



EXPEDITION REPORT

SWEDARCTIC Petermann 2015

COMPILED BY

Martin Jakobsson, Alan C. Mix and Petermann Shipboard Scientific Party



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Final Report
Petermann 2015 Expedition
Icebreaker *Oden*
29 July to 2 September 2015

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Introduction

Petermann 2015 Expedition aboard Swedish Icebreaker *Oden* Departed from Thule Airbase, northern Greenland, on 29 July 2015, transited northward via Nares Strait (NS), working in the region of Petermann Fjord (PF), Hall Basin (HB), Nares Strait (NS), and Kennedy Channel (KC), with return to Thule on 02 September 2015.

Understanding the potential for ice-ocean-climate-sea level interaction was a primary concern for the future change of the Greenland and Antarctic ice sheets and is a source of uncertainty in sea level projections for the 21st century and beyond. Sea-level rise from melting glaciers and ice sheets will undoubtedly extend beyond 2100 AD and in the long run will become the dominant term in sea level change; indeed, transient responses to anthropogenic warming and sea level will play out over the next several thousand years or longer. Projections on these long time scales are highly uncertain. The role of ice sheets and their interaction with the ocean is key.

The dynamic role of floating ice shelves or ice tongues in buttressing land ice, and the behavior of these coupled systems on long timescales, is poorly known. The floating ice tongue that fronts Petermann Glacier has been relatively stable until recently, in spite of significant regional warming. It lost 30–40% of its extent in ice calving events in 2010 and 2012. Paleoclimatology is the only observational window into the expected time frames of dynamic adjustment of the ice and sea-level systems, and thus is an essential component for understanding and projecting the likely future impact of both anthropogenic and natural climate changes.

Given this motivation, the Petermann 2015 expedition primarily addresses paleoclimatology, paleoceanography and paleoglacial dynamics to assess past variations in the Petermann, Hall Basin, and Nares Strait regions. This aspect of the study was primarily funded by US National Science Foundation (NSF) with additional funding from the Swedish Polar Research Secretariat (SPRS). Ship operations were run under Swedish leadership. Additional studies for work on the Petermann Ice Shelf were funded by the Swedish Research Council, British Antarctic Survey and NASA. Ancillary studies include the state of the biota on land and its response to a changing environment, Borehole drilling through the Petermann floating ice tongue to deploy moorings and a weather station, as well as to recover sub-ice sediment cores through the boreholes.

Particular features of the region that make it an excellent laboratory of change include:

- Petermann Glacier drains a significant marine-based sector of a large ice sheet;
- It terminates in an extensive floating ice shelf, sensitive to ice/ocean interactions;
- Its relatively simple geometry and manageable size can be resolved by realistic field programs;
- All parts of the system are accessible with reasonable logistics (~200 nautical miles from Thule);
- Nares Strait is an important conduit for southward flow of low-salinity waters, with possible global oceanographic and climatic impacts through influence on subsurface watermass formation in the Labrador Sea.
- Petermann Glacier in NW Greenland drains ~6% of the area of the Greenland Ice Sheet through Peterman Fjord (PF) into Nares Strait (NS). It is one of four major Greenland Ice Sheet outlet glaciers with a grounding line below sea level and one of only two that retain a substantial (historically ~70 km long) floating ice shelf. The Petermann system is connected to the inland ice of the Greenland Ice Sheet through an ancient (perhaps pre-glacial) channel system, which extends ~750 km from PF, deep into the inland ice along a pathway near the NEEM and NGRIP ice cores. Paleo study of the Petermann system is therefore constrained near its inland-ice source by deep ice-core data, and offers the potential to examine the glacier system from top (the ice source) to bottom (loss of ice into the ocean).

The floating ice shelf has historically advanced about 1 km/yr to balance losses from both melting and calving. At presumed steady state, based on cross sectional area and advance rate at the ice front, Petermann Glacier delivers about 13 km³/yr of ice across the grounding line into a fjord 15–20 km wide, plus an unknown amount of meltwater sourced from further inland. Abrupt calving events in 2010 and 2012 caused ice front to retreat by ~30 km; the ice shelf is now shorter than ever historically observed. This may potentially indicate a response of surface melting to atmospheric warming, or to recent northward progression of warm subsurface waters along from the subpolar North Atlantic via west and over a shallow sill at southern NS, or from the Arctic Ocean through a shallow sill in northern NS (Robeson Channel), or to intrinsic long-term variability in the ice system itself. About 80% of the ice shelf's steady-state mass loss is through basal melting; sublimation, surface melt, and episodic calving provide the remainder.

Petermann Fjord reaches depths of ~1100 m and is connected via a sill of ~400 m (until now poorly mapped) to NS. Prior to the Petermann 2015 Expedition, sediments in the fjord have never been surveyed or sampled. The fjord is covered by sea ice most of the year; in late summer much of the sea ice clears, making the region accessible for investigation from a ship via Nares Strait.

Nares Strait is connected to the Arctic and Atlantic Oceans via sills of ~400 m at 83°N and ~220 m near 80°N. These sills were significantly deeper in the early Holocene due to glacial isostatic depression, but are thought to have been blocked by grounded ice between Greenland and Ellesmere Island between about 19 000 and 8 000 years ago. This implies that paleoceanographic records may help to understand the larger role of southward flow of low-salinity waters through Nares Strait, since the flow became blocked under one climate regime (Last Glacial Maximum) and opened again under another regime (Holocene).

Peterman Ice Shelf may be poised to undergo change in the coming decades. Relatively warm Atlantic water have been observed in the subsurface Arctic Ocean over recent decades. This is changing the temperature of subsurface waters in Hall Basin and PF. Whether this will have an effect on Petermann Ice Shelf depends upon the processes controlling basal ice melt. Surface atmospheric temperatures in the region appear to be trending upward and are leading to increased glacial surface melt. Elsewhere, increasing amounts of surface water has been observed to promote fracturing of ice shelves and render them vulnerable to break up on the Antarctic Peninsula.

Will a combination of these factors enhance basal melting and calving rates and lead to full retreat of the shelf and accelerated ice losses? The answers to these questions depend critically upon understanding the processes that govern the ocean-ice shelf interactions and the ice mass balance in this setting, on a variety of scales. Greenland's inland ice might be susceptible to irreversible "tipping point" ice losses. It is difficult to assess the reality of such behavior; data from current and past variability in outlet ice glaciers such as Petermann will help to calibrate models.

Modeling studies highlight the need to understand how different processes can act on different timescales. For example, a regional-scale model of the Petermann system shows that freshwater flux dominates the seasonal scale variability, but ocean-driven sub-shelf melting near the grounding line likely dominates variability on interannual-to-decadal time scales. On century to millennial scales the inland ice mass balance and isostatic adjustment will likely be important. This again shows the critical role of paleo data in understanding the long-term responses of such systems and the interactions among its various parts; short-term "snapshot" studies may miss the processes that control the long-term responses.

Prior to the Petermann 2015 expedition, Peterman Fjord was a relatively unexplored region with very little information about its past history. Only a limited bathymetric map existed, and its sedimentary cover was completely unknown. Preliminary work on land suggests that early Holocene ice cover on land was likely more extensive than today, a remnant of the larger ice sheets. Local relative sea level was probably higher by >100 m in the early Holocene due to isostatic depression of the land. Greater regional ice volume implies faster flow of ice into the outlet glacier (favoring advance of the grounding line and shelf extent) whereas higher relative sea level would favor grounding line and ice shelf retreat. Mid-Holocene ice extent was likely less than today implying retreat of the grounding line, just when lower relative sea levels would have favored advance; which of these processes is more important is unknown.

Expedition Science Party

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GM – Geophysical Mapping

During the Petermann 2015 expedition the seafloor was continuously mapped along the entire cruise using IB *Oden*'s 12 kHz multibeam echo sounder and integrated 2.5–7 kHz chirp sub-bottom profiler. In addition, specific areas were targeted for detailed mapping in shallow water using RV *Skidbladner* equipped with a bow-mounted 200–400 kHz multibeam.

Our primary goal was to develop a virtually complete high-resolution bathymetric map of Petermann Fjord and its sill. A second priority was to develop a complete bathymetric map of Hall Basin (Greenland waters) outside Petermann Fjord, and a third goal was to develop as much bathymetric data as time and ice cover allowed in western Hall Basin and the entrance to Archer Fjord (Canadian waters). The primary goal with the RV *Skidbladner* mapping missions was to collect data in shallow areas unreachable with IB *Oden*, specifically along the margins of the tidewater glaciers draining into the Petermann Fjord. Together, these maps constrain the flow pathways of relatively warm salty bottom water into the fjord, critical for assessing the ocean's role in melting the ice shelf, and provide morphological evidence for past ice grounding lines as well as the distribution of glacial lineations that define the motions of ice streams emanating from Petermann Fjord, Nares Strait, and Archer Fjord. Simultaneous sub-bottom profiling (2.5–7 kHz chirp) along the ship track line in all of these areas provides information on sediment distribution and high-resolution acoustic stratigraphy, helping to constrain sediment transport pathways and inform the selection of coring targets.

At a more detailed level, high-resolution study of the bathymetry and near-surface sedimentation patterns in the modern Petermann Fjord and regions previously occupied by ice provide unprecedented information of tidewater glaciers and the fjord. Some observations indicate that the calving rate of a tidewater glacier is a function of water depth modulated by variations in fjord width. How ice streams in polar settings with tidewater variation advance along deep fjord basins remains unclear. Advances may be accomplished by the seaward growth of an ice-front mélange, which buttresses and restricts calving. No mélange has been observed at Petermann. An alternative model developed in Alaska posits that growth of a morainic wedge of sediment at the calving terminus of the tidewater glacier reduces water depth and allows the terminus to advance. Our detailed bathymetric, sub-bottom, and high-resolution seismic data allow us to test the sensitivity of the ice stream to changes in water depth and fjord morphology as well as assessing the character of current and past grounding lines. Our transect of cores in the context of the seismic data also allow us to describe in both space and time changes in sediment facies associated with an Arctic ice shelf and will enable us to compare this environment with Antarctic systems.

GM Equipment

Multibeam and sub-bottom profiling system

The hull-mounted multibeam echo sounder installed in IB *Oden* is a Kongsberg EM122 1°×1° 12 kHz 'full ocean depth' multibeam echo sounder including the capability of logging acoustic data in the water column (see Water Column Imaging). The sonar transmitting array is 8×1 m (resulting in a 1°-wide transmit pulse), mounted along-ship in the so-called "ice knife", which forms the deepest part of *Oden*'s hull (Figure GM-1). This array is protected from ice impact by polyurethane plates reinforced by titanium bars. Due to the ice

protection of the transmitter, the useable angular coverage is limited to approximately 140° with typical seafloor swath widths of three to four times the water depth. The receiving array measures 8×1 m (resulting in a 1° -wide receive beam) and is mounted across-ship. This array is protected from ice by a solid titanium plate. The multibeam system includes a Seatex Seapath 320 for navigation using GLONASS/GPS and motion sensor logging (roll, pitch and heave). The motion sensor unit is a Seatex MRU5. A Seapath 200 is carried on board as a spare unit.

A Kongsberg SBP120 $3^\circ \times 3^\circ$ chirp sub-bottom profiler is hull-mounted in IB *Oden* and integrated with the multibeam system. This system operates with a frequency range of 2.5–7 kHz and has an approximate resolution of 0.35 ms (~ 70 cm). The penetration is typically 50–200 m in clayey ocean sediments.

Corrections for sound speed changes in the water column come from data generated at oceanographic stations using a standard SeaBird911 CTD (see WP PO: Physical Oceanography). In addition, XBTs (eXpendable BathyThermographs) were used when necessary. The setup of the entire multibeam system including sub-bottom profiler is illustrated in Figure GM-2. Table GM-1 lists the technical specifications of the multibeam and integrated chirp sub-bottom profiling system. Table GM-2 includes the measured offsets between key multibeam components.

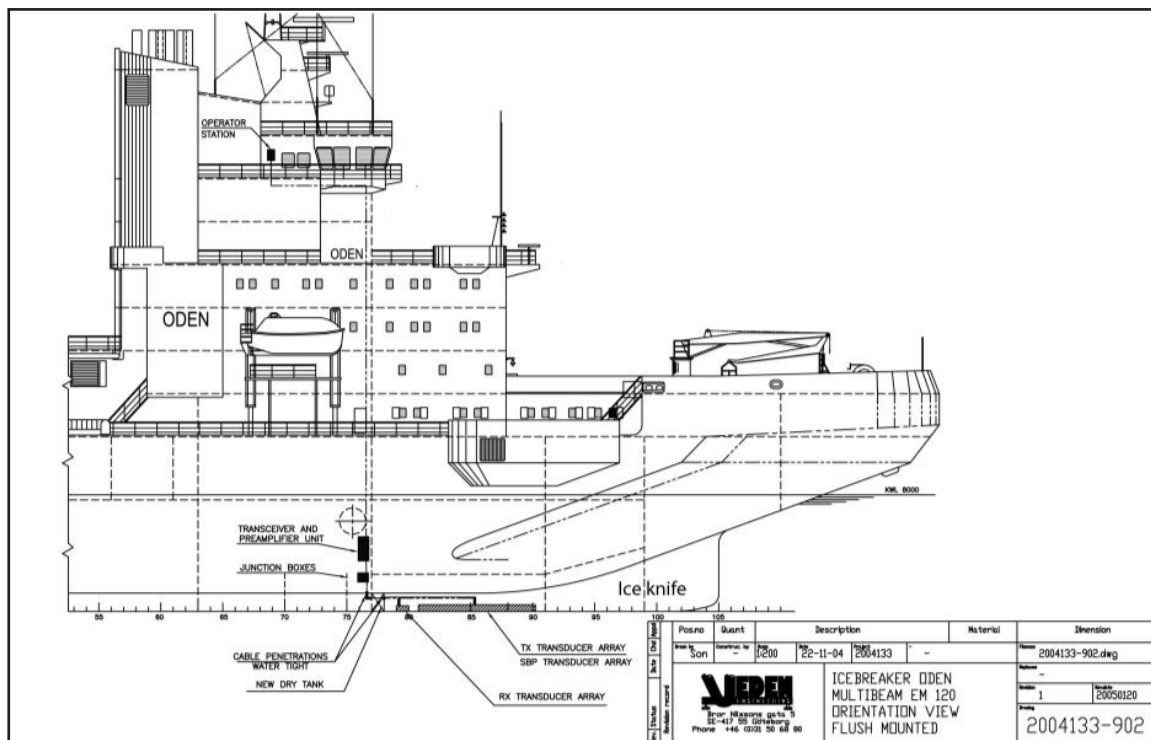


Figure GM-1: Drawing of the EM122/SBP120 system installed on the IB *Oden*.

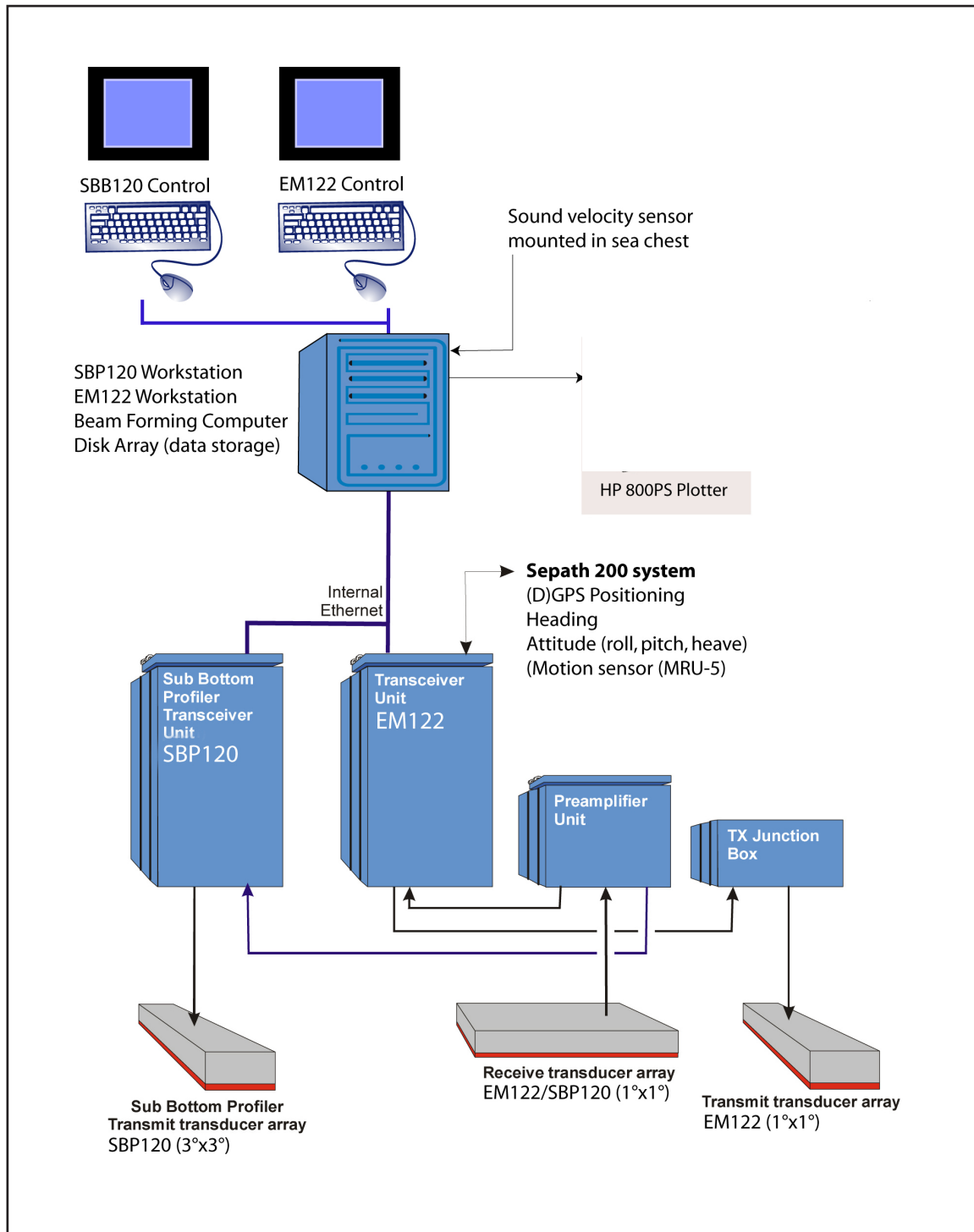


Figure GM-2: Schematic illustration of the EM122/SBP120 system installed on the IB Oden. The illustration is a modified version of Kongsberg's original.

Table GM-1. Technical specifications of IB Oden's multibeam and integrated sub-bottom profiling system.

Component	Technical specification	Serial numbers
Kongsberg EM122 multibeam	Nominal frequency: 12 kHz Beam widths: 1° × 1° Number of beams/swath: 288 No of soundings/swath: 432 Depth range: 20 to 11 000 m Coverage sector: Up to 75°, Oden's ice protection windows limit the coverage to ~65–70° Pulse forms; 2.5 and 15 ms CW and FM chirp (BT=40)	Operator station MP8300 (upgraded 2014): CZC3407HBM TRU: 110 PreAmp: 106 TX JB1: 150 TX JB2: 151 Software: SIS Version 4.1.3, build 14
Seatex MRU5 motion sensor	See output result for Seapath	MRU5: 4603
Seapath 320 GPS/GLONASS navigation system	Heading accuracy: 0.05° RMS (4 m baseline) Roll and pitch accuracy: 0.02° for ±5° amplitude Heave accuracy: 2 cm or 2%, whichever is highest. Velocity accuracy: 0.03 m/s RMS or 0.07 m/s (95 % CEP) with DGPS Positional accuracy with DGPS: 0.15 m, no DGPS available in the central Arctic Ocean, accuracy is reduced to ~2–10 m. GLONASS in addition to GPS	Processing unit (installed 2014): SP320-CA31NS2050
Seapath 200 GPS navigation system (spare unit)	Heading accuracy: 0.05° RMS (4 m baseline) Roll and pitch accuracy: 0.03° RMS for ±5° amplitude Heave accuracy: 5 cm or 5%, whichever is highest. Velocity accuracy: 0.03 m/s RMS or 0.07 m/s (95 % CEP) with DGPS Positional accuracy with DGPS: 0.15 m, no DGPS available in the central Arctic Ocean, accuracy is reduced to ~2–10 m.	Processing unit: 7148
SBP120 chirp sonar sub-bottom profiler	Operation frequency: 2.5 to 7 kHz Number of beams per ping: 11 Beam width: 3° × 3° Pulse length: 0.4 to 100 ms (navigational data is received from the Seapath system)	Operator station MP8300 (upgraded 2014): CZC3407HBZ TRU: 105 TX/RX JB: 104 CCU1: 119; CCU2: 120; CCU3: 123; CCU4: 124 Software: SBP/TOPAS 1.5.3 (2011.12.05)
SeaBird 911 CTD	Depth rating: 6800 m Temperature: certified stability of 0.001 °C in six months after calibration	CTD sensor: 859 Electronic unit: 11P45395-0750
Valeport Mini SVS/T Sound velocity sensor mounted in the sea chest		Sensor: 25509

Table GM-2. Offsets between sensors entered into the SIS, SBP 120, and Seapath 330 software. Length measurements are in meters. The MRU is set to be the ship XYZ reference point. +X forward; +Y to starboard; +Z down; +Roll starboard side down; +Pitch bow up; +Heading bow to starboard (compass convention). Note that the SBP configuration refers to roll as 'across angle,' pitch as 'alongship angle,' and yaw/heading as 'azimuth angle.'

Software	Sensor	X	Y	Z	Roll	Pitch	Heading
SIS	SP330 Pos. / Att.	0.000	0.000	0.000	-0.02°	-0.19°	+1.50°
	EM 122 TX Array	+17.590	-2.374	+9.459	-0.207°	-0.001°	+0.033°
	EM 122 RX Array	+12.242	-0.880	+9.482	+0.021°	+0.189°	+0.022°
	Waterline	-	-	1.3	-	-	-
SBP 120	SBP 120 TX Array	+17.240	+0.619	+9.464	+0.180°	+0.022°	+0.018°
	EM 122 RX Array	+12.242	-0.880	+9.482	+0.021°	+0.189°	+0.022°
	GPS	0.000	0.000	-	-	-	-
	MRU	0.000	0.000	0.000	0.000°	0.000°	-
Seapath 330	MRU5	0.000	0.000	0.000	-179.770°	-0.150°	+0.298°
	GPS Antenna 1	+3.973	-3.050	-33.327	-	-	-
	GPS Antenna 2	+6.472	-2.977	-33.263	-	-	-



Figure GM-3: RV Skidbladner with the EM2040 bow mounted multibeam in operation. The multibeam and sub-bottom profiler (located on the port side, not seen on photograph) can be hoisted up for fast transit if required. Photo: Björn Eriksson



Figure GM-5: Launching of RV Skidbladner using IB Oden's crane. Photo Björn Eriksson



Figure GM-4: RV Skidbladner lifted onboard IB Oden in Landskrona, Sweden. The cradle normally used for Oden's workboat was used for RV Skidbladner during the expedition. Photo: Martin Jakobsson

High-resolution multibeam system

RV *Skidbladner* is an Arronet 20.5 cs aluminum boat, 6.4 m long, 2.4 wide, weighing about 1.8–1.9 ton with all geophysical equipment onboard (Figures GM-3, GM-4, GM-5). RV *Skidbladner* has a Honda 150 HP outboard motor and is equipped with a Garmin 7012 GPS-navigation plotter, radar system, AES, and radio. The fuel is 95 octane unleaded standard gasoline and the tank is 157 liters. RV *Skidbladner* has a top speed of 32 knots, when all equipment is hoisted up for transit, but typical survey speed with the equipment in the water is 5–6 knots. Fuel consumption during a survey at 6 knots is approximately 10 liters/hour. All equipment is supplied with electricity from a Honda 20i 2kW generator. This generator consumes about 1 liter/hour gasoline (alkylade petrol is recommended).

A Kongsberg EM2040, 200–400 kHz 1°x1° multibeam is installed on RV *Skidbladner* with a bow mounted pole that can be hoisted up for transit (Figure GM-6). This multibeam is capable of mapping the seafloor down to approximately 500 m water depth. The navigation, heading and motion sensor system consists of a Seapath 330+ with RTK (Real Time Kinematic) capability. The motion sensor unit feeding roll, pitch and heave consists of a Seatex MRU5+ mounted in a subsea bottle on the EM2040 transducer casing. An RTK reference station comprised of a Hemisphere A325 Smart antenna connected to a Satelline-Easy pro 35W 403–473 MHz radio was used to acquire RTK corrections that were sent using the RTCM 3.0 protocol to RV *Skidbladner* (Figure GM-7). This station was placed on a height nearby each RV *Skidbladner* survey area.

Table GM-3. Technical specifications of RV Skidbladner's multibeam and sub-bottom profiling system. Specifications are derived from the manufacturer's manuals.

Component	Technical specification	Serial numbers or product numbers
Kongsberg EM2040 multibeam	• Main operation frequency: 200,300, 400 kHz • Beam widths: 1°X 1° • Number of soundings/swath: Max 800 for 200/300/400 KHz • CW Pulse lengths: 200kHz/200 and 600 µs 300 kHz/70, 200 and 600 µs 400 kHz/20, 35, and 100 µs • FM Pulse lengths: 200 kHz/12 ms; 300 kHz/6 ms; 400 kHz N/A • Depth range in ocean water: 0.5 to 400 m • Coverage sector: Up to 70° • Pulse forms; 2.5 and 15 ms CW and FM chirp (BT=40)	• TX: 110 • RX: 110
Seatex MRU5+ motion sensor mounted in sub-sea bottle		MRU5+: MRU-E-JB-2
Seapath 330+ navigation, heading and motion reference system	• GPS with RTK and SBAS correction capability that also receives GLONASS. • Roll and pitch accuracy for $\pm 5^\circ$ amplitude: 0.02° RMS • Heading accuracy with the 2 m antenna separation used on RV <i>Skidbladner</i>: 0.08°RMS • Heave accuracy: 5 cm or 5 %, whichever is highest. • Position accuracy with RTK (x and y): 1 cm + 1.6 ppm RMS • Position accuracy with RTK (z): 2 cm + 3.2 ppm RMS • During the surveys a minimum integrated accuracy around 2–15 cm was commonly reported by the Seapath system.	• Seapath 330 HMI unit: E904NS2003 • Seapath 330 processing unit: E608NS2060 • Novotell antennas: NMDT14480047H • NMDT14480051L
Hemisphere A325 Smart Antenna with RTK capability. (Used as reference station)	Mounted on a tripod along with a radio antenna.	Antenna: 940-2090-000
Kongsberg EA600 sub-bottom profiler	• Operation frequency: 15 kHz, 2 kW • Circular beam width: -3 dB 17°/-6 dB 23°	• Transducer: 099-133981 • GPT transceiver: 305121
Valeport sound velocity probe	With memory for operation without cable, max depth rating 500 m	5107
Valeport MiniSVS (sound velocity sensor)	Mounted on the transducer casing to provide continuous sound velocity measurements.	Product no: 0652047-AML
AML sound velocity sensor mounted near transducer face, and AML SVP sound velocity/pressure sensor used for depth profiling of sound velocity at stations (only spare unit)	Max depth rating: 200 m	• SV-probe:4646 • SVP-probe: 5107

Sound speed correction data is acquired using a Valeport MiniSVS mounted on the EM2040 transducer casing for continuous readings. An additional velocimeter by Valeport is used for measuring the sound velocity profile in the water column. A Kongsberg EA 600, 15 kHz, sub-bottom profiler is mounted on a pole that can be hoisted up for fast transit. Table GM-3 lists technical specifications of the multibeam and integrated chirp sub-bottom profiling system.

A 24-hour per day operation of the multibeam, including data post-processing, was achieved by six operators divided into three watches for four hours shifts (Table GM-4). Seafloor mapping with RV *Skidbladner* required two or three people. The operation of the EK 80 mid-water sonar system was also carried out by the teams listed in Table GM-4.

Multibeam Shipboard post-processing

Multibeam-bathymetric data were acquired on board *Oden* using Kongsberg Maritime's SIS Ver. 4.1.3 system control and acquisition software. The Kongsberg raw.all files were processed onboard using QPS Qimera Ver. 1.0.3 and Fledermaus, Ver. 7.4.2. Data

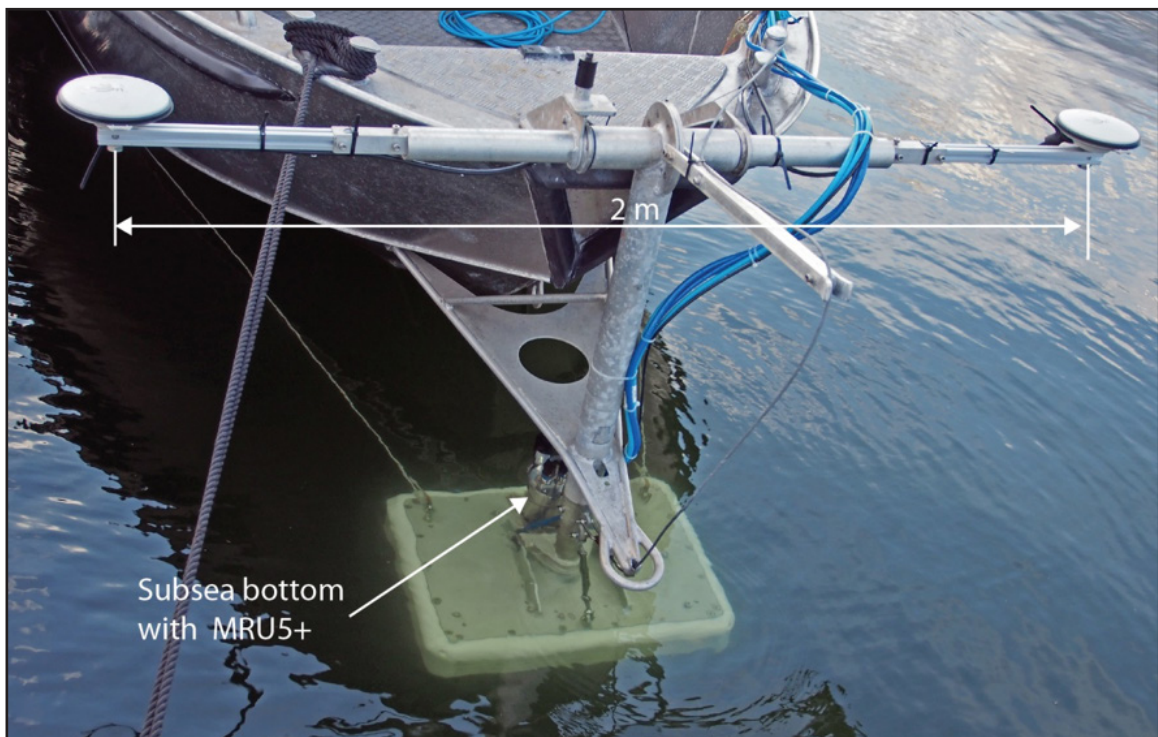


Figure GM-6: Multibeam setup on RV *Skidbladner*. The Valeport MiniSVS is not visible, it is clamped onto the subsea bottle.

Table GM-4. Multibeam watch standing and data processing teams.

Watch 1 (0–4, 12–16)	Björn Eriksson
Watch 2 (4–8, 16–20)	Rezwan Mohammad
Watch 3 (8–12, 20–24)	Kevin Jerram
RV <i>Skidbladner</i> mapping	Martin Jakobsson, Kelly Hogan, Larry Mayer, Mikael Molin, Par Ljusberg
Data Processing Team	Kelly Hogan, Christian Stranne

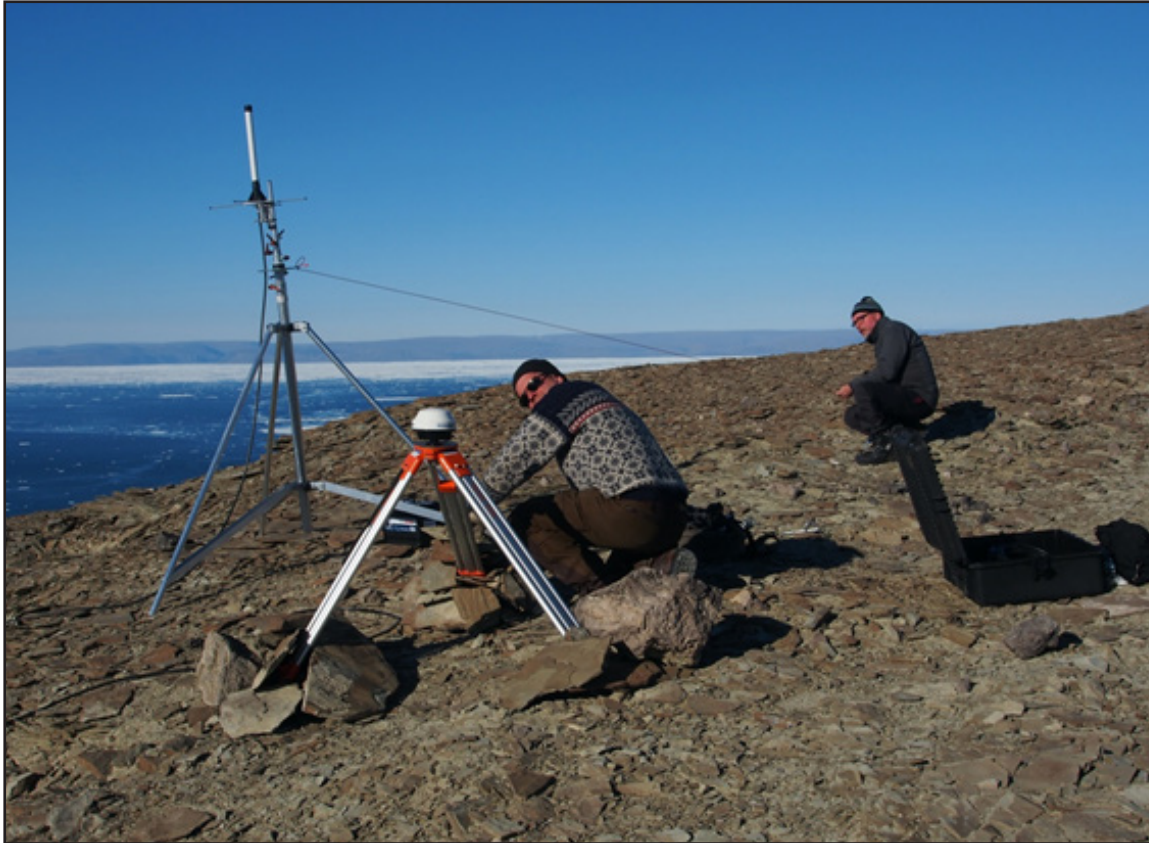


Figure GM-7: RTK reference station mounted on Hall Land for an RV Skidbladner survey.

processing included applying new sound velocity profiles, where the profile used during acquisition led to clear offsets in bathymetric soundings between adjacent lines, and removing erroneous soundings using the along-track and 3D-editing tools in Qimera. Cleaned data were gridded at a resolution commensurate with the water depth (ranging from 1 m grids for shallow water sites to 25 m grids for deepest sites) and brought into Fledermaus for 3-D visualization and exploration. Gridded bathymetric products along with all track and sample data (CTDs, XBTs, core stations, etc.) were brought into a Geographical Information System (ArcMap 10.2.1) and viewed within the context of the IBCAO Ver. 3. Arctic bathymetry (Jakobsson *et al.*, 2012) and other useful spatial datasets (e.g. recent Landsat scenes of the area, historical core locations). All data were processed using a Polar Stereographic projection with a true scale at 75°N and horizontal datum of WGS 84 (UPS North).

While the quality of most of the multibeam sonar data acquired was high, some data quality problems were encountered. The two most serious issues were “punch-through” or over-penetration of the nadir beams in shallow water and the appearance of “horns” (positive features that parallel the track on either side of the nadir beam). These issues will be discussed further in the section titled “Multibeam Data Quality Issues.” Aside from these issues, there was the expected degradation of data quality while surveying in ice, on turns or at high speed. It should be noted that due to numerous helicopter operations during the cruise, when the ship either span or sailed in small circles, many multibeam lines were produced that were not high enough quality for the final bathymetric surface. These lines were excluded from the Qimera project and not used in final gridding.

The multibeam sonar requires a detailed knowledge of the speed of sound in seawater to convert the travel-time measurements it makes into true depths, to calculate ray bending due to refraction in the water column (and thus calculate the proper location of the measurement on the seafloor) and to properly calculate the steering angle of the beam at transmit. For the most part, sound speed profile information for Petermann 2015 was provided to the EM122 through the data collected by CTD measurements supplemented by eXpendable BathyThermograph (XBT) drops (see the WP PO section for a description of the CTD system and measurements made). The sound speed of the water at the transducer head was monitored continuously by an Applied Micro Systems LTD sound velocity probe located within the sea-water intake in the ship's hull. During Petermann 2015 a total of 46 CTD stations were occupied (see WP PO). When the real-time display of the SIS indicated a problem with the sound speed profile (either noticeable refraction in the profile or a discrepancy of more than 10 m/sec between the upper values of the sound speed profile collected with the CTD and the sound speed from the AMS probe) an eXpendable BathyThermograph (XBT) was typically launched to provide updated profile information. Salinity from the nearest (or most appropriate CTD) was used to supplement the XBT data and generate a sound speed profile. During Petermann 2015 XBT measurements were made using T-5 probes in deep water and T-6 probes in shallow water. In all cases (CTD and XBT), the sound speed had to be calculated from measured temperature, salinity and depth data. The sound speed formula used for this conversion is that provided by UNESCO (Fofonoff and Millard, 1983). A Python script does this conversion, bins and thins the data, and then extends the profile to 12000 m depth as required by the SIS system. A list of the sound velocity profiles used during the Petermann 2015 expedition is provided in Table GM-5.

Data Structure and Organization

EM122 multibeam sonar data collected on the Petermann 2015 expedition were written directly to disk on the RAWDATA drive of the *multibeam2* computer on the shipboard network.

The full path of these files was: *RAWDATA/sisdata/raw/PetermannXXXX/2015/08*.

Where XXXX is “_transit” for the transit from Sweden to Thule Greenland, “2015” for the main body of the survey work until 19 August, and “2015_2” for remaining work in the Petermann region and the transit back to Thule (Table GM-6). These data were further subdivided into sub-directories for each day labelled 2015MMDD. The individual raw data files within each day file are then labelled LNNU_2015MMDD-Thhmmss_Oden.all for bathymetry and LNNU_2015MMDD-Thhmmss_Oden.wcd for water column imagery. LNNU is a four digit line number set by the SIS control system and MM is month, DD day, hh hour, mm minutes, and ss seconds (Figure GM-8). Backups of the raw data were made to two external hard drives on a daily basis during the expedition.

Multibeam Results

The EM122 bathymetry collected during the Petermann 2015 expedition represent a unique mapping dataset with exceptional coverage of the PF and adjacent HB area in northwest Greenland. The dataset directly fulfils a major objective of the project to identify glacial morphologies related to the Petermann Glacier system, and to map any bathymetric sills that could affect water mass circulation into the fjord and in NS. The data were also used heavily by other work packages to determine optimal locations for, for example,

Table GM-5. Sound velocity profiles applied during Petermann 2015 expedition.

Applied sound velocity profiles

Date	Time	Probe	Seq #	Serial #	Latitude	Longitude	Depth	Filename
2015-07-26	04:57:00	T-6		334574				20150726_T6_334574_thinned_salinity_03500.asvp
2015-07-30	14:27:49	T-6	37	334570	78.151706	-73.40551	325.74	petermann20150730_T6_334570_thinned_salinity_03500.asvp
2015-08-02	22:51:08	T-6	41	211965	80.927559	-66.0276	477.5	petermann2015_20150802_T6_211965_salinity_03500.asvp
2015-08-02	16:52:15	T-6	40	334571	80.556897	-67.90299	337.575	petermann2015_20150802_T6_334571_thinned_salinity_03500.asvp
2015-08-03	00:18:00				81.097872	-65.38481	427.25	petermann2015_20150803_T5_xxxxxx_salinity_03500.asvp
2015-08-04	21:30:00	T-5	48	366430	81.097334	-61.77954	1065.65	petermann2015_20150804_T5_366430_salinity_03500.asvp
2015-08-04	02:58:45	T-6	47	334576	81.324915	-63.82555	474.4667	petermann2015_20150804_T6_334576_salinity_03500.asvp
2015-08-07	01:53:51	CTD	2		81.189522	-62.1093	820	petermann2015_CTD_20150807_0153_002_CTD_salinity_03500.asvp
2015-08-07	09:49:15	CTD	6		80.997117	-61.4185	1049.425	petermann2015_CTD_20150807_0949_006_CTD_salinity_03500.asvp
2015-08-15	19:43:19	CTD	23		81.214889	-62.81922	431.2	petermann2015_CTD_20150815_1943_023_CTD_salinity_03500.asvp
2015-08-18	09:55:00	CTD	24		81.121709	-61.94689	969.2	petermann2015_CTD_20150818_0955_024_CTD_glacial_plumes_salinity_03500.asvp
2015-08-20	22:49:57	CTD	26		81.524057	-63.84458	613.7	petermann2015_CTD_20150820_2249_026_CTD_salinity_03500.asvp
2015-08-09	00:20:12	T-6	50	334579	81.391359	-62.61136	441.5	petermann2015_XBT_20150809_0020_T6_CTD001_salinity_03500.asvp
2015-08-10	00:11:40	T-6	51		81.246307	-62.55444	481.25	petermann2015_XBT_20150810_0011_T6_002CTD_salinity_03500.asvp

Table GM-6. Directories for Petermann 2015 Expedition.

DIRECTORY NAME	START TIME	STOP TIME
Petermann_transit	13 July 15:04	26 July 09:41
Petermann2015	29 July 23:44	19 August 17:05
Petermann2015_2	19 August 17:08	2 Sept. hh:mm

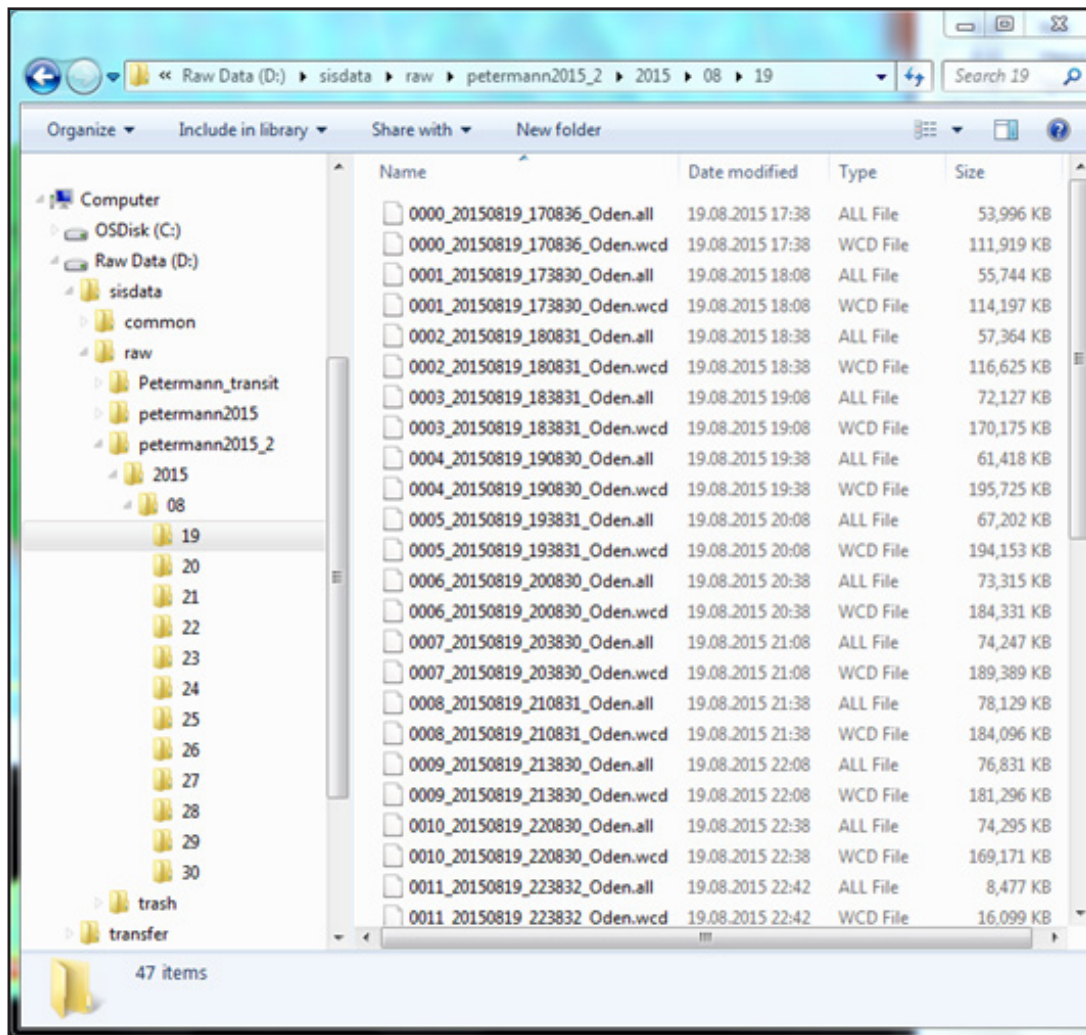


Figure GM-8: Data storage file structure for EM122 data on Petermann 2015 Expedition.

sediment coring and oceanographic measurements. The system operated continuously for the entire cruise with more than 6500 line-km of multibeam-bathymetric data representing more than 4300 km² of seafloor mapped. The survey area was confined to the PF and adjacent NS area (plus transit lines to and from Thule) and can be divided informally in to three geographic areas labelled areas 1 to 3 in Figure GM-9. Logging stopped at 01:10 on 2st September 2015 after the final transit back to Thule, northwest Greenland.

Area 1 consisted of the main survey area in PF, HB and the northern part of KC representing the main survey area for the cruise (Figure GM-10) Mapping was carried out along straight survey lines with 100 % overlap (50 % overlap on adjacent lines), wherever possible, given ice conditions. Focussed mapping was interspersed with tasks from several other work packages but the multibeam echosounder was always left on during these periods and therefore data was recorded continuously. Thus, numerous cross-cutting tracks or lines with multiple turns also exist; however, these lines were not typically used during gridding to produce final bathymetric surface unless no other survey lines existed in that area. All lines in Area 1 were utilized, along with co-located sub-bottom profiles, to find optimal locations for sediment coring and to investigate water column features (see WPs on Sediment Coring and Water Column Imaging).

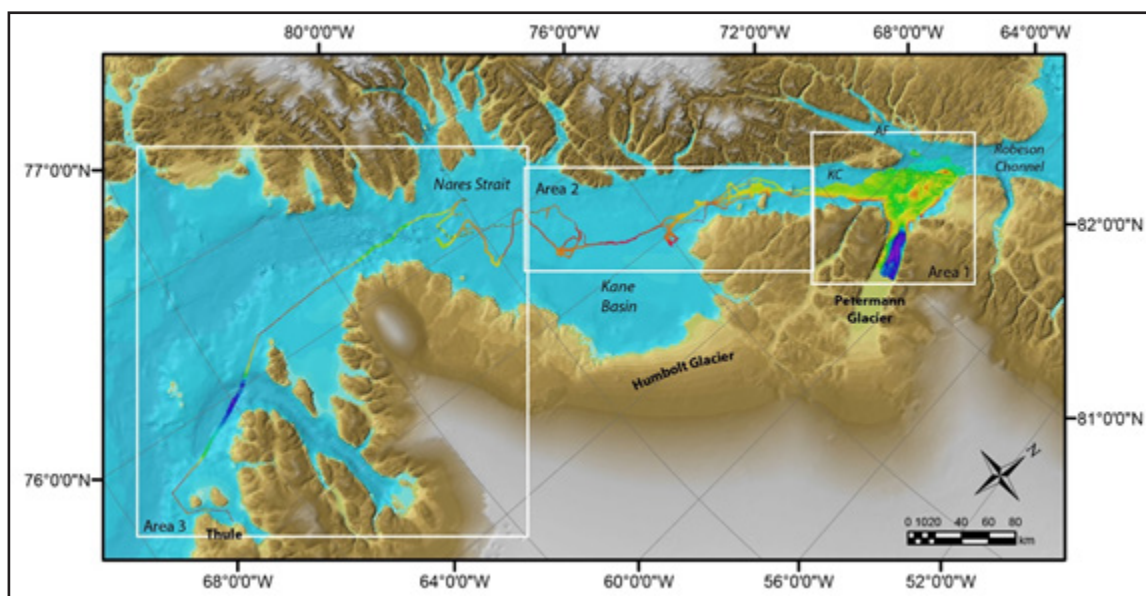


Figure GM-9: Map showing multibeam data coverage from Petermann 2015 expedition.

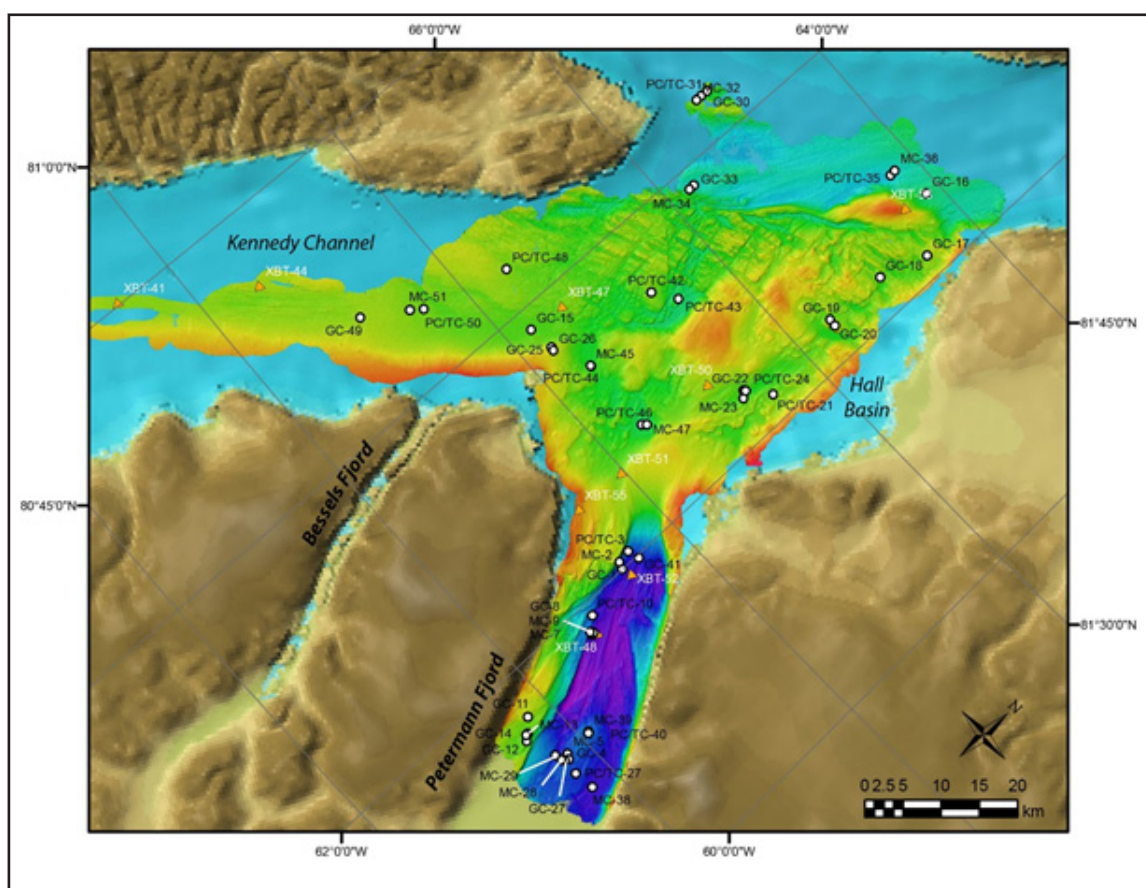


Figure GM-10: Area 1 encompassing the PF and HB area. Coring stations are marked with white circles along with the station name. All coring stations have the prefix "OD1507-" which is omitted on the map (see WP SC). The orange triangles show XBT stations.

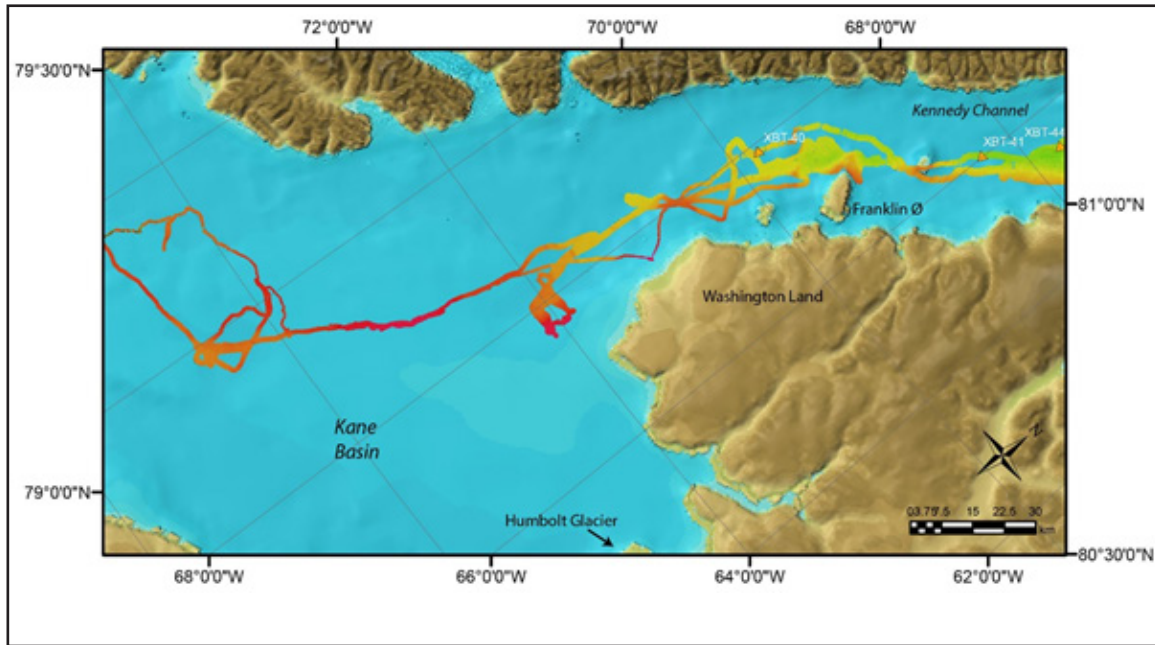


Figure GM-11: Area 2 encompassing the KC and Kane Basin area. The orange triangles show XBT stations.

Area 2 (Figure GM-11) extends from HB southwards through the KC and Kane Basin. Mapping in KC was designed to document the impact of grounded ice flowing through NS on the seafloor in order to better understand the glacial history of the region. A few coring sites were selected in this area to investigate what appears to be a grounding-zone feature in KC. Mapping in Kane Basin was also designed to document former flow-paths of grounded ice but focused on the interaction between ice flowing through NS and that originating from the Humbolt Glacier. Seafloor features of note include glacial lineations, what appear to be morainic ridges, and possible grounding-zone features.

Area 3 (Figure GM-12) represents the transit legs through Smith Sound and to and from Thule at approximately $68^{\circ} 53.1' \text{ W}$, $76^{\circ} 32.7'$. The exact locations of these lines were heavily dependent on ice conditions in NS and Smith Sound and did not include any specific mapping objectives.

The EM122 data was, for the most part, of high quality except for the expected degradation when operating in the ice and during turns. However, a known issue for the EM122 on *Oden* did occur during again during the Petermann 2015 expedition. Namely, the issue was “punch-through” at the nadir which resulted in an artifact referred to as “Eric’s horns” in the multibeam data, i.e., elevated soundings on either side of the nadir beam (Figure GM-13). These two issues appear to be interrelated with punch-through occurring in softer seafloor environments so that the echosounder picks the first nadir ring as the seafloor return and follows its parabola for some distance on either side of the nadir until it finds the correct seafloor return again. Following systematic experiments to try to identify the best settings to prevent punch-through, only a few parameters were changed in SIS during acquisition. These included turning off the Penetration Filter and turning on the Spike Filter, as per Kongsberg’s recommendations to try to reduce the Eric’s horns effect. Neither of these options appeared to systematically reduce the problem.

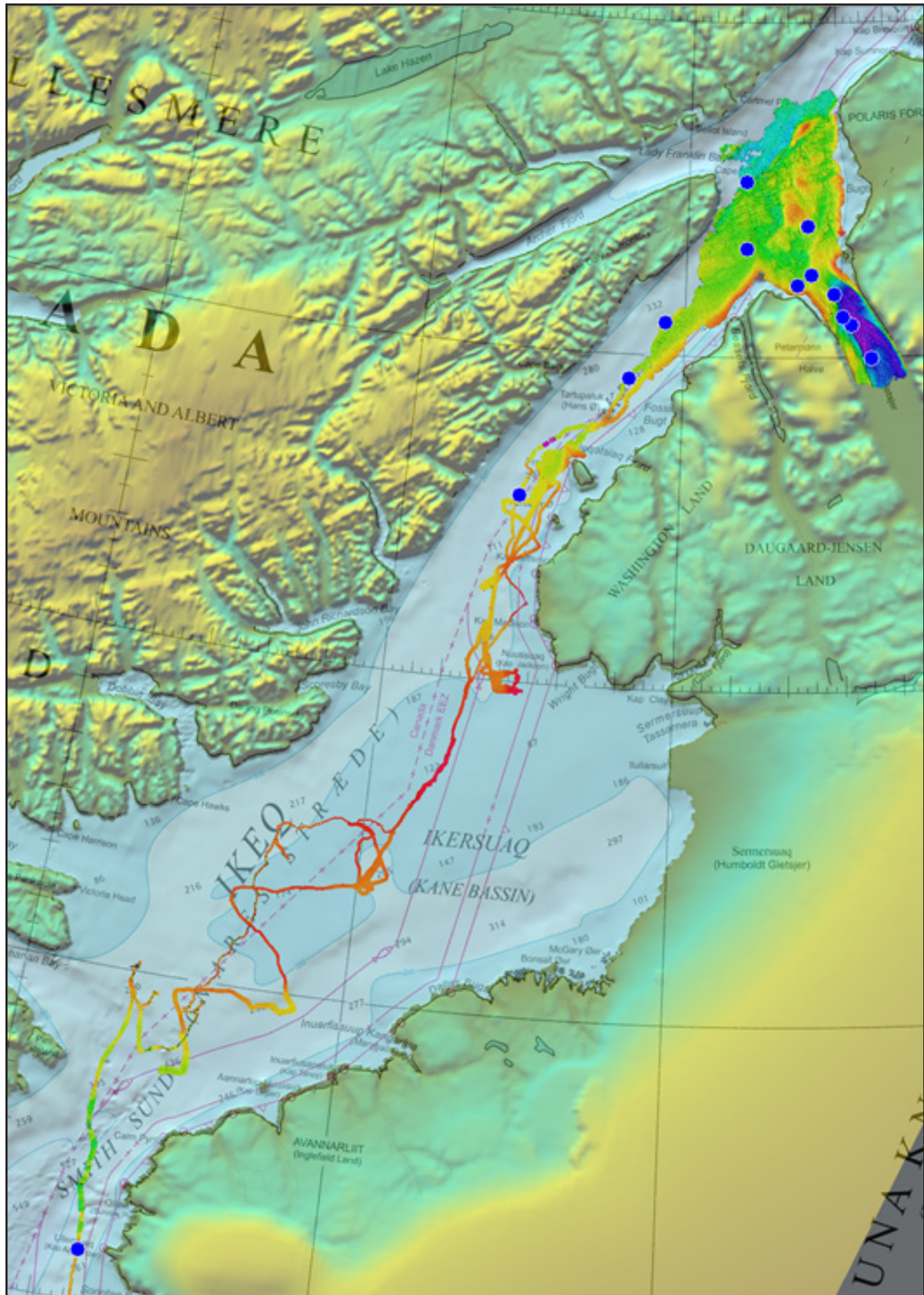


Figure GM-12: Area 3 encompassing the transit legs to and from Thule. The orange triangles show XBT stations.

High-resolution surveys with RV *Skidbladner*

Five missions were completed with RV *Skidbladner* (Figure GM-14). The first survey area is located along the coast of Hall Land. This area was visited twice since the EM2040 multibeam did not function during the first occasion. The reported error was “EM2040: Error on data from BSP 4 – master PU(793)” (Figure GM-15). This error occurred once before during the pre-expedition test survey in Lake Vättern, Southern Sweden. The problem was then intermittent and after dialog with Kongsberg identified as likely faulty sonar cables, most probably one of the sub-water connections to the transducers and/or between the TX and RX. For this reason, spare cables were brought onboard IB *Oden*. These cables were changed, however the problem remained. After additional trouble shooting, we found the real cause of the error. It was an intermittently faulty cable that connects the TX and the master PU on the deck unit. After changing this cable the EM2040 multibeam worked during all missions. Due the cable problem, only sub-bottom profiles were collected using the EA600 15 kHz echo sounder during the first survey in area A/B.

The third and fourth missions aimed to map along the margins of outlet glaciers inside PF while the fifth targeted the entrance to Bessel Fjord (Figure GM-16). The seafloor in front of the un-named glaciers in area C was successfully mapped in detail. The more northerly of the two in particular has well preserved landforms on the seafloor leading directly up to the ice margin. These landforms are unquestionably related to the glacier’s activity and will be subjected to further post cruise analyses. The innermost tidewater glaciers in focus for our mapping in area D are located along the south-eastern side of PF, i.e. inner part of the fjord. One is un-named while the other is referred to as Belgrave Glacier (Figure GM-14). The raw files during this cruise were not fully captured due to a data file handling/disk problem. However, all grids generated by the acquisition software SIS may be used to derive bathymetry from the survey, although with a lot less potential of making high quality end products.

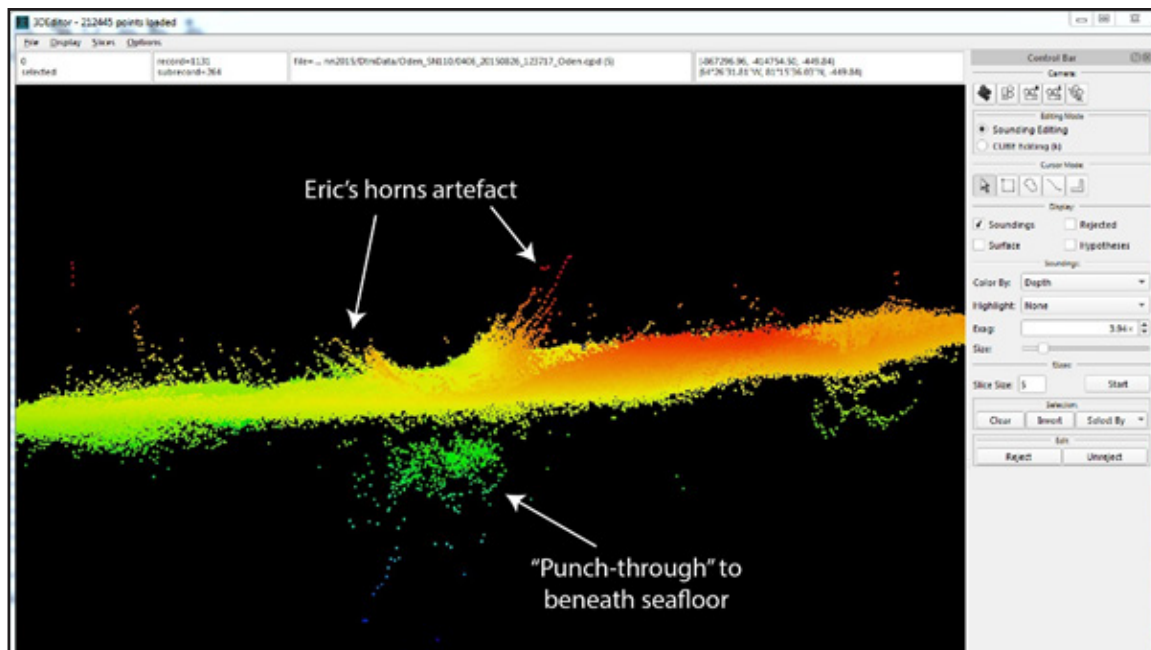


Figure GM-13: Example of “punch-through” (deep bottom detect near nadir) and Eric’s horns artefact in a line from HB, as seen in Qimera processing package, 3D Editor view.

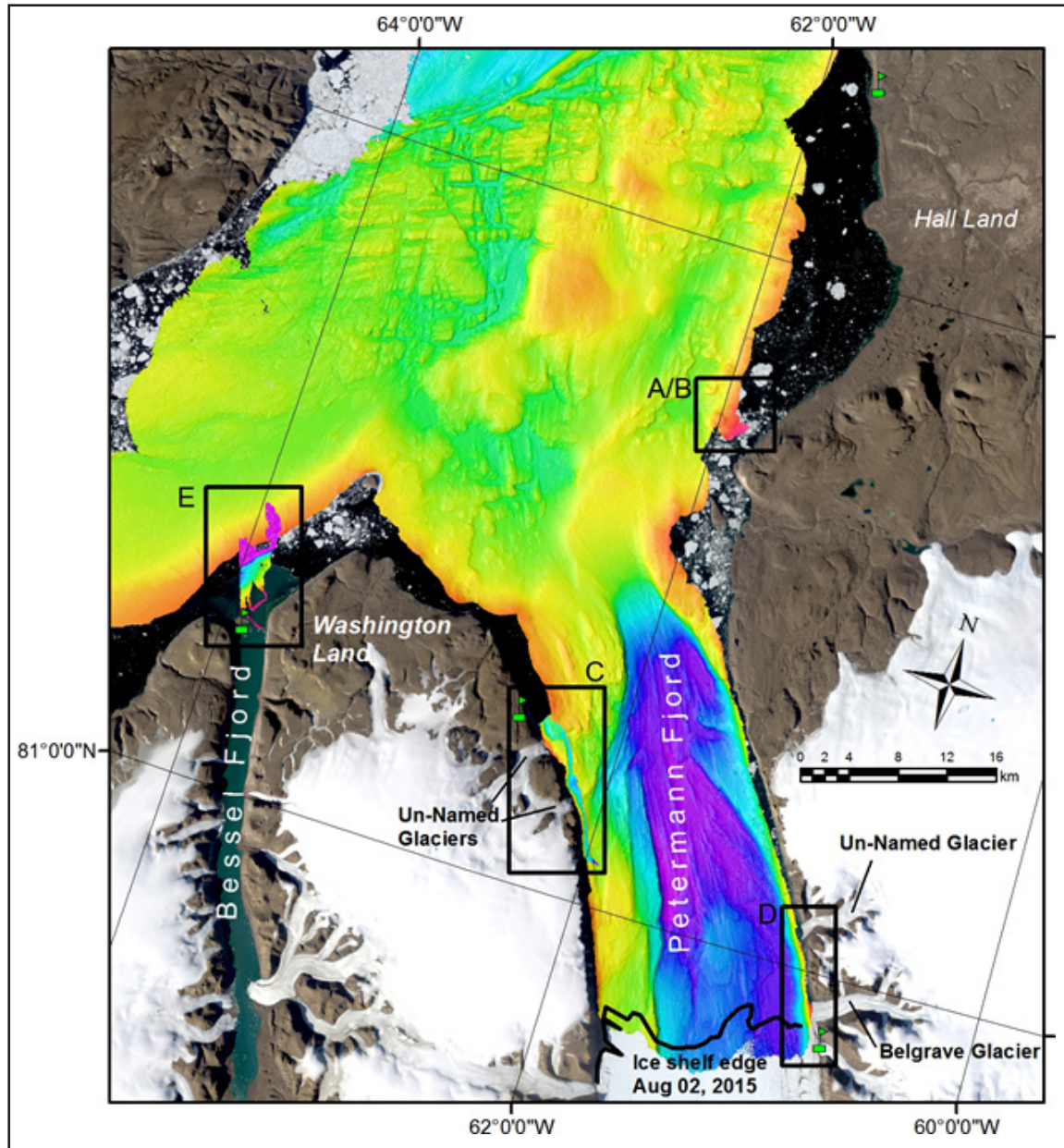


Figure GM-14: Areas surveyed with RV Skidbladner. Before each survey, the RTK reference station was mounted somewhere within radio range. The locations of the station are shown with a green flag.

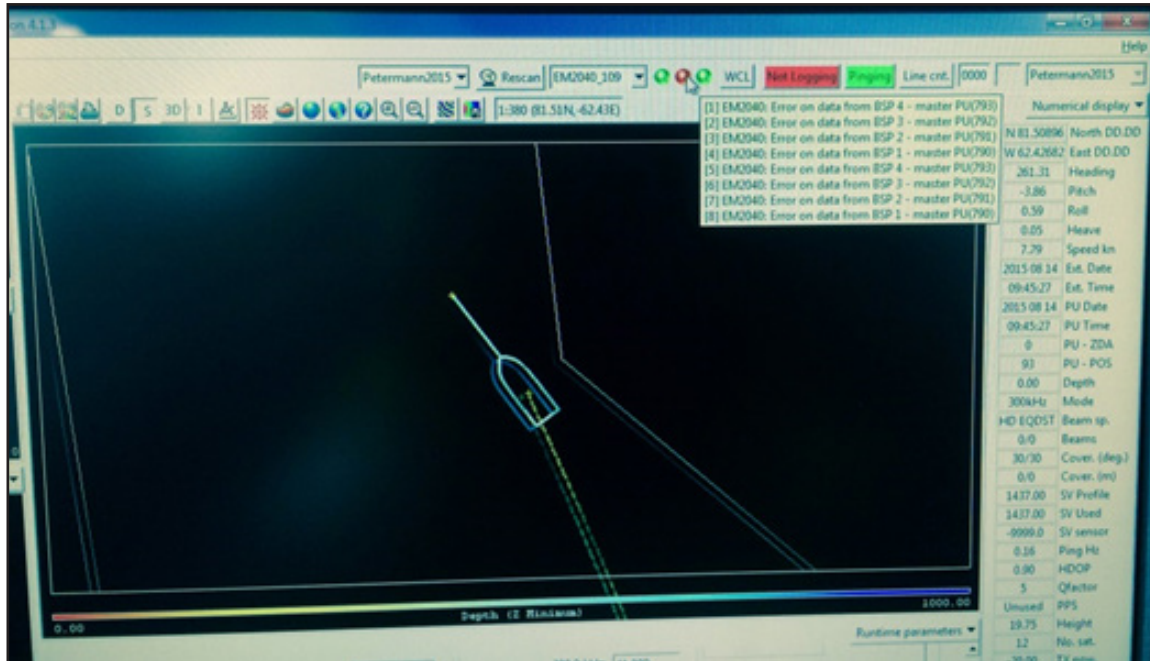


Figure GM-15: Error message during the first RV *Skidbladner* mission.

To our knowledge Bessel Fjord has never been entered before by a boat. The fjord entrance appears to consist of shallow sill that was mapped along two passages, from the island in the southern end of the fjord entrance to the other northern side. The deepest part is comprised of an approximately 33 m wide and 15 m deep passage. Judging from that ice appeared to be stuck inside of the passage we made with RV *Skidbladner*, the deepest part of the sill may in fact be even shallower than 15 m.

High-resolution sub-bottom profiling

High-resolution sub-bottom profile data were collected with the SBP-120 sub-bottom system using Kongsberg Maritime's SBP/TOPAS Ver. 1.5.3 system control and acquisition software. The TOPAS software was further used to automatically convert the raw SBP120 data files (.raw) into the industry standard SEG-Y data format (.seg) for further processing. On board the SEG-Y files were imported into the NRCAN SEGyJp2 software package authored by Bob Courtney of Natural Resources Canada. This software package allows for some gain adjustments during conversion to JPEG2 format, and it allows lines to be combined (or segmented) for ease of interpretation although this was not typically done for this dataset. It also provides a JP2 viewing tool that offers further opportunities to enhance the image produced (e.g., Figure GM-17). The output of this process was then used for core site selection (by correlating these data with the bathymetric surface in ArcGIS) and initial depositional process interpretation.

Only minor problems were experienced with this post-processing routine during the cruise. These included one period (~1300 to 1700 on 2015/08/11) when the TOPAS software did not automatically create the SEG-Y files, which then had to be re-created by replaying the .raw files in TOPAS in replay mode. These files were then run through SEGyJp2 as described above.

