbanks. Jennifer Henderson, Alex Andronikov, Rachel Soraruf, and Barbara Moore were already in Barrow. Cannon Mix from AMD informs us that helo is grounded in Fairbanks because of smoke from forest fires. This continues through next day as all of the rest of the scientific party arrives. As it looks like the helo may not be able to get to Barrow for several days we look for alternatives. HEALY is collecting CTD data about 80 miles offshore as we wait for word. Several options explored (HEALY LCVP, HEALY RHIB, BASC 22' boats and landing sites explored but none seemed viable especially for cargo (including 4000 lbs of fresh produce coming in by C-130).

We see a large (140') landing craft tied up next to a big barge NE of Barrow (next to the new football field) – it is called the GRETA and owned by Bowhead Transport. We find the local manager – Terry, and ask if it is conceivable that we rent the vessel for a transfer of cargo and passengers and he said no problem – when asked the cost he said – nothing. He wanted to do it immediately but HEALY needed to come closer in – HEALY arrived offshore early morning of the 7th and about 3000 lbs of cargo was loaded on GRETA and carried out to HEALY. Incoming science party was ferried off (carrying float suits) and outgoing party and an additional 4000 lbs of produce was brought back out to HEALY after C-130 came in. Bowhead also provided transport for passengers in Barrow and a flatbed truck for produce – all again at no charge – a remarkable display of generosity. The transfer was finished by about 1700L ADST and the HEALY got underway.

8 August 2009 JD219

Plan – steam to HARP B - recover, launch NAVO Seaglider, take CTD and then XBT then steam to HARB B site and recover.

0632Z; Recovery of HARP Buoy B

NAVO Seaglider not talking to Irridium satellite so delay launch – proceed to HARP Buoy C site.

8 Aug 2009 – JD 220

0905Z – Recover HARP Buoy C

Lay out line to proceed to Patch Test site – email from Dave Mosher on LSSL said they are hitting heavy ice and will be delayed. Based on ice imagery he suggests rendezvous point of :

75 14.5N
159 50.3W

This is to get clear water for source signature work but still be out of US EEZ. We are heading near there anyway so that is not a problem for us – they will probably not be there till Monday morning (10 August).

We have laid out a route to fill in some gaps south of the Cap and to build our coverage at the edge of the cap.

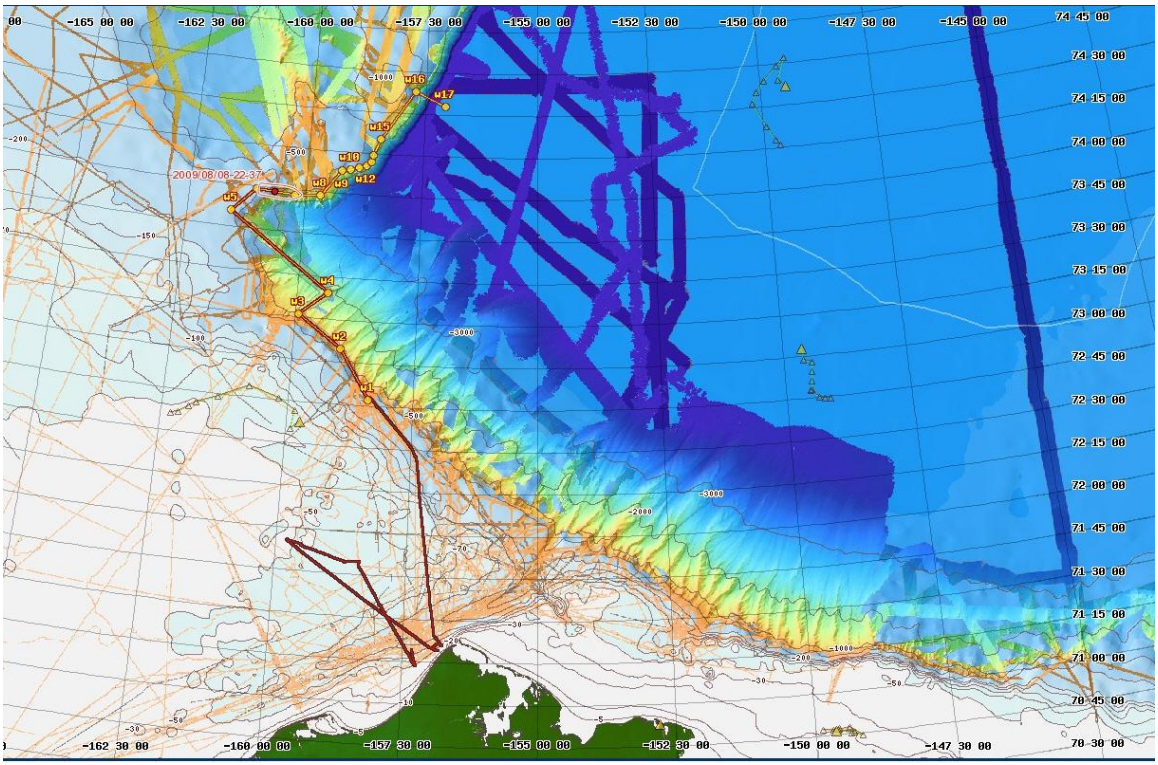


Figure 1. Overview of track and waypoints 7-8 August 2008. Snap at 2200Z 8 Aug 2009.

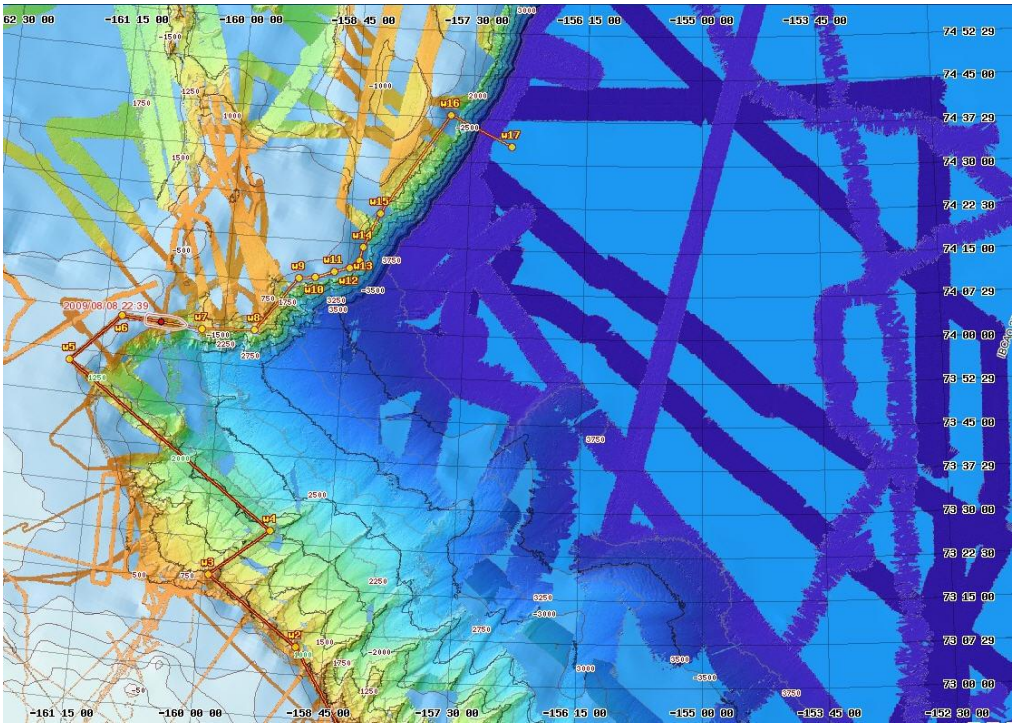


Figure 2. Waypoints laid for transit to patch test site 2200Z 8 Aug. 2009

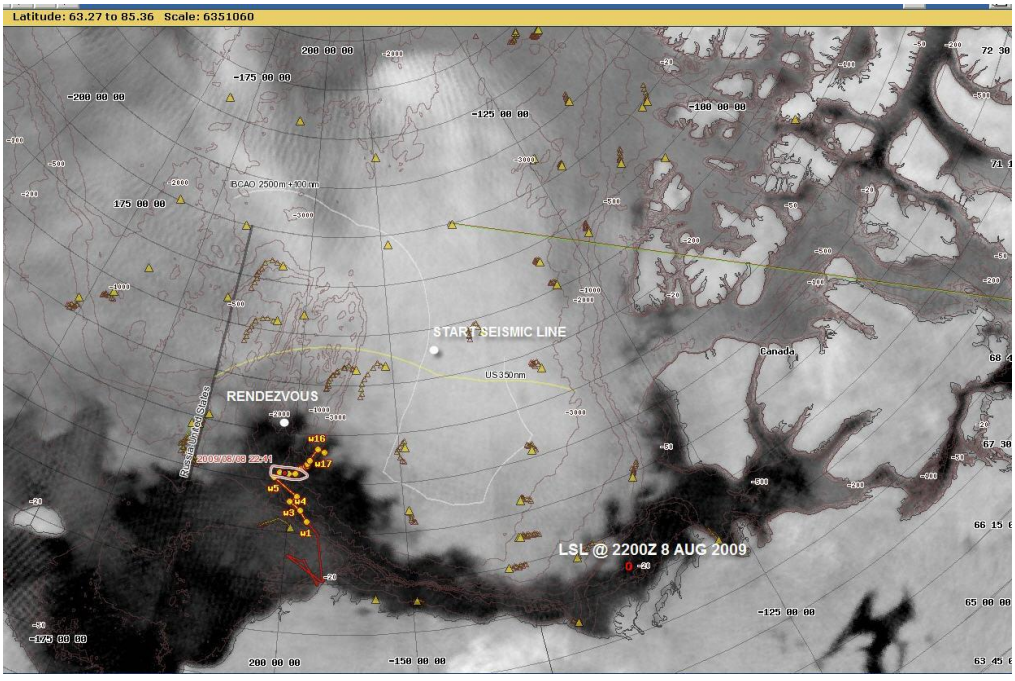


Figure 3. QuikSat image of region with position of LSSL at 2200z 8 Aug as well as proposed rendezvous site and start of Seismic line 1.

9August 2009 – DOY 221

0600Z: Arrived at deep CTD site at base of Northwind Ridge (Waypoint 17).

0608Z: CTD launched. CTD has no rosette on it so it is light and there is strong wind. Concern about wire angle.

Heard from LSSL – they are 560 nm away – ETA –mid-day on Monday

0625Z – CTD wire angle > 45 degrees – aborted with CTD at about 125m. Vessel being blown about 1.5 knots by 35 knot winds. New plan is to map to the NE along the top of the Northwind until we hit the ice and hope that wind dies down. They will also add more weight to the CTD. In the mean time we will take an XBT and an XSV and compare all to last years CTD (which was near here) and if it matches we will use a splice. We will also wait for calmer weather for the patch test – need to make sure we leave enough time before LSSL rendezvous.

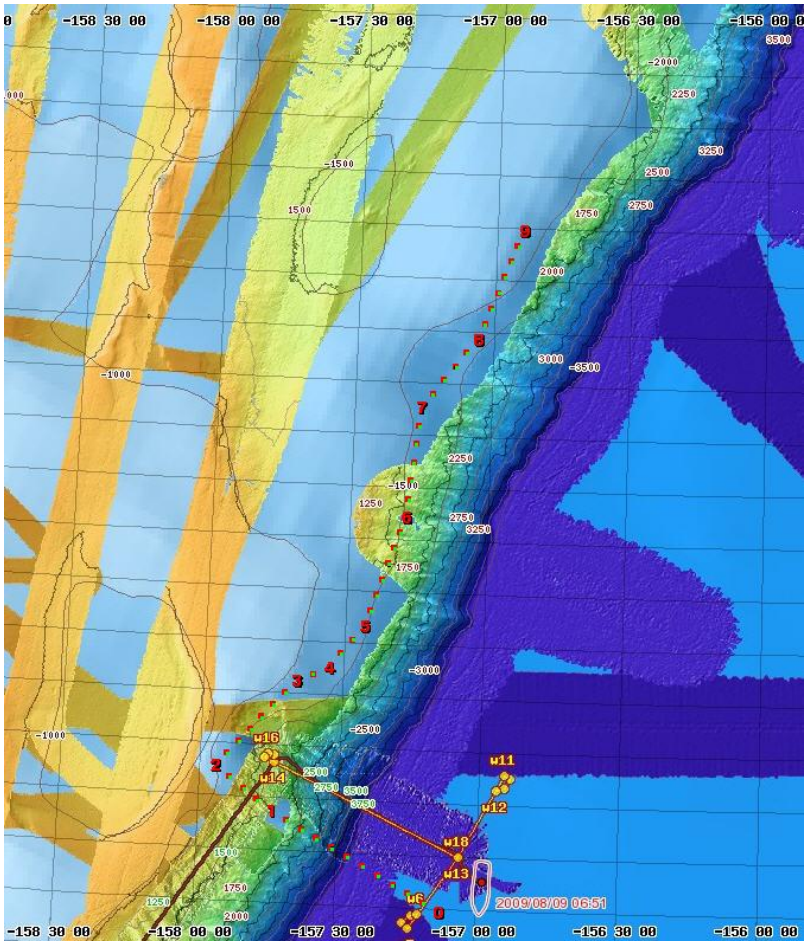


Figure 4. planned survey of top of Northwind while searching for edge of the ice shelf.

9 August 2009 DOY 221

1112Z: Jon Pazol spotted first ice on the horizon – 74 51.23N 157 33.05W – small remnants of old ice

1220Z: Ice getting a bit heavier.

1900Z: Passed out of ice into open water; mapping along track to overlap with existing data.

2100Z: Ended mapping lines along ridge to head for deep water and CTD site.

2234Z: CTD in the water lat 74-29.8N lon 157-08.5\W

10 August 2009 DOY 222

0141Z: CTD on deck; some problems with the level wind on the CDT winch

0159Z: Dropped XBT T-5 286-982

0213Z: CTD profile examined and did not differ from existing profile, which was left in the system.

0226Z: Began patch test with biases zeroed out, running roll bias line.

0229Z: Mayer on watch

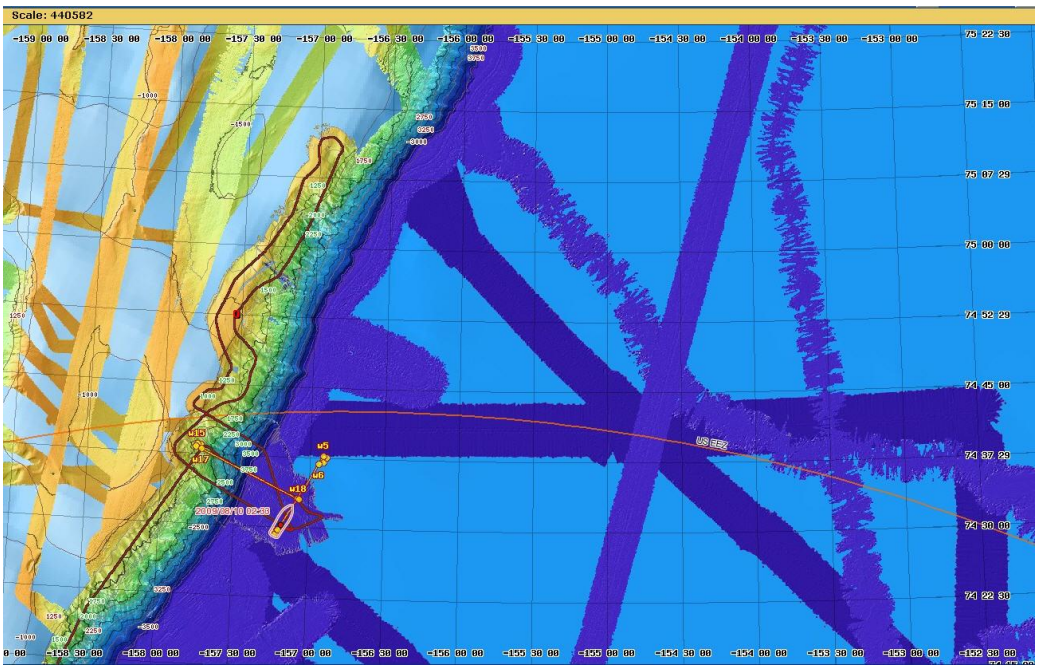


Figure 5. Overview of tracks at 0230Z 9 Aug 2009

0443Z: Roll bias run completed – SeaBeam SeaPatch software shows roll bias of

- 0.10 degrees – previously it was -0.11 . Entered -0.10

Continuing on with Pitch test

0829Z: Pitch test showed zero offset -Dale goes to bed.

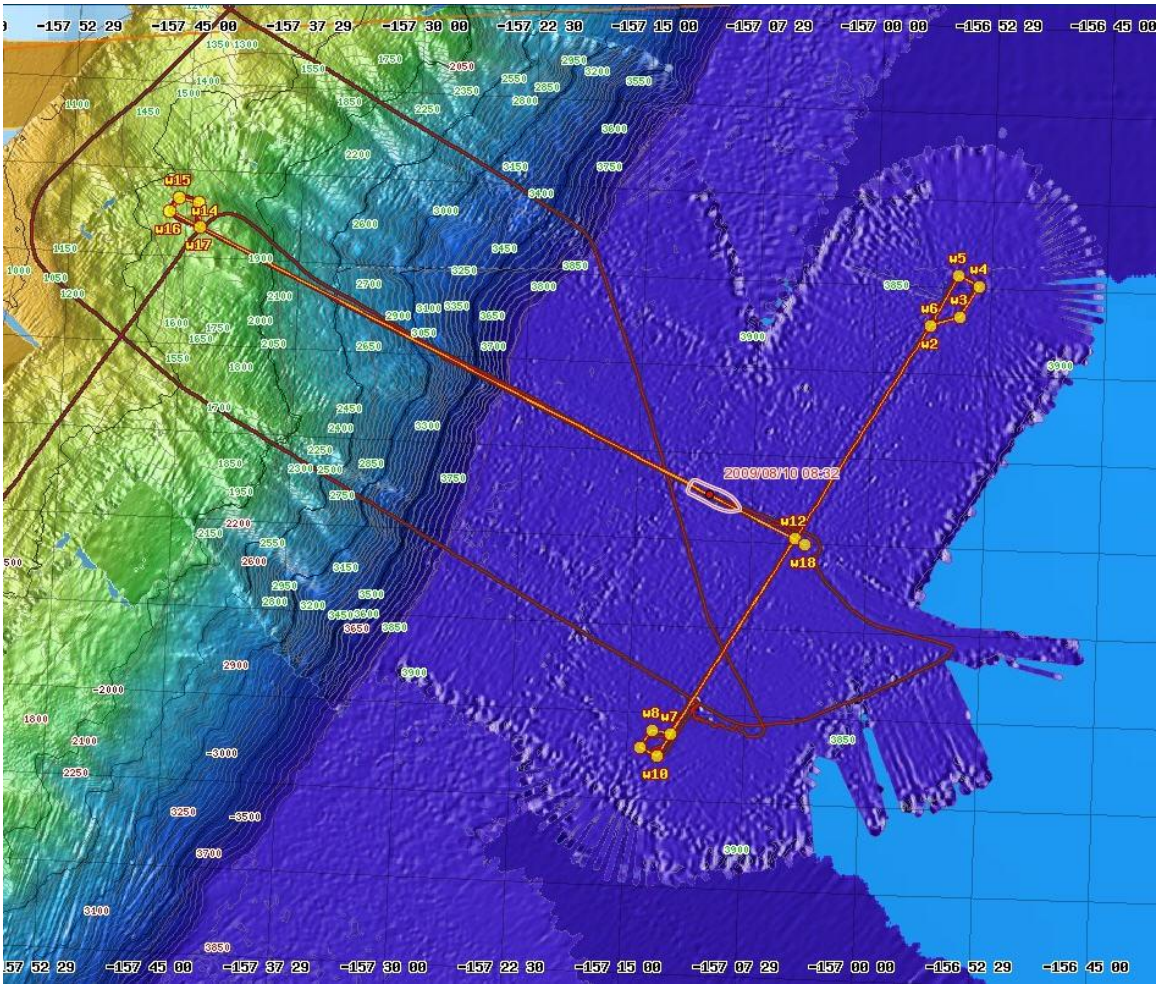


Figure 5. Patch test 10 August 2009

1012Z: Slowing to deploy AXIP and SVP thermister chain buoys for Pablo

1039Z: Will spend rest of time till rendezvous with LSSL surveying this portion of the Northwind Ridge – LSSL expects to be in vicinity around 0200Z 11 August

1400Z: Andy on watch; the Seabeam is running on 'manual' for the time being, as the system is not holding the bottom on 'auto.'

1600Z: Returned to 'auto' operation for Seabeam; seems to be holding the bottom track for now.

1615Z: Back in some some ice, about 7/10 with melting pieces of thick ice. Back to 'manual' on the Seabeam. For now, we are shifting between manual and auto depending on the ice.

1955Z: Out of the ice. Boundary consistent with earlier in the day and yesterday.

2140Z: Turning to pick up gap in data to the west.

11 August 2009 DOY 223

0000Z: Break of survey to rendezvous with LSSL. Navy detachment launched meteorological observation balloon off flight deck.

0240Z: Healy stopped for flight quarters; setting up to receive helo from LSSL.

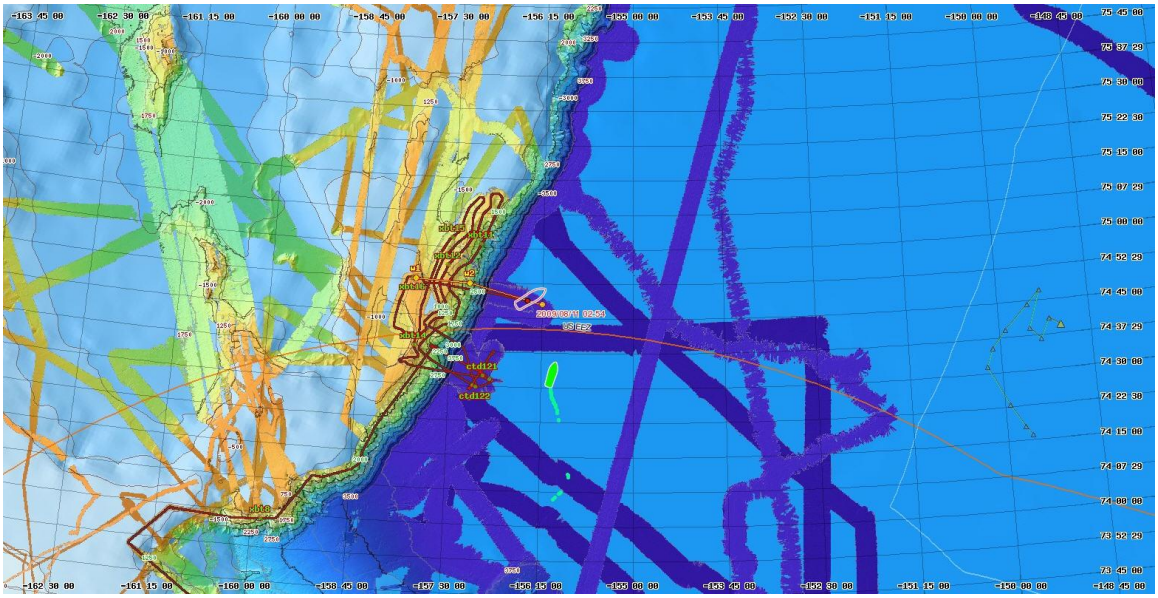


Figure 6. Overview of 10 August track plus LSSL (green) approaching HEALY on AIS

0620Z: Start seismic source signature calibration experiment

0850Z: Finish seismic source signature calibration experiment

0914Z: LSSL is taking a CTD for a couple of hours – we'll collect a bit of data run north and then offset coming back south

1241Z: LSSL ready and heading north – they will lead on a track picked by their ice observers to take advantage of leads….. We're off.

1430Z: Entering ice.

1500Z: helo ops

1545Z: back enroute following LSSL

1720Z: Altering track to move into unmapped area. Communicating with LSSL science on Ch 11.

1800Z: Dropped Deep Blue XBT TD_00019. Created and applied new SV profile.

12 August 2009 JD 224

0200L – Mayer on watch – just completed IP phone call to LSSL

Still steaming towards start of seismic line

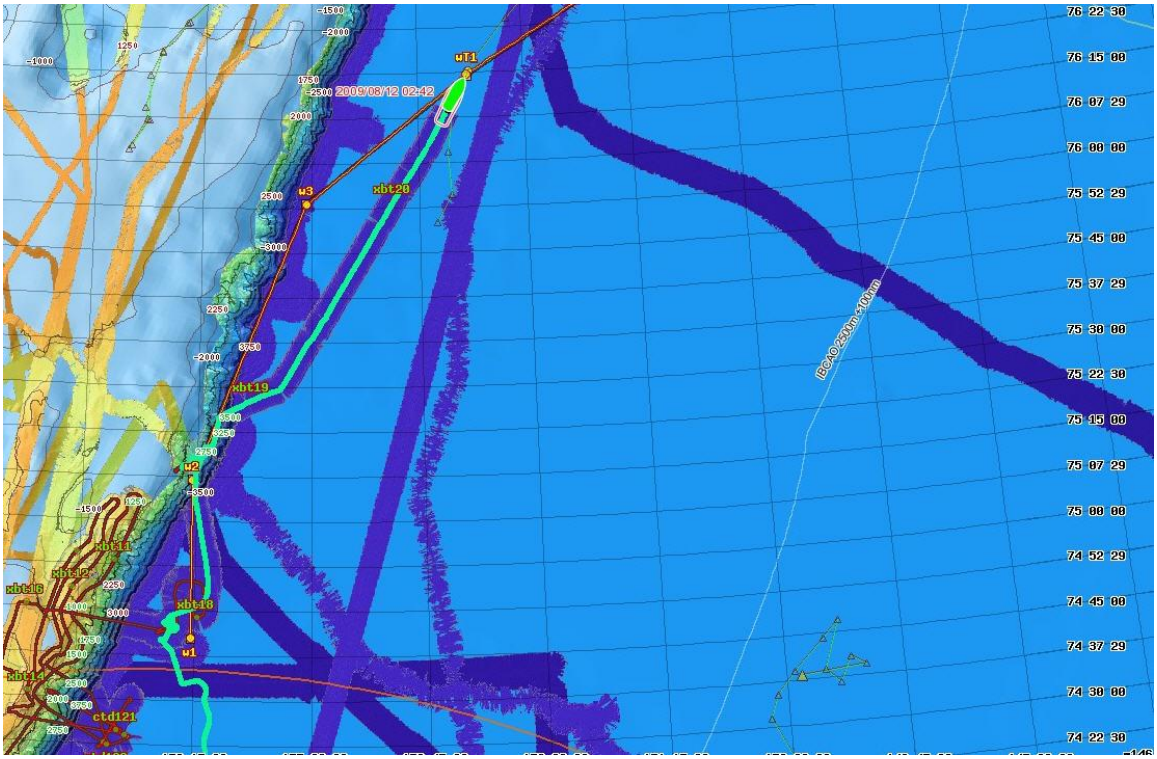


Figure 6. Overview of 10 August 2009 trackplot

0600Z – XBT taken – T5-0021 – shows interesting inflection at 1300 m

1200Z: XBT taken T5-0022 – took another T5 to see if same inflection occurred at 1300 m – it didn't

1400Z: Slowing to swap positions as LSSL begins to deploy streamer

1430Z: Helo transfer – Mike Merchant returned.

1535Z: Overtook LSSL

1600Z: Healy in the lead, LSSL trailing

1622Z: LSSL deployed seismic source and streamer

1735Z: Slowed to reduce distance ahead of LSSL.

1759Z: Dropped Deep Blue XBT 23

1830Z: LSSL having problems with gear; hauling in source (but not streamer) to examine/adjust. We will reverse course in gradual turn to head back to first waypoint for redeployment.

2046Z: Slowed to stop, ready to turn around and head back to the waypoint; paused in a pond of open water while LSSL gets their gear back in the water.

2141Z: Resumed operating speed, leading LSSL.

2354Z: Weather balloon launched

2358Z: XBT T7-24 dropped

13 August 2009 DOY 225

Mayer on watch.

0041Z: Applied new SVP from from T7-24.

0533Z: We plod on at 3.5 knts – the bottom is flat as a pancake – probably flatter – but the Louis says they are collecting good data

0607Z Deep Blue XBT taken TD-0025

1200Z: Weather balloon launch – AG1 Lemkuhl

1216Z: XBT taken T5-26 – terminal depth 1830m
XBT T5-27 failed – next in sequence will be 00028.

1400Z: Armstrong on watch

1807Z: XBT Deep Blue 29 launched. Good data until ~700 m; very similar to previous XBT; not applied to SV profile.

2025Z: Seabeam returns have been reduced to just a few beams. We will try a fish-tail maneuver to see if the problem may be ice stuck under the hull and if that will solve the problem.

2030Z: The maneuver did not seem to solve the problem, but a shift to automatic gating resulted in a return of the full swath. Not clear what caused or solved the problem, since the sonar settings other than gating were in, and remained in, manual. Steve is trying full manual operation to assess the problem, although returns are fine now in the ice typical of the past day.

2045Z: Problem traced to a "1000 m swath width" setting on Seabeam controls, that only was active when in manual control. This was set in error, probably when adjusting the gate width manually.

14 Aug 2009 DOY 226

0002Z: XBT T5 30; data good to about 1500 m; consistent with earlier profile.

0043Z: Experimented with sensitivity and gain settings on Knudsen to see if the bottom pick could be matched with the first return. Returned system to original settings after some time.

Mayer on watch. – slow and steady we go….

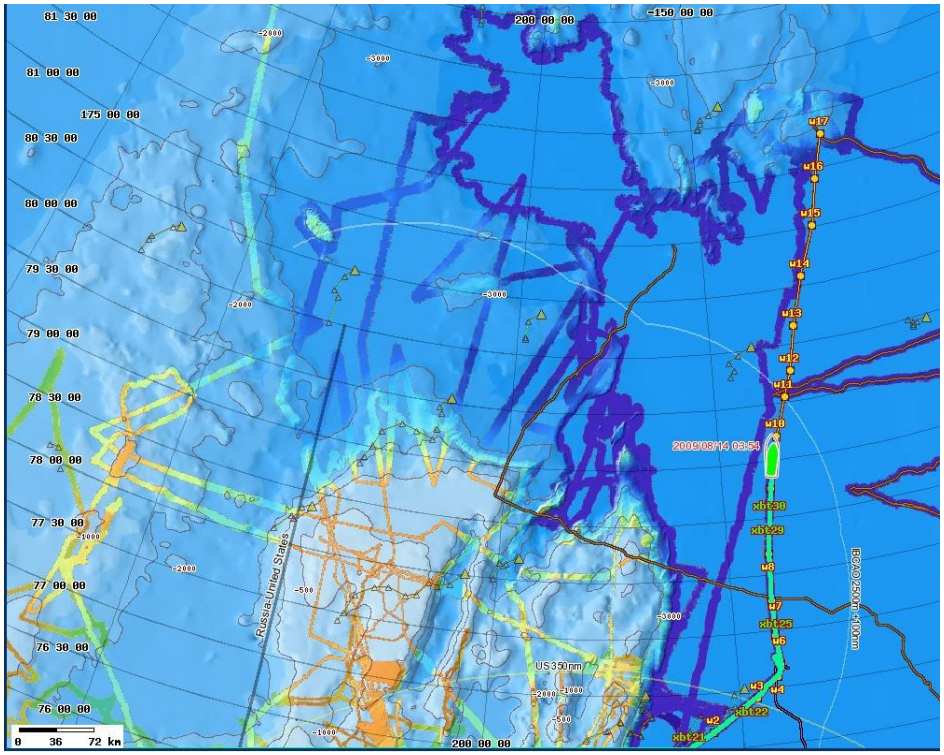


Figure 7. Overview of ship track 12/13 August 2009.

0600Z: XBT taken – T5-31 1830m wire hit ice at about 1000 m but upper part is fine.

1207Z: XBT taken – T7-00032 to 760m

1400Z: Armstrong on watch.

1456Z: Reduced speed to 2 kt; seismic gear problems on LSSL

1458Z: Seismic issue resolved; resumed speed of 4 kt.

1800Z: Two Deep Blue XBTs, #34 & #35 both failed at about 200 m due to ice.

15 August 2009 DOY 227

0007Z: XBT T7 36 dropped; data valid to about 500 m. Good data extends beyond water column structure, so will not deploy another probe.

Mayer on watch

0210Z: Hit first ridge!! Slowed to stop for moment and then broke trhough.

There have been problems with XBT numbering system – three numbers were never used: 0007, 0028, and 0033

0610Z: Started turn to starboard to start ring lines

0615Z: Rachel takes XBT- T7-0037 – but it failed at 200 m – will take another when turn is finished

0645Z: XBT-T7-0038 taken – good to 500 m

Compared XBT-38 to last in Seabeam (number 24) – different enough to justify update – Steve will update Seabeam however the Seaventure drive is still unavailable so he will have to wait.

0715Z: Steve has done an end-around on the Seaventure problem and has put in the new sound speed profile.