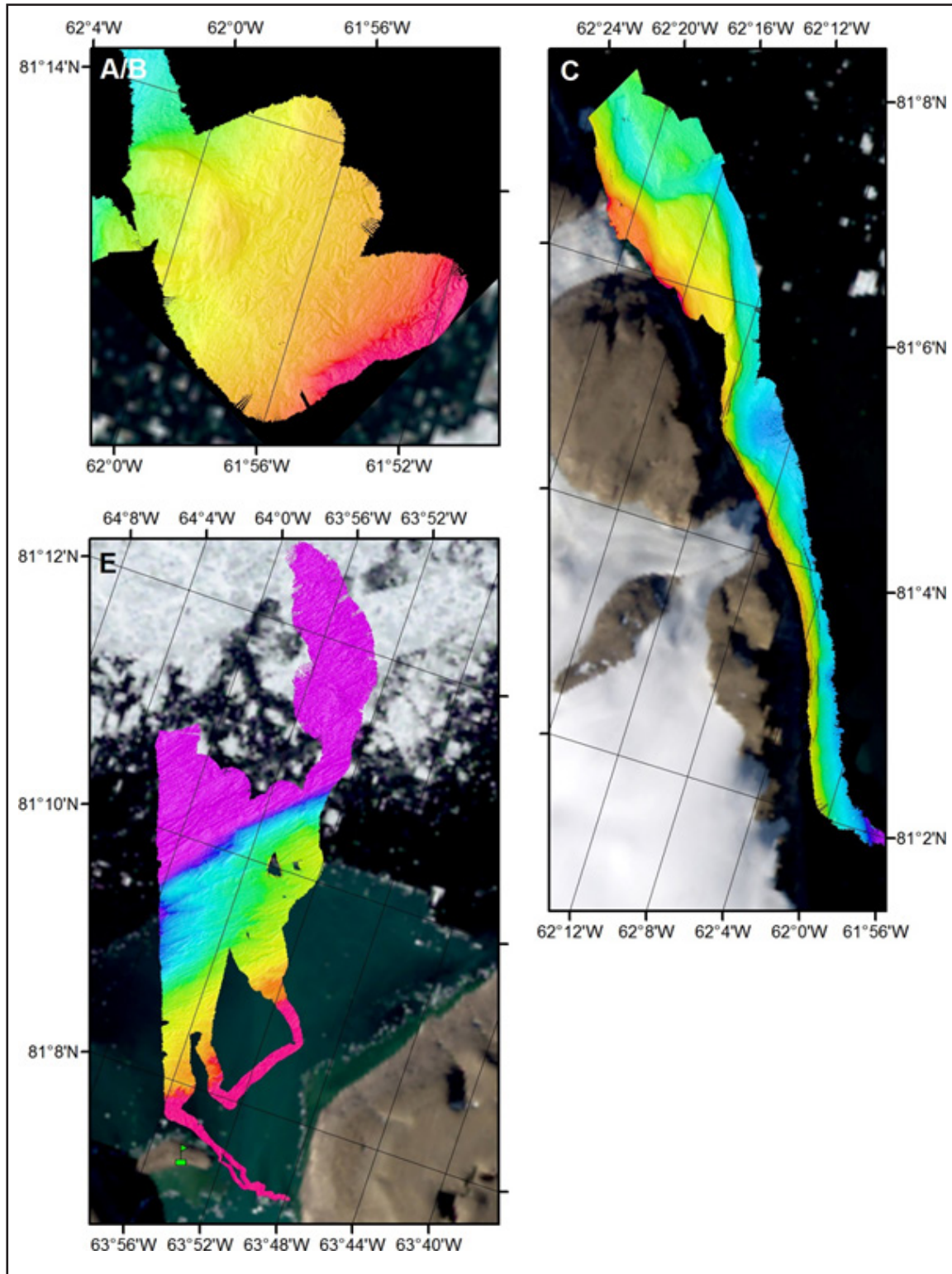


Figure GM-16: Areas A/B, C and E mapped by RV Skidbladner.

Results: Sub-bottom profiles

Data Structure and Organization

SBP data were written directly to disk in the “Raw Data” directory of the D:\ drive of the SBP acquisition computer. All raw data files (.raw), converted SEG-Y files (.seg), and any screendumps (.png) taken during the cruise were stored within D:\RAW DATA\SBP120 in folders called RAW, SEG-Y or SCREENDUMPS, respectively. Due to a hold-over in the script to save screendumps automatically these files all had the prefix “SWERUS_SBP_YYYYMMDD_UTChhmmssNUM” where NUM is an integer count for images taken that day. The RAW and SEG-Y directories were further divided into directories according to which multibeam survey was active when the data were collected, and then in folders by date labelled 2015MMDD. The individual raw data files within each day file were labelled 2015MMDDhhmmss.seg (or .raw for raw files) – Figure GM-18. Daily backups of the raw and SEG-Y data were performed on to two external hard drives.

Sub-Bottom Profiler Performance

The SBP120 sub-bottom profiling system performed excellently throughout the 35 day Petermann 2015 expedition, providing a detailed picture of the structure of the upper 0 to 60 m of below the seafloor, including bedrock structure in some instances. High-resolution sub-bottom profiler data were acquired continuously resulting in the collection of more than 6500 line-km of SBP120 data. Penetration of the seafloor varied with water depth and sediment type ranging from a minimum of <5 m in the intermittent, iceberg-scoured sediments on shallow banks to about 50 m in stratified sediments in Hall Basin (Figure GM-19); in some places in Nares Strait the sub-bottom profiler appeared to return an image of dipping bedrock layers beneath limited unlithified sediment cover (Figure GM-20).

Use of the high-resolution sub-bottom profiles was crucial for determining optimal coring locations in PF, HB and southern Robeson Channel during the expedition. This was because of the rugged morphology of the seafloor in many places, which strongly influences

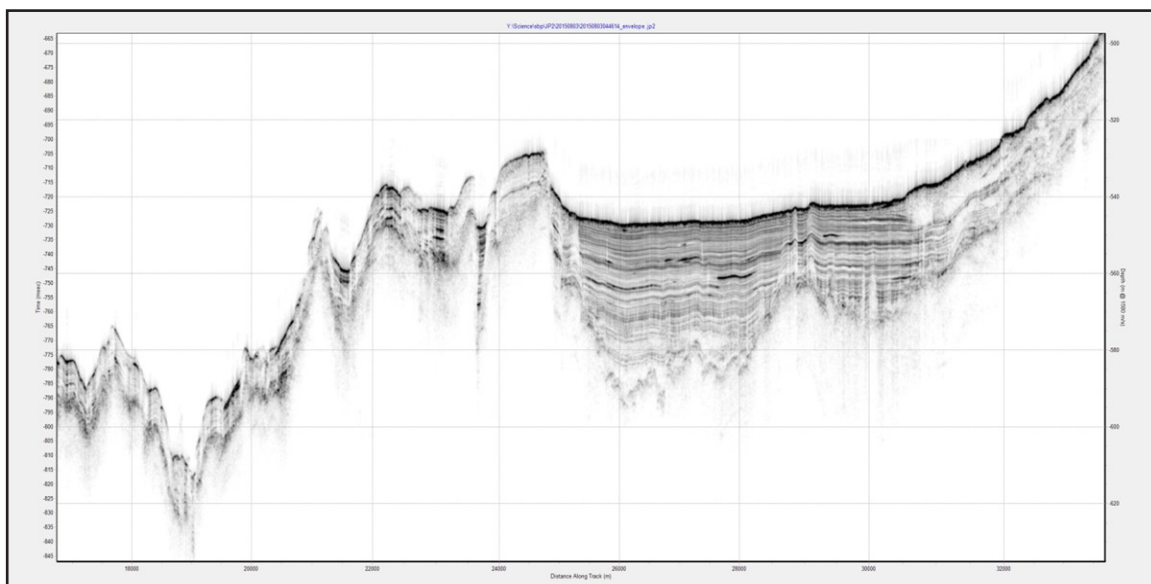


Figure GM-17: Example of shipboard processing of SBP-120 high-resolution profiler data showing basin fill sediments in Hall Basin, outside of Petermann Fjord.

the distribution of unlithified sediment in the area. Sediment thicknesses are greatest in linear depressions and isolated basins, which appear to be characterized by basin fill deposits. Outside of localized deeps the acoustic stratigraphy in Petermann Fjord and Hall Basin is rather consistent with a stratified drape unit overlying a second, acoustically homogeneous conformable unit that overlies what appears to be a non-conformable, homogeneous to transparent unit (Figure GM-21). This latter unit often corresponds to the in which glacial lineations are formed in the area.

Offshore Bessels Fjord the unlithified sediment package is characterized by stacked debris-flow deposits that appear to originate from the slope offshore Greenland and possibly from a shallow ridge across KC to the south. North of the debris-flow deposits is a linear depression or channel that appears to be flanked by stratified overbank deposits.

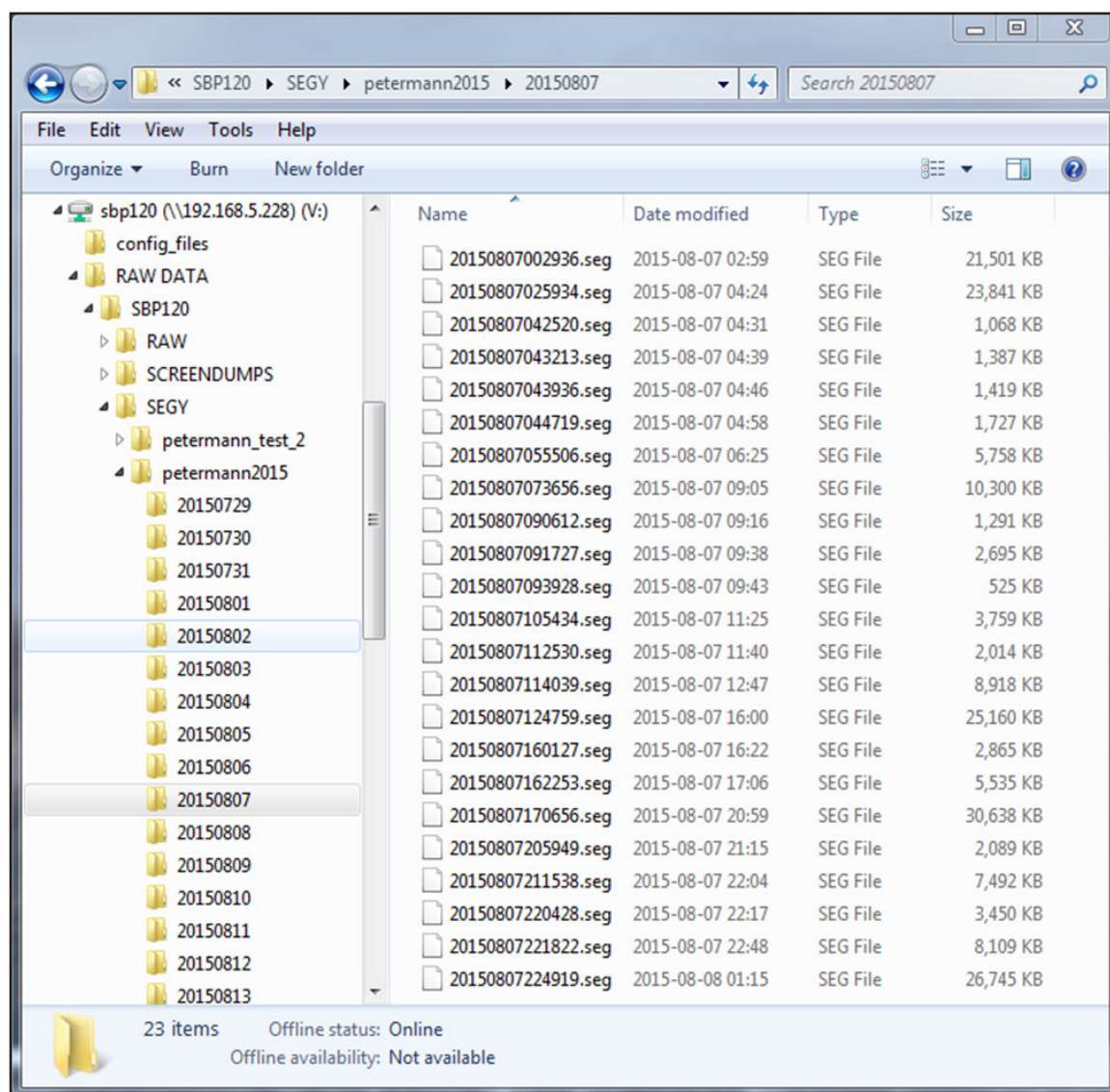


Figure GM-18: Data storage file structure for SBP120 data on Petermann 2015.

Seismic Reflection Survey

The seismic reflection operations were carried out by four members of the scientific crew on-board *Oden* as listed in Table GM-7. Help was provided by two persons from the *Oden* crew to deploy and retrieve the equipment.

Seismic reflection data were collected with an acquisition system, which consists of a standard seismic equipment setup which is modified for data acquisition under extreme ice conditions. Such extreme conditions could occur during the Petermann 2015 expedition. However, open water conditions are actually more likely.

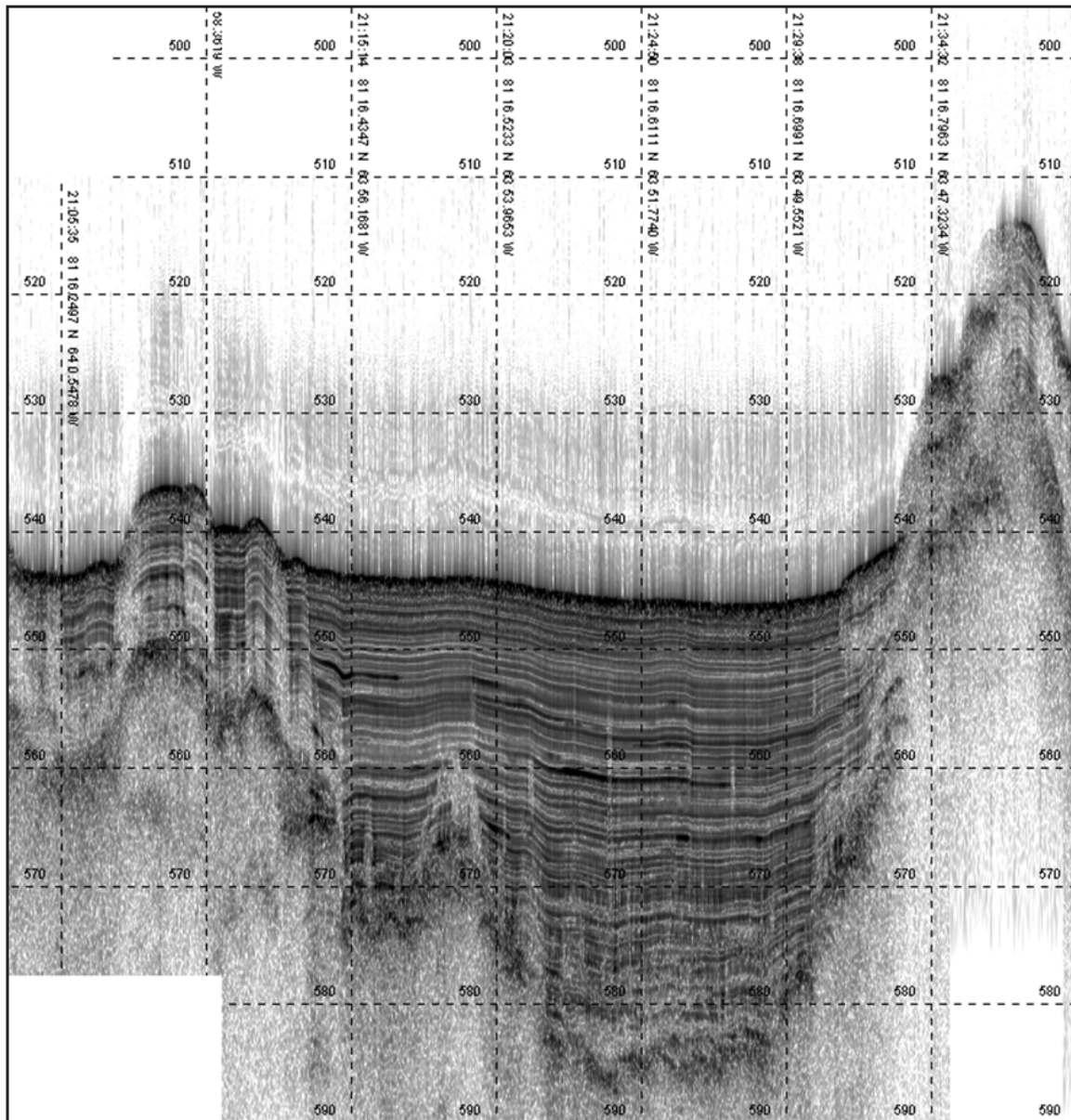


Figure GM-19: Unprocessed example of high-resolution sub-bottom profile showing approximately 35 m of stratified basin fill sediments in a localised depression in HB. Vertical scale is in m below seafloor converted using a sound velocity of 1500 m/s; water depth is approximately 530 m. Seismic penetration here is approximately 40 m below seafloor to acoustic basement (till layer?).

Table GM-7. Seismic Reflection Team.

Name	Affiliation	Function
Katrien An Heirman	GEUS	Post Doc
Egon Nørmark	Aarhus University	Processing Geophysicist
Søren Thesbjerg Andersen	Aarhus University	Student
Per Trinhammer	Aarhus University	Technician

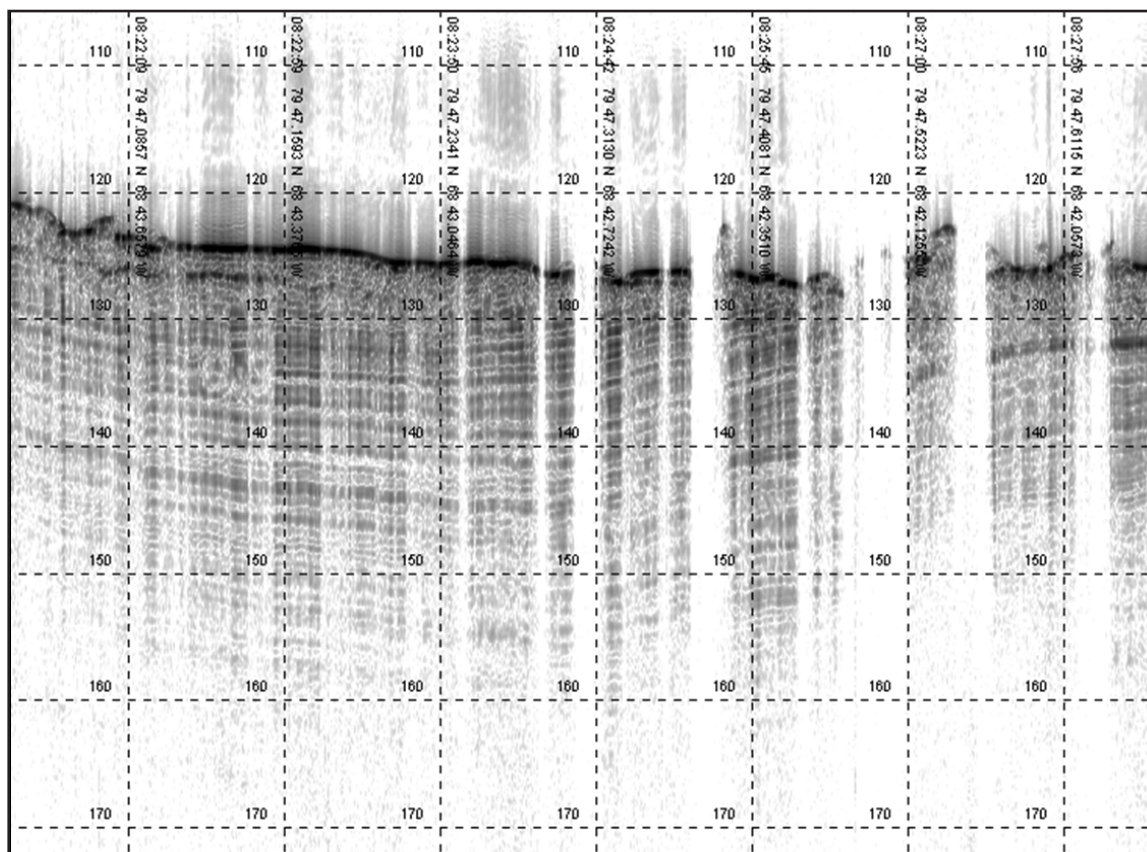


Figure GM-20: Unprocessed example of high-resolution sub-bottom profile showing a thin unit of acoustically-homogeneous material overlying a sharp angular unconformity with dipping and curved reflections below. Vertical scale in meters below seafloor converted at 1500 m/s; water depth is approximately 110 m. Acoustic penetration here is approximately 35 m below the seafloor.

The most important elements of the seismic equipment are a digital streamer and recording system produced by Geometrics, and the seismic source - a so-called GI gun - produced by Sercel. The setup of the entire system used during Petermann 2015 included the same main components as the previous three LOMROG cruises in the arctic, but with a much smaller seismic source. In the following text a brief overview of the seismic reflection equipment used on board *Oden* during the Petermann 2015 expedition is given.

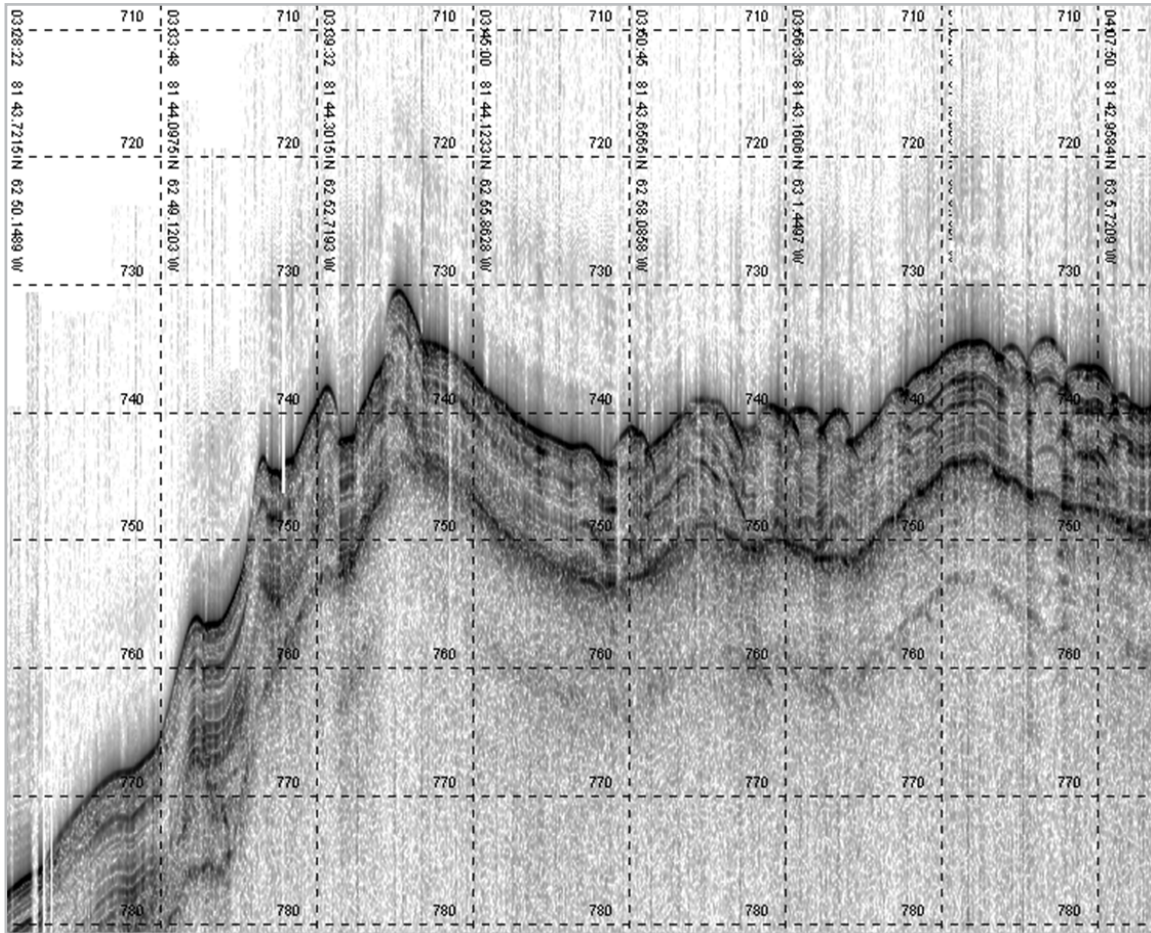


Figure GM-21: Unprocessed example of high-resolution sub-bottom profile showing two conformable units of acoustically stratified then homogeneous material overlying a diffuse, discontinuous reflection that sometimes correspond to the surface in which glacial lineations are formed. Vertical scale in meters below seafloor converted at 1500 m/s; water depth is approximately 720 m. Acoustic penetration here is approximately 35 m below the seafloor.

Seismic Source

The seismic source consists of one GI gun, 210 cu in, (Generator 105 cu in and Injector 105 cu in, Figure GM-22). The volume of the GI-gun has been chosen with ref to other surveys in similar areas.

The firing interval was set to 5 seconds and the firing pressure was at 140 bar. The pressurized air was produced by two Hamworthy 185E_MK2 70mm Series Air Compressors. A trigger pulse generated by NaviPac was sent to the gun trigger unit, Macha TGS-8 (Figure GM-23), which triggered the gun.

A time-break signal was sent to the TGS-8 trigger unit from a near-field hydrophone next to the GI gun for synchronization of the gun.

A hydrophone is placed on the GI gun (Figure GM-22). The signal from the hydrophone was recorded by the TGS-8 trigger unit for near field data.

The Macha TGS-8 is controlled from a dedicated computer running the gun control software program. Within the software program, various settings and displays were used to monitor the gun array behavior (Figure GM-24).

Streamer

The streamer is a digital Geometrics GeoEel streamer (Figure GM-25, left side) with six 50 m long live sections (total active length 300 m) and one 50 m long stretch section. The live sections contain in total 48 hydrophone groups, each composed of 8 Benthos GeoPoint hydrophones. Group separation is 6.25 m and hydrophone separation 0.78 m. Power supply unit (SPSU) to the streamer and all data communication from the streamer take place through the umbilical cable. In the front end of each live section there is an A/D module. In the front of the stretch section there is a repeater module for transmitting the signals through the lead-in cable of the streamer.

Each live section has a depth transducer installed in one end. The streamer is configured with depth transducers in either ends of the sections. Please see Appendix I “Marine Survey general information” for detailed configuration for each section.

Recording System

Data was recorded in SEG-D format (8058 revision 1) on a PC running Geometrics GeoEel controller software CNT-2. The controller was connected to the streamer power supply unit (SPSU) (Figure GM-25 right side) via Ethernet and receives the digitized signals from the streamer as well as auxiliary channels 1–8. Data was recorded simultaneously on a RAID 250 GB hard disk and a USB 1 TB hard disk.

Note: There were two identical USB external hard disks, called GeoEel Disk 1 and GeoEel Disk 2. After each line, the HD was swapped, so the raw data could be downloaded immediately on the processing PC and be processed almost simultaneously during the data collection.

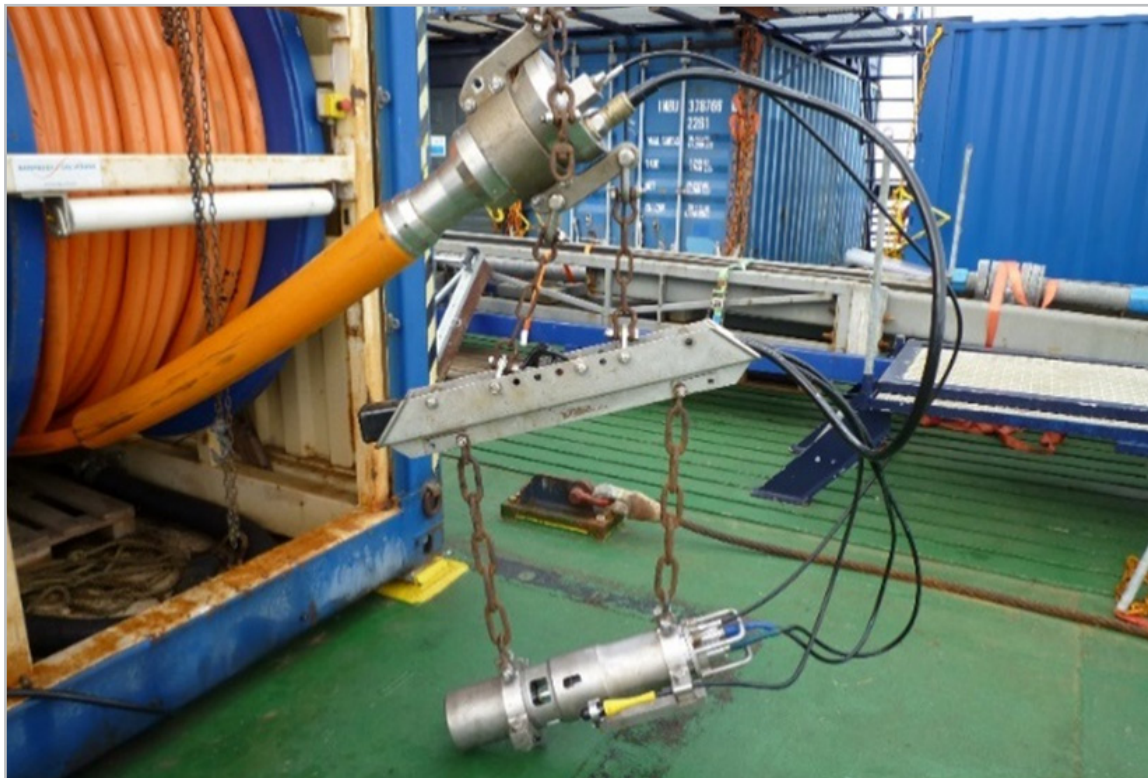


Figure GM-22: Sercel GI gun 210.



Figure GM-23: TGS-8 gun trigger unit and interface unit to umbilical (lower panel). Compressor monitor and air gun pressure (upper panel).

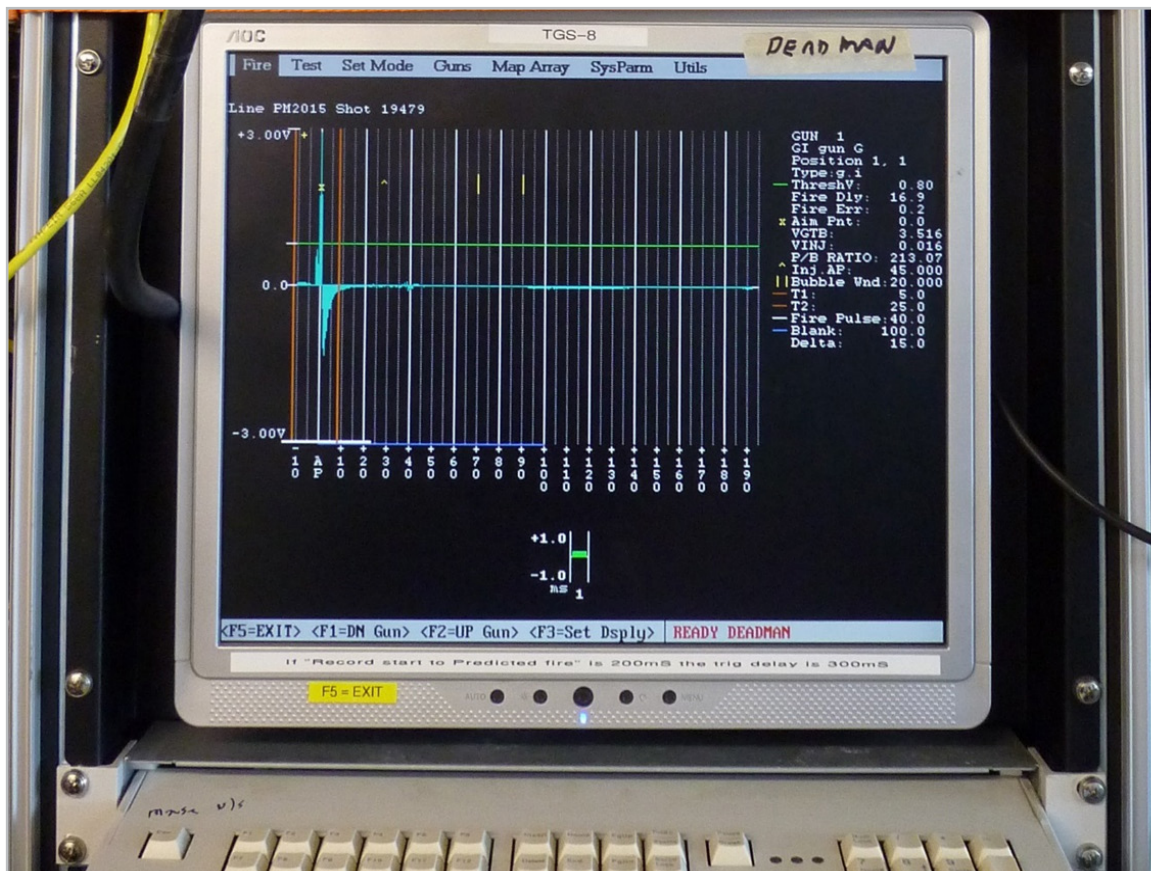


Figure GM-24: The Macha TGS-8 software running on its own dedicated computer. Display is showing the near field pulse from the air gun array.

The navigation software NaviPac sent an event trigger every 5 sec and a string to COM port 1 on the CNT-2 PC. The string contains time, event number, position (x, y for the gun cluster, and x, y for Sparker), center beam depth and the string is transferred to the SEG-D external header. The data string was also stored in a log file on the CNT-2 PC with the filename:

pm15.000x.Nav.txt.

The seismic controller provided the following display facilities during survey:

- A shot gather window (Figure GM-26), where various display settings could be changed as appropriate.
- A single channel window (Figure GM-26).
- A brute stack window (Figure GM-26).
- A noise window, showing noise values in μ bar from all 48 channels as a “snapshot” calculated between shots. Additionally, the noise can be displayed as S/N ratio in dB.
- A trigger window showing the time interval between shots and the energy of a specified hydrophone (in this set-up channel 1).
- A streamer depth window displaying the depth from each depth transducer module.

During the survey the CNT-2 software generated a log file named:

pm15.000x.log

with the following format:

- First line is read from the serial input from the NaviPac software described below (not all numbers are readable in the log file, but all data are stored in the SEG-D header and in a log file called pm15.linenummer.Nav.txt). The format of the string is: time HH:MM:SS:sss (UTC), event no, X pos, Y pos (UTM Zone 20,WGS 84) for gun and sparker, Centre beam depth <CR> <LF>.
- Second line is file no., exact CNT-2 trigger time, size in Kb and reel number.

Furthermore, data from the streamer depth transducers were stored in a text file. These files were named: pm15.000x.Depth.txt

An example of a depth file from the streamer depth transducers is shown in Figure GM-27.

Navigation and Positioning System

A separate Thales DG16 GPS was used to determine the exact geographical location of the seismic reflection equipment together with the navigation and data logging software NaviPac from EIVA A/S. The GPS has a built-in beacon and WAAS receivers for differential corrections. However, the survey area in the NS was outside the coverage area of the beacon system and most of the time also the WAAS system. For that reason, the GPS was most of the time without differential corrections. NaviPac receives antenna coordinates from the GPS.

The NaviPac system provides the trigger signal for the TGS-8, an event trigger and data string for the CNT-2 controller. The shooting interval was 5 sec. Run lines (survey lines) were generated in the so-called Helmsman's display part of NaviPac and the survey is controlled from this display (Figure GM-28). The option of distributing runline data to a



Figure GM-25: Geometrics GeoEel streamer on deck (left). Geometrics GeoEel streamer power supply unit SPSU (right).

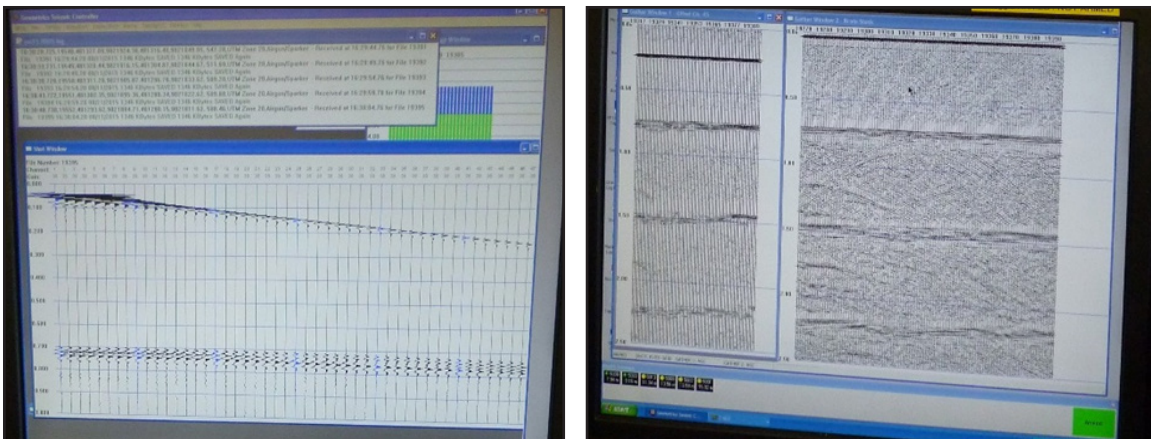


Figure GM-26: Seismic controller display facilities: trigger window, log window and shot gather window (left), brute stack and single trace window and a streamer depth window (right).

Helmsman's display on the bridge running in slave mode was not used, as ice conditions were the controlling factor of the final sail line.

Seismic container and equipment setup

In total, four containers were used for the seismic reflection operation. The winch container with the three winches for the umbilical, streamer and sheave wire, respectively, was placed on port side of the aft deck (Figures GM-29 and GM-30). On the starboard side, one compressor container and a gun workshop container were placed (Figures GM-29 and GM-30).

File: 22309, Depths: 5008: 7.42m 5022: 8.98m 5013: 11.41m 5009: 12.65m 5002: 12.75m 5001: 13.81m	
File: 22310, Depths: 5008: 7.42m 5022: 8.98m 5013: 11.41m 5009: 12.65m 5002: 12.75m 5001: 14.24m	
File: 22311, Depths: 5008: 7.60m 5022: 8.98m 5013: 11.41m 5009: 12.65m 5002: 12.75m 5001: 14.24m	
File: 22312, Depths: 5008: 7.60m 5022: 9.43m 5013: 11.41m 5009: 12.65m 5002: 12.75m 5001: 14.24m	
File: 22313, Depths: 5008: 7.60m 5022: 9.43m 5013: 11.43m 5009: 12.65m 5002: 12.75m 5001: 14.24m	
File: 22314, Depths: 5008: 7.60m 5022: 9.43m 5013: 11.43m 5009: 12.74m 5002: 12.75m 5001: 14.24m	
File: 22315, Depths: 5008: 7.60m 5022: 9.43m 5013: 11.43m 5009: 12.74m 5002: 12.83m 5001: 14.24m	
File: 22316, Depths: 5008: 7.60m 5022: 9.43m 5013: 11.43m 5009: 12.74m 5002: 12.83m 5001: 14.16m	
File: 22317, Depths: 5008: 7.45m 5022: 9.43m 5013: 11.43m 5009: 12.74m 5002: 12.83m 5001: 14.16m	
File: 22318, Depths: 5008: 7.45m 5022: 9.22m 5013: 11.43m 5009: 12.74m 5002: 12.83m 5001: 14.16m	
File: 22319, Depths: 5008: 7.45m 5022: 9.22m 5013: 11.24m 5009: 12.74m 5002: 12.83m 5001: 14.16m	

Figure GM-27: Example of a depth file generated by the CNT-2 software from the input data from the depth transducers in the active streamer live sections.

Cables were connecting the umbilical winch and the recording container placed on the port aft side of deck 4 (Figure GM-31). The recording container houses the navigation software (NaviPac) and multichannel acquisition system (Geometrics CNT-2, SPSU and TGS-8).

Seismic Reflection Equipment for Data Acquisition in Ice

The strategy and procedures for handling of air guns and streamer as practiced on Petermann 2015 were based on the experience gained during previous seismic cruises in the Arctic Ocean.

The three prime concerns were: 1) to minimize the risk for ice-induced physical damage of the equipment towed in the water behind the icebreaker; 2) to reduce the risk for elevated noise levels by having the streamer forced up into the turbulent propeller wash and 3) to find an acceptable replacement for vulnerable active streamer-depth controllers (“birds”).

It was found that the most reasonable way to achieve these goals was to:

1. Build the towing system for source and streamer as compact and robust as possible, and for the sake of avoiding entanglements, using a minimum of cables, wires and chains;
2. Increase the tow depth to relatively calm waters below the most energetic part of the propeller wash, and since this depth was unknown, to construct the tow system to allow for large flexibility in towing depth;
3. Install passive depth transducers at the source and in the streamer with a spacing suitable for obtaining depths sufficiently reliable to secure high-quality stacked sections.

Point 2 have some clear disadvantages due to the fact that the high frequency content is lower when having the gun deeper. See Appendix II, “Seismic source signature test” for detail. So our goal was to keep the gun and streamer shallow but still have the possibility to lower to tow deeper if we got into a heavy ice area. On line 0004 to line 0007 we used a buoy to keep the airgun at 6 meter water depth and had an offset from the ship to the gun of 40 meter. From line 0008 and onwards, we removed the buoy to get the flexibility to lower the array. To keep the gun and streamer in the same depth of the first lines, we use

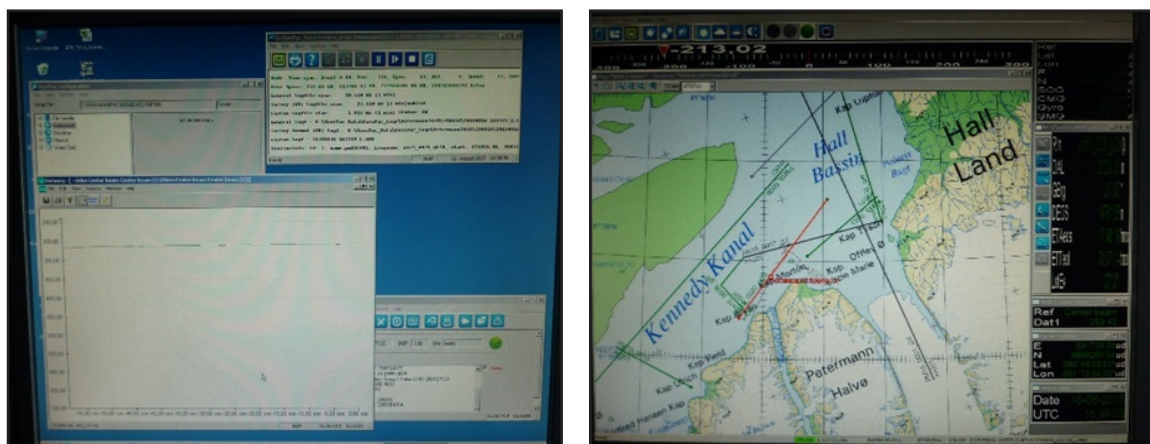


Figure GM-28: NaviPac setup window (left) and NaviPac Helmsman's display for survey control (right).

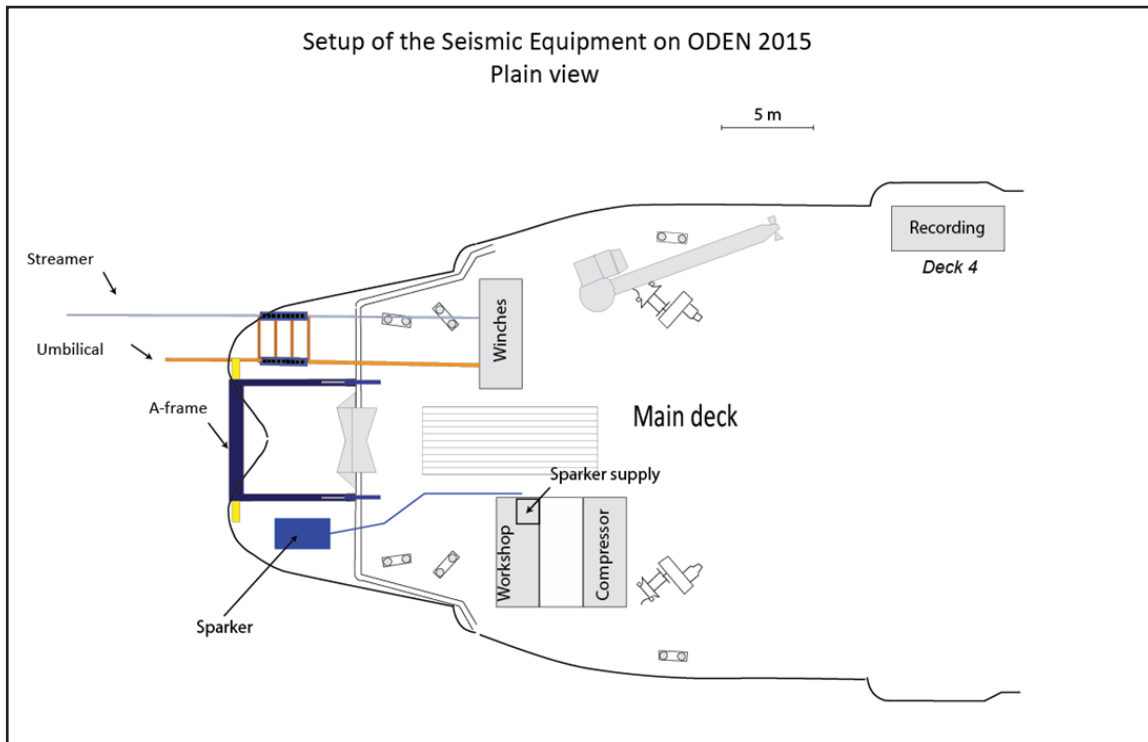


Figure GM-29: Plan view showing location of main equipment components on aft deck and deck 4.



Figure GM-30: Containers on aft deck: (A) winch container; (B) compressor container (white), workshop container (blue) in the upper layer to the right; interior of compressor container: (C) and ; (D) interior of workshop container.

an offset of only 15 meter from the ship to the gun. This worked well and we did not have to lower the gun at any time, as we could avoid going into heavy ice areas.

Equipment and Procedure for Handling Source and Streamer

The key element in the handling system is the umbilical. It is a heavy duty cable (breaking strength 50 tons) constructed to serve both the air gun (hoses for compressed air, triggering cables, cables for near field hydrophones and depth transducer) and the streamer (data communications with the A/D modules and the hydrophones, cables to depth transducers, power cables). The umbilical sits on a hydraulic winch (right side in Figure GM-32).

The sea-end of the umbilical is terminated in a robust stainless steel head with all cable and hose terminals placed on the plane lower surface of the head and protected in a cone of steel sleeves and rods (Figure GM-33). The streamer is connected to the umbilical head via a 3.5 m jumper cable contained in a robust, steel reinforced rubber hose. The gun is connected via an octopus cable to the umbilical head. The octopus and pigtail connector for the gun is secured in a U-beam between the umbilical head and the gun. The air hose is connected directly from the umbilical head to the gun.

The launching of air gun and streamer takes place in a concerted procedure composed of the following sequence of steps:

1. The umbilical in the umbilical sheave and the air gun cluster is lifted in the A-frame (Figure GM-33) by the wire winch (left hand side in the winch container as seen on Figure GM-32) and lowered to the aft deck next to the platform for docking of sheaves for streamer and umbilical.
2. The streamer is launched at low speed, preferable around 3 to 4 kn.
3. The deployment of the streamer begins by unrolling the streamer from the winch (middle section Figure GM-32) and bringing the tail end to the streamer sheave. On its way to the sheave, it is guided by two four side roller ports on the aft railing. From this point the streamer is deployed into the water. When the streamer is paid out to the desired length, here either 300 or 350 meter, the streamer is tied off with a Chinese finger on the outboard part of the streamer and disconnected from the dry end. Then the outboard end is connected to the streamer jumper cable on the umbilical head.
4. The umbilical with the air gun and the streamer is now lifted in the sheave and at the same time the A-frame is turned outwards to establish free passage for the umbilical with air gun and streamer to be brought in the final position with the 15-m or 40-m mark on the umbilical at the level of the deck.

The sketch in Figure GM-34 illustrates the complete system when the ship has reached speed of 3 to 5 knots and collection of data is ongoing and Figure GM-35 shows a photo from the aft deck during acquisition of seismic data.

On the first 4 airgun lines (0004 to 0007) a buoy was used to control the depth of the gun array. The buoy kept the gun at a depth of around 5 to 6 meter. As we were operating in nearly open water, this was possible. From line 0008 and onwards the buoy was no longer used, as we expected to go into more dense ice areas. If this happened, we were able to pay out more umbilical cable, to get the gun and streamer to dive below the ice floes. As we would like to get high frequency content in our data, we prefer to have the gun at around 6 meter, as much as possible. For that reason, we only paid out 15 meter of umbilical. With reference to the depth indicator at the front part of the streamer we estimated that the

gun was at around 6 meter. In Figure GM-36, there is a comparison between the gun at 6 meter and 20 meter water depth. It is clear that the signature and frequency spectra are much better at 6 m.



Figure GM-31: Recording container on deck 4 (left) and interior of the container (right).



Figure GM-32: Seismic winch container.

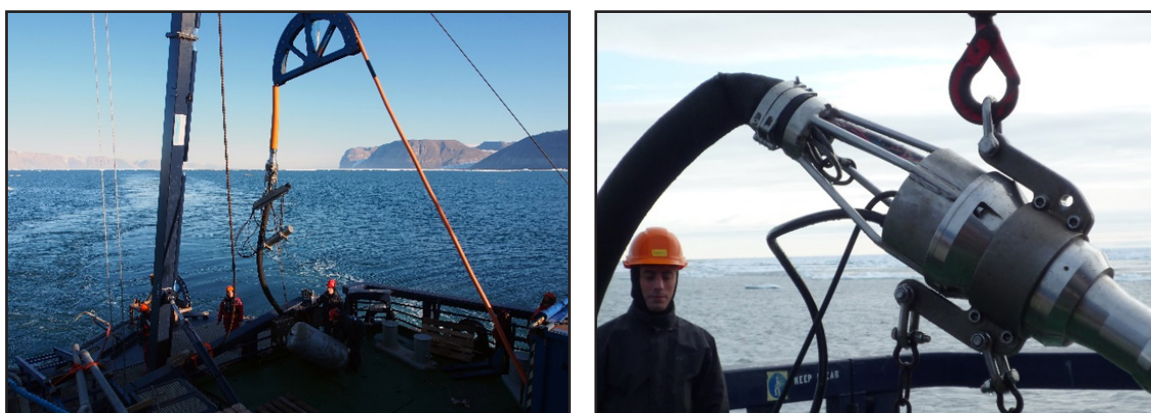


Figure GM-33: The sea end of the umbilical hanging in the A-frame (left) and close-up photo of the umbilical head (right).

Depth Monitoring System

Unfortunately, the depth transducer for the gun cluster was out of order, and the spare one was broken as well. So, we did not have the depth information from the gun. Nevertheless there were depths transducers in each active seismic section.

From the Geometrics GeoEel controller, the time interval requested by the system about depth information from the depth transducers is set. Throughout the whole survey the depth for each streamer section was interrogated during every shot.

As the streamer is connected to the head of the umbilical, and the gun is suspended beneath this with 2 m long chains, our assumption is that the gun is at the same depth as the front of the first streamer section. The distance between the gun and first section is 53 meter

As an example of streamer behavior, *Oden's* speed and depth of streamer were extracted for Line 13 as shown in Figure GM-37 and Figure GM-38. Notice that the streamer depth is stable around 6 m (+2 m) as long the speed is more than 3 m/s. At the right side of the diagram, it is clear that the streamer dive when the speed is below 2 m/s.

Seismic Reflection Acquisition Parameters

For each survey line, a marine survey sheet with acquisition parameters and equipment serial numbers etc. was completed. The acquisition parameters are summarized in Table GM-8.

Oden is equipped with GPS and other navigational systems used for navigation. A separate GPS system was used for seismic reflection data acquisition with the navigation software

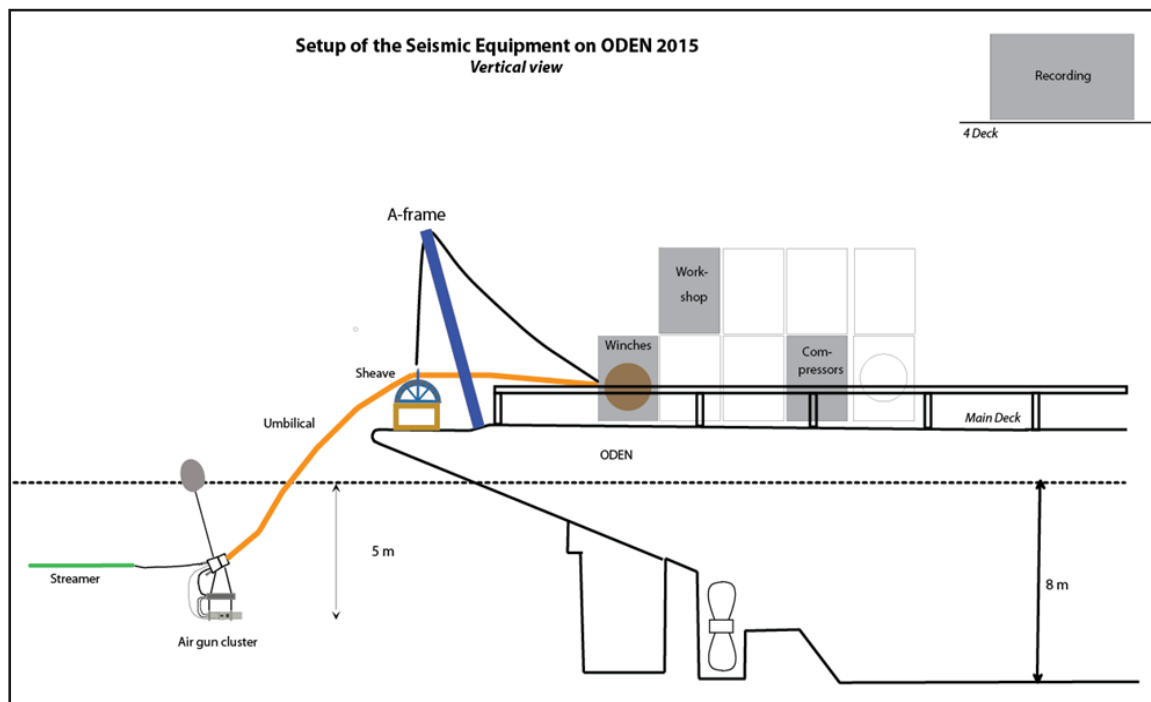


Figure GM-34: Vertical view of the setup during data acquisition. The text in the grey rectangles (containers) indicates the function they have in the seismic setup.

NaviPac to log and calculate the positions as well as to log the external data from the vessels Furuno gyro compass and the Kongsberg EM120 multi beam echo sounder. In addition, NaviPac generated the trigger signal for the seismic acquisition system.



Figure GM-35: Photo from the aft deck during seismic data acquisition with the seismic equipment deployed.

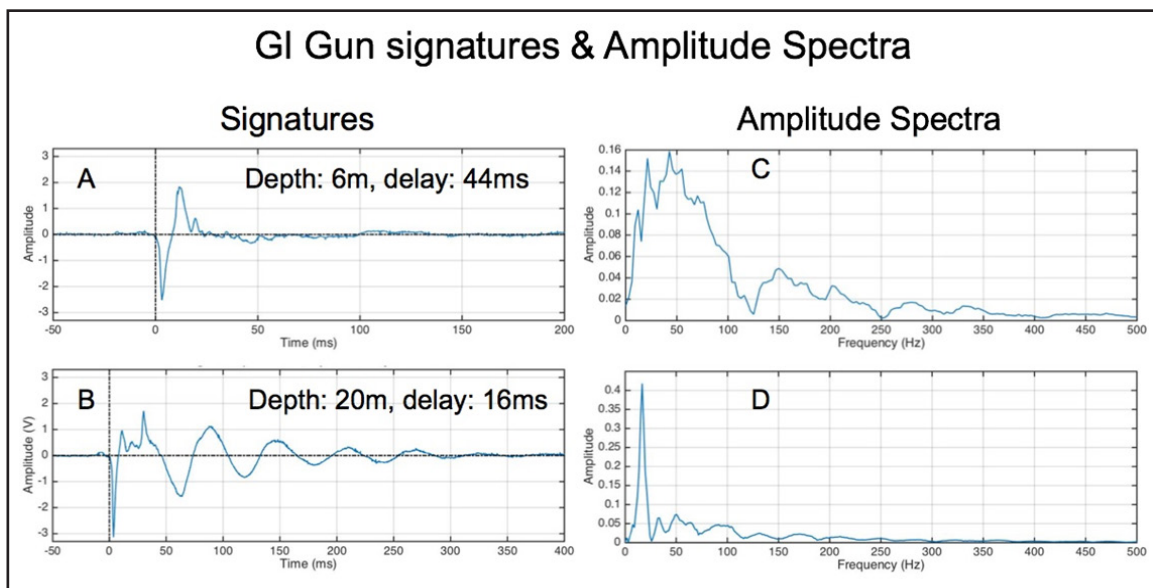


Figure GM-36: The source signature and frequency spectra of the used GI gun. Notice the very high peak at around 25 Hz in D.

Definition of Offset Points

In NaviPac a number of offset points were defined referring to the reference point of the vessel. The reference point is the midpoint of the vessel in the longitudinal and transverse direction in the horizontal plane and at the waterline in the vertical plane. A survey of the

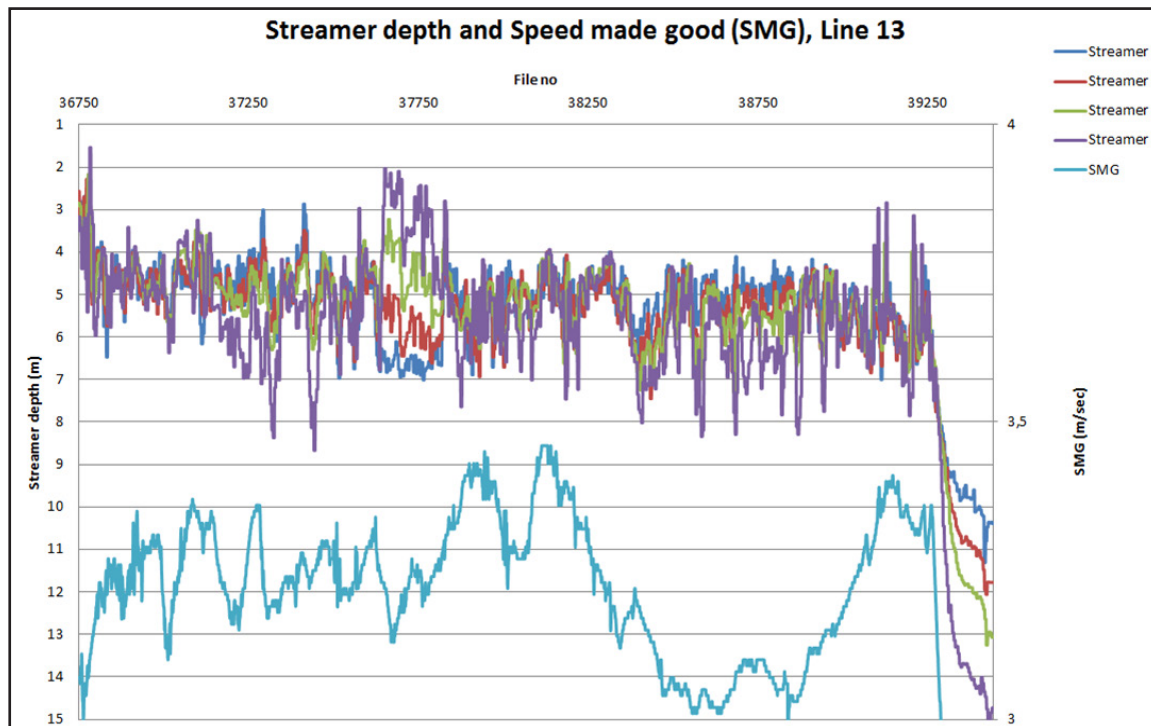


Figure GM-37: Streamer depth along line 13 and speed made good.

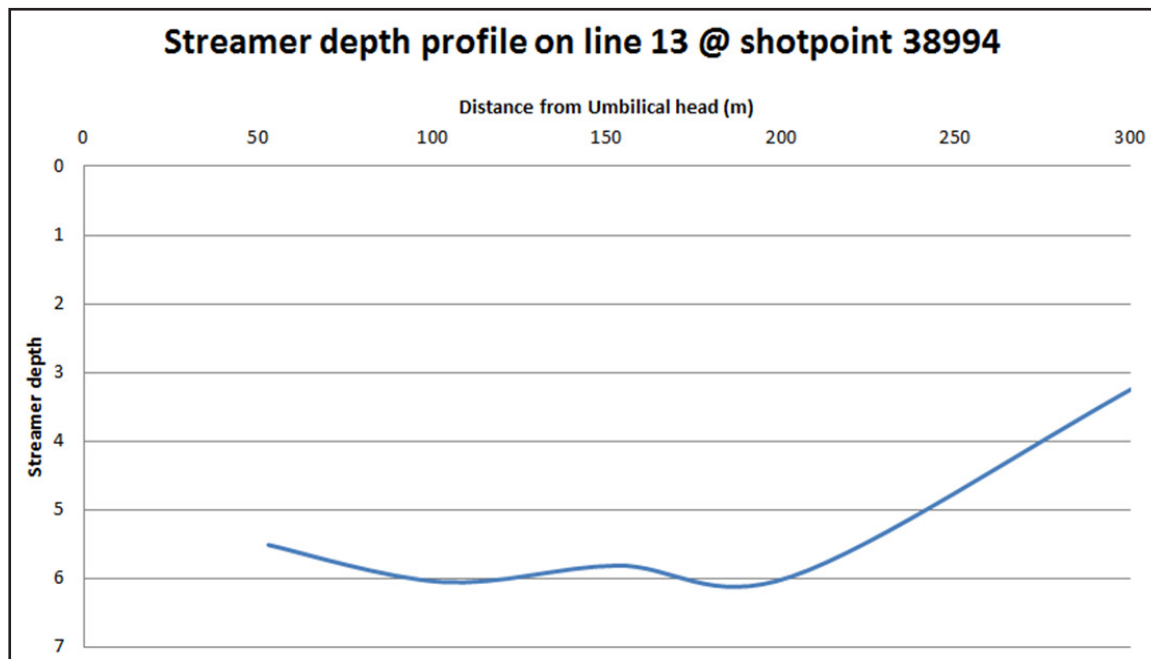


Figure GM-38: Streamer shape in the water. Notice the tail is higher than the rest. From line 14 and onwards this is changed, as we added a piece of lead at the very end of the streamer.

vessel was carried out in April 2007 by Metria and Sjökarteenheten at Landskrona Varvet in Landskrona, Sweden, using a total station and a theodolite. A local metric coordinate system was established and the x, y, and z coordinates of the reference point defined as 0,0,0. The x-axis is defined across ship and positive in the starboard direction, the y-axis is defined along ship and positive in the forward direction, while the z-axis is vertical with positive upwards. Coordinates in this local coordinate system were now established for a number of fixed points and installations onboard *Oden*.

A separate antenna was mounted for the GPS system used by the seismic acquisition system. The local coordinates of the antenna were defined measuring the distance in the x, y and z directions, respectively, to point 6 on the vessel reference point (see Appendix I). Similarly, the local coordinates of the tow point (point 3 in Appendix I) of the umbilical – towing the airguns and streamer – were defined. The vessel reference point, the GPS antenna and the umbilical tow point were all defined in NaviPac using their positions in the local coordinate system.

Additional offset points in NaviPac were the airgun midpoint and the first hydrophone of the first hydrophone group (channel 1) on the streamer. The local coordinates of these two points were defined measuring the length of the tow cable and the combined length

Table GM-8. Summary of acquisition parameters.

Source	Sercel GI gun
Chamber volume	210 cu.inch (G=105 I=105)
Gun pressure	140 bar (2000 psi)
Mechanical delay	Automatically adjusted to 0 ms
Nominal tow depth	6 m
Streamer	Geometrics GeoEel
Length of tow cable	40/15 m
Length of vibration section	53 m
No. of active sections	6/4/5
Length of active sections	300/200/250 m
No. of groups in each section	8
Total no. of groups	48/32/40
Group interval	6.25 m
No. of hydrophones in each group	8
Depth sensor	In each section
Nominal tow depth	6 m
Acquisition system	Geometrics GeoEel controller
Sample rate	0.5 ms
Low-cut filter	Out
High-cut filter	Anti-alias (405 Hz)
Gain setting	0 dB
No. of recording channels	48/32/40
No. of auxiliary channels	8
Shot interval	5 s
Record length	3 s

of the jumper cable and the vibration section of the streamer assuming a tow depth of 6 m. The length of the tow cable was from 15 to 40 m. The airgun cluster was mounted in chains under the end of the tow cable and the length of the array is ca. 0.6 m. The combined length of the jumper cable and vibration section up to channel 1 on the streamer was 53 m. The airgun midpoint and channel 1 were entered into NaviPac as offset points with coordinates relative to the tow point.

Offset coordinates used and defined in NaviPac are given in Table GM-9.

Geodetic Reference System

The geodetic datum for all positions recorded or calculated (except offset for coordinates in the local vessel coordinate system) during the survey was WGS84 and no datum shift has been applied to the data. Hence all latitude and longitude coordinates are in WGS84 datum. NaviPac used UTM projection and all x and y coordinates are given in UTM projection and WGS84 datum in zone 20N. All coordinates processed in NaviPac, were transformed to the UTM projection, meaning that all logged geographical coordinates were transformed to UTM and back to latitude and longitude. Details are given in Table GM-10.

Navigation, Positioning and Trigger Generation

Run lines (the desired survey lines) were distributed to the bridge as waypoint coordinates and the vessel was navigated using its own navigation system. Because of the ice-conditions, large deviations from the distributed survey lines were expected. A NaviPac Helmsman's display was not set up on the bridge to aid navigation. This was because the actual track of the vessel was often controlled by the local ice situation.

NaviPac received an updated GPS-antenna position and vessel gyro course every second and calculated real-time positions for the defined offset points. Positions for the vessel reference point and the umbilical tow point were calculated using the raw GPS-positions of the antenna, the local offset point coordinates and the gyro course of the vessel.

Positions for the airgun midpoint and streamer channel 1 were calculated with reference to the position of the tow point using the drag method. Using the drag method the position of the offset point is calculated by projecting the travelled distance along the sailed route of the drag point, here being the tow point.

NaviPac was also used to generate the trigger signal for the seismic system. It was decided to shoot with constant time intervals. The interval 5 s was chosen as the minimum when a recording length of 3 s was needed to secure penetration to basement.

Shooting on distance would be the alternative option, but this was discarded mainly due to the fact that the ships speed in the ice - according to experience - is difficult to control. Substantial variations can be expected and too high speed would lead to generation of a trigger pulse before termination of the recording of the previous shot. Furthermore; at low speed the extended time between consecutive shots may cause compressors to have series of unwanted stop/start sequences as the pressure passes the pre-set maximum allowed pressure.

NaviPac Log Files

In NaviPac three log files are generated during the survey. These are named `yyyymmdd_hhmmss_Z.npd` with Z being C, G or S for the custom, general or survey file format, respectively. Year, month and date are specified by yyyy, mm and dd, respectively. The hh-mmss is start time of the line.

The custom file contains for every shot:

- Time
- Event
- GI gun (position for airgun midpoint) in UTM projection
- Sparker (position) in UTM projection
- *Oden* Centre beam
- SMG (Speed Made Good in m/s).

The general file and survey file also contains the above data plus other navigation data, such as projections, offset points (in UTM projection and latitude/longitude) and GPS raw data. Furthermore, the survey file is formatted so it can be imported directly into the post processing software “NaviEdit”.

Table GM-9. Offset point coordinates.

Offset point	X (m)	Y (m)	Z (m)
Vessel reference point	0.0	0.0	0.0
GPS antenna	-11.25	13.40	25.30
Umbilical tow point	0.0	-54	4.65
Airgun midpoint	0.0	-40/15	-6
Streamer channel 1	0.0	-93/68	-6

Table GM-10. Geodetic reference system.

Geodetic datum	WGS84
Ellipsoid	WGS84
Semi-major axis (a)	6378137
Inverse flattening (1/f)	298.257223563
Eccentricity sq. (e2)	0.081819190843
Projection	UTM (north) Zone 20
Scale factor at pole	0.994
Origin latitude	0° 00' 00"N
Central meridian	-63° 00' 00"W
False northing	0 m
False easting	500.000 m

Acquisition Performance

Through the collection of the seismic lines 4–20, the acquisition system generally had a satisfactory performance. A few technical problems occurred during acquisition, but all were easily and quickly repaired and did not influence the collection on data acquisition. See more detail in chapter 5.3, “Notes during acquisition”. A total of 777.5 km of seismic data was acquired during the Petermann 2015 expedition.

Line 1 to 3 was collected data with the sparker source. The setup of the sparker had not been tested before on *Oden*, so there were a few things that turned out not to be working as hoped. First of all, the speed of the ship was around 7 kn. The ice condition required *Oden* to run on both propellers. The streamer was towed at port side and a 350 meter streamer with 1 bird in the front end to control the depth of the streamer was used. Due to the speed, the turbulence and the balancing of the streamer, it was impossible to get the bird to dive. We added extra lead on the streamer, extended the tow lead and lowered the tow point, but unfortunately there was no change. The other problem was the sparker source itself. The sparker source was towed 36 meter behind *Oden* at the starboard side. The propeller wash was high and the signal from the sparker was highly influenced by this. Consequently the data was rather noisy; even preventing the detection of the seafloor in some places. Turning off the starboard side propeller for about 15 minutes, lowered the noise level drastic. Running with only one propeller was not possible for more than 15 minutes due to engine issues on *Oden*. Therefore, data collection with sparker as a source was abandoned.

Two things to consider for future sparker work from *Oden*, would be to have a possibility to run with only the port side propeller and to have a longer power cable, so the sparker source can be towed further away from the ship.

Notes during acquisition

10 August – Airgun at 6 meter (or from 5 to 6 meter). Grey buoy connected with 3 meter chain and swivel to head of the mud hose head. Streamer connected to mud hose with 3.5 meter jumper cable. 50 m stretch section and 6 active sections. Gun is hanging below mud hose head in chain, with a U-beam for the pig tails. Air hose pig tail used is a Tuflex hose.

Streamer depth is at around 7 to 16 meter. Would have expected more like 3 meter (as it is connected to the mud hose head, that is in around 3 meter due to the grey buoy).

Umbilical cable is towed 40 m behind tow point (cable sheave cradle).

Shooting every 5 sec. Record length at 3 sec. Gun pressure @ 140 bar. Need two compressors to keep the pressure at 140 bar. If we only run with one, the pressure stays at 120 bar.

11 August @10:00, air-hose fitting from compressor to umbilical was leaking. Tighten the fitting, now it is sealed

11 August @ 13:00, changed the 2 stage pressure gauge on comp 2. The old was melted.

11/8 kl 14:15, gun controller HD went full, so the controller only shot for every 4th trigger. So we got only every 4 shots from SP 17721 to 17766. Means some around 160 shots are incorrect.

11 August kl 21, oil leak on oil cooler on comp 2. Fitting lose, tighten it and it is good again. Topped up the oil on both compressor. Comp 1 around 2 liter and comp 2 around 4 liter.

12 August, far-field signature of our gun and sparker.

17 August, deploy of gear at 10:00. On the first line 0008, we noted at the end of the line, that the injector delay was set un-correctly to 16mS. This delay was set to 16mS, when we did the far-field signature experiment. It was set back to the correct value, 44mS. This had a lot of influence on the bobble pulse.

Compressor 2, 2. Stage pressure gauge is broken again!. Leakage on SPSU @ 13:00, stays at 1300 all the time. Retrieve the streamer @ 17:00, due to helicopter operation. The guns stay out in the A frame. Expect to deploy @ 19:00. During retrieval of the streamer, section no 5013 was snatched by the cable sheave, and the hose got damaged and silicone oil was leaking. It turned also out that section 5009, had a broken depth transducer fitting inside, with the result that the streamer got filled with saltwater. The two sections were taken out and we continued with only 4 section. New sections are ready to connect next time the gear is onboard. The two new sections are 5015 and 5016.