1200Z: XBT Taken TD-00039 Deep Blue to about 550 m. Weather balloon launched

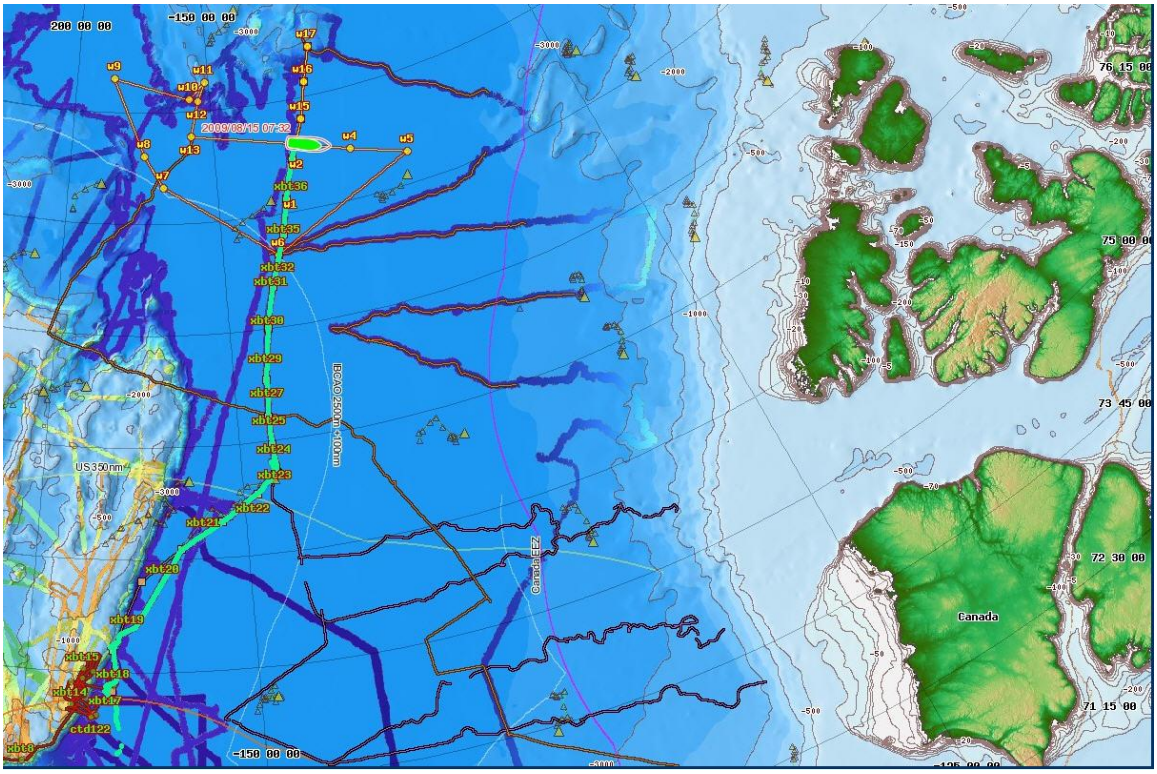


Figure 8. Overview of shiptrack 14 Aug. 2009

1600 - 1620Z: Encountered a couple thick floes that required backing and ramming to get through. Louis slowed to crawl astern of us.

1800Z: XBT T7-40 dropped but failed because of ice. Will try another XBT when ice conditions improve or when we can slow for the drop.

16 August 2009 DOY 228

0137Z: We have steamed past waypoint to allow LSSL to complete the leg. Both ships are stopping for engineering maintenance; LSSL is retrieving seismic gear for service. If the ship settles adequately we will take CTD.

0229Z: CTD in water.

0330Z: CTD winch had bad wrap – stopped deployment at about 1300 m of wire out. Will recover CTD and deal with bad wrap at a later time

0351: CTD on deck

0430Z: XBT taken – Deep Blue – XBT-00041 760 m max depth

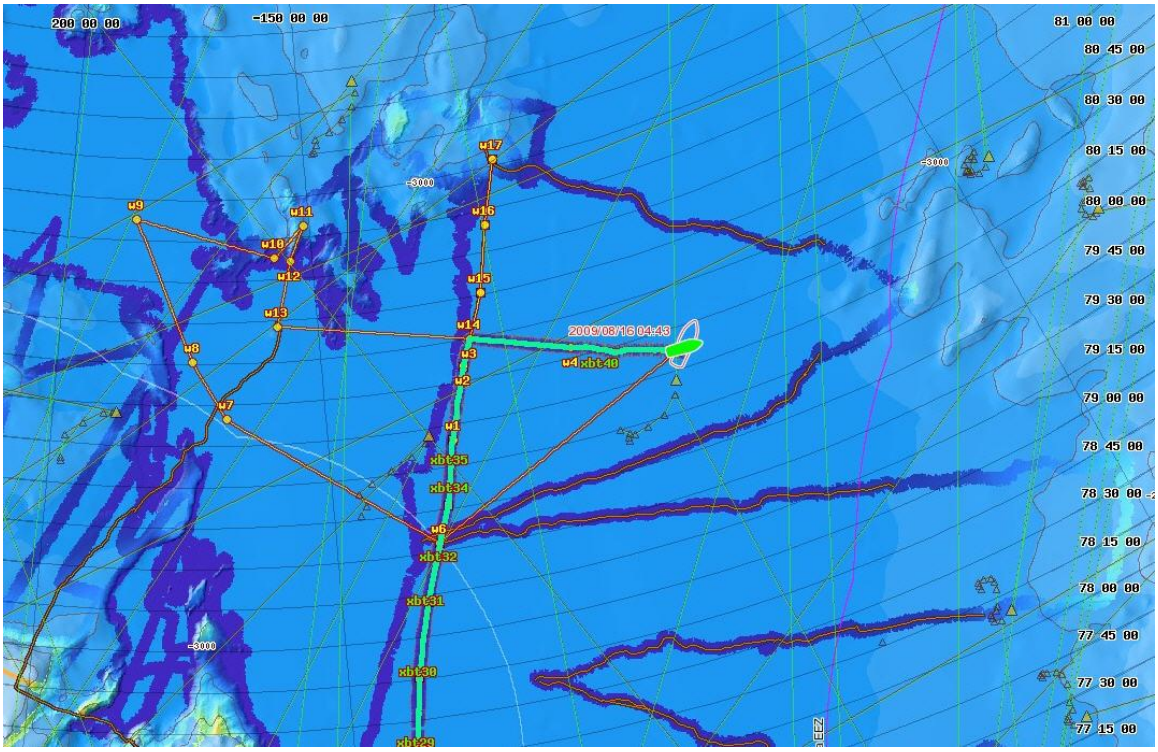


Figure 9. Trackline overview 15 August 2009

0443Z: Underway again

0524Z Looking for open pool to deploy seismic gear

0648Z: LSSL having trouble deploying gear

0727Z: LSSL sorted out problems – beginning line

1205Z: XBT – T700042 good to 760m

1802Z: Deep Blue XBT 43, good to ~300 m.

17 August 2009 DOY: 229

0000Z: XBT taken – T7-00044 good to about 650m

0013Z: Slowed to 2 kt to deploy XBT T7_00044; Good data to ~450 m.

0200Z: Mayer on watch

0600Z: XBT – Deep Blue XBT-TD-00045 – good to 760m

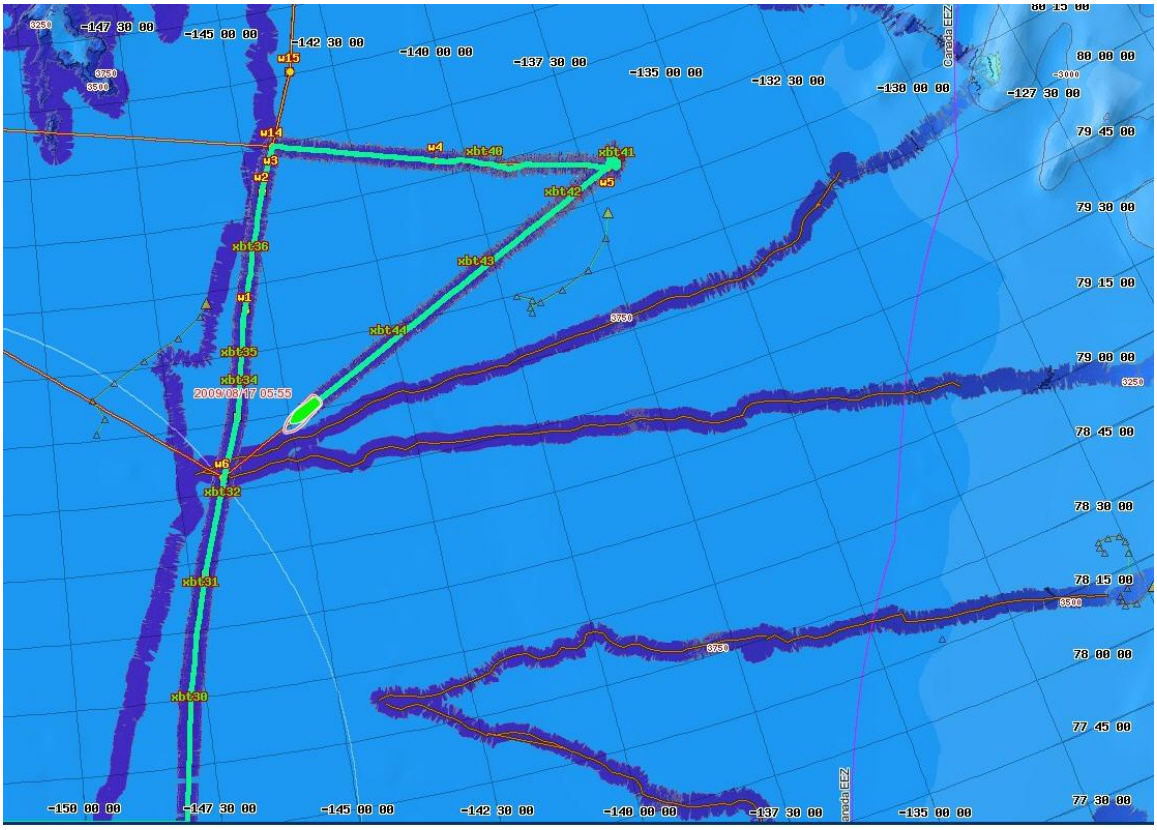


Figure 10. Trackline overview 16 August 2009

1113Z: End of line – start slow turn to the starboard to begin line running NW

1128Z : finished turn –

1200Z: launch weather balloon

1223Z: Take XBT T5_00046 – good to about 1600m

1400Z: Andy on watch

1446Z: Adjusted heading and stopped to bring Helo aboard.

1459Z: Helo off; resuming survey track.

1808Z: XBT Deep Blue_00047, good profile to 760 m. This was the 2nd XBT probe tried; the first one did not communicate with the logging system and was not dropped.

2309Z: XBT T7_00048 dropped; good data to 760 m. Deployed 1 hr early to take advantage of open water.

18 August 2009 DOY 230
0019Z: Helo landed to return exchanged personnel to home ships.

0026Z:: Applied SV profile from XBT T7_00048

0200Z: Mayer on watch

0320: Ethan deploying sonobuoy

0427Z: Ethan deploying another sonobuoy

0500Z: Louis called and is having problems with recording system – want us to slow to 2 knots.

0520Z: Problem resolved back up to 6 knts

0542Z: XBT taken Deep Blue – TD_00049 – good to 760 m

0630Z: More problems with recording system on LSSL – slowing to 2 knts

0658Z: Problems solved on LSSL – coming back up to speed

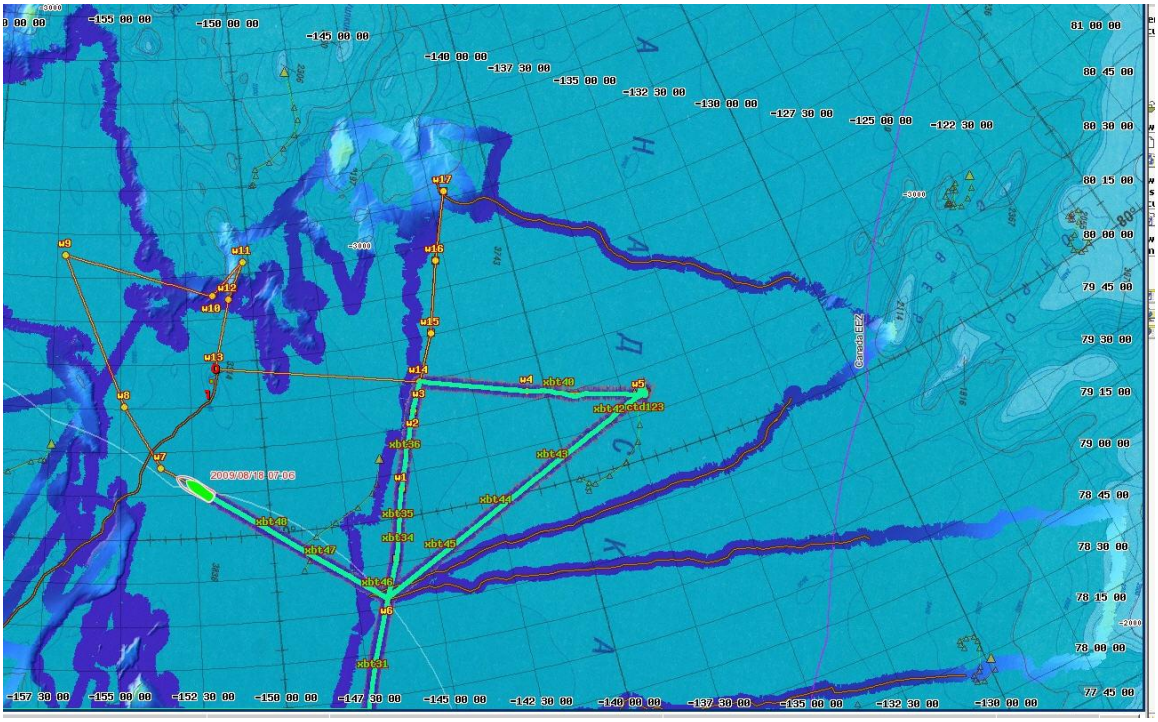


Figure 11. Overview of track 17 August 2009

0732Z: More recorder problems on LSSL – slowing to 2 knots

1103Z: Begin turn to the NW… slowly….
1157Z: XBT T5-00050 taken good to 1300m

1400Z: Andy on watch

1431Z: Slowing to 2 kt at request of LSSL. LSSL is slowing for seismic gear problems.

1446Z: Resumed normal mapping speed.

1640Z: More seismic problem on LSSL: back to 2 kt.

1650Z: Resume normal speed.

1749Z: Seismic gear problems on LSSL; reduced speed

1830Z: Resumed normal mapping speed of 4.5 kt.

1900Z: Heavy patch of ice requires backing and ramming.

2100Z: LSSL needs to pull gear – steaming to open pool of water about 7 nmi to west. At open pool LSSL will deploy CTD. We will use opportunity to address CTD wire wrap problem.

2300Z: Lowered weight over the side with ctd winch to attempt to remove wire jam on winch drum.

19 August 2009 DOY 231

0200Z: Mayer on watch

0435Z: Winch respooled – underway to meet up with LSSL

0454Z: XBT taken – T7_00052 – good to 760 m

0655Z: Starting slow turn to N to get on line ahead of LSSL

0730Z: We appear to be on line though no on has told us.

1203Z: Launched XBT – TD_00053 Deep Blue – good to 760 m

1400Z: Andy on watch

1420Z: Speeded up to get in position for helo landing

1451Z: Slowed and stopped; helo landed; Debbie H. aboard for the day

1509Z: Helo away, resumed track; Tom O' over to LSSL for the day.

1819Z: XBT Deep Blue_00054; good data to 760 m.

2352Z: XBT taken – T7-00055 good to 760 m

20 August 2003 DOY 232

0200Z: Mayer on watch

0430Z: First polar bear (and cub) spotted about 1.5 miles to port

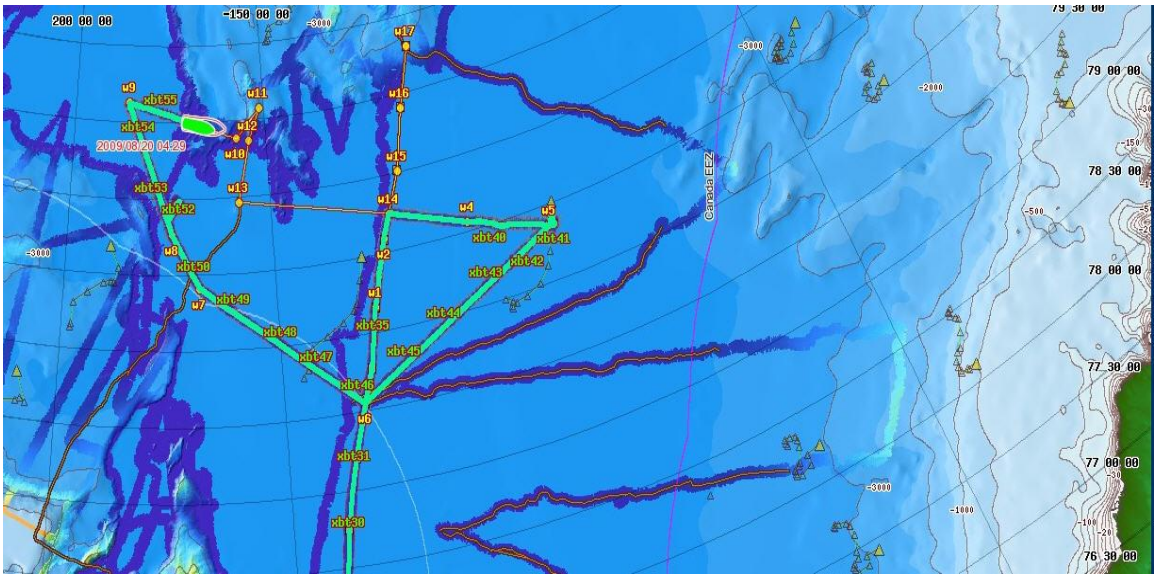


Figure 12. Overview of 18 August shiptrack

0549Z: XBT taken TD-00056 good to 760m Deep Blue

1205Z XBT taken T5-00057 – failed.

1215Z: XBT taken T5-00058 good to 1200m

1555Z: Stopped for helo ops—sent ice observers aloft for recon of bathy development area ahead.

1610Z: back underway

1659Z: Stopped foe helo ops

1710Z: underway on trackline

1840Z: Passed off the elevated terrain, crossing over the characteristic transition from slope to abyssal plain. See Figure 13.

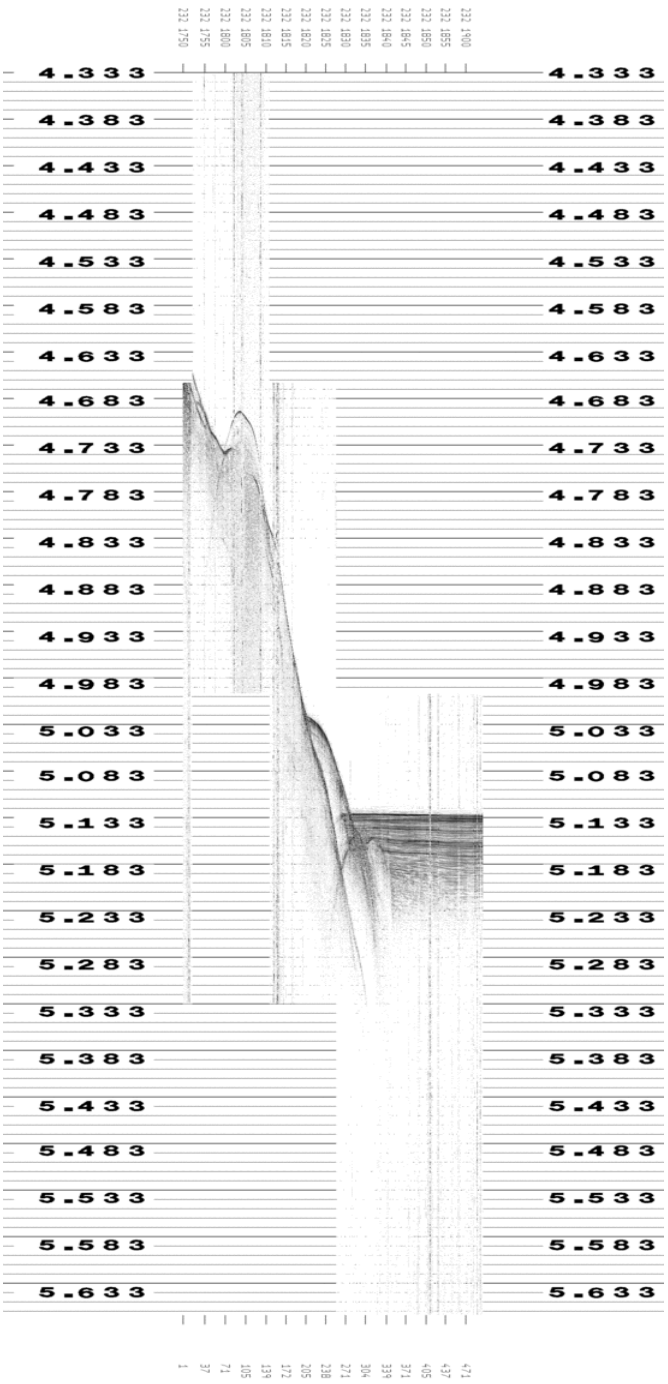


Figure 13. Transition to Abyssal Plain

2327Z: began picking up bathymetric feature on the outside starboard edge of the swath; associated with 3400 m contour on Russian map and north of 3500 m contour in IBCAO. We will run south along the length of the feature.

0235Z: began turn to west to come over toward northbound return track.

21 August 2009 DOY 233

0300Z: Begin turn to north for 014 line

0600Z: XBT taken – TD_00061 good to 760 m

0630Z: Begin turn to south – heading for start of line east.

0723Z: Begin long line to the east

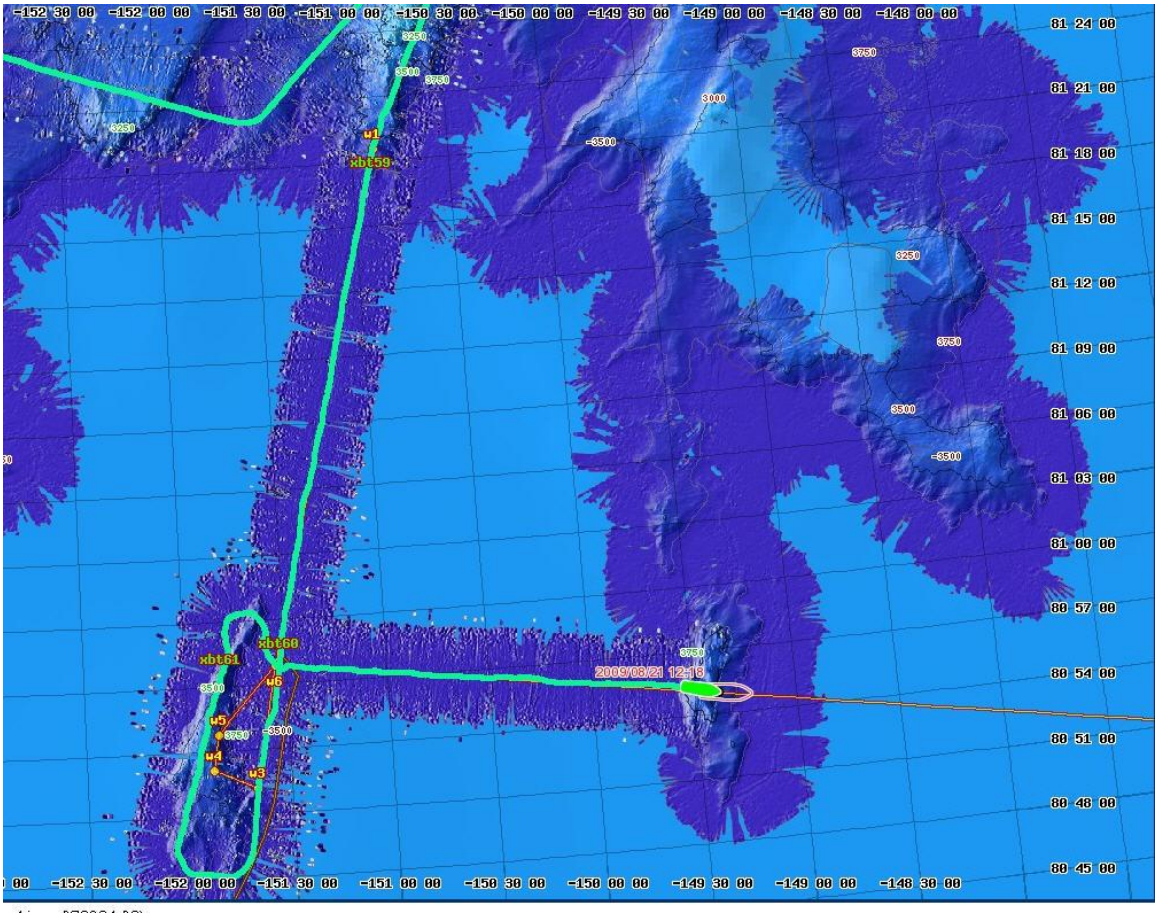


Figure 14. 20 August – Overview Track line

1208Z: XBT taken – T5-00062 good to 1830 m

1330Z: LSSL seems to have a problem with their gear – we are turning to the north to head to an open pond of water so that they can pull the gear.

1430Z: at rest in light ice awaiting completion of LSSL maintenance.

1500Z: returning to track

1554Z: Additional seismic gear problems on LSSL; returning to open water to allow LSSL to retrieve gear again.

1648Z: Heading back to track

1740Z: Back on track with seismic gear deployed fro LSSL

1751Z: XBT Deep Blue TD_00063 dropped with good data to 760 m.

2010Z: LSSL slowing for seismic troubles

2022Z: LSSL is slowing to 2 knots, and called to say that their seismic recorder has not been recording for past 2 hours. Deb believes there is no essential ECS purpose to double back to pick up gap. Deferred to her judgment, They are rebooting to start recording and we will proceed on.

2057Z: Belay that; LSSL will retrieve streamer and double back to last good data location.

2315Z: CTD in the water; we will pay out to 1300 m and examine the wire where it was jammed. If ok, we will go on to about 3000 m.

22 August 2009 DOY 234

0005Z: Wire ok, going on down

0151Z: CTD on deck

0352Z: LSSL putting gear back in

0428Z: LSSL system not working – pulling gear again

0528Z: LSSL folks need to get some sleep – they will release us for the evening so we can go off and map.

0600Z: Laid out a small survey to north west – try to pick up a gap over a high we mapped last year.

1100Z: Have to bail out of transit north before we got to prime target – its just taking too long and we need to get back to LSSL.

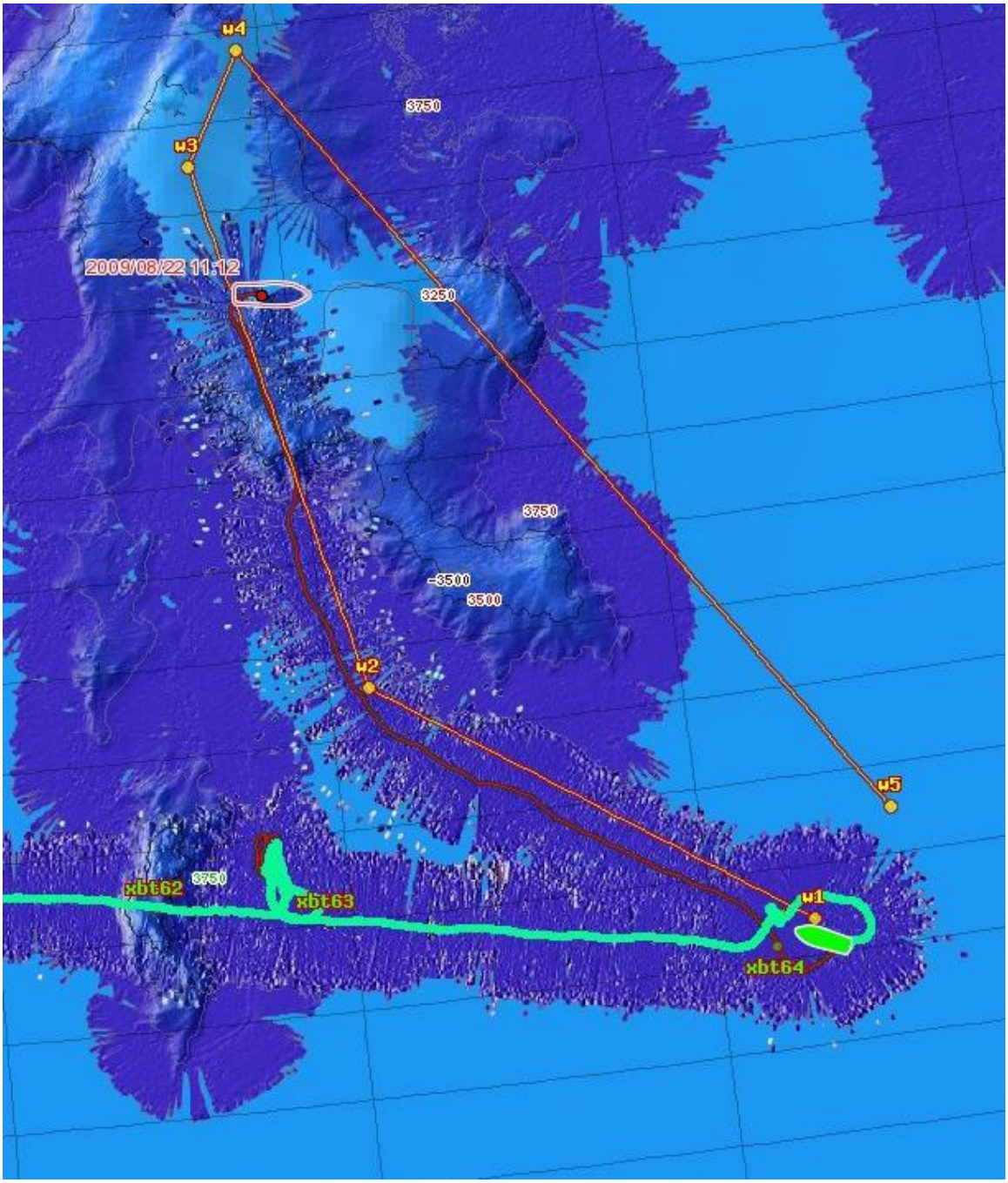


Figure 15. Track overview 21 August 2009

1207Z: XBT taken – Deep Blue – TD_00065 good to about 420 m

1400Z: Andy on watch

1616: Heaved to near LSSL.

1720Z: LSSL has discovered some defective connectors in streamer; will take appx 4.5 hrs to repair; we will do a small mapping loop to the NW.

1730Z: Deep Blue XBT TD_00066; good to 760 m.; underway to map until LSSL ready.

2038Z: Breaking off survey to rendezvous with LSSL; LSSL says they will be ready w/in 30 min.

2200Z: On line towards waypoint on N-S trackline. We are running dirct course to join this line rather than regaining our original eastbound track.

2230Z: Science party morale dinner begins. Jambalaya, Cheese Grits with Shrimp, Okra with Tomatoes, Brazilian Lentil Soup, Corn Bread, Apple Crisp.

23 August 2009 DOY 235

0000Z: XBT T7 _00067; good data to 760 m.

0200Z: LSSL seems to be working with other gun: resuming speed

0541Z: XBT taken TD-00068 good to 760m

0900Z: At end of long eastward line – now turning to the north to rejoin the 350nm line

1159Z: XBT taken – T5_00069 – good to 1830 m

1400Z: Inasmuch as this is probably our last chance to collect any data relevant to the FOS in this area , we have laid out 79 nmi. bathymetry loop from waypoint w4 to complete before crossing basin to Canadian bathymetric targets.

1801Z: XBT Deep Blue TD_00070; good data to full 760 m.

2105Z: Seafloor beginning to rise gradually on Knudsen; it appears that the abyssal sediments are bending up rather than onlapping horizontally onto a slope. See Figure 17.

24 August 2009 DOY 236

0000Z: Launched weather balloon and XBT T7 _00071 with generally good data to 760 m.

0110Z: Initiating turn to come onto bathy loop.

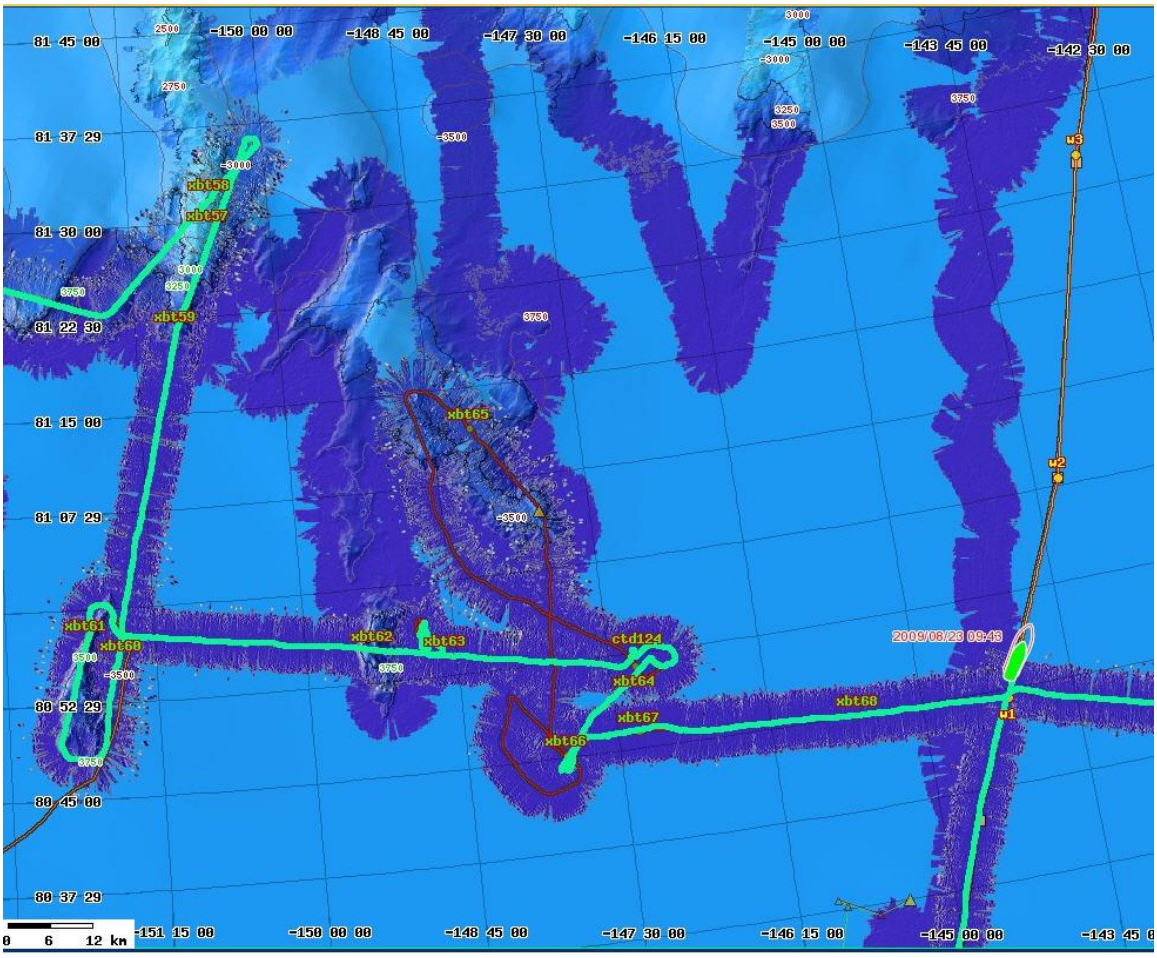


Figure 16. Overview of track 22 August 2009

0644Z: Complete first (east-west) segment of bathy loop. Now doing slow turn to south.

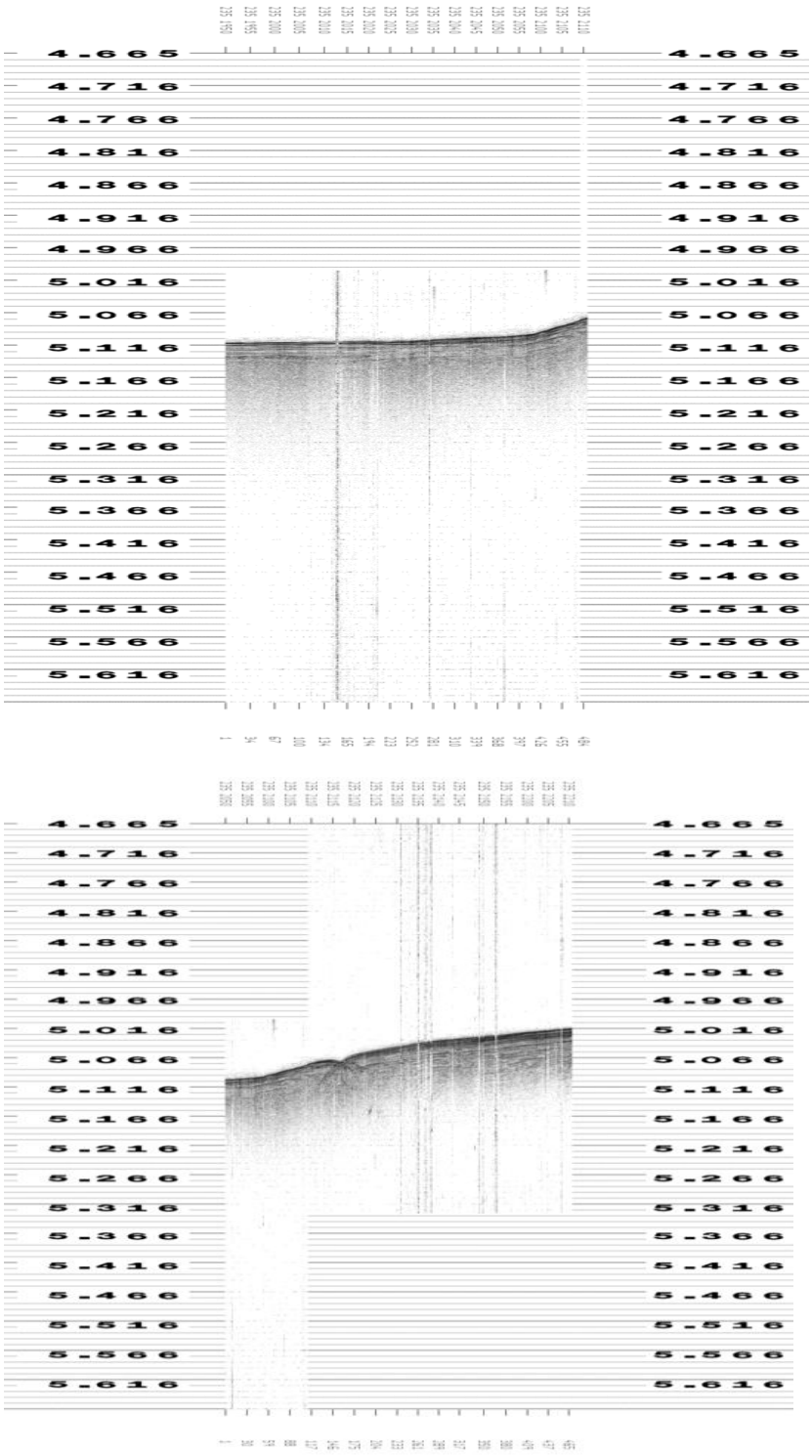


Figure 17. Sequential Subbottom pofiles on rising slope.

0551Z: XBT taken – TD_00072 good to 760 m

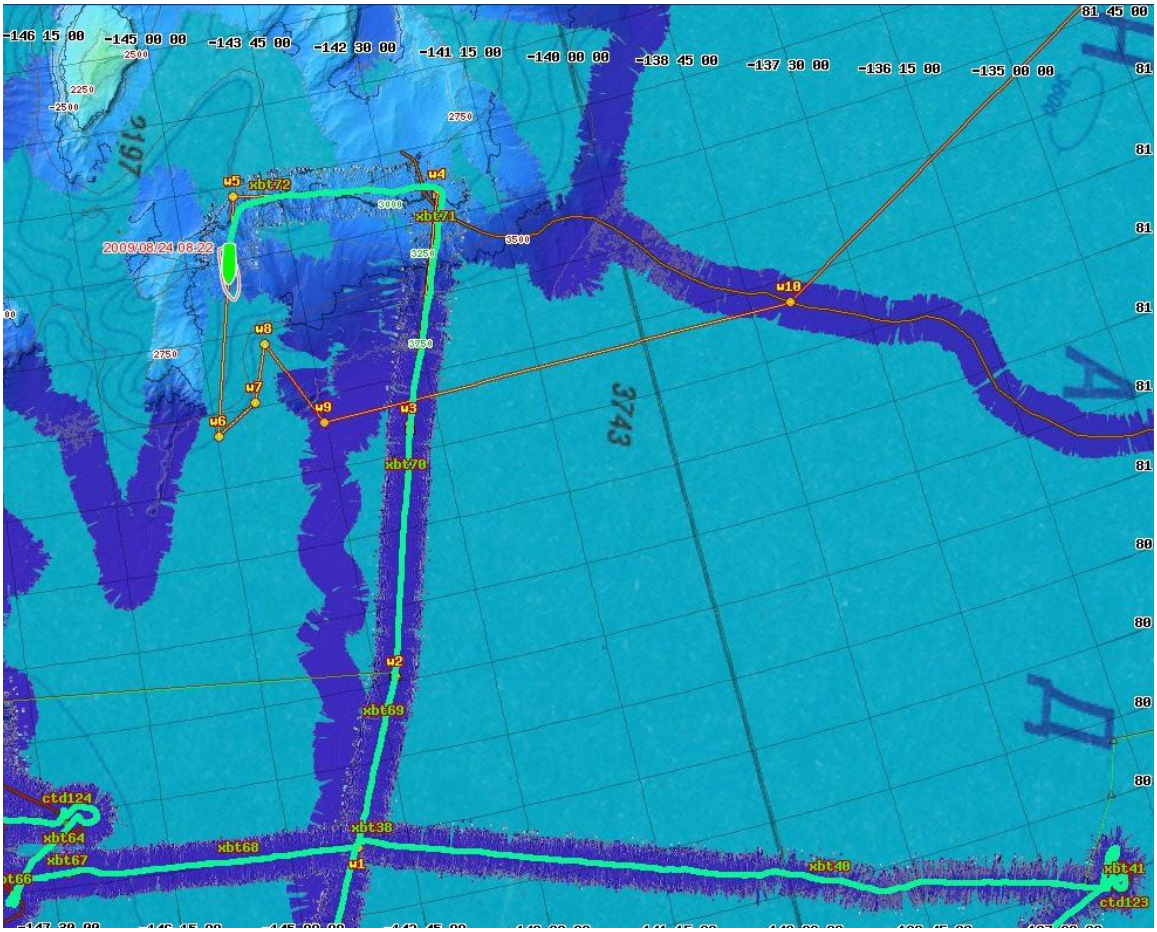


Figure 18. Overview of track 23 August 2009

1159Z: XBT taken T5-_00073 – good to 1830m

1257Z: Begin turn to NE

1400Z: turned to NNE.

1430Z-1500Z: Left track to conduct flight ops. Stopped for flight ops. Upon completion, we backed down to (nearly) regain track.

1646Z: Beginning our turn to the SE.

1744Z: XBT Deep Blue TD_00074; good data to approx. 500 m.

2010Z: Moving across the slope- plain transition; very prominent. See Figure 19.

2137Z: Slowing and maneuvering for flight ops

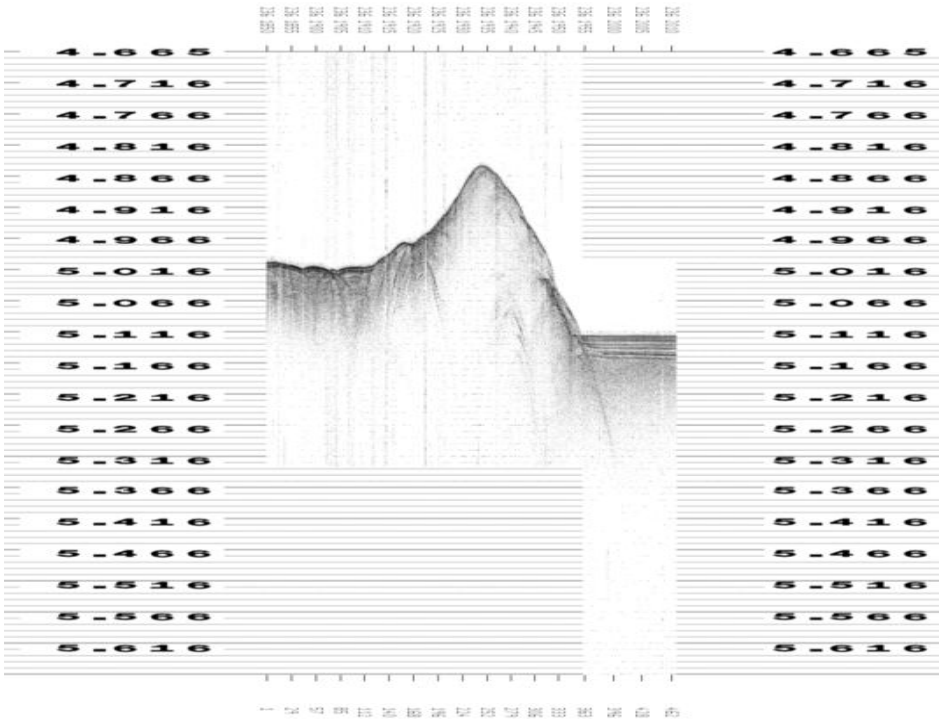


Figure 19. Slope to Plain transition

2355Z: XBT taken – T7-00075 – good to 400 m

25 August 2009 – DOY 237

0536Z: XBT taken TD_00076 good to 760 m

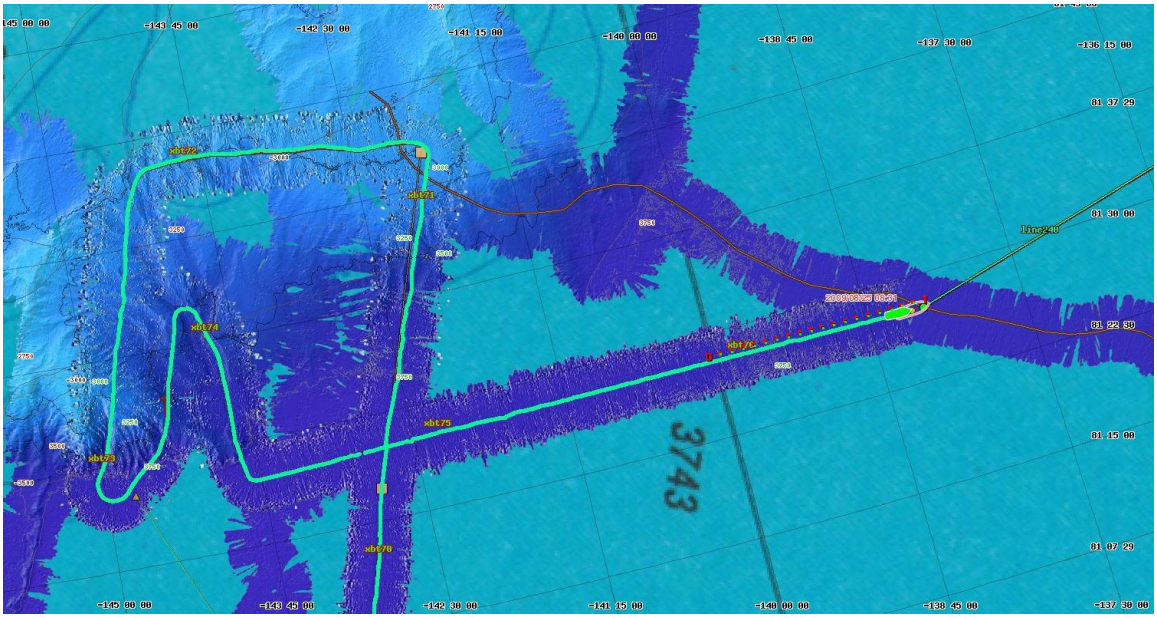


Figure 20. Overview of track 24 August 2009.

1209Z: XBT taken – T5-00078

1730Z: The Russian contour feature is rising precipitously, mostly off to the south. We will maintain a more southerly course than the planned track.

1755Z: The feature appears to be close to being a legitimate seamount.

1820Z: Joint science decision to prosecute fuller development of feature.

1851Z: XBT Deep Blue TD_00080; either it failed at approx. 250 meters or there is a large temperature anomaly over this feature ☺.

2035Z: Began 3-mile across turn to 000° to run back and fill in spine of the feature.

2200Z: Finish up survey – looks like a beautiful feature with a shoal depth of around 2630 m.. Heading back to line running NE to WP12

26 August 2009 DOY 238

0011Z: XBT taken T7_00081 good to 760m.

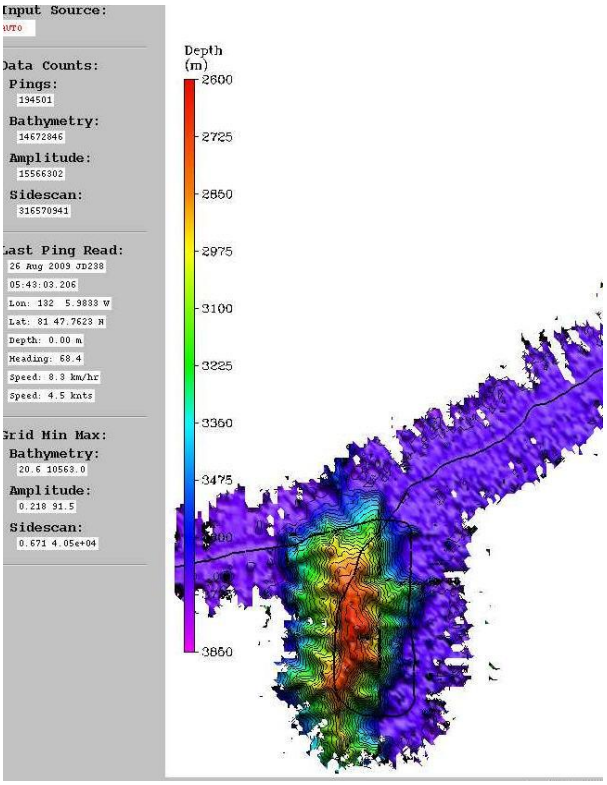


Figure 20. Survey of seamount

0600Z: Several attempts at XBT's –(00082,00083) failed will move on

1201Z: XBT taken T-5-00084 – good to 1860 m

1400Z: Andy on watch

1440Z: Flight Ops

1515Z: Flight ops complete; LSSL reports problems with seismic source; we are seeking a suitable area in which to retrieve their gear. (Note: gear performance improved later; no retrieval)

1548Z: Dropped 2 sonobuoys over the stern.

1800Z: Dropped XBT TD_00085, probe failed early from ice. Dropped XBT TD_00086; successful deployment but computer system froze and data may not be recoverable. (data recovered at 2115Z, but questionable after 340 m.)

2010Z: Turning onto Northerly track.

2139Z: Slowing and stopping for Helo ops

2215Z: Helo ops complete; backing through broken ice path to regain track.

27 August 2009 DOY 239

0056Z: Stopped in heavy ice; cyclos tripped; no returns from either Knudsen or Seabeam—maybe ice under transducers.

1019Z: completed XSV deployment successfully. XSV_00087

0128Z: Back underway

0140Z: LSSL reports that stopping flooded their gear, and they must stop to recover and repair. We are stopped waiting.

0200Z: We have decided to switch spots and have the LSSL take the lead without its seismic gear – the line north is a hyrdo line so multibeam will be the priority – we will see if data quality improves with LSSL breaking ahead of HEALY.

0535Z: XBT taken while LSSL is backing and ramming – XBT T&-00088 good to 760m

1400Z: Andy on watch; completing pass over 2nd of two large charted seamounts. Both are in the location shown in IBCAO. Both have distinct spines. The northern seamount has indications of a large slump scarp on the northeast side.

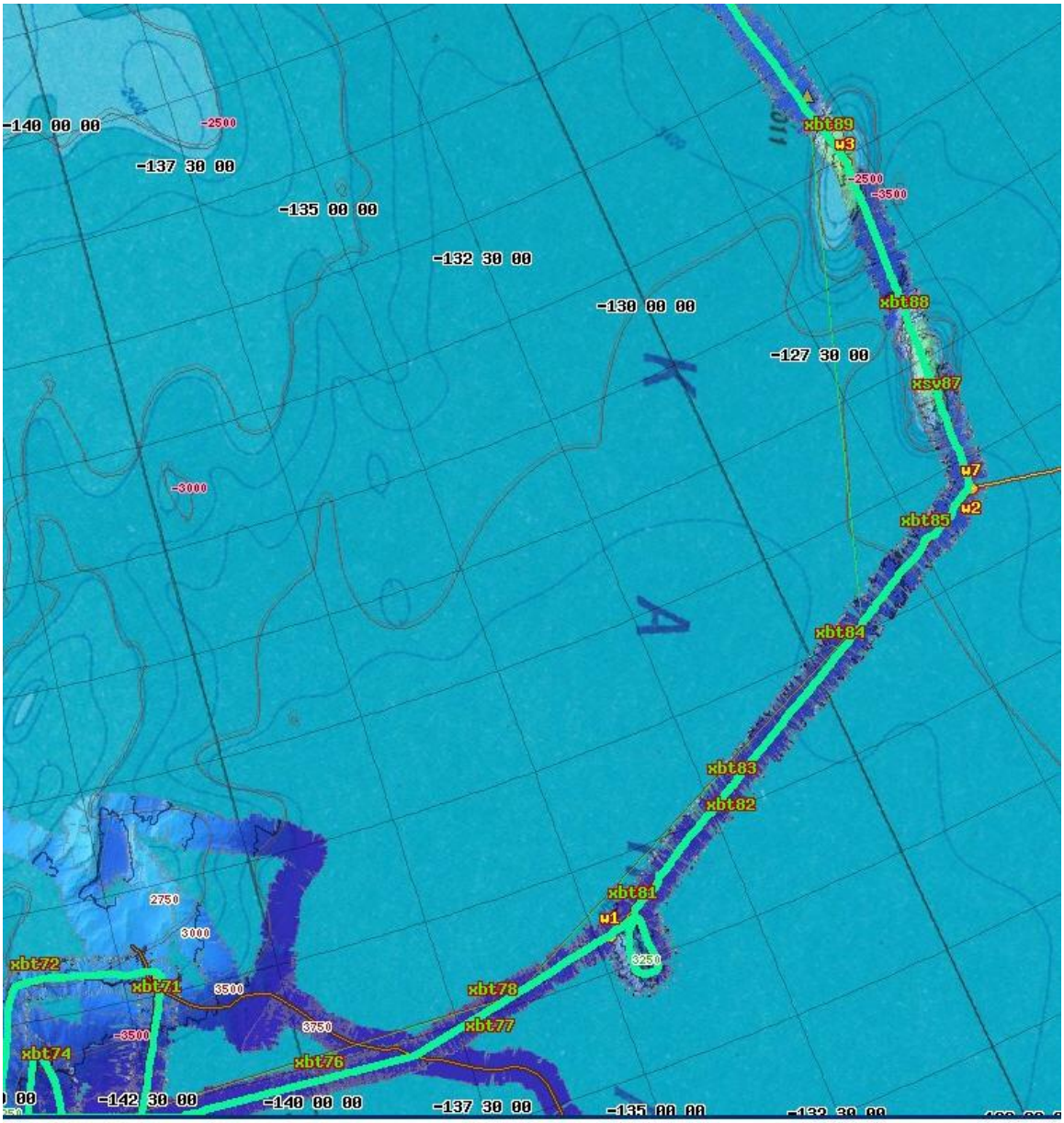


Fig. 21. Overview of track 25August 2009

1800Z: XBT T7_00090. Valid data to approximately 500 m.

2345Z: XBT TD_00091; good data the full 760 m. depth.

28 August 2009 DOY 240

0030Z: stopped for LSSL to break through ridge.

0123Z: LSSL reports they are through the ridge, we are proceeding, but the multibeam is receiving only intermittent returns.

0223L: Processing gain on Knudsen changed from 0 to 1 as an experiment.

0258Z: This is the maximum northern extent of the cruise; so far -- lat 84 12.765N lon 126 20.92W -- see below

0350Z: Stopped for LSSL to back and ram…..

0416Z: Underway?? False start - still waiting

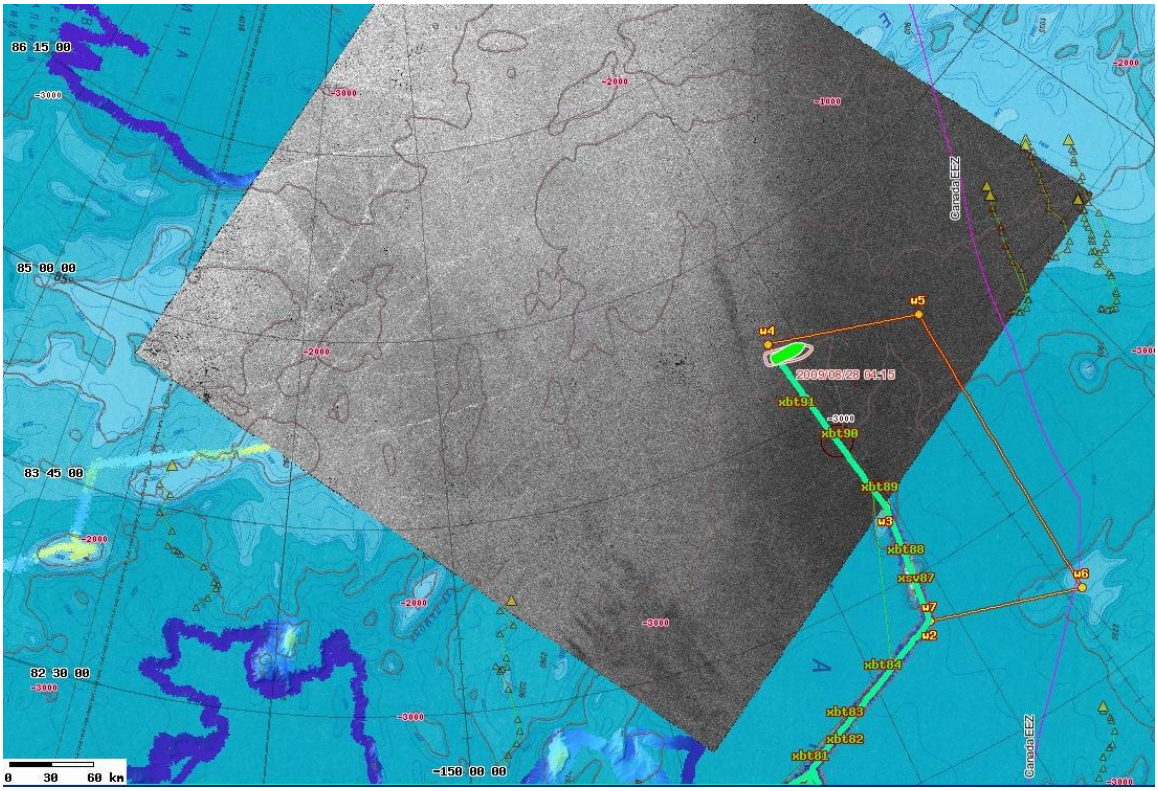


Figure 22. Overview of track 26Aug.2009 with SAR ice image

0451Z: LSSL seems to be free but now we have lost our second engine in trying to bring up the third. Should be on line in 5 – 10 minutes (we hope). In mean time LSSL has called and said they are stopping for and XCTD and a sounding – yahoo.

0532Z: It appears that the HEALY's engine problems are resolved – will try to get underway with 3 engines.

0543Z: Finally underway

0612Z: Track (to avoid heavy ridges) is taking us a bit further north – 84 13.1388.N 125 52.000W is this the farthest north point?

0612Z: XBT taken T5_00092 good to about 800 m

0800Z: Even further north – 84 13.7 N 124 15.5W

0900Z: Noticed we were heading well off the track-line – bridge called LSSL – they said they had another waypoint different from ours at 84 11N and 117 29.W – don't know where these came from – called the LSSL to speak to a scientist – no one called back.

0920Z: LSSL (and us) stopped for a "sounding" and to sort out where they are going.. Jon Biggar called back and said that they were heading to WP5 (117 33W, 83 56/.7N) but then called back later to say that they were really going to 84 11.7 N and 117 29.2 W

0937: Underway again

0955Z: LSSL called the bridge – they woke Dave and he has asked them to come back to the original waypoint – W5.

1005Z: Dave called – hopefully all sorted out - Grand Manan flag

1200Z: LSSL backing and ramming – we will take XBT and launch balloon while waiting for them to break through.

1209Z: XBT taken – XBT- TD_00093 good to 450m

1400Z: Andy on watch

1423Z: Beginning helo ops for personnel exchange.

1510Z: completed flight ops.

1545Z: LSSL placed flag on the ice

1810Z: XBT T7_00094; good data to approximately 670 m.

1953Z: Crossing the 2500 m depth contour.

29 August 2009 DOY 241

0007Z: LSSL stopped for maintenance; began CTD in open water

0035Z: CTD to 1001 m; now coming up

0055Z: CTD complete and on deck

0105Z: Underway

0155Z: Applied sound speed profile from CTD; agrees very well with profile from XBT with levitus salinity applied.

0546Z: XBT taken TD_00095 good to 760 m

0800Z: Still steaming south – getting stuck sometimes – other times moving along nicely – have veered west to avoid ice.

1157Z: XBT taken, T5_00096 good to about 1750 m

1217Z: Knudsen sounder had software crash – restarted quickly Dale checking to see if data were lost.

1420Z- 1502Z: Stopped for helo ice recon; LSSL is seeking best route to next 2500-m waypoint. Sun is out, ice is 9/10-10/10 all around, with lots of jumbles and ridges.

2000Z: Slow going through heavy ice continues; C.O. asks if more aggressive ice breaking approach would be acceptable; Andy and David agree that making forward progress should come ahead of data quality at this time.

2345Z: XBT taken – TD00098 – good to 250 m

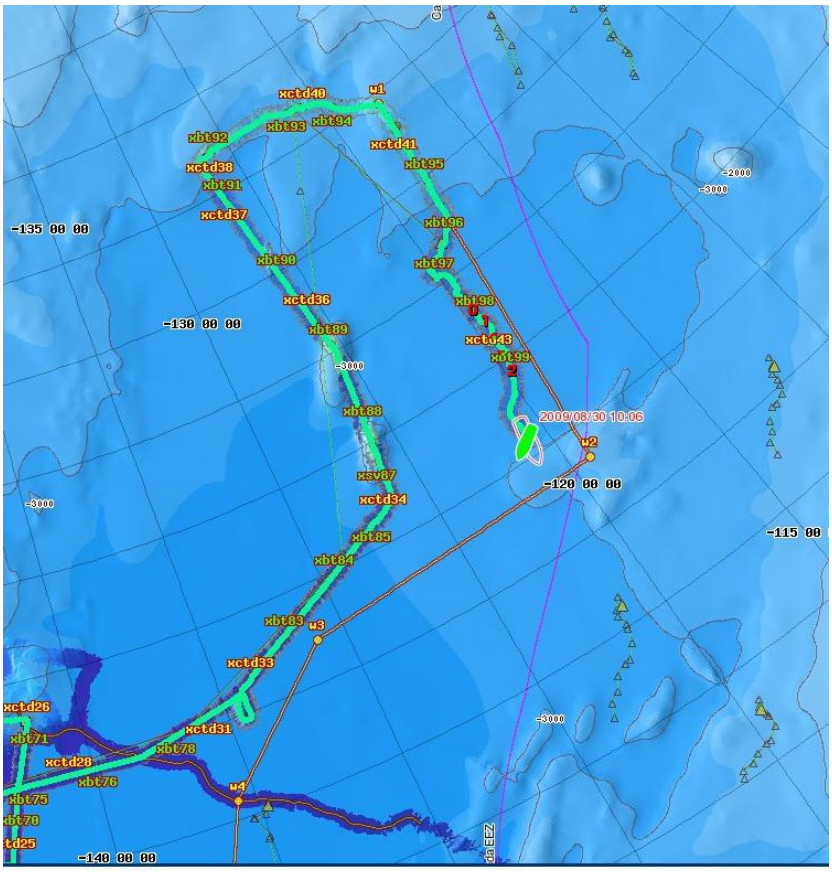


Figure 23. Track 27,28,29 August. 2009

30 August 2009 – DOY 242

0553Z: XBT taken – TD_00099 good to only 270 m but identical to 00097. Noticed there was no printout or entry for 00098 – asking MST's. Found it – also just good to 250m – but also identical to 97 and 99.

1140Z: Slowing to less than 6 knots as we turn to survey for the 2500 m contour.

1154Z: XBT taken T5_00100 good to 1400 m

1206Z: Called LSSL to suggest coming to heading of 100 to reach 2500 m contour sooner rather than later (or never)

1315Z: There is a 2500 m contour (very small on peak) off to the starboard – called Dave he is checking with Jon Biggar to see if he wants to go to that or continue on to where 2500 m contour is on Russian chart. We seem to be continuing on.

1410Z: Crossing 2500 m contour line and turning back to west.

1600Z-1700Z: We are winding back to the north to obtain a single beam depth over the peak that we have already completely mapped with multibeam. From here we will turn west to look for open water to take a cast and LSSL will deploy the seismic gear.

2000Z: We have stopped in open water for SV cast by LSSL; we will take a CTD cast going down until 2100Z based on 1hr 45min time availability provided by bridge.

2145Z: Our CTD on deck; CTD to depth of 2500m. Apparently LSSL is not ready to proceed. LSSL does not believe this lead is adequate to deploy streamer; wil need to search for another location after cast is complete.