When we had to connect the two new sections, we checked the last section for leakage. It turned out that it was this section that causes the leakage we have had for a long time. This section is taken out, so we now have configured the streamer for next deployment to 5 active sections.

27 August @ 23:00, deployment of the gear. Added one plate lead to the tail end. Depth on the tail seems to be better now and at the same depth as the rest of the streamer.

At start up of GeoEel, there were performed a reset/detect of the streamer. For some reason the new IP numbers in the reedit was not updated and result in some malfunction when starting the CNT-2 program. After editing the reedit to the right IP numbers, the program was running again.

29 August @13:00, retrieving of the seismic equipment. Under this operation, the 2nd AD-converter/active section got caught in the cable sheave and this made a perforation in the skin. (Active section s/n 5022). Furthermore, the tail rope was stock on the outer rubber boulder at the aft of the ship. These are both things that have to be improved for next project.

29 August @ 20:00, deployment of the seismic equipment. The perforation on active section s/n 5022 was repaired on the way out with vulcanized tape. After 50 min of acquisition it turned out that the planed line would cross 80 degree north line, and we had only permission to work above 80 degree north. We retrieved the seismic gear for the last time and the survey was finished from our side.

WC – Water Column Imaging

The Water Column Mapping program on Petermann 2015 was designed to explore the feasibility of using newly developed water column imaging techniques to better understand seafloor, glacial and oceanographic processes in the region. The Water Column Mapping team used both the EM122 multibeam sonar and a specially installed EK80 broad-band split-beam sonar to map the distribution of mid-water targets (biological scattering layers, fish and marine mammals, sediment plumes, gas seeps, etc.) and to understand their spatial distribution in relation to the geologic context, proximity to glacial input, and oceanographic conditions.

Equipment

Multibeam, sub-bottom profiling, and seismic profiling systems

(Described in Sections 3.1, 3.2, and 3.3, respectively)

EK60 Echosounder

The EK60 echosounder standardly installed on the *Oden* is a split-beam scientific echosounder produced by Kongsberg Maritime that is typically used for fish stock assessment and can be coupled with a number of different frequency transducers. On *Oden*, the EK60 is coupled with a Simrad ES18-11 transducer with a nominal -3 dB beamwidth of 11° at 18 kHz. The ES18-11 transducer is mounted on the ice keel at Frame 93, 60 cm starboard of the center line (Figure WC-1). The EK60 transceiver (General Purpose Transceiver or

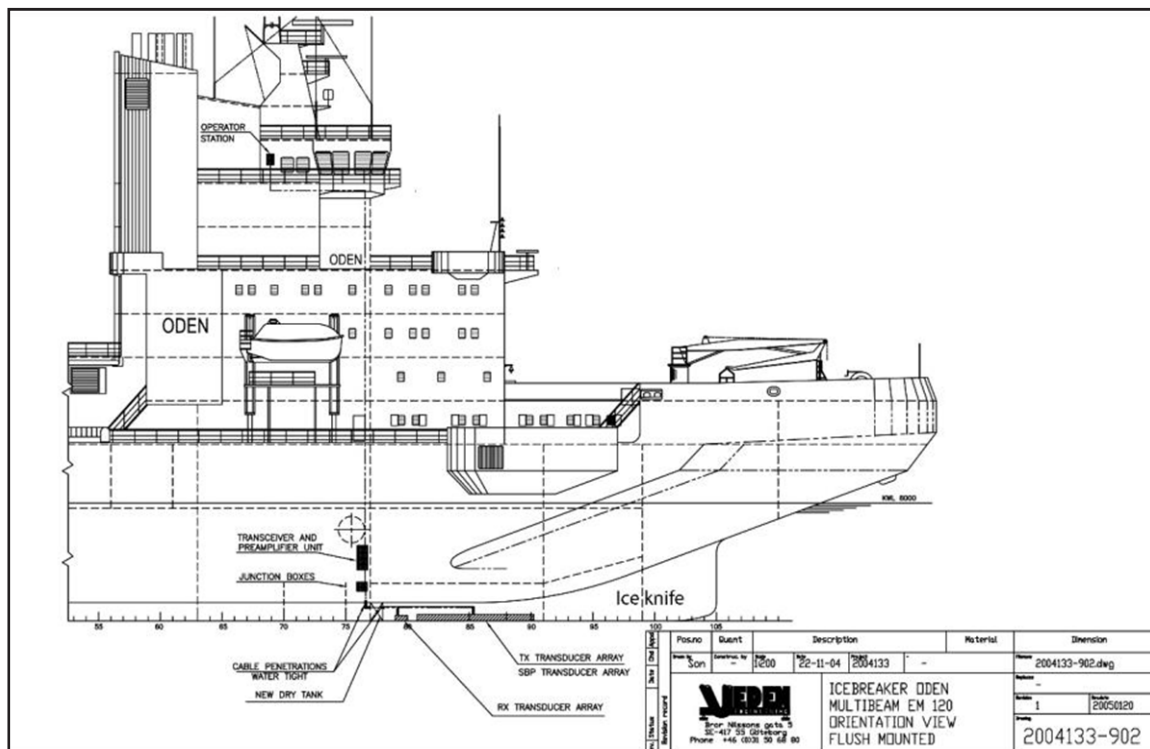


Figure WC-1: Location of EK60/80 transducer on Oden hull and the EK60 GPT and EK80 WBT in the tween deck space.

GPT) is mounted in a rack in the “tween deck” accessible through the hatch in the gym at approximately Frame 83 (Figure WC-1). The server that runs the EK60 is located in the “Apparatrum” on the fifth deck.

The EK60 echosounder has a maximum bottom detection range of approximately 7000m at 2000W of transmit power and a pulse length of 8.21 msec. The split-beam capability allows for phase measurements on individual targets and thus positioning of targets with mechanical angle resolution of approximately 0.1° within the beam. This positioning capability allows the target strengths of individual targets to be compensated for their positions relative to the main response axis and, thus, recorded target strengths can be used to compare the relative strength of individual targets. The EK60 can also be calibrated using a calibration sphere (see details below) allowing the acoustic returns from targets to be expressed as absolute target strength values.

EK80 Echosounder

For Petermann 2015, the transceiver of the split-beam echosounding system was upgraded to operate in a broadband mode. In this mode the ES18-11 transducer on the *Oden* can operate over a much broader range of frequencies. In its original mode, the system on the *Oden* is capable of transmitting and receiving narrow band (250–1000 Hz) pulses only at the transducer center frequency (18 kHz). The new wideband transceiver (WBT) is designed to achieve a frequency range of approximately an octave but was meant for use with composite transducers at frequencies of 70 kHz and above. Nonetheless, tests of the new WBT demonstrated that significant bandwidth could be achieved at lower frequencies with traditional (Tonpilz) transducers like the ES18-11 on the *Oden*.

The prototype WBT was interfaced to an ES18-11 transducer in the UNH test tanks and used to transmit linear frequency modulated acoustic pulses between 10–30 kHz as the ES18-11 was rotated from -90° to $+90^\circ$ along its equator. The tests demonstrated that the main beam behaved as expected, with a 1-way -3 dB beamwidth that varies smoothly from 6° near 30 kHz to 19° at 10 kHz, with maximum sidelobe levels of -18 dB near the design frequency (close to a theoretically predicted value of -17 dB). Above 22 kHz, increased sidelobes (or suppressed grating lobes) that are likely due to the echosounder construction (44 individual Tonpilz transducer elements) appear, but these sidelobe levels are still lower than -15 dB (1-way).

The tests also revealed that the frequency-dependent figure of merit (combined transmit and receiving response, Figure WC-2) for the ES18-11 is relatively flat between 16–22 kHz. Field trials conducted by the Water Column team at the University of New Hampshire demonstrated that the WBT was capable of producing an optimal response from a target sphere between approximately 15 and 30 kHz and this was the band chosen for operations on Petermann 2015.

Installation of EK80

The WBT was installed in the same rack as the EK60 GPT (in the tween deck at about Frame 83) with the GPT shifted to a lower position in the rack and the WBT mounted on a specially constructed mounting plate above the GPT (Figure WC-3).

Conveniently, the wiring of the ES18-11 transducer to the WBT is the same as for the GPT so the swap between the two units simply involved powering off, swapping the large Amphenol connector and Ethernet connectors and powering the other unit back on. We initially had concern that the long run of CAT-5A cable between the WBT and the

server (located in the Apparatum on the 05 deck) would not support the bandwidth of the WBT. Fortunately, this was not a problem, enabling us to use the same wiring and servers for the EK80 as for the EK60.

Given the bandwidth of the EK80, we deemed it essential to synchronize the EK80 with the EM122 and SBP120. This was accomplished by connecting a spare cable that had been run from the EM122 transceiver in the engine room (Figure WC-1) to the server rack in the Apparatum. The synch out signal (5V TTL) was found on the EM122 connector plate (pins 1 and 2) and the spare cable connected to this. On the other end of the cable a serial port was wired in and connected to the EK60/80 server providing the necessary EM122 synch pulse for the EK60/80 to run in 'slave' mode.

The operating EK80 software was installed on the EK60 acquisition computer in the

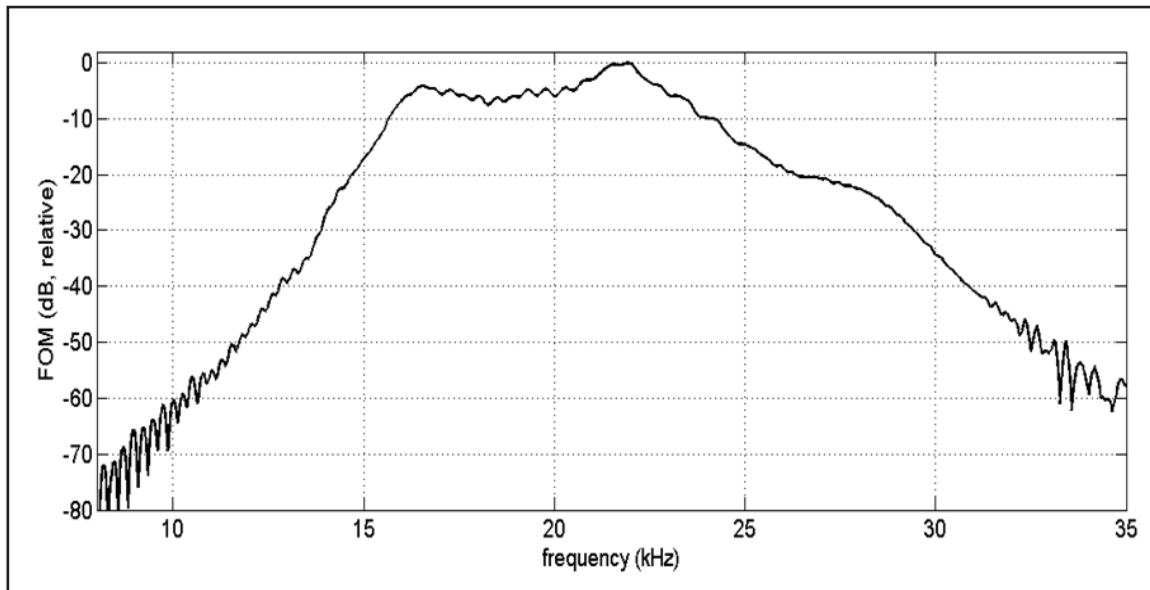


Figure WC-2: Figure of merit (combined transmit/receive response) of an ES18-11 transducer using the WBT in decibels, relative to its peak value.



Figure WC-3: EK80 WBT installed in rack with EK60 GPT in tween deck below gym. Left – front view of rack with front door open – GPT is behind gray panel on bottom. Right – back view with back door open – GPT on lower level – WBT on upper level.

Apparatum. Throughout the cruise, the EK80 software was run and monitored from the multibeam sonar watch-standers' station on the bridge. The hardware performed flawlessly throughout the 34 day program; the software experienced infrequent crashes but was easily restarted and with minimal data loss.

The EK80 collects a very large amount of data (typically 1–3 GB per hour, depending on operating parameters). To handle this large data storage requirement, a dedicated Netgear NAS device with approximately 5.5 TB of storage capacity was placed in the Apparatum next to the server rack and connected to the EK60/80 computer through the ship-board network. The EK80 recorded directly to the NAS at an average rate of 1.4 GB per hour under typical operating parameters. Some preliminary post-processing was done to verify complete recording of EK80 files using MATLAB parsers provided by Simrad and a collection of MATLAB scripts developed at UNH.

Operation

The wideband EK80 data collection was monitored by the underway geophysical watch team (see WP-MG for details). The watch team changed recording range as depth changed and monitored the records for evidence of scattering layers, plumes, gas seeps or other midwater targets. For most of the survey the EK80 was run in frequency-modulated (FM) mode with a pulse length of 1.024 msec, maximum power of 2000W, start frequency of 15 kHz, stop frequency of 30 kHz, and fast ramping. All pulse length and power setting changes are automatically logged with the data files and should be noted in the electronic log kept by the watch standers.

Calibration of the EK60/80

One of the advantages of using the EK60/80 for mapping mid-water targets is the fact that the system can be calibrated so that absolute values of acoustic backscatter and target strength can be calculated for ensonified targets. The calibration process for the EK60/80 is not simple on a vessel the size of the *Oden* but was carried out successfully during the summer of 2014 during Leg 2 of the SWERUS-C3 expedition (Figure WC-4). Below we provide an overview of the calibration process; the SWERUS-C3 Leg 2 cruise report provides a detailed description of the procedures undertaken on the *Oden*. The EK80 was calibrated again on Petermann 2015, a few hours before tying up at anchor off Thule, using the same process used on SWERUS-C3 Leg 2. The calibration took place in approximately 250 m of water and took approximately five hours with most of the time spent maneuvering the calibration sphere under the transducer in a strong current. Once positioned, the calibration sphere was easily visible (though there were many biological scatters in the area) and calibration data were collected for a range of pulse lengths and power levels. These data will be processed at the Center for Coastal and Ocean Mapping at the University of New Hampshire and will be available upon request.

To maximize utility of the EK60 and EK80 observations, target strength calibration data were collected for both systems using a 64 mm copper sphere suspended on high-strength line in the echosounder field of view (FOV) on the main response axis (MRA). Differences between the theoretical and observed TS of the sphere throughout the echosounder FOV will provide a basis for beam pattern corrections during later data analysis. The details of the procedures and equipment used for calibration of the EK60/80 on the *Oden* can be found in the document *Sphere Deployment for EK60/80 Target Strength Calibration*, in the SWERUS-C3 Leg 2 cruise report.

An example of uncalibrated target strength for the sphere and its split-beam (phase difference) position within the echosounder FOV are shown in Figure WC-5 and Figure WC-6 for one configuration over one data collection period. Conductivity-temperature-depth (CTD) profile data collected immediately before each deployment will be used to calculate sound speed and acoustic absorption profiles as well as the theoretical acoustic scattering strength of the sphere under environmental parameters at its depth and frequency of ensonification during each data collection period. The observed sphere scattering strength will be corrected for range and acoustic absorption and then compared to its theoretical value to provide target strength corrections near the MRA. Finally, a transducer model will be applied to incorporate TS offsets on the MRA and provide target strength corrections across the entire echosounder FOV for each configuration. Similar calibrations of a Simrad ES18-11 transducer using EK60 and EK80 transceivers under more controlled conditions may be coordinated at the UNH acoustic test tank if additional laboratory data will be useful for transducer model application to *Oden* field data.

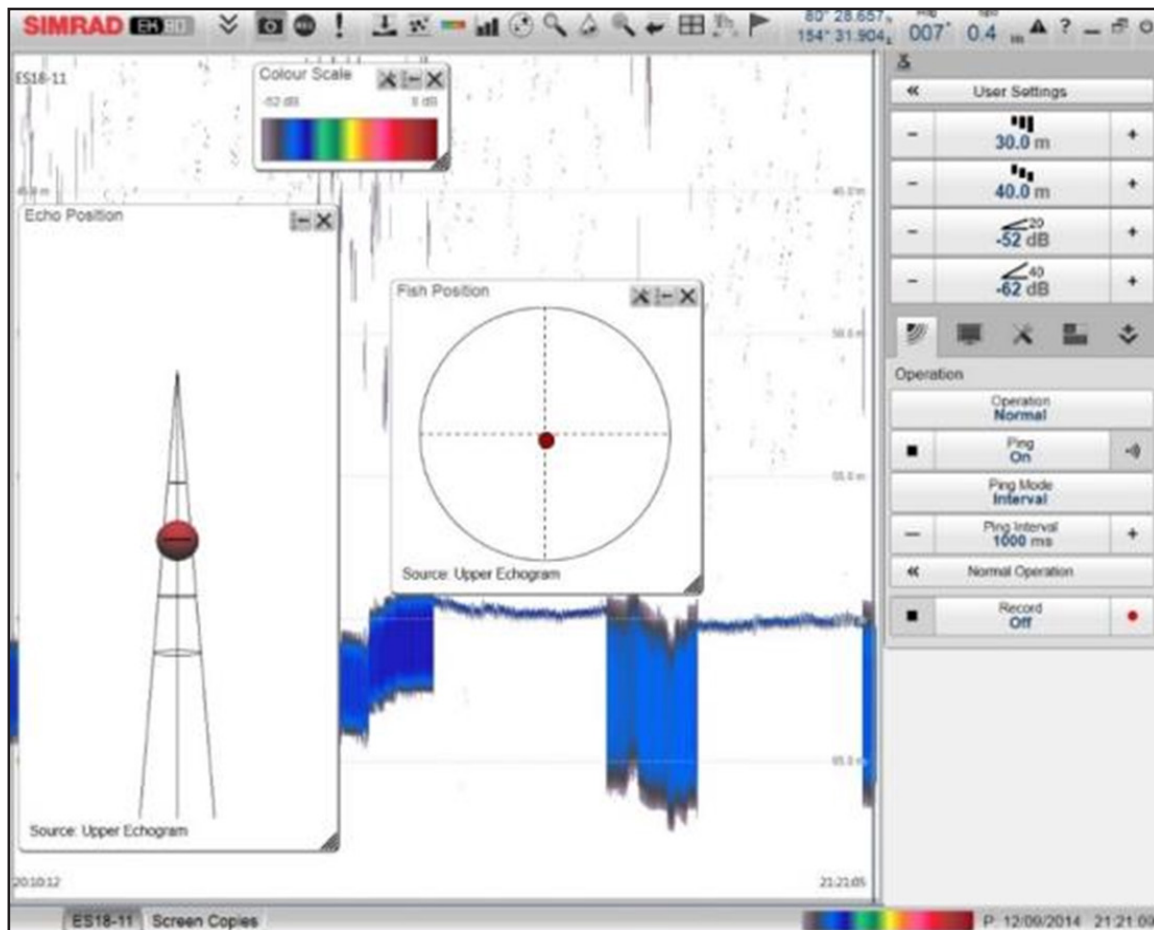


Figure WC-4: Example of calibration sphere being ensonified at Maximum Response Axis (MRA) under the *Oden*. This example is from the calibration carried out on *Oden* on 12 Sept. 2014. Note that the sphere size in the software image is indicative of acoustic scattering strength, not the physical sphere size. The EK80 WBT is installed in a rack with the EK60 GPT in the 'tween deck' area below the gym.

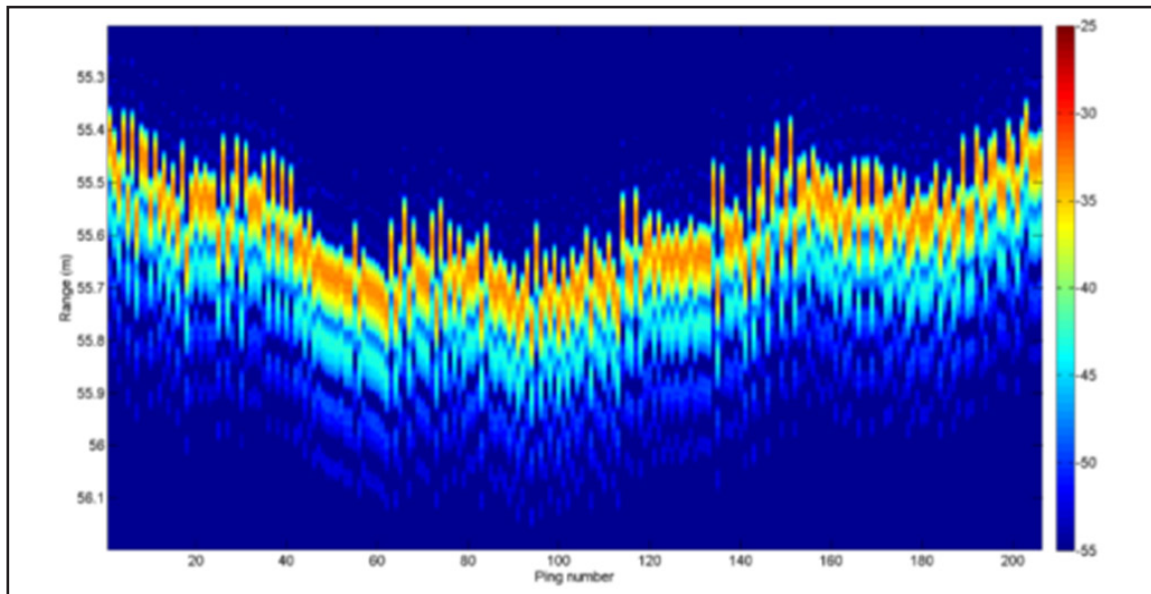


Figure WC-5: Uncalibrated target strength (dB) for the sphere over one data collection period. Low-frequency fluctuation of the sphere range is due to drifting near the MRA, whereas high-frequency fluctuation of the sphere range is due to sea surface swell and accompanying strains on the sphere support lines.

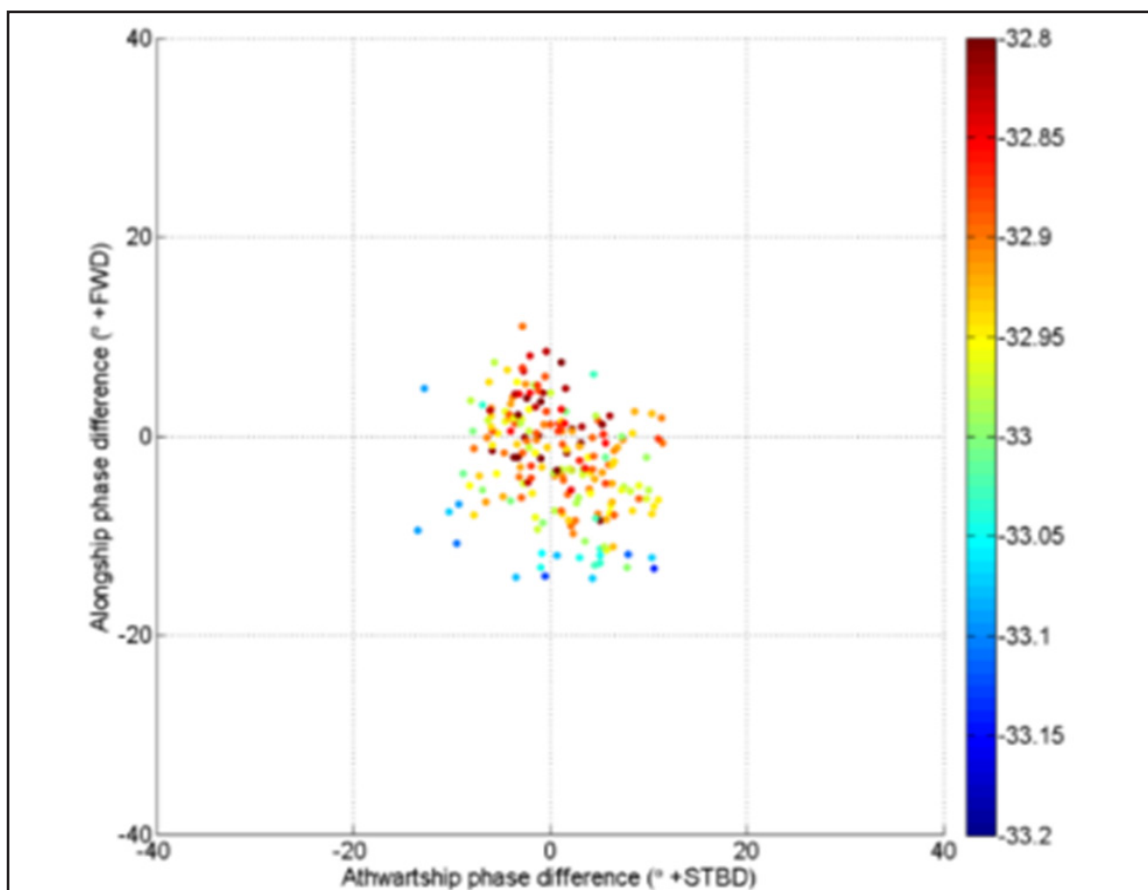


Figure WC-6: Observed target strengths for sphere detections near the MRA over the data collection period represented in Figure WC-5. Phase difference is converted to target mechanical angle along each axis through the split-aperture relationship using sound speed at the transducer face; for reference, a 40° phase difference corresponds to a mechanic angle of approximately 3° .

CW vs FM Mode and Effect of Pulse Length

During the testing phase data were collected in both the CW and FM modes of the EK80 (e.g., Figure WC-7). The comparison indicates the clear advantage that the broadband mode offers with respect to target resolution and discrimination (in this case biological scatterers). However, it was also noted that in broadband mode there was a strong precursor to the bottom (blue area above red bottom on left side of Figure WC-7). This problem is exacerbated as pulse length increases. Despite this pre-cursor, the actual detected bottom (small black ticks above red zone of bottom) remained correct for the FM mode (Figure WC-7).

Shipboard post-processing

EK80

The EK80 clearly showed the presence (or absence) of midwater targets in the acquisition and replay software modes without any additional post-processing (e.g., Figure WC-8). However, the native EK80 software does not include any capability for georeferencing or extracting targets of interest.

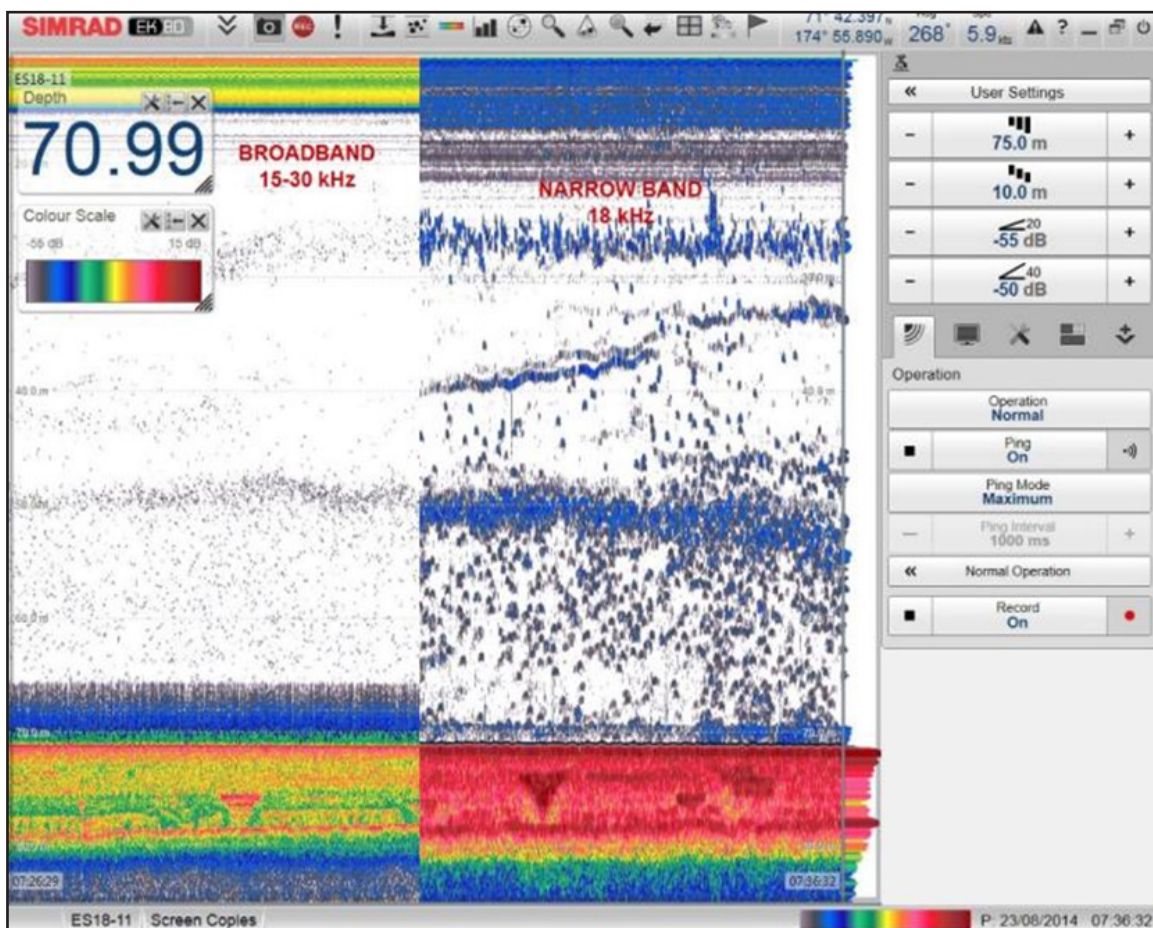


Figure WC-7: Comparison of EK80 in broadband (15–30 kHz) mode (left) with EK80 in CW mode (18 kHz) with approximately 400 Hz of bandwidth. Note much higher resolution of individual scatterers with broadband mode.

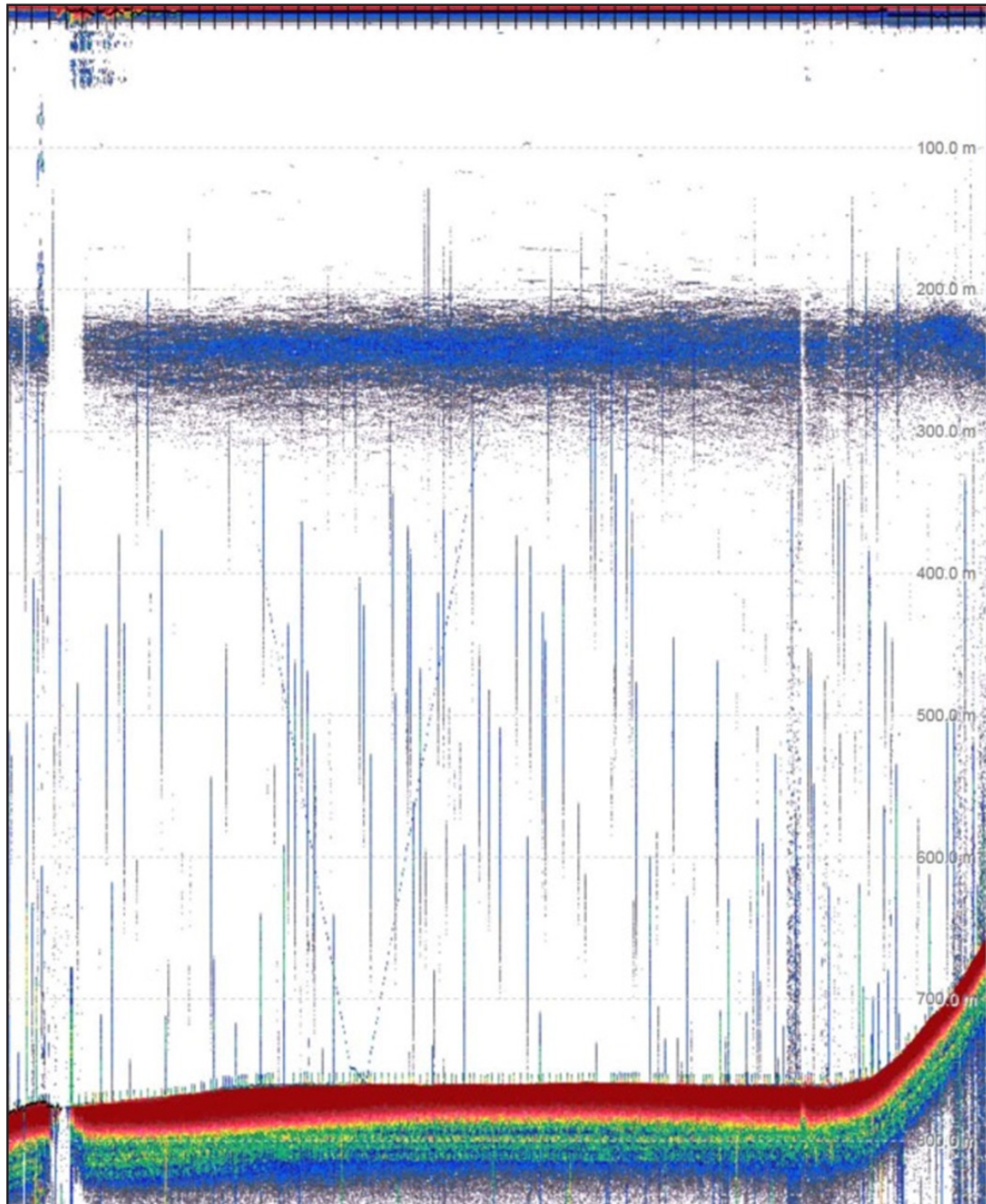


Figure WC-8: Example of midwater scattering layer on EK80. Thin vertical lines are ship-sourced noise we believe to be the action of fuel heating steam-trap valves.

To provide some capability for examining these targets in a larger context, a MATLAB script was written to perform simple threshold filtering of EK80 samples based on acoustic scattering strength. High-amplitude samples associated with bottom returns were excluded by similar filtering and the remaining water column targets in the upper 400 m were georeferenced by accounting for ship position, attitude, and transducer location relative to the motion sensor. A constant sound speed profile of 1444 m/s was applied for this first round of processing, using the approximate harmonic mean sound speed from XBT and CTD casts. A constant value was used to speed up processing, ignoring, for the meantime, the minor refraction effects at relatively short ranges (400 m or less for filtered targets) within the field of view ($\sim 6^\circ$ from nadir in all directions).

This script also compensates for the bulk of timing errors associated with drift of the Windows-based EK80 computer clock by comparing parsed NMEA position datagram times to the timestamps applied by the EK80 computer. Residual timing errors are expected to be on the order of msec, which may be further corrected by comparison to nearby EM122 ping times (not yet implemented for this dataset). In some cases, errors were encountered while parsing position data from the EK80 files; this was addressed after NMEA timing correction, by extracting vessel position from the simultaneous EM122 data for all EK80 files.

These steps represent a preliminary process for extracting and georeferencing EK80 targets for visualization with associated EM122 bathymetry and EM122 water column data in Fledermaus. Once extracted and written to text files from MATLAB, the filtered/georeferenced EK80 point clouds were brought into Fledermaus as point class objects and displayed within the 3-D scene. For comparison, images of the EK80 output display (e.g., Figure WC-8) were georeferenced and brought into the 3-D scene as vertical curtain class objects (Figure WC-9).

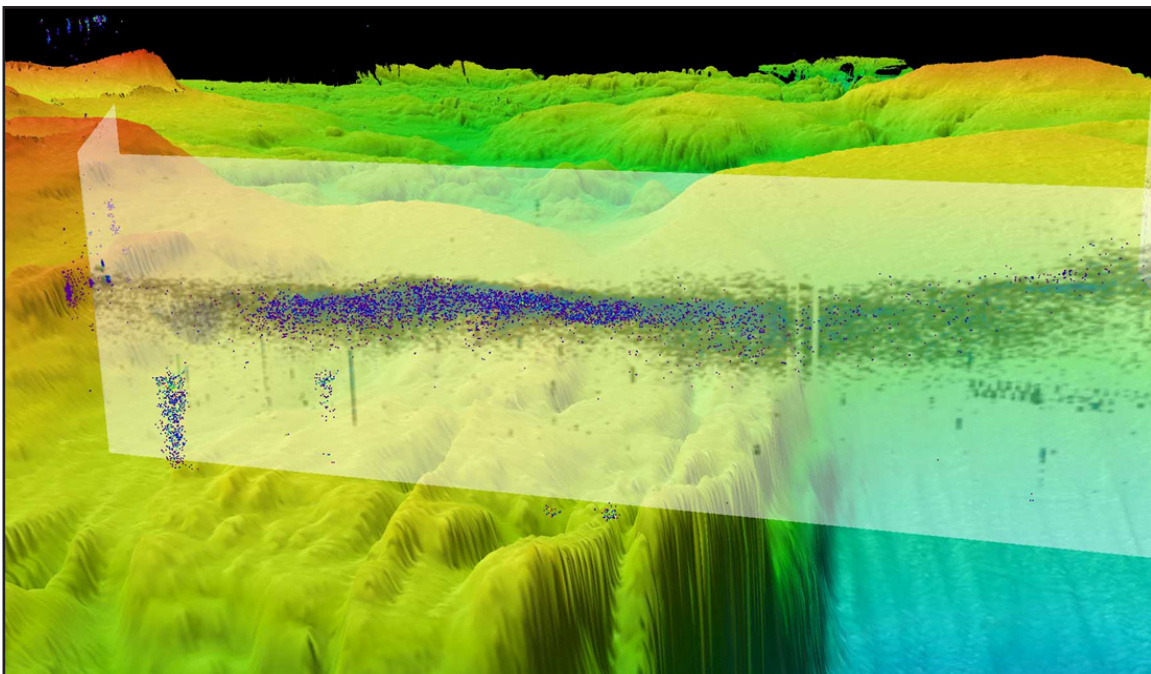


Figure WC-9: Example of midwater scattering layer points and image extracted from EK80 and brought into 3-D scene. Purple represents relatively high scattering strength.

Apart from a few files with errors due to software crashes, all EK80 files were ‘batch-processed’ to produce text files of threshold-filtered, georeferenced samples in depths shallower than 300–400 m, applying NMEA time correction and EM122 position as outlined above. Threshold filters for the water column targets were adjusted to exclude samples with volumetric scattering strengths (Sv) lower than –55 to –55 dB and higher than –35 dB. The simple bottom exclusion threshold filter was set to remove targets with Sv greater than –30 dB, which provided fairly reliable results. These values were selected based on visual scrutiny of multiple water column features to achieve a balance between suppressing apparent noise levels and maintaining the targets of interest.

EM122 Water Column Data

The EK80 provided the primary tool for the identification of midwater targets, however, some of the stronger targets were also visible in the EM122 water column data. Particularly useful was the water column data collected at higher frequency from the *Skidbladner*. In these cases the QPS Fledermaus Midwater tool was used for extraction and subsequent placement of the target within the context of seafloor bathymetry (using gridded bathymetry and the Fledermaus 3-D visualization tool (e.g., Figure WC-10).

In addition to standard QPS-FM processing, UNH-Matlab code (written by Tom Weber) was run on water column data to further remove background noise and isolate midwater targets. Once targets were isolated they were exported as 3-D point clouds to be brought into the 3-D bathymetric scene.

For those lines that displayed midwater targets, the SBP120 high-resolution subbottom profiler data were brought into the Natural Resources Canada (Bob Courtney) SEGYP2 software package and converted the JP2 images. The segment of these images corresponding to the bathymetric line that contained the midwater targets was extracted, georeferenced and also brought into the 3-D scene. Examples of this process will be shown in the results section below.

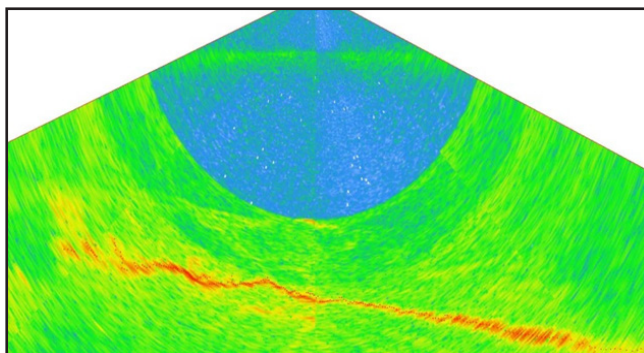
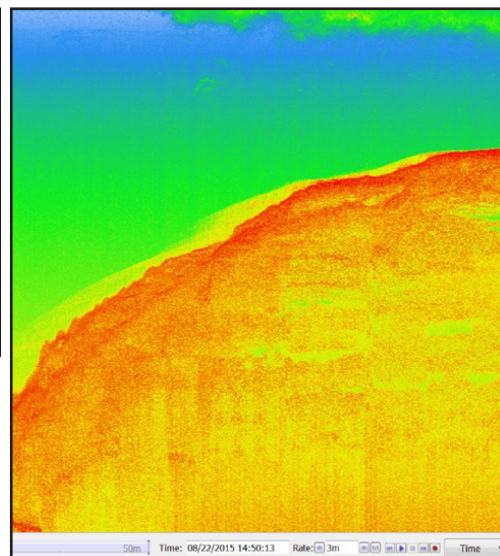


Figure WC-10: Example of midwater targets seen on multi-beam systems. 12kHz EM122 on left (probably biological scatterers – seafloor is – red line – is at 860 m.) 200 kHz EM2040 on right imaging probable sediment laden, fresh-water plume at glacier front.



Source Signature Test

In order to better interpret the acoustic measurements made aboard *Oden*, we collected source signatures of the various acoustic sources on board including the EM122, the EK80, the SPB120, and the airgun and sparker sources used by the seismic team. The high-frequency acoustic source signatures were measured on 8 August 2015; the seismic source signatures were measured on 12 August 2015.

Source signature data was collected with a Reson TC4034 hydrophone (Figure WC-11) connected to 75m of RG58 cable. Input from the hydrophone was put into a Stanford Research Systems SR560 Pre-Amp, monitored on a Tektronix digital scope and digitized with a National Instruments Digital Acquisition Board (USB 6361 DAQ) (Figure WC-12).

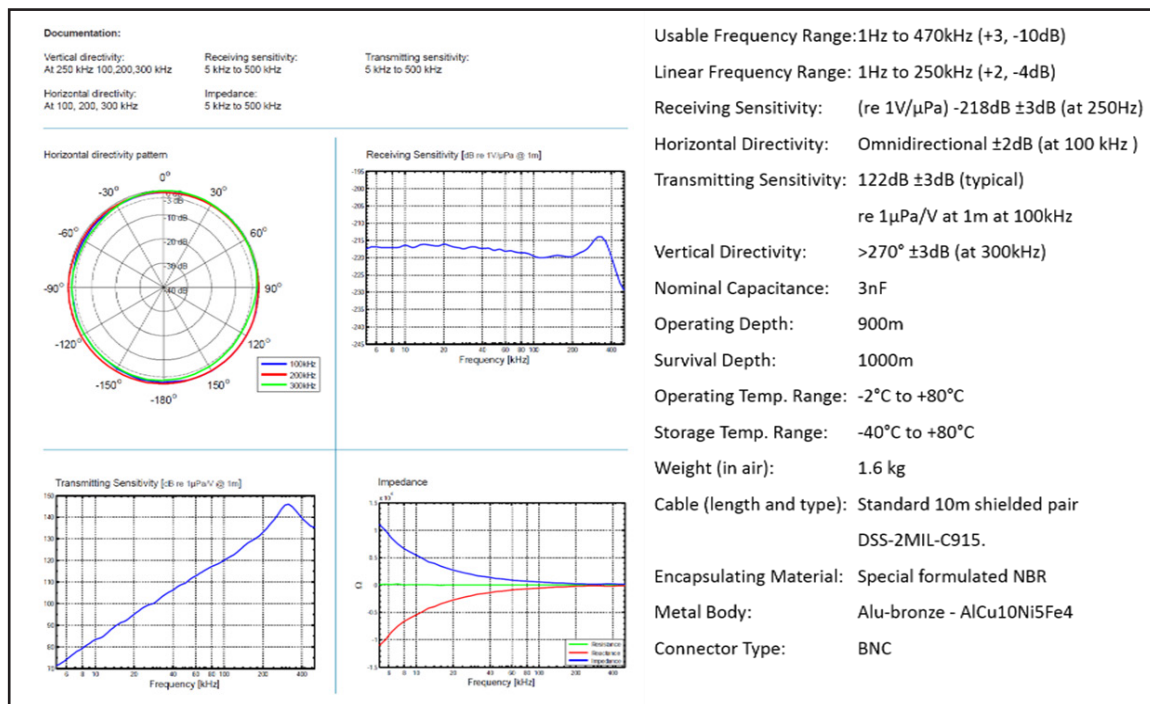


Figure WC-11: Specifications and response curves for the Reson TC4034 hydrophone.

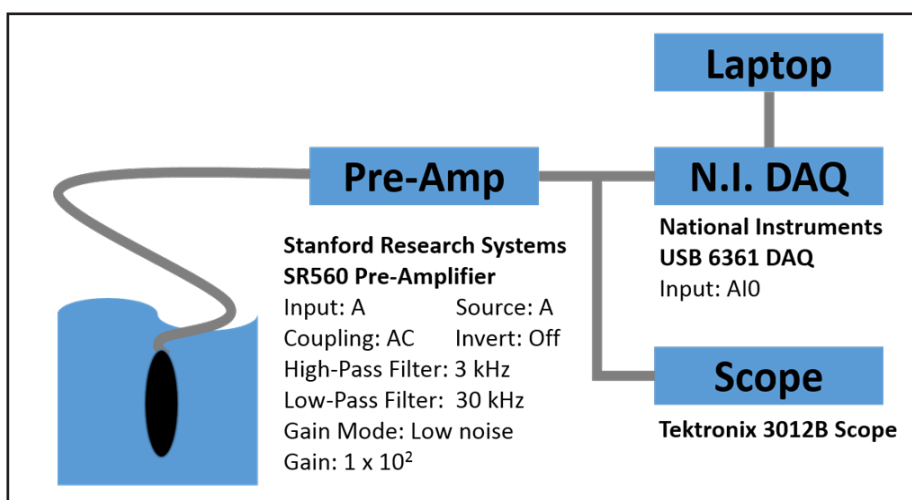


Figure WC-12: Schematic of source signature test setup.

MATLAB code written by Tom Weber of UNH captured the signal received on the hydrophone in 10 second intervals with each file being labeled with the time of recording. Measurements were conducted in approximately 1000 m of water near the middle of the fjord (Figure WC-13) with the hydrophone lowered as close to the alongship center of the EM122 transmitter as possible (Figure WC-14).

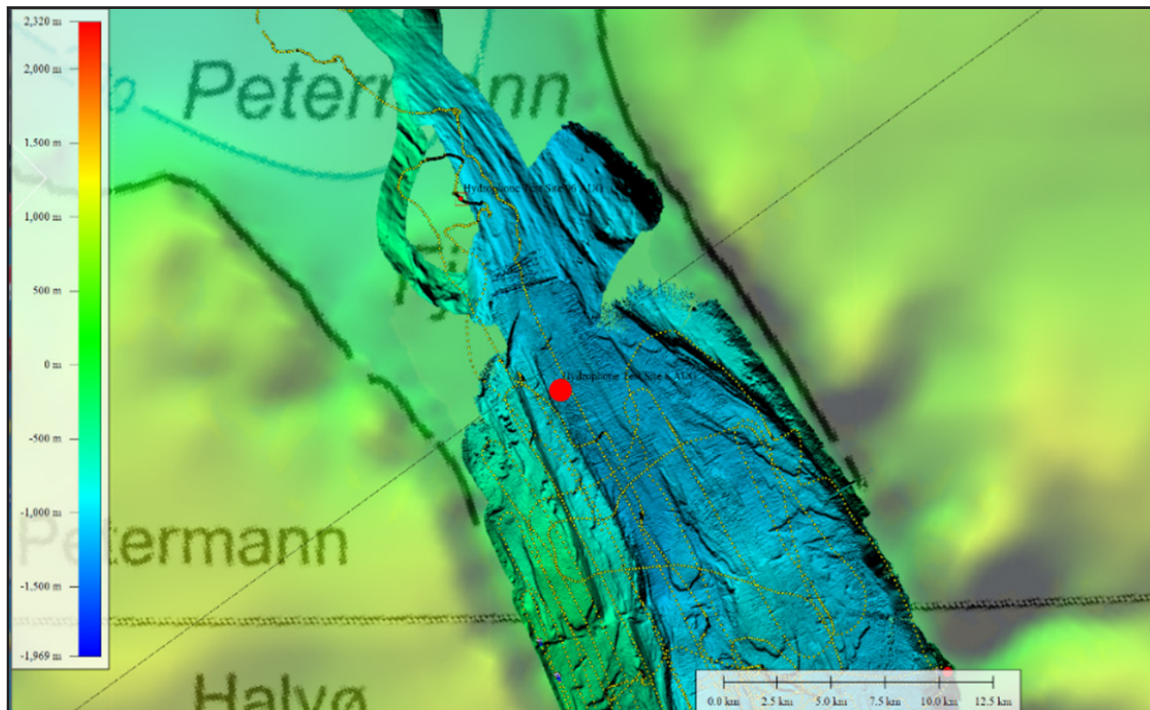


Figure WC-13: Location of hydrophone source signature tests (red dot). The depth scale ranges from 0 m (green) to approximately 2000 m (dark blue).

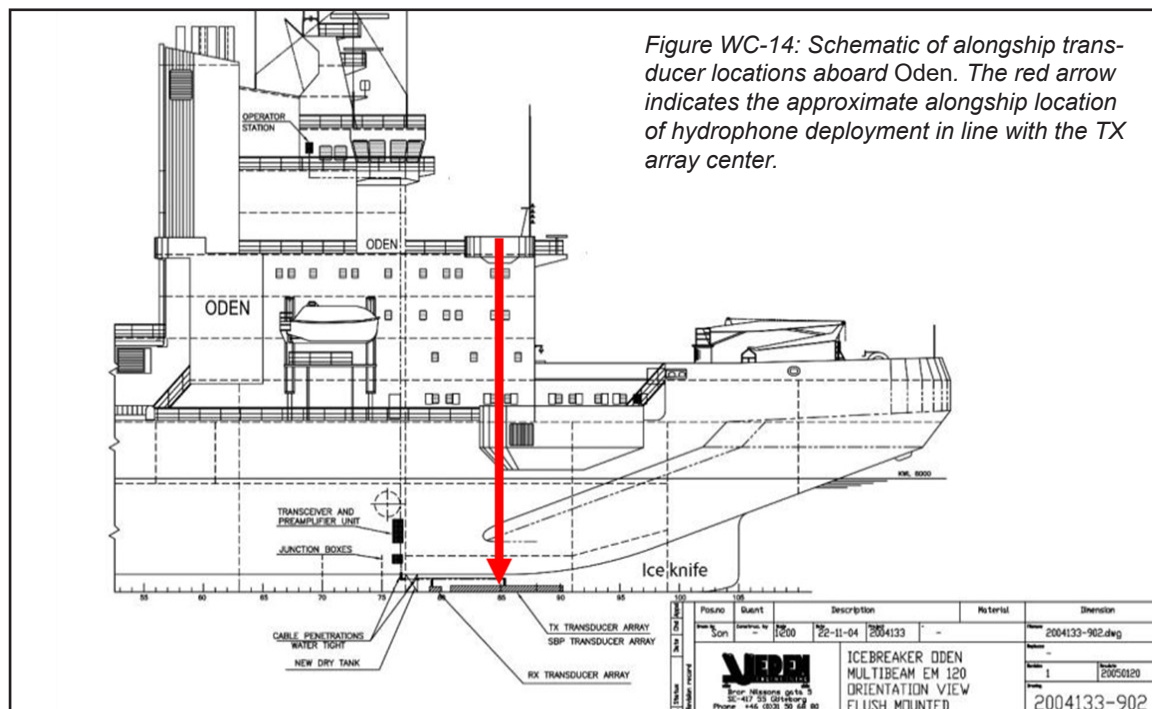


Figure WC-14: Schematic of alongship transducer locations aboard Oden. The red arrow indicates the approximate alongship location of hydrophone deployment in line with the TX array center.

Water Column Mapping Results

Data Structure and Organization

EK80 data were written directly on a 5.45 TB, Netgear NAS device provided by the University of New Hampshire and located in the Apparatum. Data were placed in the “data/EK80” directory and were organized by day. The individual files are labelled PETERMANN2015-D2015MMDD-Thhmmss.raw with each file representing approximately 15 minutes of data and being approximately 500MB in size (Figure WC-15). The NAS device automatically backs up all data on a mirrored drive. These data will be archived at the University of New Hampshire but can be made available upon request.

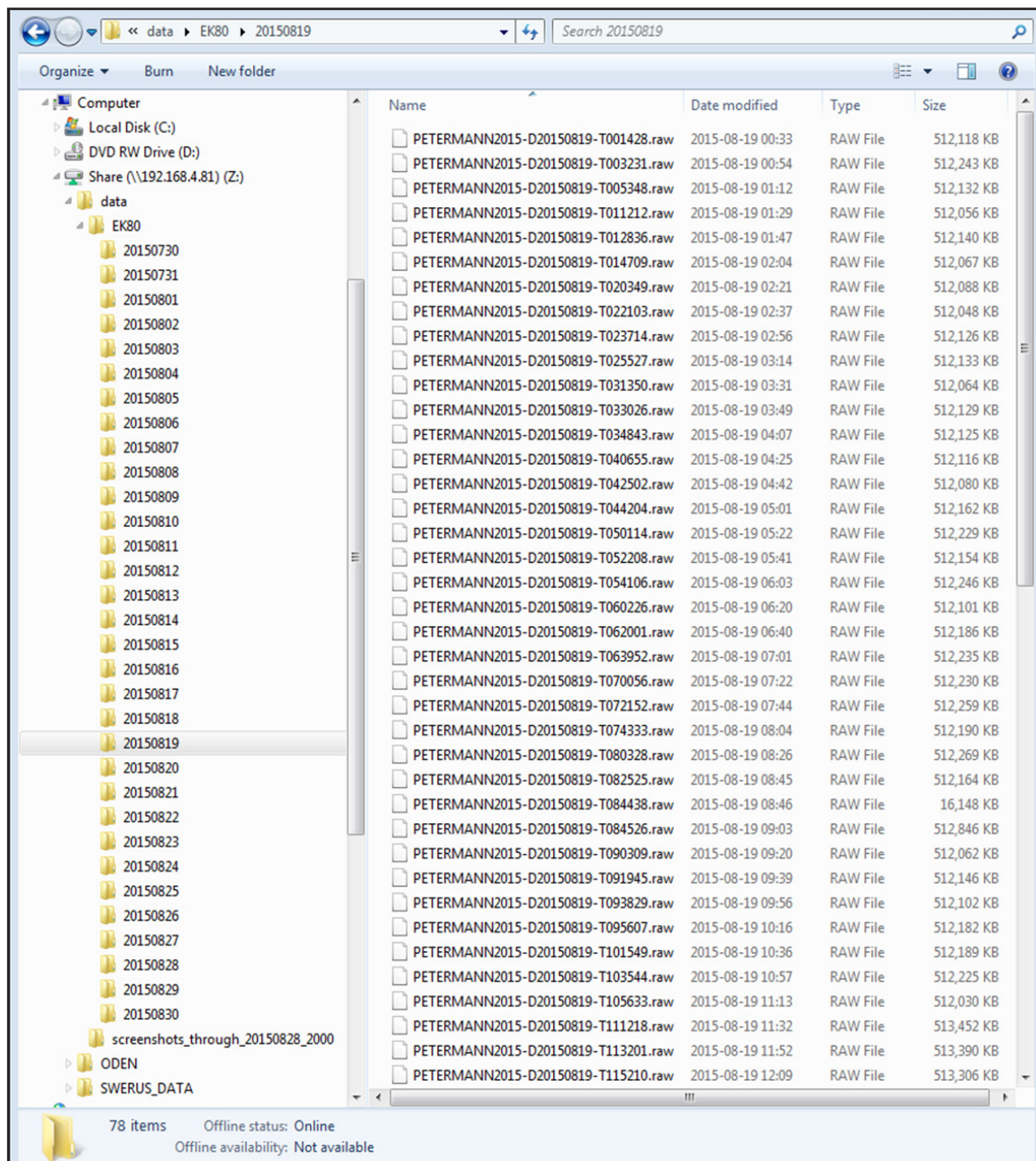


Figure WC-15: Example of data file structure for collection of EM80 data.

EK80 Water Column Features

EK80 data were collected for the entire cruise from departure from Thule on 29 July to the securing of the systems approaching Thule on 1 Sept. A total of ca 1.1 Terabytes of EK80 data were recorded. The EK80 midwater mapping system was operated in tandem with the EM122 multibeam sonar and SBP120 subbottom profiler for the duration of the expedition, yielding complete broadband (15–30 kHz) midwater coverage within the 11° beam. In addition to real-time monitoring of the EK80 by the geophysical mapping watchstanders, all EK80 files were reviewed on a daily basis using its native software and/or MATLAB ‘batch processing’ (in upper 400 m) to identify features of interest. In all cases, a broadband acoustic artifact is evident resulting from operation of steam trap valves in the ship’s fuel and ballast water heating system. An example of this noise while drifting over a layer of biological scatterers is presented in Figure WC-16 for reference when examining other echograms.

While future processing may be directed toward masking this noise (the engineers aboard *Oden* cannot turn off the offending valves), the noise was sufficiently random in time and uniform in its signature that it did not appreciably interfere with the detection of features in the EK80 data. Features detected generally fall into several categories outlined below. Interpretation of these features are preliminary acoustic observations is based on related experience with the EK80 (e.g., gas plumes) and/or circumstantial evidence (e.g., seals observed on the surface diving beneath the ship). The categories presented here are not conclusive and require more in-depth analysis. Though the exact color scales are different in each example, all echograms shown here are presented as volumetric scattering strength with a color scale from blue (weak) through green to red (strong) and can be related to the absolute calibration of the EK80.

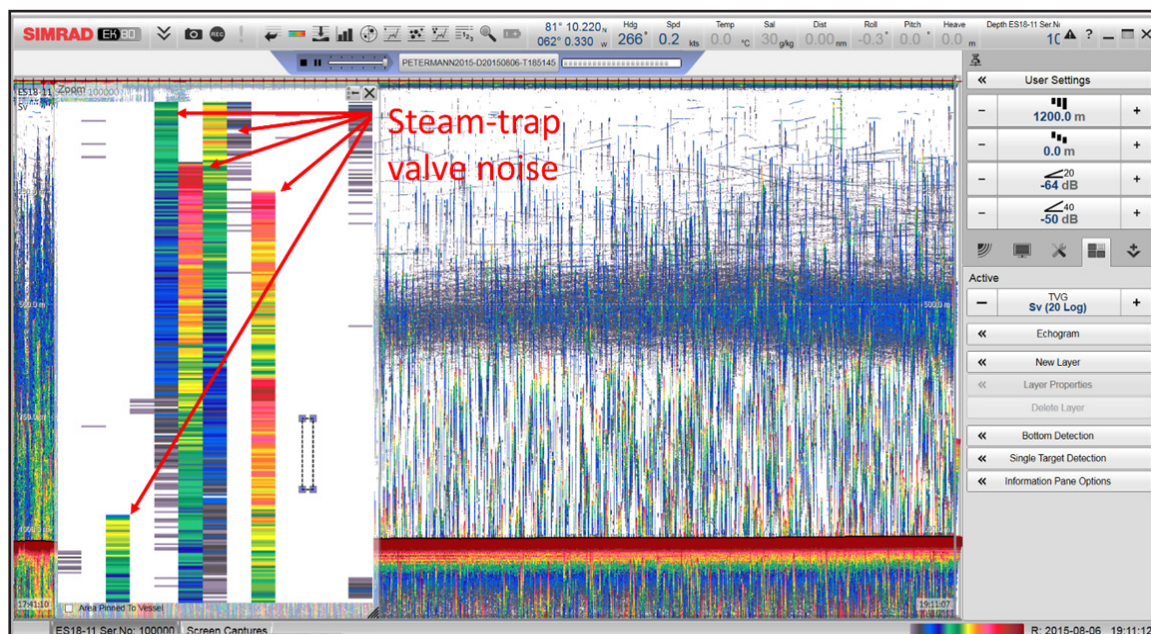


Figure WC-16: Steam-trap noise apparent in all EK80 data, with magnified examples of individual pings on left. An unusually large amount of gain is added in this example in order to emphasize the artifact. While present throughout the expedition, this noise did not interfere with normal interpretation of the EK80 data.

Biological Scatterers and Water Column Structure

Originally developed for fisheries research, the EK60 and its successor, the EK80, are widely used for the express purpose of detecting biological scatterers in the water column. Accordingly, biological scatterers were observed frequently as individuals and as diffuse layers throughout this expedition, with continuous records lasting up to several hours. Observations were made with the vessel both underway during surveys and while drifting for water and sediment sampling. In some cases, the low-noise measurements made while drifting revealed the movements of individual animals and the position of the CTD during water column profiles. Examples of a CTD through a biological layer is presented in Figure WC-17. Comparison of many CTD profiles to their simultaneous EK80 echograms suggests a shallow limit to the upward migrations of these biological scatterers that is highly correlated with contrasts in density among water layers, at least within Petermann Fjord. Figures WC-18 and WC-19 present additional examples of biological scatterers in diffuse layers and as individuals resolvable in the EK80. It is believed that individual seals swimming near the vessel were observed during dives, providing possible insights into feeding behaviors.

The example above is typical of the scattering layer seen within the deeper regions of Petermann Fjord. Within this regime, the scattering layer is typically shallow (between 100 and 200m) deep and at each of the CTD stations, the top of the scattering layer coincided with the bottom of the halocline; when this layer was strong, it was also clearly visible on the EM122 water column data (Figure WC-18). There was also an indication that the strength of the scattering layer increased in proximity to the outlet glaciers along the walls of the fjord.

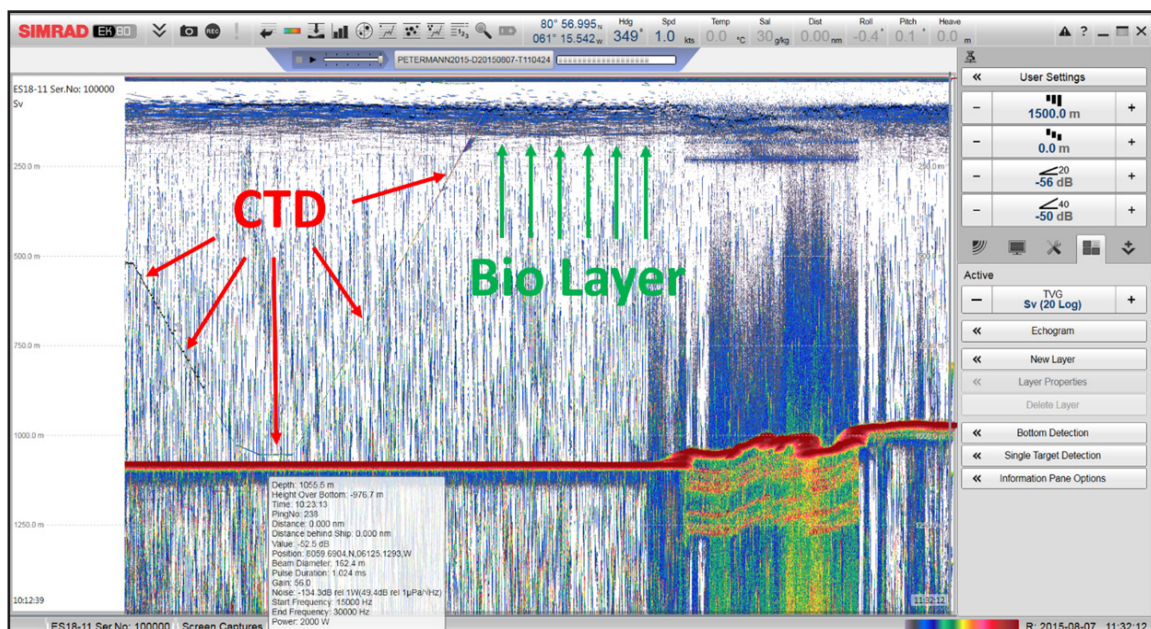


Figure WC-17: An example of EK80 data collected while drifting for a CTD cast. In this case, the drift of the vessel allowed the CTD to fall within the field of view of the EK80, showing its depth versus time. The CTD passed through a layer of diffuse biological scatterers before retrieval on deck and getting underway (noisy region with predominantly blue water column in last third of echogram).

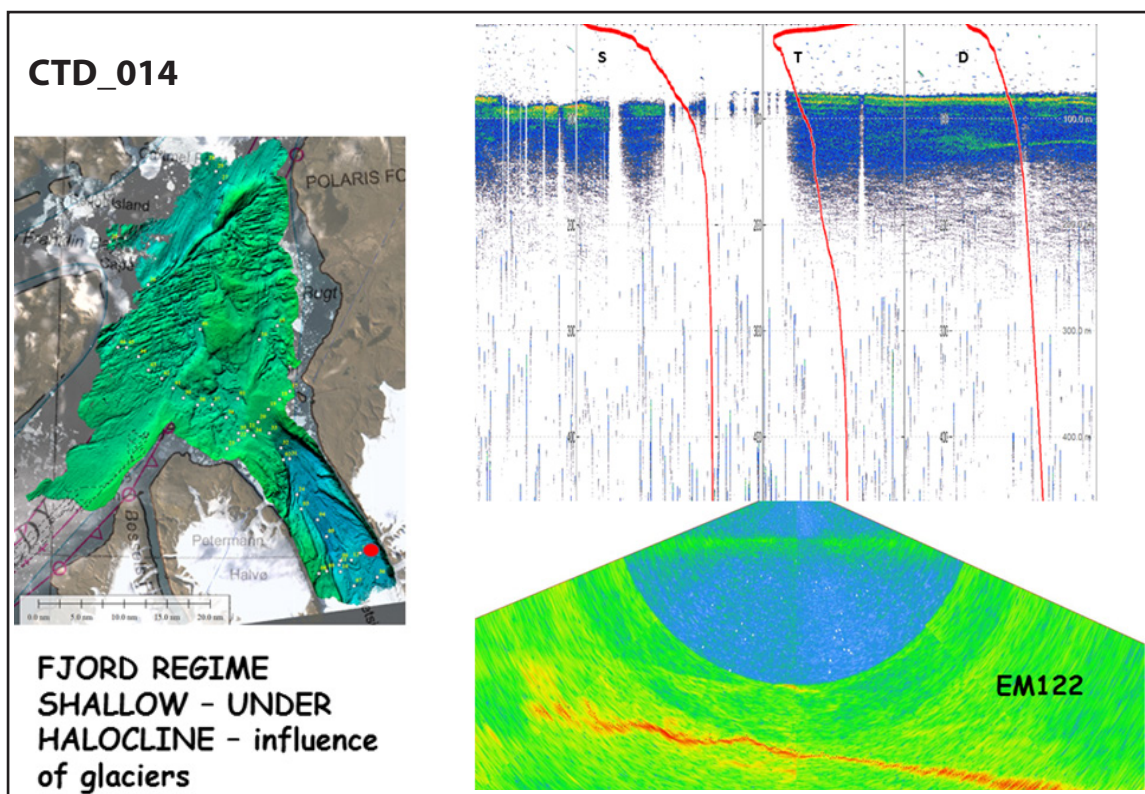
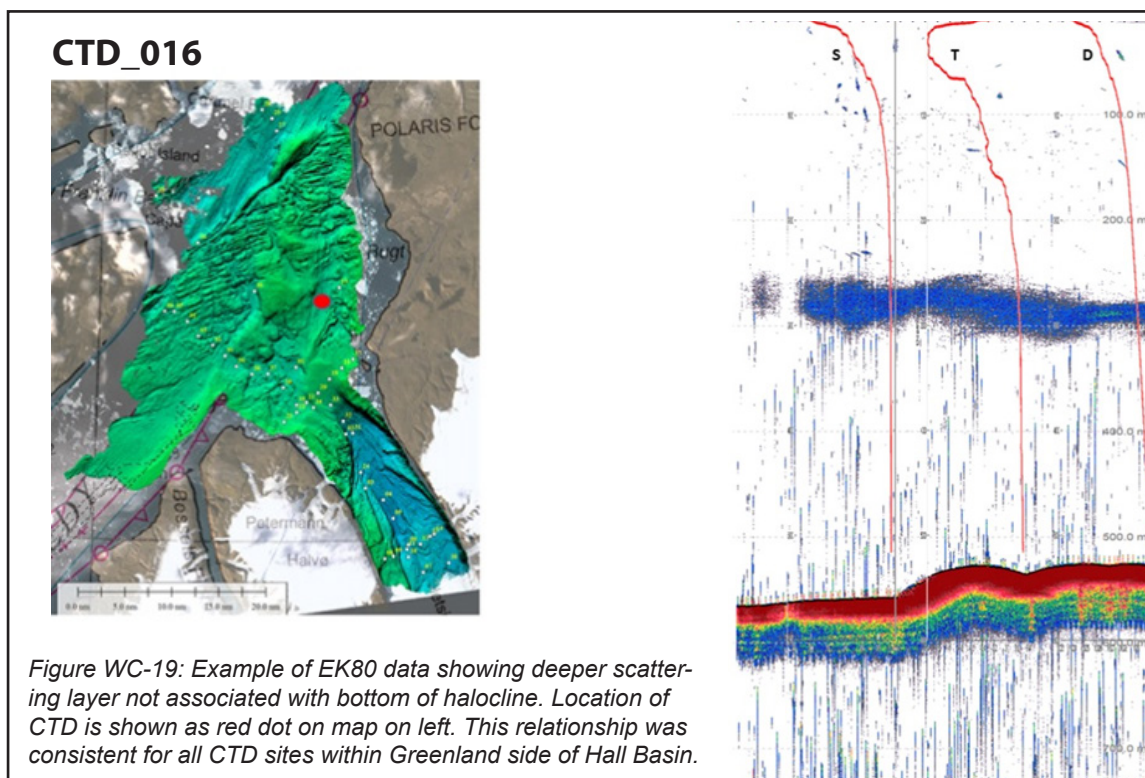


Figure WC-18: An example of EK80 data showing shallow scattering layer associated with bottom of halocline. Location of CTD is shown as red dot on map on left. This relationship was consistent for all CTD sites within the deeper part of the fjord. Same layer is seen on EM122 water column display (lower right inset).



Relative to the CTD sites, two other regimes for the scattering layer was observed. Outside of the fjord on the Greenland side of HB, the scattering layer was consistently deeper (300–400 m depth) and far below the depth of the halocline (Figure WCR-5).

A regime existed where there was no apparent scattering layer (using a consistent display level of -58 dB). The region of no scattering layer was on the Canadian side of the HB and a small area on the southeastern side of the fjord. The distribution of the depth of the scattering layer for all CTD sites is presented in Figure WC-20.

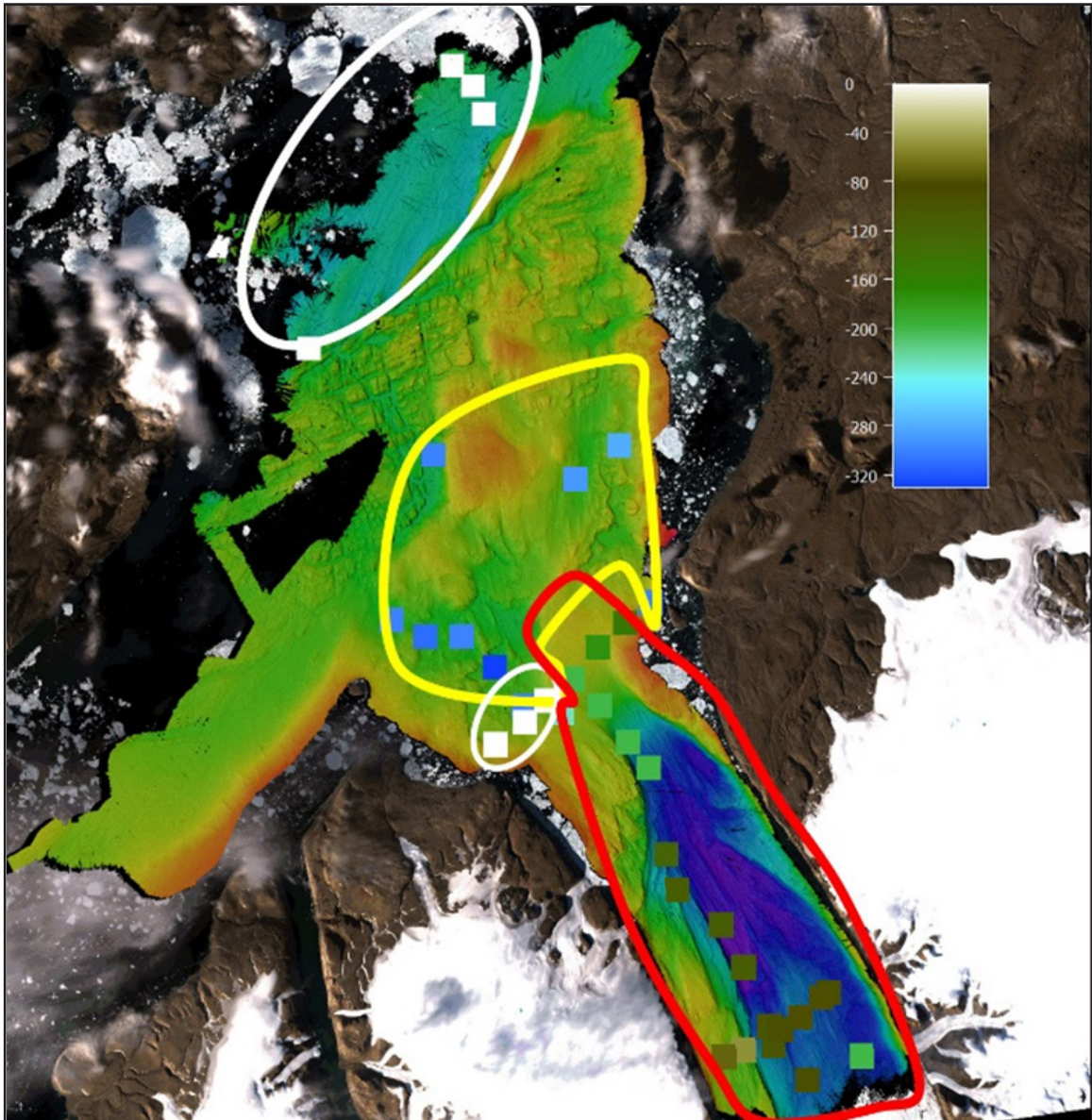


Figure WC-20: Depth of the top of the scattering layer for all CTD sites on Petermann 2015. Red outlined area represents the “fjord regime” with shallow scattering layer at base of halocline; yellow outlined area is zone of relatively deep scattering layer not associated with base of halocline and white outline encloses areas of no apparent scattering layer.