2220Z: Entering sound speed profile for CTD 126 into SeaBeam system. The sound speed profile for CTD matches very closely with that of CTD 125 and also with the profiles generated from XBT 100 with Levitus, and the XCTD 044 recently taken by LSSL. This provides confidence that LSSL XCTD profiles can confidently be used for SeaBeam SS profiles.

2225Z: LSSL request that Healy take lead and they will watch ice and weather for opportunity to stream—may not be for a while.

31 August 2009 DOY 243

0000Z: Launched weather balloon; no XBT deployed due to heavy ice and very recent CTD. Poor multibeam and sub-bottom performance also because of heavy ice. Priority is getting into position for seismic, so we will not slow to improve.

0103Z: LSSL began deploying gear

0124Z: LSSL seismic guns in the water – getting underway in HEALY leading LSSL mode – enroute to LSSL Line 23 WPB – a new waypoint added to allow us to pass on the southern side of the new seamount we found.

0557Z: XBT taken TD_00101 good to 760m

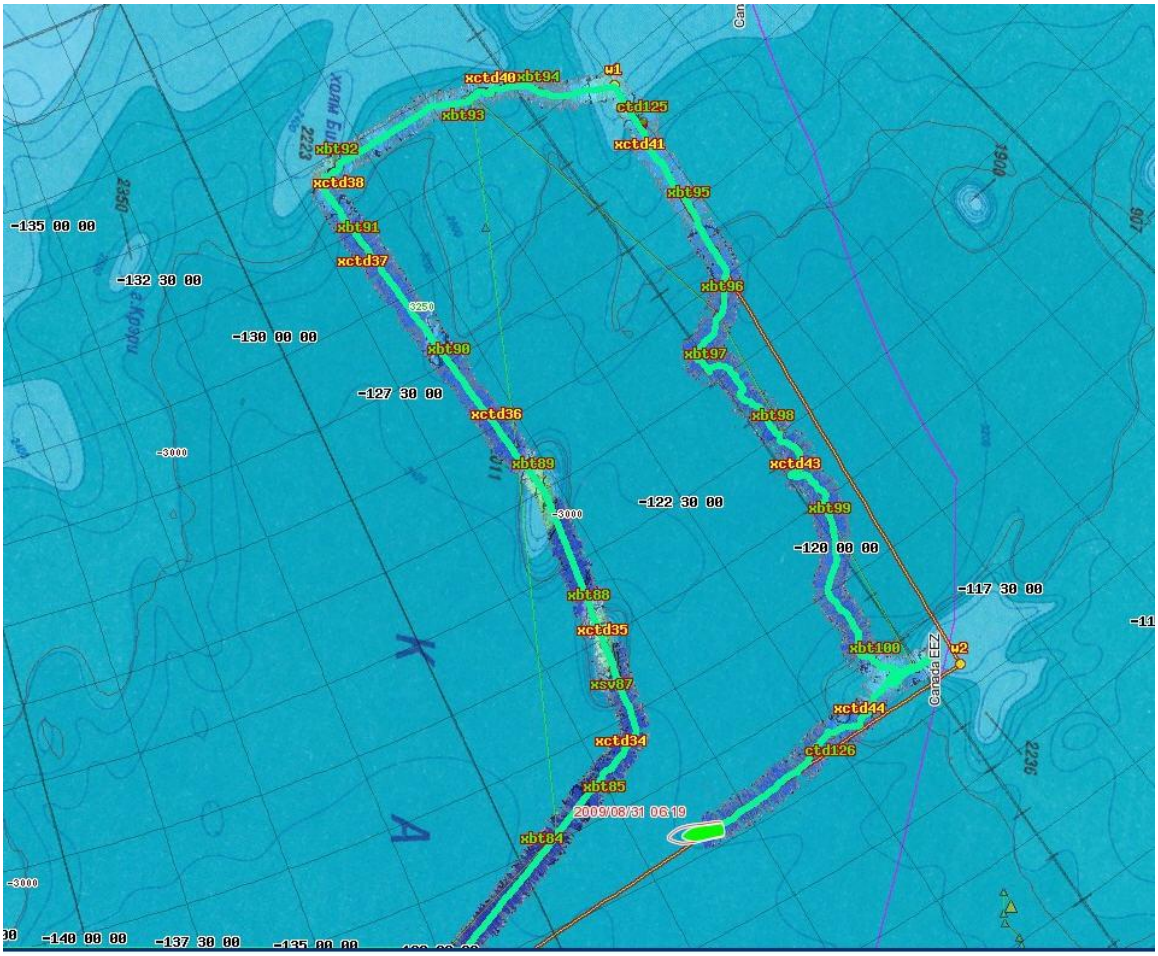


Figure 23. trackline for 30 August 2009

0820Z: Healy stopped to let LSSL get a little closer – during this time we have no Knudsen and no Seabeam returns – probably ice under hull – will see what happens when we get moving.

0826Z: Getting underway – Knudsen comes back – multibeam eventually – but noisy

1211Z: XBT taken – T7_00102 good to 760 m – Balloon launched

1400Z: Andy on watch

1440Z: Stopped briefly for flight ops; flight quarters intermittent for the next couple hours.

1813Z: XBT taken TD_00103 good to about 600 m

1 Sept 2009 DOY 244

0017Z: XBT taken – T5_00104 good to 1830 m

0100Z: Davy Jones summons all bluenoses to the flight deck and hanger

0300-0425Z: Crossing the southern extent of the seamount we diverted around on our steam to the northeast.

0550Z: XBT taken – TD_00105 good to about 680m

1159Z: XBT taken – T7_00106 good to 760 m

1755Z: XBT TD_00107, good to about 250 m; agrees well, to that point with previous XBT. Will leave SV profile unchanged.

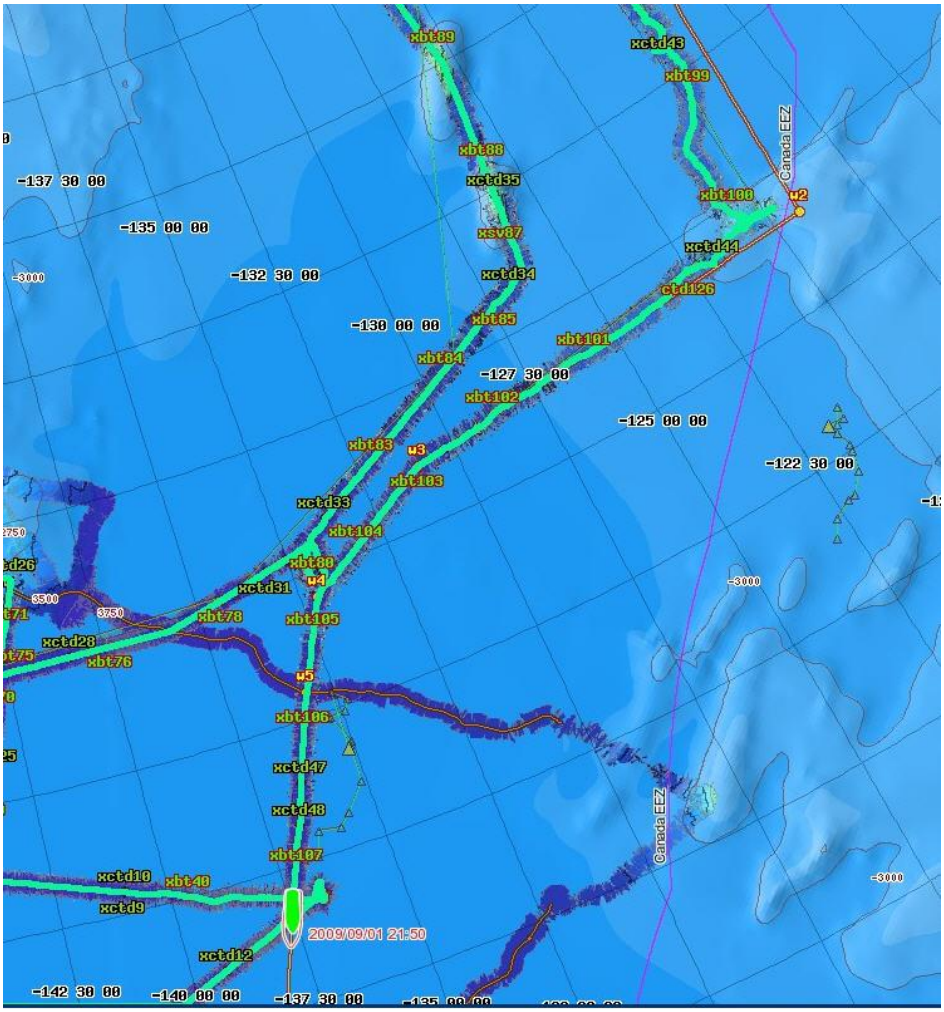


Fig. 24. Overview of 30,31 August 2009 track.

02 September 2009 DOY 245

0018Z: XBT T7_00108 was anomalous, showing temperature increasing smoothly to almost 10 C at 760 m. Dropped XBT T7_00109; good data to 760 m.

0537Z: XBT taken TD_00110 good to 760 m

0700Z: Beautiful sunset!!! It will be up soon though

1100Z: Bluenoses awoken for PT

1206Z: XBT taken – T5_00111 good to 1830 m

1215Z: King Neptune and court aboard to initiate blue noses into realm of the Polar Bear.

1400Z: Andy on watch

1806Z: XBT TD_00112 good to 760 m.

1900Z: Watchstanders noted "frown" in multibeam swath. Called Dale to locate LSSL XCTD profile from this morning. Evaluated new SV profile and decided to enter profile from LSSL XCTD 50.

03 September 2009 DOY 246

0022Z: XBT T7_00113, good data to 760 m.

0330Z: Have looked at XCTD's from LSSL – 50 seemed to have an anomalous kick at about 50 m – LSSL took another 51 but was good only to 200 m – then took a third – 52 that was good to 800 m and looked identical to 51 near surface and matches our XBT (113) – Steve has entered XCTD 52 into the Seabeam system.

0314Z: Trouble with streamer on LSSL – slowing to 2 knts

0424Z: LSSL needs to pull streamer

0455Z : LSSL called – they say at least 2 hours – we will take a CTD – we have maneuvered to an appropriate spot – LSSL will update us with progress –

0520Z: LSSL called – it will be at least 6 hours – we will take full depth CTD and then play it by ear.

0730Z: CTD on board – checked with LSSL – they say most likely 6AM but could be sooner. This precludes visit to one contour in vicinity (a 3800 m small depression – not too exciting) that is 25 miles away. Instead we will do cross-line pattern so look at refraction issue and stay in vicinity of LSSL. Shame Pablo isn't on board – we could have deployed one of his buoys on a nice piece of ice right next to us (talked to Kyle about it and he didn't think piece was that nice).

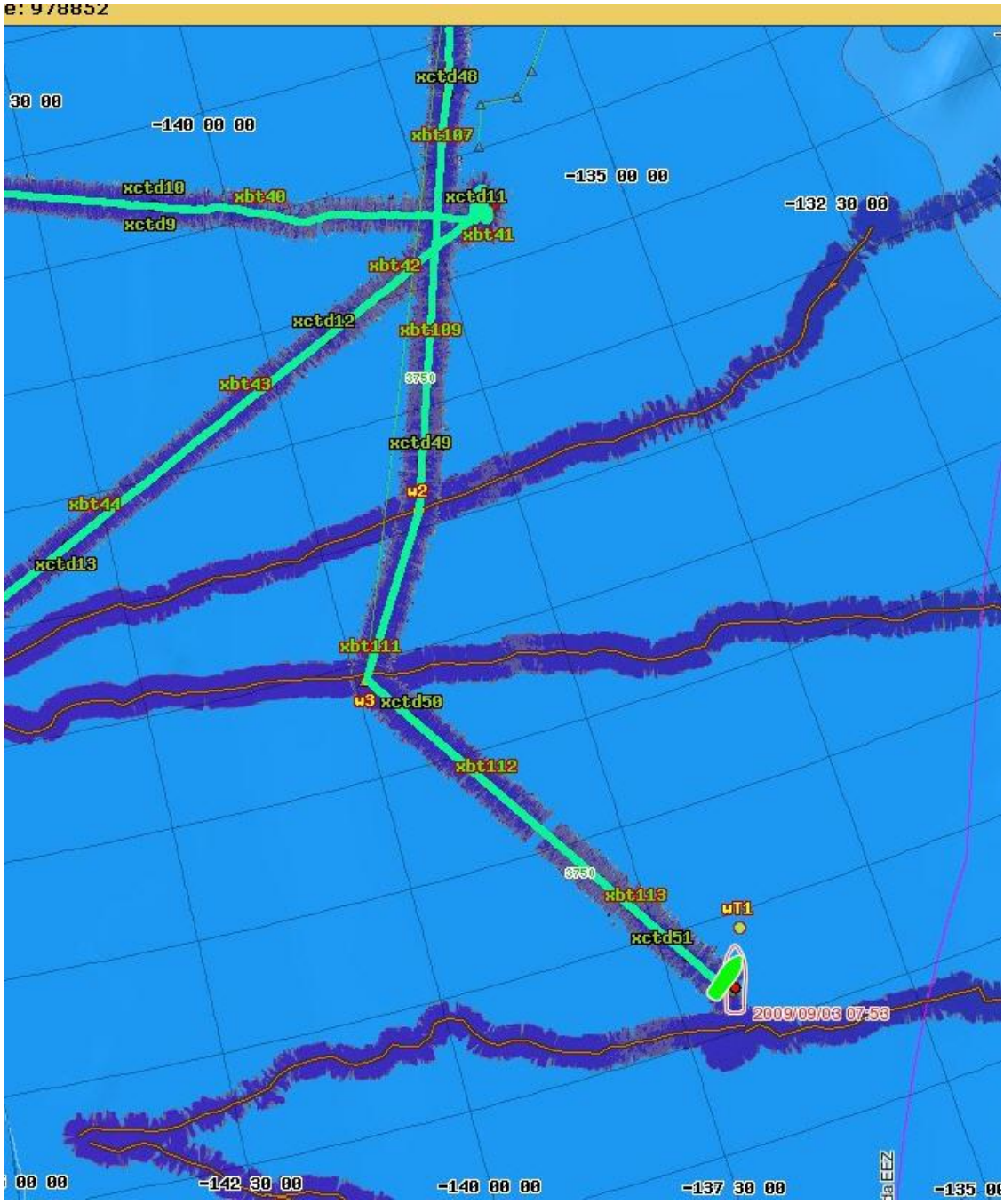


Fig. 25 – Overview of Track 1 – 2 Sept. 2009

0900Z: LSSL now reports wont be ready till 8AM local (5 hours from now) – still not enough time to go anywhere of interest –

1157Z: XBT taken – TD_00114 good to 760 m

1345Z: Dave Mosher called – still no good sign for streamer – they are thinking of deploying single channel streamer but this is last resort. Dave wants to think about contingencies. He suggests a bathy program on Sever Spur and then dredge at new seamount. Sever Spur is about 126 nmi away to north and east. Erin has looked at ice and says some very bad ridging in between here and there. Dont see value (except scientific curiousity) of dredging new seamount as it will probably have no role in ECS. If we dredge would rather see it done in place that helps address A/M and Chukchi origins.

1400Z: Andy on watch

1449Z: Increasing Knudsen processing gain in steps to determine if higher OG can increase depth of usable record without clipping signal. Only very intermittent returns from SeaBeam—attributed to possibility of ice or bubble under xdcr while stationary.

1746Z: XBT T5_00115 good to full depth.

2050Z: Since we started moving and the SeaBeam did not improve, we called Dale to see if we could get the system working again. Scraping ice did not work, but a change in the manual surface sound speed input got the system going again

2100Z: We are stopped again, however, as the ship's force tries to move gear around on the flight deck and stow the crane.

Flight ops complete; we will do a little mapping in the vicinity while we waait for LSSL.

0000Z: 3 Sept 2009 DOY 247

0006Z: XBT taken – TD_00116 good to about 400 m

LSSL attempted to deploy their streamer but ice closed in on it – they need to haul it back in.

0300Z: Maneuvering to find place to deploy streamer

0451Z: Back on the track

0544Z: XBT-taken T7-00117 – good to 760 m

1149Z: XBT taken TD_00118 – failed

1200Z: XBT taken – TD_00119 good to 550m

1400Z: Andy on watch

1806Z: XBT T5_00120 failed at 300 m.

2210Z: Crossed a curved linear depression on the seafloor, visible in both SeaBeam and Knudsen displays—a partially filled portion of a sinuous downslope channel?

2250Z: Another deepening of seafloor; bathymetry while of low relief, may be a little more complex than indicated at 2210Z.

05 September 2009 DOY 248

0003Z XBT taken TD_00121 good to 620m

0200Z: At conference call with LSSL, Captains were uncomfortable with ice conditions for rafting as we headed south and west. Decision to continue to south and east to stay in ice but still collect useful seismic – new waypoint given to bridge.

0555Z: XBT taken – T7_00122 good to 760

1154Z: Weather balloon launched

1218Z: XBT taken – TD_00123 good to 760m

1400Z: Andy on watch

1430Z – 1455Z: Stopped for flight ops

1605Z: LSSL has seismic gear aboard; we are proceeding NE to find better location for rafting. LSSL will parallel.

1630Z: Maneuvering for rafting.

1755Z: LSSL coming alongside.

1830Z: Suspended the acquisition watch.

1840Z: XBT TD_00124 postponed because of ice collected around the ship.

1934Z: XBT TD_00124 taken good to 760m

Rafted with LSSL – BBQ etc

06 September 2009 DOY 249

0530Z – LSSL unrafted and underway.

0540Z: Healy underway

0556Z: Shaft problem on HEALY – all stop

0610Z: Starting up again

0634Z: XBT taken T5_00125 good to 1830 m but noisy

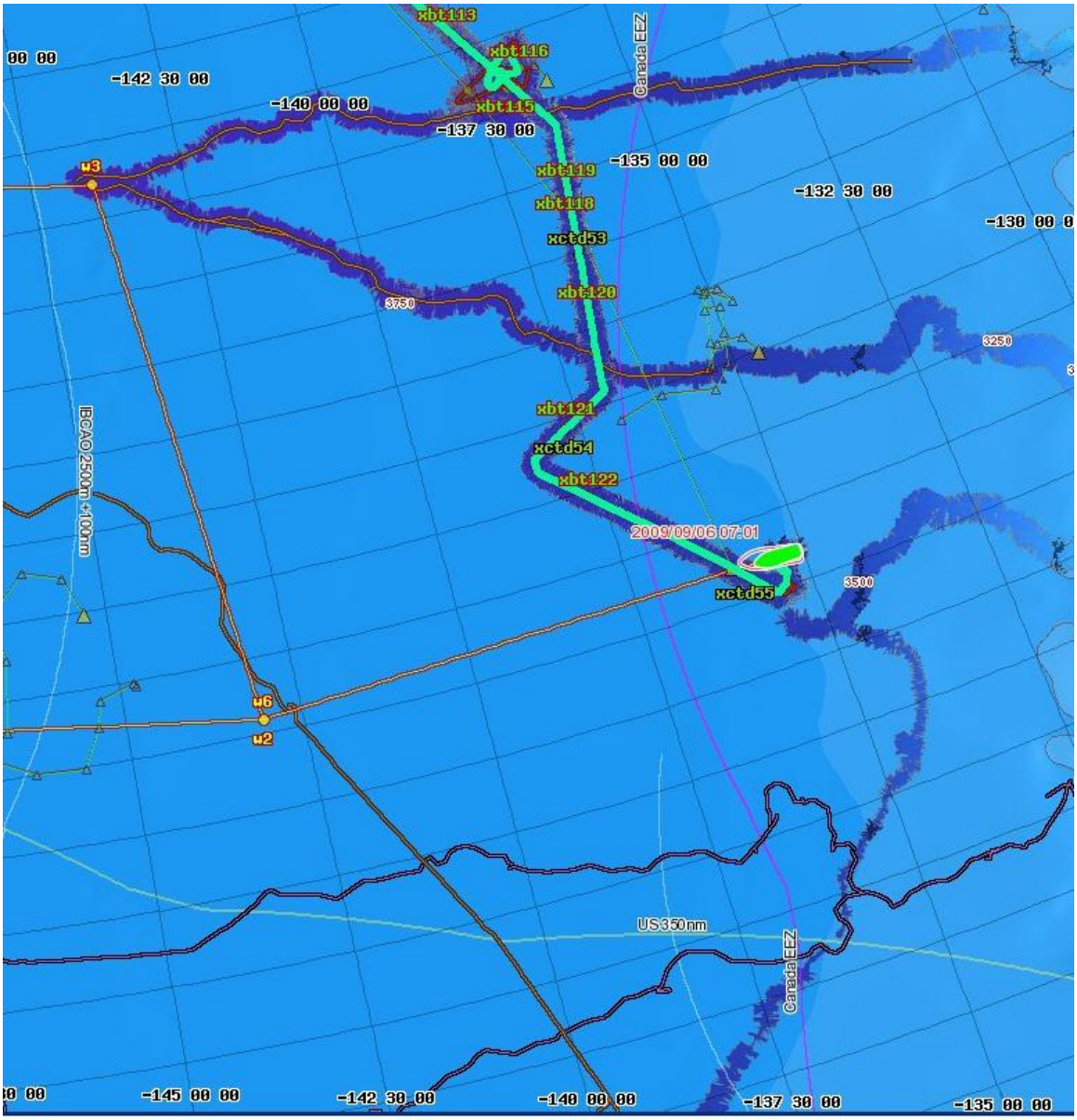


Figure 26. Overview of shiptrack September 3, 4 and 5 2009

O700: LSSL reports trouble with compressor – slowing to 2 knots

0823Z: pick up speed to 4-5 knts

1150Z: Balloon released.

1158Z: XBT taken TD_00126 good to 760m

1400Z: Andy on watch.

1755Z: XBT T7_00127; good data to apprx. 600 m.

1945Z: Left pack and broke off from LSSL escort; changed course to 301 enroute to next waypoint on Russian chart feature nea Northwind Ridge.

2000Z: Back into pack (pack front is oriented NW-SE).

2345Z: XSV S2_00128; good sv data to about 1150 m; will enter into SeaBeam for use as active sv profile.

07 September 2009 DOY 250

0554Z: XBT taken – TD_00129 good to 760 m

1045Z: Dale changed Seabeam Transceiver to AUTO – to improve quality of record

1157Z XBT taken T5_00130 good to 1830 m

1400Z: Andy on watch.

1640Z: Altered track across waypoint based on Alex request to cross gravity high and then back toward dredge waypoint when the desirability of change was reassessed.

1824Z: XBT TD_00131; good to 760 m.

1825Z: Adjusting track to revised dredge site (an eastward-facing slope was selected to avoid wind on stern as would be the case at originally planned site) to map alongside existing coverage.

1905Z: Crossing toe of previously mapped bathymetric feature.

2100Z: Approaching dredge site

2146Z: Dredge in water – Dredge HLY0905_DS_1 SeaBeam depth 3835 m.

Target depth 3600 – 3200 m

Stopping wire at 3600 m wire out – will maneuver up track to intersect with target.

Max tension about 7500 lbs – when off bottom weighed about 400 lbs more than when going down

08 September 2009 DOY 251:

0240Z: Dredge on deck -- most mud but some rocks with manganese coating - many small erratics.

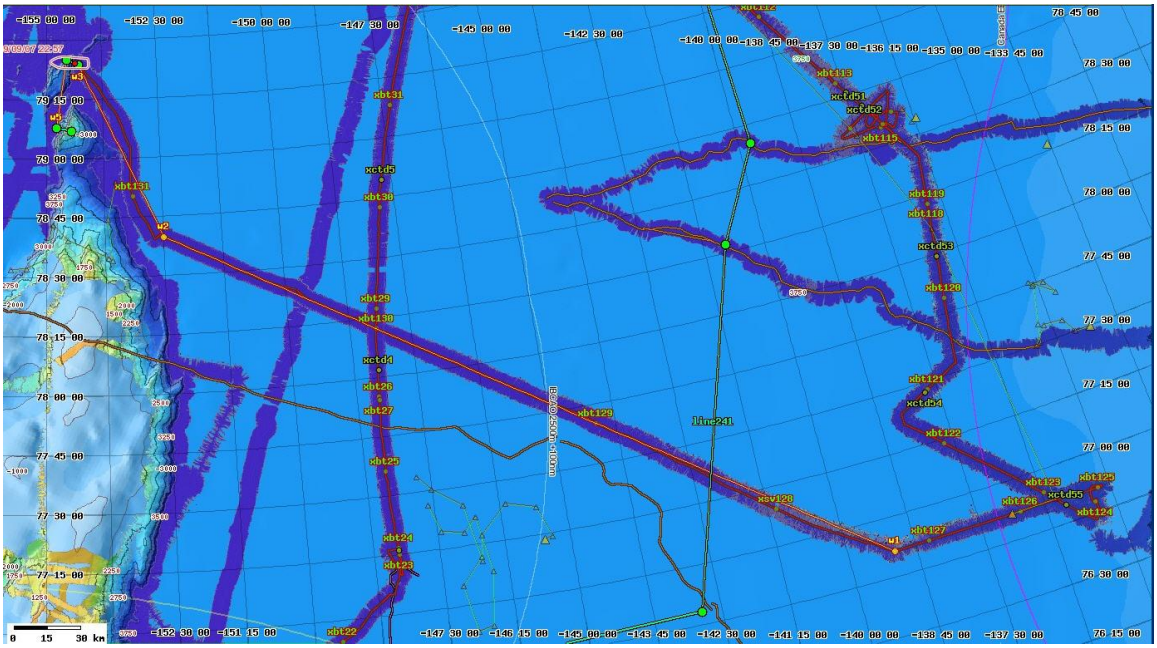


Fig. 27 Track overview 5, 6 Sept 2009.

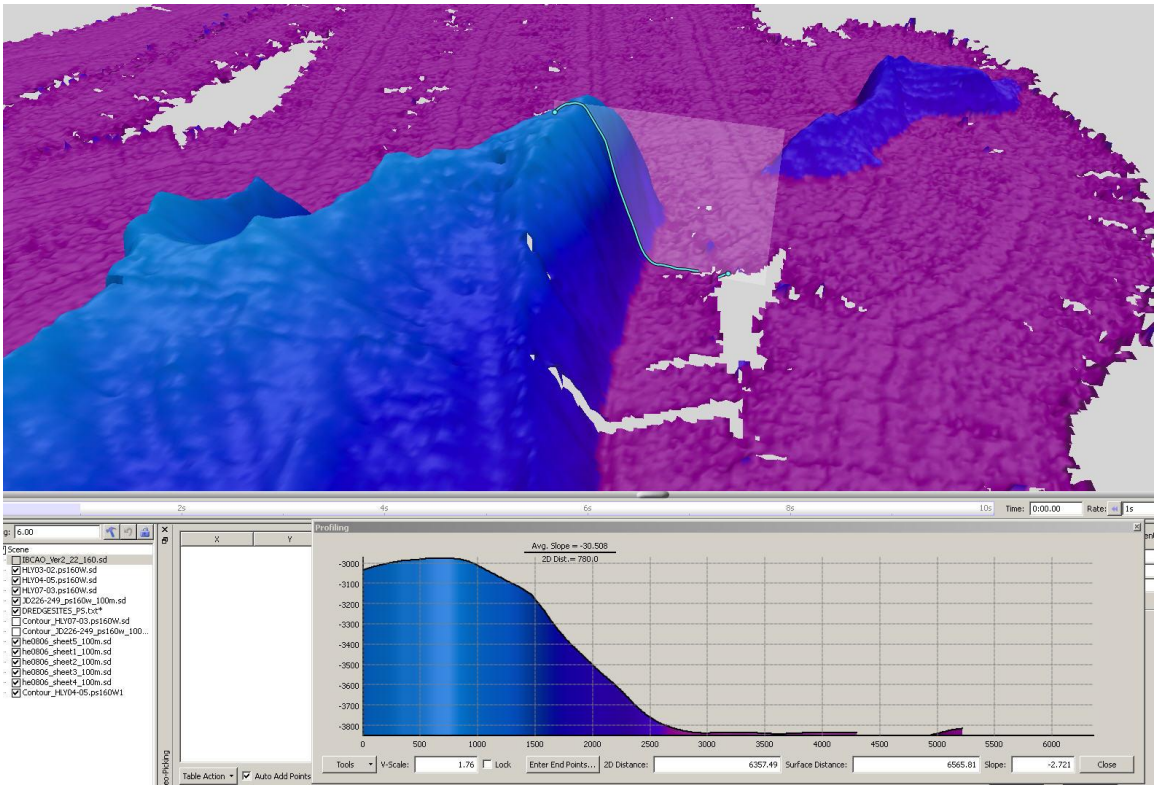


Figure 28. Proposed Dredge Site – HLY-0905-DS1

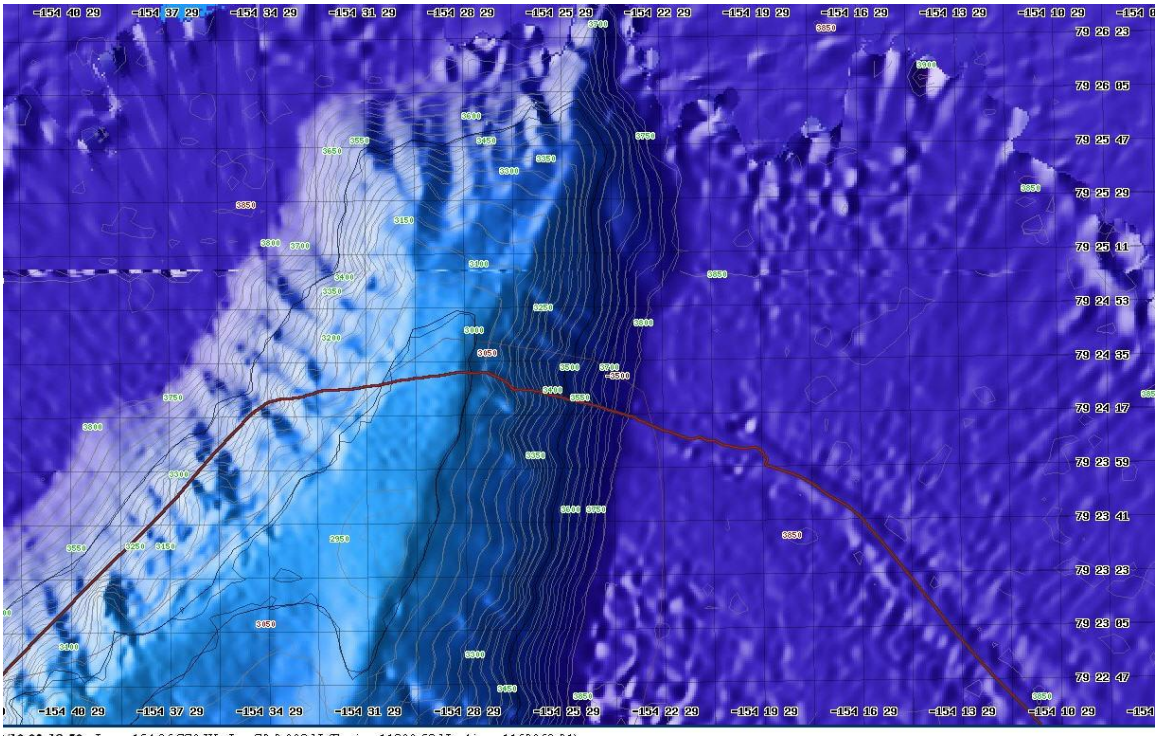


Figure 29. Dredge Site 1 – as run

0320Z: Underway en route to a mapping track to fill in coverage along the slope/plain transition

0542Z: XSV taken because we saw large difference in surface water between last night's XSV and the XBT's plus Levitus. XSV S3_00132 good to 1860 m

0550Z: XBT taken XBT_T7_0133 good to 760 m

0612Z: Steve entered XSV-132 profile into seabeam

1156Z: XBT taken TD_00134 good to 760 m

1400Z: Andy on watch; en route to Dredge Site 2

1730Z: Reached vicinity of dredge sit 2; slowed and stopped for drift evaluation.

1859Z: On station and ready to dredge; dredge deployed; we will aim dredge for steep section of Healy Seamount eastern flank beginning at approximately 2700 m depth, and dredge upslope.

2012Z: Dredge is on the bottom.

2200Z: Dredge is stuck on the seafloor; maneuvering ship and manipulating wire to attempt to free dredge from seafloor without exceeding breaking or elastic limits of weak link or cable.

2357Z: Dredge is free and coming up; estimated 400 lb. load of seafloor material.

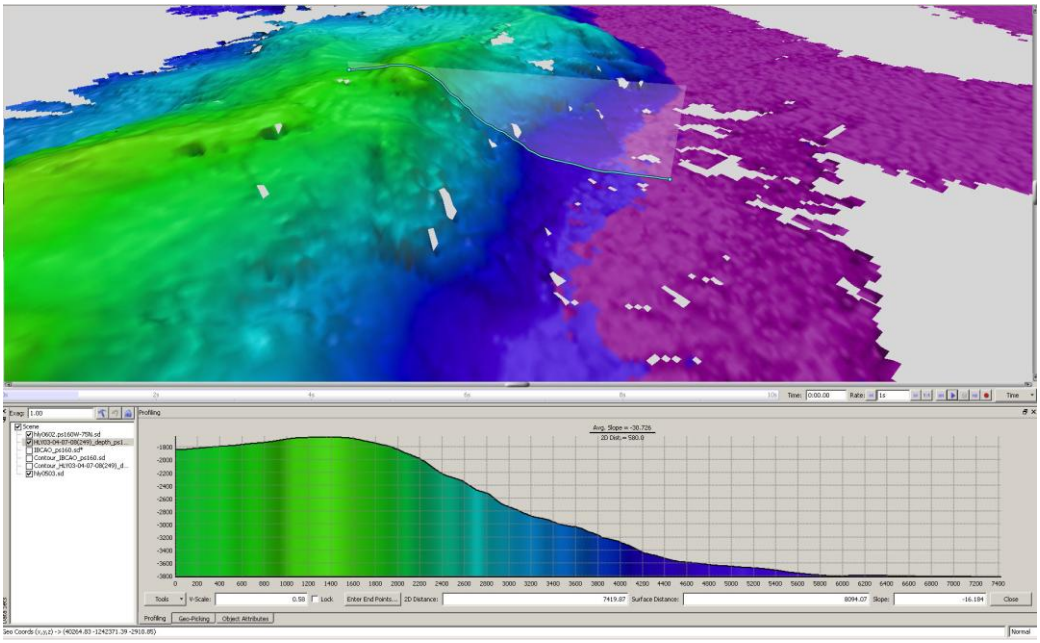


Figure 30. Proposed dredge Site HLY-0905_DS2

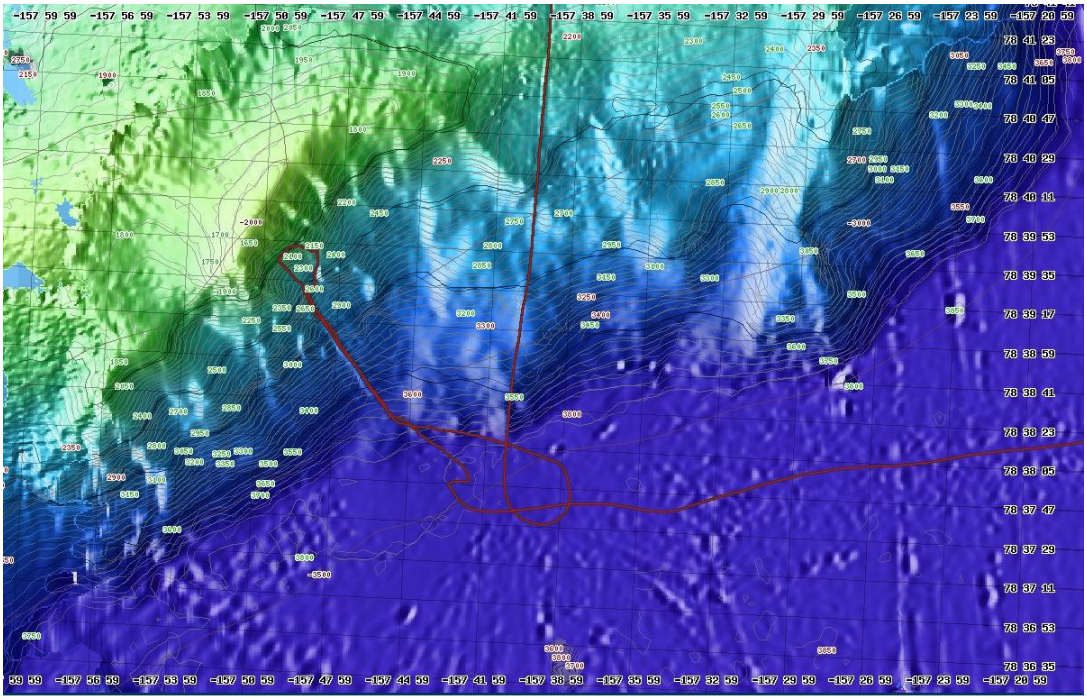


Figure 31. Dredge Site 2 – as run

09 September 2009 DOY 252

0040Z: Dredge on deck with combination of mud and rocks.

0100Z: Began mapping loop vicinity of Healy Seamount

0536Z: XBT taken – T5_0135 good to 1830m

1155Z: XBT taken – TD_00136 – good to 769 m

1400Z: Andy on watch

1710Z: Crossing subbottom feature visible in Knudsen; no impact on surface bathymetry or near-surface sediments.

1758Z: XBT T7_00137 good to Approx 650 m. Bottom of temperature bulge has moved up from about 100 m to about 50 m.

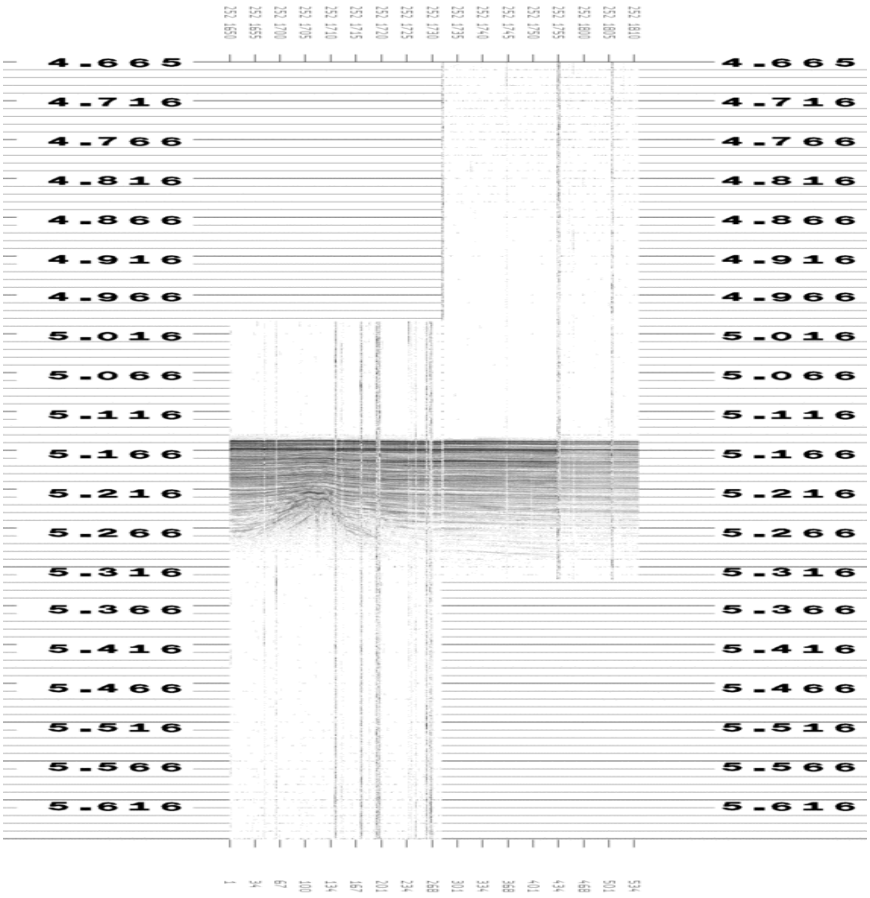


Figure 32. Subbottom feature

1910Z: Crossing sub-bottom feature similar to that seen at 1710Z, but on opposite side of basin.

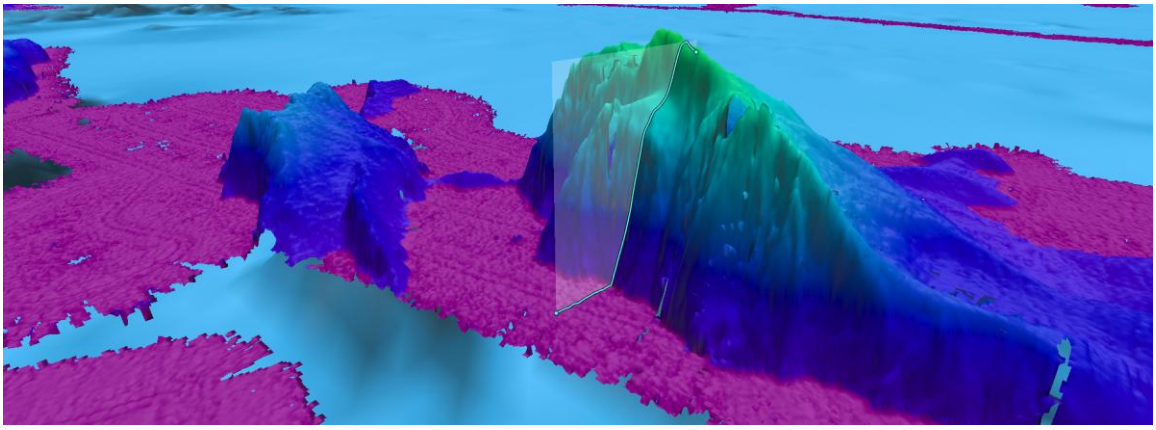


Figure 33. Proposed Dredge Site HLY0905_DS3

2013Z: Stopped at dredge site for drift test and preparation for dredge.

2040Z: Dredge in water at Dredge Site 3.

2203Z: Dredge at target depth of 2700m - 3300 m. Ship is moving slowly upslope so that dredge will land near this depth

2232Z: Dredge on seafloor; will begin dredging by hauling in and paying out to work dredge upslope. Tension log is being kept at control station.

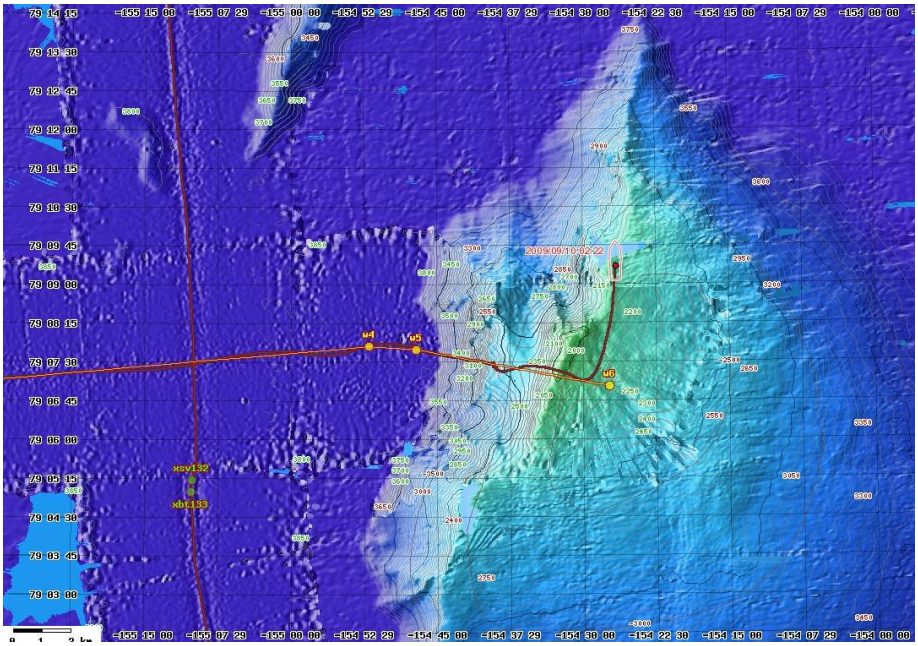


Figure 34. Dredge Site HLY0905_DS3 – as run

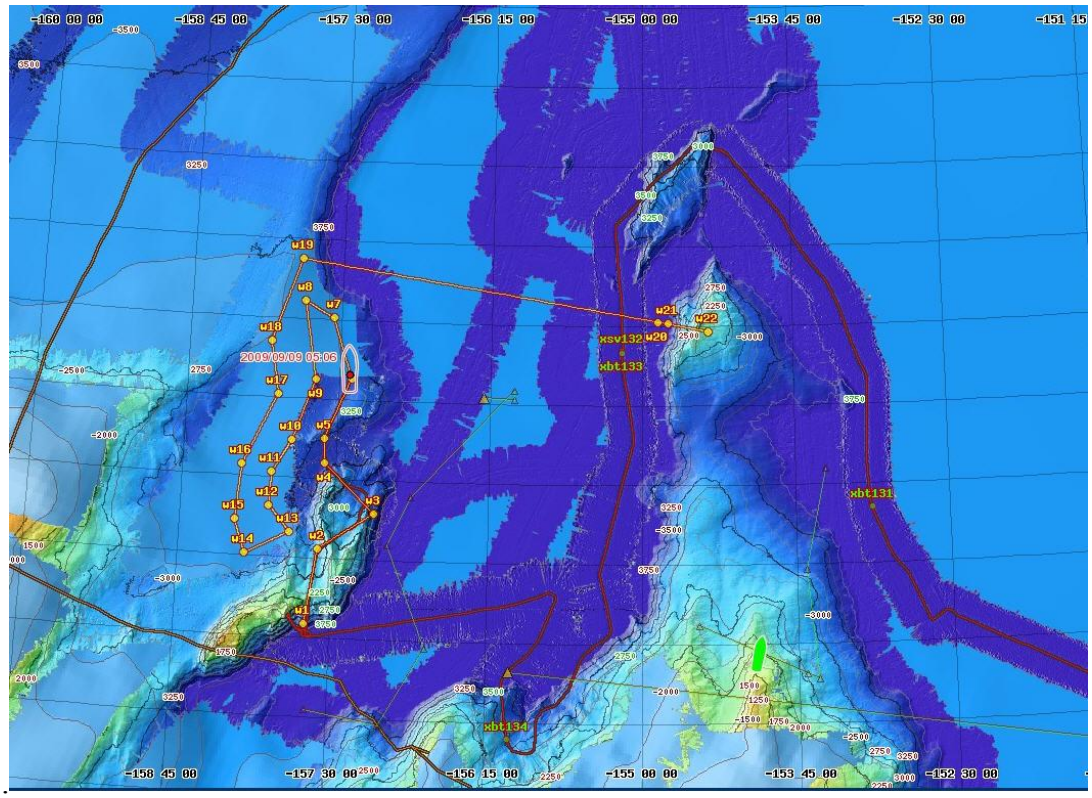


Figure 32. Track overview 7 and 8 September 2009

10 September 2009: DOY 253

0120Z: Dredge on deck – an absolute beauty – full of rock about 1000 lbs; almost no mud.

0155Z: Underway to begin surveying towards next dredge site (Healy seamount again); starting with a diversion to north to fill gap in bathymetry on this feature.

0305Z: Bridge stopping to work on bows-thruster

0345Z: Bow thruster work complete – underway again

0357Z: Stopping to test bow thruster again

0410Z: Underway again

0544Z: XBT taken, TD_00138 good to 760 m

1152Z: XBT taken T5_00139 – good to 1400 m

1400Z: Andy on watch; filling in bathymetry along slope-basin transition area; guiding bridge with SeaView screen.

1754Z: XBT TD_00141; good to 760 m. TD_00140 failed.

1800Z: After several hours of sinuous courses through this indentation, we seem to have traced the "foot of the slope" in this area. We will head for Healy Seamount to set up for dredge.

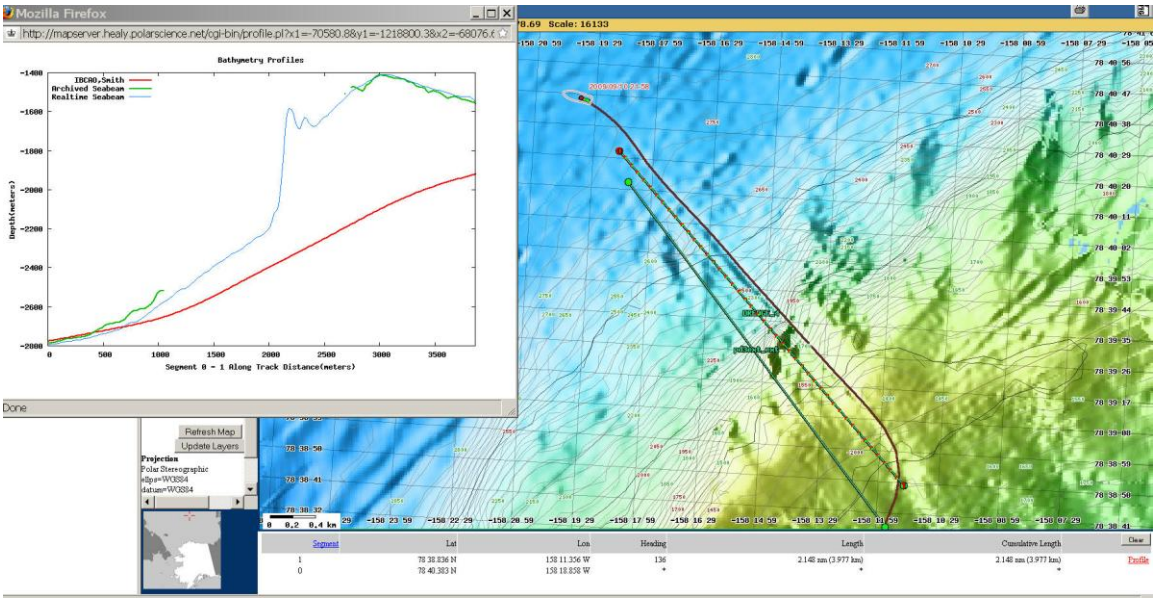


Figure 33. Proposed line for Dredge Site HLY0905_DS4

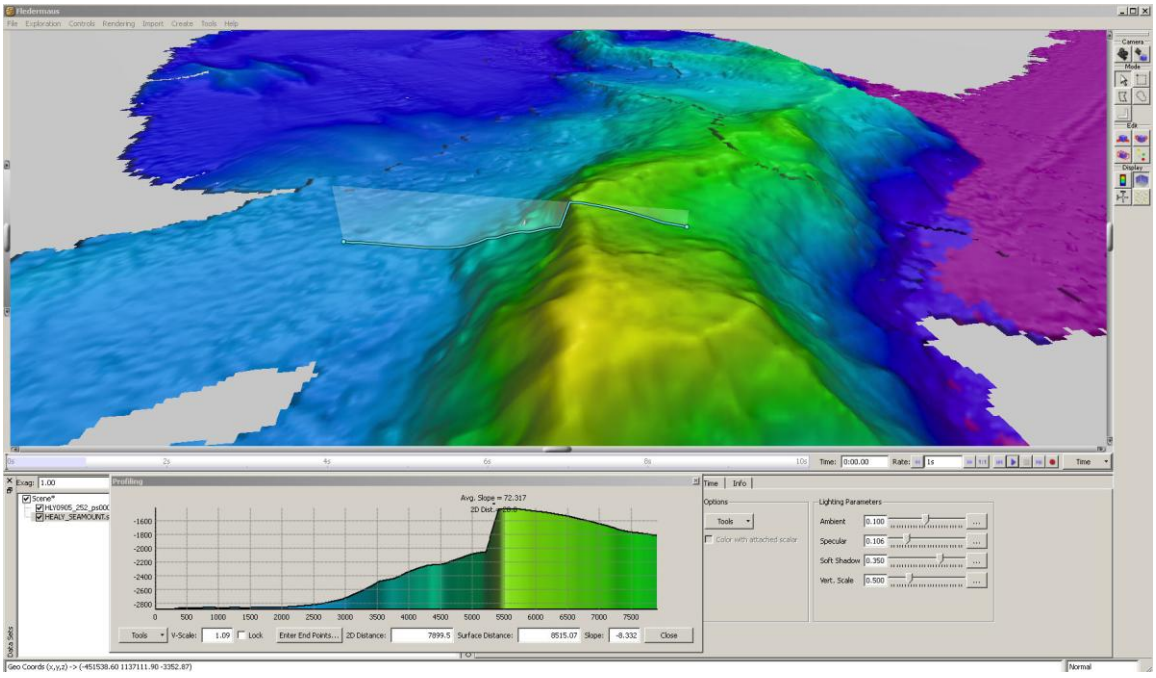


Figure 34. Proposed line for Dredge Site HLY0905_DS4

2240Z: Moving slowly toward the dredge deployment site. Target depth between 2200m and 1700 m

2302Z: Dredge in water

11 Sept 2009 DOY 254

0200Z: Dredge off bottom – on way up.

0227Z: Dredge on deck

0538Z: XBT taken – T7_0142 good to 760 m

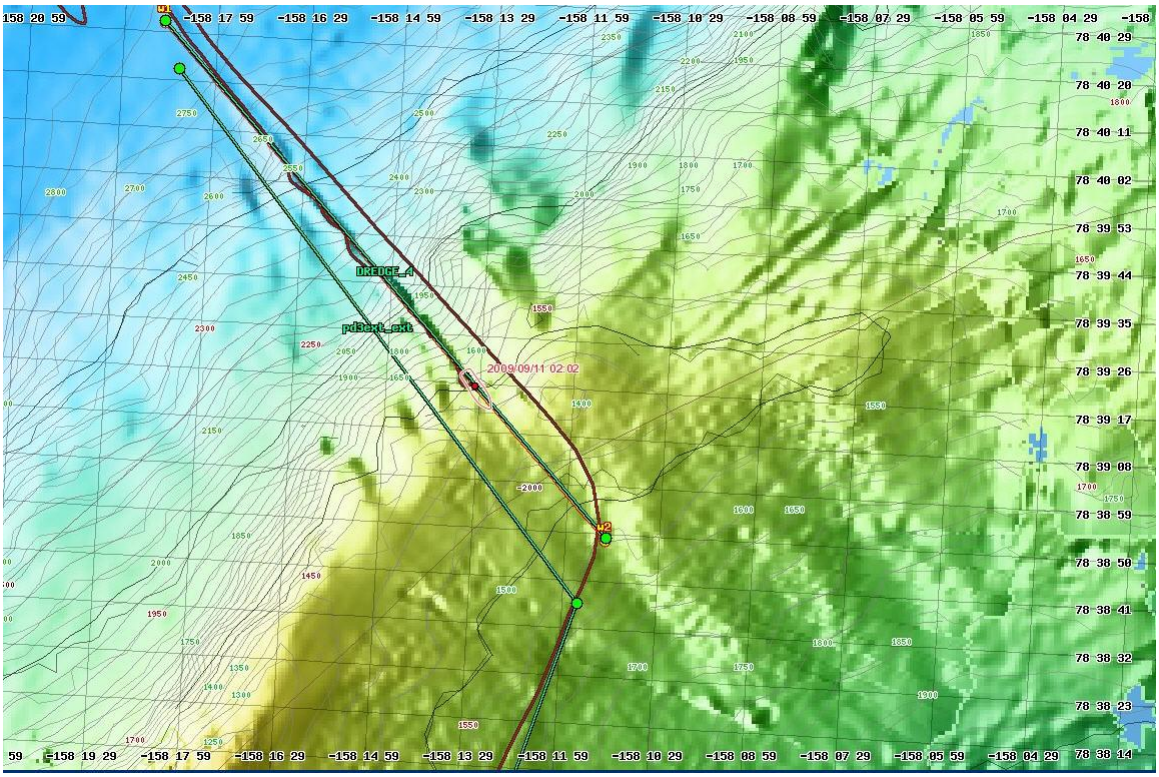


Figure 35. Dredge Site HLY0905_DS_4 As run

1020Z: Several simultaneous dropouts of Seabeam and Knudsen (probably ice) have asked bridge to slow to 5 knots for a few minutes to see if it clears up. It did.

1030Z: back up to speed

1200Z: Two XBT attempts failed – 143 and 144

1400Z: Andy on watch

1542Z: Crossed directly over pockmark on plateau; the pockmark is visible on the Knudsen plot, with a very prominent hyperbolic reflection centered directly under the pockmark. Likely interpretation is that the hyperbolic reflection is from the edge of the crater approaching and side and rear edge receding.

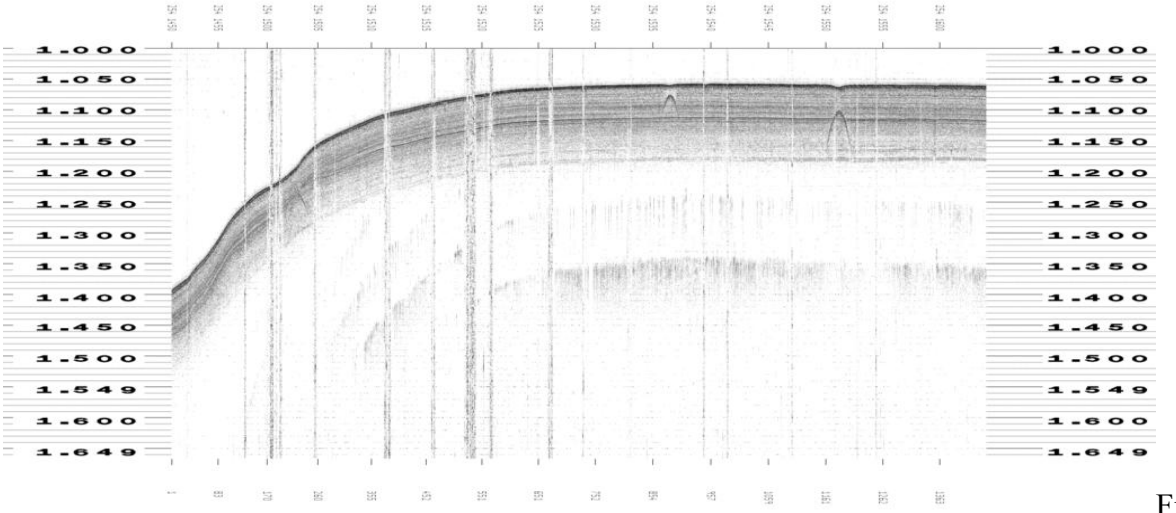


Figure 36. Hyperbolic reflections from pockmarks

1752Z: XBT T5_00145 Good to terminal depth of 1830 m.

12 September 2009 DOY 255

0001Z: XBT TD_00146 good data to about 700 m. Profile largely unchanged, will retain existing SV profile.

0100Z: Diverting around field of large pieces of thick blue ice.

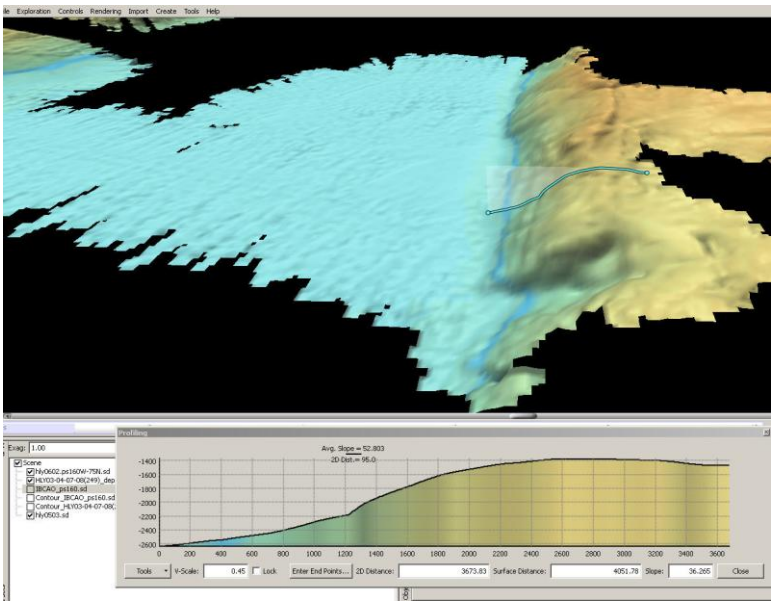


Figure 37. 3-D view of proposed Dredge Site 5

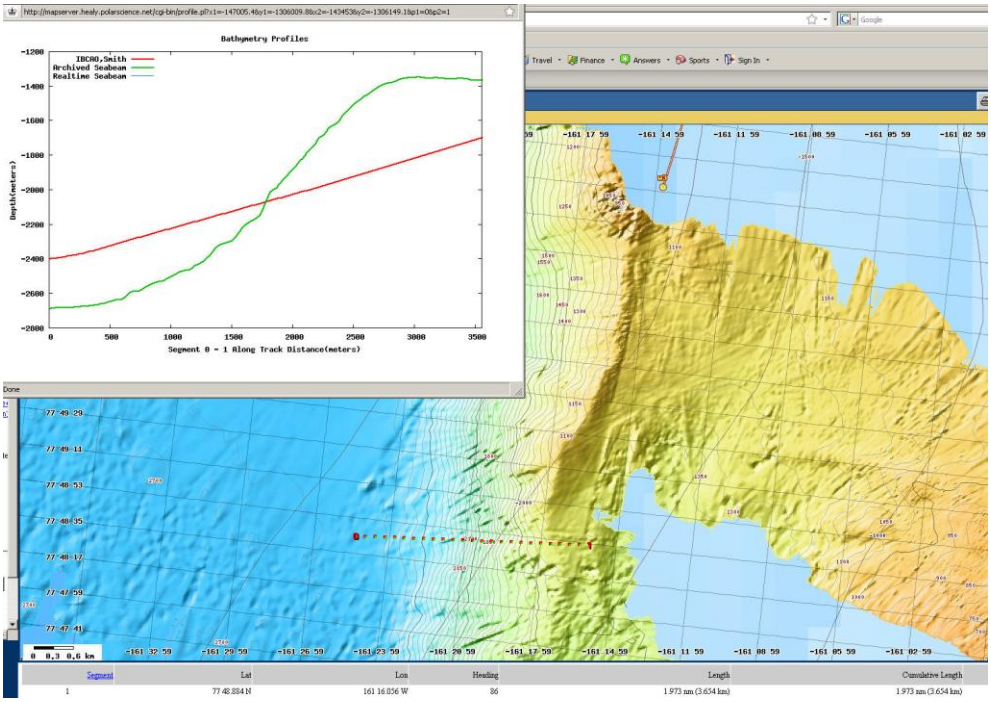


Figure 38. Proposed Dredge Site 5

0301Z: Dredge 5 in the water.

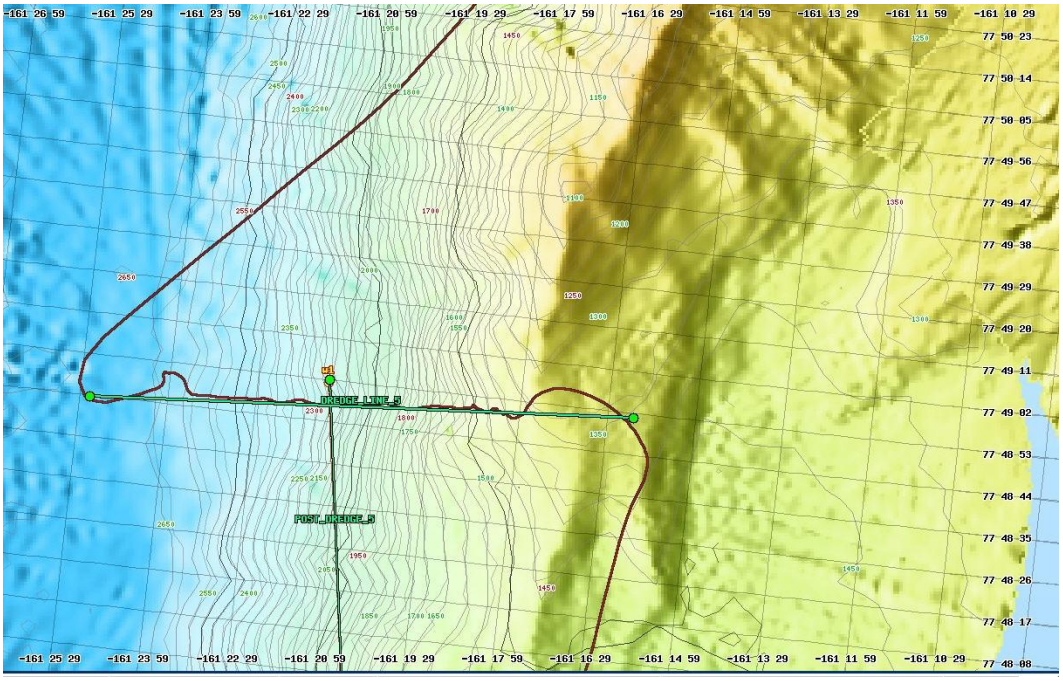


Figure 39. Dredge Site HLY0905_DS5 – as run

0559Z: Dredge off the bottom

0630Z: Dredge on deck – BEAUTIFUL BAG FULL OF ROCKS!! Many appear to be metamorphic

0640Z: Underway – will run down eastern wall of rift and then cross over to pick up base of groove site and pockmark area.