Association with Glacial Fronts

Increased backscatter amplitude was observed consistently in shallow (< 300 m) layers near the outflows of several small side glaciers during repeated surveys along the walls of PF, in some cases extending for several km of acoustic observation toward the interior of the fjord. While it is unclear at this point whether these backscatter anomalies represent sediment-laden glacial meltwater plumes or enhanced biological activity related to the input of material derived from the glacier, the association of enhanced backscatter with the glacial front is unquestionable. Figure WC-21 depicts a scattering layer between 125–250 m depth observed during a single pass along the fjord wall. This figure is annotated with heading changes and EM122 depth mode changes to provide some context for other backscatter trends visible in these examples. Notably, water column noise is reduced during turns because bubbles swept beneath the hull are directed away from the transducer face; however, the glacial runoff remains visible throughout the turn.

An artifact at approximately 240 m depth develops after the EM122 changes depth mode from MEDIUM to DEEP; this is associated with increases in pulse duration and power. Because the EM122 provides the transmission trigger for the EK80 and SBP during its first of two pulses when operating in dual-swath mode, the visible artifact (extending horizontally through time at a constant range of 240 m) is actually the second swath of the dual-swath transmission cycle. As with the steam-trap valve noise, this does not appreciably interfere with interpretation of the EK80 data.

Several examples of repeat and extended observations of enhanced backscatter between 125–250 m while passing in front of sidewall glaciers under a variety of ship headings and positions, increase confidence that these acoustic backscatter anomalies are not geometric artifacts or other noise sources. Figure WC-22 includes three passes in front of a side glacier shown in Figure WC-23 with three corresponding transects of the enhanced

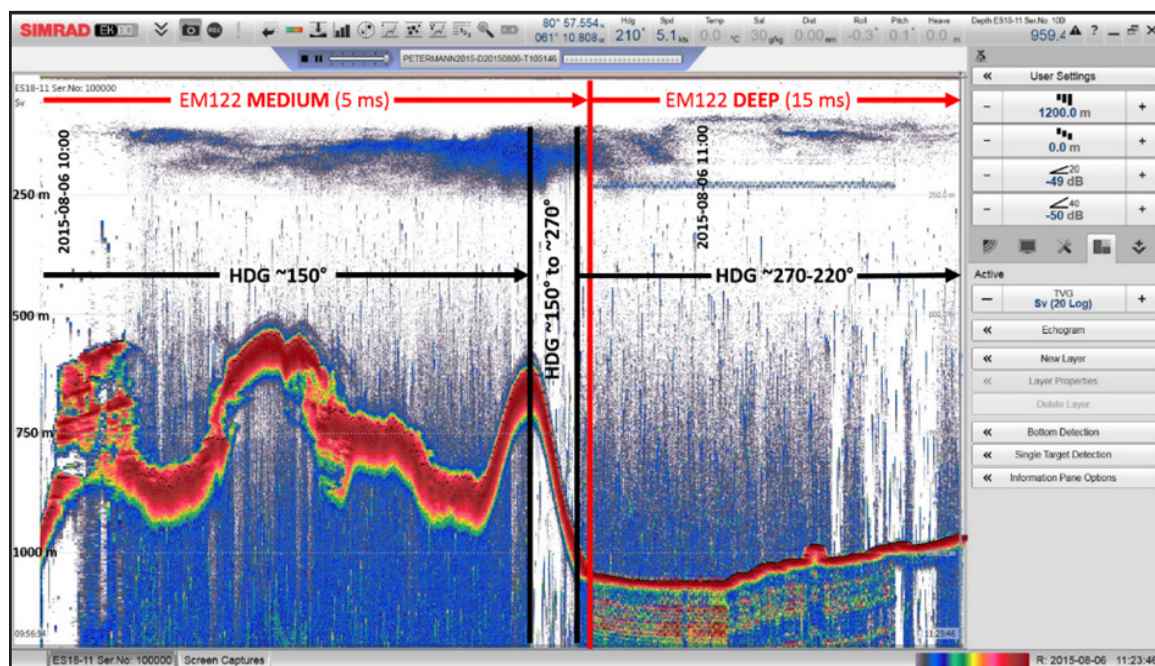


Figure WC-21: An extended observation of enhanced backscatter at a glacial front, annotated to provide context for changes in the acoustic environment due to turns and EM122 depth mode changes.

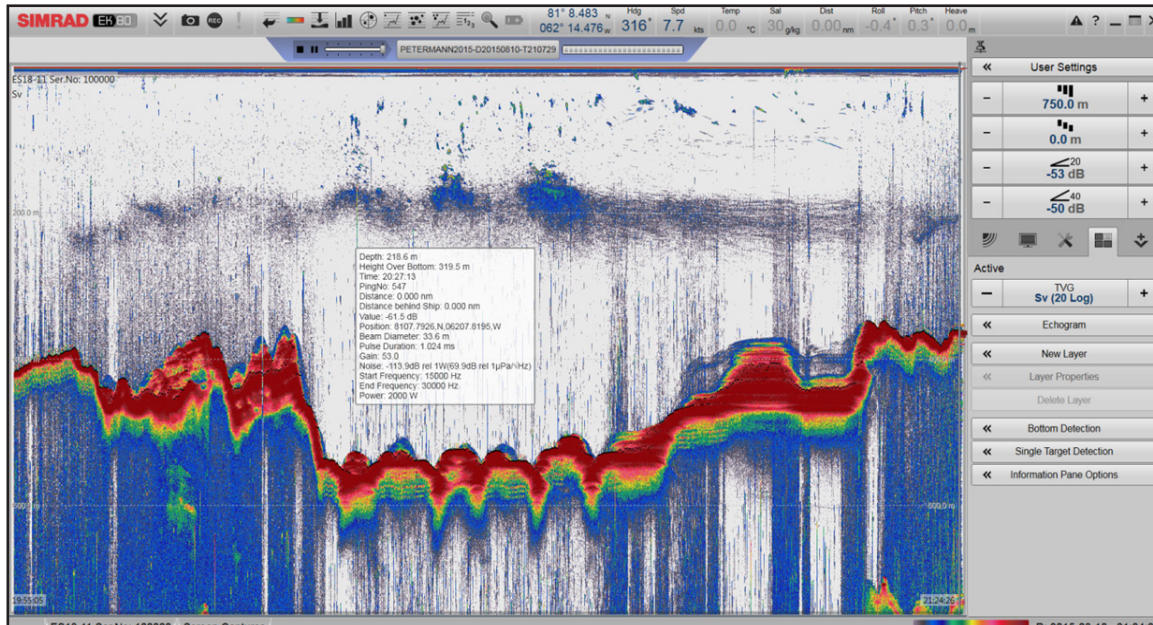


Figure WC-22: Repeat survey passes in front of a side glacier (Figure WC-23, below) revealed consistent observations of a likely an enhanced midwater backscatter plume extending into the fjord. The transects of the plume appear as three distinct clusters of scatterers with elevated backscatter strength (blue-green on this color scale) at a depth of approximately 200 m in the middle of the echogram. Small clusters of individual biological scatterers are evident between 30–150 m above the plumes and later in the echogram, possibly suggesting an important habitat role for these plumes.



Figure WC-23: Several side glaciers in Petermann Fjord appeared to produce enhanced midwater backscatter layers that extend into the fjord at depths of approximately 250 m. Multiple passes in front of the glacier shown here resulted in repeat EK80 observations of the enhanced backscatter plume, shown above in Figure WC-22.

backscatter plume, showing increasing depth range and cross-sectional area with each pass. One particularly extended observation of a glacially enhanced plume was made while surveying on a heading away from the fjord wall and then circling and returning at an oblique angle to cross over the initial survey line (Figure WC-24), showing marked variation in depth and thickness of the plume with horizontal extent into the fjord.

Vertical Plumes

A target that was characteristic of gas bubbles rising from the seafloor was observed during the transit north through NS (Figure WC-25). This was the only feature during the expedition which appeared beyond a reasonable doubt to resemble gas bubbles, based on previous experience with routine EK80 observations of such plumes in other regions of the world. Based on the relatively shallow source depth (~150 m), it is likely that the gas bubbles reached the surface. The tapering effect of the acoustic observation is likely due to the plume leaving the beamwidth as the ship passed. The site was revisited on the return transit to Thule, but ice prevented getting the EK80 directly over the target (in 150m of water we would need to be within 23m of the target to have it ensonified by the 11 degree EK80). The EM122 data will be analyzed at a later time to see if the seep is seen in these data.

Several midwater features observed with the EK80 during this expedition do not readily fit into categories for interpretation based on our previous experience. A large plume was seen around Joe Island on the 17 of August (Figure WC-26) that rose quickly to the surface like gas but appeared to spread laterally near the surface (though this may also be an artifact of ship maneuvering). A return to this site ten days later did not reveal anything at this location but at the same depth a very similar feature was observed less than 3 n.m.

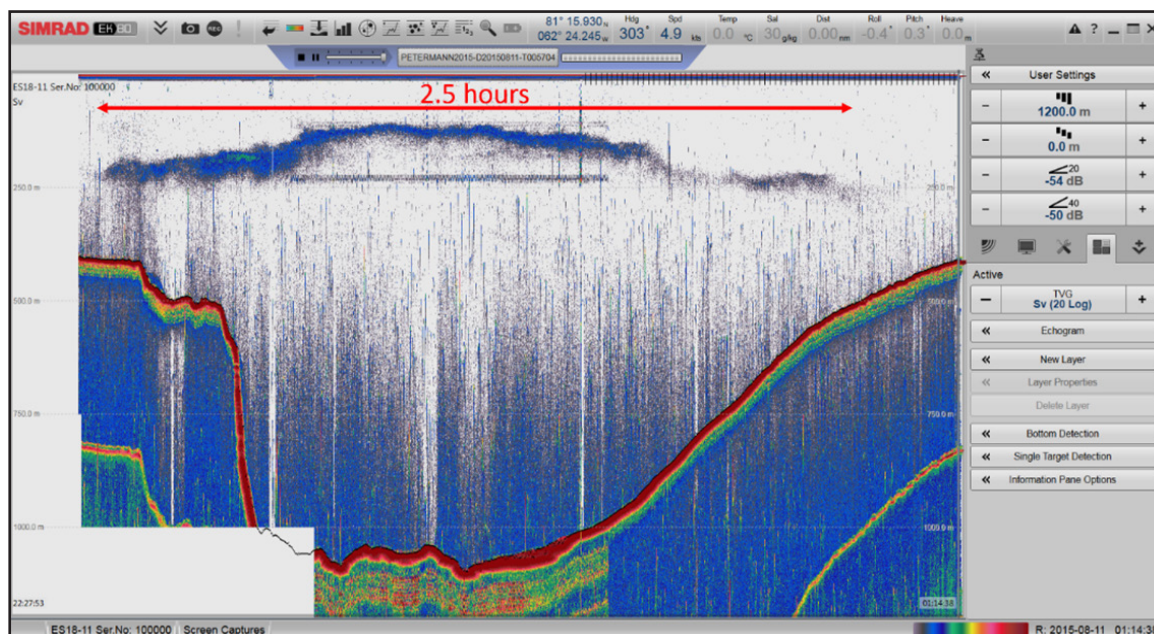


Figure WC-24: A midwater survey transect perpendicular to the fjord wall, driving away from the glacier and then returning at an oblique angle, included an extended observation of the backscatter plume over 2.5 hours. The plume appears to rise from approximately 225 m to 150 m as the seafloor depth drops precipitously from approximately 400 m to 1100 m. The EM122 DEEP mode artifact is visible for the middle portion of this echogram.

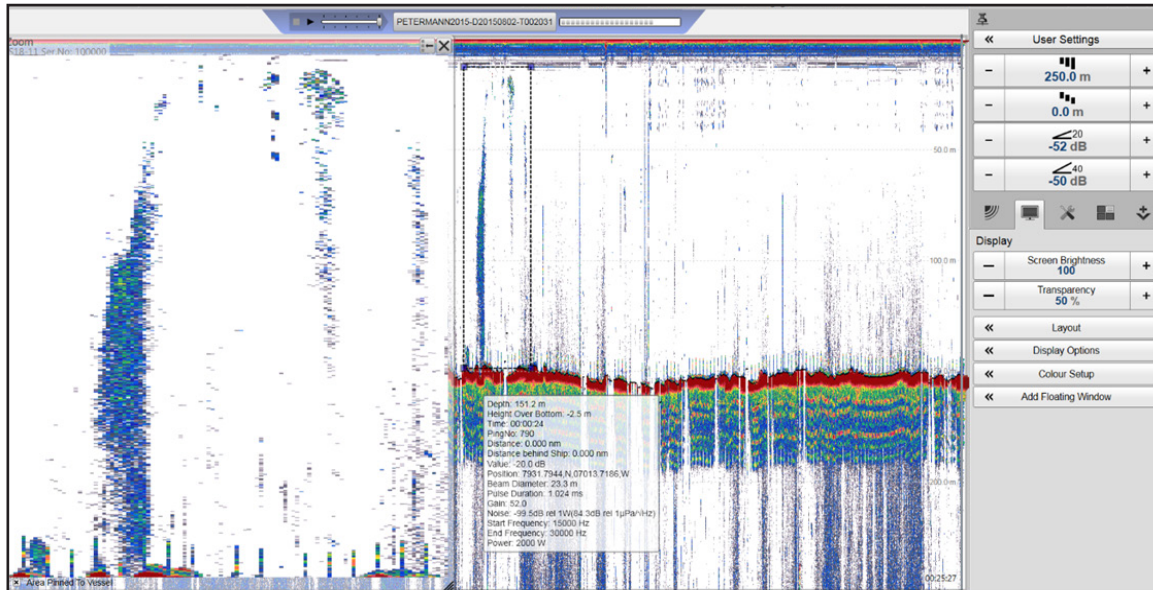


Figure WC-25: A possible methane gas plume emanating from the seabed during the transit north from Thule. The magnified image at left reveals two possible additional plumes with much weaker acoustic backscatter results in this view, perhaps because the plumes are well removed from the EK80 beamwidth. This is the only gas plume observation during the expedition in which we have high confidence of the interpretation.

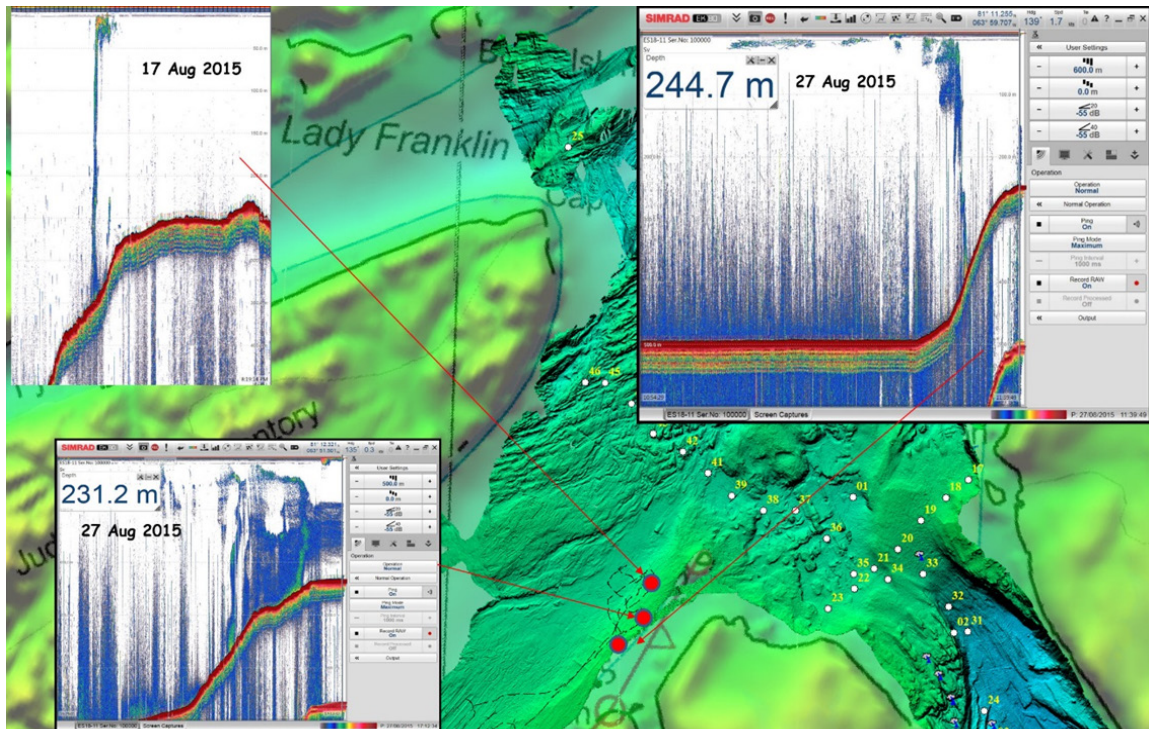


Figure WC-26: Two distinct plumes of unknown origin, one appearing to connect continuously from the sea-floor at a depth of 400 m to the surface, were observed near Joe Island on the 17th of August (image in upper left). Disturbances near the surface may be partly due to ship maneuvers which commenced at the time of observation. However, the acoustic backscatter anomalies extending from the seafloor are not believed to be in any way related to the ship maneuvers. A revisit to the site revealed nothing at the original site but a similar target emanating from the same depth less than 3 n.m. away (image in upper right). Also visible in this image is the likely trace of a seal seen swimming around the vessel at the time. In between these two sites a large acoustic anomaly including seep-like targets and perhaps many biological scatterers was seen again emanating from the same depth. The lateral distribution of these targets may indicate that they are freshwater plumes.

away (Figure WC-26). On the same day (27 August) a very massive feature was observed in the same general vicinity (Figure WC-27) which included both seep-like features and biological scatterers.

A final intriguing EK80 observation was of the impact of the passage of the piston corer through a dense biological scattering layer at approximately 375 m water depth (Figure WC-27). Here as the corer is retrieved from the seafloor and passes through the scattering layer, the scattering layer appears to follow the corer up. Another possibility is that we are seeing sediment shed from the corer as it rises through the water column, but we do not see this before the corer passes through the scattering layer, implying that we are seeing a disturbance of the scattering layer.

EM2040 Water Column Features

The EM2040 mounted on the *Skidbladner* provided another excellent opportunity to explore water-column processes at an even higher-resolution scale. Generally, the *Skidbladner* operating its multibeam at between 200 and 400 kHz, provided very clean water column imagery of the upper 100 to 200 m (Figure WC-28).

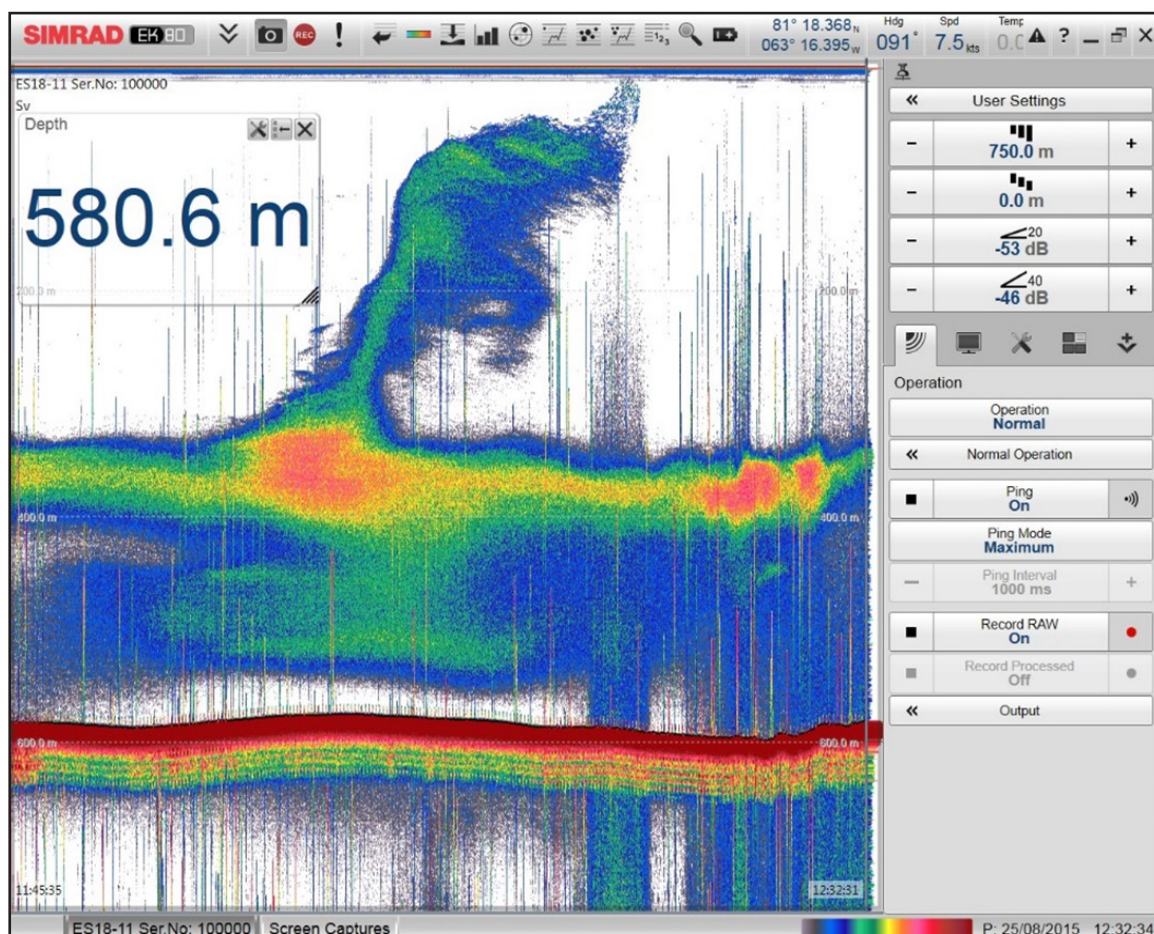


Figure WC-27: In at least one case, the diffuse biological layer at approximately 375 m appears to have been entrained or attracted by a core during its ascent and retrieval, as evidenced by the upward migration and later dispersion of these scatterers in the middle of this echogram. It is possible that the coring apparatus is shedding sediment during ascent, though this is not apparently the case near the bottom.

Indicative of the high-resolution that the EM2040 water column is capable of is Figure WC-29. Here the small (40 cm x 9 cm diameter) sound velocity profiler is clearly seen being lowered through the water column. Also seen is the track of what is most likely a seal (seen on the surface) diving to explore and examine the SVP. Small individual scatterers are also visible throughout the water column.

Most impressive is the ability of the EM2040 to discern subtle oceanographic features in the water column. An example is presented in Figure WC-29 and WC-30. Here the *Skidbladner* making its closest approach to a sidewall glacier on the southwest side of PF (Figures WC-30 and WC31). As the vessel approaches the glacier a strong near-surface scattering layer is seen, most likely representing a sediment-laden fresh-water plume from the glacier. Further away from the glacier, the backscatter decreases yet differences in the acoustic response clearly indicate differences in water properties and mixing. Here it appears the meltwater plume continues but denuded of its sediment load. Images like these indicate the tremendous potential of high-resolution water column mapping to provide detailed insight into glacial, sedimentary and oceanographic process.

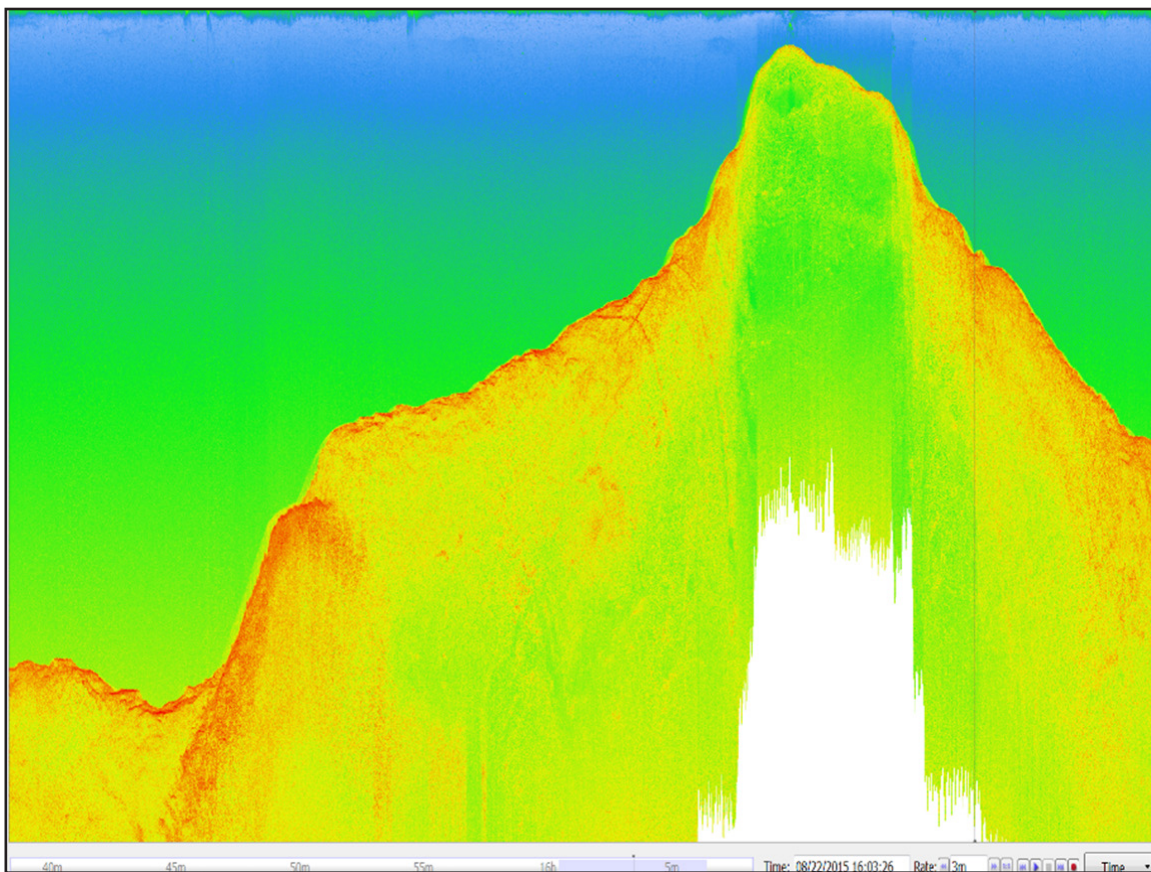


Figure WC-28: Example of water-column data collected by Skidbladner during survey of glacier front in PF. This example is of a stacked water-column view. The vessel is steaming from left to right towards (and then away) from the glacier. All beams in a single swath are displayed in a single vertical row of pixels thus any target seen in the 400 cross-track beams will be seen in this display. The shoalest point on the seafloor is approximately 15 m deep, the deepest point is 296 m.

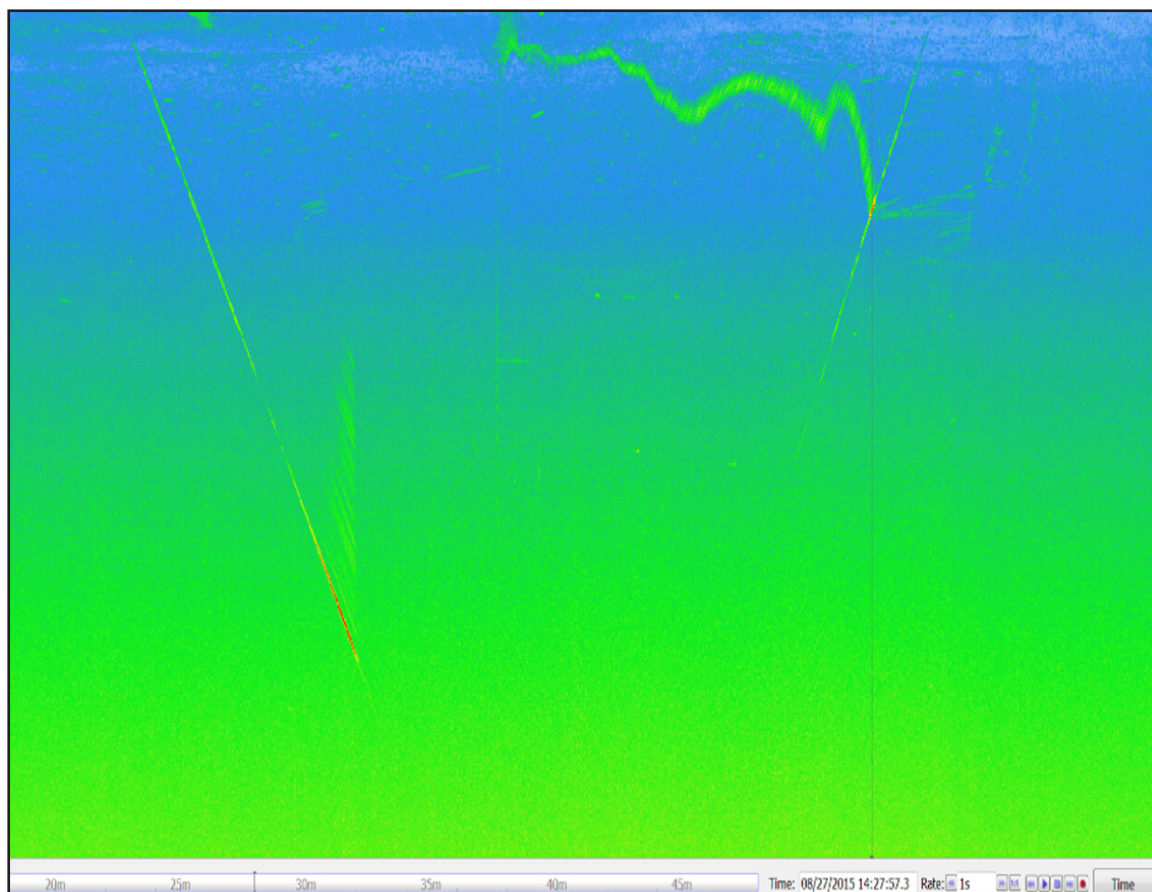


Figure WC-29: EM2040 water column data during sound velocity probe (SVP) lowering. The probe is seen being lowered on the left side (and likely expelling some trapped gas bubbles). Upon return of the SVP it appears to be examined by a seal that had been seen on the surface during the SVP lowering. Interception depth of SVP and seal is about 37 m.

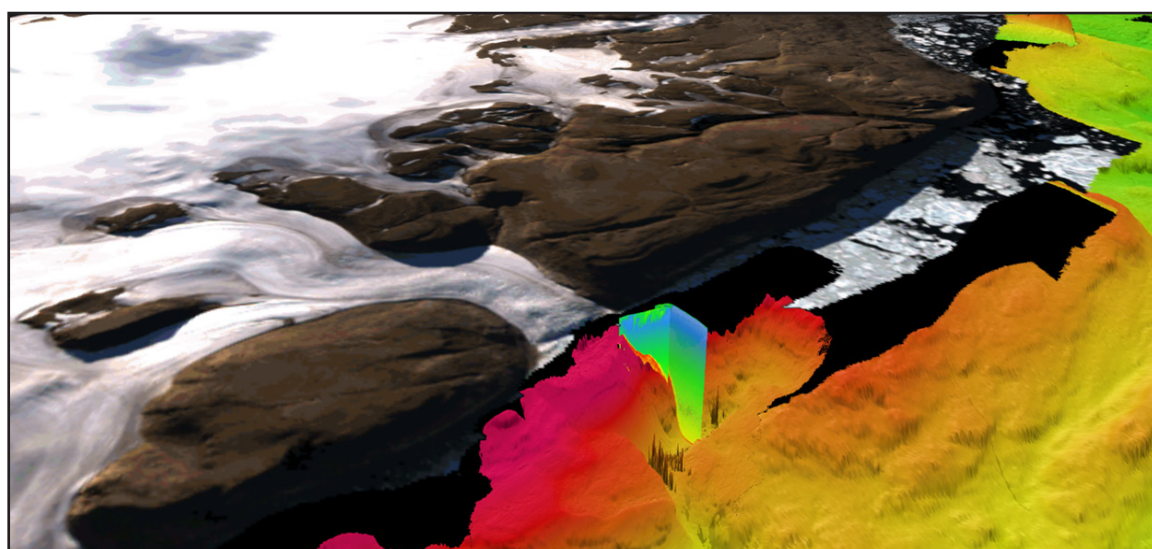


Figure WC-30: Satellite imagery of PF showing sidewall glacier on southwest side of the fjord combined with bathymetry from both Oden and Skidbladner. Blue and green curtain in front of glacier is water column data collected with EM2040 on Skidbladner. This line is displayed in more detail in Figure WC-31.

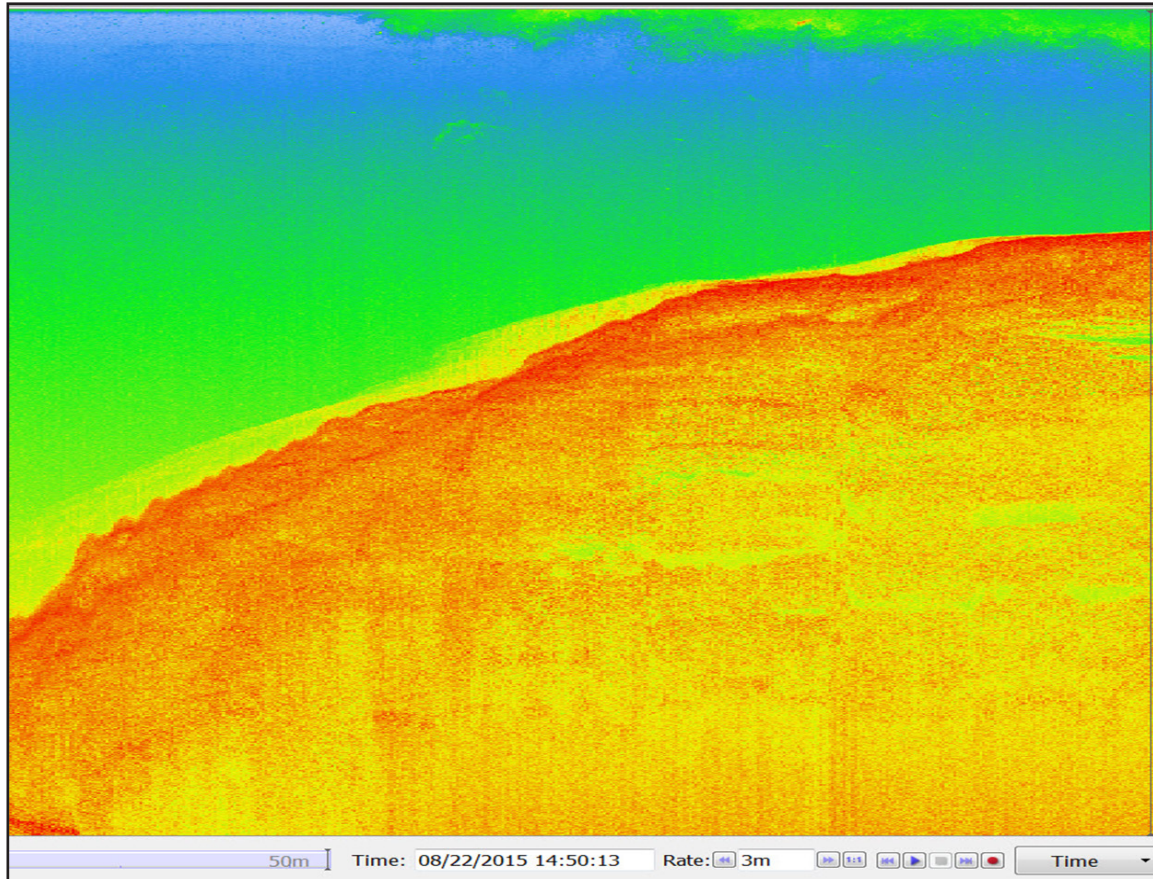


Figure WC-31: EM2040 water column data approaching the sidewall glacier shown in Figure WC-30. Light green target in upper 15 m is likely sediment-laden fresh water entering fjord from glacier. Moving away from glacier, sediment content decreases but indication of freshwater plume and mixing is still evident.

PO – Physical Oceanography

Staffing: Andreas Muenchow, Christian Stranna, Celine Heuze.

Equipment and Operations

The University of Gothenburg provided a SeaBird 911+ CTD system mounted inside a 24-bottle water sampling rosette (Figure PO-1). The CTD system consisted of a primary and secondary conductivity and temperature sensor set each with their own pump to provide a constant flushing of these sensors by seawater. A single pressure sensor, altimeter, and oxygen sensor complemented the system operating raw data at 24 Hz. The oxygen sensor was connected to the pump of the secondary C/T sensors. Serial numbers and most recent calibrations are shown in Table PO-1.

The system was operated in two shifts each consisting of two scientists operating computer system, electric winch, and hydraulic A-frame. Axel Meiton of the Swedish Polar Secretariat provided invaluable training, guidance, and assistance in operation of both winch and A-frame on the bow of the ship during deployment and recovery operations. Furthermore, he gave advice freely in the repair and maintenance of the CTD system.

We collected 46 vertical casts (Figure PO-2 and Table PO-2) that generally included a surface and bottom water sample collected in two glass vials for later oxygen isotope and dissolved inorganic carbon determinations. The latter vial was pre-prepared by Chris Holm and/or Maureen Walczak-Davies of Oregon State University with chemicals to which



Figure PO-1: The University of Gothenburg SeaBird 911+ CTD system mounted inside a 24-bottle water sampling rosette.

Table PO-1: Sensors on CTD-Rosette.

Sensor	S/N	Calibration Date	Comment
Temperature-1	4766	12-June-2015	Primary Sensor
Conductivity-1	3314	17-June-2015	Primary Sensor
Pressure	81331	17-Nov.-2011	
Temperature-2	4098	12-June-2015	Secondary Sensor
Conductivity-2	2401	17-June-2015	Secondary Sensor
Oxygen	1928	30-May-2015	SBE43
Altimeter	850	14-Aug.-2015	after "mud sample"

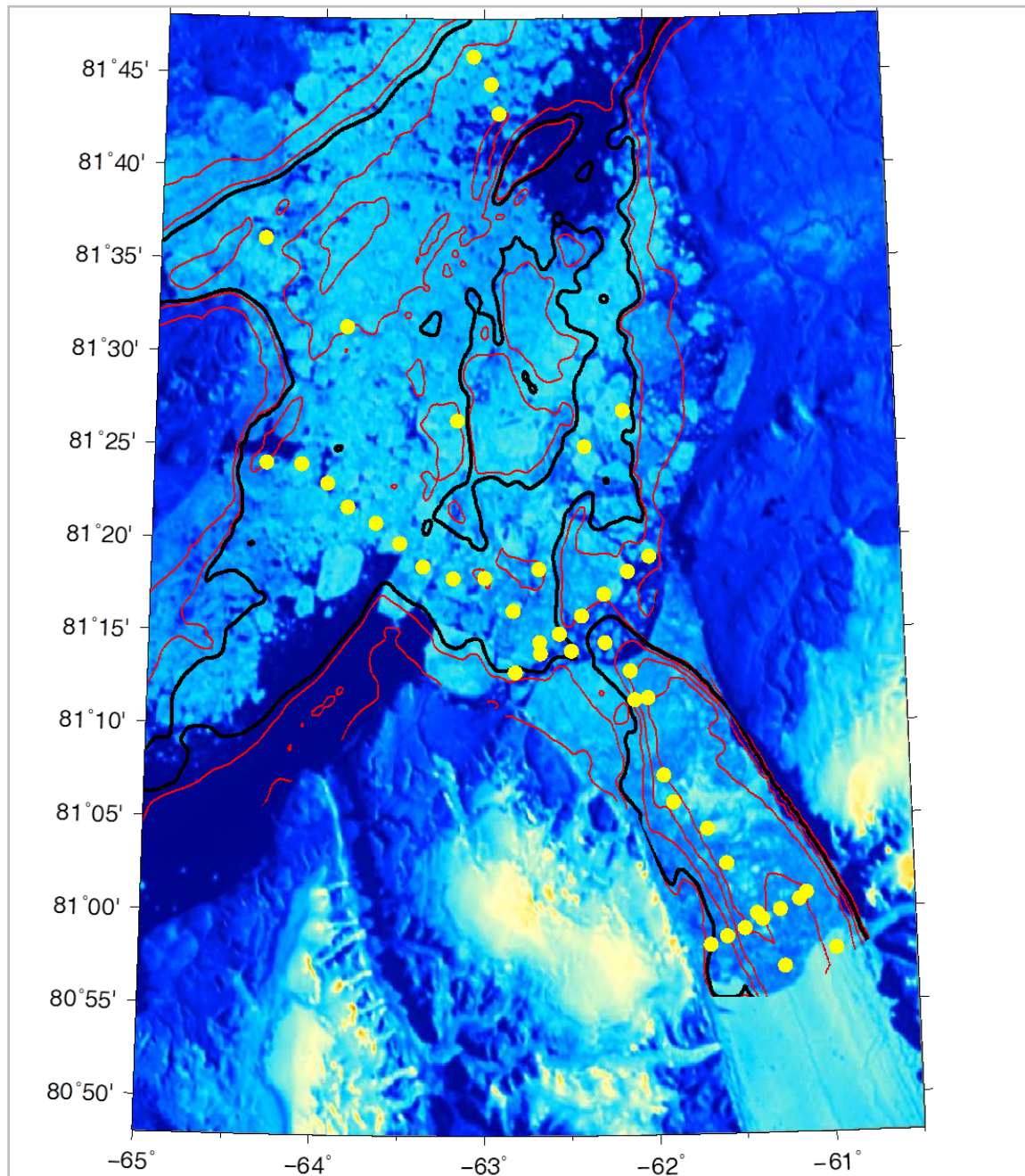


Figure PO-2: Map of study area with CTD cast locations (yellow). Contours are 450-m (black) and 200-m through 1000-m depth in 200-m intervals (red). Background is a July 2015 MODIS image.

Table PO-2: List of all CTD-Rosette casts.

Cast	Date and time, Day/Month/Year/UTC	Latitude, N	Longitude, W	Depth, m
001	03/8/2015/21:32	81.3070	62.6758	616
002	07/8/2015/01:53	81.1895	62.1093	835
003	07/8/2015/05:00	81.0978	61.8935	941
004	07/8/2015/06:34	81.0732	61.6967	1087
005	07/8/2015/08:11	81.0420	61.5877	1137
006	07/8/2015/09:49	80.9970	61.4183	1058
007	07/8/2015/11:45	80.9490	61.2645	949
008	07/8/2015/22:24	80.9693	61.6910	428
009	07/8/2015/23:23	80.9767	61.5935	502
010	08/8/2015/00:22	80.9833	61.4917	1001
011	08/8/2015/02:06	80.9912	61.3882	1022
012	08/8/2015/03:24	80.9995	61.2838	924
013	08/8/2015/04:37	81.0088	61.1733	980
014	08/8/2015/05:46	81.0147	61.1297	1008
015	13/8/2015/22:34	81.4487	62.1608	465
016	14/8/2015/14:43	81.4170	62.3947	557
017	15/8/2015/12:51	81.3182	62.0123	335
018	15/8/2015/13:59	81.3048	62.1440	357
019	15/8/2015/15:04	81.2843	62.2853	385
020	15/8/2015/16:07	81.2652	62.4195	404
021	15/8/2015/17:23	81.2492	62.5552	477
022	15/8/2015/18:38	81.2318	62.6677	517
023	15/8/2015/19:43	81.2147	62.8183	438
024	18/8/2015/09:55	81.1217	61.9467	978
025*	19/8/2015/21:57	81.6023	64.3577	520
026	20/8/2015/22:49	81.5238	63.8445	620
027	21/8/2015/14:06	81.7153	62.9110	777
028	21/8/2015/16:33	81.7665	63.0690	638
029	21/8/2015/18:10	81.7418	62.9580	694
030	22/8/2015/17:39	80.9642	60.9662	1040
031	23/8/2015/18:25	81.1915	62.0313	989
032	23/8/2015/19:43	81.2157	62.1342	762
033	23/8/2015/20:54	81.2412	62.2827	514
034	23/8/2015/22:01	81.2337	62.4818	470
035	23/8/2015/23:04	81.2417	62.6733	536
036	24/8/2015/00:09	81.2698	62.8302	563
037	24/8/2015/01:12	81.2993	63.0005	619
038	24/8/2015/02:12	81.2987	63.1875	595
039	24/8/2015/03:07	81.3092	63.3700	590
040	24/8/2015/16:28	81.4402	63.1655	656
041	25/8/2015/17:37	81.3300	63.5105	562
042	25/8/2015/18:42	81.3482	63.6545	533
043	25/8/2015/20:07	81.3622	63.8268	508
044	25/8/2015/21:28	81.3833	63.9517	523
045	25/8/2015/22:27	81.4005	64.1105	534
046	25/8/2015/23:33	81.4012	64.3235	641

(*) Cast 25 should be discarded because pump failed

about 2–3 ml of water was added via a syringe. Oxygen isotope bottles and lids as well as syringes were rinsed 3 times with sea water. No samples were taken for salinity calibrations.

The CTD-rosette was deployed on the bow of the ship after being moved ~20 m from a heated van to the forward A-frame with a hand-drawn trolley. Care was taken to keep the winch cable clear of the trolley. Once in position under the forward A-frame near the deployment location and after the ship's engines were shut off, we deployed the CTD-rosette system via hydraulic A-frame and electric winch over the bow of the ship. The ship drifted freely at this time for the 60–90 minutes that it took us to complete down- and up-casts in water always shallower than 1200 meters.

Once in the water, control of the CTD-Rosette system moved from the scientist operating on the forward deck to the heated CTD van where both computer and computerized winch controls were located. Starting the SeaBird deck unit to power the system in the water, we entered meta data (longitude, latitude, depth, and time), manually, waited for the pumps to turn on (~60 seconds), and then start data collection at vertical speeds of about 1 m/s to a pre-set depth 25–50 meters off the expected bottom. Once close to the seafloor, we stopped the CTD, triggered the bottom bottle, and started the upcast at a constant speed of about 1 m/s.

Bottles for water samples were triggered during the upcast “on the fly,” that is, without stopping or slowing down the upcast. Pressure, salinity, and potential temperature are extracted from the raw 24 Hz data for the two scans corresponding to times when command to fire a bottle from the deck unit was sent and confirmation was received by the deck unit that a bottle has indeed fired. Table PO-3 lists these data for all 241 bottle samples taken.

Table PO-3: List of water sampling locations and ocean properties sorted by cast and bottle on cast. Water parameters pressure (press), potential temperature (theta), salinity (Sal), and oxygen (ox) are given for time-1 and time-2 that correspond, respectively, to the time the command was given to fire a bottle and the time that confirmation of the bottle close was received. Date, time, longitude, and latitude are those are the start of the cast.

Cast	Bot	press1	press2	theta1	theta2	Sal1	Sal2	ox1	ox2	Date	Time	Long	Lat
2	2	709.1	707.5	0.292	0.292	34.776	34.777	6.36	6.36	2015-Aug-07	01:53	62.1000	81.1833
2	3	606.9	605.2	0.289	0.289	34.774	34.775	6.37	6.36	2015-Aug-07	01:53	62.1000	81.1833
2	4	505.2	503.5	0.276	0.275	34.765	34.764	6.37	6.37	2015-Aug-07	01:53	62.1000	81.1833
2	5	454.6	453.0	0.265	0.262	34.759	34.757	6.38	6.37	2015-Aug-07	01:53	62.1000	81.1833
2	6	404.4	402.8	0.250	0.250	34.750	34.750	6.38	6.39	2015-Aug-07	01:53	62.1000	81.1833
2	7	353.4	351.8	0.213	0.213	34.732	34.732	6.40	6.39	2015-Aug-07	01:53	62.1000	81.1833
2	8	303.3	301.6	0.175	0.169	34.716	34.713	6.41	6.41	2015-Aug-07	01:53	62.1000	81.1833
2	9	252.7	251.0	0.071	0.069	34.672	34.671	6.44	6.43	2015-Aug-07	01:53	62.1000	81.1833
2	10	202.1	200.4	-0.063	-0.065	34.610	34.607	6.46	6.47	2015-Aug-07	01:53	62.1000	81.1833
2	11	151.2	149.4	-0.309	-0.320	34.495	34.491	6.53	6.52	2015-Aug-07	01:53	62.1000	81.1833
2	12	100.1	98.5	-0.533	-0.556	34.005	33.981	6.65	6.66	2015-Aug-07	01:53	62.1000	81.1833
2	13	74.9	73.3	-0.885	-0.938	33.269	33.136	6.97	7.01	2015-Aug-07	01:53	62.1000	81.1833
2	14	49.7	48.0	-1.215	-1.226	31.992	31.905	7.54	7.61	2015-Aug-07	01:53	62.1000	81.1833
2	15	25.1	25.2	-1.295	-1.298	31.000	31.008	8.86	8.85	2015-Aug-07	01:53	62.1000	81.1833
2	16	9.9	9.5	-1.153	-1.176	28.217	28.136	9.28	9.26	2015-Aug-07	01:53	62.1000	81.1833
3	1	934.7	934.7	0.296	0.296	34.778	34.778	5.39	5.39	2015-Aug-07	05:00	61.8912	81.0977

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Cast	Bot	press1	press2	theta1	theta2	Sal1	Sal2	ox1	ox2	Date	Time	Long	Lat
3	3	407.7	406.0	0.255	0.254	34.753	34.752	6.37	6.38	2015-Aug-07	05:00	61.8912	81.0977
3	4	251.7	250.1	0.070	0.068	34.662	34.661	6.41	6.42	2015-Aug-07	05:00	61.8912	81.0977
3	5	201.8	200.2	-0.178	-0.215	34.574	34.563	6.47	6.47	2015-Aug-07	05:00	61.8912	81.0977
3	6	150.3	148.7	-0.362	-0.364	34.413	34.410	6.54	6.54	2015-Aug-07	05:00	61.8912	81.0977
3	7	100.4	98.7	-0.593	-0.601	33.796	33.785	6.68	6.68	2015-Aug-07	05:00	61.8912	81.0977
4	1	1081.2	1081.2	0.288	0.287	34.810	34.804	9.21	9.14	2015-Aug-07	06:34	61.6980	81.0732
4	3	910.7	909.1	0.286	0.286	34.776	34.777	6.34	6.34	2015-Aug-07	06:34	61.6980	81.0732
4	4	707.8	706.2	0.288	0.288	34.774	34.774	6.34	6.34	2015-Aug-07	06:34	61.6980	81.0732
4	5	606.9	605.2	0.286	0.286	34.771	34.771	6.36	6.35	2015-Aug-07	06:34	61.6980	81.0732
4	6	505.6	504.0	0.281	0.281	34.768	34.768	6.35	6.36	2015-Aug-07	06:34	61.6980	81.0732
4	7	455.0	453.4	0.277	0.276	34.764	34.764	6.34	6.35	2015-Aug-07	06:34	61.6980	81.0732
4	8	404.0	402.4	0.268	0.268	34.759	34.758	6.37	6.36	2015-Aug-07	06:34	61.6980	81.0732
4	9	353.4	351.7	0.242	0.241	34.741	34.741	6.36	6.37	2015-Aug-07	06:34	61.6980	81.0732
4	10	303.0	301.2	0.163	0.157	34.702	34.702	6.39	6.39	2015-Aug-07	06:34	61.6980	81.0732
4	11	251.6	250.0	0.041	0.037	34.647	34.645	6.41	6.42	2015-Aug-07	06:34	61.6980	81.0732
4	12	201.2	199.4	-0.125	-0.127	34.572	34.572	6.43	6.44	2015-Aug-07	06:34	61.6980	81.0732
4	13	151.0	149.2	-0.378	-0.381	34.440	34.439	6.50	6.50	2015-Aug-07	06:34	61.6980	81.0732
4	14	99.8	98.0	-0.574	-0.584	33.864	33.852	6.66	6.67	2015-Aug-07	06:34	61.6980	81.0732
5	1	1134.2	1134.2	0.291	0.291	34.778	34.778	4.42	4.42	2015-Aug-07	08:12	61.5870	81.0418
6	1	1044.1	1044.1	0.295	0.295	34.779	34.779	4.82	4.82	2015-Aug-07	09:49	61.4187	80.9972
6	3	910.6	909.0	0.290	0.290	34.778	34.778	6.34	6.33	2015-Aug-07	09:49	61.4187	80.9972
6	4	707.8	706.1	0.287	0.287	34.772	34.773	6.35	6.35	2015-Aug-07	09:49	61.4187	80.9972
6	5	607.2	605.5	0.286	0.286	34.772	34.771	6.35	6.35	2015-Aug-07	09:49	61.4187	80.9972
6	6	505.4	503.8	0.282	0.282	34.769	34.769	6.35	6.35	2015-Aug-07	09:49	61.4187	80.9972
6	7	454.5	452.9	0.276	0.276	34.765	34.764	6.35	6.36	2015-Aug-07	09:49	61.4187	80.9972
6	8	404.2	402.5	0.265	0.265	34.758	34.758	6.35	6.36	2015-Aug-07	09:49	61.4187	80.9972
6	9	353.8	352.2	0.225	0.225	34.737	34.737	6.36	6.36	2015-Aug-07	09:49	61.4187	80.9972
6	10	303.0	301.3	0.162	0.162	34.707	34.707	6.38	6.38	2015-Aug-07	09:49	61.4187	80.9972
6	11	252.1	250.5	0.057	0.053	34.660	34.658	6.39	6.40	2015-Aug-07	09:49	61.4187	80.9972
6	12	201.3	199.6	-0.160	-0.178	34.577	34.572	6.44	6.45	2015-Aug-07	09:49	61.4187	80.9972
6	13	151.3	149.7	-0.371	-0.372	34.394	34.391	6.51	6.51	2015-Aug-07	09:49	61.4187	80.9972
6	14	100.9	99.3	-0.572	-0.598	33.903	33.859	6.65	6.67	2015-Aug-07	09:49	61.4187	80.9972
6	15	75.3	73.6	-0.826	-0.846	33.026	33.009	6.84	6.89	2015-Aug-07	09:49	61.4187	80.9972
6	16	50.4	48.7	-1.063	-1.089	32.243	32.164	7.24	7.29	2015-Aug-07	09:49	61.4187	80.9972
6	18	9.8	9.3	0.122	0.169	29.321	29.325	9.39	9.39	2015-Aug-07	09:49	61.4187	80.9972
7	1	931.2	931.2	0.286	0.286	34.777	34.777	5.65	5.65	2015-Aug-07	11:45	61.2500	80.9333
9	1	485.6	0.0	0.284	-0.000	34.769	0.000	5.54	0.00	2015-Aug-07	23:23	61.5937	80.9667
9	3	454.8	453.2	0.283	0.284	34.770	34.770	6.36	6.36	2015-Aug-07	23:23	61.5937	80.9667
9	4	403.6	402.1	0.275	0.275	34.764	34.764	6.37	6.37	2015-Aug-07	23:23	61.5937	80.9667
9	5	353.4	351.7	0.236	0.234	34.742	34.740	6.38	6.38	2015-Aug-07	23:23	61.5937	80.9667
9	6	303.0	301.4	0.173	0.164	34.712	34.709	6.39	6.39	2015-Aug-07	23:23	61.5937	80.9667
9	7	252.6	250.9	0.106	0.107	34.675	34.673	6.39	6.39	2015-Aug-07	23:23	61.5937	80.9667
9	8	202.3	200.6	-0.036	-0.036	34.570	34.568	6.42	6.42	2015-Aug-07	23:23	61.5937	80.9667
9	10	101.1	99.4	-0.582	-0.612	33.878	33.837	6.65	6.65	2015-Aug-07	23:23	61.5937	80.9667
9	12	50.5	48.9	-1.025	-1.035	32.353	32.252	7.24	7.30	2015-Aug-07	23:23	61.5937	80.9667
9	13	25.0	24.6	-1.057	-1.048	30.463	30.428	8.71	8.72	2015-Aug-07	23:23	61.5937	80.9667

Cruise Report

Cast	Bot	press1	press2	theta1	theta2	Sal1	Sal2	ox1	ox2	Date	Time	Long	Lat
9	14	10.0	9.6	-0.709	-0.695	29.733	29.729	9.50	9.51	2015-Aug-07	23:23	61.5937	80.9667
10	1	917.5	917.5	0.294	0.294	34.777	34.777	5.69	5.69	2015-Aug-08	00:22	61.4833	80.9833
11	1	1010.8	1010.8	0.289	0.289	34.778	34.778	5.80	5.80	2015-Aug-08	02:06	61.4377	80.9843
12	1	894.1	894.2	0.287	0.287	34.777	34.777	5.84	5.86	2015-Aug-08	03:24	61.2835	81.0000
29	1	687.0	687.1	0.302	0.302	34.816	34.816	6.60	6.60	2015-Aug-21	18:11	62.9565	81.7422
29	2	10.0	10.0	-1.539	-1.539	29.914	29.914	9.30	9.30	2015-Aug-21	18:11	62.9565	81.7422
13	1	977.5	977.5	0.290	0.290	34.777	34.777	5.39	5.39	2015-Aug-08	04:37	61.1667	81.0088
14	1	1000.5	1000.7	0.287	0.287	34.776	34.776	4.65	4.62	2015-Aug-08	05:46	61.1230	81.0148
15	1	475.3	475.3	0.309	0.309	22.375	22.375	5.24	5.24	2015-Aug-13	22:34	62.1623	81.4475
16	1	522.2	522.2	0.283	0.283	34.763	34.763	5.73	6.33	2015-Aug-14	14:43	62.3833	81.4167
16	2	505.5	503.8	0.282	0.281	34.762	34.762	6.36	6.36	2015-Aug-14	14:43	62.3833	81.4167
16	3	454.3	452.5	0.271	0.270	34.756	34.755	6.36	6.36	2015-Aug-14	14:43	62.3833	81.4167
16	4	404.1	402.4	0.258	0.258	34.748	34.747	6.36	6.36	2015-Aug-14	14:43	62.3833	81.4167
16	5	353.3	351.6	0.249	0.249	34.741	34.741	6.36	6.36	2015-Aug-14	14:43	62.3833	81.4167
16	6	293.4	291.8	0.227	0.227	34.730	34.729	6.37	6.38	2015-Aug-14	14:43	62.3833	81.4167
16	7	252.2	250.6	0.197	0.194	34.713	34.712	6.39	6.40	2015-Aug-14	14:43	62.3833	81.4167
16	8	202.1	200.6	0.094	0.093	34.655	34.654	6.40	6.39	2015-Aug-14	14:43	62.3833	81.4167
16	9	151.3	149.9	-0.281	-0.266	34.481	34.479	6.45	6.46	2015-Aug-14	14:43	62.3833	81.4167
16	10	100.5	99.0	-0.458	-0.461	34.117	34.113	6.59	6.59	2015-Aug-14	14:43	62.3833	81.4167
16	11	75.4	74.1	-0.654	-0.662	33.746	33.713	6.67	6.69	2015-Aug-14	14:43	62.3833	81.4167
16	12	50.9	49.5	-1.277	-1.280	32.941	32.921	6.79	6.81	2015-Aug-14	14:43	62.3833	81.4167
16	13	24.4	22.7	-1.361	-1.391	32.148	31.932	7.85	7.96	2015-Aug-14	14:43	62.3833	81.4167
16	14	10.9	11.1	-0.567	-0.577	30.190	30.212	9.41	9.41	2015-Aug-14	14:43	62.3833	81.4167
17	1	323.7	323.7	0.172	0.172	34.708	34.708	5.78	5.81	2015-Aug-15	12:51	62.0123	81.3183
18	1	345.1	345.1	0.213	0.213	34.726	34.726	5.43	5.43	2015-Aug-15	13:59	62.1438	81.3045
18	3	303.1	301.5	0.196	0.194	34.719	34.718	6.39	6.39	2015-Aug-15	13:59	62.1438	81.3045
18	4	262.7	261.0	0.125	0.120	34.689	34.687	6.42	6.42	2015-Aug-15	13:59	62.1438	81.3045
18	5	242.1	240.4	0.092	0.077	34.673	34.666	6.43	6.43	2015-Aug-15	13:59	62.1438	81.3045
18	6	227.1	225.5	0.001	-0.011	34.641	34.635	6.43	6.43	2015-Aug-15	13:59	62.1438	81.3045
18	7	201.6	199.9	-0.158	-0.158	34.580	34.580	6.47	6.46	2015-Aug-15	13:59	62.1438	81.3045
18	8	151.0	149.4	-0.282	-0.300	34.512	34.498	6.50	6.49	2015-Aug-15	13:59	62.1438	81.3045
18	9	100.4	98.8	-0.541	-0.539	34.067	34.045	6.61	6.63	2015-Aug-15	13:59	62.1438	81.3045
18	10	75.0	73.4	-0.705	-0.703	33.629	33.606	6.76	6.77	2015-Aug-15	13:59	62.1438	81.3045
18	11	50.3	48.7	-0.979	-0.981	32.808	32.803	7.02	7.05	2015-Aug-15	13:59	62.1438	81.3045
18	12	24.7	23.0	-1.152	-1.153	31.698	31.612	7.87	8.01	2015-Aug-15	13:59	62.1438	81.3045
18	13	9.8	9.4	-0.807	-0.783	30.308	30.230	9.22	9.24	2015-Aug-15	13:59	62.1438	81.3045
19	1	377.4	377.4	0.273	0.273	34.756	34.756	5.56	5.57	2015-Aug-15	15:04	62.2847	81.2840
20	1	398.9	398.9	0.269	0.269	34.754	34.754	5.41	5.41	2015-Aug-15	16:07	62.4195	81.2652
21	1	457.1	457.1	0.316	0.316	34.792	34.792	5.57	5.57	2015-Aug-15	17:23	62.5553	81.2493
21	2	404.1	402.4	0.309	0.309	34.787	34.786	6.38	6.37	2015-Aug-15	17:23	62.5553	81.2493
21	3	353.5	351.9	0.288	0.288	34.768	34.767	6.37	6.38	2015-Aug-15	17:23	62.5553	81.2493
21	4	303.0	301.3	0.253	0.252	34.738	34.738	6.39	6.38	2015-Aug-15	17:23	62.5553	81.2493
21	5	252.0	250.3	0.171	0.168	34.679	34.677	6.37	6.37	2015-Aug-15	17:23	62.5553	81.2493
21	6	202.1	200.4	-0.079	-0.080	34.598	34.598	6.43	6.43	2015-Aug-15	17:23	62.5553	81.2493
21	7	151.0	149.5	-0.273	-0.284	34.519	34.513	6.46	6.45	2015-Aug-15	17:23	62.5553	81.2493
21	8	100.2	98.5	-0.584	-0.591	34.233	34.223	6.45	6.46	2015-Aug-15	17:23	62.5553	81.2493

Petermann 2015 Expedition

Cast	Bot	press1	press2	theta1	theta2	Sal1	Sal2	ox1	ox2	Date	Time	Long	Lat
21	9	74.8	73.2	-0.921	-0.872	33.744	33.705	6.47	6.54	2015-Aug-15	17:23	62.5553	81.2493
21	10	49.5	47.8	-1.175	-1.186	33.039	33.008	6.89	6.98	2015-Aug-15	17:23	62.5553	81.2493
21	11	25.1	23.4	-1.445	-1.479	31.997	31.915	7.77	7.87	2015-Aug-15	17:23	62.5553	81.2493
22	1	504.5	504.5	0.315	0.315	34.790	34.790	5.81	5.81	2015-Aug-15	18:38	62.6667	81.2167
23	1	425.7	425.7	0.303	0.303	34.782	34.782	6.17	6.17	2015-Aug-15	19:43	62.8192	81.2000
24	1	990.8	990.8	0.298	0.298	34.781	34.781	12.20	12.20	2015-Aug-18	09:55	61.9472	81.1217
24	2	505.1	503.5	0.278	0.277	34.762	34.761	6.35	6.36	2015-Aug-18	09:55	61.9472	81.1217
24	3	353.7	352.0	0.215	0.209	34.728	34.725	6.36	6.36	2015-Aug-18	09:55	61.9472	81.1217
24	4	251.8	250.1	-0.007	-0.012	34.645	34.644	6.40	6.41	2015-Aug-18	09:55	61.9472	81.1217
24	5	151.0	149.3	-0.276	-0.288	34.536	34.531	6.46	6.46	2015-Aug-18	09:55	61.9472	81.1217
24	6	100.6	99.0	-0.356	-0.482	34.280	34.250	6.53	6.52	2015-Aug-18	09:55	61.9472	81.1217
24	7	4.6	4.2	-0.828	-0.828	34.297	34.288	36.92	36.90	2015-Aug-18	09:55	61.9472	81.1217
26	1	565.4	563.8	0.298	0.298	34.822	34.822	6.63	6.62	2015-Aug-20	22:50	63.8447	81.5242
26	2	505.1	503.4	0.300	0.300	34.819	34.819	6.63	6.63	2015-Aug-20	22:50	63.8447	81.5242
26	3	454.5	452.9	0.300	0.300	34.813	34.812	6.63	6.63	2015-Aug-20	22:50	63.8447	81.5242
26	4	404.6	402.9	0.297	0.297	34.800	34.800	6.63	6.62	2015-Aug-20	22:50	63.8447	81.5242
26	5	353.3	351.7	0.283	0.283	34.770	34.769	6.62	6.61	2015-Aug-20	22:50	63.8447	81.5242
26	6	303.2	301.6	0.261	0.259	34.749	34.747	6.63	6.62	2015-Aug-20	22:50	63.8447	81.5242
26	7	252.4	250.8	0.190	0.188	34.695	34.694	6.61	6.61	2015-Aug-20	22:50	63.8447	81.5242
26	8	202.2	200.6	-0.013	-0.018	34.583	34.580	6.64	6.65	2015-Aug-20	22:50	63.8447	81.5242
26	9	150.8	149.2	-0.252	-0.261	34.425	34.419	6.69	6.70	2015-Aug-20	22:50	63.8447	81.5242
26	10	100.4	98.8	-1.201	-1.192	33.430	33.404	6.74	6.74	2015-Aug-20	22:50	63.8447	81.5242
26	11	75.1	73.6	-1.419	-1.422	32.681	32.672	6.95	6.98	2015-Aug-20	22:50	63.8447	81.5242
26	12	50.3	48.9	-1.694	-1.696	31.389	31.375	8.44	8.47	2015-Aug-20	22:50	63.8447	81.5242
26	13	24.8	23.1	-1.598	-1.593	30.775	30.735	9.09	9.10	2015-Aug-20	22:50	63.8447	81.5242
26	14	10.4	10.4	-1.540	-1.540	30.223	30.223	9.27	9.27	2015-Aug-20	22:50	63.8447	81.5242
27	1	782.2	0.0	0.302	-0.000	34.816	0.000	6.60	0.00	2015-Aug-21	14:06	62.9103	81.7157
27	2	708.1	706.5	0.312	0.312	34.807	34.808	6.59	6.60	2015-Aug-21	14:06	62.9103	81.7157
27	3	606.3	604.7	0.313	0.311	34.803	34.803	6.60	6.60	2015-Aug-21	14:06	62.9103	81.7157
27	4	505.8	504.2	0.297	0.297	34.788	34.787	6.61	6.60	2015-Aug-21	14:06	62.9103	81.7157
27	5	454.5	453.0	0.280	0.280	34.770	34.770	6.61	6.60	2015-Aug-21	14:06	62.9103	81.7157
27	6	404.5	403.0	0.268	0.268	34.763	34.763	6.61	6.61	2015-Aug-21	14:06	62.9103	81.7157
27	7	353.5	352.0	0.263	0.262	34.760	34.759	6.62	6.62	2015-Aug-21	14:06	62.9103	81.7157
27	8	303.4	302.0	0.238	0.237	34.745	34.745	6.63	6.63	2015-Aug-21	14:06	62.9103	81.7157
27	9	252.4	250.9	0.176	0.174	34.706	34.705	6.63	6.62	2015-Aug-21	14:06	62.9103	81.7157
27	10	202.7	201.2	0.083	0.081	34.644	34.644	6.64	6.64	2015-Aug-21	14:06	62.9103	81.7157
27	11	151.4	149.8	-0.148	-0.148	34.491	34.489	6.69	6.69	2015-Aug-21	14:06	62.9103	81.7157
27	12	101.4	99.9	-0.681	-0.698	33.977	33.947	6.76	6.77	2015-Aug-21	14:06	62.9103	81.7157
27	13	74.6	73.1	-1.179	-1.236	33.152	33.037	6.92	6.95	2015-Aug-21	14:06	62.9103	81.7157
27	14	50.6	49.1	-1.668	-1.685	31.414	31.374	8.35	8.41	2015-Aug-21	14:06	62.9103	81.7157
27	15	24.7	23.0	-1.607	-1.598	30.847	30.821	8.91	8.93	2015-Aug-21	14:06	62.9103	81.7157
27	16	11.8	11.8	-1.535	-1.535	30.188	30.188	9.29	9.29	2015-Aug-21	14:06	62.9103	81.7157
28	1	638.3	638.3	0.284	0.284	34.825	34.825	6.62	6.62	2015-Aug-21	16:33	63.0667	81.7667
28	2	12.0	12.0	-1.549	-1.549	30.025	30.025	9.20	9.20	2015-Aug-21	16:33	63.0667	81.7667
29	1	687.0	687.1	0.302	0.302	34.816	34.816	6.60	6.60	2015-Aug-21	18:11	62.9565	81.7422
29	2	10.0	10.0	-1.539	-1.539	29.914	29.914	9.30	9.30	2015-Aug-21	18:11	62.9565	81.7422