1155Z: Stopping to XSV

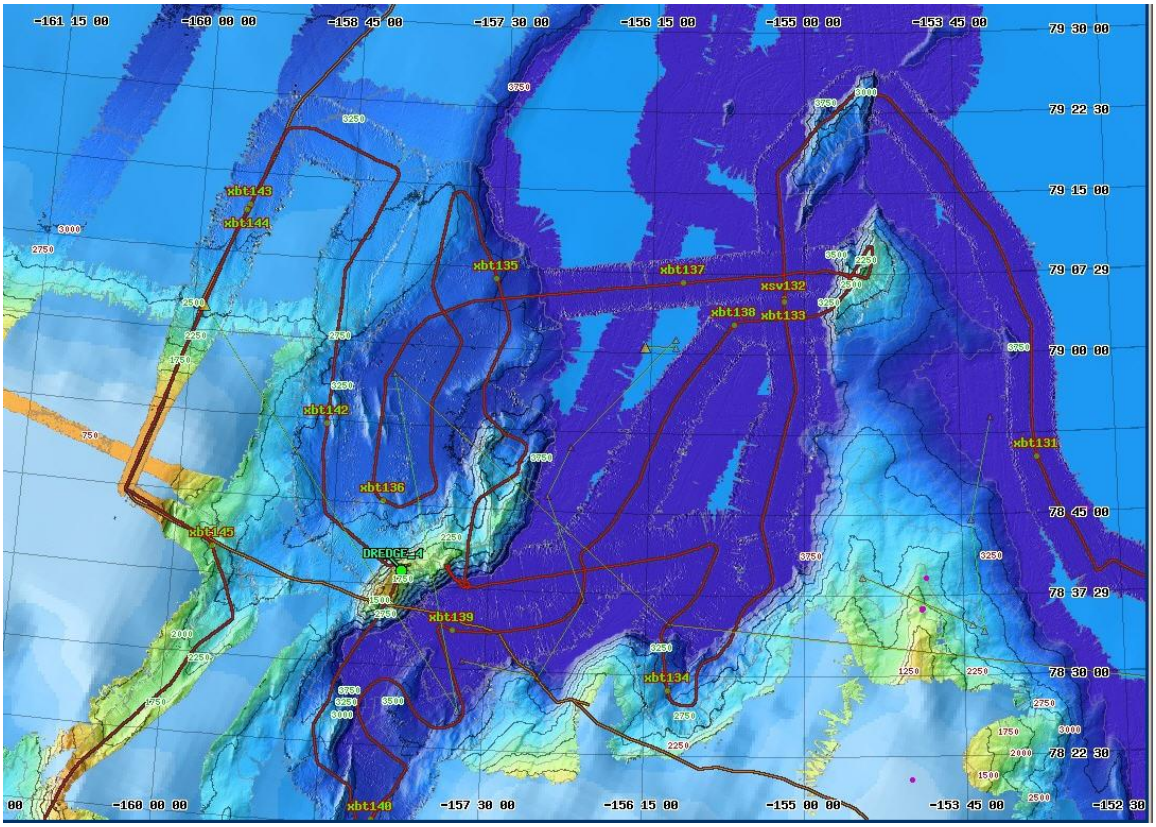


Figure 40. Overview of tracklines Sept 9,10,11 2009

1159Z: XSV taken – S2_00147 good to 1990 m

1204Z: Underway again.

1400Z: Andy on watch; chief scientist has laid out a track to fill some gaps at the north end of the large dune area.

1500Z: We have revealed an area of parallel "dunes" on the seafloor. Very fortuitous track.

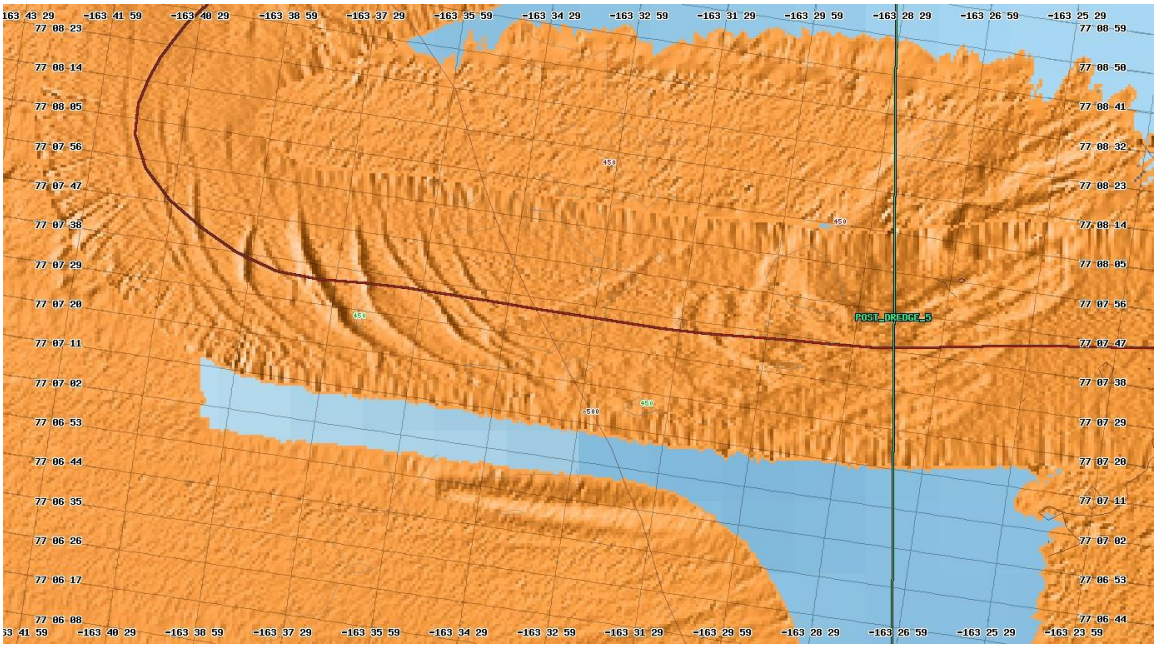


Figure 41. Parallel dune-like features.

1715Z: Beginning systematic survey to add coverage over southern end of large dune area.

1754Z: XBT T7_00148, data good to seafloor at appx 475m.

2354Z: XBT TD_00149, data good to seafloor at appx 420m.

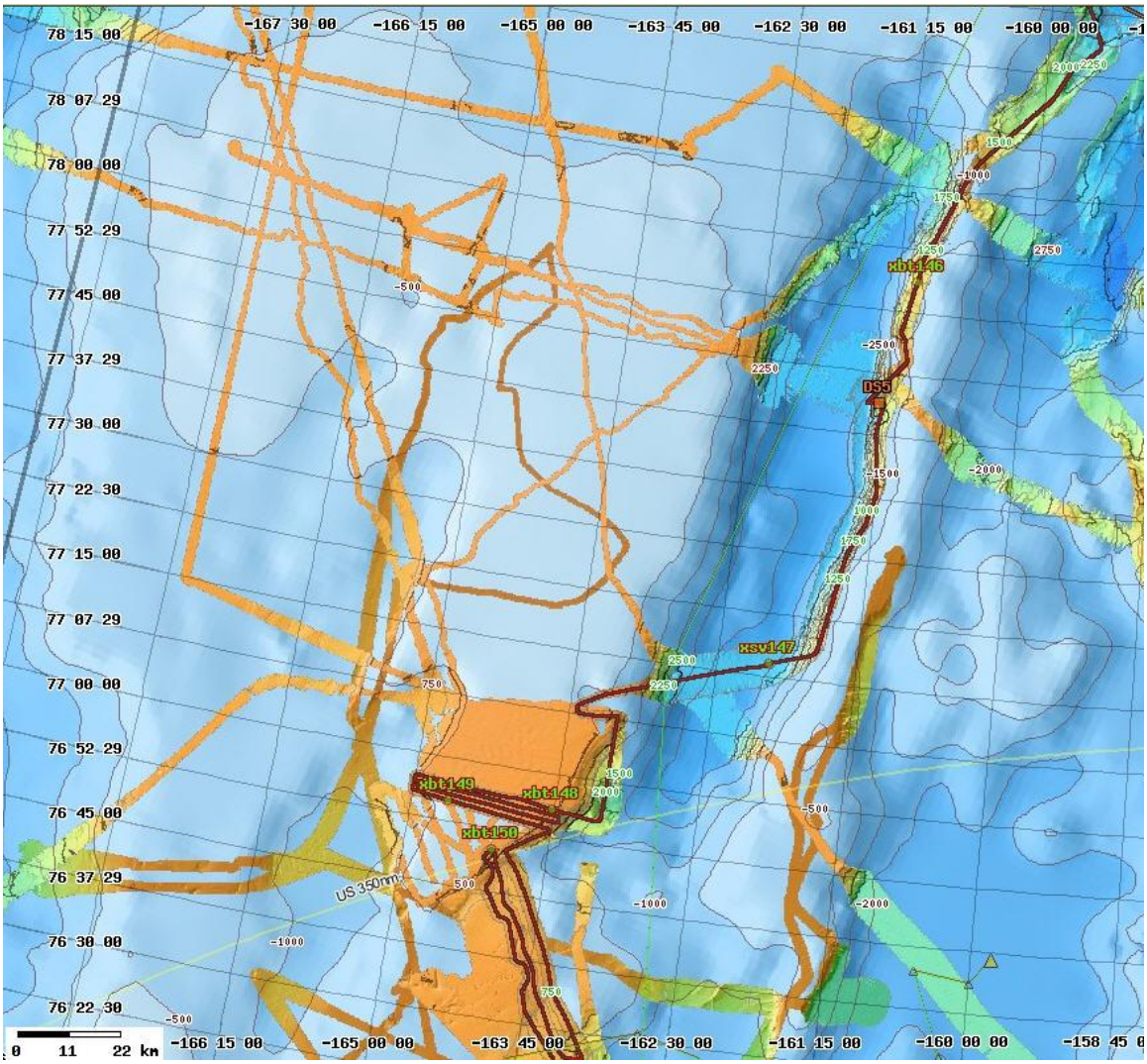


Figure 42. Overview of shiptrack 11-13 Sept.

13 Sept 2009 DOY 256

0200Z: Finished up bottom side of groove field – now heading south along pockmark area

0559Z: XBT taken – T7_00150 good to seafloor depth of 545m

1154Z: XBT taken – TD_00151 good to 760 m. This shows same complex structure as previous XBT's but surface temp is offset by almost 1 degree!! (now zero as opposed to -1).

1401Z: Dale has concluded that the change is real – he can adjust or perhaps we should take an XSV at next 0600Z.

1425Z: Andy on watch. Following track toward SeaGlider rendezvous point. Track is laid out to fill in gaps in multibeam coverage.

1801Z: XBT TD_00152 failed; XBT TD_00153 deployed; wide fluctuations in temperature in top 50 meters of water column. Questionable temperatures at deeper levels.

2102Z: XBT TD_00154 same wide fluctuations in top 50 meters, more reasonable values than 00153 throughout the water column. Entered new SV profile from 00154. Will plan on taking XSV at a stop this evening.

14 September 2009 DOY 257

0133Z: Stopped to recover Seaglider; glider is on the surface in the reported position.

0200Z: Glider aboard.

0333Z: stopping for XSV S2_00155 good to 1400 m – which is water depth

0526Z: XBT taken – T7_00156 – good to 760 m

0624Z: Slowing to deploy one of Pablo's buoys

0654Z: Pablo deployed SVP Ocean Drifter

0950Z: Slowing to deploy another SVP Ocean Drifter

0959Z: Kyle deployed SVP Ocean Drifter

1152Z: AG-1 launches his last balloon!!!

1200Z: At HARP Site C – coming to stop. Setting up HARP and maneuvering into precise position.

1249Z: 10 yards from site –

1254Z: Deploying HARP C 72 47.1065N 158 24.0852W

1300Z: Underway to HARP SITE B

1400Z: Andy on watch

1530Z: Slowing for deployment of HARP B

1558Z: Harp B deployed; resuming speed en route to HARP A2 site.

1815Z: Approaching HARP A2 site at reduced speed to map area for final drop location.

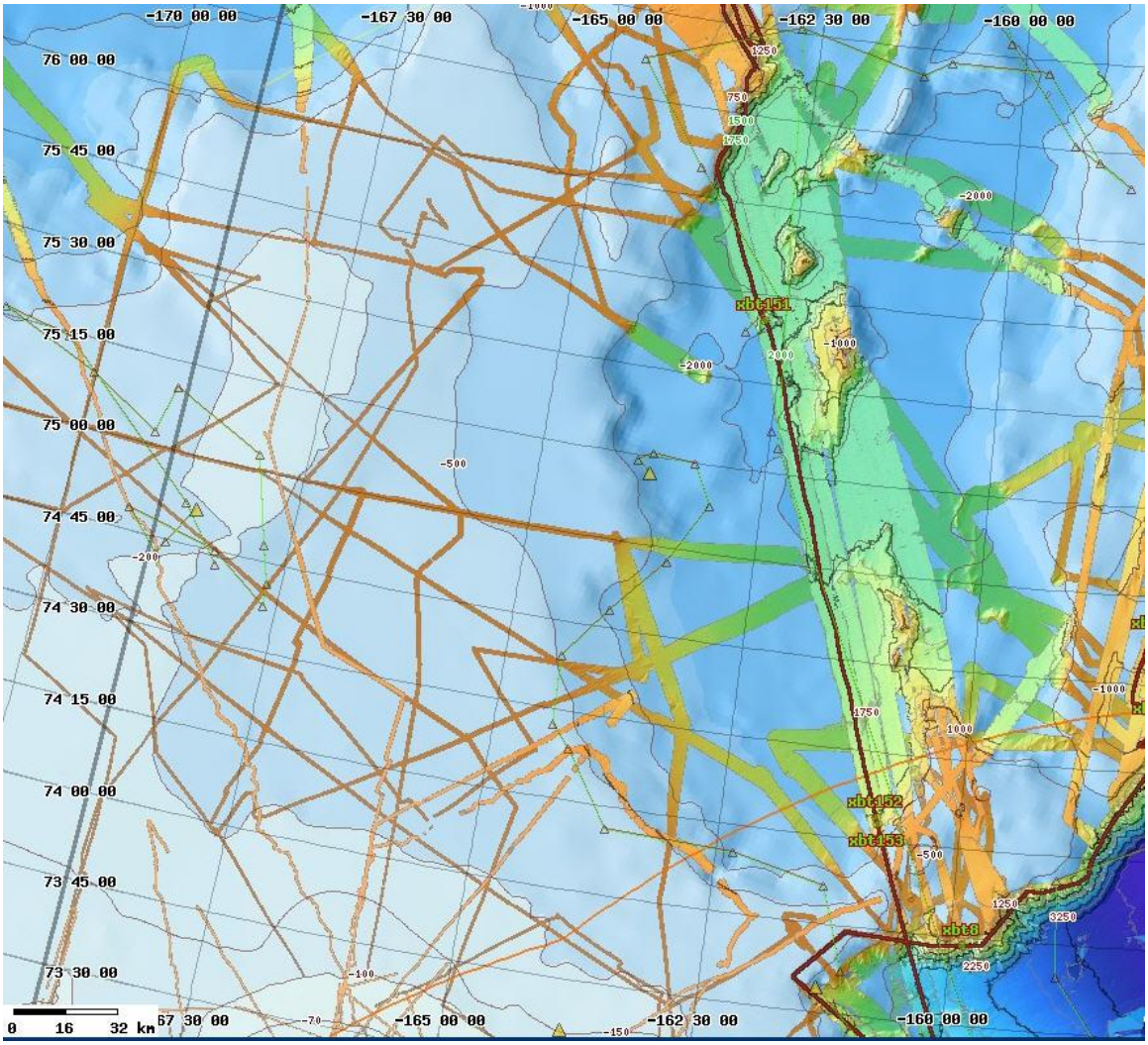


Figure 43. Shiptrack overview 13-14 Sept. 2009

1820Z: Confirmed that original coordinates are suitable for deployment; will drop on NE-SW track

1907Z: Dropped HARP A2

1920Z: Resuming speed and track to Met buoy site

15 September 2009 DOY 258

0121Z: Buoy alongside --- Seabeam secured to facilitate acoustic release

0124Z: Buoy on deck

0130Z: Seabeam back on

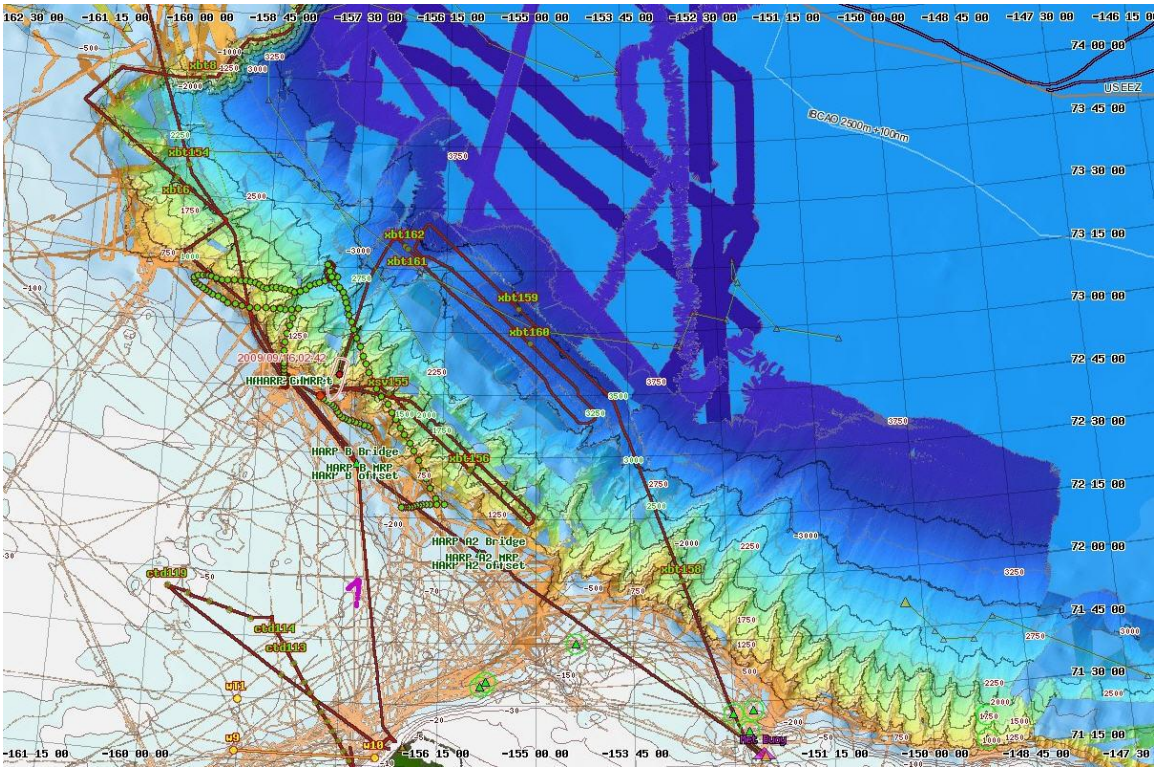


Figure 44. Overview of shiptrack 14-16 Sept. 2009

0221Z: Underway to start of survey line

DREDGE WEIGHT – 1508 lbs of rocks being shipped back

0544Z: XBT taken T5_00158 good to 1830m

0802Z: Call from bridge – slowing to 10 knts as we are approaching ice??

0900Z – Now slowing to 7 knts

1015Z: Aurora sighted!!

1027Z: "Through the ice" – now going 17.2 knots

1037Z: Noted some narrowing of swath – loss of outer beams – will slow to 16 knots

1151Z: XBT taken TD_00159 – good to 760 m-

1400Z: Andy on watch

1811Z: XBT TD_00160; good to terminal depth of 760 m.

16 Sept. 2009 DOY 259

0025Z: XBT taken T7_00162 good to 760m

0235Z: Official end of logging for HLY0905.

Statistics from Brian:

Seismic – (through 1945Z 6 Sept when LSSL and HEALY separated) – 2982.9 km

1610.6 nmi

Non-seismic 6602.1 km

3564.8 nmi

Total: 9585.0 km

5175.4 nmi

APPENDIX A: HARP and SOURCE SIGNATURE TESTS

Ethan Roth
Research Engineer
Marine Physical Laboratory
Scripps Institution of Oceanography
University of California, San Diego

HARP Ops

During HLY-08-05, two autonomous seafloor instruments – known as High-frequency Acoustic Recording Packages (HARPs) shown in figure 1 – were deployed to locations in the Chukchi Sea along the continental slope north of Point Barrow (see figure 2). These instruments are used to passively monitor year-round and collect acoustic data such as ambient noise, marine mammal vocalizations, and anthropogenic activities. The primary goal on HLY-09-05 was to recover the HARPs on the transit north and redeploy them on the return to Barrow. With support from the Alaska Department of Fish and Game, a third HARP was added to the project for deployment on this cruise.

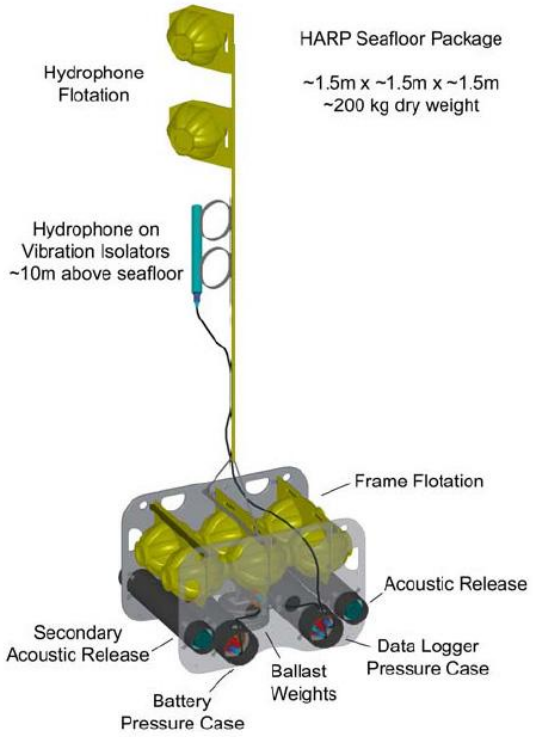


Fig. 1 – High-frequency Acoustic Recording Package in moored seafloor configuration.

On August 8, 2009, Healy arrived at HARP Site 'B' (72° 27.626 N, 157° 23.932 W, 234 meters depth) and reassessed the recovery operation due to thick fog conditions. Once a plan was established, a 12 kHz transducer was dropped over the starboard side and used to send acoustics commands based on a series of timed pings at specific frequencies. The mooring transponders were enabled, allowing for slant or horizontal range estimation by measuring the two-way travel time. This functionality was used to calculate Healy's rate of drift from the fixed mooring position. A small RHIB was then deployed approximately 300 meters off Healy's bow prior to releasing the anchor weight in order to optimize our recovery mobility. A release command was transmitted resulting in the anchor weight dropping and the package floating to the surface at a rate of approximately 50 meters per minute.

Once sighted at the surface, personnel aboard the RHIB made their approach to the HARP, coiling and attaching the hydrophone and 10 meter float line to the mooring frame. Healy repositioned so the mooring package was approximately 50 meters off the stern. On the fantail, spectra wire running from a winch through the aft A-frame block was tossed to the RHIB, which was then hooked into the HARP's center bail. The frame was gently hauled into the transom and lifted until tag lines could be attached. The A-frame was once again positioned outward until the HARP could be transferred onto the fantail deck, at which point the operation ended in successful completion. Healy immediately transited to HARP Site 'C' (72° 47.908 N, 158° 23.880 W, 327 meters depth), where approximately three hours later the same operation mentioned above was carried out, once again in success.

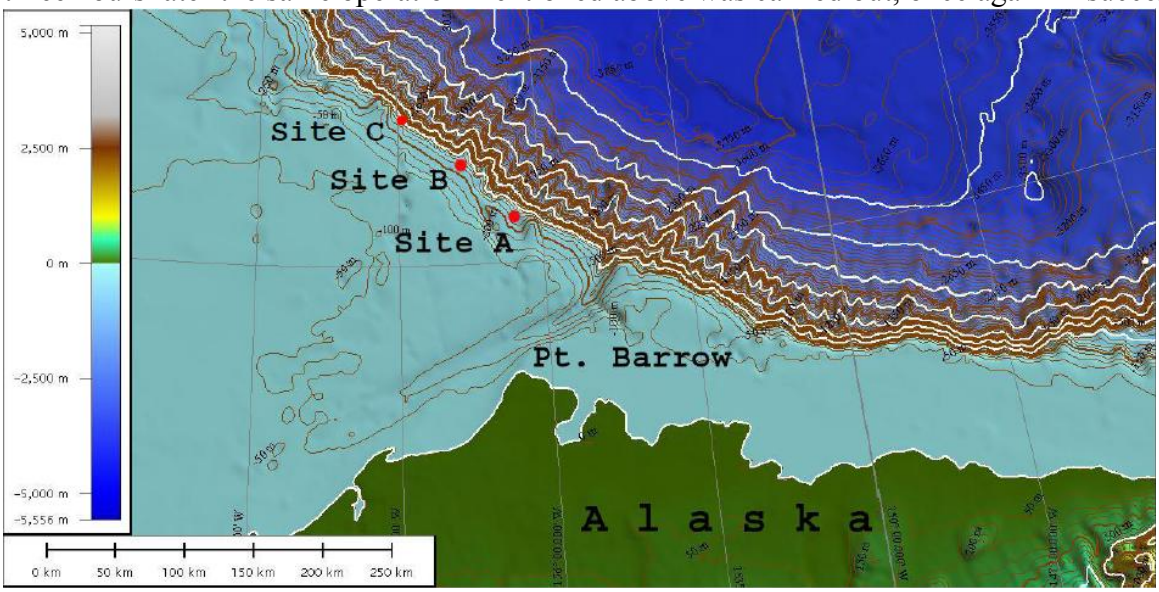


Fig. 2 – HARP instrument locations (bathymetric map courtesy of Larry Mayer at CCOM, UNH).

Throughout the cruise, both HARPs were subsequently broken down so the data could be retrieved and hardware could be evaluated for performance. Though small amounts of data can be spot-checked for quality purposes, all data processing and signal analysis is performed back at SIO since such high sample rate data requires computing power not available during the cruise. Both instruments were refurbished and the mooring frames were prepared once again for redeployment at the same locations in order to maintain the continuing long-term time series.

On September 14, 2009, Healy arrived 500 meters downwind of the northernmost deployment location – HARP Site 'C' – and slowed to ≤1 knot. The mooring package was staged on the fantail directly under the A-frame's wide-block sheave and the 9/16" wire, attached to a quick release, was connected to the center bail. Two taglines ran through each of the forward D-rings. Once within approximately 100 meters of the drop location, the two floats and hydrophone attached to a 10 meter cable were lowered to the water and subsequently streamed aft of the vessel. The winch and A-frame were used to pick up the HARP, slowly swing it out and lower it until the frame was submerged just below the water. The quick release was pulled and the HARP sank to the bottom at the location 72° 47.9373 N, 158° 23.9449 W at 337 meters depth. Healy immediately transited to HARP Site 'B', where approximately three hours later the same operation mentioned above was carried out. The new location is 72° 27.6871 N, 157° 23.995268 W at 235 meters depth. With the additional third HARP and nominal new site, Healy transited to HARP Site 'A2' and conducted a survey of the seafloor with the multibeam sonar to ensure the drop location would not land the instrument in an ice scour or canyon. Once the target location was determined for deployment, the same operation was carried out in success. The new location is 72° 6.90185 N, 155° 44.01929 W at 250 meters depth.

Source Signature Test

Measuring absolute sound pressure levels are required of the LSSL seismic source array for environmental assessment purposes. The 190- and 180-dB radii are the zones of marine mammal mitigation for purposes of IHA permitting, as stated by the U.S. National Marine Fisheries Service. Though the sound field will be numerically modeled by the Geologic Survey of Canada (GSC) to provide a full 3D perspective of sound pressures, this model will benefit by being groundtruthed with direct field-based measurements.

On August 11, 2009, a seismic source calibration experiment was carried out in open water at the first rendezvous position between the Louis S. St. Laurent (LSSL) and Healy. Implementing a two-ship operation, the sound pressure field was measured with hydrophone receivers on the Healy – which remained stationary and as quiet as possible – and the seismic airgun source on the LSSL. Two independent, calibrated hydrophones (GSC and SIO) were hung vertically in the water column from the Healy while the LSSL towed the seismic source (3 G-guns: 2 x 520 in^3, 1 x 150 in^3) in a walk away or figure 8 geometry (as defined in SEG standard) at a survey speed of 3-4 knots (see figure 3). The straight line transect of the figure 8 pattern was 4 km (2 km on either side of the center). This report will only describe the experimental parameters of the SIO hydrophone and recording system.

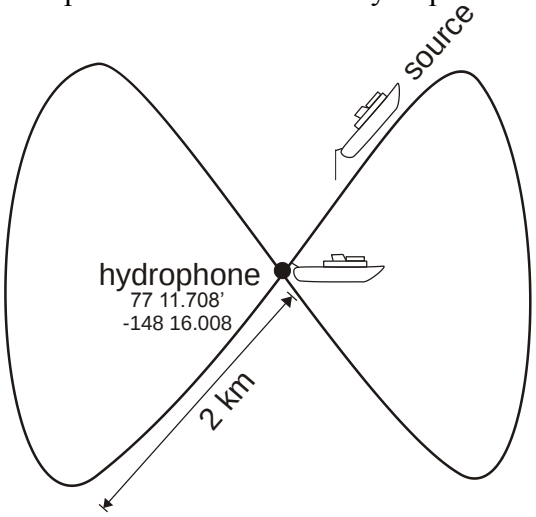


Fig. 3 – Walk away (figure 8) geometry carried out for the seismic source calibration experiment.

The evolution took place in an area with an average water depth of approximately 3860 meters. The hydrophone was lowered over the starboard side of Healy to a depth of approximately 145 meters so it would be below any interference from the hull of the vessel, but well above the bottom so as not to record multipath propagation arrivals mixed in with the direct signal arrival. Precise absolute position information of the hydrophone wire placement and source array were measured relative to the ship position GPS and heading in order to calculate the distance between source and receiver. Though the tail-end of the hydrophone was weighed down, there will undoubtedly be some uncertainty associated with the exact location of the hydrophone due to drift caused by subsurface currents.

An IRIG-B time code signal was digitized and the amplitude-modulated 1 kHz sine wave carrier was recorded simultaneously with the hydrophone signal on a 2-channel data acquisition system sampling at 22.05 kHz. All components of the hydrophone and recorder ran off DC batteries in order to avoid picking up electronic noise (i.e. 60 cycles). Analysis of this data will yield absolute sound pressure levels at specified ranges ($\leq$ 2 km) in order to understand the spreading loss of the seismic source as it propagates through the water column.

Sonobuoy Ops

An ancillary goal of HLY-09-05 was to opportunistically deploy expendable sonobuoy hydrophones in order to make radiated sound measurements of airgun propagation and icebreaker noise during various modes of propulsion, ice breaking conditions, and when marine mammals were sighted. A total of 21 sonobuoys (see table 1) were hand-launched throughout the cruise at times of opportunity to record acoustic signals including active sound sources, ship-generated noise, and ambient noise.

The Sparton AN/SSQ-57B is a Low Frequency Analysis and Recording (LOFAR) sonobuoy that provides omnidirectional passive acoustic signature data to the monitoring unit. The sonobuoy is calibrated and can be used to accurately measure ambient noise, and through post-event analysis, provides sound pressure level measurements. When deployed in seawater, a saltwater battery is activated, a CO_2 cartridge inflates a float bag with a RF transmitter inside, and a 400 ft cable with baffles drops out into the water column with a hydrophone, preamplifier, and weight attached to the tail-end (see figure 4). The analog acoustic signal is transmitted from the RF transmitter to an omni-directional, vertical line antenna mounted atop either Healy's Aloft Conn or LSSL's crow's nest, with an antenna splitter/amplifier, two FM radio receivers, digitizer, and recorder set up near the bridge. The sonobuoy hydrophone has a flat frequency response up to approximately 24 kHz. After 8 hours, the sonobuoy stops transmitting and a burn resistor punctures the float bag, resulting in the unit scuttling. More often though, the sonobuoy would be out of radio transmit range first (>10 km) since omnidirectional antennas have lower signal strength than directional Yagi antennas.

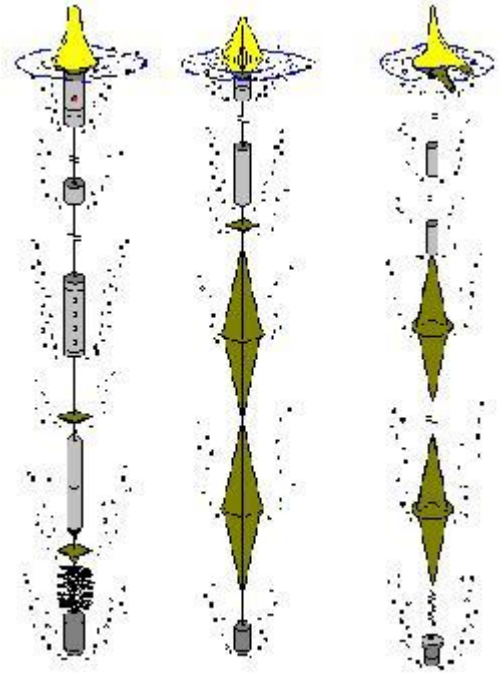


Fig. 4 – Sonobuoy configurations following deployment.

From August 24-27, 2009, the receiver station was set up on the LSSL while every few hours, two sonobuoys were deployed off Healy (in the lead breaking ice) with about 20-30 minutes lag time in between deployments. Additionally, there was one day where the LSSL was not shooting seismics and was in the lead breaking ice for Healy; sonobuoys were deployed off the LSSL to measure the noise radiation pattern of Healy off the bow and stern.

High frequency (f_s = 48 kHz) data was recorded using the real-time DAQ software Ishmael (developed by Mellinger), while both channels were also simultaneously acquired by a TEAC recording system (provided by the LSSL science party), which had a low-pass roll off at 1.5 kHz. In addition to the two sonobuoy channels, the LSSL GPS NMEA string was recorded on the third channel

of the TEAC. The LSSL science party also provided their backup Zypher GPS time clock – synched with the primary Zypher clock that's used to provide the seismic airgun shot-time trigger (either 17 or 20 second interval) – which output a 100 ms square-wave trigger pulse that was recorded on the TEAC's fourth channel.

With the shot times of the seismic source, it's possible to estimate the range of the sonobuoy by measuring the direct arrival time of the signal. If the range of the hydrophone receiver from the source is known, then sound pressure levels can be determined more accurately since transmission or spreading loss is a function of distance between source and receiver. Incorporating various factors such as sea ice conditions, water depth, sound speed, and the radiation pattern around the vessel, this data will be analyzed to try and better understand the characteristics of active sound source propagation in the Arctic Ocean.

Table 1 – Sonobuoy Deployment Log

Cast	Date/Time (local)	Latitude	Longitude	Water Depth (m)
01H	15Aug09 2000	80° 20.784 N	136° 45.786 W	3781
02H	17Aug09 2130	80° 09.700 N	151° 18.430 W	3862
03H	17Aug09 2230	80° 11.970 N	151° 38.950 W	3862
04H	19Aug09 2216	81° 28.851 N	153° 35.370 W	3808
05L	24Aug09 1530	81° 27.272 N	143° 25.242 W	3830
06H	25Aug09 0823	81° 32.646 N	135° 55.195 W	3718
07H	25Aug09 0824	81° 32.911 N	135° 45.356 W	3712
08H	25Aug09 0905	81° 33.273 N	135° 37.002 W	3709
09H	25Aug09 1205	81° 35.500 N	134° 30.600 W	3010
10H	25Aug09 1226	81° 35.797 N	134° 22.150 W	3008
11H	25Aug09 1458	81° 38.036 N	134° 20.312 W	3012
12H	25Aug09 1532	81° 38.814 N	134° 33.161 W	2727
13H	25Aug09 1842	81° 38.275 N	133° 58.127 W	3692
14H	25Aug09 1900	81° 38.564 N	133° 54.346 W	3735
15H	26Aug09 0948	82° 04.662 N	128° 06.220 W	3560
16H	26Aug09 1010	82° 04.646 N	128° 07.047 W	3552
17H	26Aug09 1246	82° 08.910 N	127° 48.247 W	3500
18H	26Aug09 1300	82° 02.925 N	127° 27.315 W	3466
19H	26Aug09 1445	82° 13.108 N	126° 14.988 W	3452
20L	27Aug09 0957	83° 20.300 N	125° 45.600 W	3350
21L	27Aug09 1044	83° 24.200 N	125° 49.800 W	3350

Note:
- Local time is Mountain Standard Time (UTC – 6hrs).
- For cast number, H denotes a Healy deployment and L denotes a LSSL deployment.

APPENDIX B: NIC REPORT

FROM: Pablo Clemente-Colón, Chief Scientist
National Ice Center - NOAA

SUBJECT: Trip Report – *Healy* HLY0905
Barrow, AK, August 7 - September 16, 2009

HIGHLIGHTS

- NIC provided two sea ice analysts and sea ice observers during the cruise
- NIC provided remote sensing data collection, analysis during cruise
- USIABP buoys were deployed during cruise

The primary science objective of the 2009 USCGC *Healy* cruise HLY09035 was to support seismic operations on the Canadian Coast Guard icebreaker *Louis St. Laurent* (*LSSL*)and to collect morphologic data in support of determining the extended continental shelf (ECS) of the United States. Thus, most of the cruise was carried out as a U.S. – Canada Joint ECS mapping mission. The Healy departed from Barrow, AK on 7 August, 2009 and returned their on 16 September. The cruise Co-Chief Scientists were Larry Mayer, from the Center for Coastal and Ocean Mapping (CCOM)/Joint Hydrographic Center (JHC) at the University of New Hampshire (UNH) and Andy Armstrong, from NOAA/NOS and JHC.

Four members of the National Ice Center (NIC) participated in the HLY0905 cruise. This included AG1 Steve Lilgreen, and Georgette Holmes, sea ice analysts, LT Kyle Obrock as ice observer and myself. NIC personnel on land and aboard worked to secure access to required imagery for tactical support and to provide near-real time analysis and daily tailored sea ice support during icebreaking operations. A daily sea ice brief was initially given by AG1 Lilgreen to the *Healy*'s Commanding Officer, CAPT Fred Sommer and the Co-Chief Scientists. Once the *Healy* and *LSSL* met and exchange personnel a Canadian sea ice observer, Erin Clark, joined us and Ms. Holmes joined the ice observer aboard the *LSSL*, Barbara Molyneaux. Although Ms. Holmes only spent a week aboard the *LSSL* she was able to see firsthand the image and sea ice analysis process used by the their observer, fly in one of the Canadian helicopter ice reconnaissance missions, and attend some of the briefs to *LSSL* Captain, Marc Rothwell, and Chief Scientist, David Mosher. Ms. Clark remained on the Healy for several weeks until final separation of the two icebreakers. The presence of Ms. Clark on the *Healy* allows us to have adequate access to RADARSAT-2 imagery previously scheduled by the Canadian Ice Service (CIS) throughout this time. I also had the opportunity of flying with her on one of the ice reconnaissance missions over 65 nm ahead of the icebreakers.

The NIC ice analysts and Canadian ice observer aboard the *Healy* worked in concert to obtain, share, and analyze imagery and other products to produce analysis and forecast for the daily brief. Presentation of the sea ice information at the brief was also rotated among them each day. In order to ensure a consistent understanding and presentation of the sea ice conditions and weather data, I lead a daily pre-brief meeting with the NIC analysts, the Canadian observer, and AG1 Richard Lemkuhl, a weather forecaster sent onboard to develop concept of operations in the Arctic for the Naval Maritime Forecast Center (NMFC). Both weather and sea ice briefs were dry-run and discussed at the pre-brief.

Among other ancillary programs carried out a non-interference basis during the cruise, the NIC was able to deployed a number of buoys as part of the U.S. International Arctic Buoy Program (USIABP) development, testing, and refreshment program. Two of these were prototype thermistor chain buoys, a WOCE SVP UpTempO drifter and an AXIB seasonal buoy were deployed in open water. These buoys were designed to provide subsurface temperature information up to 50m depth, in addition to meteorological, that can be useful in characterizing the upper ocean response to increase warming and the effect on sea ice formation and melting. Unfortunately, shortly after deployment, it was found out that although the location and weather data from the buoys was being received correctly, the thermistor chains in both buoys were not reporting usable data. The problem was analyzed by the developer Clearwater and it was found that part of the problem related to the lack of electrical connectivity between the top and bottom of the thermistor chain. As a result of this malfunction, two additional thermistor buoys being sent to Canada for pickup by LSSL for deployment later this season were corrected before shipment and should provide good subsurface data. Our intention of attempting the recovery of the faulty buoys was thwarted as they both stopped transmitting their location days after deployment. Seven other standard SVP drifters were also deployed in open ocean throughout the cruise in both the Arctic Ocean or scheduled for deployment by the *Healy* crew on the Bering Sea.

In addition, two ice beacons were brought onboard the *Healy* for deployment on some of the thickest multi-year ice (MYI) floes. Unfortunately, multi-year floes suitable for deployment were not readily found as the region covered was dominated by first year ice (FYI). A request was made to the Chief Scientist and the Captain of the *LSSL* for an opportunity to search for a floe and deploy one of the beacons using the helicopter. After some thought, the initial response was understandably negative given the relative risk of an operation that was not in the LSSL science plan. After spending a few days on the LSSL and providing talk on the extreme changes of the Arctic sea ice pack and the role of the buoy program in tracking it the decision was reversed. The talk was an update from one presented early on the Healy and explained the precipitous loss of MYI up to date. Thankfully, I flew back to the Healy, pick one of the ice beacons along with LT Obrock and Ms. Clark and searched for a floe for deployment. Once more, with no MYI floes in sight a thick FYI one was finally selected and the beacon successfully deployed on it about 7 miles from the icebreakers track. The second ice beacon was packed back for return and pick up in Seattle.

The NIC personnel also carried on a program of routine observations covering nearly 24/7 sea ice characterization of the ice cover for the validation of remote sensing techniques and operational analysis. This included the collection of photographic evidence and assessments of ice thickness as the Healy navigate through ice pack. In addition to my *Healy* and *LSSL* talks, science talks were given aboard the *Healy* by Lt Obrock one on sea ice type characterization, AG1 Lilgreen on the NIC analysis, and Ms. Holmes on satellite identification of sea ice.

During this cruise, we were able to confirm the analysis by NIC, JPL, and others based on remote sensing that depicted the region covered during this cruise, as noted above, as one essentially dominated by a FYI pack. In fact, where some significant presence of old ice was observed it was essentially second year ice with only traces of older ice actually seen throughout the cruise. Unfortunately, this observation was at times at variance with the analysis made aboard the *LSSL*, which tend to show significant over estimation of the concentration of MYI in the region. The inconsistent observations were noted by both NIC analysts as well as Ms. Clark.

ACTION ITEMS

- Organize in-situ observations, remote sensing data, and NIC analyses into a database for further analysis and assessment of NIC products.
- Call a meeting of shore and onboard participants to identify lessons learned on NIC sea ice support to the *Healy*.
- Discuss ice observations with the CIS Science Team within the context of NAIS
- Track the status of the ice beacon deployed on the FYI floe.
- Investigate proposing directly to NSF for buoy deployment time aboard *Healy* in 2010

APPENDIX C: HEALY 0905 XBT/CTD LOG

08/08/09	#####	5	72 47.72461N	158 25.50879W	1030376	T-7	Y	280	Bottom Impact 2
08/08/09	#####	6	73 33.90527N	160 7.92773W	1059306	DB	Y	760	
08/08/09	#####	8	73 58.59619N	159 52.38379W	1059298	DB	Y	760	
08/09/09	7:08:35	9	74 31.53467N	156 57.10156W	286980	T-5	Y	1830	
08/09/09	7:22:18	10	74 31.4541N	156 55.79199W	46173	XSV-02	Y	1970	XSV drop, not xm
08/09/09	#####	11	75 0.73584N	157 7.07812W	1059302	DB	Y	760	
08/09/09	#####	12	74 55.95312N	157 34.16992W		DB	Y	760	
08/10/09	1:59:07	13	74 30.17822N	157 10.52246W	286982	T-5	Y	1830	
08/10/09	#####	14	74 38.43262N	157 59.43262W	1059303	DB	Y	760	
08/10/09	#####	15	75 1.99414N	157 31.60938W	286978	T-5	Y	1830	
08/11/09	0:12:56	16	74 52.97314N	158 3.00586W	1059299	DB	Y	760	
08/11/09	5:35:34	17	74 49.50732N	156 31.39746W	326856	T-5	Y	1830	
08/11/09	#####	18	74 51.4248N	156 13.6543W	326855	T-5	Y	1830	
08/11/09	#####	19	75 27.89697N	155 39.5887W	1059308	DB	Y	760	
08/12/09	0:10:45	20	76 1.08936N	154 3.46289W	1030377	T-7	Y	760	
08/12/09	5:58:48	21	76 31.49902N	152 2.93066W	326854	T-5	Y	1830	
08/12/09	#####	22	76 54.55127N	149 30.35938W	326863	T-5	Y	1830	
08/12/09	#####	23	77 14.96143N	148 16.48145W	1059300	DB	Y	760	
08/12/09	#####	24	77 16.73096N	148 16.84395W	1053441	T-7	Y	760	
08/13/09	5:59:28	25	77 36.1123N	148 21.24707W	1059304	DB	Y	760	
08/13/09	#####	26	77 55.07031N	148 18.44336W	326860	T-5	Y	1830	
08/13/09	#####	27	77 54.29639N	148 18.61621W	326857	T-5	N	800	Ice
08/13/09	#####	29	78 17.31641N	148 9.54199W	1059309	DB	Y	760	
08/14/09	0:02:44	30	78 42.63574N	147 49.35449W	326858	T-5	N	1300	Ice
08/14/09	5:56:47	31	79 7.98096N	147 18.45312W	326861	T-5	N	950	Ice
08/14/09	#####	32	79 33.08984N	146 33.03809W	1053449	T-7	N	630	Ice
08/14/09	#####	34	79 57.25293N	145 50.29004W	1059305	DB	N	-	Ice, whole profile
08/14/09	#####	35	79 57.69092N	145 49.95312W	1059301	DB	N	-	Ice, whole profile
08/15/09	0:00:32	36	80 20.76465N	145 12.2959W	1053445	T-7	N	450	Ice
08/15/09	6:14:57	37	80 44.59619N	144 17.36621W	1053444	T-7	N	150	Ice
08/15/09	6:42:15	38	80 44.55225N	144 7.2207W	1053402	T-7	Y	760	
08/15/09	#####	40	80 30.16748N	139 35.28027W	1053406	T-7	N	150	Ice
08/16/09	4:33:08	41	80 21.34668N	136 43.73145W	1059323	DB	Y	760	
08/16/09	#####	42	80 16.66748N	138 9.3916W	1053407	T-7	N	600	Ice
08/16/09	#####	43	80 6.979N	140 24.53027W	159324	DB	N	150	Ice
08/17/09	0:13:14	44	79 56.18457N	142 36.25488W	1053410	T-7	N	400	Ice
08/17/09	5:52:13	45	79 44.9248N	144 38.44531W	1059326	DB	Y	760	
08/17/09	#####	46	79 35.42725N	146 49.03809W	342605	T-5	N	1500	Ice
08/17/09	#####	47	79 48.93555N	148 28.5791W	1059328	DB	Y	760	
08/17/09	#####	48	80 0.29199N	149 58.62793W	1053443	T-7	Y	760	
08/18/09	5:42:04	49	80 14.47363N	152 0.93066W	1059327	DB	Y	760	
08/18/09	#####	50	80 28.16846N	153 48.55859W	342606	T-5	N	1100	Ice
08/18/09	#####	51	80 49.06104N	155 0.37012W	1059329	DB	Y	760	
08/19/09	4:59:03	52	80 58.38477N	154 41.21777W	1053438	T-7	Y	760	
08/19/09	#####	53	81 10.04932N	155 52.99805W	1059330	DB	Y	760	
08/19/09	#####	54	81 30.25244N	156 48.52246W	1059331	DB	Y	760	
08/19/09	#####	55	81 33.80322N	155 25.80859W	1053439	T-7	Y	760	
08/20/09	5:49:58	56	81 27.20264N	152 57.18848W	1059332	DB	Y	760	
08/20/09	#####	57	81 31.68994N	150 30.69922W	342607	T-5	N	-	Ice, whole profile
08/20/09	#####	58	81 31.74219N	150 30.19141W	342608	T-5	N	1100	Ice
08/20/09	#####	59	81 21.59521N	150 53.36035W	1059333	DB	Y	760	

08/21/09	0:06:21	60	80 58.20947N	151 31.3252W	1053440	T-7	Y	760	
08/21/09	5:31:18	61	80 57.64404N	151 49.21582W	1059366	DB	Y	760	
08/21/09	#####	62	80 55.11768N	149 26.23242W	342602	T-5	Y	1830	
08/21/09	#####	63	80 54.09717N	148 50.44531W	1059360	DB	Y	760	
08/22/09	5:39:07	64	80 51.4585N	147 17.2627W	1053442	T-7	Y	760	
08/22/09	#####	65	81 11.75342N	148 25.75195W	1059361	DB	N	430	Ice, ship speed 7
08/22/09	#####	66	80 45.13135N	147 56.27539W	1059359	DB	Y	760	
08/22/09	#####	67	80 46.27979N	147 19.68066W	1053446	T-7	Y	760	
08/23/09	5:41:09	68	80 44.98828N	145 31.68164W	1059362	DB	Y	760	
08/23/09	#####	69	80 55.94727N	143 45.84082W	342601	T-5	Y	1830	
08/23/09	18:01:33`70	70	81 19.9585N	142 58.13184W	1059358	DB	Y	760	
08/24/09	0:13:10	71	81 43.82129N	142 0.80957W	1053403	T-7	Y	760	
08/24/09	5:51:29	72	81 50.43066N	143 52.18848W	1059363	DB	Y	760	
08/24/09	#####	73	81 29.9917N	144 59.04395W	342603	T-5	Y	1830	
08/24/09	#####	74	81 37.85693N	143 58.47559W	1059367	DB	N	530	Ice
08/24/09	#####	75	81 27.76953N	142 17.97852W	1053411	T-7	N	370	Ice
08/25/09	5:36:06	76	81 27.95996N	139 47.51562W	1059364	DB	Y	760	
08/25/09	#####	77	81 30.70361N	136 54.0127W	342604	T-5	N	450	Ice
08/25/09	#####	78	81 30.7583N	136 51.37598W	326862	T-5	N	1050	Ice
08/25/09	#####	79	81 35.4043N	134 13.7627W	1059368	DB	N	-	Wire Dx? Profile I
08/25/09	#####	80	81 35.16211N	134 13.74414W	1059365	DB	N	250?	Ice, whole profile
08/25/09	#####	81	81 36.92041N	134 14.81152W	1053447	T-7	Y	760	
08/26/09	5:52:35	82	81 47.95361N	132 2.65527W	1059369	DB	N	150?	Ice, whole profile
08/26/09	5:58:38	83	81 48.09424N	132 0.84863W	1059354	DB	N	-	Wire Dx? Profile I
08/26/09	#####	84	81 59.14209N	129 27.92676W	326864	T-5	Y	1830	
08/26/09	#####	85	82 7.69629N	127 20.90332W	1059355	DB	N	130	Ice
08/27/09	1:11:54	87	82 23.98828N	126 3.13867W	46168	XSV-02	Y	2000	XSV drop, transm
08/27/09	5:35:47	88	82 35.9209N	125 50.3219W	1053448	T-7	Y	760	
08/27/09	#####	89	82 2.85059N	125 26.49316W	1059356	DB	N	360	Ice
08/27/09	#####	90	83 29.46777N	125 55.30859W	1053404	T-7	N	490	Ice
08/27/09	#####	91	83 58.00977N	126 28.52051W	1059351	DB	Y	760	
08/28/09	6:12:01	92	84 13.00098N	125 54.82617W	326863	T-5	N	570	May be good to 9
08/28/09	#####	93	84 10.74129N	121 30.62207W	1059357	DB	N	420	Ice
08/28/09	#####	94	84 4.25293N	119 27.80957W	1053408	T-7	N	680	Ice
08/29/09	5:46:47	95	83 29.53418N	117 55.48828W	1059346	DB	Y	760	
08/29/09	#####	96	83 11.42478N	118 43.18457W	326859	T-5	Y	1830	Noise?
08/29/09	#####	97	83 2.95125N	120 5.78809W	1059347	DB	Y	760	Noise?
08/29/09	#####	98	82 46.08594N	119 36.9873W	1053412	T-7	N	260	Ice
08/30/09	5:53:18	99	82 25.50781N	119 46.26172W	1059352	DB	N	250	Ice
08/30/09	#####	100	81 58.87891N	120 46.74609W	34200	T-5	N	1350	1350, unsure of c
08/31/09	5:57:59	101	81 48.53213N	125 55.75391W	1059348	DB	Y	760	
08/31/09	#####	102	81 467852N	128 41.22559W	1053413	T-7	Y	760	
08/31/09	#####	103	81 42.98535N	131 0.58887W	1059353	DB	N	580	Ice
09/01/09	0:17:28	104	81 31.70361N	133 15.30957W	342599	T-5	Y	1830	
09/01/09	5:55:21	105	81 17.15137N	135 0.31934W	1059349	DB	Y	760	
09/01/09	#####	106	80 57.25684N	136 0.17871W	1053409	T-7	Y	760	
09/01/09	#####	107	80 35.45947N	136 54.33691W	105934	DB	N	600	???
09/02/09	0:18:28	109	80 11.78662N	137 49.77734W	105356	T-7	Y	760	
09/02/09	5:37:05	110	79 51.77637N	138 32.66406W	1059338	DB	Y	760	
09/02/09	#####	111	79 29.61621N	139 45.63965W	342598	T-5	Y	1830	
09/02/09	#####	112	79 10.40283N	138 49.45117W	1059334	DB	Y	760	
09/03/09	0:15:06	113	78 48.74951N	137 37.26172W	1053566	T-7	Y	760	
09/03/09	#####	114	78 36.80225N	137 36.80078W	1059343	DB	Y	760	
09/03/09	#####	115	78 34.58691N	136 58.92285W	342615	T-5	Y	1830	

09/04/09	0:00:29	116	78 37.58643N	136 39.7207W	1059339	DB	Y	760	
09/04/09	5:44:45	117	78 35.20654N	136 54.93066W	1053567	T-7	Y	760	
09/04/09	#####	118	78 12.80322N	136 33.41602W	1059335	DB	N	-	Whole profile bac
09/04/09	#####	119	78 12.64258N	136 33.52637W	1059344	DB	N	550	Ice?
09/04/09	#####	120	77 48.76514N	136 50.03516W	342616	T-5	N	300	Ice
09/05/09	0:03:47	121	77 28.14551N	137 41.00781W	1059340	DB	N	600	Ice
09/05/09	5:34:43	122	77 13.84424N	137 41.2959W	1053559	T-7	Y	760	
09/05/09	#####	123	76 54.21387N	136 12.02344W	1059336	DB	Y	760	
09/05/09	#####	124	76 47.84033N	135 21.40137W	1059345	DB	Y	760	
09/06/09	6:39:34	125	76 50.99658N	135 13.97852W	342612	T-5	Y	1830	
09/06/09	#####	126	76 51.61133N	136 43.16797W	1059341	DB	Y	760	
09/06/09	#####	127	76 51.51025N	138 29.7793W	1053568	T-7	Y	760	
09/06/09	#####	128	77 9.3418N	141 5.40332W	46165	XSV-02	N	800	Unknown cause
09/07/09	5:54:39	129	77 40.20703N	144 7.54883W	1059337	DB	Y	760	
09/07/09	#####	130	78 12.26318N	148 12.33203W	342611	T-5	Y	1830	
09/07/09	#####	131	78 50.22559N	153 8.06445W	1059398	DB	Y	760	
09/08/09	5:42:37	132	79 5.21338N	155 10.10352W	46116	XSV-02	N	800	High winds/Wire
09/08/09	5:50:00	133	79 4.9834N	155 10.22363W	1053563	T-7	Y	760	
09/08/09	#####	134	78 28.54297N	156 3.94141W	1059394	DB	Y	760	
09/09/09	5:36:51	135	79 6.46826N	157 32.03809W	342610	T-5	Y	1830	
09/09/09	#####	136	78 45.3125N	158 21.79492W	1059395	DB	Y	760	
09/09/09	#####	137	79 6.58789N	155 59.93945W	1053562	T-7	Y	760	
09/10/09	5:44:49	138	79 2.70166N	155 34.79297W	1059402	DB	Y	760	
09/10/09	#####	139	78 33.54541N	157 45.74805W	342609	T-5	Y	1830	Corrupt >1000m
09/10/09	#####	140	78 15.59814N	158 18.91504W	1059403	DB	N	-	Whole profile bac
09/10/09	#####	141	78 15.34131N	158 19.69922W	1059396	DB	Y	760	
09/11/09	5:38:18	142	78 52.11035N	158 51.12598W	1053564	T-7	Y	760	
09/11/09	#####	143	79 12.03271N	159 36.2998W	1059400	DB	N	200	Wake?
09/11/09	#####	144	79 11.42041N	159 37.69629W	1059404	DB	N	-	Whole profile bac
09/11/09	#####	145	78 39.97852N	159 41.66992W	342620	T-5	Y	1830	
09/12/09	0:00:02	146	78 3.646N	161 4.06934W	1059399	DB	N	700	Unknown cause
09/12/09	#####	147	77 16.49463N	162 2.68359W	46167	XSV-02	Y	2000	
09/12/09	#####	148	76 55.79053N	163 46.12793W	1053560	T-7	Y	760	Bottom impact 4
09/12/09	#####	149	76 54.94824N	164 40.99023W	1059405	DB	Y	760	Bottom impact 4
09/13/09	5:59:33	150	76 49.98877N	164 14.125W	1053561	T-7	Y	545	Bottm impact 45
09/13/09	#####	151	75 40.74609N	162 44.44629W	1059401	DB	Y	760	
09/13/09	#####	152	74 18.83643N	160 52.93848W	1059397	DB	N	-	Whole profile bac
09/13/09	#####	153	74 17.92627N	160 51.78906W	1059370	DB	Y	760	
09/13/09	#####	154	73 37.29736N	159 58.10938W	1059374	DB	Y	760	
09/14/09	3:26:30	155	72 44.83936N	156 59.87598W	46174	XSV-02	Y	1400	Bottom impact 1
09/14/09	5:26:22	156	72 26.89062N	155 52.85742W	1053565	T-7	Y	760	
09/14/09	#####	157	72 47.69824N	158 18.92188W	1059378	DB	Y	450	Bottom impact 4
09/14/09	5:44:02	158	71 59.73682N	153 5.61133W	34614	T-5	Y	1830	
09/15/09	#####	159	73 5.79346N	155 14.24121W	1059375	DB	Y	760	
09/15/09	#####	160	72 57.45605N	155 4.8418W	1059379	DB	Y	760	
09/15/09	#####	161	73 19.84375N	156 47.6582W	1059371	DB	N	-	Whole profile bac
09/16/09	0:03:51	162	73 20.6875N	156 50.55078W		T-7	Y	760	No *.rdf file
08/08/09	#####	CTD120	72 48.03N	158 25.77W		CTD	Y	310	Xmit full 310 pro
08/09/09	#####	CTD122	74 29.81N	157 08.05W		CTD	Y	3800	Xmit 1000m prof
08/16/09	2:31:05	CTD123	80 20.86N	136 45.52W		CTD	Y	1330	Xmit 1314m prfil
08/02/09	#####	CTD124	80 52.51N	147 15.31W		CTD	Y	3712	Xmit 1050m prof
08/29/09	0:08:01	CTD125	83 47.77N	117 30.37W		CTD	Y	1022	Xmit 1009m prof
08/30/09	#####	CTD126	81 52.23N	122 31.05W		CTD	Y	2555	Xmit 1100m prof
09/03/09	5:21:31	CTD127	78 35.12N	136 53.31W		CTD	Y	3651	Xmit 1050m prof

APPENDIX D: USN METOC REPORT

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Naval Meteorology and Oceanography Command
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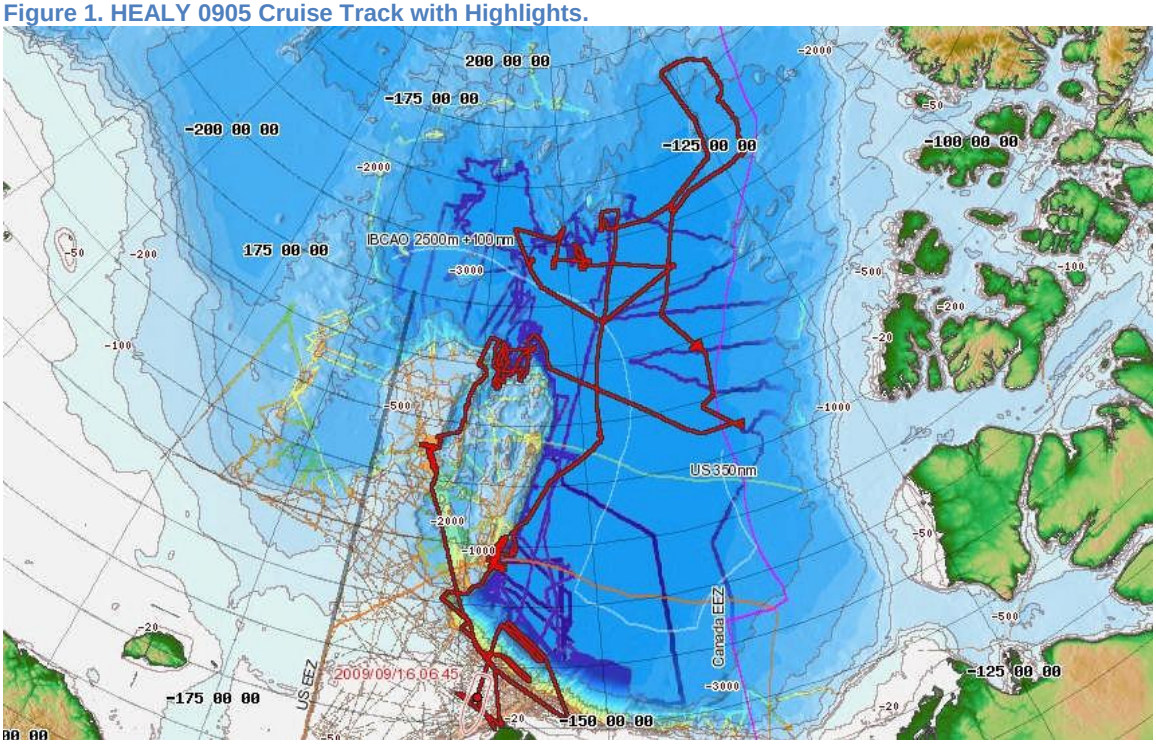
METOC MISSION SUMMARY FOR HEALY 0905

Executive Summary

From August 7 through September 16, 2009 I deployed aboard USCGC HEALY (WAGB-20) during the 5th leg of her Arctic West '09 deployment (HLY 0905). I was accompanied by AG1(AW/SW) Richard Lehmkuhl, from Naval Maritime Forecast Center, Norfolk (NMFC-N). We embarked as guests of the science party led by Chief Scientist, Dr. Layer Mayer of the University of New Hampshire Center for Coastal and Ocean Mapping / Joint Hydrographic Center (UNH-CCOM/JHC).

The HEALY 0905 leg was a Department of State (DoS) funded mission to continue the joint US-Canadian exploration of the Arctic Extended Continental Shelf. The Canadian Icebreaker CCGS LOUIS S. ST. LAURENT (LSSL) hosted the lead (supported) science team and towed seismic gear with HEALY supporting the mission by breaking a path ahead of LSSL and mapping the seafloor with her multibeam sonar. HEALY's movements were at the discretion of LSSL. The primary science objective of the cruise was to collect morphologic data in support of determining the extended continental shelf of the United States and Canada. Multibeam and chirp sub-bottom data were critical datasets. HEALY would also dredge rock samples in support of ECS studies. An overview of the track and major events is provided in Figure 1.

Figure 1. HEALY 0905 Cruise Track with Highlights.



Per the standing MOU between USCG, NOAA and the Navy, the Naval Ice Center (NIC) also embarked the personnel in support of its traditional missions of ice imagery analysis and the International Arctic Buoy Program (IABP): LT Kyle Obrock, AG1(AW) Steve Lilgreen, and Ms. Georgette Holmes. NIC Chief Scientist Pablo Clemente-Colon (NOAA) was also aboard. Details of the NIC mission will only be summarized in this report.

Goals of the METOC (i.e. non-NIC) mission aboard HEALY were to:

- Deploy and recover of one SeaGlider unmanned undersea vehicle (UUV). The SeaGlider would be controlled from the Glider Operations Center (GOC).

- Perform, encode, and transmit, XBT and CTD observations.

- Perform, encode, and transmit RAWINDSONDE upper air meteorological observations.

- Acquire and transmit ocean and atmospheric surface observations in an operationally relevant timeline, to ensure receipt in support of model run time at the Naval Oceanographic Office (NAVO) and Fleet Numerical Meteorological and Oceanographic Center (FNMOC).

 Acquire and archive any and all available oceanographic and meteorology records from HEALY considered ancillary to the mapping operation. Data would be turned over to NAVO and FNMOC to support model validation efforts as tasked by CNMOC. *Mapping data remained the sole property of UNH-CCOM until submission to NGDC and was not requested. This included multi-beam mapping sonar and sub-bottom profile data.*

 Develop forecaster first-hand experience and knowledge in support of Arctic operations.

 Develop first-hand experience of ship operations within the Arctic, to include deck, navigation and engineering evolutions.

 Develop and foster relationships with embarked science teams, USCG and NOAA personnel with the aim of determining opportunities for future collaboration.

All of the goals were successfully met as follows:

 SeaGlider 131 was deployed in the Chukchi Sea on the morning of 8 August and successfully recovered on 14 September.

 152 XBT drops were performed and transmitted to NAVO, 104 without apparent quality issues. XBT data included XBTs supplied by the Navy and those supplied and expended through the UNH-CCOM mapping protocol.

 7 full-depth CTDs (up to 3.5km depth) were performed and transmitted to NAVO.

 An automated script was developed by the onboard science support [Lamont-Doherty Earth Observatory (LDEO), Columbia University] to immediately transmit via email all XBTs for the current and all future missions.