Cruise Report

Cast	Bot	press1	press2	theta1	theta2	Sal1	Sal2	ox1	ox2	Date	Time	Long	Lat
30	1	1040.9	1040.9	0.291	0.291	34.773	34.773	6.50	6.50	2015-Aug-22	17:39	60.9638	80.9645
30	2	10.4	10.4	-0.632	-0.632	30.301	30.301	9.86	9.86	2015-Aug-22	17:39	60.9638	80.9645
31	1	988.8	988.8	0.286	0.286	34.773	34.772	6.51	6.51	2015-Aug-23	18:26	62.0167	81.1833
31	2	905.1	903.5	0.286	0.286	34.772	34.772	6.54	6.54	2015-Aug-23	18:26	62.0167	81.1833
31	3	809.5	807.8	0.288	0.288	34.771	34.771	6.56	6.55	2015-Aug-23	18:26	62.0167	81.1833
31	4	708.2	706.6	0.288	0.288	34.769	34.769	6.56	6.56	2015-Aug-23	18:26	62.0167	81.1833
31	5	606.8	605.1	0.287	0.287	34.767	34.767	6.58	6.57	2015-Aug-23	18:26	62.0167	81.1833
31	6	505.3	503.7	0.282	0.282	34.764	34.764	6.59	6.58	2015-Aug-23	18:26	62.0167	81.1833
31	7	455.1	453.4	0.280	0.280	34.762	34.762	6.58	6.59	2015-Aug-23	18:26	62.0167	81.1833
31	8	404.6	402.9	0.274	0.273	34.758	34.758	6.59	6.59	2015-Aug-23	18:26	62.0167	81.1833
31	9	353.0	351.3	0.246	0.243	34.743	34.741	6.60	6.60	2015-Aug-23	18:26	62.0167	81.1833
31	10	302.5	300.8	0.181	0.180	34.712	34.712	6.61	6.62	2015-Aug-23	18:26	62.0167	81.1833
31	11	252.5	250.7	0.109	0.108	34.682	34.681	6.63	6.63	2015-Aug-23	18:26	62.0167	81.1833
31	12	201.5	199.9	-0.030	-0.031	34.619	34.619	6.66	6.66	2015-Aug-23	18:26	62.0167	81.1833
31	13	151.0	149.4	-0.220	-0.221	34.506	34.501	6.70	6.70	2015-Aug-23	18:26	62.0167	81.1833
31	14	100.6	99.0	-0.527	-0.597	34.079	34.059	6.79	6.77	2015-Aug-23	18:26	62.0167	81.1833
31	15	75.2	73.4	-0.879	-0.907	33.556	33.499	6.90	6.93	2015-Aug-23	18:26	62.0167	81.1833
31	16	49.8	48.2	-1.238	-1.265	32.576	32.513	7.37	7.40	2015-Aug-23	18:26	62.0167	81.1833
31	17	24.4	22.7	-1.269	-1.239	31.376	31.292	8.48	8.58	2015-Aug-23	18:26	62.0167	81.1833
31	18	11.7	11.7	-1.122	-1.122	30.518	30.518	9.21	9.21	2015-Aug-23	18:26	62.0167	81.1833
32	1	748.8	748.8	0.287	0.287	34.770	34.770	6.54	6.54	2015-Aug-23	19:43	62.1333	81.2000
32	2	13.9	13.9	-1.067	-1.067	31.041	31.041	8.86	8.86	2015-Aug-23	19:43	62.1333	81.2000
33	1	502.1	502.1	0.284	0.284	34.765	34.765	6.57	6.57	2015-Aug-23	20:54	62.2667	81.2333
33	2	10.7	10.7	-0.991	-0.992	30.562	30.568	9.27	9.27	2015-Aug-23	20:54	62.2667	81.2333
34	1	467.3	467.3	0.313	0.313	34.798	34.798	6.60	6.60	2015-Aug-23	22:01	62.4667	81.2333
34	2	10.0	10.0	-0.908	-0.908	30.613	30.613	10.14	10.14	2015-Aug-23	22:01	62.4667	81.2333
35	1	530.8	530.8	0.314	0.314	34.797	34.797	6.59	6.59	2015-Aug-23	23:04	62.6742	81.2418
35	2	9.8	9.4	-0.860	-0.849	30.867	30.828	9.65	9.68	2015-Aug-23	23:04	62.6742	81.2418
36	1	557.8	557.8	0.313	0.313	34.798	34.798	6.57	6.57	2015-Aug-24	00:09	62.8307	81.2700
36	2	10.5	10.0	-0.770	-0.664	30.727	30.568	9.75	9.74	2015-Aug-24	00:09	62.8307	81.2700
37	1	611.7	611.7	0.312	0.312	34.801	34.801	6.58	6.58	2015-Aug-24	01:12	63.0010	81.2993
37	2	9.9	9.4	-1.159	-1.178	30.474	30.450	9.44	9.48	2015-Aug-24	01:12	63.0010	81.2993
38	1	592.7	592.7	0.310	0.310	34.799	34.799	6.58	6.58	2015-Aug-24	02:12	63.1890	81.2988
38	2	10.0	9.6	-1.035	-0.914	30.197	30.142	9.70	9.71	2015-Aug-24	02:12	63.1890	81.2988
39	1	586.0	586.0	0.316	0.316	34.794	34.794	6.57	6.56	2015-Aug-24	03:07	63.3725	81.3093
39	2	506.2	504.6	0.306	0.306	34.785	34.785	6.58	6.57	2015-Aug-24	03:07	63.3725	81.3093
39	3	454.6	453.0	0.303	0.303	34.782	34.782	6.58	6.58	2015-Aug-24	03:07	63.3725	81.3093
39	4	404.2	402.5	0.288	0.285	34.770	34.768	6.58	6.58	2015-Aug-24	03:07	63.3725	81.3093
39	5	353.9	352.3	0.253	0.252	34.751	34.750	6.58	6.59	2015-Aug-24	03:07	63.3725	81.3093
39	6	303.5	301.8	0.203	0.200	34.723	34.722	6.58	6.59	2015-Aug-24	03:07	63.3725	81.3093
39	7	252.4	250.7	0.128	0.129	34.688	34.688	6.60	6.60	2015-Aug-24	03:07	63.3725	81.3093
39	8	201.7	200.1	0.103	0.094	34.651	34.647	6.60	6.60	2015-Aug-24	03:07	63.3725	81.3093
39	9	151.5	149.9	-0.109	-0.118	34.561	34.556	6.65	6.65	2015-Aug-24	03:07	63.3725	81.3093
39	10	100.1	98.4	-0.429	-0.446	34.253	34.234	6.71	6.70	2015-Aug-24	03:07	63.3725	81.3093
39	11	74.9	73.3	-0.655	-0.666	33.952	33.929	6.78	6.77	2015-Aug-24	03:07	63.3725	81.3093
39	12	50.0	48.4	-1.051	-1.098	33.322	33.260	6.91	6.94	2015-Aug-24	03:07	63.3725	81.3093

Petermann 2015 Expedition

Cast	Bot	press1	press2	theta1	theta2	Sal1	Sal2	ox1	ox2	Date	Time	Long	Lat
39	14	25.0	24.6	-1.421	-1.427	31.954	31.921	7.87	7.89	2015-Aug-24	03:07	63.3725	81.3093
39	15	9.9	9.5	-1.120	-1.100	30.091	30.063	9.50	9.53	2015-Aug-24	03:07	63.3725	81.3093
40	1	638.7	638.7	0.306	0.306	34.810	34.810	6.60	6.60	2015-Aug-24	16:28	63.1648	81.4402
40	2	555.9	554.3	0.307	0.307	34.805	34.805	6.61	6.60	2015-Aug-24	16:28	63.1648	81.4402
40	3	504.6	503.0	0.306	0.306	34.796	34.795	6.60	6.61	2015-Aug-24	16:28	63.1648	81.4402
40	4	455.0	453.4	0.303	0.302	34.787	34.786	6.61	6.61	2015-Aug-24	16:28	63.1648	81.4402
40	5	404.4	402.7	0.293	0.292	34.775	34.774	6.60	6.60	2015-Aug-24	16:28	63.1648	81.4402
40	6	353.7	352.0	0.277	0.277	34.764	34.764	6.60	6.60	2015-Aug-24	16:28	63.1648	81.4402
40	7	302.6	301.1	0.248	0.245	34.746	34.744	6.61	6.61	2015-Aug-24	16:28	63.1648	81.4402
40	8	252.9	251.5	0.211	0.210	34.725	34.725	6.62	6.61	2015-Aug-24	16:28	63.1648	81.4402
40	9	202.2	200.7	0.115	0.112	34.670	34.669	6.63	6.63	2015-Aug-24	16:28	63.1648	81.4402
40	10	151.6	150.1	-0.133	-0.144	34.514	34.503	6.67	6.68	2015-Aug-24	16:28	63.1648	81.4402
40	11	100.3	98.7	-0.478	-0.488	34.127	34.111	6.81	6.81	2015-Aug-24	16:28	63.1648	81.4402
40	12	75.7	74.3	-0.783	-0.768	33.730	33.702	6.87	6.91	2015-Aug-24	16:28	63.1648	81.4402
40	13	49.9	48.4	-1.157	-1.194	32.820	32.670	7.30	7.34	2015-Aug-24	16:28	63.1648	81.4402
40	14	24.5	23.0	-1.467	-1.499	31.317	31.179	8.57	8.79	2015-Aug-24	16:28	63.1648	81.4402
40	15	10.0	10.0	-0.738	-0.738	30.042	30.042	9.91	9.91	2015-Aug-24	16:28	63.1648	81.4402
41	1	576.2	576.2	0.309	0.309	34.802	34.802	6.59	6.59	2015-Aug-25	17:37	63.5072	81.3297
41	2	9.9	9.4	-1.314	-1.073	30.226	30.070	9.76	9.82	2015-Aug-25	17:37	63.5072	81.3297
42	1	490.6	490.5	0.306	0.306	34.802	34.802	6.60	6.60	2015-Aug-25	18:42	63.6503	81.3488
42	2	9.9	9.5	-1.426	-1.414	30.533	30.514	9.39	9.42	2015-Aug-25	18:42	63.6503	81.3488
43	1	483.6	483.6	0.304	0.304	34.810	34.810	6.61	6.61	2015-Aug-25	20:07	63.8252	81.3635
43	2	10.8	11.1	-1.555	-1.554	30.446	30.459	9.18	9.18	2015-Aug-25	20:07	63.8252	81.3635
44	1	510.1	510.1	0.305	0.305	34.807	34.807	6.60	6.60	2015-Aug-25	21:28	63.9500	81.3833
44	2	10.8	10.8	-1.513	-1.513	30.196	30.196	9.24	9.24	2015-Aug-25	21:28	63.9500	81.3833
45	1	542.8	542.8	0.303	0.303	34.802	34.802	6.59	6.59	2015-Aug-25	22:27	64.1000	81.4000
45	2	10.8	10.8	-1.543	-1.543	30.157	30.157	9.26	9.26	2015-Aug-25	22:27	64.1000	81.4000
46	1	597.2	597.2	0.300	0.300	34.805	34.805	6.59	6.59	2015-Aug-25	23:33	64.3230	81.4013
46	2	505.3	503.6	0.299	0.299	34.800	34.799	6.59	6.59	2015-Aug-25	23:33	64.3230	81.4013
46	3	454.8	453.1	0.303	0.303	34.796	34.796	6.59	6.60	2015-Aug-25	23:33	64.3230	81.4013
46	4	404.5	402.9	0.304	0.303	34.780	34.780	6.59	6.59	2015-Aug-25	23:33	64.3230	81.4013
46	5	353.2	351.6	0.269	0.266	34.751	34.750	6.59	6.59	2015-Aug-25	23:33	64.3230	81.4013
46	6	303.6	302.1	0.215	0.215	34.713	34.712	6.59	6.58	2015-Aug-25	23:33	64.3230	81.4013
46	7	252.0	250.4	0.097	0.091	34.642	34.640	6.60	6.61	2015-Aug-25	23:33	64.3230	81.4013
46	8	202.0	200.5	-0.168	-0.173	34.486	34.482	6.66	6.66	2015-Aug-25	23:33	64.3230	81.4013
46	9	150.6	149.2	-0.673	-0.672	34.214	34.212	6.71	6.70	2015-Aug-25	23:33	64.3230	81.4013
46	10	100.2	98.6	-1.099	-1.132	33.486	33.466	6.57	6.58	2015-Aug-25	23:33	64.3230	81.4013
46	11	75.1	73.5	-1.386	-1.386	32.891	32.887	6.72	6.72	2015-Aug-25	23:33	64.3230	81.4013
46	12	50.1	48.4	-1.591	-1.609	31.727	31.686	8.12	8.25	2015-Aug-25	23:33	64.3230	81.4013
46	13	24.5	22.9	-1.341	-1.511	30.632	30.474	9.02	9.17	2015-Aug-25	23:33	64.3230	81.4013
46	14	10.6	10.5	-1.494	-1.492	29.928	29.913	9.31	9.31	2015-Aug-25	23:33	64.3230	81.4013

We expect the water contained within the bottles to originate from a level above the recorded bottle firing and closing. Past experience showed this vertical offset to be nearly constant for constant profiling speeds in the range of 6–8 meters. Precise determination of this offset, if required, can be done with a lagged regression analysis of bottle salinities with salinities estimated from the raw 24 Hz measurements of pressure, temperature, and conductivity.

We stopped data collection when the CTD-Rosette system arrived within about 4–8 meters of the surface and turned off the power of the unit. Mechanical control of the system then went to the scientist on the deck who recovered the instrument package via A-frame and winch. We generally left the instrument on the foredeck during section work when air temperatures were above freezing, but moved it back into the heated van when temperatures were below freezing.

CTD operations on IB *Oden* were severely limited in the coastal waters of Nares Strait and PF due to the inability of the ship to hold position while drifting freely. Hence CTD operations outlined above were possible only at times of minimal wind (<5 m/s), minimal currents (<0.5 m/s), and locations generally 2 nautical miles away from the coast.

Time Line

The Gothenburg University CTD Rosette system was assembled upon arrival on the ship on July-29 and July-30 and was deployed for the first time on 03-Aug.-2015 in Hall Basin as part of a CT/D sensor intercomparison.

Cast-001: C/T/D sensor intercomparison

The 911+ system served as the reference for 16 SBE37sm and 3 LoTUS buoys. The SBE37sm were slated for subsequent deployment under the iceshelf of Petermann Gletscher. Bottles were removed for this first cast that was lowered at much reduced vertical winch speeds (~ 0.25 m/s) to allow the internally recording SBE37sm sensors sampling at 6 second intervals to adequately sample the vertical profile at ~ 1.5 m vertical resolution. On the upcast we stopped the CTD at about 10 different depth levels for 15 minutes to give the thermistors on the LoTUS buoys time to adjust to the temperatures at this depth. LoTUS buoys have internal temperature sensors not in direct contact with the water and thus have a much longer time constant relative to fast response thermistors on both SBE-911 and SBE37sm systems.

Cast-002

At the onset of this cast the water depth was 920-m, however, steeply sloping bottom topography and a ship drifting rapidly into shallower water caused trepidation to all in the CTD van when during the upcast at 1 m/s the pressure on the CTD frequently indicated the sensor to be below rather than above the bottom. Hence it is likely that contact was made during the upcast with steep topography. When the CTD was safely aboard after a harrowing cast, water depth was 450 meters. Nevertheless, we collected a full set of 16 water samples, however, it is not entirely clear what bottom depths these water samples correspond to.

Cast-015: Bottom contact

The altimeter provided cumbersome readings from Cast-1 through Cast-15. During this cast the secondary sensors collected mud from the bottom at 470-m depth, because the CTD operator falsely believed a reading from the ship's navigation system indicating a water depth of 485-m.

This bottom sample was then used to “calibrate” the altimeter which then correctly displayed the distance to the bottom within a 60-m range. Prior to this “mud sample” primary and secondary sensors agreed to within 0.002 psu and C in salinity and temperature at depths below 400-m. Cleaning and flushing the cell with both salty and distilled water, we found offset between primary and secondary sensors of about -0.006 psu for salinity and less than 0.001 for temperature (Figure PO-3).

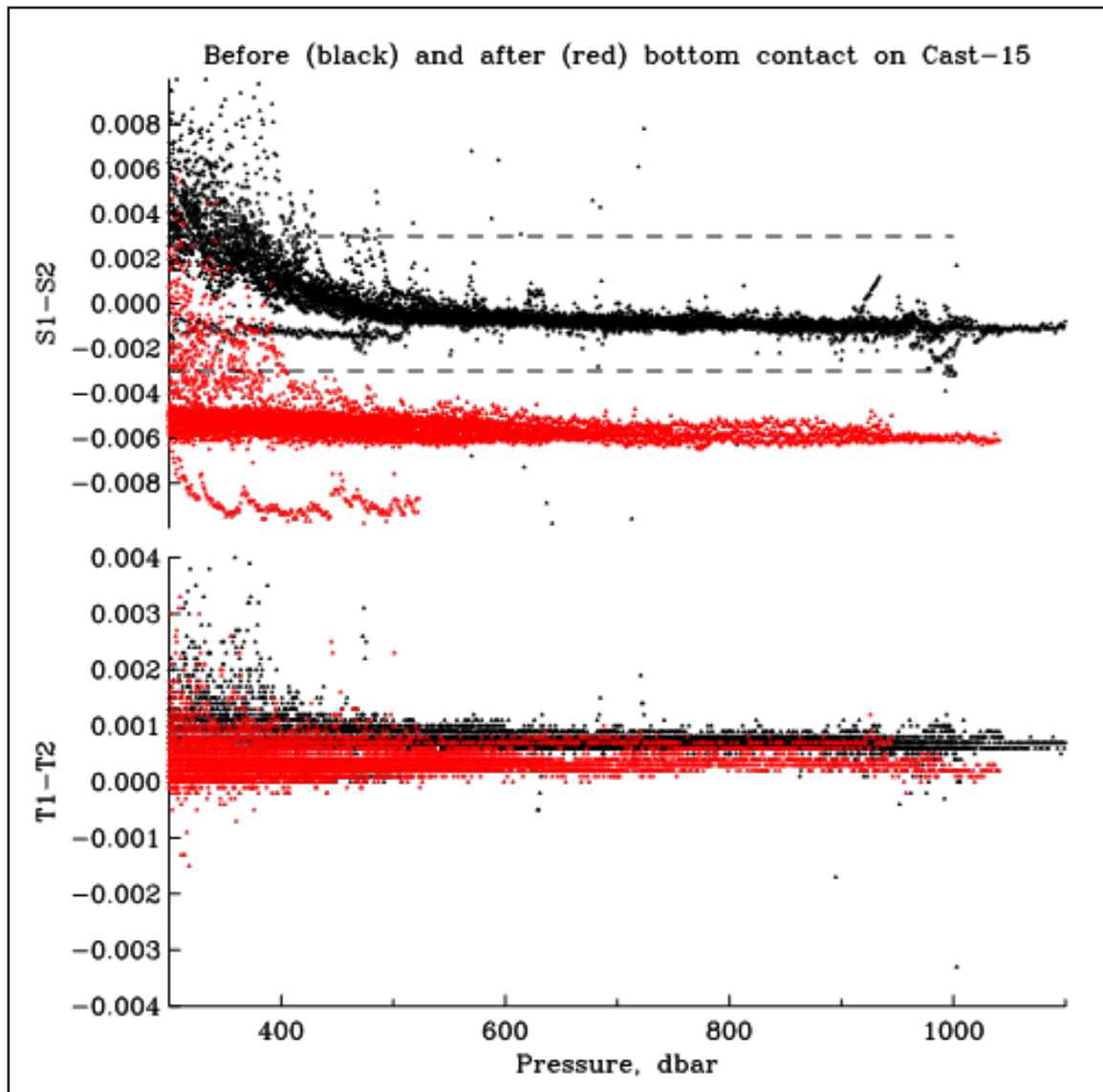


Figure PO-3: Comparison for all 46 casts of the two sensors pairs during the down cast below 300-m depths. Color indicates time before (black) and after (red) bottom contact (Cast-015) when sensor system-2 collected mud.

Cast-024 and Cast-025: Catastrophic pump failure

At about 940-m depth into the downcast of Cast-024 CTD operators noticed an intermittently failing pump and an excessive amount of spiking on the upcast. Furthermore, bottles failed to fire in the water, but all bottles fired in the heated CTD van. On the subsequent Cast-025 the next day (Aug.-19) the pump failed completely and all data from this cast should be discarded as unreliable.

Subsequent diagnostics revealed:

- a. a wrong fuse in the deck unit, e.g., 1 Amp that should be 0.5 Amp (replaced fuse);
- b. a loose and leaky bulkhead connector on pump #2 (S/N 055750, replaced unit);
- c. an incorrectly seated pin connecting power to pump #2 (cleaned and re-seated).

All subsequent casts worked as designed. Furthermore, spurious spikes in the oxygen sensors near the bottom disappeared that, we believed prior to this pump failure, were caused by rapid changes in winch speed such as caused near the bottom or when ice forced us to stop the winch.

It is possible that the faulty pump with S/N 055750 may not have functioned according to specifications on Cast-001 through Cast-025. Careful future processing and analysis needs to investigate this in more detail. This is true especially with regard to the oxygen sensor that has a slower response time constant than thermistors and conductivity sensors.

Physical Profiling

On July-30 we presented to the Chief Scientist a detailed station list of 9 sections consisting of 7–9 stations for the 96 hours of allocated CTD survey time. The sections were prioritized as mission critical, highly desirable, and desirable to resolve spatial and temporal scales that impact circulation and mixing of ocean water towards the floating glacier.

The mission critical section along PF (Section-1a) extending across the outer sill (Section-1b) towards Canada across Hall Basin (Section-1c) was completed as designed in 3 segments. A second mission critical section across the entrance to PF (Section-3) was completed as designed, while the third such section across northern Robeson Channel was cut short and reduced to 3 closely spaced stations on account of ice and time.

A highly desirable section across the terminus of Petermann Gletscher was completed as designed (Section-2) while equally desirable along-fjord sections adjacent to the south-eastern and north-western fjord walls were impractical on account of unrealistic expectations of station-keeping abilities and time.

No desirable sections across Kennedy Channel were attempted on account of ice and time.

Table PO-4 summarize accomplished sections, casts, as well as wire, transit, and maneuvering time spent on CTD and bottle water sampling operations.

Data Processing

Preliminary data processing was done using SeaBird's processing software as outlined in Table PO-5. The initial 24 Hz hexadecimal files were processed in the following steps with the detailed processing parameters shown also. The resolution of 24 Hz is generally lost after processing step "5. loopedit" and a much reduced file results after processing step "7. binavg." The so processed data are shown as profile plots discussed briefly below.

Table PO-4: Organization of CTD cast and water sampled by section and time.

CTD Casts	Date	Hours	Bottles	Comment
01	Aug.-03	5	0	Intercomparison SBE37sm
02 - 07	Aug.-07	10	52	Section-1a: Petermann along center
08 - 14	Aug.-07/08	8	16	Section-2: Petermann across terminus
15 + 16	Aug-13+14	2	15	Coring Sites
17 - 23	Aug.-15	8	28	Section-3: Petermann across entrance
24 + 25* + 26	Aug.18, 19, 20	3	21	Coring Sites
27 - 29	Aug.-21	5	22	Section-4: Robeson Channel
30	Aug.-22	1	2	Coring Site
31 - 39	Aug.-23/24	9	46	Section-1b: Petermann across sill
40	Aug.-24	1	15	Coring Site
41 - 46	Aug.-25	7	24	Section-1c: Across Hall Basin
Totals		59	241	

Table PO-5: CTD Processing steps and processing parameters.

Routine	Function
1. datcnv	Conversion of measured properties to ascii
2. alignctd	Alignment of temperature and conductivity sensors
3. wildedit	Spike removal
4. celltm	Thermal mass of sensors
4. filter	smoothing
5. loopedit	Removal of upcast
6. derive	Estimation of derived properties (salinity, pot. Temp., density, etc.)
7. binavg	Vertical bin average

```
# datcnv_date = Aug 26 2015 10:55:22, 7.23.2 [datcnv_vars = 6]
# datcnv_in = C:\Users\CTD\Cast_raw\OD1507_046CTD.hex C:\Users\CTD\Desktop\
Petermann\09P-0613_OD1507.xmlcon
# datcnv_skipover = 0
# datcnv_ox_hysteresis_correction = yes
# datcnv_ox_tau_correction = yes
# alignctd_date = Aug 26 2015 10:56:56, 7.23.2
# alignctd_in = C:\Users\CTD\Processed\andreas\OD1507_046CTD.cnv
# alignctd_adv = sbeoxoML/L 3.00
# wildedit_date = Aug 26 2015 10:58:16, 7.23.2
# wildedit_in = C:\Users\CTD\Processed\andreas\OD1507_046CTD.cnv
# wildedit_pass1_nstd = 10.0
# wildedit_pass2_nstd = 20.0
# wildedit_pass2_mindelta = 0.000e+000
# wildedit_npoint = 100
# wildedit_vars = prDM to90C t190C coS/m c1S/m sbeoxoML/L
```

```

# wilddedit_excl_bad_scans = yes
# celltm_date = Aug 26 2015 10:59:38, 7.23.2
# celltm_in = C:\Users\CTD\Processed\andreas\OD1507_046CTD.cnv
# celltm_alpha = 0.0300, 0.0300
# celltm_tau = 7.0000, 7.0000
# celltm_temp_sensor_use_for_cond = primary, secondary
# filter_date = Aug 26 2015 11:00:51, 7.23.2
# filter_in = C:\Users\CTD\Processed\andreas\OD1507_046CTD.cnv
# filter_low_pass_tc_A = 0.030
# filter_low_pass_tc_B = 0.150
# filter_low_pass_A_vars = prDM t90C t190C coS/m c1S/m sbeoxoML/L
# filter_low_pass_B_vars =
# loopedit_date = Aug 26 2015 11:02:08, 7.23.2
# loopedit_in = C:\Users\CTD\Processed\andreas\OD1507_046CTD.cnv
# loopedit_minVelocity = 0.000
# loopedit_surfaceSoak: minDepth = 4.0, maxDepth = 16, useDeckPress = 1
# loopedit_excl_bad_scans = no
# Derive_date = Aug 26 2015 11:03:09, 7.23.2 [derive_vars = 8]
# Derive_in = C:\Users\CTD\Processed\andreas\OD1507_046CTD.cnv C:\Users\CTD\
Desktop\Petermann\09P-0613_OD1507.xmlcon
# binavg_date = Aug 26 2015 11:04:14, 7.23.2
# binavg_in = C:\Users\CTD\Processed\andreas\OD1507_046CTD.cnv
# binavg_bintype = decibars
# binavg_binsize = 1
# binavg_excl_bad_scans = yes
# binavg_skipover = 0
# binavg_surface_bin = no, min = 0.000, max = 0.000, value = 0.000

```

Results

For each cast we provide in graphical form how salinity, potential temperature, and oxygen vary as function of pressure in decibars that for practical purposes can be taken as depth in meters. The upper layer from the surface to 400-m depth is shown on the bottom left with scales different for the bottom layer below 400-m on the bottom right.

The insert shows an outline of the location of all stations with the particular cast highlighted by a large triangle. The top panel shows variations of potential temperature as a function of salinity with the insert showing details of water property variations associated with the warm and salty Atlantic layer that enters our study area from the north via Robeson Channel (Casts 027, 028, and 029).

One of these plots is shown below as Figure PO-4.

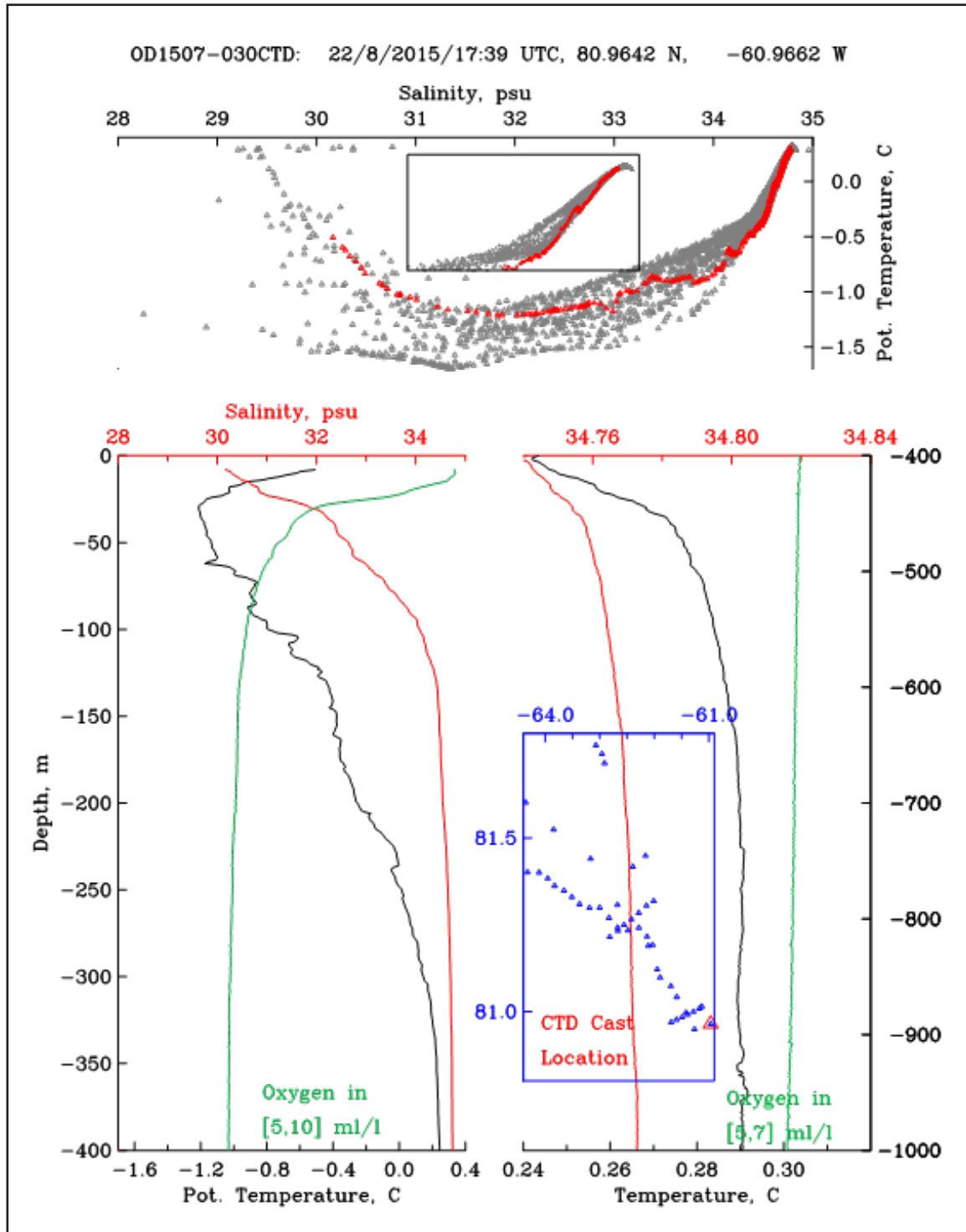


Figure PO-4: Example plot for Cast-030 at south-eastern terminus of Petermann Gletscher. The graph summarizes both profile- and meta-data after processing outlined above. The entire set of uniformly processed and scaled graphs were available on the `~/pub/Science/CTD` drive during the entire expedition.

SC – Sediment Coring and Core Processing

Staffing: Joe Stoner, Ann Jennings, Laurence Dyke, Chris Moser, Brendan Reilly, Maureen Walczak, Paul Walczak, Maziet Cheseby, Alan Mix, Martin Jakobsson. Markus Karasti, Draupnir Einarsson.

Sediment coring involved both piston/gravity coring for up to 12 m long cores and multicoring specifically targeting the uppermost surface sediment sequence. Exact coring locations were selected at sea based on geophysical survey

Equipment and Methods

Piston/gravity corer

The Stockholm University piston corer was used. It was built 1996 to take up to 12 m long sediment cores from the aft deck of *Oden*, (Figure SC-1). The corer has standard metric dimensions of barrel, screws and couplings. It has been upgraded several times since it was first built. The latest upgrade makes it possible to switch between two different dimensions of the core barrel/liner system. The change between dimensions requires changing core barrel, couplings, liner and piston. The core head including release arm remains the same between the two setups. The original liner dimension has an inner/outer diameter of 80/88 mm while the new wider diameter setup can take a liner dimension with an outer diameter of 110 mm.



Figure SC-1: Gravity/Piston Coring System deployed from *Oden*'s A-Frame.

Transparent polycarbonate liners were used for the smaller diameter while standard PVC pipes were used for the larger. The small diameter corer with transparent liner is only brought along as a spare unit. The core head can be loaded with a maximum of 1360 kg lead weights. The standard release arm is designed so that a trigger weight of 1/10 of the main core head weight should be used. Hydrostatic safety releases are used to arm the release arm. Three complete core heads will be brought on board, and two setups of barrel/couplings for each of the diameters. Typical pullouts of the piston core system were about 9,000–10,000 kg.

When liner was inserted into the coring system, it was first marked in indelible ink with a straight line along the core, for orienting the core sections, important for paleomagnetic or sedimentary fabric analyses. The orientation line later became the splitting line when the cores are split on the saw system.

Piston corer launching system

A support “cradle” was built in 1996. A rail that launches the cradle was constructed and manufactured in 2007 to improve the safety of the coring procedure. This rail was mounted for the coring operations during the Petermann Expedition (Figure SC-2). In addition to the main coring winch, a small winch is optimal to have handy for launching and recovering of the corer.

Multicorer

An Ocean Instruments MC-800 8-core multicorer (Figure SC-3) supplied by Oregon State University was used to acquire undisturbed surface sediment cores. This system is also equipped with a Niskin-type water bottle, which is triggered by the core landing mechanism, for collection of bottom waters at the coring site. The multicore frame was on some

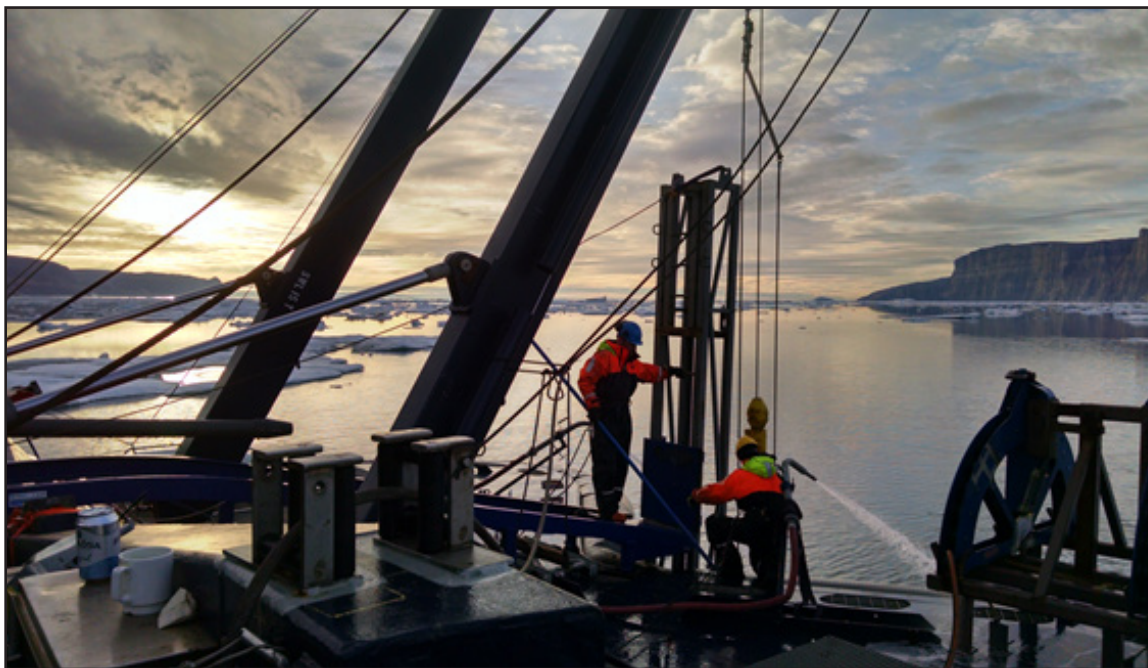


Figure SC-2: Core cradle system in its tilted-up position at the end of the rail system, while recovering a piston core.

deployments equipped with a camera system to document conditions at the landing site. The multicore was operated from the same coring wire as the piston core, with the terminated wire transferred between coring devices. Prior to launch, the eight “shovels” and “corks” that seal the bottom and top of the multicore tubes are cocked, and a metal safety pin keeps the system from triggering on deployment. Typical pullouts for the multicore are <2000 kg. Recovery requires two boat hooks (normal ship’s gear) to grasp slippable tag lines. After recovery, the archival team will first sample water from the multicore’s Niskin bottle, and someone from the water team will transport it to the lab for bottling similar to the pore waters (discussed elsewhere).

After recovery, the archival team removed individual cores from the multicore to a secure area (ideally near the fantail) where they are extruded vertically with a piston system from their polycarbonate tubes into less expensive butyrate plastic tubes, which are cut to the length of sediment recovered. At this time selected samples may be taken from some tubes, such as a soft biogenic “fluff” layer if present. After multicores are secured in capped liners and labeled, they were moved to the sediment laboratory for track analysis, splitting, photography, and visual description in the same way as piston core samples.

Porewater samples were taken from one multicore tube during the archival process, by inserting a Rhizon sampler into one pre-drilled coring tube (sealed with electrical tape during coring operations). Rhizon samples were taken at 10 cm intervals, for porewater chemical measurements.



Figure SC-3: OSU Multicore system deployed from Oden’s A-Frame.

Core Splitting and Storage

After preliminary shipboard analysis and visual description, sediment cores were stored in a refrigerated container supplied by Oregon State University. The cores are first measured for porewater and sediment physical properties, then split on deck using the Oregon State University core splitting system (Figure SC-4), and described in the sediment lab. After this processing, they are stored in D-Tubes (each D-Tube 1.6 m long), photographed and visually described, packed in reinforced waxed cardboard boxes, and stored in the refrigerated van. Additional short cores recovered by the ice-shelf drilling team were returned to *IB Oden* via helicopter; these cores will be relatively short (< 1 m).

Care was taken to prevent freezing of the sediment cores, which would destroy the possibility to carry out some critical post-cruise measurements. All cores, are archived and available for use at the Oregon State University Marine and Geology Repository.

Coring Results

Fifty three core deployments were successfully completed on *IB Oden*. Seven core deployments were attempted from the moving ice camp on Petermann Ice Shelf; six were successfully recovered. Here PC is Piston Core, TC is Multicore, MC is Multicore, GC is gravity core, and UI is Uwitec Core (see Ice Shelf, Section 9). PF is PF, KC is Kennedy Channel;



Figure SC-4: Splitting cores using the OSU core splitting saw.

PB is Polaris Bugt; NS is Nares Strait, HB is Hall Basin. For sub-ice shelf coresites, camp numbers are noted. During coring operations, ship drift was a significant issue, resulting in a strategy of 1) finding the site, 2) heaving to, in order to assess ship drift, 3) repositioning the ship to anticipate the net drift direction and distance between deployment and landing of coring gear on the sea floor, 4) lowering coring gear and holding off the bottom, 5) triggering coring gear at the sea floor, as close as possible to the original target, while monitoring the real-time subbottom profiler. A failure of the clock and real-time latitude and longitude readout during coring led to a need to correct core locations after recovery based on the nearest location on the shiptrack at the time of coring. Locations reported here are those corrected latitudes and longitudes.

Table SC- 1: OD1507 Core Recovery.

Cores Taken from Oden							
Seq.	Sample ID	Area	Corrected Lat	Corrected Lon	Water Depth	# sections	MSCL length (cm)
1	OD1507-001GC	PF	81.17035	-61.99971	1007	3	454.5
2	OD1507-002MC	PF	81.17385	-62.06188	873	8	51-56
3	OD1507-003PC	PF	81.19011	-62.06804	959.5	4	606
3	OD1507-003TC	PF	81.19011	-62.06804	959.5	1	95.3
4	OD1507-004GC	PF	80.97053	-61.25389	968	3	446
5	OD1507-005MC	PF	80.97516	-61.26854	960	3	68
6	OD1507-006PC	PF	80.97153	-61.23323	970	5	729.7
6	OD1507-006TC	PF	80.97153	-61.23323	970	1	96.4
7	OD1507-007MC	PF	81.09192	-61.79402	1056	2	69
8	OD1507-008GC	PF	81.09460	-61.79563	1062	3	444.6
9	OD1507-009MC	PF	81.09302	-61.81274	1064	6	48
10	OD1507-010PC	PF	81.10814	-61.90283	970	4	576.3
10	OD1507-010TC	PF	81.10814	-61.90283	970	1	100.8
11	OD1507-011GC	PF	80.97082	-61.67405	473	2	169.1
12	OD1507-012GC	PF	80.95029	-61.54612	526	2	252
13	OD1507-013MC	PF	80.95743	-61.58067	522	7	37-40
14	OD1507-014GC	PF	80.95459	-61.58203	522.5	2	188.5
15	OD1507-015GC	KC	81.27967	-63.83491	543	3	406.5
16	OD1507-016GC	NS	81.73312	-62.54456	657.5	3	382.6
17	OD1507-017GC	PB	81.68413	-62.16954	442	3	265.3
18	OD1507-018GC	PB	81.62659	-62.29892	520	3	435.2
19	OD1507-019GC	PB	81.54930	-62.31952	510	1	144.6
20	OD1507-020GC	PB	81.54832	-62.26260	435	1	149.8
21	OD1507-021PC	PB	81.44104	-62.19330	464	6	777.4
21	OD1507-021TC	PB	81.44104	-62.19330	464	1	38
22	OD1507-022GC	PB	81.42009	-62.37601	564	3	415.7
23	OD1507-023MC	PB	81.41144	-62.34445	558	8	15-22
24	OD1507-024PC	PB	81.41902	-62.36152	571	6	893.2
24	OD1507-024TC	PB	81.41902	-62.36152	571	1	12.8
25	OD1507-025GC	KC	81.28378	-63.63639	404	0	0
26	OD1507-026GC	KC	81.28358	-63.61789	401	0	0
27	OD1507-027GC	PF	80.96737	-61.24662	961	3	396.6
28	OD1507-028MC	PF	80.96523	-61.28363	973	0	0

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29	OD1507-029MC	PF	80.96349	-61.32184	1028	0	0
30	OD1507-030GC	NS	81.61971	-64.35251	576	3	369.3
31	OD1507-031PC	NS	81.61055	-64.35221	569	5	606.6
31	OD1507-031TC	NS	81.61055	-64.35221	569	0	0
32	OD1507-032MC	NS	81.60379	-64.35180	527	0	0
33	OD1507-033GC	NS	81.53574	-63.85184	759	3	370.1
34	OD1507-034MC	NS	81.56411	-63.36174	699	8	19-33
35	OD1507-035PC	NS	81.71570	-62.85319	807	5	740.6
35	OD1507-035TC	NS	81.71570	-62.85319	807	0	0
36	OD1507-036MC	NS	81.72350	-62.87582	769	8	23-34
37	OD1507-037PC	PF	80.96573	-60.95471	1041	6	847.6
37	OD1507-037TC	PF	80.96573	-60.95471	1041	2	201.5
38	OD1507-038MC	PF	80.96896	-60.95958	1041	7	22-59
39	OD1507-039MC	PF	81.01120	-61.27631	931	8	55-61
40	OD1507-040PC	PF	81.00940	-61.27154	932	3	384.6
40	OD1507-040TC	PF	81.00940	-61.27154	932	3	318.8
41	OD1507-041GC	PF	81.19372	-61.97728	991	3	441.9
42	OD1507-042PC	HB	81.41466	-63.45167	488	3	405.6
42	OD1507-042TC	HB	81.41466	-63.45167	488	2	175.5
43	OD1507-043PC	HB	81.43340	-63.25782	614	7	735.8
43	OD1507-043TC	HB	81.43340	-63.25782	614	1	26.4
44	OD1507-044PC	HB	81.30432	-63.31505	575	5	661
44	OD1507-044TC	HB	81.30432	-63.31505	575	2	190.9
45	OD1507-045MC	HB	81.30410	-63.32251	576	6	16-41
46	OD1507-046PC	HB	81.30242	-62.71482	626	7	999.2
46	OD1507-046TC	HB	81.30242	-62.71482	626	2	176.2
47	OD1507-047MC	HB	81.30681	-62.68801	619	8	38-44
48	OD1507-048PC	KC	81.30180	-64.31790	477	4	495.8
48	OD1507-048TC	KC	81.30180	-64.31790	477	0	0
49	OD1507-049GC	KC	81.13667	-64.76658	450	3	308.6
50	OD1507-050PC	KC	81.20008	-64.49841	504	4	548.7
50	OD1507-050TC	KC	81.20008	-64.49841	504	2	255.8
51	OD1507-051MC	KC	81.18673	-64.56273	489	0	0
52	OD1507-052PC	KC	81.24189	-63.99781	523	4	495.8
52	OD1507-052TC	KC	81.24189	-63.99781	523	1	40.7
53	OD1507-053MC	KC	81.23518	-64.05209	517	8	18-39

Cores Taken from Ice Camp, Petermann Ice Tongue (see Section 9, Ice Shelf operations)

Deployment #	Name	Area	Corrected Lat	Corrected Lon	Water Depth (m)	# sections	MSCL length (cm)
1	OD1507-001UI	Site 1	80.73733	-60.78450	570	1	18
2	OD1507-002UI	Site 1	80.73733	-60.78450	570	2	236.9
3	OD1507-003UI	Site 1	80.73733	-60.78450	570	2	231
4	no core - empty	Site 2	80.58083	-59.96767	722	0	0
5	OD1507-004UI	Site 3	80.66617	-60.49550	840	1	67
6	OD1507-005UI	Site 3	80.66617	-60.49550	840	2	202
7	OD1507-005UI	Site 3	80.66617	-60.49550	840	3	251

Sediment Physical Properties

Shipboard analyses of sediment physical properties were used for two main purposes:

1. Provide a basis for initial stratigraphic interpretations, inter-core correlation and planning for more detailed post-cruise subsampling strategies.
2. Provide preliminary assessments of regional heat flow patterns by combining in situ temperature measurements with sediment thermal conductivity measurements.

To accomplish these shipboard goals, all sediment cores were logged as whole-rounds on a Geotek Multi-Sensor Core Logger (MSCL). This system provided continuous measurements of sediment bulk density, compressional wave velocity, electrical resistivity and magnetic susceptibility. Split sections were later digitally imaged using a separate Geotek digital line-scan camera.

GEOTEK Multi-Sensor Core Logger (MSCL): The MSCL is a fully automated core logging system equipped with transducers for measuring compressional wave velocity, magnetic susceptibility sensors for measuring the volume of magnetic minerals within cores, a Cs-137 radioactive source for measuring the bulk density of sediments, and an electrical resistivity sensor.

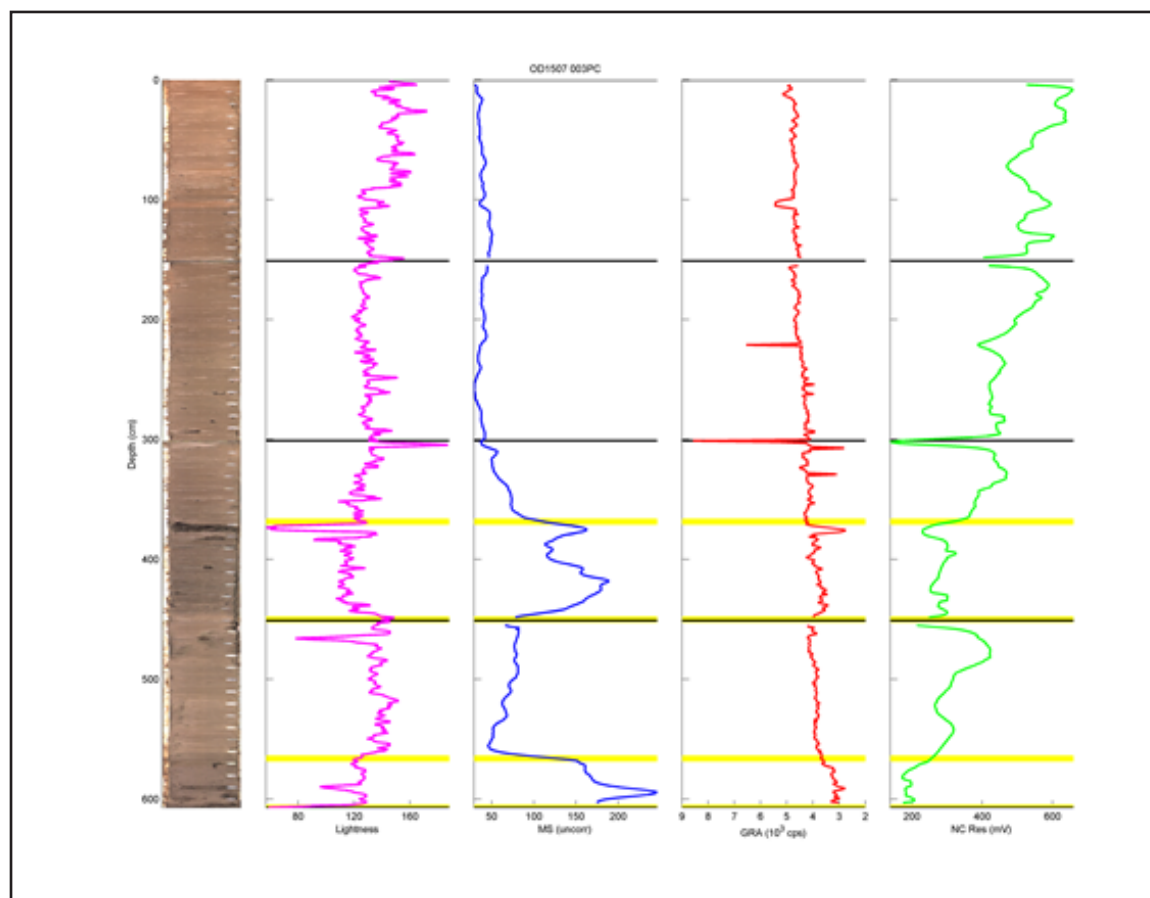
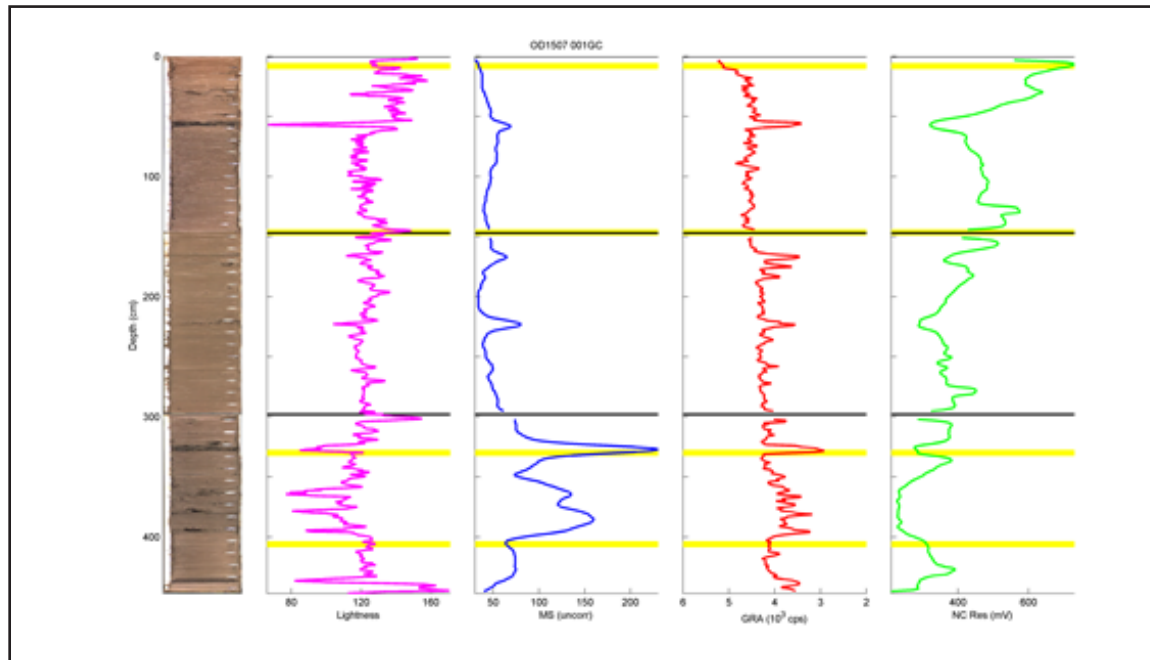
Core Splitter: The core splitter has dimensions of 300cm x 60cm x 50cm (LxWxH) and a weight of approx. 45 kg. It is designed to ensure reproducible and constant downcore thicknesses in split cores – which is a benefit for future post-cruise analysis of sediments. It incorporates a circular saw to cut the plastic core liners, and uses a thin wire to slice through the sediments. Ideally this splitter would be placed near the laboratory where the MSCL is, so that cores may be split after they are analyzed in whole-round form on the MSCL. Depending on workflow and staffing, the core splitting device may be operated by the core describing team or the physical properties team.

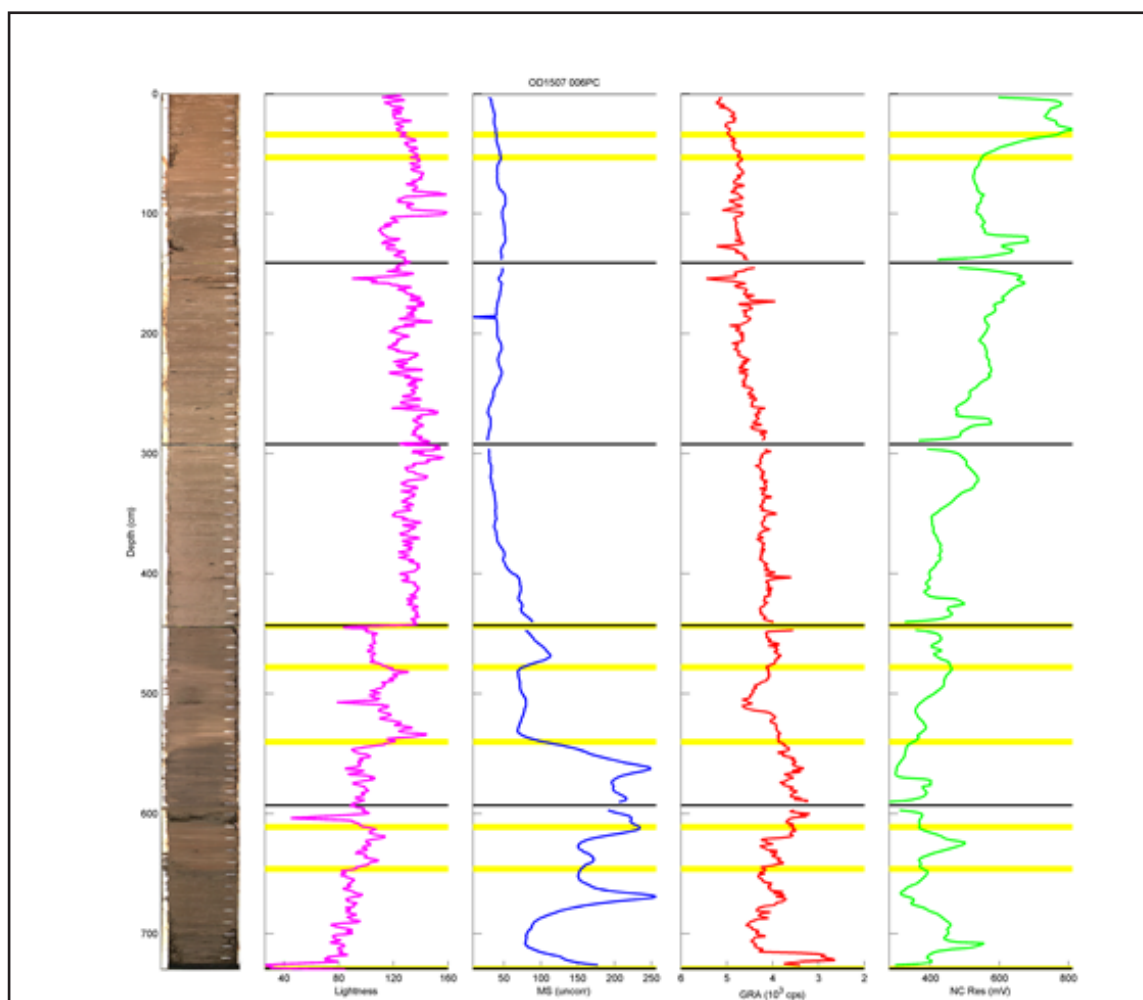
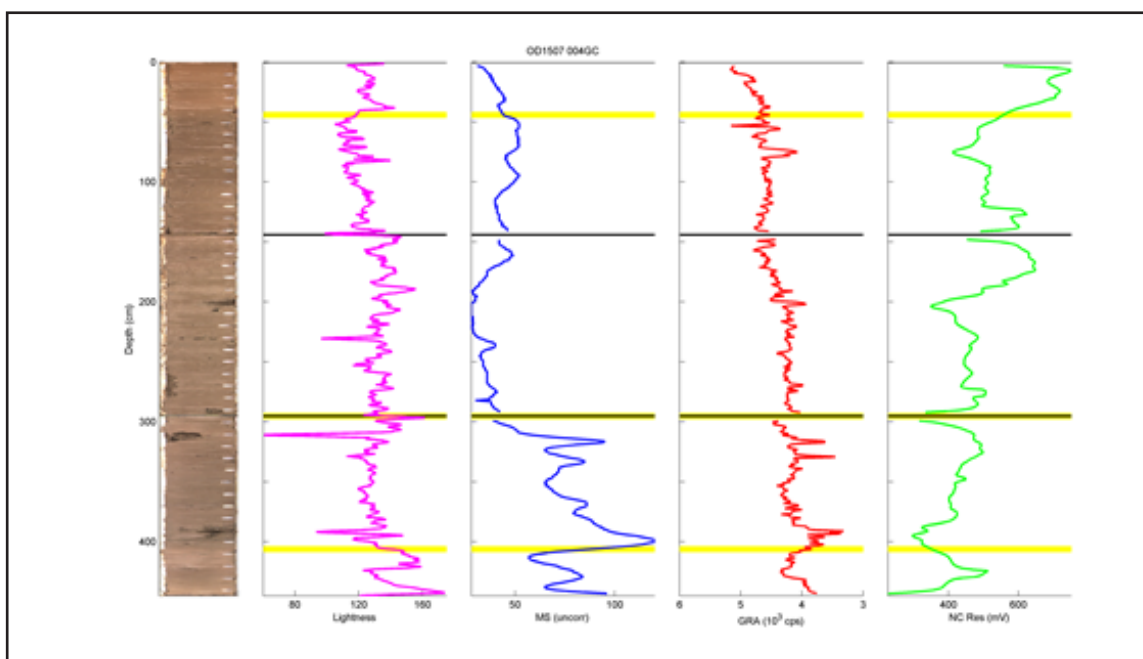
Split-Core Photography . Core photographs will be made on archive halves of cores (in parallel with visual description of working halves of cores) using a GEOSCAN III Line Scan Camera System which is about 2 m in length when fully assembled. Space will be required in the core-describing area for this operation. Depending on workflow and staffing, the photography system may be operated by the core describing team or the physical properties team.

ANTARES Miniature Temperature Probes: In situ temperature measurements will be taken with reusable ANTARES miniature temperature probes that are attached to the outside of each core barrel. Each stainless steel temperature logger is 16 cm long and 1.5 cm in diameter. They are programmed and the data downloaded using a laptop and small programming station (20.5 x 7 x 12.5 cm). 15 probes were brought onto the ship, with 4–5 probes used on each core. Programming and downloading of the temperature probes should be done at the aft of the ship.

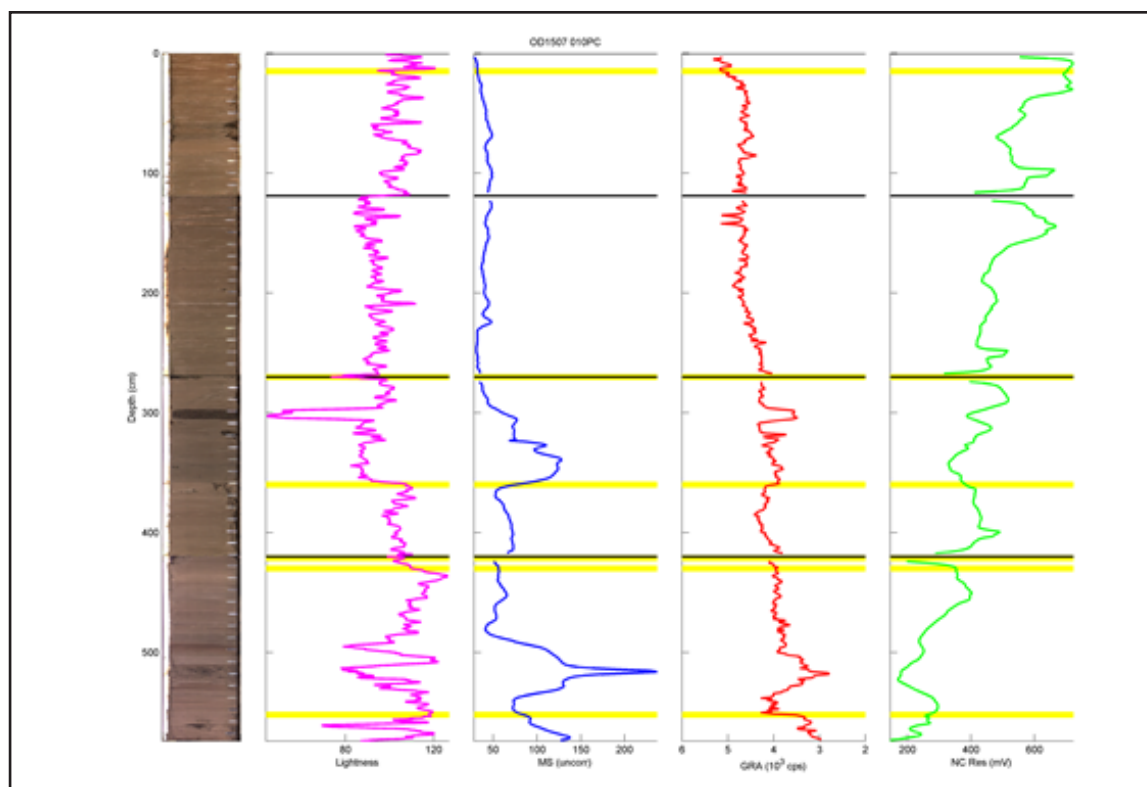
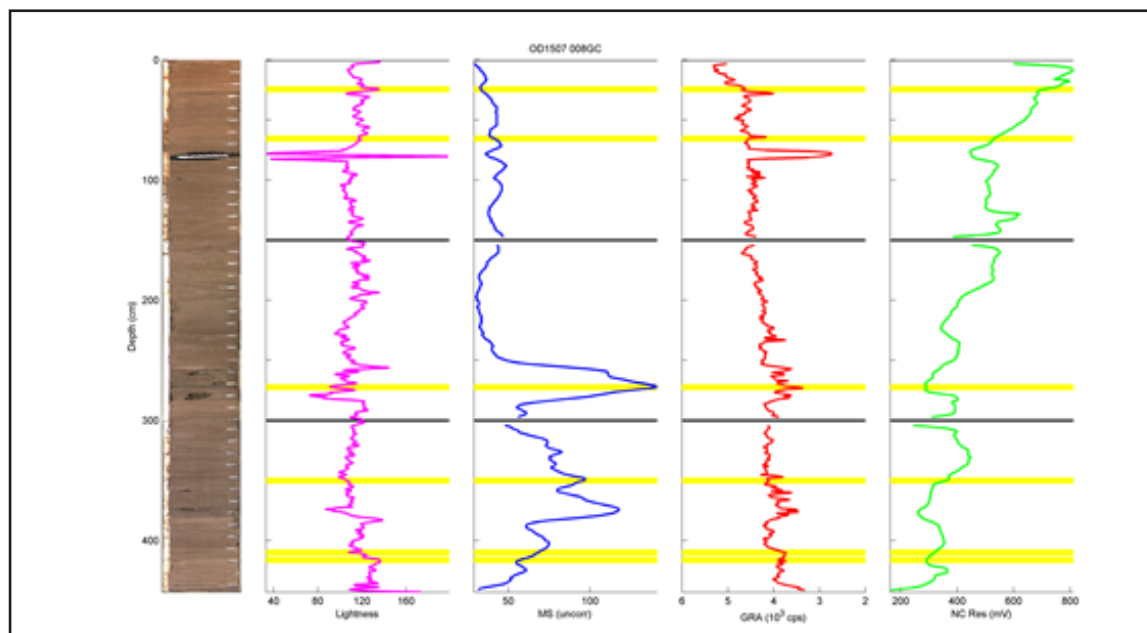
All core data and physical processes data were processed post-cruise and are available at the Oregon State University Core Repository. Shipboard MSCL Records are provided as images in Figure SC-5.

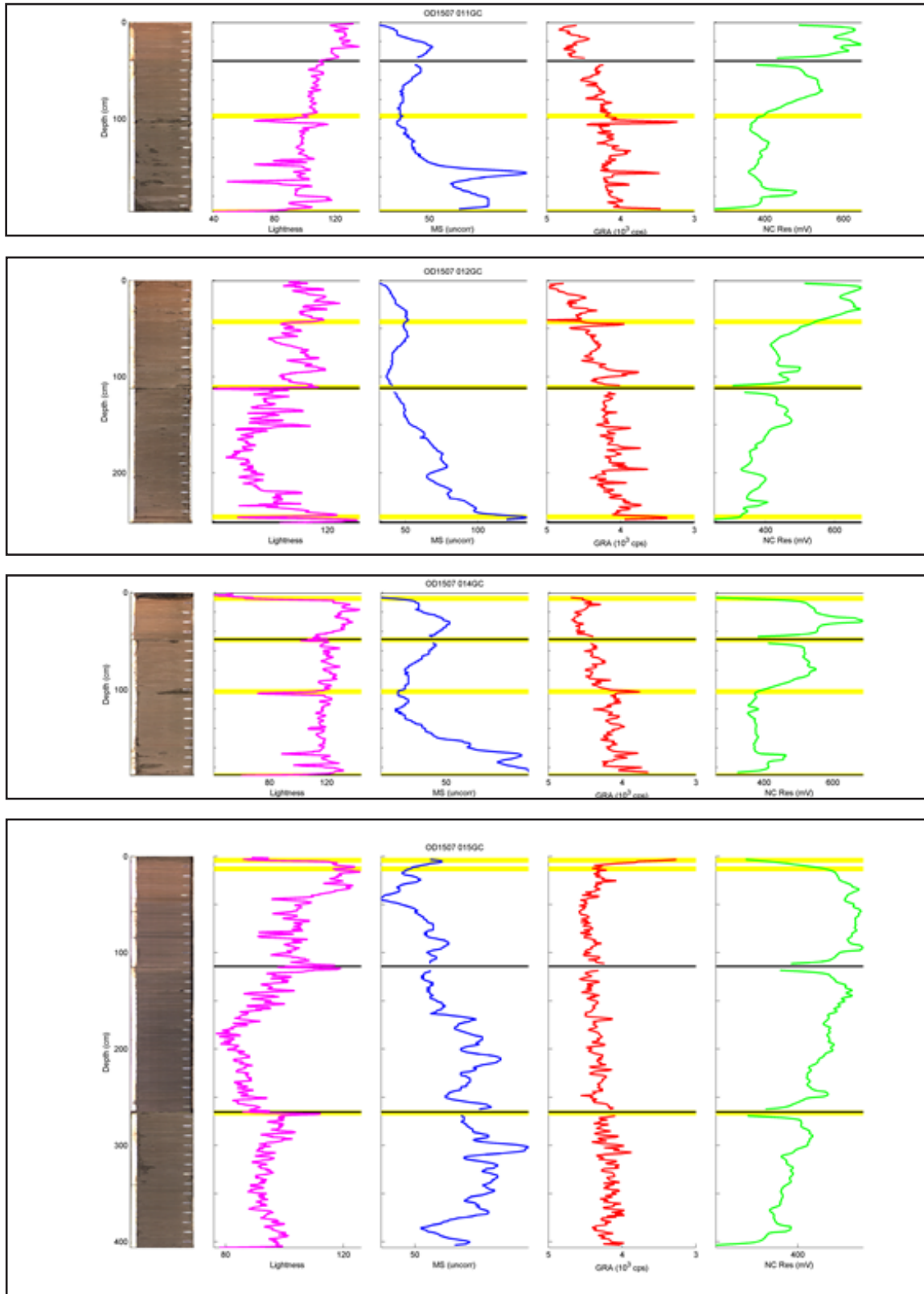
Figure SC-5 (below, 30 panels): Sediment core Multi-sensing core logging and digital line-scan camera data images analyzed at sea.