 67 valid RAWINDSONDE measurements were taken and transmitted to FNMOC.

 Raw data from the ships automated sensor networks were archived and transported back for use at NAVO, FNMOC and NRL.

 AG1(AW/SW) Lehmkuhl provided MET services to the ship and embarked science party. Observations and feedback for the Forecaster’s Guide and NMFC-N watch floor was generated. Cross-training occurred between AG1 Lehmkuhl and the ship’s Marine Science Technicians (MSTs).

 Extensive interviews were conducted with key personnel from HEALYs wardroom, including CO, XO, OPSO/NAV, ENG, MPA, and Marine Science Officer. The interviews revealed, and in many cases demonstrated, the difficulties and challenges of surface ship operations in the Arctic. Additionally, I stood duties as a deck watch officer, qualifying as Officer of the Deck (Icebreaking).

 Interviews were also conducted with other science party members to determine future opportunities for collaboration. These interactions had the benefits of:

- Providing a forum to communicate and advertise the Navy Oceanography mission to two (2) schoolteachers embarked via the NOAA Teacher-at-Sea and NSF ARMADA programs.

- Received training in the UN Convention Law of the Sea.

- Received training from Canadian Ice Service aboard HEALY and LOUS S.ST. LAURENT.

- Received hydrographic and mapping training.

Both the HEALY's crew and the Chief Scientist responded enthusiastically to the METOC mission and openly stated the desire to conduct future operations together. The METOC mission on HLY 0905 opened access to a valuable platform and partnerships, which could, with relatively little difficulty, be developed into long-standing operating relationships supporting CNO strategy and execution guidance.

Priority toward conducting future operations aboard. HEALY is critical to the NOe if the Navy truly anticipates extending surface ship operations into the Arctic. She is the only oceanographic survey ship in the US inventory capable of access to the marginal ice zone and ice covered waters. Additionally, her military crew and PATHFINDER (TAGS- 60) class equivalent capabilities lend HEALY to execution of the operational oceanographic mission.

Marine Mammal Observer Observations US-Canada Extended Continental Shelf Survey

August 7 – September 16
2009

MRAG Americas, Inc.

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MARINE MAMMAL OBSERVER
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NOAA
HEALY CRUISE 0905

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Introduction

The United States and Canada embarked on a joint venture aboard two ships from August 8th through-September 16th of 2009. The USCGC Healy and the CCGS Louis S. St. Laurent (Louis) collected seismic and bathymetric data on the Extended Continental Shelf that lies offshore both countries. The collection of data focused on the areas beyond the 200 nautical mile Exclusive Economic Zone where utilizing two ice breaking vessels would allow for a successful cruise. The Healy was the lead vessel breaking ice while conducting multibeam and subprofile surveys. The Louis followed collecting seismic reflection and refraction data. During periods of light ice conditions the vessels were able to separate and double their data collection.

Sounds produced during data collection, particularly by the seismic equipment, had the potential to disrupt the behavior of marine mammals within the area. Certain measures were taken including course alteration, allowance of an approximately one kilometer "safety zone" where marine mammals were observed, and seismic equipment shutdown where marine mammals were observed in proximity. Onboard the Healy were two marine mammal observers (MMOs) Justin Pudenz (NOAA), and George Neakok, an Alaska Native Community observer (ANCO) while the Louis housed three MMOs representing the Canadian Hunters and Trappers Community. The MMOs from both vessels were able to communicate in "real time" using VHF radio channel 6 to inform the other vessel when a marine mammal was detected.

Hereinafter this report will document how operations were conducted by the MMOs including specific sightings, methods, format for reporting conditions, and vessel activities during and pertaining to marine mammal observations. A logbook and multiple data forms were completed daily to ensure the accuracy and integrity of the collected data for future reference, interpretation and analysis. Copies of complete data forms from MMOs aboard the Healy are included Appendex 1, 2 and 4. Also, a spreadsheet obtained from the chief scientist aboard the Healy portrays the dates and times of seismic operations onboard the Louis in Appendix 5.

Description of Daily Activities

The Healy MMOs observed from the bridge of the vessel and were allowed unobstructed access to all areas and instruments required for data collection. All operations aboard the Healy were made during daylight hours. Systematic scans or sweeps with binoculars and naked eye were directed forward while the vessel was underway and in all directions during stationary periods. During transit to and from data collection sites, MMOs monitored for marine mammals up to 8 hours within a 24 hour period. Healy MMOs could monitor up to 12 hours a day for a maximum of 4 consecutive hours in a row to avoid fatigue. When both MMOs aboard the Healy were monitoring at the same time, each observed from opposite sides of the bridge. Monitoring aboard the Louis was underway 24 hours a day, each MMO observing 8 hour shifts. Healy observers were able to be contacted by phone or page during off-watch periods. Bridge personnel were willing to monitor for marine mammals during these periods and were supplied with forms to accompany any sightings while MMOs were off-watch.

Responsibilities of the MMO

- Performing monitoring procedures described in the MMO handbook;
- Abiding by the communication plan to be established between the 2 ships at the onset of the cruise;
- Adhering to a logbook of daily operations (activities and results); ensuring data are recorded correctly for data entry and data sheets are copied (and stored separately) for backup purposes;
- Acting as a source of marine mammal information;
- Providing observation schedules and nighttime standby schedules to the *Healy* Chief Scientist
- Abiding by the safety procedures of the vessel and acting in a responsible manner at all times.

Data Recording

Effort Report Form

The data was collected and recorded on two primary forms developed by NMFS and MRAG. The NOAA MMO completed an Effort Report form hourly during daily observations which were preformed while seismic operations were and were not being conducted. The MMO recorded the following information.

- Vessel name;
- Observer names and affiliations;
- Date;
- Time and latitude/longitude when daily visual survey began and ended;
- Environmental conditions during visual survey were recorded hourly; this provides a measure of ability to accurately estimate take from observer data;
    - Wind speed and direction (average sustained);
    - Air and water temperature
    - Sea state (Beaufort sea/wind scale);
    - Swell (height in feet);
    - Weather conditions (e.g. rain, fog, haze, clear skies, cloud cover, ice conditions, etc.);
    - Ice Cover (% of water surface);
    - Overall visibility (based on distance to horizon in kilometers).

Tidal Stage and closest tide were not pertinent in the arctic conditions and were not recorded.

Sighting Form

A Sighting form was completed when a marine mammal was observed and the following information was recorded:

- Date, time, location, vessel activity, seismic state and heading.
- Species, group size and individual characteristics.
- Behavior during initial sighting and post initial sighting or response to vessel encounter.
- Mammal bearing and distance from vessel and behavior pace (e.g. positive, sedate, or moderate).
- Sea state, ice cover, overall visibility (km), sun glare, wind speed (kn) and direction, air (F) and water temperatures (C), depths, and any other environmental parameters notable for individual sightings.

The NOAA MMO on Healy was not able to accurately judge the apparent reaction of the mammals to seismic vessel and closest point of approach due to the distance between the Healy and Louis.

If the same mammal or group of mammals was sighted multiple times, they were assigned the same number in the sight id column on the sighting form. A comment noting when a mammal was seen multiple times was also included in the comment section of the form. The sighting codes were ordered sequentially for the entire cruise.

Information necessary to complete the various data forms was available from instruments on the bridge and personal observation. Information regarding seismic, multibeam, and subprofile specifics were provided by the science party.

USF&W Sighting Forms

There were also two unique forms to be completed upon the sighting of polar bears or walruses. MRAG delivered a copy of the Polar Bear/Walrus Sighting forms to the USF&W at the end of the cruise, since these species are managed by them.

A form was available for off-watch sightings or sightings made by bridge personnel if a MMO could not be located. If sightings occurred when the MMOs were off duty, the MMO was paged to the bridge and recorded the sighting. If the mammals moved on prior to the MMO's arrival an Appendix A: Data Sheet for Bridge Personnel when Marine Mammal Sighted form was completed. If the MMO recorded the mammal from an Appendix A form on the sighting form, the Sight ID number was recorded in the comment section of the Appendix A form.

Logbook

The NOAA MMO completed a daily logbook, which is included in Appendix 3 at the end of this report. The logbook was recorded in two sections; Daily Notes and Marine Mammal Sighting Log. The MMO recorded the following information in each section:

- Daily activities including hours on watch, coordination efforts with crew and other MMOs, general sighting information and unusual sightings or events were recorded in the Daily Notes.
- Changes in the vessel operations including seismic information, icebreaking, or any other outstanding or pertinent items were recorded in the Daily Notes.
- Any reasons for compromised or obstructed visibility (e.g. swell height, sea state, wind speed, glare, weather conditions, equipment malfunction, etc.) were recorded in the Daily Notes.
- A detailed summary of all MMO observations including mammal distance from and direction relative to vessel, sighting cues, behavior and any actions implemented in response (e.g. delays, power down, shut down, course alteration, etc.) were recorded in the Marine Mammal sighting log. Ancillary information, such as seal breathing holes and bear tracks were also included in this section.

Data Codes

OBSERVER
Two letter initials of on-duty obs.

OBSERVER LOCATION

BR	Bridge
FB	Flying Bridge
ST	Stern

DATE/TIME
Two number values (ie. 01, not 1)

WATCH START–END

WS	Watch Start
WE	Watch End

SEISMIC ACTIVITY

LS	Line Shooting
SH	Shooting Betw/Off.Lines
ST	Seismic Testing
SZ	Safety Zone Shut-Down
SD	Shut-Down
PZ	Safety Zone Power-down
PD	Power-down
OT	Oth (comment&describe)

 # GUNS
Enter Number of Operating Airguns,

88	Varying (e.g., ramp-up)
99	Unknown

ARRAY VOLUME
Enter operating volume, or

99	Unknown

ARRAY DEPTH
Depth at which guns are being towed

POSITION
Two digit Degrees
Two digit, two decimal Minutes

WATER DEPTH
In meters

SEA STATE
See Beaufort Scale sheet

VISIBILITY (# KM)
0 – 10 km
Or > < 3.5 if variable

LIGHT OR DARK

L	Light (day)
D	Darkness

GLARE AMOUNT

NO	None
LI	Little
MO	Moderate
SE	Severe

MARINE MAMMAL SPECIES

Baleen Whales

BHW	Bowhead Whale
UMW	Unidentifed Mysticete

Large Toothed Whales

BW	Beluga Whale
KW	Killer Whale
NW	Narwhal

Dolphins

UD	Unidentified Dolphin

Porpoises

UP	Unidentified Porpoise

Pinnipeds

BS	Bearded Seal
HS	Hooded Seal
RS	Ringed Seal
HPS	Harp Seal
US	Unidentified Seal
UP	Unidentified Pinniped
PWA	Pacific Walrus

Bear

PB	Polar Bear

MOVEMENT

PE	Across Bow
ST	Swim Toward
SA	Swim Away
FL	Flee
SP	Swim Parallel
MI	Mill
NO	No movement
DE	Dead
UN	Unknown

INDIVIDUAL BEHAVIOR

MA	Mating
SI	Sink
FD	Front Dive
TH	Thrash Dive
DI	Dive
LO	Look
LG	Logging
SW	Swim
BR	Breach
LT	Lobtail
SH	Spyhop
FS	Flipper Slap
FE	Feeding
FL	Fluking
BL	Blow
BO	Bow Riding
PO	Porpoising
RA	Rafting
WR	Wake Riding
AG	Approaching Guns
RE	Resting
OT	Other (describe)
NO	None (sign seen only)
UN	Unknown

GROUP BEHAVIOR (BEHAVIORAL STATES)

TR	Travel
SA	Surface Active
ST	Surface Active-Travel
MI	Milling
FG	Feeding
RE	Resting
OT	Other (describe)
UN	Unknown

BEHAVIOR PACE

PO	Positive
SE	Sedate
MO	Moderate

 # RETICLES or ESTIMATE

(of Initial Distance, etc.; Indicate Big eyes or Fujinons in comments)

0 to 16	Number of reticles
E	Estimate, by eye

CLOSEST POINT OF APPROACH (CPA)
Nearest distance of individ/group (m)

SIGHTING CUE

BO	Body
HE	Head
SP	Splash
FL	Flukes
DO	Dorsal Fin
BL	Blow
BI	Birds

IDENTIFICATION RELIABILITY

MA	Maybe
PR	Probably
POI	Positive

Summary Sightings

The following is an overview of individual sightings made by Justin Pudenz (NOAA) onboard the Healy. During the Healy cruise 0806 in 2008, the same MMOs observed 3 unidentified seals, 4 ringed seals, and six polar bears over a 25 day period. Visibility was much better and ice conditions were much heavier than experienced for the early part of Healy cruise 0905 in 2009. Although sighting conditions were less than ideal due to heavy fog conditions for much of the cruise, the Healy MMOs observed 44 ringed seals, 16 bearded seals, 13 unidentified seals, 7 polar bears, and 3 bowhead whales.

Most seals exhibited similar behaviors and movements when encountered. Only a brief description is noted unless unusual or abnormal behavior occurred during the observation. Each polar bear encounter was different from the onset of the interaction, thus polar bear sightings are explained in more depth in order to capture all details during the observation. Sightings of tracks and other types of marine mammal signs, as well as anything unique were recorded in the Marine Mammal Sighting Log. For a more detailed description of individual sightings, refer to the completed forms and logbook.

August 12, 2009

A ringed seal was observed at 1019 (77 11.4° N, 148 16.7° W), swimming in open water at ~200m. The vessel was stationary and no seismic operations were underway.

A ringed seal was observed at 1705 (77 14.8° N, 148 16.9° W), ~200m from vessel, the seal surfaced twice then swam away from vessel until it dove. Seismic operations were ongoing during this observation.

Bear tracks were observed at 2200 (77 31.2° N, 148 20.0° W), bearing 60 degrees from the vessel's course.

August 13, 2009

A ringed seal was observed at 0006 (77 36.5° N, 148 21.2° W), it surfaced on port side of the Healy at ~300m and quickly dove. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2218 (79 01.1° N, 147 28.8° W), on the ice in front of the vessel ~300m. The seal dove when the vessel approached and dove. Seismic operations were ongoing during this observation, the vessel slowed when the seal was spotted

A seal carcass was observed on the ice at 1300 (78 21.4° N, 148 06.6° W), surrounded by bear tracks and blood. Further investigation showed that the kill was made 50m off the port side of the vessels course and was dragged to 75m starboard of the vessels course. The bear tracks left the scene to the starboard side at 90 degrees from the vessels course.

August 14, 2009

An unidentified seal was observed at 1444 (80 08.3° N, 145 36.2° W at ~1500m from the Healy. The seal was on the ice and did not move as the vessel passed. Seismic operations were ongoing during this observation.

An unidentified seal was observed at 2125 (80 34.3° N, 144 45.3° W at ~1500m from the Healy. The seal was on the ice and moved it head as the vessel passed. Seismic operations were ongoing during this observation.

August 15, 2009

A ringed seal was observed at 1759 (80 23.2° N, 137 22.6° W), surfacing in a small opening of water several times at ~300m before diving for good. The vessel was stationary and no seismic operations were underway.

August 16, 2009

A bearded seal was observed at 1629 (79 59.4° N, 141 58.6° W), on the ice at ~800m and 300 degrees of the port side. The seal was aware of the vessel and moved it head back and forth for ~1 minute before diving into an ice hole. Seismic operations were ongoing during this observation.

August 17, 2009

Two bearded seals were observed at 2023 and 2025 (80 07.7° N, 151 00.8° W), on the ice at ~500m and 50 degrees of the starboard side and ~1500m and 350 degrees to the port side respectively. The seal to the starboard was aware of the vessel and moved it head back and forth continuously before diving into the water. The seal to the port side did not move until the vessel approached within 500m at which time it dove into the water. Seismic operations were ongoing during this observation.

An unidentified seal was observed at 2103 (80 08.6° N, 151 09.3° W) at ~2500m from the Healy. The seal was on the ice and moved it head from side to side. This was probably a bearded seal, but due to the distance a positive id was not possible. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2202 (80 10.9° N, 151 29.0° W), on the ice at ~1200m and 330 degrees to the port side. The seal was aware of the vessel and moved it head back and forth continuously before diving into the water. Seismic operations were ongoing during this observation.

August 18, 2009

A bearded seal was observed at 0027 (80 15.6° N, 152 12.4° W), on the ice at ~2000m and 10 degrees to the starboard side. The seal moved moderately before diving into the water when the vessel approached within ~1000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 0035 (80 16.0° N, 152 18.0° W), on the ice at ~800m and 350 degrees to the port side. The seal moved slightly before diving into a ice hole. Seismic operations were ongoing during this observation.

A bearded seal was observed at 0045 (80 16.3° N, 152 19.3° W), on the ice at ~2000m and 300 degrees to the port side. The seal moved slightly before diving into an ice hole when the vessel approached within ~1000m. Seismic operations were ongoing during this observation.

A bearded seal was observed at 0112 (80 16.5° N, 152 21.0° W), on the ice at ~1500m and 300 degrees to the port side. The seal moved slightly but did not dive. Seismic operations were ongoing during this observation.

A bearded seal was observed at 0131 (80 17.3° N, 152 27.6° W), on the ice at ~2500m and 10 degrees to the starboard side. The seal moved from side top side before diving into the water when the vessel approached within ~1000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1343 (80 53.4° N, 155 10.9° W), surfaced ~100m off the starboard bow then turned forward and dove. Seismic operations were ongoing during this observation.

August 19, 2009

An unidentified seal was observed at 2123 (81 30.0° N, 153 57.2° W) at ~2000m and 45 degrees off starboard side of the Healy. The seal was on the ice and did not move or dive as the vessel passed within 1000m. Seismic operations were ongoing during this observation.

A bearded seal was observed at 2142 (81 29.9° N, 153 55.2° W), on the ice at ~1500m and 45 degrees to the starboard side. The seal did not move or dive as the vessel passed within 1000m. Seismic operations were ongoing during this observation.

An unidentified seal was observed at 2147 (81 29.6° N, 153 49.8° W) at ~1500m and 270 degrees off port side of the Healy. The seal was on the ice and moved from side to side but did not dive as the vessel passed within 1200m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2159 (81 29.3° N, 153 43.9° W), on the ice at ~500m and 45 degrees to the starboard side. The seal dove into an ice hole when the vessel approached within ~400m. Seismic operations were ongoing during this observation.

A polar bear sow and cub was observed at 2210 (81 28.8° N, 153 34.1° W), on the ice walking parallel to the vessels course at 2000m and 270 degrees of the port side. The bears paralleled the vessel for about 5 minutes before increase pace towards an unidentified seal basking on the ice. The seal was sighted at 2231 (81 28.7° N, 153 29.7° W), on the ice moving side to side as the bears approached The seal was most likely a bearded seal, but a positive id was not possible. The bears came within 100m of the seal before it retreated into an ice hole. The bears remained near the ice hole until out of view. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2256 (81 28.3° N, 153 18.9° W), swimming in a small opening of water at ~400m and 20 degrees of the starboard side before diving. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2310 (81 28.1° N, 153 12.9° W), on the ice at ~2000m and 10 degrees to the starboard side. The seal moved in a circle than dove into an ice hole when the vessel approached within ~800m. Seismic operations were ongoing during this observation.

A bearded seal was observed at 2311 (81 28.1° N, 153 12.9° W), on the ice at ~2500m and 340 degrees to the port side of the vessel. The seal barely moved before diving into an ice hole as the vessel passed within 1000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2315 (81 27.7° N, 153 06.0° W), on the ice at ~2500m and 270 degrees to the port side. The seal dove into an ice hole when the vessel approached within ~1000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2326 (81 27.6° N, 153 03.9° W), on the ice at ~1500m and 340 degrees to the port side. The seal dove into an ice hole when the vessel approached within ~800m. Seismic operations were ongoing during this observation.

A bearded seal was observed at 2330 (81 27.5° N, 153 03.9° W), on the ice at ~2500m and directly ahead of the vessel. The seal barely moved before diving into an ice hole as the vessel closed within 800m. Seismic operations were ongoing during this observation.

August 20, 2009

A ringed seal was observed at 1223 (81 20.5° N, 150 55.2° W), on the ice at ~2500m and 340 degrees to the port side. The seal moved in a circle several times but did not dive as the vessel approached within ~1000m. Seismic operations were ongoing during this observation.

Bear tracks were observed at 1235 (81 19.9° N, 150 56.9° W), bearing 350 degrees from the vessel's course.

A ringed seal was observed at 1311 (81 17.4° N, 151 00.5° W), on the ice at ~1000m and 270 degrees to the port side. The seal moved it head up and down as the vessel passed by. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1536 (81 08.4° N, 151 15.9° W), on the ice at ~1000m and 240 degrees to the port side. The seal remained motionless as the vessel passed by. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1606 (81 06.7° N, 151 19.6° W), on the ice at ~2500m and 340 degrees to the port side. The seal was moving nervously and dove into an ice hole when the vessel approached within ~2000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1611 (81 05.9° N, 151 20.3° W), on the ice at ~2600m and 320 degrees to the port side. The seal dove into an ice hole when the vessel approached within ~1000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1616 (81 05.6° N, 151 21.2° W), on the ice at ~1500m and 10 degrees to the starboard side. The seal moved frequently but did no t dive as the vessel approached within ~800m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 16236 (81 05.1° N, 151 22.4° W), on the ice at ~1500m and 350 degrees to the port side. The seal moved very little before dove into an ice hole when the vessel approached within ~1000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2258 (80 55.6° N, 151 53.5° W), on the ice at ~500m and 45 degrees to the starboard side. The seal moved around a lot, but did not dive as the vessel passed by. Seismic operations were ongoing during this observation.

August 21, 2009

A polar bear sub adult was observed at 1000 (80 55.1° N, 148 59.2° W), on the ice walking along the trackline between the Healy and Louis. The seismic equipment was not deployed and the vessels were steaming in a circle to improve the trackline. The bear was spotted at 1000m behind the vessel and came within 600m of both vessels. The bear fled for about 200m when nearing the Louis, before walking again.

A ringed seal was observed at 1640 (80 52.4° N, 147 15.6° W), on the ice at ~150m and 90 degrees to the starboard side. The seal did not move as both vessels sat nearby. Seismic operations were not ongoing during this observation.

A bearded seal was observed at 1654 (80 52.4° N, 147 15.6° W), on the ice at ~800m and 10 off the starboard side of the vessel. The seal moved its head before diving into an ice hole. Seismic operations were not ongoing during this observation.

An unidentified seal was observed at 2237 (80 51.3° N, 147 01.3° W) at ~2000m and 30 degrees off starboard side of the Healy. The seal was on the ice and did not move as the vessel passed within 1800m. Seismic operations were not ongoing during this observation.

August 23, 2009

A polar bear adult male was observed at 1115 (81 17.8° N, 143 02.6° W), on the ice at 2000m walking towards the vessel at 350 degrees of the port side of the vessel. The bear closed within 600m, then began to walk parallel to the vessel until it came to an open area of water. The bear moved closer to Louis and then milled around until out of view. Seismic operations were discontinued while the bear was nearby.

A ringed seal was observed at 1617 (81 36.4° N, 142 20.9° W), on the ice at ~2500m and 45 degrees to the starboard side. The seal moved its head side to side then up and down as the vessel came within 2000m. Seismic operations were ongoing during this observation.

A bearded seal was observed at 1803 (81 43.0° N, 142 07.1° W), on the ice at ~2500m and 350 off the port side of the vessel. The seal flopped around and turned 180 degrees but did not dive as the vessel passed within 1500m. Seismic operations were ongoing during this observation.

An unidentified seal was observed at 2045 (81 48.7° N, 142 30.2° W) at ~2500m and 60 degrees off starboard side of the Healy. The seal was on the ice and did not move until it dove into an ice hole as vessel passed within 1800m. Seismic operations were ongoing during this observation.

August 24, 2009

Bear tracks were observed at 1718 (81 27.6° N, 142.34.1° W), bearing 250 degrees from the vessel's course.

A ringed seal was observed at 1605 (81 27.4° N, 143 05.8° W), on the ice at ~2500m and 350 degrees to the port side. The seal did not move as the vessel passed by at 1500m. Seismic operations were ongoing during this observation.

August 29, 2009

Bear tracks which appeared to be a sow with cub were observed at 1536 (82 56.8° N, 119 38.8° W), bearing 250 degrees from the vessel's course.

An unidentified seal was observed at 2239 (82 30.5° N, 119 30.4° W) at ~1000m and 270 degrees off port side of the Healy. The seal was swimming and popped head up twice, exposing part of its body the second time. Seismic operations were not ongoing during this observation.

September 1, 2009

A ringed seal was observed at 0849 (80 46.6° N, 136 27.1° W), on the ice at ~200m and 10 degrees to the starboard side of vessel. The seal dove into a small patch of open water as the vessel passed by. Seismic operations were ongoing during this observation.

A ringed seal was observed at 0853 (80 46.4° N, 136 27.5° W), on the ice at ~1500m and 350 degrees to the port side. The seal dove into a small patch of open water as the vessel passed by at 1000m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 0912 (80 39.8° N, 136 41.0° W), on the ice at ~500m and 80 degrees to the starboard side. The seal was moving when first sighted and dove into the water when the vessel was at 450m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1037 (80 39.8° N, 136 41.0° W), on the ice at ~2000m and 95 degrees to the starboard side. The seal did not move as the vessel passed by at 2000m. Seismic operations were ongoing during this observation.

A bearded seal was observed at 1048 (80 39.1° N, 136 42.9 W), on the ice at ~1300m and 270 degrees off the port side of the vessel. The seal moved its head slightly, and then inched forward into the water as the vessel passed within 900m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1558 (80 20.1° N, 137 31.2° W), on the ice at ~1500m and 270 degrees to the port side. The seal did not move as the vessel passed by at 1500m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1626 (80 18.5° N, 137 35.1° W), on the ice at ~1500m and 340 degrees to the port side. The seal moved its head side to side and dove as the vessel passed by at 1200m. Seismic operations were ongoing during this observation.

Bear tracks which appeared to be a sow with cub were observed at 1647 (80 17.2° N, 137 37.9° W), bearing 200 degrees from the vessel's course.

A ringed seal was observed at 1705 (80 15.6° N, 137 41.7° W), on the ice at ~800m and 45 degrees to the starboard side of the Healy. The seal moved its head side to side and up and down but did not dive as the vessel passed by at 400m. Seismic operations were ongoing during this observation.

Bear tracks which appeared to be a sow with cub were observed at 1723 (80 15.1° N, 137 42.7° W), bearing 45 degrees from the vessel's course.

A ringed seal was observed at 1726 (80 14.8° N, 137 43.2° W), on the ice at ~900m and 70 degrees to the starboard side of the Healy. The seal moved its head side to side but did not dive as the vessel passed by at 600m. Seismic operations were ongoing during this observation.

An unidentified seal was observed at 1750 (80 13.3° N, 137 46.6° W) at ~2000m and 300 degrees off port side of the Healy. The seal dove into its hole as the Healy passed within 1000m. Seismic operations were ongoing during this observation.

An unidentified seal was observed at 1759 (80 12.6° N, 137 48.0° W) at ~1000m and 45 degrees off starboard side of the Healy. The seal dove into an ice hole as the Healy passed within 900m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 2014 (80 04.9° N, 138 04.7° W), on the ice at ~1800m and 350 degrees to the port side of the Healy. The seal moved its head side to side and dove into an ice hole as the vessel passed by at 400m. Seismic operations were ongoing during this observation.

September 2, 2009

A polar bear adult male was observed at 0500 (79 33.0° N, 139 33.7° W), on the ice at 1600m at 160 degrees of the stern of the vessel. The bear was ~500 to 600m off the bow of the Louis. The bear seemed curious and walked along with vessels for about 30 minutes closing within 1500m of the Healy. Seismic operations were discontinued while the bear was nearby.

A ringed seal was observed at 0623 (79 28.6° N, 139 49.2° W), swimming at 300m and 270 degrees to the port side of the Healy. The seal broke through the thin ice in a channel then dove. Seismic operations were ongoing during this observation.

A bearded seal was observed at 1634 (78 55.1° N, 137 57.7 W), on the ice at ~800m and 270 degrees off the port side of the vessel. The seal moved its head slightly then remain still as vessel passed within 600m. Seismic operations were ongoing during this observation.

September 4, 2009

A bearded seal was observed at 1634 (77 31.0° N, 137 13.8 W), on the ice at ~1500m and 340 degrees off the port side of the vessel. The seal moved its head side to side and up and down then remain still as vessel passed within 1200m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1638 (77 30.9° N, 137 14.4° W), on the ice at ~800m and 45 degrees off the starboard side of the vessel. The seal moved slightly then remain still as vessel passed within 700m. Seismic operations were not occurring during this observation.

A ringed seal was observed at 1646 (77 30.6° N, 137 17.2° W), on the ice at ~800m and 270 degrees off the port side of the vessel. The seal moved head up and down but did not dive as vessel passed within 700m. Seismic operations were ongoing during this observation.

Two ringed seal were observed at 1704 (77 30.1° N, 137 22.1° W), about 50m apart on the same ice floe at ~1000m and 60 degrees off the starboard side of the vessel. The northern most seal dove immediately upon sighting and the second seal moved around in all directions but did not enter the water as vessel passed within 600m. Seismic operations were ongoing during this observation.

A ringed seal was observed at 1753 (77 28.4 ° N, 137 38.9° W), on the ice at ~600m and 150 degrees off the starboard side of the vessel. The seal moved very little as vessel passed at 600m. Seismic operations were ongoing during this observation.

Bear tracks were observed at ~1830 (77 27.4° N, 137 48.2° W), bearing 270 degrees from the vessel's course.

September 5, 2009

A bearded seal was observed at 0958 (76 44.0° N, 135 29.1 W), on the ice at ~2500m and 340 degrees off the port side of the vessel. The seal did not move until a course change from the Healy, but did not move as vessel passed within 800m. Seismic operations were not active during this observation.

September 9, 2009

A polar bear adult male was observed at 1016 (79 05.3° N, 157 02.0° W), lying down on a large ice floe at 2500 to 3000m at 280 degrees of the port side of the vessel. The bear got up and walked 180 degrees from the vessel for ~100m then stood on hind legs towards the vessel for ~1 minute. The bear continued walking for another 100m before lying down again until out of site.. Seismic operations were discontinued while the bear was nearby.

An unidentified seal was observed at 1016 (79 05.3° N, 157 02.0° W) at ~1500m and 280 degrees off port side of the Healy. The seal pooped up in the foreground of the bear above then dove. Seismic operations were not ongoing during this observation.

An unidentified seal was observed at 1553 (79 07.6° N, 154 43.4° W) at ~1500m and 260 degrees off port side of the Healy. The seal watched with head up as the as the Healy passed by at 1500m. Seismic operations were not active during this observation.

September 10, 2009

A ringed seal was observed at 1023 (78 21.9 ° N, 158 13.1° W), swimming 150m and 280 degrees off the port side of the vessel. The seal swam away from vessel and then dove. Seismic operations were not active during this observation.

A ringed seal was observed at 1116 (78 17.3 ° N, 158 13.9° W), swimming 100m and 330 degrees off the port side of the vessel. The seal swam away from vessel and then dove. Seismic operations were not active during this observation.

A polar bear adult was observed at 2118 (78 39.50° N, 158 19.6° W), walking on ice floe 2500m at 80 degrees of the starboard side of the vessel. The bear hid behind an ice structure and continued to stay out of sight as vessel moved forward. Once vessel had passed the bear continued to walk across flow in a 45 degree direction from its original path. Seismic operations were not active while the bear was nearby.

September 11, 2009

A ringed seal was observed at 2202 (77 48.8 ° N, 161 20.6° W), swimming 20m and 90 degrees off the starboard side of the vessel. The seal appeared curious as it surfaced multiple times before swimming away. Vessel was almost stationary and preparing to dredge. No seismic activity was occurring.

September 13, 2009

An unidentified seal was observed at 2043 (72 45.9 ° N, 157 27.5° W), swimming 30m and 350 degrees off the port side of the vessel. The seal dove almost immediately Vessel was traveling at 15.5 knots. No seismic activity was occurring.

September 16, 2009

A bowhead whale was observed at 1105 (71 17.5 ° N, 157 04.0° W), swimming away at 2000m and 150 degrees off the starboard side of the vessel towards the shore. No seismic activity was occurring.

Two bowhead whales were observed at 1121 (71 18 ° N, 157 01.2° W), at 100m and 90 degrees off the starboard side of the vessel. The whales surfaced, blew, and moved away from the vessel at 90 degrees. No seismic activity was occurring.

A ringed seal was observed at 1130 (71 18.2 ° N, 156 57.1° W), swimming 100m and 45 degrees off the starboard side of the vessel. The seal surfaced with head and body multiple times before diving away. No seismic activity was occurring.

Conclusion

During the duration of this cruise everyone aboard both vessels were very willing, helpful, and responsive when marine mammals were encountered. The communication between the MMOs, scientists, and Coast Guard personnel along with vessel to vessel contact was excellent and undoubtedly resulted in a pleasant achievement of individual goals and expectations for all parties involved. For future marine mammal observation programs I believe data collection protocols between all MMOs from the different organizations involved should be standardized so the information collected can be interpreted in the same manner under a common goal.