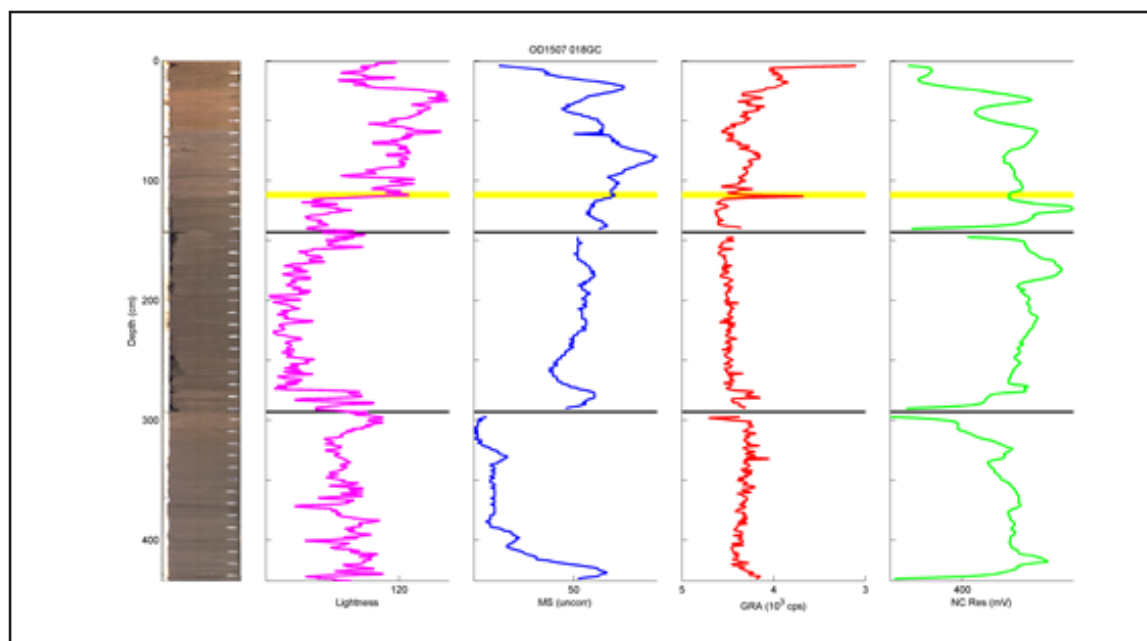
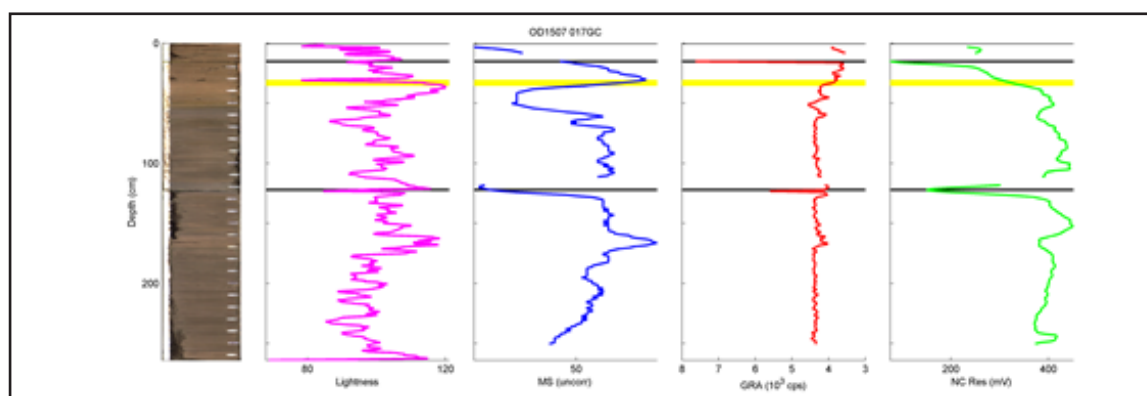
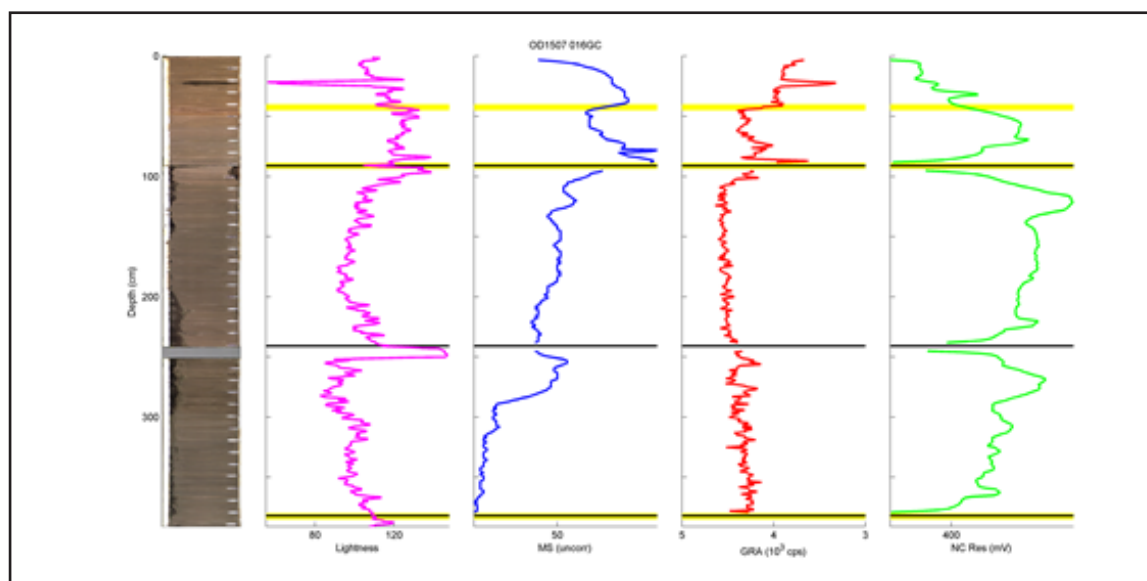


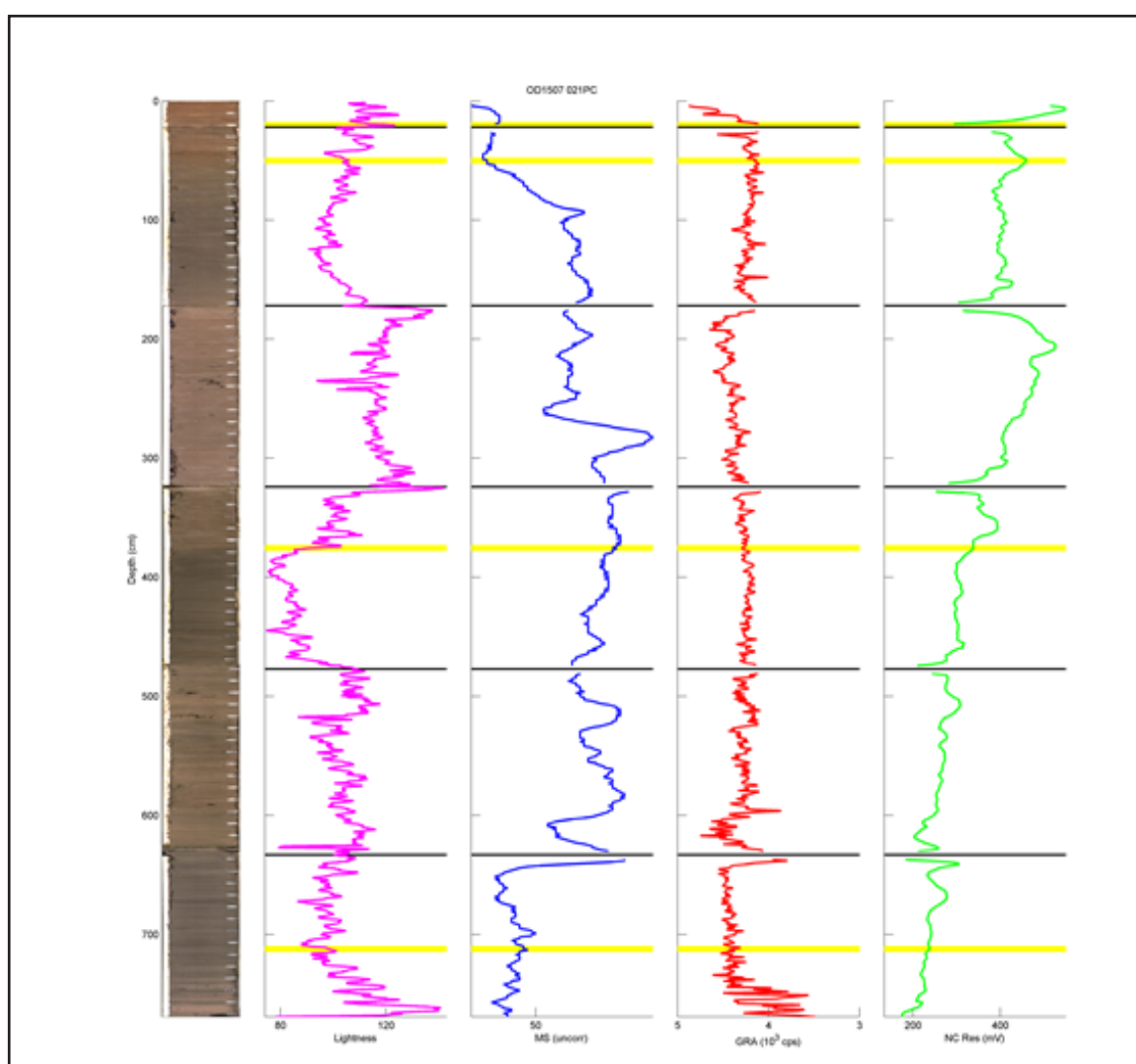
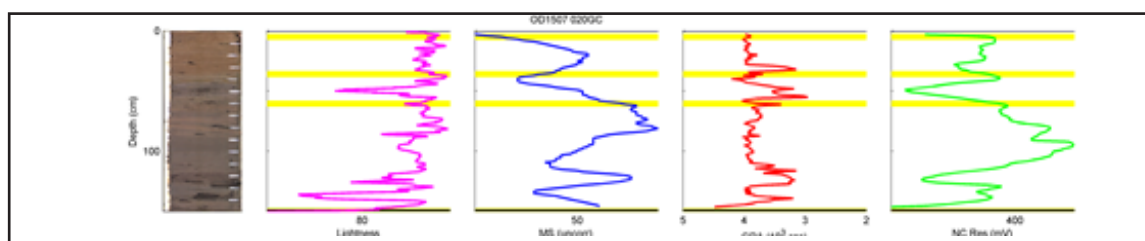
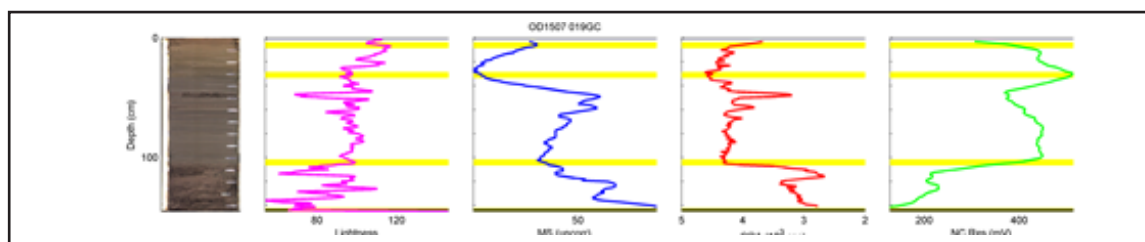
Cruise Report



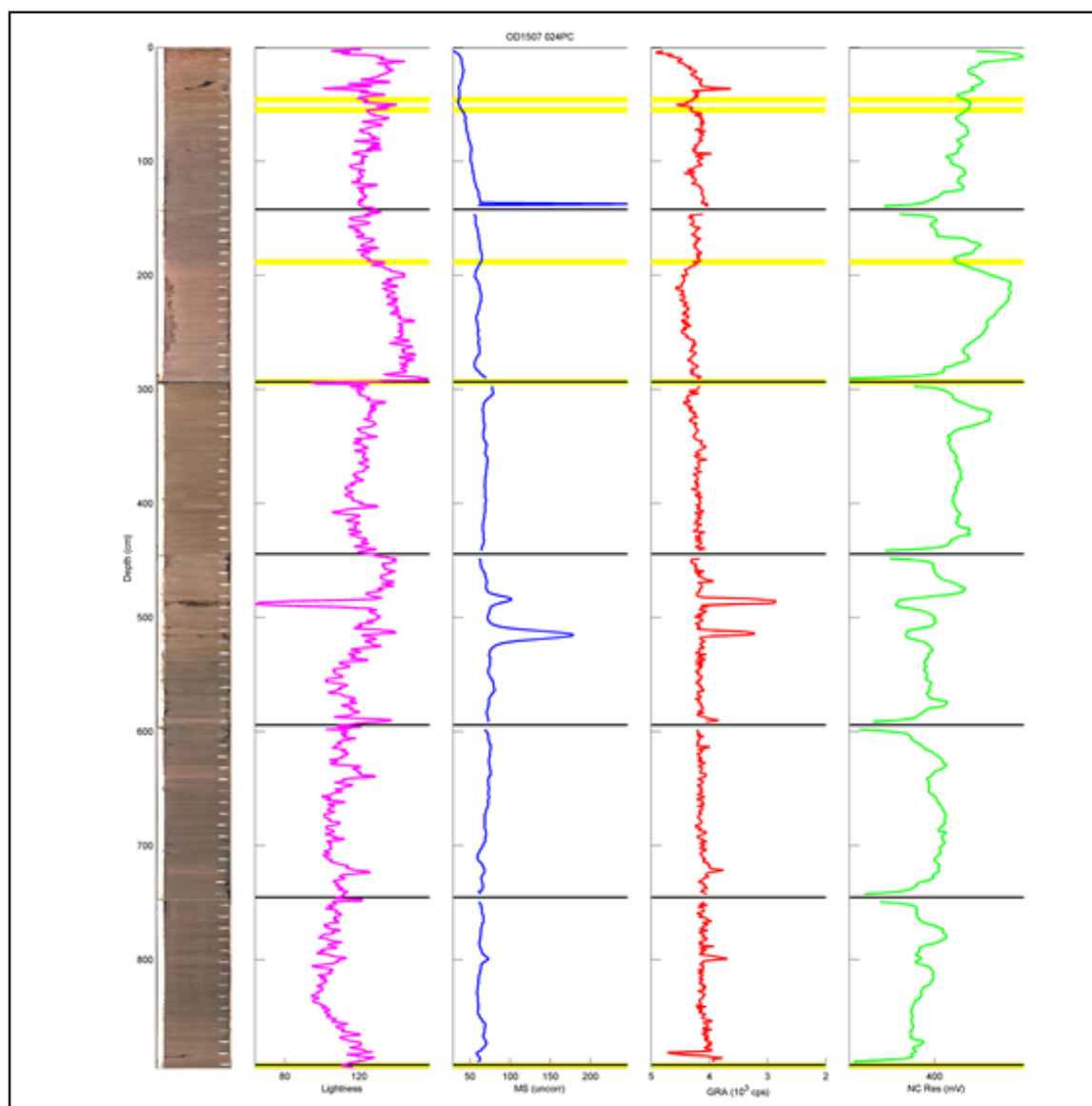
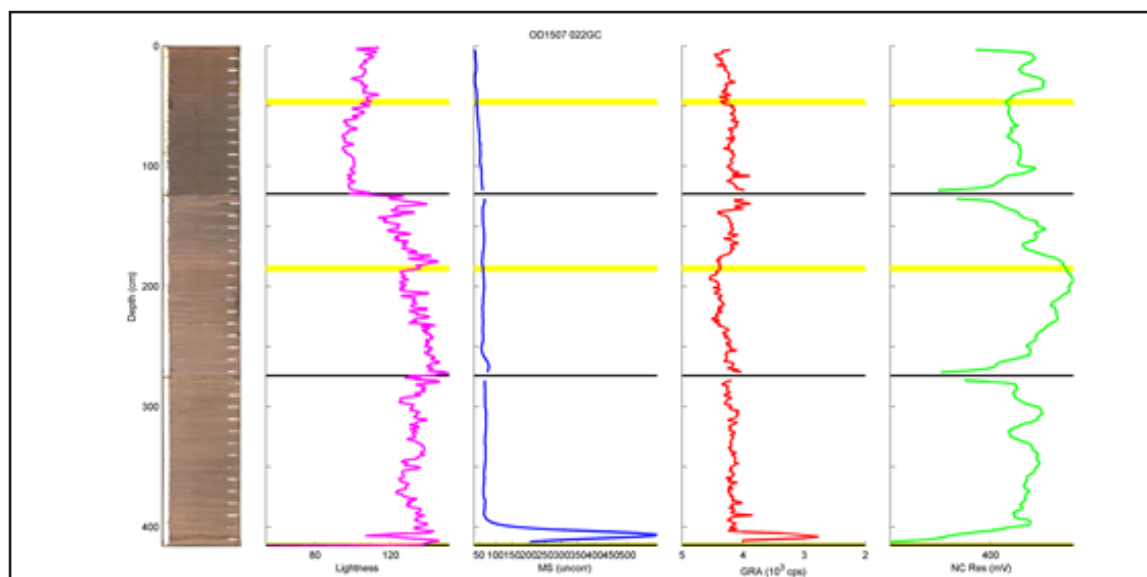


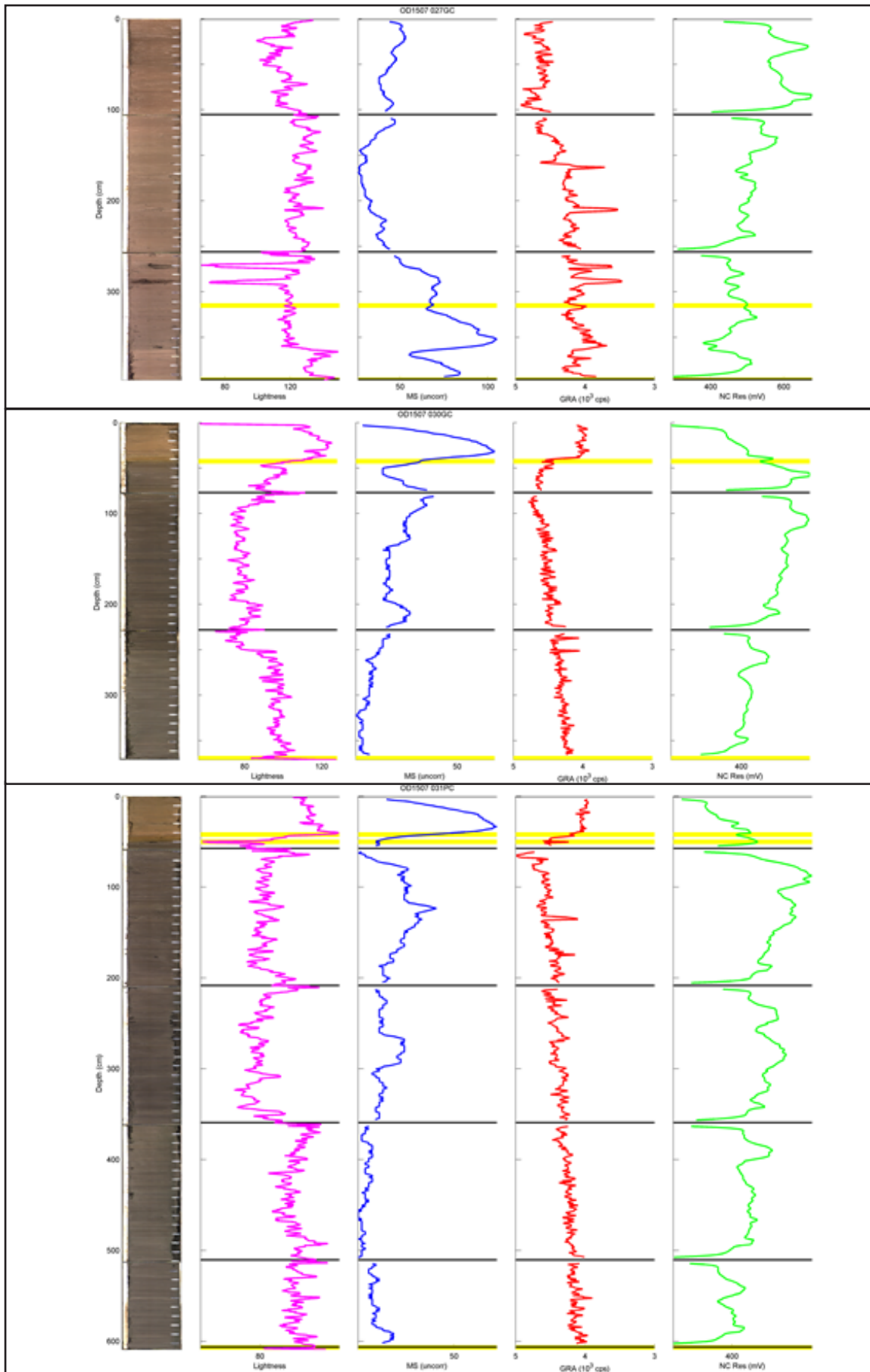
Cruise Report



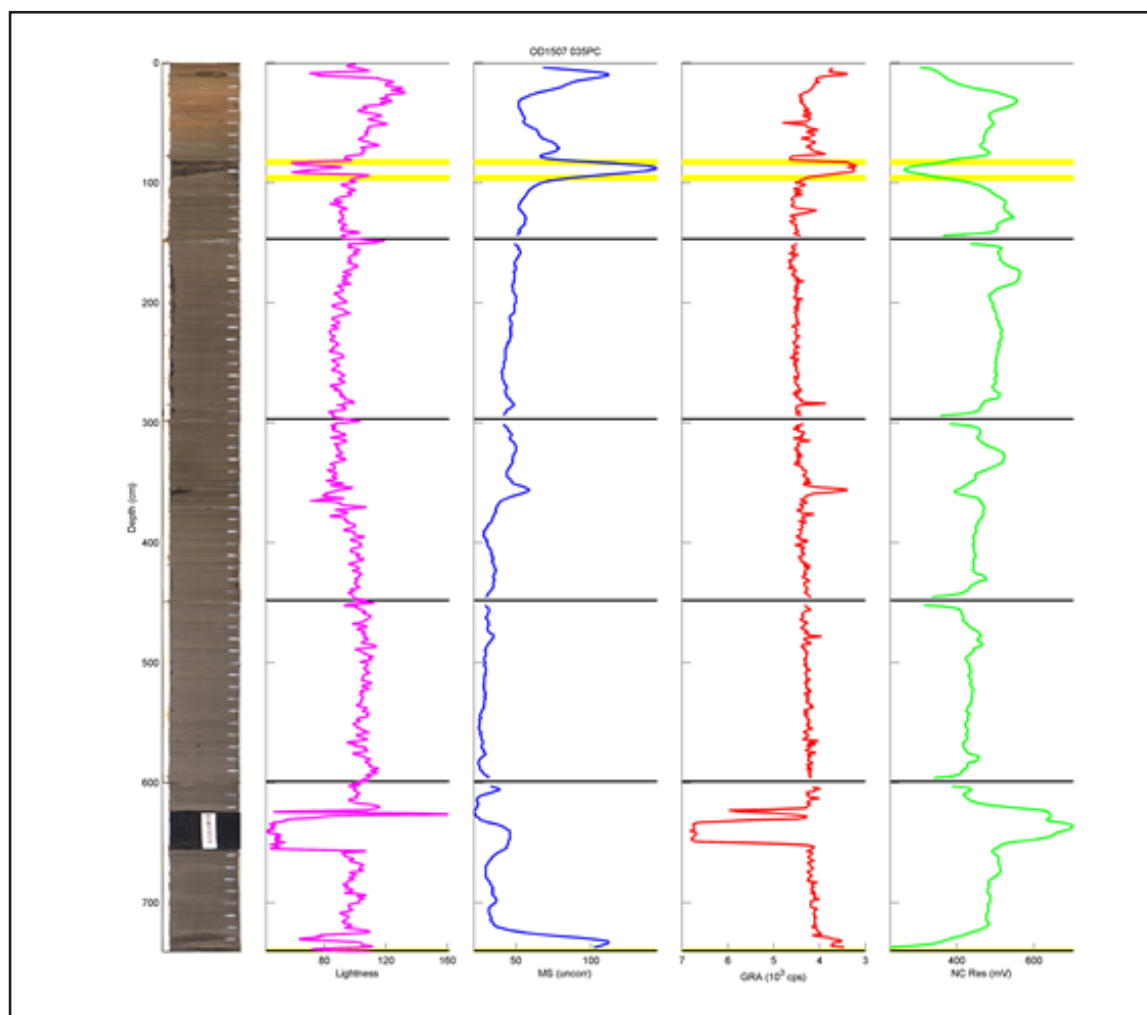
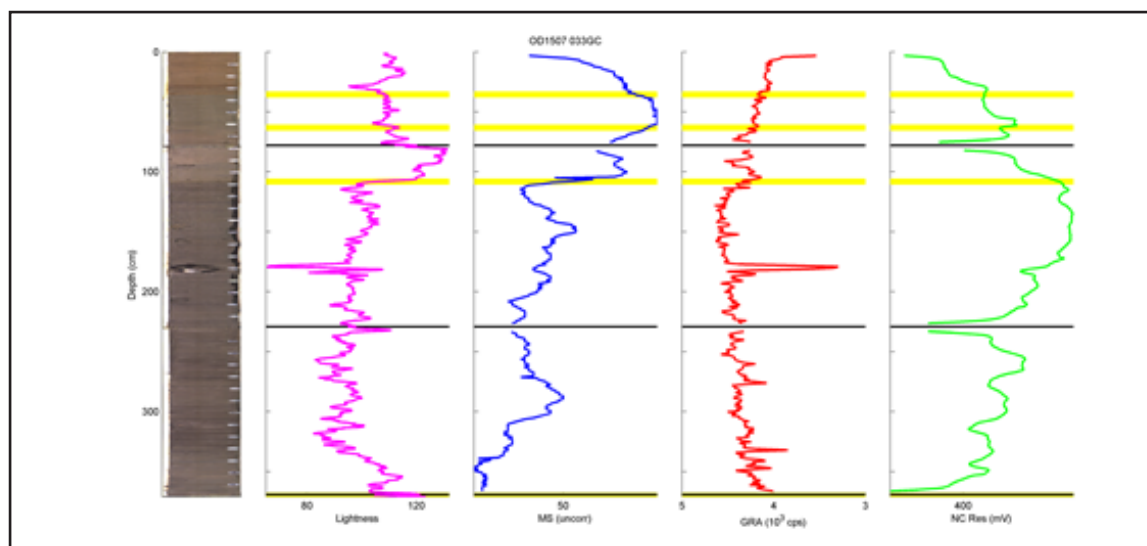


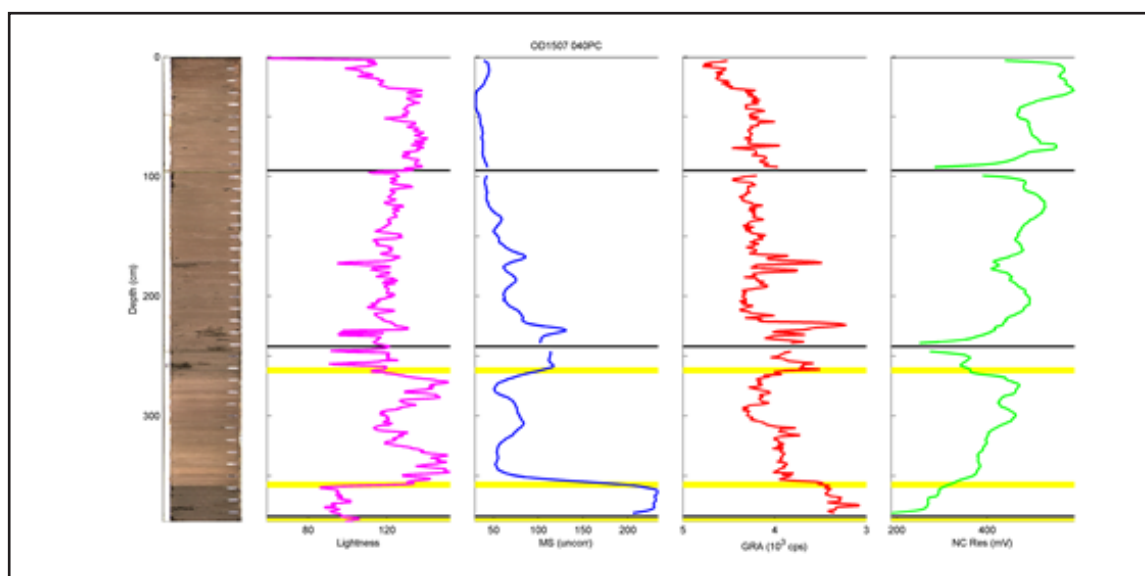
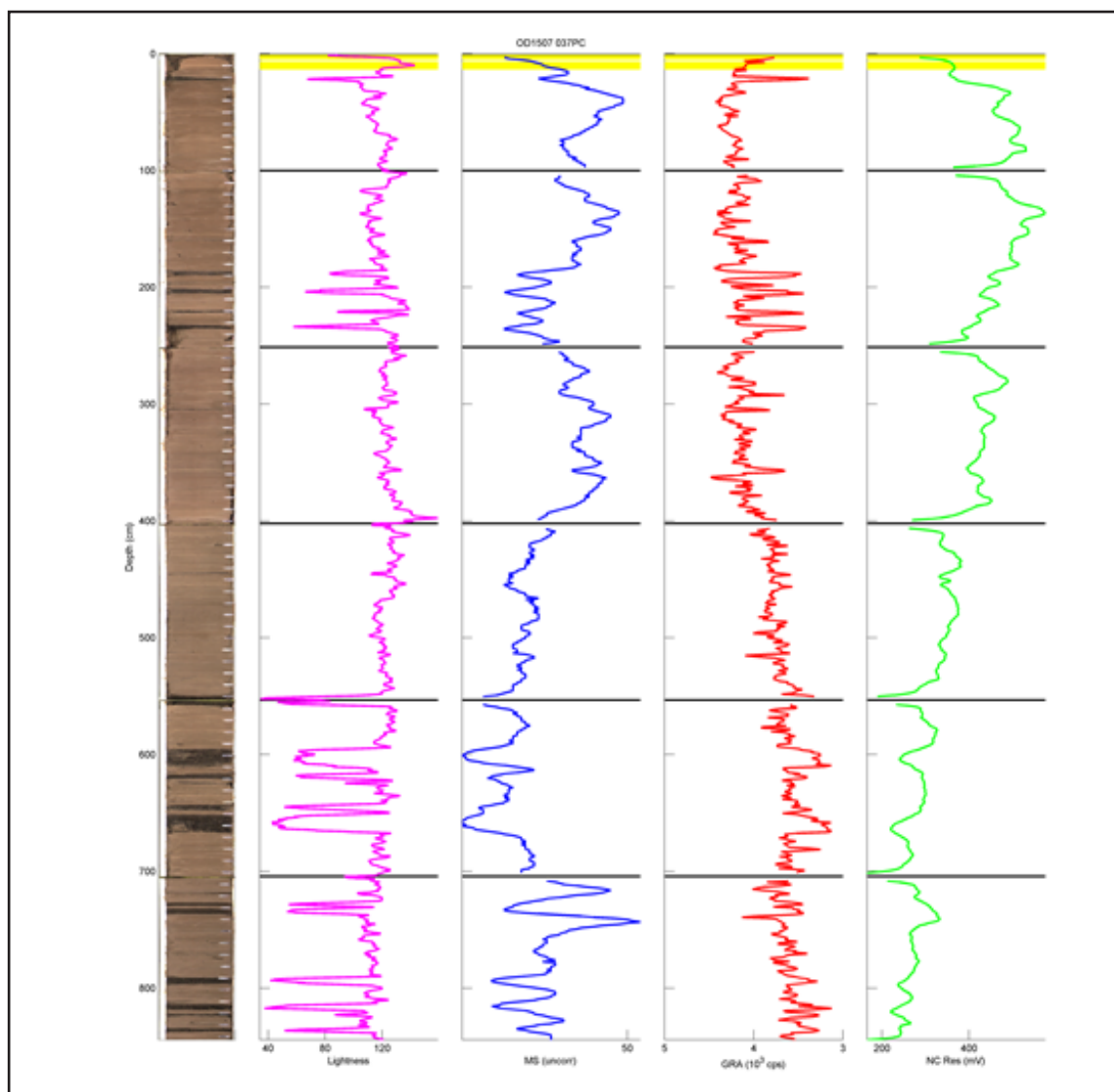
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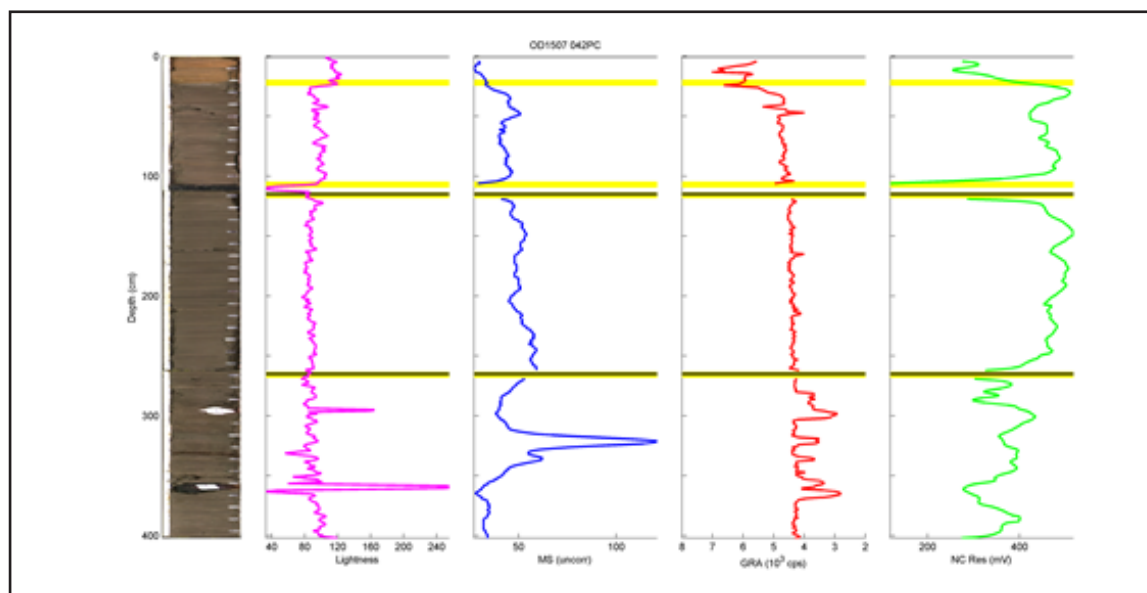
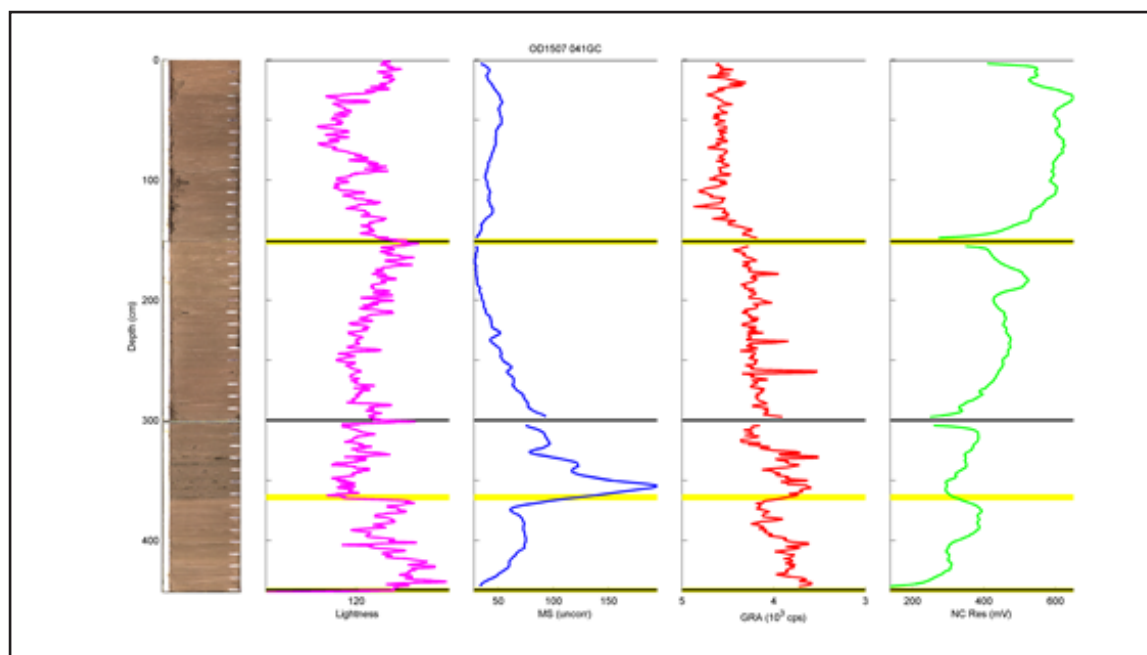


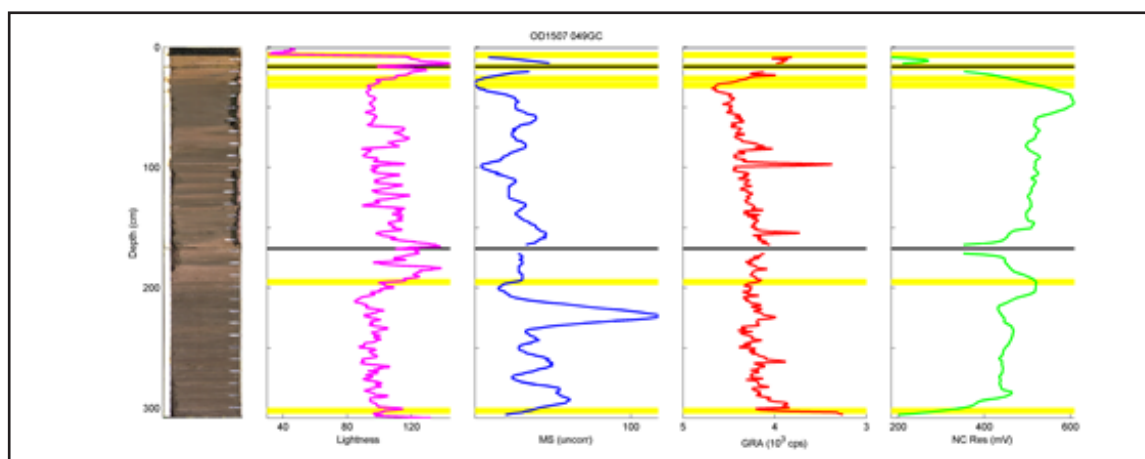
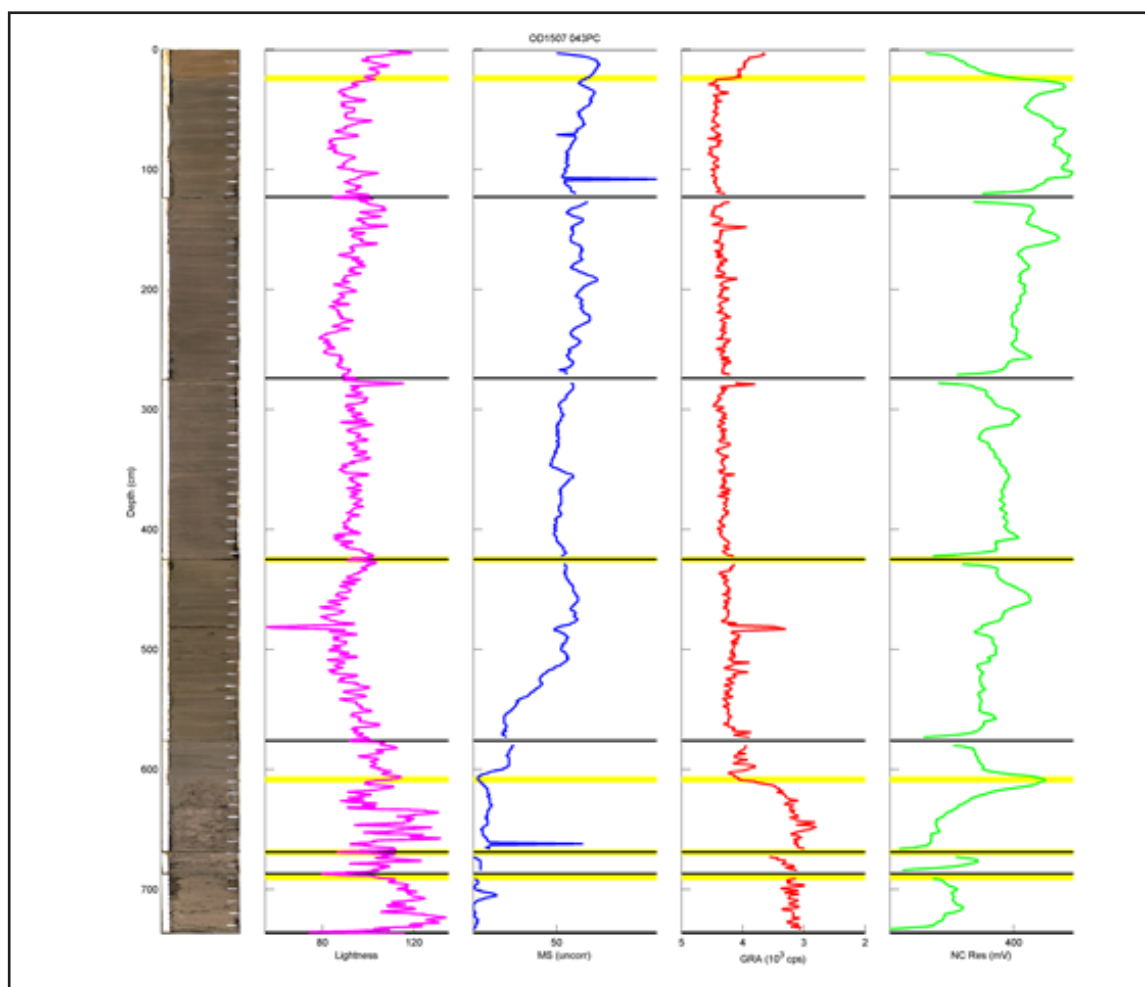
Cruise Report

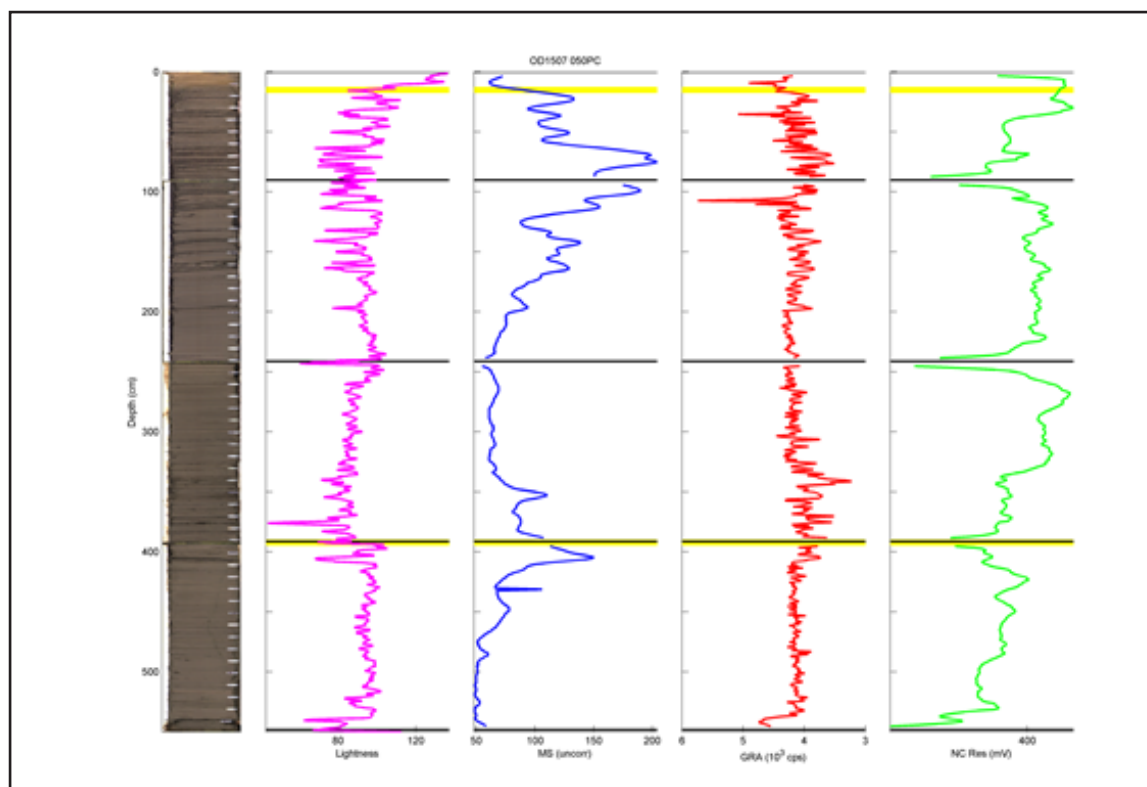




Cruise Report







Core visual descriptions

Cores were described using the paper description sheets (Example in Figure SC-6). Core Name, Section Number, Location and Water Depth and Interval Depth were all entered on the sheets (see appendix). There should be one description sheet for every section of core opened during the OD1507 expedition.

The core sections were examined for changes in lithology; with distinct intervals noted. Contacts between lithologies were indicated by drawing a line across the core description sheet with the type of contact (sharp, gradational, or mottled) noted. The centimeter location of each contact interval is noted. Within these contact lines, that particular lithologic unit is described.

Using the Munsell color chart, the color of each significant unit was assessed using a tiny sample of sediment on the tip of a toothpick and the color code entered in the color column. Write the color word description under remarks. If large mottles are present, the color of the mottles was noted in remarks. Descriptions combine the color with the general composition of the sediment, for ex. Dark olive green clay.

Grain size parameters used are clay ($<4\mu\text{m}$), silt ($4\mu\text{m}$ to $62\mu\text{m}$), sand ($62\mu\text{m}$ – 2mm) and gravel ($>2\text{mm}$). The grain size of the sediment was determined approximately by rubbing a small sample between fingertips and entered as an “X” in the appropriate grain size column, the grain size may include more than one category, e.g. silty clay with the dominant grain size first if there is more than one category.

CORE LOG

Waiting half core for description.

CORE ID 021507-0226C

SECTION 03W

Lat. 81° 25.221

Long. 62° 22.624

Water Depth 564 cm

NST: Unknown

Measured: 141.0 cm

Section Top 274.6 cm	Color	contact		biogenous mat				grain size				structure				REMARKS
		sharp	grad.	foram.	calc. nanno	rad.	diatom	spicules	radiolaria	mod. shell	gravel	clay	grad. bed	grad. bed	homogen	
274.6 cm	10YR 5/2 Greyish Brown														Date Open & Desc. <u>18th August 2015</u> Interval Depth <u>274.6 - 415.6</u> 274.6 - 415.6 cm: whole section characterized by greyish brown (10YR 5/2) clay with minimal silt + sand content, very faintly laminated and some areas of darker stringers. Little sign of disturbance. - No major colour variation. - Interrupted at base by two coarse sand sub-units. Smear slide @ 350 cm Forams: 397 - 403.5 cm <i>Oridorsalis indurata</i>, <i>Trochodonta</i>, <i>Cass. Neo</i>, <i>NPS</i>, <i>Elphidium excavatum</i>.	
280 cm																
290 cm																
300 cm																
310 cm																
320 cm																
330 cm																
340 cm																
350 cm																
360 cm																
370 cm														390 - 391 cm poorly sorted sand, fining-up, sharp basal contact, gradational top. Possible load structures? 404 cm Sandy layer with clay distributed top + base, both boundaries are sharp 410 cm homogeneous / poorly sorted Rock from 405 - 407 cm in D-Tube (in labeled bag). has mag. Sus. of 480 in 14 cm loop.		
380 cm	Greyish Brown	X	X									X				
390 cm	10YR 5/2	X									X		X			
400 cm		X														
415.6 cm	Base of Core/Section															

BASE OF SECTION + CORE

Fossils: X-Present C-Common B-Barren
A-Abundant R-Rare

145.6 - 294.6
+ 141.0
+ 6 = 141.0 415.6

graded bed (turbidite)

ss-smear slide

Figure SC-6: Example shipboard core description data sheet. Shipboard sheets were later transcribed and further details added at the OSU Marine and Geology Repository in Corvallis, OR, where the original paper sheets and final digital descriptions are archived.

Dominant structural features were noted with an "X" in the appropriate structure column, e.g., laminated. Any particularly useful or unusual features, ex: foram sand, turbidite, shells, ash layer, etc) are noted in the remarks.

Smear slides were taken near top of each section and in major intervals and at bottom of last section, and noted on description sheet in remarks column as depths where smear slides are taken, e.g. ss 15cm. Smear slides were preserved and are archived at the Oregon State University Marine and Geological Repository.

Following visual descriptions, and selected sampling, exposed sediment surfaces were covered with plastic wrap, taped with masking tape at top and bottom; and label top with core ID, section, length, WORK or ARCH. Each wrapped core section was secured in a D-tube, tape end cap on, label D-tube and endcap with Core ID, length, and WORK or ARCH. (WORK and ARCH if both pieces will fit in same tube), and stored in the core refrigerator.

SL – Relative Sea Level Histories

Staffing: Alan Mix, Anna Glueder, Brendan Reilly, Jorie Clark, Chris Holm.

Objectives

Available limited constraints from ^{14}C dating of fossil shells in Hall Land [England, 1985], Washington Land [Bennike, 2002], both adjacent to the mouth of PF, and Cape Baird, Ellesmere Island [England, 1999] show that local relative sea level was >100 m higher than at present in the region during the early Holocene ($\sim 8,000$ ^{14}C years ago) due to isostatic subsidence from growth of the Greenland and Innuitian ice sheets during the last glaciation. The sea-level highstand (marine limit) also constrains the time of deglaciation of the coast. Relative sea level has since been falling due to isostatic rebound of the land and seafloor following deglaciation. Late-Holocene relative sea level changes, potentially associated with Neoglacial ice advances, are unconstrained.

The scientific objectives of the 2015 terrestrial sea-level task were to improve on existing understanding of the relative sea level fall over the Holocene following ice sheet retreat by sampling material for dating from raised marine landforms and sediments. These improved data will help to constrain glacial isostatic adjustment models, which provide the time history of changing ice-mass loads since the last glacial maximum. This understanding of uplift history will constrain changes in the depth of the sill at the mouth of PF as well as of the fjord itself, which is important to set boundary conditions for understanding interactions among the floating ice shelf, the outlet glacier, and grounded inland ice, as well as for interpreting paleo records inside the fjord.

In order to achieve these objectives, we obtained fossil (shell and wood), marine-sediment and rock samples from sites uplifted by isostatic rebound following ice sheet retreat. From among seven potential target areas, our field work during the expedition focused on three areas: 1) Washington Land near Kap Morton and Bessel's Fjord, 2) Hall Land near Polaris Bay, and 3) Cape Baird on Ellesmere Island. Newer GNSS-based technologies for precise field surveying, improved AMS dating precision for radiocarbon, and better regional calibration of cosmogenic surface exposure dates provide ample opportunities to refine reconstructions of relative sea level change.

Methods

The team consisted of four members plus a bear guard. Access to the field areas was from the ship, via helicopter, and extensive hiking (Figure SL-1). Samples were photographed and located and elevation noted using GNSS (Trimble Pathfinder) and hand-held GPS (Garmin GPS-Map64); sample elevations are given in height above reference ellipsoid (HAE; WGS84). At each station the GPS elevation of the current sea level (correcting high-water line for nominal tidal variations of $\pm 1\text{m}$) was recorded, so that elevations are documented relative to reference ellipsoid and local sea level. Post-collection differential correction of GNSS positions and elevations based on KMOR station data improved accuracy.

The field team sampled several different proxy materials (Figure SL-2) from uplifted marine sediments and landforms for dating including 1) mollusk shells, where possible in sedimentological context of beach ridges or deltas ideally articulated in growth position, but whole valves, broken shells and fragments were also collected, 2) bulk sediments,

potentially containing benthic foraminifera characteristic of shallow water habitats, 3) driftwood, and 4) cobbles and boulders on surfaces of marine and glacial landforms. Each of these proxies has strengths and weaknesses. Mollusks are easy to identify and date, and offer the possibility of recording interannual-to-decadal variability in ocean conditions via geochemical tracers, but ages may be subject to uncertainties in marine reservoir ages and the organisms may live up to ~30 m below sea level; hence, they must be interpreted in sedimentological and geomorphic context. Benthic foraminifera may in some cases provide narrower estimates of water depth, but are also subject to reservoir age issues. Driftwood is not subject to reservoir age problems and is likely deposited close to the high-tide line, but is subject to long-distance transport from distant forests.

Cobbles and boulders were sampled for cosmogenic dating (^{10}Be). Large boulders deposited below sea level by icebergs are unlikely to be reworked after deposition, and are exposed to cosmic rays as sea level falls below them. They must be assumed to have not turned during their exposure history because cosmic rays attenuate rapidly in rock, and



Figure SL-1. Surveying for datable materials by hiking.



Figure SL-2. Sampling for shells, boulders and bulk sediments.

the time spent underwater prior to exposure must be accounted for. Cobbles can also be dated by cosmogenic isotopes, but they are likely frost-heaved in arctic settings and may have been buried in other sediment. If they have remained near or at the surface, however, post-depositional movement is less of an issue because there is little attenuation of cosmic rays due to their small size (<5 cm). Both boulders and cobbles may have previous exposure histories, referred to as “inheritance.” Cosmogenic exposure dates thus can provide an estimate the time a boulder has resided above sea level, but cobbles may underestimate true exposure age, and inheritance would likely induce overestimates of exposure age. If possible, it is important to sample enough materials to spot outliers. By addressing all of these sample types, we hope to leverage their relative strengths and compensate for their weaknesses.

Field Results

The sea-level team completed 14 days of field work in the Nares Strait region with close helicopter support from *IB Oden*, and collected datable materials (shells and bulk sediments that might contain foraminifera for radiocarbon dates and cobbles and boulder samples for cosmogenic dating) from raised marine sediments and features to reconstruct local relative sea level history. Work was conducted on three areas adjacent to Petermann Fjord in Greenland (Kap Morton, Hall Land, and Bessels Fjord) and on Cape Baird, Ellesmere Island. Sampled sites span elevations from sea level to more than 150 meters HAE. In total, we collected 607 samples (see metadata Table SL-1).

Table SL-1 Metadata for samples collected for paleo sea-level analysis (sorted by region). HASL is height above sea level, calculated from measured Trimble height above ellipsoid, corrected using base station KMOR, and then differenced to the nearest empirically measured sea level with the same corrections. Latitude is positive north. Longitude is positive east.

Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
146	Hall Land	shell	A. borealis	38.62	81.566394	-61.417326
147	Hall Land	bone	unidentified	6.50	81.554707	-61.523330
148	Hall Land	shell	H. arctica	5.38	81.554888	-61.552062
149	Hall Land	bulk	surface sed.	2.84	81.554552	-61.578512
150	Hall Land	bulk	surface sed.	0.00	81.555031	-61.597999
152	Hall Land	bulk	surface sed.	2.25	81.554616	-61.594794
153	Hall Land	shell frags	unidentified	2.25	81.554616	-61.594794
154	Hall Land	bulk	surface sed.	3.26	81.556250	-61.577932
155	Hall Land	bulk	surface sed.	7.88	81.559740	-61.540825
156	Hall Land	bulk	surface sed.	11.51	81.559696	-61.540785
158	Hall Land	shell frags	unidentified	16.06	81.559463	-61.540925
160	Hall Land	bone	unidentified	16.10	81.558032	-61.537294
161	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
162	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
163	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
164	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
165	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
166	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
167	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
168	Hall Land	cobble	red granite	16.10	81.558032	-61.537294

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Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
169	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
170	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
171	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
172	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
173	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
174	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
175	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
176	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
177	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
178	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
179	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
180	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
181	Hall Land	cobble	red granite	16.10	81.558032	-61.537294
182	Hall Land	charcoal	red granite	24.71	81.559548	-61.531847
183	Hall Land	bone	red granite	24.71	81.559548	-61.531847
184	Hall Land	shell frags	unidentified	25.51	81.560934	-61.517838
186	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
187	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
188	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
189	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
190	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
191	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
192	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
193	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
194	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
195	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
196	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
197	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
198	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
199	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
200	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
201	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
202	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
203	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
204	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
205	Hall Land	cobble	red granite	26.36	81.560835	-61.517628
206	Hall Land	bulk	surface sed.	14.23	81.561012	-61.521616
207	Hall Land	bulk	surface sed.	19.27	81.561115	-61.521579
208	Hall Land	shell frags	unidentified	32.07	81.561313	-61.498856
209	Hall Land	bulk	surface sed.	32.07	81.561313	-61.498856
210	Hall Land	shells	H. arctica	36.69	81.562826	-61.435700
211	Hall Land	shell	H. arctica	36.69	81.562826	-61.435700
212	Hall Land	bulk	surface sed.	36.69	81.562826	-61.435700
213	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
214	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
215	Hall Land	cobble	red granite	37.06	81.562671	-61.437776

Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
216	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
217	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
218	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
219	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
220	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
221	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
222	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
223	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
224	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
225	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
226	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
227	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
228	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
229	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
230	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
231	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
232	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
233	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
234	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
235	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
236	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
237	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
238	Hall Land	cobble	red granite	37.06	81.562671	-61.437776
241	Hall Land	shell frags	unidentified	42.91	81.567741	-61.404829
242	Hall Land	shell frags	unidentified	42.91	81.567741	-61.404829
243	Hall Land	bulk	surface sed.	42.67	81.567934	-61.402975
244	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
245	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
246	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
247	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
248	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
249	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
250	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
251	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
252	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
253	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
254	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
255	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
256	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
257	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
258	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
259	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
260	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
261	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
262	Hall Land	cobble	red granite	40.80	81.572342	-61.361504
263	Hall Land	cobble	red granite	40.80	81.572342	-61.361504

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Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
264	Hall Land	shell frags	unidentified	45.36	81.573718	-61.334676
265	Hall Land	shell frags	unidentified	45.70	81.573803	-61.333793
266	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
267	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
268	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
269	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
270	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
271	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
272	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
273	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
274	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
275	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
276	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
277	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
278	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
279	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
280	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
281	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
282	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
283	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
284	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
285	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
286	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
287	Hall Land	cobble	red granite	45.70	81.573803	-61.333793
288	Hall Land	bulk	surface sed.	61.69	81.577079	-61.284478
289	Hall Land	shell frags	unidentified	64.47	81.576989	-61.284020
290	Hall Land	shell frags	unidentified	66.81	81.576316	-61.272379
291	Hall Land	bulk	surface sed.	66.81	81.576316	-61.272379
292	Hall Land	shell	H. arctica	69.05	81.577732	-61.224393
293	Hall Land	shell	H. arctica	100.41	81.580773	-61.208761
294	Hall Land	shell frags	unidentified	98.81	81.581045	-61.209725
296	Hall Land	bulk	surface sed.	35.46	81.573348	-61.212238
298	Hall Land	shell	H. arctica	98.87	81.595687	-60.699700
299	Hall Land	bulk	surface sed.	95.36	81.598933	-60.718714
300	Hall Land	shell	unidentified	90.46	81.603228	-60.711162
301	Hall Land	bulk	surface sed.	90.46	81.603228	-60.711162
302	Hall Land	shell	H. arctica	90.46	81.603228	-60.711162
303	Hall Land	bulk	surface sed.	98.01	81.606701	-60.692058
304	Hall Land	shell frags	unidentified	97.51	81.606989	-60.686733
305	Hall Land	shell frags	unidentified	92.28	81.608103	-60.674160
307	Hall Land	bulk	surface sed.	92.28	81.608103	-60.674160
308	Hall Land	bulk	surface sed.	131.61	81.549795	-60.708995
309	Hall Land	shell frag	unidentified	130.22	81.550981	-60.715887
311	Hall Land	shell frag	unidentified	127.16	81.554424	-60.721907
312	Hall Land	bulk	surface sed.	120.14	81.558824	-60.741662
314	Hall Land	shell frag	unidentified	102.27	81.561703	-60.759790

Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
315	Hall Land	shell frags	unidentified	107.20	81.560986	-60.745444
316	Hall Land	shell frag	unidentified	106.46	81.560925	-60.744790
317	Hall Land	boulder	unidentified	124.73	81.550573	-61.096454
318	Hall Land	boulder	unidentified	114.04	81.553106	-61.095934
319	Hall Land	shell frags	unidentified	124.73	81.550573	-61.096454
320	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
321	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
322	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
323	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
324	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
325	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
326	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
327	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
328	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
329	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
330	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
331	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
332	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
333	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
334	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
335	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
336	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
337	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
338	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
339	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
339	Hall Land	cobble	red granite	113.74	81.553135	-61.094154
340	Hall Land	shell frag	unidentified	113.74	81.553135	-61.094154
341	Hall Land	shell	H. arctica	13.55	81.491847	-61.289784
343	Hall Land	shell	A. borealis	7.36	81.491392	-61.303758
344	Hall Land	shell	A. borealis	7.43	81.491355	-61.303914
345	Hall Land	shell	H. arctica	5.50	81.491233	-61.307543
346	Hall Land	shell	H. arctica	5.71	81.491282	-61.307473
347	Hall Land	shell	H. arctica	5.13	81.491275	-61.309464
348	Hall Land	shell	H. arctica	5.11	81.491314	-61.311569
349	Hall Land	shell	H. arctica	4.48	81.491247	-61.311590
350	Hall Land	shell	H. arctica	4.32	81.491262	-61.313399
350	Hall Land	shell	A. borealis	4.32	81.491262	-61.313399
351	Hall Land	shell	H. arctica	3.61	81.490760	-61.316727
352	Hall Land	shells	H. arctica	3.12	81.490579	-61.318176
353	Hall Land	boulder	unidentified	1.72	81.489459	-61.324567
354	Hall Land	shell	A. borealis	1.79	81.489346	-61.325191
355	Hall Land	shell	H. arctica	1.07	81.489058	-61.328637
356	Hall Land	shell	A. borealis	1.40	81.489073	-61.329029
356	Hall Land	shell	A. borealis	1.40	81.489073	-61.329029
358	Hall Land	boulder	unidentified	1.15	81.489523	-61.329774
359	Hall Land	shell	A. borealis	0.21	81.489523	-61.329774

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Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
360	Hall Land	bulk	surface sed.	1.21	81.489507	-61.328775
361	Hall Land	bulk	surface sed.	3.33	81.489335	-61.320336
362	Hall Land	shell frag	H. arctica	7.24	81.488788	-61.305880
363	Hall Land	shell	H. arctica	12.31	81.488287	-61.299221
364	Hall Land	bulk	surface sed.	13.25	81.488287	-61.299221
365	Hall Land	boulder	unidentified	14.88	81.488200	-61.296576
366	Hall Land	shell frags	H. arctica	13.95	81.488200	-61.296576
367	Hall Land	shell frags	unidentified	17.03	81.488002	-61.293147
368	Hall Land	bulk	surface sed.	17.96	81.488002	-61.293147
369	Hall Land	shell	H. arctica	20.05	81.488025	-61.291118
370	Hall Land	shell frags	H. arctica	22.27	81.487914	-61.288600
371	Hall Land	shell frag	unidentified	22.27	81.487914	-61.288600
371	Hall Land	bulk	surface sed.	23.21	81.487914	-61.288600
372	Hall Land	shell frag	H. arctica	144.47	81.487808	-61.287359
373	Hall Land	bulk	surface sed.	144.47	81.487808	-61.287359
374	Hall Land	shell frag	unidentified	145.95	81.655085	-60.543577
375	Hall Land	shell frags	unidentified	143.70	81.654444	-60.543489
376	Hall Land	bulk	surface sed.	143.70	81.654444	-60.543489
377	Hall Land	bulk	surface sed.	136.62	81.660128	-60.592626
378	Hall Land	bulk	surface sed.	145.01	81.664041	-60.613916
379	Hall Land	shell frags	unidentified	145.75	81.663866	-60.624191
380	Hall Land	bulk	surface sed.	145.75	81.663866	-60.624191
381	Hall Land	shell frags	unidentified	132.74	81.665392	-60.617976
382	Hall Land	bulk	surface sed.	132.74	81.665392	-60.617976
383	Hall Land	shell frags	H. arctica	131.74	81.666493	-60.613651
384	Hall Land	shell frag	unidentified	124.15	81.669016	-60.599581
385	Hall Land	shell frags	unidentified	127.58	81.671585	-60.592562
386	Hall Land	shell frags	unidentified	128.36	81.672061	-60.591901
387	Hall Land	bulk	surface sed.	128.36	81.672061	-60.591901
388	Hall Land	shell	H. arctica	100.72	81.579716	-61.172947
389	Hall Land	shell	H. arctica	99.67	81.578936	-61.172100
390	Hall Land	shell	H. arctica	99.67	81.578936	-61.172100
391	Hall Land	shell frags	unidentified	99.67	81.578936	-61.172100
392	Hall Land	boulder	unidentified	97.69	81.577312	-61.171554
393	Hall Land	shell	H. arctica	99.67	81.578936	-61.172100
394	Hall Land	shell	H. arctica	98.30	81.577998	-61.171588
395	Hall Land	shell	H. arctica	97.69	81.577312	-61.171554
396	Hall Land	shell	H. arctica	97.69	81.577312	-61.171554
397	Hall Land	shell	H. arctica	97.69	81.577312	-61.171554
398	Hall Land	shell	H. arctica	97.69	81.577312	-61.171554
399	Hall Land	shell	H. arctica	97.69	81.577312	-61.171554
400	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
401	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
402	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
403	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
404	Hall Land	cobble	red granite	97.64	81.576636	-61.170434

Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
405	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
406	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
407	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
408	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
409	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
410	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
411	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
412	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
413	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
414	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
415	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
416	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
417	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
418	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
419	Hall Land	cobble	red granite	97.64	81.576636	-61.170434
420	Hall Land	bulk	surface sed.	97.64	81.576636	-61.170434
421	Hall Land	boulder	sandstone	96.73	81.577897	-61.168796
422	Hall Land	shell	H. arctica	97.96	81.580362	-61.177565
423	Hall Land	shell	H. arctica	97.96	81.580362	-61.177565
424	Hall Land	shell	H. arctica	97.96	81.580362	-61.177565
425	Hall Land	shell	H. arctica	95.24	81.581225	-61.182952
426	Hall Land	shell	H. arctica	97.35	81.583680	-61.188375
427	Hall Land	shell	H. arctica	96.40	81.582600	-61.199636
428	Hall Land	shell	H. arctica	96.40	81.582600	-61.199636
429	Hall Land	shell	H. arctica	96.40	81.582600	-61.199636
430	Hall Land	shell frags	H. arctica	96.40	81.582600	-61.199636
431	Hall Land	bulk	surface sed.	96.40	81.582600	-61.199636
432	Hall Land	shell	H. arctica	97.81	81.582439	-61.208633
433	Hall Land	shell	H. arctica	97.81	81.582439	-61.208633
434	Hall Land	shell	H. arctica	97.81	81.582439	-61.208633
435	Hall Land	shell	H. arctica	97.81	81.582439	-61.208633
436	Hall Land	shell	H. arctica	97.81	81.582439	-61.208633
437	Hall Land	boulder	unidentified	98.17	81.581785	-61.205790
438	Hall Land	shell	H. arctica	92.76	81.583426	-61.210370
439	Hall Land	shell	H. arctica	92.76	81.583426	-61.210370
440	Hall Land	bulk	surface sed.	92.76	81.583426	-61.210370
441	Hall Land	shell	H. arctica	98.80	81.581279	-61.207559
442	Hall Land	bulk	surface sed.	98.80	81.581279	-61.207559
443	Hall Land	boulder	unidentified	98.40	81.581545	-61.206266
444	Hall Land	bulk	surface sed.	none	81.58	-61.20
445	Hall Land	shell frags	H. arctica	63.90	81.577210	-61.198626
479	Bessel Fjord	shell	A. borealis	1.99	81.121146	-63.915713
481	Bessel Fjord	shell	H. arctica	3.02	81.121038	-63.916017
482	Bessel Fjord	shell	M. truncata	2.77	81.120858	-63.916328
483	Bessel Fjord	bulk	surface sed.	0.00	81.120713	-63.916123
484	Bessel Fjord	bulk	surface sed.	1.17	81.121091	-63.917492

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Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
485	Bessel Fjord	bulk	surface sed.	1.76	81.121094	-63.916393
486	Bessel Fjord	bulk	surface sed.	26.52	81.122678	-63.921701
487	Bessel Fjord	bulk	surface sed.	17.11	81.121165	-63.933651
488	Bessel Fjord	bulk	surface sed.	21.30	81.121643	-63.930709
489	Bessel Fjord	shell frags	unidentified	21.30	81.121643	-63.930709
490	Bessel Fjord	shell frags	unidentified	27.69	81.123277	-63.920201
491	Bessel Fjord	bulk	surface sed.	52.85	81.123303	-63.907801
492	Bessel Fjord	shell frags	unidentified	52.57	81.123212	-63.907842
493	Bessel Fjord	boulder	unidentified	52.76	81.122985	-63.908508
494	Bessel Fjord	shell frags	unidentified	38.31	81.124112	-63.880175
495	Bessel Fjord	bulk	surface sed.	38.31	81.124112	-63.880175
496	Bessel Fjord	bulk	surface sed.	28.41	81.123705	-63.887434
585	Bessel Fjord	shell frag	H. arctica	15.10	80.740243	-63.127900
587	Bessel Fjord	shell	H. arctica	5.45	80.743402	-63.130557
587	Bessel Fjord	shell	A. borealis	5.45	80.743402	-63.130557
589	Bessel Fjord	shell	A. borealis	5.45	80.743402	-63.130557
589	Bessel Fjord	shell	H. arctica	5.45	80.743402	-63.130557
589	Bessel Fjord	shell	Macoma sp?	5.45	80.743402	-63.130557
590	Bessel Fjord	wood	unidentified	6.77	80.743483	-63.129864
591	Bessel Fjord	wood	unidentified	5.44	80.746168	-63.121988
592	Bessel Fjord	bulk	surface sed.	1.67	80.751143	-63.106678
593	Bessel Fjord	shell	A. borealis	2.81	80.749805	-63.106894
594	Bessel Fjord	bulk	surface sed.	3.90	80.749324	-63.110459
595	Bessel Fjord	shell	A. borealis	3.59	80.746900	-63.098264
596	Bessel Fjord	bulk	surface sed.	6.13	80.745652	-63.094181
597	Bessel Fjord	shell	M. truncata	12.29	80.745085	-63.093636
598	Bessel Fjord	shell frags	unidentified	11.89	80.743729	-63.097774
599	Bessel Fjord	shell	A. borealis	11.89	80.743729	-63.097774
599	Bessel Fjord	shell	H. arctica	11.89	80.743729	-63.097774
600	Bessel Fjord	bulk	surface sed.	15.66	80.740218	-63.106972
601	Bessel Fjord	bulk	surface sed.	56.41	80.734022	-63.125010
603	Bessel Fjord	shell frags	unidentified	23.78	80.731101	-63.157712
604	Bessel Fjord	shell	A. borealis	0.00	80.731100	63.157700
605	Bessel Fjord	shell frags	H. arctica	0.00	80.731100	63.157700
606	Bessel Fjord	cobble	red granite	23.81	80.731380	-63.151679
607	Bessel Fjord	shell	H. arctica	35.93	80.732584	-63.140863
4	Kap Morton	bulk	surface sed.	n/a	n/a	n/a
5	Kap Morton	shell	H. arctica	11.73	81.200116	-63.335500
7	Kap Morton	wood	unidentified	19.00	81.195350	-63.334783
8	Kap Morton	bulk	surface sed.	n/a	81.195366	-63.334800
9	Kap Morton	wood	unidentified	13.32	81.195322	-63.334734
10	Kap Morton	boulder	crystalline	20.46	81.195156	-63.333615
11	Kap Morton	bulk	surface sed.	n/a	81.195283	-63.333300
16	Kap Morton	shell frags	H. arctica	85.00	81.182900	-63.336500
16	Kap Morton	shell	H. arctica	85.00	81.182900	-63.336500
17	Kap Morton	shell	H. arctica	80.06	81.182961	-63.337866

Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
18	Kap Morton	wood	unidentified	77.60	81.183057	-63.338112
19	Kap Morton	bone	unidentified	88.00	81.182967	-63.337883
20	Kap Morton	shell frags	H. arctica	89.00	81.182980	-63.337860
21	Kap Morton	wood	unidentified	75.14	81.182887	-63.339959
22	Kap Morton	wood	unidentified	85.00	81.183083	-63.338183
23	Kap Morton	wood	unidentified	79.00	81.182916	-63.339950
24	Kap Morton	bulk	surface sed.	n/a	81.183033	-63.338150
25	Kap Morton	shell	H. arctica	81.03	81.182526	-63.338043
26	Kap Morton	shell	H. arctica	83.88	81.181997	-63.337454
27	Kap Morton	boulder	gneiss	87.85	81.181105	-63.334759
28	Kap Morton	shell frag	unidentified	89.32	81.181154	-63.342421
29	Kap Morton	shell frags	unidentified	88.33	81.181997	-63.337454
30	Kap Morton	bulk	surface sed.	88.33	81.181997	-63.337454
31	Kap Morton	shell frags	unidentified	93.50	81.179291	-63.344385
31	Kap Morton	shell	H. arctica	93.50	81.179291	-63.344385
32	Kap Morton	shell frags	unidentified	94.42	81.178821	-63.345096
32	Kap Morton	shell	H. arctica	94.42	81.178821	-63.345096
33	Kap Morton	bone	unidentified	96.62	81.178383	-63.345495
34	Kap Morton	shell	H. arctica	97.30	81.178184	-63.345701
35	Kap Morton	shell frag	unidentified	102.59	81.176942	-63.345912
36	Kap Morton	bulk	surface sed.	102.59	81.176942	-63.345912
38	Kap Morton	shell frags	unidentified	134.46	81.170498	-63.328734
39	Kap Morton	shell frags	unidentified	120.15	81.170151	-63.336470
40	Kap Morton	shell frags	unidentified	116.57	81.170061	-63.339498
41	Kap Morton	shell frags	unidentified	129.00	81.167883	-63.338483
42	Kap Morton	bone	unidentified	129.00	81.167883	-63.338483
45	Kap Morton	bulk	surface sed.	9.62	81.198733	-63.344224
46	Kap Morton	bulk	surface sed.	9.62	81.198733	-63.344224
47	Kap Morton	bulk	surface sed.	9.32	81.198733	-63.344224
48	Kap Morton	bone	unidentified	9.15	81.198875	-63.345468
49	Kap Morton	cobble	red granite	8.79	81.198771	-63.346532
50	Kap Morton	cobble	red granite	8.15	81.199133	-63.347402
51	Kap Morton	cobble	red granite	8.90	81.199165	-63.347290
52	Kap Morton	cobble	red granite	9.84	81.199174	-63.347464
53	Kap Morton	cobble	red granite	9.00	81.199139	-63.347463
54	Kap Morton	cobble	red granite	9.07	81.199119	-63.347052
55	Kap Morton	cobble	red granite	10.24	81.199007	-63.346808
56	Kap Morton	cobble	red granite	9.86	81.198779	-63.346901
57	Kap Morton	cobble	red granite	10.14	81.198713	-63.346602
58	Kap Morton	cobble	red granite	10.15	81.198645	-63.346920
59	Kap Morton	cobble	red granite	10.33	81.198584	-63.347093
60	Kap Morton	cobble	red granite	10.75	81.198556	-63.347024
61	Kap Morton	cobble	red granite	9.91	81.198516	-63.347244
62	Kap Morton	cobble	red granite	9.74	81.198488	-63.347178
63	Kap Morton	cobble	red granite	11.26	81.198462	-63.346914
64	Kap Morton	cobble	red granite	10.58	81.198473	-63.346814

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Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
65	Kap Morton	cobble	red granite	10.47	81.198459	-63.346901
66	Kap Morton	cobble	red granite	11.56	81.198427	-63.347067
67	Kap Morton	cobble	red granite	11.56	81.198427	-63.347067
68	Kap Morton	cobble	red granite	11.56	81.198427	-63.347067
69	Kap Morton	cobble	red granite	11.56	81.198427	-63.347067
70	Kap Morton	cobble	red granite	11.56	81.198427	-63.347067
71	Kap Morton	bulk	surface sed.	13.38	81.197926	-63.349038
72	Kap Morton	bulk	surface sed.	13.38	81.197926	-63.349038
73	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
74	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
75	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
76	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
77	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
78	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
79	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
80	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
81	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
82	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
83	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
84	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
85	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
86	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
87	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
88	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
89	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
90	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
91	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
92	Kap Morton	cobble	red granite	24.64	81.196929	-63.355913
93	Kap Morton	bulk	surface sed.	24.79	81.197006	-63.354447
94	Kap Morton	bulk	surface sed.	26.59	81.196796	-63.357389
95	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
96	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
97	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
98	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
99	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
100	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
101	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
102	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
103	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
104	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
105	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
106	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
107	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
108	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
109	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
110	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438

Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
111	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
112	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
113	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
114	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
115	Kap Morton	cobble	red granite	43.01	81.194185	-63.349438
116	Kap Morton	bulk	surface sed.	42.66	81.194227	-63.349514
117	Kap Morton	bulk	surface sed.	41.92	81.194171	-63.347955
118	Kap Morton	bulk	surface sed.	42.88	81.193841	-63.349373
119	Kap Morton	bone	unidentified	46.13	81.191694	-63.351185
120	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
121	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
122	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
123	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
124	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
125	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
126	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
127	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
128	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
129	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
130	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
131	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
132	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
133	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
134	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
135	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
136	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
137	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
138	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
139	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
140	Kap Morton	cobble	red granite	51.35	81.190379	-63.347444
141	Kap Morton	bulk	surface sed.	52.13	81.190353	-63.346534
142	Kap Morton	bulk	surface sed.	50.89	81.190823	-63.350397
143	Kap Morton	shell frags	unidentified	59.84	81.188942	-63.350010
144	Kap Morton	bulk	surface sed.	59.84	81.188942	-63.350010
145	Kap Morton	bulk	surface sed.	65.60	81.188193	-63.349939
239	Kap Morton	shell	A. borealis	n/a	81.497283	61.303750
239	Kap Morton	shell	H. arctica	n/a	81.497283	61.303750
240	Kap Morton	shell	A. borealis	n/a	81.498000	61.310600
353	Kap Morton	boulder	unidentified	3.16	81.489459	-61.324567
357	Kap Morton	bulk	surface sed.	1.44	81.489134	-61.330801
358	Kap Morton	boulder	unidentified	2.58	81.489523	-61.329774
360	Kap Morton	bulk	surface sed.	2.64	81.489507	-61.328775
361	Kap Morton	bulk	surface sed.	4.76	81.489335	-61.320336
364	Kap Morton	bulk	surface sed.	14.68	81.488287	-61.299221
365	Kap Morton	boulder	unidentified	16.32	81.488200	-61.296576
368	Kap Morton	bulk	surface sed.	19.40	81.488002	-61.293147

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Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
371	Kap Morton	bulk	surface sed.	24.64	81.487914	-61.288600
498	Kap Morton	shell frags	H. arctica	127.35	81.168140	-63.352652
499	Kap Morton	shell frags	H. arctica	137.26	81.166755	-63.346588
500	Kap Morton	shell frags	unidentified	142.20	81.165482	-63.342932
501	Kap Morton	bulk	surface sed.	124.18	81.168783	-63.347047
502	Kap Morton	shell	unidentified	124.18	81.168783	-63.347047
503	Kap Morton	shell frag	unidentified	128.54	81.167740	-63.336216
504	Kap Morton	shell frags	unidentified	131.69	81.167385	-63.333476
505	Kap Morton	shell frags	unidentified	144.67	81.166038	-63.329016
506	Cape Baird	bulk	surface sed.	0.81	81.530788	-64.473605
508	Cape Baird	bulk	surface sed.	0.00	81.532298	-64.484717
509	Cape Baird	bulk	surface sed.	1.58	81.531958	-64.485284
510	Cape Baird	bulk	surface sed.	1.58	81.531958	-64.485284
511	Cape Baird	bulk	surface sed.	0.61	81.531842	-64.484880
512	Cape Baird	bulk	surface sed.	15.97	81.530825	-64.492232
513	Cape Baird	shell frags	unidentified	15.44	81.529397	-64.490133
514	Cape Baird	boulder	unidentified	42.02	81.528352	-64.498792
515	Cape Baird	shell frags	unidentified	42.02	81.528352	-64.498792
516	Cape Baird	shell frags	unidentified	51.15	81.528165	-64.504535
517	Cape Baird	bulk	surface sed.	90.68	81.527996	-64.520342
518	Cape Baird	bulk	surface sed.	115.67	81.529277	-64.532218
519	Cape Baird	boulder	unidentified	112.94	81.528721	-64.542854
520	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
521	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
522	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
523	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
524	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
525	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
526	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
527	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
528	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
528	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
529	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
530	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
531	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
532	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
533	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
534	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
535	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
536	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
537	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
538	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
539	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
540	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
541	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
542	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861

Sample #	Region	Type	Subtype	(HASL) m	Latitude	Longitude
543	Cape Baird	cobbles	red granite	113.66	81.528695	-64.541861
544	Cape Baird	shell frags	unidentified	180.75	81.531369	-64.600990
545	Cape Baird	bulk	surface sed.	180.75	81.531369	-64.600990
546	Cape Baird	shell frags	unidentified	187.11	81.531458	-64.603676
547	Cape Baird	shell frags	M. truncata	85.67	81.527922	-64.570101
548	Cape Baird	shell frags	unidentified	84.51	81.527708	-64.569649
549	Cape Baird	shell frags	unidentified	90.07	81.527484	-64.569700
550	Cape Baird	shell frags	unidentified	84.26	81.526733	-64.566822
551	Cape Baird	bulk	surface sed.	75.00	81.526767	-64.566683
552	Cape Baird	shell	M. truncata	58.72	81.526654	-64.557759
552	Cape Baird	shell	M. truncata	58.72	81.526654	-64.557759

Kap Morton

We spent 3.5 days (August 4, 5, 7 and half a day on 17th) at Kap Morton just south of the entrance to PF (81°11.398' N, 63°18.818' W) (Figure SL-3). Field investigations focused on 5 prominent terraces, interpreted as deltaic in origin. The terraces occur from sea level to approximately 130 meters HAE. Sediments underlying the lower terrace surfaces exposed in river cuts revealed seaward dipping beds (foreset beds) overlain by a ~1 m of horizontal bed (topset beds). Shell fragments, tentatively identified as *Mya truncata* and *Hiatella arctica*, were collected from the surfaces of the terraces at 95–130 meters HAE for radio-carbon dating (note: species identification of all collected shells will be verified following further examination). An archaeological site comprised of a gray chert midsection of a projectile point, a base fragment, and three flakes was identified near the edge of terrace 3 with seaward view. The site was photographed and GPS'd and left in place. We sampled a granitic gneiss boulder on terrace number 2 and a granitic boulder on terrace 5 for ¹⁰Be cosmogenic dating. Additionally, sets (20) of granitic cobbles, with each cobble measuring approximately 5×5×5 centimeters, were collected from terraces 2–5 also for ¹⁰Be cosmogenic dating. Each sampled boulder and cobble was numbered, photographed, and GPS'd using a Trimble GNSS and a handheld Garmin. A prominent moraine crests above the highest terrace at approximately 148 meters HAE. Shell fragments were collected on the moraine surface at approximately 133 meters HAE.



Figure SL-3. Delta terraces located on Kap Morton.

Hall Land

We spent 7 days (August 8, 9, 12–16) at five areas on Hall Land immediately north of PF. Investigations focused on beaches, low-elevation terraces (likely deltaic), the Petermann moraine, and exposures of marine sediments in central Hall Land and in uplifted sequences exposed in a river cut near the Petermann moraine. (Figure SL-4).

Details for each sub-area in Hall Land are provided below.

Low-elevation beaches – We investigated raised beaches located on the northern shore of PF (81°34.786' N, 61°10.462' W). Complete whole valves of mostly *Mya truncata* and *Hiatella arctica* were collected from raised beaches from modern sea level up to an elevation of 35 meters HAE. Three boulders (two granitic and a sandstone) were also sampled from these surfaces at 15, 17 and 27 meters HAE.

Deltaic terraces – We investigated deltaic terraces located on the west coast of Hall Land, adjacent to PF (81°34.035' N, 63°24.148' W). We collected shell fragments (predominantly *Mya truncata* and *Hiatella arctica*), surface bulk sediments for forams (n=18), and 5 sets (n=20) of cobble samples. Shell fragments were collected on the surfaces of the terraces up to 84 meters HAE. An intact valve (*Mya truncata* or *Hiatella arctica*) was collected at 48 m HAE.

On the edge of terrace number 2 at an elevation of 39 meters, we located an archaeological site that was previously reported by Knuth (1968, 1981) as an Independence I site with a radiocarbon date of 4,365 yr BP from an muskox horn-core, suggesting to Knuth that relative sea level was below the site elevation (21 m asl, ~34 m HAE) at that time.



Figure SL-4. Delta feature located on Hall Land, dissected by river erosion following uplift. View is toward Polaris Bugt.

A gray chert projectile point missing the tip and base, a chert flake and the base of a point made from banded mahogany chert were identified, photographed, GPS'd and left in place.

Petermann Moraine

We sampled materials from the surface of the Petermann moraine to constrain the age of moraine formation (81°34.786' N, 61°10.462' W). We sampled 3 granitic boulders on the crest of the Petermann moraine and collected one set of 20 granite cobbles for ¹⁰Be cosmogenic dates. We collected intact valves (n=27) of mostly *Mya truncata* and *Hiatella arctica* from the moraine surface, including a few (n=6) that were in situ. This included a complete articulated bivalve (*Mya truncata* and *Hiatella arctica*) collected at 111 meters HAE and intact valves (*Mya truncata* and *Hiatella arctica*) collected at 114 m HAE on the moraine crest. We also collected 5 bulk sediment samples for forams.

Central Hall Land

England (1985) used dates obtained from shells collected at 110 meters to constrain the Holocene marine limit in this area to 150 m. In the same area (81°35.667' N, 60°42.132' W), we collected shell fragments and samples of surface marine sediments for forams from elevations ranging up to approximately 145 meter HAE.

Uplifted marine sequence exposed by river cut River erosion into underlying sediments exposed a sequence of diamict overlain by massive and laminated marine silty clays (81°34.786' N, 61°10.462' W). We collected bulk samples of marine sediments for forams immediately above the contact with the diamict and at regular intervals to the top of the sequence. Distinct in situ shells (not yet identified species) within the laminated section were also collected. Additionally, we collected u-channel samples for paleomagnetic and sedimentologic studies from the laminated silty clays at two sections throughout the sequence.

Bessels Fjord

On August 17, 2015, we investigated the relative sea level history on an island situated at the entrance of Bessels Fjord that was deposited by the retreating ice sheet as a moraine (81°07.268' N, 63°54.935' W). Abundant shell fragments occurred at low elevations, and we collected a sample at an elevation of approximately 58 meters. Three bulk sediment samples of marine muds were taken from 3 areas: a raised shoreline (33 m HAE) and on flat surfaces at ~40 meter HAE and at 60 meter. One granitic gneiss boulder was sampled on the crest of the island. The Petermann 2015 Boulder Team returned to the island and sampled an additional 3 boulders for use in the relative sea level study.

On August 27, 2015, we completed field work inland of Bessels Fjord (81°43.939' N, 63°05.695' W). Intact valves of *Mya truncata*, *Hiatella arctica*, *Astarte borealis* and not yet identified species were collected from modern sea level up to 50 meters HAE. Bulk marine sediment samples for forams were taken from the modern delta, tidal flats, raised tidal flats, and other raised marine sediments (Figure SL-5). Driftwood and a birch-bark peel in the modern delta were also collected.

Cape Baird

On August 20 and 21, 2015, we investigated the relative sea level history on Cape Baird, Ellesmere Island (Figure SL-6). We collected 10 shell fragments, and 10 sediment samples from present sea level to elevations up to 170 meters HAE. One granite boulder was sampled on a flat terrace at an elevation of 56 meters HAE.

We also investigated an exposed sequence of diamict overlain by laminated and massive marine muds and sands. We sampled the diamict, interbedded sands and muds just above the contact with the diamict, and a unit with massive and laminated clays overlying the interbedded sands and mud. Dipping interbedded sands (foresets) and horizontal topset beds, forming a terrace and interpreted as deltaic, capped the sequence and were also sampled for bulk sediment. Granite and gneiss cobbles (n=20) were collected on the terrace surface at an elevation of approximately 56 meters HAE.



Figure SL-5. Raised beaches located inland on Bessels Fjord.

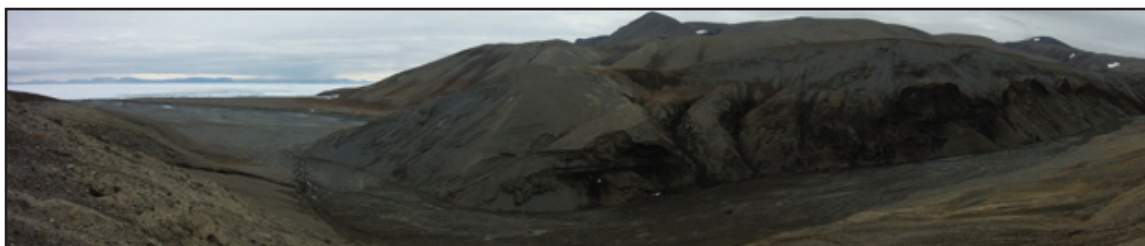


Figure SL-6 . Cape Baird, Ellesmere, Canada.

TI – Terrestrial Ice Retreat History

Staffing: Shaun Marcott, Julia Rosen, Liz Ceperley, Mel Reusche.

Objectives and Methods

The principal aim of the was to obtain rock samples from sites ranging across Washington Land, which included sites near the Petermann Glacier itself, coastal sites near Nares Strait, and in the unglaciated sections of Washington Land. The scientific project is for cosmogenic exposure dating of moraines and erratic boulders on Washington and Hall Land to understand the ice sheet areal retreat history over the last 15,000 years.

Main interactions were with the Helicopter Air Unit. Camp sites were selected based on suitable water source and proximity to sample locations. Flights brought equipment to the camp location from the ship, and provided support for travel to multiple locations across Washington Land not accessible by hiking (e.g. islands in the NS; locations far from field camp).

Daily communications from land operations to IB *Oden* utilized HF Single Radio-telephones, VHF FM Mobile Radio/Transceiver, and other handheld communication devices. The evacuation route, which was not needed, was via helicopter to IB *Oden*. Personal safety gear (e.g. stoves, first aid, survival bags) were provided to each land member and the majority of participants carried firearms (rifles) and “pepper” spray for bear safety. Electric trip lines and other bear warnings and deterrents were used while in camp. All members received firearm safety courses and polar bear training before arriving in Greenland. Safe operating standards were followed and appropriate training for survival in Arctic regions was completed by all members of the field team. Rock samples were transported post-expedition to the University of Wisconsin, Madison.

Results

Each rock sample weighed ~ 2kg, and were collected by hammer and chisel. from the surface of boulders such as granite or gneiss deposited by the inland ice

Table TI-1: Terrestrial Rock Samples – (Wash Lnd = Wash. Lnd, D-J Lnd.. = D-J Lnd.; GIS = Greenland Ice Sheet; Croz Isld = Crozier Island; Franklin Isld = Franklin Island; Wash Lnd Cst = Washington Land Coast)

Seq.	Sample ID	Location	Latitude	Longitude	Elev (m)	Rock type	Wt (g)
1	OD1507-PG-AG1-001	Wash Lnd	80.86353	60.40277	107	Gneiss	500
2	OD1507-PG-ICE-001-15	DJ Lnd	80.24445	59.33118	400	Granite	500
3	OD1507-PG-ILL-001-15	DJ Lnd	80.28454	59.46758	374	Granite	500
4	OD1507-PG-ILL-002-15	DJ Lnd	80.28426	59.46681	374	Gneiss	500
5	OD1507-PG-ILL-003-15	DJ Lnd	80.28423	59.46672	374	Gneiss	500
6	OD1507-PG-ILL-004-15	DJ Lnd	80.41074	60.02106	128	Gneiss	500
7	OD1507-PG-ILL-005-15	DJ Lnd	80.41133	60.02584	132	Granite	500
8	OD1507-PG-ILL-006-15	DJ Lnd	80.41314	60.03829	125	Schist	500
9	OD1507-PG-ILL-007-15	DJ Lnd	80.4153	60.04908	120	Gneiss	500
10	OD1507-PG-INT-001-15	Wash Lnd	80.29436	61.78998	430	Granite	500

Cruise Report

Seq.	Sample ID	Location	Latitude	Longitude	Elev (m)	Rock type	Wt (g)
11	OD1507-PG-INT-002-15	Wash Lnd	80.29418	61.79069	426	Granite	500
12	OD1507-PG-INT-003-15	Wash Lnd	80.29393	61.78586	425	Gneiss	500
13	OD1507-PG-INT-004-15	Wash Lnd	80.31985	61.73439	513	Gneiss	500
14	OD1507-PG-INT-005-15	Wash Lnd	80.3186	61.75051	513	Granite	500
15	OD1507-PG-INT-006-15	Wash Lnd	80.31941	61.78326	505	Granite	500
16	OD1507-PG-INT-007-15	Wash Lnd	80.36923	60.93844	561	Gneiss	500
17	OD1507-PG-INT-008-15	Wash Lnd	80.36859	60.91145	553	Granite	500
18	OD1507-PG-INT-009-15	Wash Lnd	80.36972	60.92255	548	Granite	500
19	OD1507-PG-INT-010-15	Wash Lnd	80.4792	61.315	460	Sandstone	500
20	OD1507-PG-INT-011-15	Wash Lnd	80.47982	61.31351	459	Gneiss	500
21	OD1507-PG-INT-012-15	Wash Lnd	80.48026	61.3136	460	Sandstone	500
22	OD1507-PG-INT-013-15	Wash Lnd	80.48014	61.31685	457	Sandstone	500
23	OD1507-PG-INT-014-15	Wash Lnd	80.47913	61.31289	460	Granite	500
24	OD1507-PG-INT-015-15	Wash Lnd	80.47199	61.7322	556	Sandstone	500
25	OD1507-PG-INT-016-15	Wash Lnd	80.47282	61.74727	547	Gneiss	500
26	OD1507-PG-INT-017-15	Wash Lnd	80.47208	61.75193	541	Granite	500
27	OD1507-PG-INT-018-15	Wash Lnd	80.47134	61.75547	539	Gneiss	500
28	OD1507-PG-INT-019-15	Wash Lnd	80.47182	61.75793	538	Granite	500
29	OD1507-PG-INT-020-15	Wash Lnd	80.17779	63.85379	522	Gneiss	500
30	OD1507-PG-INT-021-15	Wash Lnd	80.17724	63.83907	520	Granite	500
31	OD1507-PG-INT-022-15	Wash Lnd	80.17462	63.82534	517	Granite	500
32	OD1507-PG-INT-023-15	Wash Lnd	80.1753	63.84866	522	Gneiss	500
33	OD1507-PG-INT-024-15	Wash Lnd	80.17711	63.86211	516	Granite	500
34	OD1507-PG-INT-025-15	Wash Lnd	80.35446	60.46074	605	Gneiss	500
35	OD1507-PG-INT-026-15	Wash Lnd	80.35168	60.44889	596	Gneiss	500
36	OD1507-PG-INT-027-15	Wash Lnd	80.35163	60.4486	599	Granite	500
37	OD1507-PG-INT-028-15	Wash Lnd	80.35424	60.45561	608	Sandstone	500
38	OD1507-PG-INT-029-15	Wash Lnd	80.20477	61.2289	698	Sandstone	500
39	OD1507-PG-INT-030-15	Wash Lnd	80.20257	61.22029	673	Granite	500
40	OD1507-PG-INT-031-15	Wash Lnd	80.20325	61.21224	667	Gneiss	500
41	OD1507-PG-INT-032-15	Wash Lnd	80.20008	61.23079	674	Granite	500
42	OD1507-PG-INT-033-15	Wash Lnd	80.20085	61.23774	675	Granite	500
43	OD1507-PG-INT-034-15	Wash Lnd	80.08791	62.05042	571	Sandstone	500
44	OD1507-PG-INT-035-15	Wash Lnd	80.0896	62.03705	565	Granite	500
45	OD1507-PG-INT-036-15	Wash Lnd	80.09026	62.03189	570	Sandstone	500
46	OD1507-PG-INT-037-15	Wash Lnd	80.09041	62.03164	570	Granite	500
47	OD1507-PG-INT-038-15	Wash Lnd	80.08667	62.04079	558	Granite	500
48	OD1507-PG-INT-039-15	Wash Lnd	80.18272	60.81947	574	Gneiss	500
49	OD1507-PG-INT-040-15	Wash Lnd	80.18311	60.81689	579	Granite	500
50	OD1507-PG-INT-041-15	Wash Lnd	80.18278	60.8248	592	Granite	500
51	OD1507-PG-INT-042-15	Wash Lnd	80.18153	60.83125	587	Granite	500
52	OD1507-PG-INT-043-15	Wash Lnd	80.53694	61.17809	462	Sandstone	500
53	OD1507-PG-INT-044-15	Wash Lnd	80.53701	61.17109	465	Sandstone	500
54	OD1507-PG-INT-045-15	Wash Lnd	80.53667	61.16914	466	Granite	500
55	OD1507-PG-INT-046-15	Wash Lnd	80.53638	61.16824	467	Granite	500

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Seq.	Sample ID	Location	Latitude	Longitude	Elev (m)	Rock type	Wt (g)
56	OD1507-PG-INT-047-15	Wash Lnd	80.53966	61.16046	469	Sandstone	500
57	OD1507-PG-INT-048-15	Wash Lnd	80.56022	61.44104	505	Sandstone	500
58	OD1507-PG-INT-049-15	Wash Lnd	80.55926	61.44065	502	Gneiss	500
59	OD1507-PG-INT-050-15	Wash Lnd	80.5596	61.43766	504	Gneiss	500
60	OD1507-PG-INT-051-15	Wash Lnd	80.55752	61.4536	499	Gneiss	500
61	OD1507-PG-INT-052-15	Wash Lnd	80.55575	61.4563	498	Gneiss	500
62	OD1507-PG-LB-001-15	DJ Lnd	80.24551	59.33919	387	Gneiss	500
63	OD1507-PG-LB-002-15	DJ Lnd	80.2456	59.34514	385	Sandstone	500
64	OD1507-PG-LD-001-15	DJ Lnd	80.24445	59.33118	413	Gneiss	500
65	OD1507-PG-LD-002-15	DJ Lnd	80.24442	59.33088	399	Granite	500
66	OD1507-PG-LD-003-15	DJ Lnd	80.24438	59.33059	399	Sandstone	500
67	OD1507-PG-OLL-001-15	DJ Lnd	80.40543	59.99876	146	Gneiss	500
68	OD1507-PG-OLL-002-15	DJ Lnd	80.40754	60.00824	139	Sandstone	500
69	OD1507-PG-OLL-003-15	DJ Lnd	80.41221	60.03484	131	Sandstone	500
70	OD1507-PG-OLL-004-15	DJ Lnd	80.41232	60.03578	131	Sandstone	500
71	OD1507-PG-PBM-001-15	GIS Margin	79.8989	64.16595	14	Gneiss	500
72	OD1507-PG-PBM-002-15	GIS Margin	79.89909	64.16507	14	Sandstone	500
73	OD1507-PG-PBM-003-15	GIS Margin	79.89925	64.16254	14	Gneiss	500
74	OD1507-PG-PBM-004-15	GIS Margin	79.8993	64.16254	9	Sandstone	500
75	OD1507-PG-PBM-005-15	GIS Margin	79.89949	64.16056	5	Gneiss	500
76	OD1507-PG-PBM-006-15	GIS Margin	79.89835	64.17158	16	Granite	500
77	OD1507-PG-PBM-007-15	GIS Margin	79.89837	64.172	11	Gneiss	500
78	OD1507-PG-PBMO-001-15	GIS Margin	79.90038	64.14326	5	Granite	500
79	OD1507-PG-PBMO-002-15	GIS Margin	79.90038	64.14326	5	Sandstone	500
80	OD1507-PG-PBMO-003-15	GIS Margin	79.90057	64.13525	5	Granite	500
81	OD1507-PG-PBMO-004-15	GIS Margin	79.90069	64.13225	5	Sandstone	500
82	OD1507-PG-PBMO-005-15	GIS Margin	79.90075	64.13042	5	Sandstone	500
83	OD1507-PG-PBMO-006-15	GIS Margin	79.90079	64.12825	5	Gneiss	500
84	OD1507-PG-PBMO-007-15	GIS Margin	79.8998	64.15991	9	Gneiss	500
85	OD1507-PG-PBMO-008-15	GIS Margin	79.89954	64.16179	13	Sandstone	500
86	OD1507-PG-PBMO-009-15	GIS Margin	79.8995	64.16211	12	Sandstone	500
87	OD1507-PG-RLO-001-15	Hall Lnd	80.66801	59.83541	112	Sandstone	500
88	OD1507-PG-RLO-002-15	Hall Lnd	80.66804	59.84115	108	Sandstone	500
89	OD1507-PG-RLO-003-15	Hall Lnd	80.66808	59.85122	104	Sandstone	500
90	OD1507-PG-RLO-004-15	Hall Lnd	80.66804	59.8224	117	Sandstone	500
91	OD1507-PG-RLO-005-15	Hall Lnd	80.66837	59.81484	126	Sandstone	500
92	OD1507-PG-RLO-006-15	Hall Lnd	80.66861	59.80894	135	Sandstone	500
93	OD1507-PG-TRA-001-15	DJ Lnd	80.284	59.468	373	Granite	500
94	OD1507-PG-TRA-002-15	DJ Lnd	80.282	59.477	372	Granite	500
95	OD1507-PG-TRA-003-15	DJ Lnd	80.41093	60.28128	269	Gneiss	500
96	OD1507-PG-TRA-004-15	DJ Lnd	80.4133067	60.16712	260	Granite	500
97	OD1507-PG-TRA-005-15	DJ Lnd	80.41046	60.27906	269	Granite	500
98	OD1507-PG-TRA-006-15	DJ Lnd	80.3884	60.21334	417	Granite	500
99	OD1507-PG-TRA-007-15	DJ Lnd	80.38857	60.21154	417	Granite	500
100	OD1507-PG-TRA-008-15	DJ Lnd	80.38857	60.21154	417	Gneiss	500

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Seq.	Sample ID	Location	Latitude	Longitude	Elev (m)	Rock type	Wt (g)
101	OD1507-PG-TRA-009-15	DJ Lnd	80.39014	60.19943	408	Gneiss	500
102	OD1507-PG-TRA-010-15	DJ Lnd	80.39088	60.20732	398	Granite	500
103	OD1507-PG-TRA-011-15	DJ Lnd	80.39151	60.2012	398	Granite	500
104	OD1507-PG-TRA-012-15	DJ Lnd	80.42776	60.14168	165	Gneiss	500
105	OD1507-PG-TRA-013-15	DJ Lnd	80.42922	60.15117	161	Gneiss	500
106	OD1507-PG-TRA-014-15	DJ Lnd	80.42995	60.15691	170	Granite	500
107	OD1507-PG-TRA-015-15	DJ Lnd	80.42996	60.15639	170	Gneiss	500
108	OD1507-PG-TRA-016-15	DJ Lnd	80.43068	60.158	168	Gneiss	500
109	OD1507-PG-TRA-017-15	DJ Lnd	80.43049	60.16132	169	Granite	500
110	OD1507-PG-TRA-018-15	DJ Lnd	80.43139	60.17095	156	Gneiss	500
111	OD1507-PG-TRA-019-15	DJ Lnd	80.43202	60.17045	155	Sandstone	500
112	OD1507-PG-TRA-020-15	DJ Lnd	80.43523	60.17637	127	Gneiss	500
113	OD1507-PG-TRA-021-15	DJ Lnd	80.42379	60.11566	140	Gneiss	500
114	OD1507-PG-TRA-022-15	DJ Lnd	80.42268	60.09697	127	Gneiss	500
115	OD1507-PG-TRA-023-15	DJ Lnd	80.42132	60.09134	122	Granite	500
116	OD1507-PG-TRA-024-15	DJ Lnd	80.41428	60.08076	149	Granite	500
117	OD1507-PG-TRA-025-15	DJ Lnd	80.4127	60.09988	133	Granite	500
118	OD1507-PG-TRA-026-15	DJ Lnd	80.41314	60.09821	132	Gneiss	500
119	OD1507-PG-TRA-027-15	DJ Lnd	80.41193	60.11368	114	Sandstone	500
120	OD1507-PG-TRA-028-15	DJ Lnd	80.41686	60.11578	117	Gneiss	500
121	OD1507-PG-TRA-029-15	DJ Lnd	80.41691	60.11706	118	Granite	500
122	OD1507-PG-TRA-030-15	DJ Lnd	80.42117	60.11407	140	Granite	500
123	OD1507-PG-TRA-031-15	DJ Lnd	80.42188	60.11744	145	Gneiss	500
124	OD1507-PG-TRA-032-15	DJ Lnd	80.42236	60.11551	141	Granite	500
125	OD1507-PG-TRA-033-15	DJ Lnd	80.3964	59.9611	164	Gneiss	500
126	OD1507-PG-TRA-034-15	DJ Lnd	80.39369	59.94995	193	Granite	500
127	OD1507-PG-TRA-035-15	DJ Lnd	80.39173	59.94673	207	Gneiss	500
128	OD1507-PG-TRA-037-15	DJ Lnd	80.38895	59.95318	221	Granite	500
129	OD1507-PG-TRA-038-15	DJ Lnd	80.38781	59.94767	225	Granite	500
130	OD1507-PG-TRA-039-15	DJ Lnd	80.38892	59.93661	210	Granite	500
131	OD1507-PG-TRA-040-15	DJ Lnd	80.38912	59.93492	217	Granite	500
132	OD1507-PG-TRA-041-15	DJ Lnd	80.40009	59.98918	150	Gneiss	500
133	OD1507-PG-WM-001-15	GIS Margin	79.92294	63.75527	119	Sandstone	500
134	OD1507-PG-WM-002-15	GIS Margin	79.92296	63.755	104	Granite	500
135	OD1507-PG-WM-003-15	GIS Margin	79.92256	63.75896	110	Granite	500
136	OD1507-PG-WM-004-15	GIS Margin	79.92259	63.75846	117	Gneiss	500
137	OD1507-PG-WM-005-15	GIS Margin	79.92263	63.74754	123	Gneiss	500
138	OD1507-PG-WM-006-15	GIS Margin	79.92242	63.73957	125	Sandstone	500
139	OC1507-PG-CI-01-15	Croz Isld	80.48739	67.19393	198	Granite	500
140	OC1507-PG-CI-02-15	Croz Isld	80.48763	67.19155	199	Gneiss	500
141	OC1507-PG-CI-03-15	Croz Isld	80.49081	67.20953	158	Granite	500
142	OC1507-PG-CI-04-15	Croz Isld	80.4911	67.20883	162	Granite	500
143	OC1507-PG-CI-05-15	Croz Isld	80.49145	67.20979	163	Granite	500
144	OC1507-PG-CI-06-15	Croz Isld	80.49437	67.20858	167	Gneiss	500
145	OD1507-PG-FI-01-15	Franklin Isld	80.63552	66.73059	430	Gneiss	500

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Seq.	Sample ID	Location	Latitude	Longitude	Elev (m)	Rock type	Wt (g)
146	OD1507-PG-FI-02-15	Franklin Isld	80.63626	66.7323	418	Granite	500
147	OD1507-PG-FI-03-15	Franklin Isld	80.6365	66.73209	420	Granite	500
148	OD1507-PG-FI-04-15	Franklin Isld	80.63702	66.73371	423	Gneiss	500
149	OD1507-PG-FI-05-15	Franklin Isld	80.63651	66.72712	428	Granite	500
150	OD1507-PG-FI-06-15	Franklin Isld	80.63599	66.72961	428	Granite	500
151	OD1507-PG-JI-01-15	Joe Island	81.25072	63.51956	180	Gneiss	500
152	OD1507-PG-JI-02-15	Joe Island	81.25157	63.52574	159	Gneiss	500
153	OD1507-PG-JI-03-15	Joe Island	81.25131	63.52753	157	Sandstone	500
154	OD1507-PG-JI-04-15	Joe Island	81.2513	63.52773	157	Gneiss	500
155	OD1507-PG-BF-01-15	Bessels Fjord	81.12402	63.88223	14	Granite	500
156	OD1507-PG-BF-02-15	Bessels Fjord	81.12462	63.89378	14	Granite	500
157	OD1507-PG-BF-03-15	Bessels Fjord	81.12382	63.90018	28	Granite	500
158	OD1507-PG-WC-01-15	Wash Lnd Cst	80.53908	66.48159	384	Gneiss	500
159	OD1507-PG-WC-02-15	Wash Lnd Cst	80.53912	66.48158	382	Gneiss	500
160	OD1507-PG-WC-03-15	Wash Lnd Cst	80.53842	66.48456	378	Gneiss	500
161	OD1507-PG-WC-04-15	Wash Lnd Cst	80.53848	66.48288	376	Granite	500
162	OD1507-PG-WC-05-15	Wash Lnd Cst	80.56556	66.21538	522	Gneiss	500
163	OD1507-PG-WC-06-15	Wash Lnd Cst	80.56317	66.22414	528	Gneiss	500

IS – Ice Shelf Drilling and Sub-Ice Sampling

Staffing: Paul Anker (British Antarctic Survey), Mike Brian (British Antarctic Survey), Keith Nicholls (British Antarctic Survey), Peter Washam (University of Delaware).

The primary aim of the activity was to recover sediment cores from beneath the ice shelf. Ancillary aims were to investigate the interactions between the ocean and the ice shelf, and particularly the impact on that interaction of the strong basal topography present on Petermann Ice Shelf. A hot water drill was used to make access holes at three locations, allowing an attempt to be made to recover sediment cores, CTD profiling of the water column beneath the ice shelf, and the installation of oceanographic instruments beneath the ice shelf.

Careful site selection was critical to the success of the program. The site needed to be in a location of scientific interest – above a basal canyon at an appropriate distance from the grounding line – and near a supply of surface water for the hot-water drill. The surface needed to be flat enough for setting up the drill and for camping, and in a location that would not be inundated during the peak of the melt season (June), as that would destroy the loggers. We were fortunate to have access to high-resolution images from June 2015 which showed the likely maximum extent of surface flooding, and sites were selected under advice from those images. A final requirement was a site survey with the radar to ensure that the ice was not too thick for the hose available on the hose drum, and that there were no indications of basal crevasses in the vicinity.

KN and MB flew to DS1 on 08/03. PW and PA joined them on 08/05, and the equipment was flown from the ship the same day. The work at the site was completed by 08/09. On 08/09 KN and MB reconnoitred DS2 and the move of equipment to that site began late that afternoon. The move to DS2 was completed on 08/10. During that day, UNAVCO GPS units were installed at GPS2 and GPS4 by MB and PW; KN reconnoitred and selected the location for DS3; and the AWS was temporarily established at DS3 by KN, Andreas Muenchow and Jari Krützfeldt. The work at DS2 was completed by 08/15 and the move to DS3 made on 08/16. DS3 was completed by 08/21. On 08/22 all equipment was transferred to a temporary depot on land at the northeast of the ice shelf, within easy reach of the ship. On 08/23 the equipment was recovered to the ship. Also on 08/23 KN and PW revisited the four GPS sites to collect the instruments. On 08/27 the three drill sites were revisited by KN plus others from *Oden* to make modifications to the logger code at DS1 and DS2, and to calibrate the Automatic Weather Station (AWS) wind direction sensor at DS3.

Short-term GPS installations

Four GPS receivers were installed at four sites, three on the ice shelf and one 20 km upstream of the grounding line. The ice shelf sites were 0.4, 2 and 25 km downstream of the grounding line. The aim of the 2 and 25-km two ice shelf sites was to determine the tidal forcing on the glacier, the tidally-induced strain in the floating tongue, and to determine the tidal amplitudes in PF. The 0.4-km site was to study the response of the hinge-zone to the tidal forcing. The aim of the Upstream site, located on the grounded glacier, was to measure any response of the glacier to the tidal forcing at the grounding line.

Three receivers were Trimbles supplied by UNAVCO, the fourth (deployed at GPS3) was a BAS instrument. All receivers were scheduled to record every 10 seconds, and all generated data files of the appropriate size. The data have yet to be converted.

Table IS-1: Summary of borehole operations and observations.

Site name	Code	Position (km from grounding line)	Seabed depth (m)	Ice thickness (m)	Dates	Observations
Sill	DS1	N80° 44.24 W060° 47.07 (25 km)	570	97	08/03–08/10	Three sediment cores Borehole and water column video CTD profiles Moored instrument record (08/07–) 5.1-day radar record
Sill	GPS1	N80° 44.24 W060° 47.07 (25 km)	570	97	08/06–08/23	GPS record
Deep	DS3	N80° 39.97 W060° 29.73 (15 km)	840	99	08/11–08/22	Weather station (08/1–) Three sediment cores Borehole and water column video CTD profiles Moored instrument record (08/20–) Radar record (08/21–)
Grounding line	DS2	N80° 34.85 W059° 58.06 (2 km)	722	380	08/10–08/16	Borehole and water column video CTD profiles Moored instrument record (08/14–) Radar record (08/15–)
Grounding line	GPS3	N80° 34.85 W059° 58.06 (2 km)	722	380	08/11–08/23	GPS record
Bending zone	GPS2	N80° 32.83 W060° 03.96 (0.4 km)			08/10–08/23	GPS record
Upstream	GPS4	N80° 24.99 W059° 17.85 (-20 km)			08/10–08/23	GPS record

Phase-sensitive radar

Three phase-sensitive radar instruments (ApRES) were taken into the field. Instruments were established at sites 2 and 3, and have been left for the long term. A short (5.1-day) record was obtained from Site 1.

The radars are FMCW systems (frequency modulated continuous wave) which transmit a second-long chirp, linearly changing in frequency from 200 to 400 MHz during the chirp. By comparing the received and transmitted signals, the distance between antenna and reflecting target can be determined to within 0.2 m. By measuring the phase also, the precision can be increased by a factor of up to about 1000, depending on the strength of the returned signal. The returns from reflecting horizons within the ice and from the ice base enable the three contributions to thinning to be observed: basal melting, surface ablation and ice strain.

The long-term deployments were configured to make a 20-chirp measurement every hour, with the processed results from every 12th measurement being transmitted over an Iridium datalink. Housekeeping data are sent as a separate message once per day. The radars are remotely reconfigurable over the Iridium link.

Automatic weather station (AWS)

A University of Delaware AWS was deployed at DS3, 25 km from the grounding line. The data logging system that captured the AWS data served also to interrogate the sub-ice shelf instruments deployed at the site, and record the data. The data logging system also transmitted all AWS and oceanographic data via an Iridium link. The data logging system is based around two Campbell Scientific CR1000 loggers, and uses a full dial-up Iridium modem, enabling the option for complete remote reprogramming of the system if necessary.

The station was initially and temporarily set up within 50 m of the Drill Site 3 (DS3) location. This happened during the move from DS1 to DS2. After the deployment of the instrument string at DS3, the AWS was dismounted and moved to the borehole to be established as a permanent installation. This allowed the sub-ice shelf instruments to be connected.

Over the week following the final installation of the AWS the ship's meteorologists noted a discrepancy with reported wind directions, and a subsequent revisit on 08/27 allowed a calibration to be performed and the wind directions to be corrected.

AWS Sensors	Height above ice (m)
RM Young 05103 (wind)	3.69
Vaisala HMP155 (temp/humid)	3.08
Vaisala HMP155 (temp/humid)	1.09
Vaisala CS106 (pressure)	0.54
Garmin GPS 16xHVS	3.00

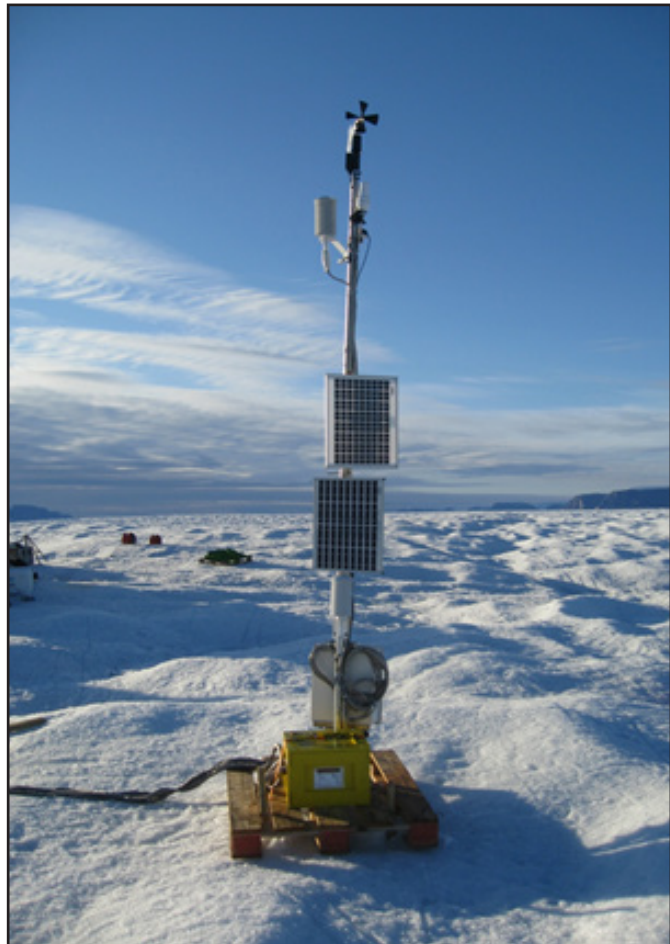


Figure IS-2. Weather Station.

Sub-Shelf Sediment coring

At each drill site, the procedure was to prepare the drill and the instrumentation to be used, and then to create the access hole with the hot water drill. Once the hole had been created, around 6 to 8 hours were available before refreezing risks jeopardising the final activity of lowering the oceanographic instrumentation.

As the bathymetry of the ice-shelf-covered portion of PF is unknown the initial requirement was to determine the depth to the sea floor. This was found by using a “mini-corer” as a plumb-weight, a short corer consisting of a weight, a valve, a 60-cm length of core

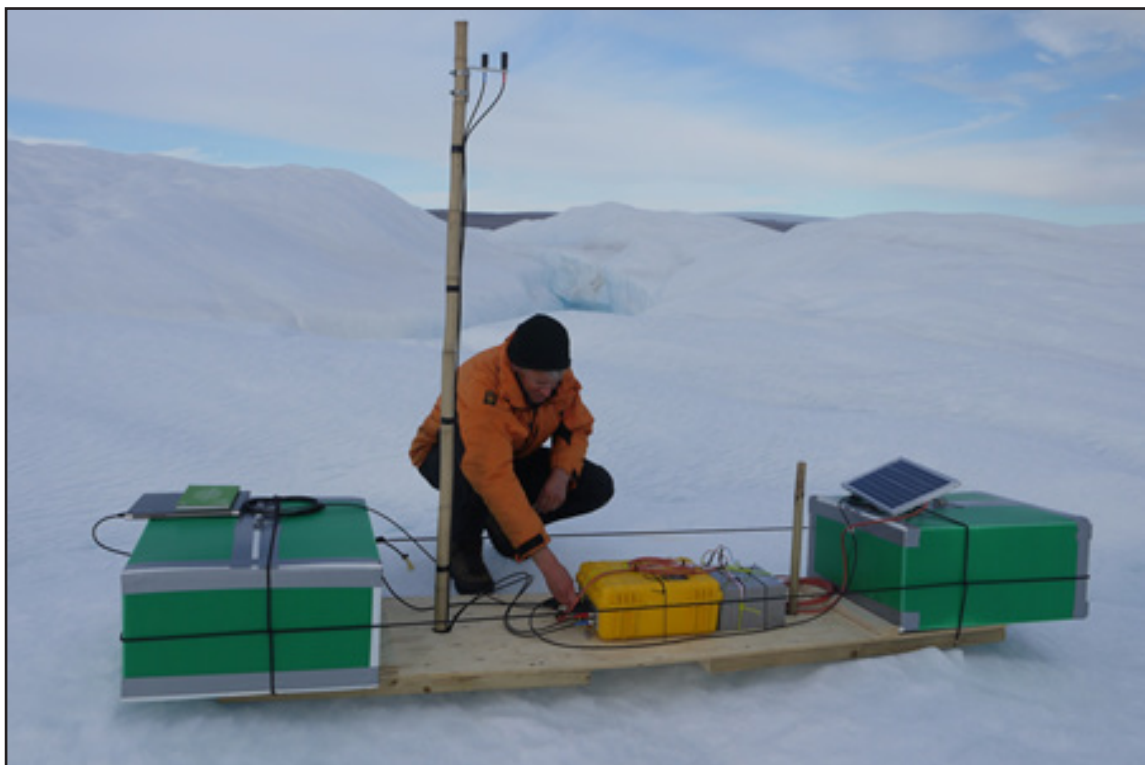


Figure IS-1. Installing phase-sensitive radar for long-term measurements of ice-shelf thinning. The green boxes contain the receiver and transmitter antennas, the yellow box contains the instrument, and the grey block to the right is the battery. A solar panel was included in the power system. The bamboo is used to support an Iridium and GPS antenna.



Figure IS-3. Cores recovered from Site DS1.

liner, and a core-catcher. The mini-corer was lowered using a doubled Kevlar rope, loaded onto the spare CTD winch. When the rope went slack the wire-out counter was used to get an estimate of the depth to the sea floor.

A GoPro camera in underwater housing, together with an underwater light, was mounted 1.5 m above the mini-corer to give a visual indication of the conditions within the borehole, at the opening at the base of the borehole, the conditions within the water column, and at the sea floor.

At sites 1 and 3, the mini-corer returned very close to a full core. At site 2, no core was recovered, and the video footage showed the corer lying on its side. The performance of the 3-m corer followed the same pattern for the three sites, with two long cores being recovered at sites 1 and 3, with nothing from site 2, despite several attempts.

The cores were prepared and sent to the ship as soon as possible for curating and storage.

Table IS-2. Cores recovered from Site DS1.

Label	Length	Start	End	Total length	Date and time
Mini Corer					
ODO0715-001ISC-01					08/08 1400
Main Corer 1					
ODO0715-002ISC-01	100	0	100		08/08 1515
ODO0715-002ISC-02	136.5	100	236.5	236.5	
ODO0715-002ISC-CC	From core catcher. Bagged.				
Main Corer 2					
ODO0715-003ISC-01	111	0	111		08/08 1600
ODO0715-003ISC-02	119.5	111	230.5	230.5	
ODO0715-003ISC-CC	From core catcher. Bagged.				

Table IS-3. Cores recovered from Site DS2.

Label	Length	Start	End	Total Length	Date and time
Mini Corer					
ODO0715-004ISC-01	Small deposit on outside of corer tube.				08/13 0200

Table IS-4. Cores recovered from Site DS3.

Label	Length	Start	End	Total Length	Date and time
Mini Corer					
ODO0715-005ISC-01	67		67	67	08/18 1600
ODO0715-005ISC-02	From core catcher. Non oriented between caps				
Main Corer 1					
ODO0715-006ISC-01	100	0	100		08/18 1900
ODO0715-006ISC-02	102	100	202	202	
ODO0715-006ISC-03	From core catcher. Bagged.				
Main Corer 2	Marked with longitudinal orientation lines				
ODO0715-007ISC-01	94	0	94		08/18 2130
ODO0715-007ISC-02	100	94	194		
ODO0715-007ISC-03	67	194	261	261	
ODO0715-007ISC-04	From core catcher. Oriented between caps ie, top/bottom				



Figure IS-4. Cores Recovered Site DS3.

Sub-Shelf CTD profiling

A Seabird Electronics Fastcat (SBE49) CTD profiler (Serial Number 0220), with a pumped conductivity cell, connected to a PDIM (Power and Data Interface) and mounted in a frame, was used to obtain temperature and salinity profiles at each of the three drill sites. The deck unit was an SBE36. The electrically-powered winch held 2700°m of 1/8th inch Rochester contrahelically-wound coaxial cable. Two casts were made at each site, the casts showing minimal differences and suggesting that a longer series of casts would reveal little behaviour in the time available (Figure IS-5).

Notable here is the barely modified Atlantic Water from about 430°m to the sea floor, even near to the grounding line, and the warmth of the water very near to the ice shelf base, especially near the grounding line where it hovers around zero degrees. The potential temperature versus salinity plot below shows clear evidence of glacial ice melting into Atlantic Water, but higher in the water column the properties deviate dramatically, indicating the contribution of high levels of melt water either from the grounding line, and/or through conduits from the surface of the glacier.

Sub ice shelf moorings

The moorings consist of Seabird Electronics Microcats (SBE37SM), two each at sites 1 and 2, and 5 at Site 3 (Table IS-5). In order to cross-calibrate all the instruments, they were mounted on the ship's CTD frame, and a cast was performed. The frame was stopped at five depths and left for 20 minutes while the instruments logged data at one data frame every six seconds. The instruments were clamped to a Kevlar mooring rope, held taut by a 20-kg ballast weight. A single, three-core cable connected each instrument to the data logger at the surface, providing two-way communications over a 4800-baud RS-232 link. During deployment, the cables were clipped to the rope at 10-m intervals to provide them with mechanical support.

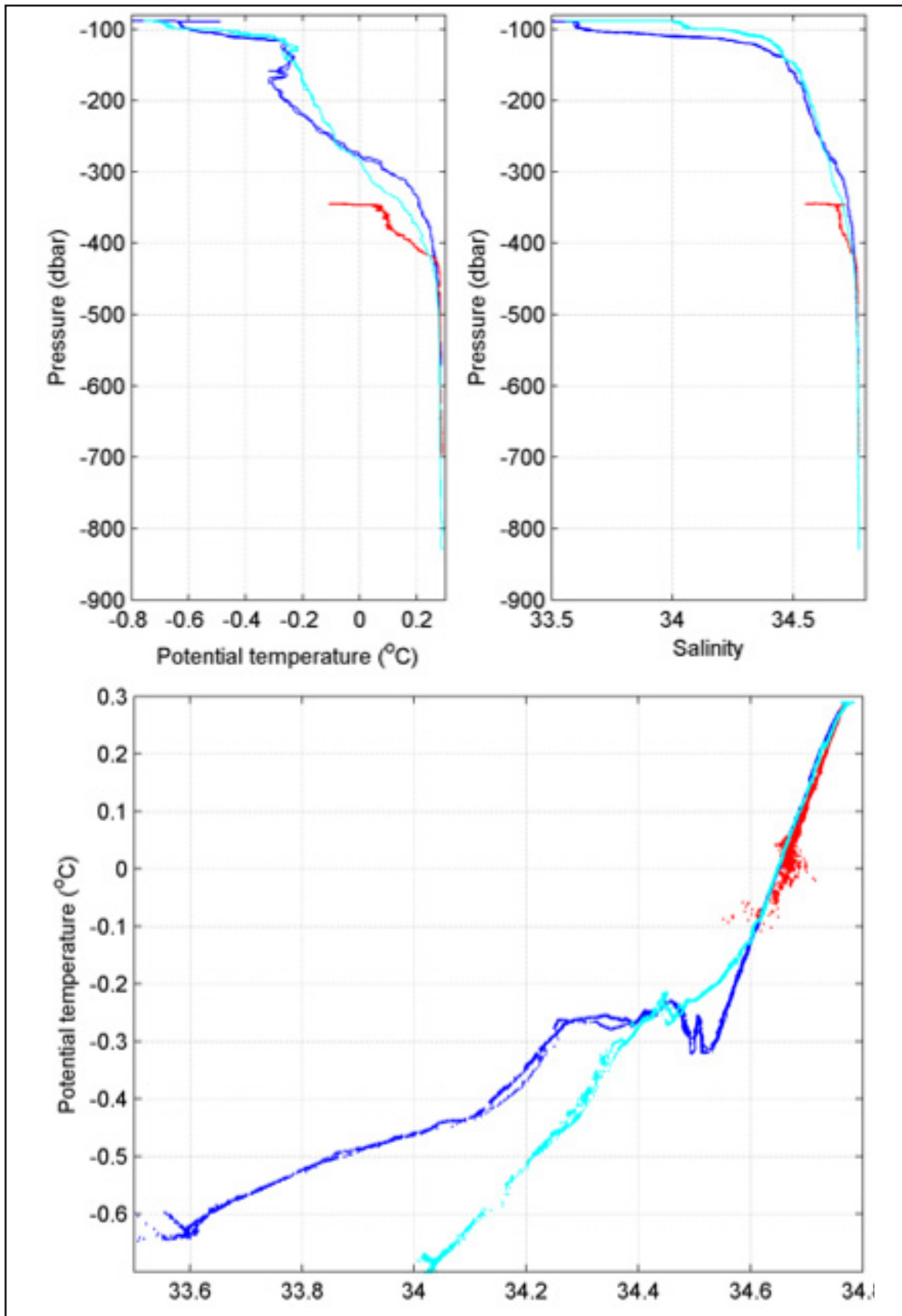


Figure IS-5. Vertical profiles of potential temperature (left) and salinity (right) from DS1 (blue), DS2 (cyan) and DS3 (red).

At sites 1 and 2, the Microcats were programmed to log measurements autonomously at 15-minute intervals. Those data are recorded internally within the instruments, and every 15 minutes, the data logger asynchronously requests the last measurement made. In this mode, a copy of the data is stored on the Microcat. At Site 3 the instruments operate in a mode in which a measurement is made and reported whenever a request is sent from the logger.

Site DS1		
Instrument	Sensors	Pressure
1767	CT	115
2919	CTP	565
Site DS2		
Instrument	Sensors	Pressure
2896	CT	362
2918	CTP	572
Site DS3		
Instrument	Sensors	Pressure
2905	CT	97
2904	CT	117
2900	CT	296
2899	CT	450
2926	CTP	810

Table IS-5. Microcat sensors on sub-ice moorings

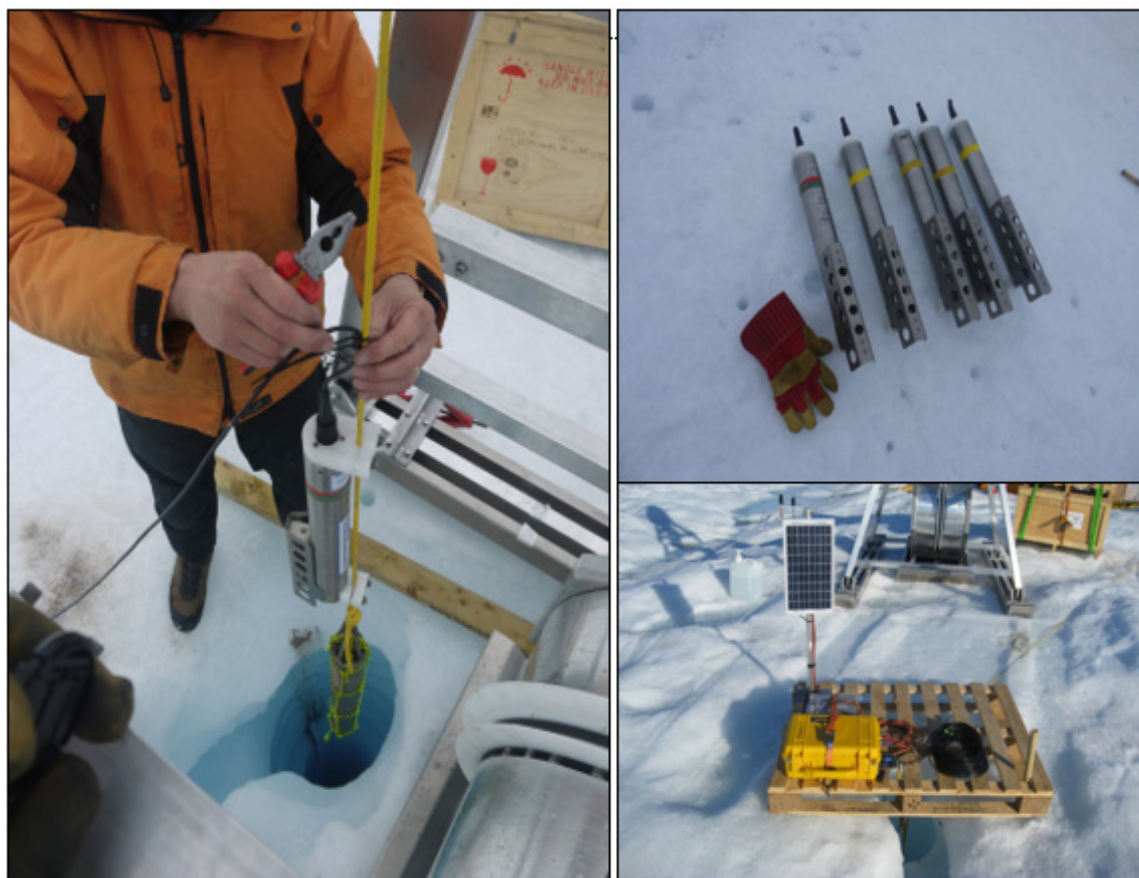


Figure IS-6. Instruments for DS3 (top right), surface installation at DS1 (bottom right), deploying mooring (Left).

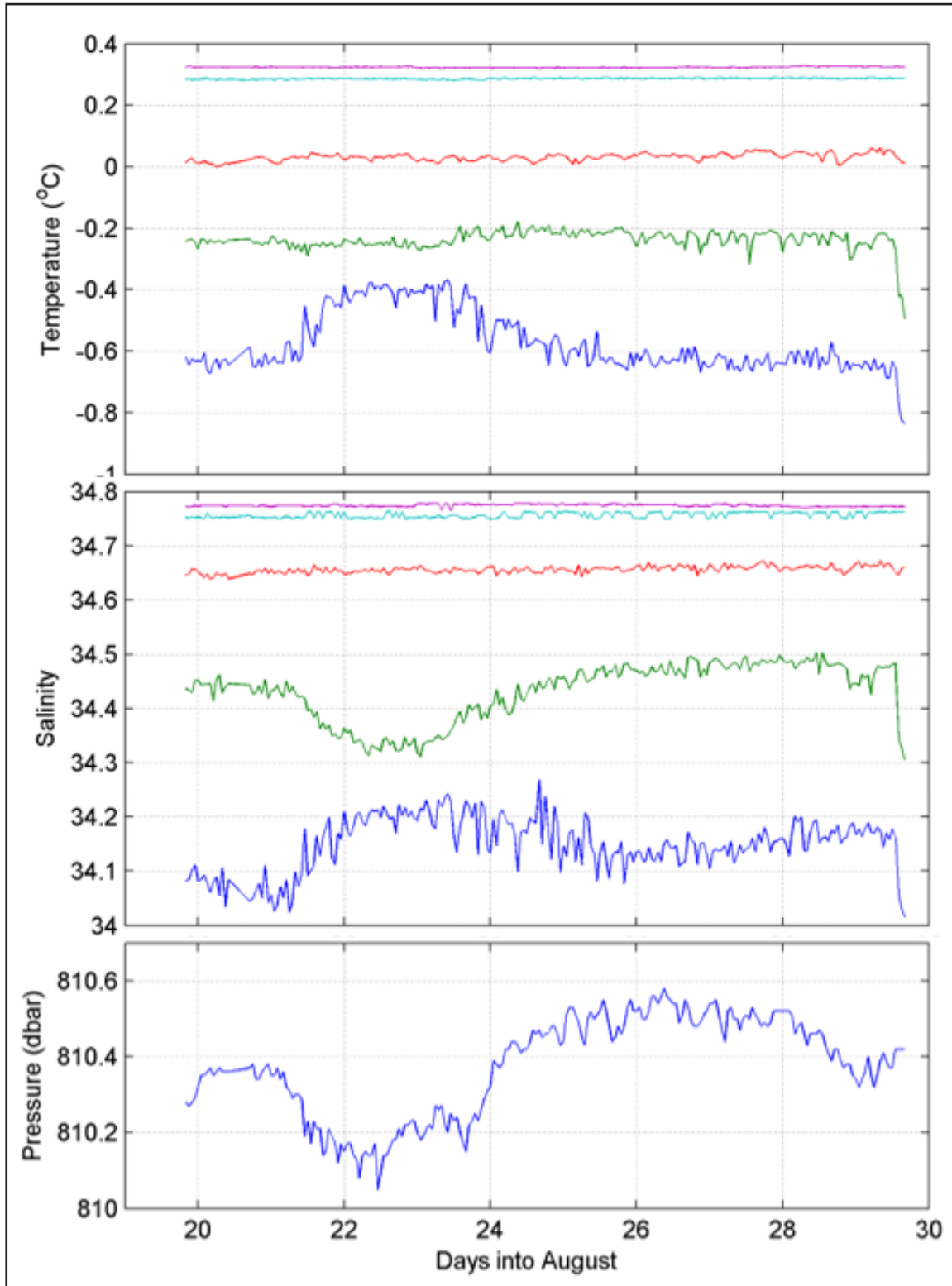


Figure IS-7. Upper panel shows nine-day temperature time series from instruments at DS3. The deepest sensors show very little variability. The upper sensors show more variability, with strong changes within a few meters of the ice base. The middle panel shows similar changes in the salinities recorded in the upper few tens of meters. The pressure variability (lower panel) shows a small but distinct simultaneous uplift in the mooring. A plausible interpretation is the passage of an eddy, possibly resulting from baroclinic instability in a shear flow between the deep and much shallower water.

TB – Terrestrial Biology

Staffing: Fredrik Dalerum, Nicolas Lecomte, Åsa Lindgren, Tomas Meijer, Patricia Pecnerova.

Because global warming is expected to have the greatest effects in cold areas, climate change will likely have stronger ecological consequences in the Arctic compared to warmer zones. This report describes a field effort in the high Arctic region of the Hall Basin that form part of a larger program aiming to quantify the properties of Arctic ecosystems across different sites with the long-term aim of evaluating the potential ecological consequences of a climate driven loss of connectivity among Arctic species communities.

Using the logistics of the *Oden* Icebreaker, we collected data on present and past ecological communities on one site on Hall Land, one site on Washington land (both on Greenland) and one site on Judge Daly Promontory on Ellesmere Island, Nunavut, Canada. Despite a general similarity in vegetation cover and low productivity, and despite relatively small geographic distances, our three sites showed differences both in terms of plant and animal communities. These differences appeared to primarily be driven by the relative occurrences of different species, and not by unique species communities on each site.

Our future analyses will aim at further identifying these differences, quantify what consequences they have for different components of biodiversity, and how they may influence patterns of trophic interactions. We will also investigate potential geological drivers for the quantified differences, particularly considering the different geological origins of the three sites and the potential for the Hall Basin and the Petermann Glacier to act as population barriers.

Arctic environments are characterized by a harsh climate and by low human population densities, and are hosting relatively simple ecosystems. However, alterations of Arctic ecosystems may have large effects on humanity, as they provide important ecosystem services at local and global scales¹. Because of their relative simplicity, Arctic ecosystems are also ideal model systems for evaluating the often complicated ecological effects of environmental disturbances such as global warming². Because global warming is expected to have the greatest effects in cold areas, climate change will likely have stronger ecological consequences in the Arctic compared to other areas². Such climate driven changes may substantially alter our ability to manage endemic Arctic biodiversity and the ecosystem services it provides³.

In addition, in high Arctic environments the direct geological imprint on ecological communities is stronger than in more temperate areas, both because of the relatively recent geological emergence of the Arctic land areas but also and because of the marginal conditions hamper the rate of biotic alterations of the environment. These processes further adds to the complexity of evaluating the ecological consequences of global warming.

The marginal conditions in Arctic environments have generated ecological communities that consist of few species which are often weak competitors⁴. Subsequently, many Arctic

1 Chapin III FS, et al. (2005) In: *Ecosystems and human well-being: current state and trends* (Millennium Ecosystem Assessment, eds), pp 717–743. Island Press, New York.

2 Chapin III FS, Körner C (1996) In: *Functional roles of Biodiversity: a global perspective* (Mooney HA, et al., eds.), pp 7–32. John Wiley & Sons Ltd., Chichester.

3 Ims R, Ehrich D, et al. (2013) In: *Arctic Biodiversity Assessment* (Arctic Council, eds.), pp 385–440.

4 Chernov YI (1995). *Diversity of the arctic terrestrial fauna*. In: *Arctic and alpine biodiversity: Patterns, causes and ecosystem consequences* (Chapin III FS, Körner C, eds.), pp 81–95. Springer-Verlag, Berlin.

species were pushed from their original distributions during the past inter-glacials and became increasingly isolated⁵. Past and present connectivity within Arctic environments has thus played important roles in structuring Arctic species communities. Since the structure of species communities may be critical for their ecological function, the degree of isolation between animal and plant populations in the Arctic may substantially influence local ecosystem properties and subsequently the supply of ecosystem services.

We expect that current global warming will drive a northward expansion of more competitive warm adapted species⁶. Such a process means that Arctic species eventually will be marginalized to Arctic islands, as it did in the previous warming events. Therefore, we have initiated a long-term research program that aims to quantify the ecological consequences of a climate-driven marginalization in the Arctic. The scientific objectives of this program are firstly to quantify the properties of Arctic ecosystems across different sites and relate them to past and present connectivity. Secondly, we will utilize past climate data and modern climate models to forecast the potential effect of climate change on further fragmentation of the Arctic, and how such fragmentation will influence the ecosystem services provided by Arctic environments. Our field efforts in the high Arctic region around the Hall Basin has been part of this larger research program.

The study sites of our expedition were concentrated around the Hall Basin, which allowed us to explore the effects of small scale isolation between plant and animal populations. We sampled three sites, two on the Greenland part of Nares Strait, separated by the Petermann Glacier, and another site on Judge Daly Promontory on Ellesmere Island. In addition, these three study sites offer the additional advantage in that they will enable an evaluation of the effect of geological origin on ecological communities in marginal environments, since most of the area on Hall land has emerged from the ocean whereas the areas on both Washington Land and Judge Daly Promontory have emerged from glaciers.

This field effort was conducted under expedition permit C15-15 from the Government on Greenland and associated survey license G15-021, a permission from the Government of Greenland to conduct research in the northeast Greenland National Park, wildlife research permit W2015-50 from the Department of Environment, Government of Nunavut, and under Government of Nunavut approval 8WCL-WL-11 for the use of water and deposit of waste on Ellesmere Island. The expedition was effectively closed 2015-08-26, when all expedition members safely boarded Swedish icebreaker *Oden* by helicopter.

Methods

We collected data on present and past ecological communities on one site on Hall Land, one site on Washington land (both on Greenland) and one site on Judge Daly Promontory on Ellesmere Island, Nunavut, Canada (Figure TB-1). At each site, we conducted all our research activities using a fixed camp as our logistic base. We were transported to and from these base camps and the ice breaker *Oden* using helicopters. We collected both structured data along pre-identified sample transects as well as recorded opportunistic observations of birds and mammals. We collected faecal, bone feather and hair samples linked to targeted species of the ecosystem (Table TB-1).

⁵ Callaghan TV, et al. (2005) In: *Arctic climate impact assessment (ACIA, eds.)*, pp 243–352. Cambridge University Press, Cambridge.

⁶ Reiss J, et al. (2009) *Tr Ecol Evol* 24:505–514.

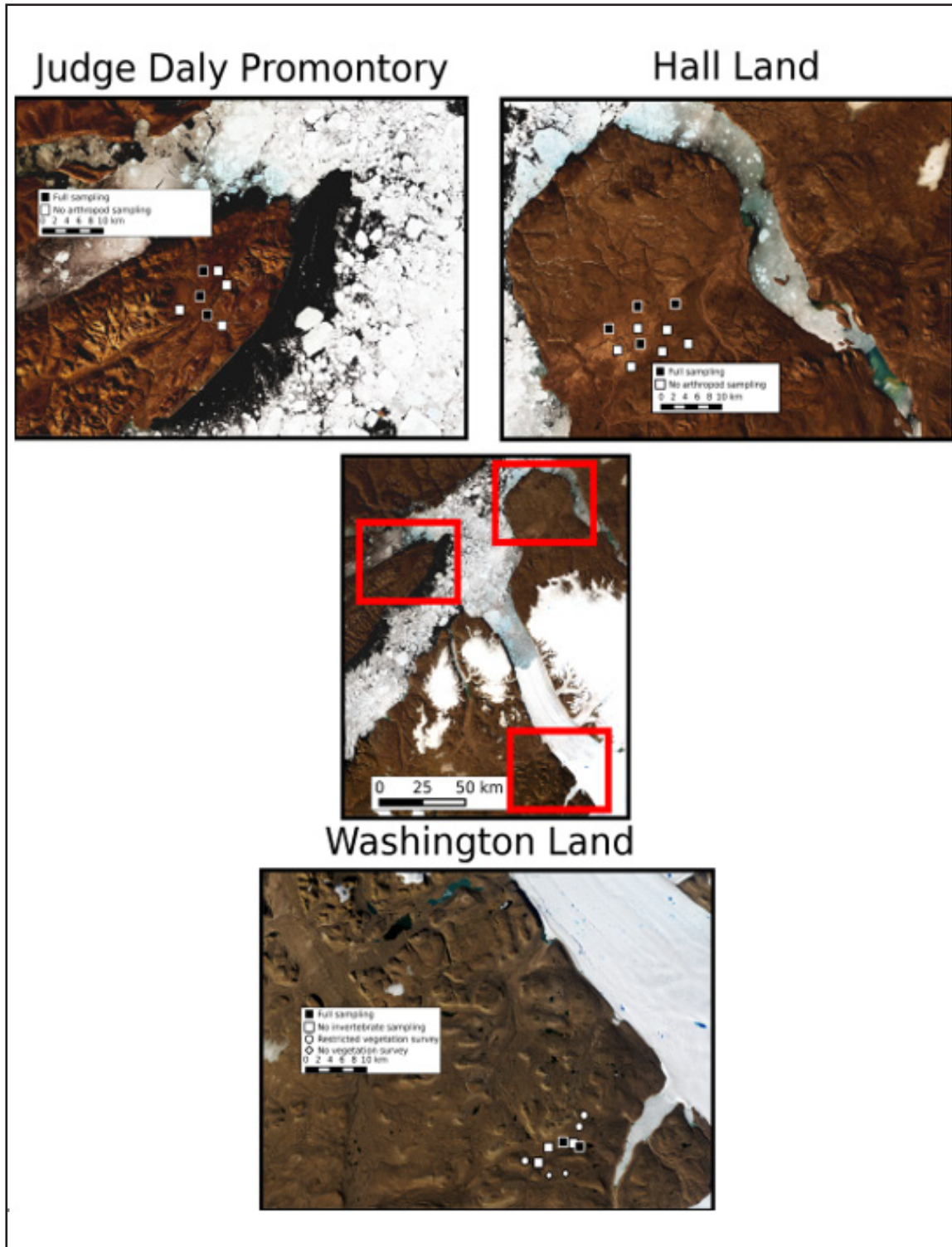


Figure TB-1. Study areas and survey transects on the three sites on Hall land, Washington Land and on Judge Daly promontory.

Structured data collection along pre-defined transects

The structured data collection was centered around 1-km long transects. Each transect had 5 sample stations placed 250 meters apart (Figure TB-2). At each study site, we randomly placed 10 transect locations using a stratified random protocol. To do so, we placed a grid with 3×3 km cells over each study area, and within each cell we randomly selected a coordinate constrained so that two coordinates were not closer than 2 km to overlap. Logistical and weather limitations did not allow us to collect a full set of data on Washington land and the Judge Daly Promontory. The transects were laid out along each cardinal direction from the starting coordinate in a rotating schedule following the same order as they were recorded. Detailed locations for each sample station along these transects are given in Table TB-1.

Survey and sampling of plant communities

We quantified plant community structure using the ITEX point-intercept method. At each sample station, we created a 25×25 meter square, whose corners and center were hosting one 1 m² square plot (Figure TB-2). Over each plot, we laid out a grid with a 10-cm resolution, and selected the corner, the center points as well as 20 random cell intersections as sample points. This protocol gave us 25 sampling points for each plot, amounting for 625 for each sample station and 3125 for each transect. At each point, we recorded the identity, tissue type (e.g., vegetative, reproductive, dead), live or dead plant, and height of each plant that touched a vertically inserted stick. At each plot, we also visually estimated the total % of vegetation cover, the height of the tallest living plant, and recorded a complete list of plant species. We also recorded a list of the plant species occurring within the 25×25 meter square. We collected live tissue samples from one individual plant of the most common species within each plot.

Collection of soil samples

To enable quantification of soil microbes and soil chemistry, we pooled approximately 125 ml of soil from each 1 m² plot across each 25×25 meter sample station. These soil samples

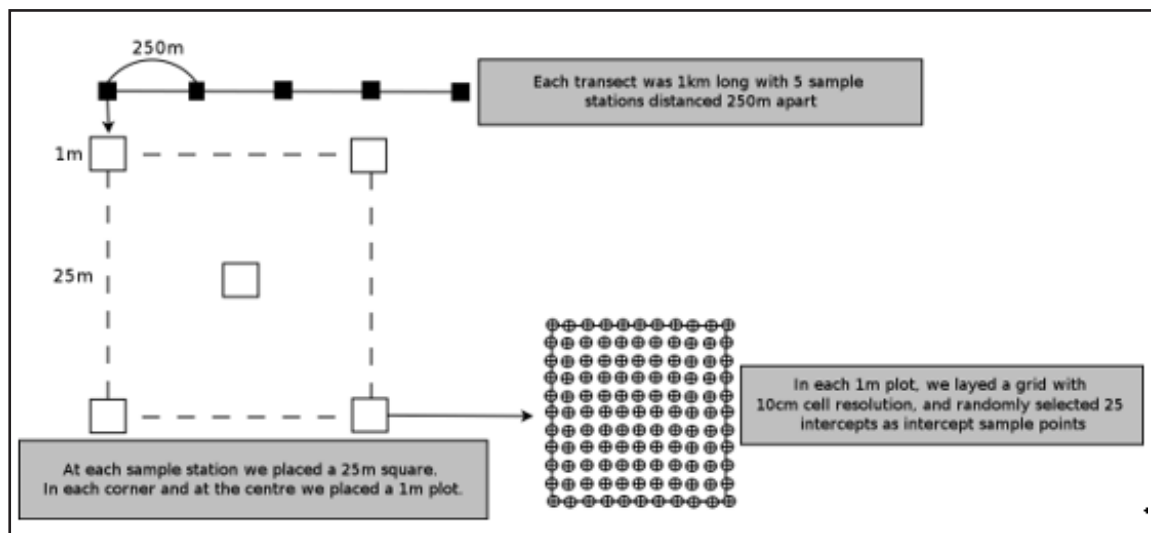


Figure TB-2. Schematic illustration of the 1 km transects, including the 5 sample stations and the 1 m² sample plots.

were collected approximately 5 cm from the surface. We also collected soil samples down to approximately 40cm depth, both at control locations and at identified dens and resting sites of predators, to enable an evaluation of the effects of predator assembled prey remains on soil chemistry. Details about these soil samples are given in [appendix 2](#).

Survey and sampling of arthropods

We surveyed and sampled arthropods along some of the transects that we collected data on plant communities. We used a combination of pitfall (Figure TB-3a) and Malaise (Figure TB-3b) traps to enable collection of both ground-living and flying arthropods. Along each transect where we trapped arthropods, we placed one pitfall trap at the centre of each 1 m² plot resulting in 5 traps per station and 25 traps per transect. Each pitfall trap consisted of a small plastic jar with a diameter of 65 mm filled with approximately 40 ml of 40% propylene glycol (Figure TB-3a), a normal setting for pitfall trapping. The traps were kept open for 4 days, after which the trapped arthropods were transferred for long-term storage in 95% ethanol until identification of their respective taxa.

We sampled flying arthropods using Malaise traps (Figure TB-3b) at the beginning of the transects where pitfall traps were set. Due to a limitation in the number of available traps, we only placed one Malaise traps at the starting point of each of the allocated transects. At each Malaise trap, we also placed 6 pitfalls in two lines on each side of the malaise trap to maximise the capture rate. The arthropods trapped in the Malaise traps were collected in a plastic bottle containing 80% ethanol. At the end of each trapping period, the content of this collection bottle was transferred into a fluid sealed plastic bag or sample tube for long-term storage until identification.

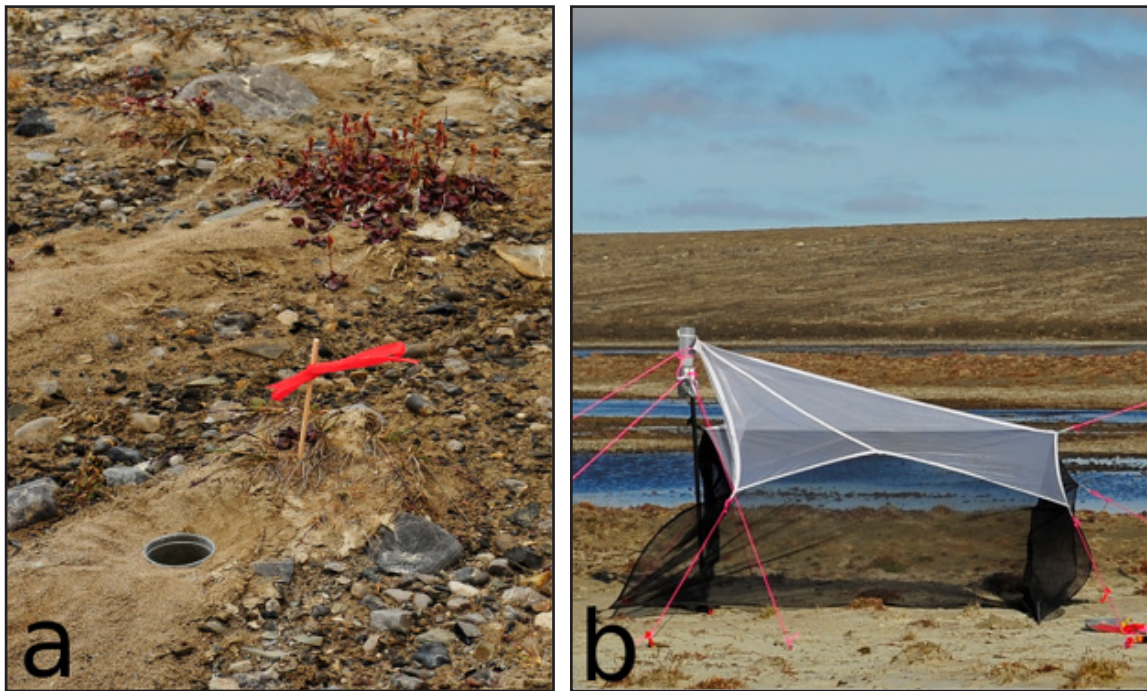


Figure TB-3. Pitfall (a) and Malaise (b) traps used to survey invertebrate communities.

Survey and sampling of birds and mammals

To assess the abundance of birds and mammals, we used 10-minute point observations at each sampling station. For each observation, we recorded the observation distance to allow the data to be converted to densities according to standard distance techniques.

At each 1 m² sample plot as well as within the 25×25 meter square at each sample station, we counted all groups of herbivore pellets, all individual predator faeces as well as all lemming winter nests.

Between each sample station, we also conducted a line transect sampling where we recorded all observations of birds and mammals, as well as all observed groups of herbivore pellets, lemming winter nests carnivore faeces.

Data on resource use, genetic structure and animal abundance

In addition to data collected along the pre-defined transects, we actively searched for pellets from herbivores, faeces from carnivores, feather, fur and bone samples, as well as dens, nest, and resting sites from avian and mammalian predators. Pellets and faeces were collected for later determination of resource use (Table TB-1). Feather and fur samples were collected for later determination of resource use using stable isotope analyses. Bone samples were collected both for later determination of resource use as well as a source of genetic material for determination of present and past (in old bones) genetic structure. Locations for each collected sample are given in Table TB-3.

While walking to and from transects as well as while actively searching for pellets, faeces and other samples, we also logged our movements on hand-held GPS units, and recorded all observations of birds and mammals, all lemming winter nests and all tracks of predators. For each observation, we either recorded the momentary direction of movement, the direction of the observation, and the distance to the observed animal, nest or track, or we directly recorded the estimated perpendicular distance to the momentary direction of movement at the time of observation. All these data will allow us to derive the density of vertebrates in respective study area.

Research activities and preliminary results

Hall land

We deployed our camp on Hall Land from August 3–August 13. Our base camp was located in the low lying valley of the south central part of Hall Land (81.5945 N/60.7027 W).

During our 10 days on Hall Land, we either observed or found evidence for the presence of 7 mammal species and 12 bird species. Of these, we directly observed muskoxen and arctic hare as well as 9 bird species (Table TB-1).

We recorded observations of lemming nests, carnivore tracks and observations of birds and mammals along a total of 135 km of tracks, during which we observed 44 lemming nests (3.3 nests/10 km), we observed 19 birds (1.4 birds/10 km), and 9 muskoxen (*Ovibos moschatus*) (0.7 animals/10 km, one was a single male and the other a group of 8 individuals) (Table TB-2). However, we found very little evidence for active lemming activity.

We collected data on plant communities and the relative abundance of herbivores and carnivores along a total of 10 transects distributed across our study area (Figure TB-1). Overall, vegetation cover was low, and we observed a distinct shift in plant communities at

approximately 100 meters of altitude with an increase in *Salix* dominated plant communities above this level. We sampled arthropod communities along 4 of the 10 transects (Figure TB-1). Close to the base camp, we also put out 5 pitfall traps and one set of Malaise traps and associated pitfall traps which were left for the whole field period but emptied every 48 hours as a continuous monitoring scheme.

We collected a total of 401 pellet and faecal samples, 18 feather, 29 fur and 145 bone and tooth samples (Table TB-4), of which 95 were regarded to be historical and potentially contain genetic data on past populations. Most of these historical bones were from colored lemming.

We collected soil samples at each of the sample stations along the pre-defined transects, and also at an additional 12 locations.

Washington Land

We deployed our camp on Washington Land from August 15 to August 18. We used a site on the eastern part of Washington Land as our base camp (80.2585 N/60.7958 W).

We either observed or found evidence for the presence of the same 7 mammal species as on Hall land, and 12 bird species. However, only 8 of the bird species were observed also on both Hall land and on Judge Daly Promontory. Two species were observed also on Hall land but not on Judge Daly Promontory (common raven *Corvus corax* and red know *Calidris canutus*) and two species were observed or confirmed also on Judge Daly Promontory but not on Hall land (king eider *Somateria spectabilis* and red throated loon *Gavi stellata*). No bird species were exclusively observed on Washington Land. Mammals observed included muskoxen (during helicopter flight), Arctic hare, and Arctic fox (Table 1). Notably, we observed large aggregations of Arctic hares. These groups were relatively common, and consisted of 2 to 130 loosely associated individuals. We also found shore-bird remains consistent with falcon predation. However, we observed very few evidence for any resident caribou populations.

We recorded observations of lemming nests, carnivore tracks and observations of birds and mammals along a total of 78 km of tracks, during which we observed 11 lemming nests (1.4 nests/10 km), 408 hares (52 animals/10 km, these hares were often aggregated in groups, average group size 31 ± 45 individuals), and 97 birds (12 birds/10 km) (Table TB-2).

We collected a full set of data on plant communities and the relative abundance of herbivores and carnivores along 5 transects distributed across our study area (Figure TB-1). We sampled arthropod communities along two of these 5 transects. Data on plant species richness and vegetation cover as well as the relative abundance of herbivores and carnivores was collected along an additional three transects, and data on the relative abundance of herbivores and carnivores was obtained for the remaining two transects.

We collected a total of 300 pellet and faecal samples, 19 feather, 19 fur and 79 bone and tooth samples (Table TB-4), of which 31 were regarded to be historical.

We collected soil samples at each of the sample stations along the pre-defined transects, and also at an additional location that was a snowy owl resting place.

Judge Daly Promontory

We deployed our camp on Judge Daly Promontory from August 19 to August 26. Our base camp was located in the north-central part of the peninsula (81.3833 N/65.2430 W).

We either observed or found evidence for the presence of the same 7 mammal species as on Hall and Washington land, and we also observed 2 tracks and one faeces from polar bear (*Ursus maritimus*). We observed or found evidence for the presence of 14 bird species, of which 8 had also been observed on both Hall and Washington land, 2 species had been observed also on Hall (semipalmated plover *Charadrius semipalmatus* and Baird's sandpiper *Calidris bairdii*) and 2 species (king eider *Somateria spectabilis* and red throated loon *Gavi Stellata*) had been observed or confirmed also on Washington land. Two species were only found on Judge Daly Promontory. We observed a Lapland longspur (*Calcarius laponicus*), an American pipit (*Anthus rubescens*) and we found a feather from gyrfalcon *Falco rusticolus*. We also directly observed a snowy owl (*Bubo scandiacus*). The only mammal species we directly observed was Arctic hare. These occurred in substantially lower densities than on Washington Land, and only in small aggregations of up to 6 individuals. A fresh, dead collared lemming was also recorded.

We recorded observations of lemming nests, carnivore tracks and observations of birds and mammals along a total of 135 km of tracks, during which we observed 73 lemming nests (5.4 nests/10 km), 132 observations birds (9.7 birds/10 km), and 10 hares (0.7 hares/10 km) (Table TB-2). In contrast to both sites in Greenland, we found frequent indications of recent lemming activity, including a fresh lemming carcass that appeared to only have been one or a few days old.

Also of note is that we observed a restricted area, approximately 0.5 km², with a large abundance of fossil trees. These were either embedded or loose on the surface along ridges of dark fine grained sediments (Figure TB-4). The most abundant site for these trees were along a side drainage to the main valley in the core of our study area (81.4163 N, 65.2613 W).

We collected a full set of data on plant communities and the relative abundance of herbivores and carnivores along seven transects distributed across the study area (Figure TB-1). We sampled arthropod communities along 3 of the 7 transects (Table TB-3). Our general impression was that of a more productive landscape, possibly due to more available surface water.



Figure TB-4. Fossil trees discovered in the central parts of Judge Daly Promontory, Ellesmere Island (81.4163 N, 65.2613 W).

We collected a total of 303 pellet and faecal samples, 23 feather, 10 fur and 203 bone and tooth samples (Table TB-4), of which 120 were regarded to be historical. Most of these historical samples came from large and medium sized mammals.

Detailed locations

Detailed locations in UTM zones are given for sample stations (Table TB-5), Species and tissue types (Table TB-6), and soil samples (Table TB-7).

Discussion and future analyses

Across all three sites, we generally observed a low level of primary productivity, exemplified by the low vegetation cover. Although we arrived after the peak of productivity, our protocol allowed us to measure a robust picture of the vegetation present in these high Arctic sites. Despite a general similarity in vegetation cover and despite being separated by at most 150 km, our three sites showed clear signs of ecological differences both in terms of plant and animal communities. These differences appeared to primarily be driven by the relative occurrences of different species, rather than by exclusion or inclusion of individual species in the local communities. Our future analyses will aim at further identifying these differences, quantify what consequences they have for different components of biodiversity, and how they influence patterns of trophic interactions. We will also evaluate the potential impact of the Hall Basin and the Petermann Glacier as population barriers for different organism groups, and how such loss in connectivity has influenced local ecosystem properties in past and present times. Finally, we will investigate potential geological drivers for the quantified differences, particularly considering the different geological origins of the three sites.

We will use collected pellets from herbivores to estimate the patterns of herbivore resource utilizations, both through DNA barcoding and through stable isotope analyses. Similarly, we will use collected faeces from carnivores and pellets from avian predators to estimate patterns of predation. We will use collected bone, feather, and hair material to trace resource use through stable isotope markers. We will quantify patterns of antagonistic trophic interactions using modern application of graph theory⁷, contrast these patterns between the three sites, and correlate them with the relative pairwise distances between sites to enable an evaluation of the effects of connectivity on trophic complexity. To enable quantifications also of mutualistic interactions, we will evaluate how and which plant species are dispersed by different mammals and birds. Data for these quantifications will come from seeds identified in collected pellets and faeces. We will quantify and contrast these interactions in the same way as the antagonistic ones. We will also use dynamic extensions of the ECOPATH models⁸ to further evaluate differences in ecosystem dynamics between the three sites.

We will use analyses of ancient DNA obtained from collected bones and teeth to estimate past diversity of and connectivity among populations of the main mammalian herbivore species, i.e. muskox, Arctic hare, and lemming, across the 3 sites. We will simultaneously use DNA analyses of contemporary plant and animal samples to estimate present connectivity. Bone and tooth samples will be radiocarbon dated to obtain a reliable chronology. DNA extractions will be done in a dedicated aDNA laboratory at the Swedish Museum

⁷ Miranda M et al. (2013) *Meth Ecol Evol* 4:897–905.

⁸ Legagneux P, et al. (2012) *Ecology* 93:1707–1716.

of Natural History. Genetic analysis of modern and subfossil samples will follow standard methods for DNA extraction⁹. We will target both autosomal genomic DNA and variable parts of the mitochondrial genome. The resulting genetic data will be analysed using standard computational analyses as well as simulations coupled with approximate Bayesian computation to evaluate the timing and extent of past demographic changes as well as levels of population connectivity during different time periods.

Finally, we will use existing models of predicted climate change (<http://www.ipcc-data.org/index.html>) to evaluate the potential of intrusion by warm adapted species and subsequent changes in the local communities on each site. In addition, we will estimate the predicted change in connectivity of the three sites under different climate scenarios, and evaluate the potential influences of such connectivity alterations on ecosystem properties.

⁹ Rohland N, Hofreiter M (2007) *Biotechniques* 42:343–352.

Table TB-1. Observed species birds and mammals, and indication as to whether or not the animal species were directly observed or if we only found tracks, faeces or other remains as evidence of their presence.

Scientific name	Common name	Directly observed ¹
HALL LAND		
<u>Mammals</u>		
<i>Canis lupus</i>	wolf	No
<i>Alopex lagopus</i>	Arctic fox	No
<i>Mustela erimnea</i>	stoat	No
<i>Ovibos moschatus</i>	muskoxen	Yes
<i>Rangifer tarandus</i>	reindeer	No
<i>Lepus arcticus</i>	Arctic hare	Yes
<i>Dicrostonyx groenlandicus</i>	collared lemming	No
<u>Birds</u>		
<i>Corvus corvax</i>	common raven	Yes
<i>Bubo scanidacus</i>	snowy owl	No
<i>Stercorarius parasiticus</i>	parasitic skua	Yes
<i>Stercorarius longicaudus</i>	long-tailed skua	Yes
<i>Larus hyperboreus</i>	glaucus gull	Yes
<i>Chen caerulescens</i>	snow goose	No
<i>Lagopus mutus</i>	ptarmigan	No
<i>Charadrius semipalmatus</i>	semipalmated plover	Yes
<i>Calidris bairdii</i>	Baird's sandpiper	Yes
<i>Calidris canutus</i>	red knot	Yes
<i>Calidris alba</i>	sanderling	Yes
<i>Plectrophenax nivalis</i>	snow bunting	Yes
WASHINGTON LAND		
<u>Mammals</u>		
<i>Canis lupus</i>	wolf	No
<i>Alopex lagopus</i>	Arctic fox	Yes
<i>Mustela erimnea</i>	stoat	No
<i>Ovibos moschatus</i>	muskoxen	Yes
<i>Rangifer tarandus</i>	reindeer	No
<i>Lepus arcticus</i>	Arctic hare	Yes
<i>Dicrostonyx groenlandicus</i>	collared lemming	No
<u>Birds</u>		
<i>Corvus corvax</i>	common raven	Yes
<i>Bubo scanidacus</i>	snowy owl	No
<i>Stercorarius parasiticus</i>	parasitic skua	Yes
<i>Stercorarius longicaudus</i>	long-tailed skua	Yes
<i>Larus hyperboreus</i>	glaucus gull	Yes
<i>Chen caerulescens</i>	snow goose	No
<i>Lagopus mutus</i>	ptarmigan	No
<i>Calidris canutus</i>	red knot	Yes
<i>Calidris alba</i>	sanderling	Yes
<i>Plectrophenax nivalis</i>	snow bunting	Yes
<i>Gavi stellata</i>	red throated loon	Yes
<i>Somateria spectabilis</i>	king eider	No

¹Only relevant for mammals and birds

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Scientific name	Common name	Directly observed ¹
JUDGE DALY PROMONTORY		
<u>Mammals</u>		
<i>Ursus maritimus</i>	polar bear	No
<i>Canis lupus</i>	wolf	No
<i>Alopex lagopus</i>	Arctic fox	No
<i>Mustela erimnea</i>	stoat	No
<i>Ovibos moschatus</i>	muskoxen	No
<i>Rangifer tarandus</i>	reindeer	No
<i>Lepus arcticus</i>	Arctic hare	Yes
<i>Dicrostonyx groenlandicus</i>	collared lemming	Yes ²
<u>Birds</u>		
<i>Bubo scanidacus</i>	snowy owl	Yes
<i>Falco rusticolus</i>	gyr falcon	No
<i>Stercorarius parasiticus</i>	parasitic skua	Yes
<i>Stercorarius longicaudus</i>	long-tailed skua	Yes
<i>Larus hyperboreus</i>	glaucus gull	Yes
<i>Chen caerulescens</i>	snow goose	Yes
<i>Lagopus mutus</i>	ptarmigan	No
<i>Calidris alba</i>	sanderling	Yes
<i>Pluvialis squatarola</i>	black-bellied plover	Yes
<i>Gavi stellata</i>	red throated loon	Yes
<i>Somateria spectabilis</i>	king eider	No
<i>Anthus rubescens</i>	American pipit	Yes
<i>Plectrophenax nivalis</i>	snow bunting	Yes
<i>Calcarius lapponicus</i>	Lapland longspur	Yes

²We found the carcass of a very recently and completely intact dead individual

Table TB-2. Observations of mammals (only muskoxen and Arctic hare were observed while recording observations), birds, lemming winter nests and tracks of wolf and Arctic fox recorded while walking across the three study areas. Total distance of tracked walking observations were 135 km on Hall land, 78 km on Washington Land and 135 km on Judge Daly Promontory.

Observation	Number of animals or nests	Animals or nests / 10 km
HALL LAND		
Muskoxen	9	0.7
Arctic hare	0	0
Birds	19	1.4
Lemming winter nests	44	3.3
WASHINGTON LAND		
Muskoxen	0	0
Arctic hare	408	52
Birds	97	12
Lemming winter nests	11	1.4

Observation	Number of animals or nests	Animals or nests / 10 km
JUDGE DALY PROMANTORY		
Muskoxen	0	0
Arctic hare	10	0.7
Birds	132	9.7
Lemming winter nests	73	5.4

Table TB-3. Location of the starting point of the 1 km transects in each of the three study areas, the direction and average altitude of each transect as well as an indication as to whether or not arthropods were trapped. Details for the location of each sample station are given in Table TB-5.

Transect	Lat/Long	Direction	Altitude	Arthropods	Note
HALL LAND					
Ha-2	81.6009 N / 60.5935 W	North	89	Yes	
Ha-4	81.6231 N / 60.6147 W	North	103	No	
Ha-5	81.6536 N / 60.6013 W	West	121	Yes	
Ha-6	81.6241 N / 60.9082 W	South	88	Yes	
Ha-9	81.5889 N / 60.3740 W	East	125	No	
Ha-12	81.6190 N / 60.3162 W	North	140	No	
Ha-13	81.5978 N / 60.1069 W	North	173	No	
Ha-14	81.6544 N / 60.2193 W	East	101	Yes	
Ha-17	81.5937 N / 60.8268 W	South	75	No	
Ha-18	81.5697 N / 60.6952 W	West	89	No	
WASHINGTON LAND					
Wa-1	80.2696 N / 60.7535 W	East	333	Yes	
Wa-2	80.2626 N / 60.8837 W	West	359	No	
Wa-3	80.2669 N / 60.6652 W	South	312	No	
Wa-4	80.2619 N / 60.6115 W	North	297	Yes	
Wa-5	80.2499 N / 60.9543 W	North	366	No	
Wa-6	80.2902 N / 60.6073 W	East	434	No	Only restricted vegetation data recorded
Wa-7	80.2250 N / 60.8891 W	West	537	No	No vegetation data recorded
Wa-8	80.2254 N / 60.7434 W	Est	504	No	No vegetation data recorded
Wa-9	80.3057 N / 60.5596 W	South	424	No	Only restricted vegetation data recorded
Wa-10	80.2443 N / 61.0943 W	South	577	No	Only restricted vegetation data recorded
JUDGE DALY PROMONTORY					
EI-4	81.4445N / 65.1789 W	South	272	Yes	
EI-5	81.3878 N / 65.5468 W	North	296	No	
EI-10	81.4084 N / 65.3499 W	North	204	Yes	
EI-11	81.4437 N / 65.3267 W	West	280	Yes	
EI-12	81.4516 N / 65.5966 W	East	172	No	
EI-15	81.3685 N / 65.1203 W	South	148	No	
EI-20	81.4254 N / 65.0884 W	West	193	No	

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Table TB-4. Summary of collected pellets from herbivores, faeces from mammalian predators and snow bunting, pellets from avian predators as well as feather, fur and bone samples.

Bones and teeth						
Species	Pellets/Faeces	Feather	Fur	Soft tissue	Contemporary	Ancient
HALL LAND						
Mammals						
Muskoxen	51		15	2	4	
Caribou	19					1
Arctic hare	36		5	1	9	
Lemming	30		1		18	98
Wolf	18		1			
Arctic fox	108		6		2	
Stoat	15					
Unknown mammal					7	1
Birds						
Snowy owl	59	3				
Ptarmigan	27	5			1	
Snow goose	12	5				
Snow bunting	5				1	
WASHINGTON LAND						
Mammals						
Muskoxen	26		4	1	3	
Caribou	1					
Arctic hare	42		15	6	11	9
Lemming	8				23	8
Wolf	13					
Arctic fox	97		1			
Stoat	2					
Unknown mammal					8	13
Birds						
Snowy owl	20		4			
Ptarmigan	38		1			
Snow goose	18		4		1	
Snow bunting	4					
JUDGE DALY PROMONTORY						
Mammals						
Muskoxen	27		2	3	18	4
Caribou	22					1
Arctic hare	28		3	1	4	1
Lemming	33		6	1	7	8
Wolf	19					
Arctic fox	63		1			
Stoat	20					
Unknown mammal					54	106

Bones and teeth						
Species	Pellets/Faeces	Feather	Fur	Soft tissue	Contemporary	Ancient
Birds						
Snowy owl	16	1				
Ptarmigan	26	1				
Snow goose	32	19				
Snow bunting	4					

Table TB-5. Location (UTM Zone 20N and Lat/Long), altitude and an indication of whether or not arthropods were trapped for each sample station along the pre-defined transects.

Site	Transect	Arthrop.	Station	Northing	Easting	Lat	Long	Altitude
Ellesmere	EI4	No	1	9043502	463818	81.4445	-65.1790	311
Ellesmere	EI4	No	2	9043251	463756	81.4422	-65.1822	283
Ellesmere	EI4	No	3	9043008	463743	81.4401	-65.1824	262
Ellesmere	EI4	No	4	9042759	463705	81.4378	-65.1841	258
Ellesmere	EI4	No	5	9042509	463654	81.4356	-65.1866	244
Ellesmere	EI5	No	1	9037428	457436	81.3878	-65.5468	289
Ellesmere	EI5	No	2	9037681	457466	81.3901	-65.5457	298
Ellesmere	EI5	No	3	9037931	457486	81.3923	-65.5452	300
Ellesmere	EI5	No	4	9038181	457503	81.3946	-65.5448	295
Ellesmere	EI5	No	5	9038432	457313	81.3967	-65.5568	296
Ellesmere	EI10	Yes	1	9039569	460814	81.4082	-65.3501	206
Ellesmere	EI10	Yes	2	9039535	461063	81.4080	-65.3351	202
Ellesmere	EI10	Yes	3	9039449	461302	81.4073	-65.3206	199
Ellesmere	EI10	Yes	4	9039317	461520	81.4062	-65.3072	209
Ellesmere	EI10	Yes	5	9039190	461737	81.4052	-65.2939	204
Ellesmere	EI11	Yes	1	9043507	461362	81.4437	-65.3268	302
Ellesmere	EI11	Yes	2	9043459	461107	81.4432	-65.3420	294
Ellesmere	EI11	Yes	3	9043427	460876	81.4428	-65.3558	279
Ellesmere	EI11	Yes	4	9043455	460612	81.4430	-65.3718	270
Ellesmere	EI11	Yes	5	9043410	460364	81.4425	-65.3866	258
Ellesmere	EI14	Yes	1	9037035	462043	81.3860	-65.2706	175
Ellesmere	EI14	Yes	2	9037152	462249	81.3871	-65.2585	173
Ellesmere	EI14	Yes	3	9037277	462475	81.3883	-65.2453	173
Ellesmere	EI14	Yes	4	9037435	462697	81.3898	-65.2324	170
Ellesmere	EI14	Yes	5	9037568	462882	81.3911	-65.2216	168
Ellesmere	EI15	No	1	9034762	464420	81.3665	-65.1235	146
Ellesmere	EI15	No	2	9034727	464481	81.3662	-65.1198	139
Ellesmere	EI15	No	3	9034477	464481	81.3639	-65.1193	133
Ellesmere	EI15	No	4	9034219	464549	81.3616	-65.1146	147
Ellesmere	EI15	No	5	9033966	464458	81.3593	-65.1195	174
Ellesmere	EI20	No	1	9041322	465256	81.4255	-65.0878	224
Ellesmere	EI20	No	2	9041279	465007	81.4250	-65.1026	233
Ellesmere	EI20	No	3	9041291	464739	81.4250	-65.1187	179
Ellesmere	EI20	No	4	9041261	464521	81.4247	-65.1318	166
Ellesmere	EI20	No	5	9041261	464259	81.4246	-65.1475	162
Hall	H2	Yes	1	9061090	539232	81.6009	-60.5935	90

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Site	Transect	Arthrop.	Station	Northing	Easting	Lat	Long	Altitude
Hall	H2	Yes	2	9061328	539296	81.6030	-60.5890	92
Hall	H2	Yes	3	9061579	539277	81.6052	-60.5895	90
Hall	H2	Yes	4	9061829	539240	81.6075	-60.5911	91
Hall	H2	Yes	5	9062081	539214	81.6097	-60.5921	80
Hall	H4	No	1	9063561	538785	81.6231	-60.6147	97
Hall	H4	No	2	9063796	538918	81.6252	-60.6059	99
Hall	H4	No	3	9064042	538962	81.6274	-60.6026	103
Hall	H4	No	4	9064288	539016	81.6296	-60.5986	106
Hall	H4	No	5	9064534	539069	81.6317	-60.5947	109
Hall	H5	Yes	1	9066970	538862	81.6536	-60.6013	123
Hall	H5	Yes	2	9069668	539105	81.6777	-60.5793	116
Hall	H5	Yes	3	9066938	539353	81.6532	-60.5711	123
Hall	H5	Yes	4	9066922	539605	81.6529	-60.5556	123
Hall	H5	Yes	5	9066907	539851	81.6527	-60.5405	120
Hall	H6	Yes	1	9063481	534010	81.6241	-60.9082	93
Hall	H6	Yes	2	9063219	534117	81.6217	-60.9022	96
Hall	H6	Yes	3	9062966	534118	81.6194	-60.9027	85
Hall	H6	Yes	4	9062717	534132	81.6172	-60.9024	85
Hall	H6	Yes	5	9062467	534141	81.6150	-60.9024	82
Hall	H9	No	1	9059910	542869	81.5889	-60.3740	132
Hall	H9	No	2	9059765	542619	81.5877	-60.3897	124
Hall	H9	No	3	9059621	542531	81.5864	-60.3955	129
Hall	H9	No	4	9059560	542275	81.5860	-60.4113	130
Hall	H9	No	5	9059465	542045	81.5852	-60.4256	127
Hall	H12	No	1	9063312	543656	81.6190	-60.3162	133
Hall	H12	No	2	9063422	543955	81.6199	-60.2975	135
Hall	H12	No	3	9063520	544190	81.6206	-60.2828	140
Hall	H12	No	4	9063664	544395	81.6218	-60.2698	144
Hall	H12	No	5	9063749	544635	81.6225	-60.2548	147
Hall	H13	No	1	9059908	535478	81.5916	-60.8263	192
Hall	H13	No	2	9061118	547256	81.5978	-60.1020	238
Hall	H13	No	3	9061362	547311	81.6000	-60.0979	161
Hall	H13	No	4	9061600	547322	81.6021	-60.0965	138
Hall	H13	No	5	9061852	547323	81.6043	-60.0956	137
Hall	H14	Yes	1	9067334	545114	81.6544	-60.2148	95
Hall	H14	Yes	2	9067386	545370	81.6547	-60.1989	94
Hall	H14	Yes	3	9067449	545617	81.6552	-60.1835	107
Hall	H14	Yes	4	9067474	545869	81.6553	-60.1679	101
Hall	H14	Yes	5	9067457	546122	81.6550	-60.1523	107
Hall	H17	No	1	9059908	535478	81.5916	-60.8263	75
Hall	H17	No	2	9059682	535373	81.5896	-60.8332	72
Hall	H17	No	3	9059449	535273	81.5876	-60.8399	71
Hall	H17	No	4	9059225	535167	81.5856	-60.8469	83
Hall	H17	No	5	9058984	535090	81.5835	-60.8521	74
Hall	H18	No	1	9059908	535478	81.5916	-60.8263	99
Hall	H18	No	2	9057142	537548	81.5661	-60.7063	84

Site	Transect	Arthrop.	Station	Northing	Easting	Lat	Long	Altitude
Hall	H18	No	3	9057006	537336	81.5650	-60.7196	84
Hall	H18	No	4	9056901	537106	81.5641	-60.7338	90
Hall	H18	No	5	9056875	536857	81.5640	-60.7491	86
Washington	Wa1	Yes	1	8912493	542378	80.2696	-60.7535	342
Washington	Wa1	Yes	2	8912514	542625	80.2697	-60.7404	328
Washington	Wa1	Yes	3	8912526	542880	80.2697	-60.7268	332
Washington	Wa1	Yes	4	8912539	543135	80.2697	-60.7133	338
Washington	Wa1	Yes	5	8912558	543391	80.2698	-60.6997	327
Washington	Wa2	No	1	8911625	539950	80.2626	-60.8837	352
Washington	Wa2	No	2	8911637	539691	80.2628	-60.8974	358
Washington	Wa2	No	3	8911647	539439	80.2630	-60.9107	359
Washington	Wa2	No	4	8911607	539187	80.2627	-60.9242	361
Washington	Wa2	No	5	8911565	538935	80.2624	-60.9376	364
Washington	Wa3	No	1	8912267	544054	80.2669	-60.6652	297
Washington	Wa3	No	2	8912014	544025	80.2647	-60.6673	286
Washington	Wa3	No	3	8911764	544010	80.2625	-60.6686	308
Washington	Wa3	No	4	8911513	543999	80.2602	-60.6697	320
Washington	Wa3	No	5	8911260	543982	80.2580	-60.6712	351
Washington	Wa4	Yes	1	8911744	545089	80.2619	-60.6115	298
Washington	Wa4	Yes	2	8911993	545072	80.2641	-60.6119	297
Washington	Wa4	Yes	3	8912273	545058	80.2666	-60.6120	297
Washington	Wa4	Yes	4	8912503	545026	80.2687	-60.6132	295
Washington	Wa4	Yes	5	8912749	544991	80.2709	-60.6146	300
Washington	Wa5	No	1	8910161	538668	80.2499	-60.9543	368
Washington	Wa5	No	2	8909917	538614	80.2477	-60.9576	369
Washington	Wa5	No	3	8909662	538555	80.2455	-60.9612	359
Washington	Wa5	No	4	8909383	538487	80.2430	-60.9653	362
Washington	Wa5	No	5	8909101	538357	80.2405	-60.9727	373
Washington	Wa6	No	1	8914907	545040	80.2902	-60.6073	439
Washington	Wa6	No	2	8914873	544790	80.2900	-60.6206	438
Washington	Wa6	No	3	8914868	544533	80.2901	-60.6342	418
Washington	Wa6	No	4	8914821	544284	80.2897	-60.6475	442
Washington	Wa6	No	5	8914770	544039	80.2894	-60.6607	434
Washington	Wa7	No	1	8907422	540002	80.2250	-60.8891	529
Washington	Wa7	No	2	8907202	539814	80.2231	-60.8994	533
Washington	Wa7	No	3	8907181	539532	80.2230	-60.9143	537
Washington	Wa7	No	4	8907191	539287	80.2231	-60.9272	541
Washington	Wa7	No	5	8907166	539038	80.2230	-60.9404	544
Washington	Wa8	No	1	8907575	542760	80.2254	-60.7434	529
Washington	Wa8	No	2	8907422	543674	80.2237	-60.6955	517
Washington	Wa8	No	3	8907422	543674	80.2237	-60.6955	492
Washington	Wa8	No	4	8907422	543519	80.2238	-60.7037	492
Washington	Wa8	No	5	8907422	543674	80.2237	-60.6955	488
Washington	Wa9	No	1	8916673	545864	80.3057	-60.5596	443
Washington	Wa9	No	2	8916423	545864	80.3035	-60.5601	439
Washington	Wa9	No	3	8916168	545863	80.3012	-60.5608	416

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Site	Transect	Arthrop.	Station	Northing	Easting	Lat	Long	Altitude
Washington	Wa9	No	4	8915918	545885	80.2990	-60.5601	415
Washington	Wa9	No	5	8915672	545843	80.2968	-60.5629	406
Washington	Wa10	No	1	8909440	536043	80.2443	-61.0943	572
Washington	Wa10	No	2	8909213	536050	80.2422	-61.0944	574
Washington	Wa10	No	3	8908965	536068	80.2400	-61.0938	577
Washington	Wa10	No	4	8908716	536074	80.2378	-61.0940	580
Washington	Wa10	No	5	8908467	536114	80.2355	-61.0923	582

Table TB-6. Date, location (UTM Zone 20N and Lat/Long), species and type of tissues for collected animal samples.

Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EIFD001	2015-08-22	Arctic fox	Scat	9037334	458305	81.3873	-65.4947
Ellesmere	EIFD002	2015-08-22	Caribou	Scat	9037678	457463	81.3900	-65.5459
Ellesmere	EIFD003	2015-08-22	Muskoxen	Scat	9037681	457466	81.3901	-65.5457
Ellesmere	EIFD004	2015-08-22	Arctic fox	Scat	9037681	457466	81.3901	-65.5457
Ellesmere	EIFD005	2015-08-22	Muskoxen	Scat	9037935	457487	81.3924	-65.5451
Ellesmere	EIFD006	2015-08-22	Muskoxen	Scat	9038181	457498	81.3946	-65.5451
Ellesmere	EIFD007	2015-08-22	Muskoxen	Fur	9038181	457498	81.3946	-65.5451
Ellesmere	EIFD008	2015-08-22	Muskoxen	Bone	9037994	459064	81.3935	-65.4510
Ellesmere	EIFD009	2015-08-22	Lemming	Scat	9037994	459064	81.3935	-65.4510
Ellesmere	EIFD010	2015-08-22	Wolf	Scat	9037979	459164	81.3934	-65.4450
Ellesmere	EIFD011	2015-08-22	Muskoxen	Scat	9037913	459220	81.3928	-65.4414
Ellesmere	EIFD012	2015-08-22	Muskoxen	Scat	9037406	459623	81.3884	-65.4161
Ellesmere	EIFD013	2015-08-22	Muskoxen	Scat	9037406	460234	81.3887	-65.3796
Ellesmere	EIFD014	2015-08-22	Caribou	Scat	9037402	460264	81.3886	-65.3778
Ellesmere	EIFD015	2015-08-23	Muskoxen	Scat	9041015	464660	81.4225	-65.1229
Ellesmere	EIFD016	2015-08-23	Hare	Scat	9041322	465256	81.4255	-65.0878
Ellesmere	EIFD017	2015-08-23	Arctic fox	Jaw	9041254	464868	81.4247	-65.1109
Ellesmere	EIFD018	2015-08-23	Hare	Scat	9041291	464739	81.4250	-65.1187
Ellesmere	EIFD019	2015-08-23	Lemming	Scat	9041291	464739	81.4250	-65.1187
Ellesmere	EIFD021	2015-08-23	Arctic fox	Scat	9041278	464693	81.4249	-65.1215
Ellesmere	EIFD022	2015-08-23	Muskoxen	Jaw	9040905	464511	81.4215	-65.1316
Ellesmere	EIFD023	2015-08-23	Muskoxen	Fur	9040905	464511	81.4215	-65.1316
Ellesmere	EIFD024	2015-08-23	Arctic fox	Scat	9040905	464511	81.4215	-65.1316
Ellesmere	EIFD025	2015-08-23	Hare	Scat	9040905	464511	81.4215	-65.1316
Ellesmere	EIFD026	2015-08-23	Lemming	Scat	9037008	462708	81.3860	-65.2308
Ellesmere	EIFD027	2015-08-22	Goose	Feather	9036733	462227	81.3834	-65.2589
Ellesmere	EIFD028	2015-08-24	Goose	Scat	9037180	462408	81.3874	-65.2491
Ellesmere	EIFD029	2015-08-24	Muskoxen	Scat	9039224	462182	81.4056	-65.2674
Ellesmere	EIFD030	2015-08-24	Caribou	Scat	9039630	462267	81.4093	-65.2632
Ellesmere	EIFD031	2015-08-24	Goose	Scat	9039873	462217	81.4115	-65.2668
Ellesmere	EIFD032	2015-08-24	Goose	Scat	9039927	462148	81.4119	-65.2711
Ellesmere	EIFD033	2015-08-24	Goose	Scat	9039927	462148	81.4119	-65.2711
Ellesmere	EIFD034	2015-08-24	Hare	Scat	9040177	461997	81.4141	-65.2807
Ellesmere	EIFD035	2015-08-24	Muskoxen	Scat	9040194	461991	81.4143	-65.2811

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EIFD036	2015-08-24	Hare	Scat	9040229	461984	81.4146	-65.2816
Ellesmere	EIFD037	2015-08-24	Hare	Scat	9040290	461950	81.4151	-65.2838
Ellesmere	EIFD038	2015-08-24	Goose	Scat	9040312	461945	81.4153	-65.2841
Ellesmere	EIFD040	2015-08-24	Hare	Scat	9040220	461745	81.4144	-65.2959
Ellesmere	EIFD041	2015-08-24	Hare	Scat	9040707	461618	81.4187	-65.3047
Ellesmere	EIFD042	2015-08-24	Ptarmigan	Scat	9040707	461618	81.4187	-65.3047
Ellesmere	EIFD043	2015-08-24	Caribou	Scat	9041057	461458	81.4218	-65.3151
Ellesmere	EIFD044	2015-08-24	Hare	Scat	9041057	461458	81.4218	-65.3151
Ellesmere	EIFD045	2015-08-24	Caribou	Scat	9041110	461445	81.4223	-65.3160
Ellesmere	EIFD046	2015-08-24	Ptarmigan	Scat	9041110	461445	81.4223	-65.3160
Ellesmere	EIFD047	2015-08-24	Caribou	Scat	9042692	461351	81.4364	-65.3255
Ellesmere	EIFD048	2015-08-24	Ptarmigan	Scat	9042795	461398	81.4373	-65.3229
Ellesmere	EIFD049	2015-08-24	snow bunting	Scat	9042795	461398	81.4373	-65.3229
Ellesmere	EIFD050	2015-08-24	Caribou	Scat	9043067	461418	81.4398	-65.3224
Ellesmere	EIFD051	2015-08-24	Hare	Scat	9043067	461418	81.4398	-65.3224
Ellesmere	EIFD052	2015-08-24	Hare	Jaw	9043249	461437	81.4414	-65.3217
Ellesmere	EIFD053	2015-08-24	Hare	Scat	9043492	461354	81.4436	-65.3272
Ellesmere	EIFD054	2015-08-24	Snowy owl	Pellet	9043492	461354	81.4436	-65.3272
Ellesmere	EIFD055	2015-08-24	Arctic fox	Scat	9043492	461354	81.4436	-65.3272
Ellesmere	EIFD056	2015-08-24	Ptarmigan	Scat	9043426	460866	81.4428	-65.3564
Ellesmere	EIFD057	2015-08-24	Caribou	Scat	9043426	460866	81.4428	-65.3564
Ellesmere	EIFD058	2015-08-24	Hare	Scat	9043426	460866	81.4428	-65.3564
Ellesmere	EIFD059	2015-08-24	Arctic fox	Scat	9043423	460377	81.4426	-65.3858
Ellesmere	EIFD060	2015-08-24	snow bunting	Scat	9043374	460052	81.4420	-65.4053
Ellesmere	EIFD061	2015-08-24	snow bunting	Scat	9043132	460031	81.4398	-65.4059
Ellesmere	EIFD062	2015-08-24	Wolf	Scat	9043132	460031	81.4398	-65.4059
Ellesmere	EIFD063	2015-08-24	Snowy owl	Pellet	9043132	460031	81.4398	-65.4059
Ellesmere	EIFD064	2015-08-20	Gyr falcon	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EIFD065	2015-08-20	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EIFD066	2015-08-24	Snowy owl	Pellet	9040156	461726	81.4138	-65.2969
Ellesmere	EINL001	2015-08-20	Lemming	Scat	9036802	461971	81.3839	-65.2743
Ellesmere	EINL002	2015-08-20	Lemming	Scat	9036802	461971	81.3839	-65.2743
Ellesmere	EINL003	2015-08-20	Lemming	Scat	9036802	461971	81.3839	-65.2743
Ellesmere	EINL004	2015-08-20	Lemming	Scat	9036802	461971	81.3839	-65.2743
Ellesmere	EINL005	2015-08-20	Lemming	Scat	9036802	461971	81.3839	-65.2743
Ellesmere	EINL006	2015-08-20	Arctic fox	Scat	9036802	461971	81.3839	-65.2743
Ellesmere	EINL007	2015-08-20	Arctic fox	Scat	9036802	461971	81.3839	-65.2743
Ellesmere	EINL008	2015-08-22	Hare	Scat	9035833	463073	81.3756	-65.2063
Ellesmere	EINL009	2015-08-22	Jaeger	Pellet	9035833	463073	81.3756	-65.2063
Ellesmere	EINL010	2015-08-22	Ptarmigan	Scat	9035833	463073	81.3756	-65.2063
Ellesmere	EINL011	2015-08-22	Arctic fox	Scat	9035833	463073	81.3756	-65.2063
Ellesmere	EINL012	2015-08-22	Snowy owl	Pellet	9035833	463073	81.3756	-65.2063
Ellesmere	EINL013	2015-08-22	Caribou	Scat	9035833	463073	81.3756	-65.2063
Ellesmere	EINL014	2015-08-22	Muskoxen	Bone	9035934	463363	81.3766	-65.1892
Ellesmere	EINL015	2015-08-22	Hare	Bone	9035934	463363	81.3766	-65.1892
Ellesmere	EINL016	2015-08-22	Arctic fox	Scat	9035863	463741	81.3761	-65.1665

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EINL016-B	2015-08-22	Arctic fox	Scat	9035699	464455	81.3749	-65.1235
Ellesmere	EINL017	2015-08-22	Hare	Scat	9035863	463741	81.3761	-65.1665
Ellesmere	EINL017-B	2015-08-22	Snowy owl	Pellet	9035699	464455	81.3749	-65.1235
Ellesmere	EINL018	2015-08-22	Jaeger	Pellet	9035863	463741	81.3761	-65.1665
Ellesmere	EINL018-B	2015-08-22	Ptarmigan	Scat	9035699	464455	81.3749	-65.1235
Ellesmere	EINL019	2015-08-22	Lemming	Bone	9035863	463741	81.3761	-65.1665
Ellesmere	EINL019-B	2015-08-22	Jaeger	Pellet	9035699	464455	81.3749	-65.1235
Ellesmere	EINL020	2015-08-22	Ptarmigan	Scat	9035863	463741	81.3761	-65.1665
Ellesmere	EINL020-B	2015-08-22	Hare	Bone	9035699	464455	81.3749	-65.1235
Ellesmere	EINL021	2015-08-22	Unk mammal	Bone	9035863	463741	81.3761	-65.1665
Ellesmere	EINL021-B	2015-08-22	Muskoxen	Carcass	9035653	464861	81.3746	-65.0991
Ellesmere	EINL022	2015-08-22	Muskoxen	Bone	9035928	464012	81.3768	-65.1504
Ellesmere	EINL022-B	2015-08-22	Arctic fox	Scat	9035653	464861	81.3746	-65.0991
Ellesmere	EINL023	2015-08-22	Jaeger	Pellet	9035681	463955	81.3745	-65.1533
Ellesmere	EINL023-B	2015-08-22	Hare	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL024	2015-08-22	Hare	Scat	9035681	463955	81.3745	-65.1533
Ellesmere	EINL024-B	2015-08-22	Ptarmigan	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL025	2015-08-22	Arctic fox	Scat	9035681	463955	81.3745	-65.1533
Ellesmere	EINL025-B	2015-08-22	Hare	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL026	2015-08-22	Jaeger	Pellet	9035681	463955	81.3745	-65.1533
Ellesmere	EINL026-B	2015-08-22	Arctic fox	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL027	2015-08-22	Lemming	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL027-B	2015-08-22	Jaeger	Pellet	9036097	465356	81.3787	-65.0706
Ellesmere	EINL028	2015-08-22	Hare	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL028-B	2015-08-22	Ptarmigan	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL029	2015-08-22	Lemming	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL030	2015-08-22	Ptarmigan	Feather	9036097	465356	81.3787	-65.0706
Ellesmere	EINL031	2015-08-22	Lemming	Scat	9036097	465356	81.3787	-65.0706
Ellesmere	EINL032	2015-08-22	Caribou	Scat	9035859	465202	81.3765	-65.0792
Ellesmere	EINL033	2015-08-22	Ptarmigan	Scat	9035859	465202	81.3765	-65.0792
Ellesmere	EINL034	2015-08-22	Arctic fox	Scat	9035859	465202	81.3765	-65.0792
Ellesmere	EINL035	2015-08-22	Snowy owl	Pellet	9035859	465202	81.3765	-65.0792
Ellesmere	EINL036	2015-08-22	Jaeger	Pellet	9035859	465202	81.3765	-65.0792
Ellesmere	EINL037	2015-08-22	Polar Bear	Scat	9035859	465202	81.3765	-65.0792
Ellesmere	EINL038	2015-08-22	Muskoxen	Bone	9035859	465202	81.3765	-65.0792
Ellesmere	EINL039	2015-08-22	Arctic fox	Scat	9035846	464772	81.3763	-65.1049
Ellesmere	EINL040	2015-08-22	Wolf	Scat	9034986	464483	81.3685	-65.1203
Ellesmere	EINL041	2015-08-22	Hare	Bone	9034986	464483	81.3685	-65.1203
Ellesmere	EINL042	2015-08-22	Muskoxen	Scat	9034986	464483	81.3685	-65.1203
Ellesmere	EINL043	2015-08-22	Stoat	Scat	9034174	464494	81.3612	-65.1178
Ellesmere	EINL044	2015-08-22	Arctic fox	Scat	9034219	464549	81.3616	-65.1146
Ellesmere	EINL045	2015-08-22	Arctic fox	Scat	9033966	464458	81.3593	-65.1195
Ellesmere	EINL046	2015-08-22	Unk mammal	Bone	9033966	464458	81.3593	-65.1195
Ellesmere	EINL047	2015-08-22	Unk mammal	Bone	9034040	464783	81.3601	-65.1003
Ellesmere	EINL048	2015-08-22	Arctic fox	Scat	9034040	464783	81.3601	-65.1003
Ellesmere	EINL049	2015-08-22	Unk mammal	Bone	9034040	464783	81.3601	-65.1003

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EINL050	2015-08-22	Muskoxen	Bone	9034040	464783	81.3601	-65.1003
Ellesmere	EINL051	2015-08-22	Muskoxen	Carcass	9033952	465487	81.3596	-65.0582
Ellesmere	EINL052	2015-08-22	Muskoxen	Bone	9031480	467021	81.3379	-64.9618
Ellesmere	EINL053	2015-08-22	Unk mammal	Bone	9033233	466374	81.3534	-65.0038
Ellesmere	EINL054	2015-08-22	Muskoxen	Scat	9033801	466322	81.3585	-65.0081
Ellesmere	EINL055	2015-08-22	Wolf	Scat	9033801	466322	81.3585	-65.0081
Ellesmere	EINL058	2015-08-22	Wolf	Scat	9033801	466322	81.3585	-65.0081
Ellesmere	EINL059	2015-08-22	Wolf	Scat	9033801	466322	81.3585	-65.0081
Ellesmere	EINL060	2015-08-22	Muskoxen	Scat	9033801	466322	81.3585	-65.0081
Ellesmere	EINL061	2015-08-22	Arctic fox	Scat	9033801	466322	81.3585	-65.0081
Ellesmere	EINL062	2015-08-22	Muskoxen	Bone	9033801	466322	81.3585	-65.0081
Ellesmere	EINL063	2015-08-23	Arctic fox	Scat	9040739	464357	81.4199	-65.1404
Ellesmere	EINL064	2015-08-23	Arctic fox	Scat	9040739	464357	81.4199	-65.1404
Ellesmere	EINL065	2015-08-23	Snowy owl	Pellet	9040739	464357	81.4199	-65.1404
Ellesmere	EINL066	2015-08-23	Snowy owl	Pellet	9040739	464357	81.4199	-65.1404
Ellesmere	EINL067	2015-08-23	Hare	Scat	9040739	464357	81.4199	-65.1404
Ellesmere	EINL068	2015-08-23	Jaeger	Pellet	9040739	464357	81.4199	-65.1404
Ellesmere	EINL069	2015-08-23	Jaeger	Pellet	9040739	464357	81.4199	-65.1404
Ellesmere	EINL070	2015-08-23	Hare	Fur & Skin	9040739	464357	81.4199	-65.1404
Ellesmere	EINL071	2015-08-23	Muskoxen	Scat	9040514	464172	81.4179	-65.1510
Ellesmere	EINL072	2015-08-23	Caribou	Scat	9039629	463822	81.4098	-65.1701
Ellesmere	EINL073	2015-08-23	Stoat	Scat	9039365	463671	81.4074	-65.1785
Ellesmere	EINL074	2015-08-23	Stoat	Scat	9039365	463671	81.4074	-65.1785
Ellesmere	EINL075	2015-08-23	Lemming	Fur	9039365	463671	81.4074	-65.1785
Ellesmere	EINL076	2015-08-23	Jaeger	Pellet	9039365	463671	81.4074	-65.1785
Ellesmere	EINL077	2015-08-23	Jaeger	Pellet	9039365	463671	81.4074	-65.1785
Ellesmere	EINL078	2015-08-23	Lemming	Scat	9039365	463671	81.4074	-65.1785
Ellesmere	EINL079	2015-08-23	Goose	Scat	9039365	463671	81.4074	-65.1785
Ellesmere	EINL080	2015-08-23	Arctic fox	Scat	9039365	463671	81.4074	-65.1785
Ellesmere	EINL081	2015-08-23	Goose	Scat	9039365	463671	81.4074	-65.1785
Ellesmere	EINL082	2015-08-23	Goose	Feather	9038954	463306	81.4036	-65.1994
Ellesmere	EINL083	2015-08-23	Goose	Scat	9038954	463306	81.4036	-65.1994
Ellesmere	EINL084	2015-08-23	Arctic fox	Scat	9038954	463306	81.4036	-65.1994
Ellesmere	EINL085	2015-08-23	Stoat	Scat	9038954	463306	81.4036	-65.1994
Ellesmere	EINL086	2015-08-23	Stoat	Scat	9038954	463306	81.4036	-65.1994
Ellesmere	EINL087	2015-08-23	Arctic fox	Scat	9038954	463306	81.4036	-65.1994
Ellesmere	EINL088	2015-08-23	Hare	Scat	9038954	463306	81.4036	-65.1994
Ellesmere	EINL089	2015-08-23	Muskoxen	Scat	9038954	463306	81.4036	-65.1994
Ellesmere	EINL090	2015-08-23	Wolf	Scat	9038683	463224	81.4012	-65.2037
Ellesmere	EINL091	2015-08-23	Muskoxen	Bone	9038683	463224	81.4012	-65.2037
Ellesmere	EINL092	2015-08-23	Arctic fox	Scat	9038683	463224	81.4012	-65.2037
Ellesmere	EINL093	2015-08-23	Lemming	Fur	9038683	463224	81.4012	-65.2037
Ellesmere	EINL094	2015-08-23	Lemming	Scat	9038683	463224	81.4012	-65.2037
Ellesmere	EINL095	2015-08-23	Ptarmigan	Scat	9038683	463224	81.4012	-65.2037
Ellesmere	EINL096	2015-08-23	Caribou	Scat	9038683	463224	81.4012	-65.2037
Ellesmere	EINL097	2015-08-23	Stoat	Scat	9038683	463224	81.4012	-65.2037

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EINL098	2015-08-23	Lemming	Scat	9038426	462966	81.3988	-65.2186
Ellesmere	EINL099	2015-08-23	Lemming	Fur	9038426	462966	81.3988	-65.2186
Ellesmere	EINL100	2015-08-23	Stoat	Scat	9038426	462966	81.3988	-65.2186
Ellesmere	EINL101	2015-08-23	Lemming	Scat	9038326	462866	81.3978	-65.2243
Ellesmere	EINL102	2015-08-23	Stoat	Scat	9038326	462866	81.3978	-65.2243
Ellesmere	EINL103	2015-08-23	Stoat	Scat	9038466	463266	81.3992	-65.2007
Ellesmere	EINL104	2015-08-23	Hare	Scat	9038466	463266	81.3992	-65.2007
Ellesmere	EINL105	2015-08-23	Goose	Scat	9038466	463266	81.3992	-65.2007
Ellesmere	EINL106	2015-08-23	Goose	Feather	9038466	463266	81.3992	-65.2007
Ellesmere	EINL107	2015-08-23	Caribou	Scat	9038466	463266	81.3992	-65.2007
Ellesmere	EINL109	2015-08-23	Goose	Scat	9038466	463266	81.3992	-65.2007
Ellesmere	EINL110	2015-08-23	Muskoxen	Scat	9038466	463266	81.3992	-65.2007
Ellesmere	EINL111	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL112	2015-08-23	Goose	Scat	9036721	462491	81.3833	-65.2431
Ellesmere	EINL113	2015-08-23	Goose	Scat	9036721	462491	81.3833	-65.2431
Ellesmere	EINL114	2015-08-23	Goose	Scat	9036721	462491	81.3833	-65.2431
Ellesmere	EINL115	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL116	2015-08-23	Muskoxen	Bone	9036721	462491	81.3833	-65.2431
Ellesmere	EINL117	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL118	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL119	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL120	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL121	2015-08-23	Goose	Feather	9037035	462043	81.3860	-65.2706
Ellesmere	EINL122	2015-08-23	Goose	Feather	9037035	462043	81.3860	-65.2706
Ellesmere	EINL123	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL124	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EINL125	2015-08-23	Goose	Feather	9036721	462491	81.3833	-65.2431
Ellesmere	EIPP001	2015-08-19	Lemming	Skull	9037598	462473	81.3912	-65.2462
Ellesmere	EIPP002	2015-08-19	Wolf	Scat	9040739	464515	81.4200	-65.1310
Ellesmere	EIPP003	2015-08-19	Muskoxen	Bone	9040739	464515	81.4200	-65.1310
Ellesmere	EIPP004	2015-08-19	Muskoxen	Bone	9040739	464515	81.4200	-65.1310
Ellesmere	EIPP005	2015-08-20	Arctic fox	Scat	9038339	462200	81.3977	-65.2642
Ellesmere	EIPP006	2015-08-20	Muskoxen	Scat	9038518	462193	81.3993	-65.2651
Ellesmere	EIPP007	2015-08-20	Arctic fox	Scat	9038621	462181	81.4002	-65.2660
Ellesmere	EIPP008	2015-08-20	Hare	Fur	9038782	462185	81.4017	-65.2662
Ellesmere	EIPP009	2015-08-20	Lemming	Scat	9039655	461867	81.4094	-65.2873
Ellesmere	EIPP010	2015-08-20	Goose	Scat	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP011	2015-08-20	Goose	Scat	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP012	2015-08-20	Goose	Scat	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP013	2015-08-20	Muskoxen	Scat	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP014	2015-08-20	Goose	Scat	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP015	2015-08-20	Lemming	Scat	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP016	2015-08-20	Stoat	Scat	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP017	2015-08-20	Lemming	Fur	9039987	461908	81.4124	-65.2856
Ellesmere	EIPP018	2015-08-20	Snowy owl	Pellet	9040978	461886	81.4212	-65.2893
Ellesmere	EIPP019	2015-08-20	Unk mammal	Bone	9041547	461877	81.4263	-65.2911

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EIPP020	2015-08-20	Muskoxen	Scat	9042007	461595	81.4303	-65.3092
Ellesmere	EIPP021	2015-08-20	Caribou	Scat	9042007	461595	81.4303	-65.3092
Ellesmere	EIPP022	2015-08-20	Lemming	Scat	9042195	461557	81.4320	-65.3119
Ellesmere	EIPP023	2015-08-20	Arctic fox	Scat	9042588	461485	81.4355	-65.3172
Ellesmere	EIPP024	2015-08-20	Arctic fox	Fur	9042588	461485	81.4355	-65.3172
Ellesmere	EIPP025	2015-08-20	Ptarmigan	Scat	9042588	461485	81.4355	-65.3172
Ellesmere	EIPP026	2015-08-20	Wolf	Scat	9043137	461337	81.4404	-65.3274
Ellesmere	EIPP027	2015-08-20	Snowy owl	Feather	9043506	461365	81.4437	-65.3266
Ellesmere	EIPP028	2015-08-20	Unk mammal	Bone	9043507	461362	81.4437	-65.3268
Ellesmere	EIPP029	2015-08-20	Muskoxen	Bone	9043506	461365	81.4437	-65.3266
Ellesmere	EIPP030	2015-08-20	Muskoxen	Bone	9043506	461365	81.4437	-65.3266
Ellesmere	EIPP031	2015-08-20	Lemming	Carcass	9043421	460408	81.4426	-65.3840
Ellesmere	EIPP032	2015-08-20	Muskoxen	Scat	9043416	460690	81.4426	-65.3670
Ellesmere	EIPP033	2015-08-20	Arctic fox	Scat	9043037	460900	81.4393	-65.3534
Ellesmere	EIPP034	2015-08-20	Stoat	Scat	9043037	460900	81.4393	-65.3534
Ellesmere	EIPP035	2015-08-20	Stoat	Scat	9043037	460900	81.4393	-65.3534
Ellesmere	EIPP036	2015-08-20	Lemming	Skull	9043037	460900	81.4393	-65.3534
Ellesmere	EIPP037	2015-08-20	Lemming	Scat	9042742	461082	81.4367	-65.3418
Ellesmere	EIPP038	2015-08-20	Arctic fox	Scat	9041854	461592	81.4290	-65.3090
Ellesmere	EIPP039	2015-08-20	Muskoxen	Bone	9041854	461592	81.4290	-65.3090
Ellesmere	EIPP040	2015-08-20	Ptarmigan	Scat	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP041	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP042	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP043	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP044	2015-08-20	Lemming	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP045	2015-08-20	Caribou	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP046	2015-08-20	Caribou	Antler	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP047	2015-08-20	Hare	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP048	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP049	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP050	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP051	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP052	2015-08-20	Unk mammal	Bone	9041727	461813	81.4279	-65.2954
Ellesmere	EIPP053	2015-08-20	Wolf	Scat	9046346	462317	81.4694	-65.2761
Ellesmere	EIPP054	2015-08-20	Lemming	Scat	9039682	462480	81.4098	-65.2506
Ellesmere	EIPP055	2015-08-20	Stoat	Scat	9039682	462480	81.4098	-65.2506
Ellesmere	EIPP056	2015-08-20	Lemming	Scat	9038706	462698	81.4012	-65.2353
Ellesmere	EIPP057	2015-08-21	Wolf	Scat	9038077	462772	81.3956	-65.2294
Ellesmere	EIPP058	2015-08-21	Lemming	Carcass	9038399	462927	81.3985	-65.2209
Ellesmere	EIPP059	2015-08-21	Lemming	Scat	9038399	462927	81.3985	-65.2209
Ellesmere	EIPP060	2015-08-21	Caribou	Scat	9039251	462928	81.4061	-65.2228
Ellesmere	EIPP061	2015-08-21	Wolf	Scat	9039360	462961	81.4071	-65.2210
Ellesmere	EIPP062	2015-08-21	Unk mammal	Bone	9039813	462596	81.4111	-65.2439
Ellesmere	EIPP063	2015-08-21	Wolf	Scat	9039946	462460	81.4122	-65.2524
Ellesmere	EIPP064	2015-08-21	Unk mammal	Bone	9041061	462360	81.4221	-65.2610
Ellesmere	EIPP065	2015-08-21	Unk mammal	Bone	9040348	462311	81.4158	-65.2623

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EIPP066	2015-08-21	Wolf	Scat	9040348	462311	81.4158	-65.2623
Ellesmere	EIPP067	2015-08-21	Unk mammal	Bone	9040348	462311	81.4158	-65.2623
Ellesmere	EIPP068	2015-08-21	Arctic fox	Scat	9040348	462311	81.4158	-65.2623
Ellesmere	EIPP069	2015-08-21	Unk mammal	Bone	9040426	462332	81.4165	-65.2612
Ellesmere	EIPP070	2015-08-21	Unk mammal	Bone	9040426	462332	81.4165	-65.2612
Ellesmere	EIPP071	2015-08-21	Unk mammal	Bone	9040426	462332	81.4165	-65.2612
Ellesmere	EIPP072	2015-08-21	Lemming	Bone	9040810	462303	81.4199	-65.2638
Ellesmere	EIPP073	2015-08-21	Unk mammal	Bone	9040856	462296	81.4203	-65.2644
Ellesmere	EIPP074	2015-08-21	Hare	Carcass	9040856	462296	81.4203	-65.2644
Ellesmere	EIPP075	2015-08-21	Ptarmigan	Scat	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP076	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP077	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP078	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP079	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP080	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP081	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP082	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP083	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP084	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP085	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP086	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP087	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP088	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP089	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP090	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP091	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP092	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP093	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP094	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP095	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP096	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP097	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP098	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP099	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP100	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP101	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP102	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP103	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP104	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP105	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP106	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP107	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP108	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP109	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP110	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853
Ellesmere	EIPP111	2015-08-21	Unk mammal	Bone	9041528	461973	81.4262	-65.2853

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EIPP204	2015-08-23	Lemming	Scat	9037695	463053	81.3923	-65.2117
Ellesmere	EIPP205	2015-08-23	Lemming	Scat	9037909	463203	81.3942	-65.2032
Ellesmere	EIPP206	2015-08-23	Lemming	Fur	9037909	463203	81.3942	-65.2032
Ellesmere	EIPP207	2015-08-23	Stoat	Scat	9037909	463203	81.3942	-65.2032
Ellesmere	EIPP208	2015-08-23	Lemming	Scat	9059382	469856	81.5886	-64.8461
Ellesmere	EIPP209	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP210	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP211	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP212	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP213	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP214	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP215	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP216	2015-08-23	Lemming	Bone	9040739	464357	81.4199	-65.1404
Ellesmere	EIPP217	2015-08-23	Muskoxen	Carcass	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP218	2015-08-23	Arctic fox	Scat	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP219	2015-08-23	Lemming	Scat	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP220	2015-08-23	Stoat	Scat	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP221	2015-08-23	Lemming	Carcass	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP222	2015-08-23	Arctic fox	Scat	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP223	2015-08-23	Stoat	Scat	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP224	2015-08-23	Stoat	Scat	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP225	2015-08-23	Arctic fox	Scat	9040908	464515	81.4215	-65.1313
Ellesmere	EIPP226	2015-08-23	Caribou	Scat	9040658	464341	81.4192	-65.1412
Ellesmere	EIPP227	2015-08-23	Caribou	Scat	9040575	464237	81.4184	-65.1473
Ellesmere	EIPP228	2015-08-23	Arctic fox	Scat	9040575	464237	81.4184	-65.1473
Ellesmere	EIPP230	2015-08-23	Snowy owl	Pellet	9040437	464099	81.4172	-65.1553
Ellesmere	EIPP231	2015-08-23	Arctic fox	Scat	9040437	464099	81.4172	-65.1553
Ellesmere	EIPP232	2015-08-23	Lemming	Skull	9040189	464026	81.4149	-65.1591
Ellesmere	EIPP233	2015-08-23	Goose	Feather	9039623	463803	81.4098	-65.1712
Ellesmere	EIPP234	2015-08-23	Arctic fox	Scat	9039623	463803	81.4098	-65.1712
Ellesmere	EIPP235	2015-08-23	Goose	Scat	9039623	463803	81.4098	-65.1712
Ellesmere	EIPP236	2015-08-23	Goose	Feather	9039623	463803	81.4098	-65.1712
Ellesmere	EIPP237	2015-08-23	Goose	Scat	9039623	463803	81.4098	-65.1712
Ellesmere	EIPP238	2015-08-23	Goose	Scat	9039623	463803	81.4098	-65.1712
Ellesmere	EIPP239	2015-08-23	Goose	Scat	9039623	463803	81.4098	-65.1712
Ellesmere	EIPP240	2015-08-19	Muskoxen	Bone	9037956	462921	81.3945	-65.2202
Ellesmere	EITM001	2015-08-20	Unk mammal	Bone	9039087	461916	81.4043	-65.2830
Ellesmere	EITM002	2015-08-20	Unk mammal	Bone	9039599	462283	81.4090	-65.2622
Ellesmere	EITM012	2015-08-21	Muskoxen	Scat	9035795	463201	81.3753	-65.1985
Ellesmere	EITM013	2015-08-21	Jaeger	Pellet	9035649	463622	81.3741	-65.1731
Ellesmere	EITM014	2015-08-21	Snowy owl	Pellet	9035649	463622	81.3741	-65.1731
Ellesmere	EITM015	2015-08-21	Arctic fox	Scat	9035649	463622	81.3741	-65.1731
Ellesmere	EITM016	2015-08-21	Jaeger	Pellet	9035649	463622	81.3741	-65.1731
Ellesmere	EITM017	2015-08-21	Arctic fox	Scat	9035320	464289	81.3714	-65.1326
Ellesmere	EITM018	2015-08-21	Arctic fox	Scat	9035176	464304	81.3701	-65.1313
Ellesmere	EITM019	2015-08-21	Ptarmigan	Scat	9035176	464304	81.3701	-65.1313

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EITM020	2015-08-21	Hare	Scat	9035176	464304	81.3701	-65.1313
Ellesmere	EITM021	2015-08-21	Lemming	Scat	9035128	464379	81.3697	-65.1268
Ellesmere	EITM022	2015-08-21	Ptarmigan	Scat	9035128	464379	81.3697	-65.1268
Ellesmere	EITM023	2015-08-21	Stoat	Scat	9034917	464609	81.3679	-65.1126
Ellesmere	EITM024	2015-08-21	Lemming	Scat	9034731	464357	81.3662	-65.1272
Ellesmere	EITM026	2015-08-21	Wolf	Scat	9035203	463412	81.3701	-65.1846
Ellesmere	EITM027	2015-08-21	Muskoxen	Bone	9035321	463282	81.3711	-65.1926
Ellesmere	EITM028	2015-08-21	Ptarmigan	Scat	9035321	463282	81.3711	-65.1926
Ellesmere	EITM029	2015-08-21	Lemming	Scat	9035339	463058	81.3712	-65.2060
Ellesmere	EITM030	2015-08-21	Lemming	Scat	9035339	463058	81.3712	-65.2060
Ellesmere	EITM031	2015-08-21	Hare	Skull	9035339	463058	81.3712	-65.2060
Ellesmere	EITM032	2015-08-21	Arctic fox	Scat	9035339	463058	81.3712	-65.2060
Ellesmere	EITM033	2015-08-21	Ptarmigan	Scat	9035339	463058	81.3712	-65.2060
Ellesmere	EITM034	2015-08-21	Ptarmigan	Feather	9035320	462881	81.3709	-65.2166
Ellesmere	EITM035	2015-08-21	Unk mammal	Bone	9035320	462881	81.3709	-65.2166
Ellesmere	EITM036	2015-08-21	Arctic fox	Scat	9035453	462735	81.3721	-65.2256
Ellesmere	EITM037	2015-08-21	Arctic fox	Scat	9035453	462735	81.3721	-65.2256
Ellesmere	EITM038	2015-08-21	Arctic fox	Scat	9035453	462735	81.3721	-65.2256
Ellesmere	EITM039	2015-08-21	Muskoxen	Tooth	9035453	462735	81.3721	-65.2256
Ellesmere	EITM040	2015-08-21	Muskoxen	Bone	9035453	462735	81.3721	-65.2256
Ellesmere	EITM041	2015-08-21	Ptarmigan	Scat	9035494	462744	81.3724	-65.2251
Ellesmere	EITM042	2015-08-21	Arctic fox	Scat	9035494	462744	81.3724	-65.2251
Ellesmere	EITM043	2015-08-21	Muskoxen	Bone	9035494	462744	81.3724	-65.2251
Ellesmere	EITM045	2015-08-21	Hare	Fur	9035576	462786	81.3732	-65.2228
Ellesmere	EITM046	2015-08-21	Arctic fox	Scat	9035736	462429	81.3745	-65.2445
Ellesmere	EITM047	2015-08-21	Snowy owl	Pellet	9035736	462429	81.3745	-65.2445
Ellesmere	EITM048	2015-08-21	Arctic fox	Scat	9035619	462287	81.3734	-65.2527
Ellesmere	EITM049	2015-08-21	Lemming	Scat	9035619	462287	81.3734	-65.2527
Ellesmere	EITM050	2015-08-21	Lemming	Scat	9035464	461999	81.3719	-65.2695
Ellesmere	EITM051	2015-08-21	Arctic fox	Scat	9035512	461668	81.3722	-65.2894
Ellesmere	EITM052	2015-08-21	Arctic fox	Scat	9035512	461668	81.3722	-65.2894
Ellesmere	EITM053	2015-08-21	Arctic fox	Scat	9035512	461668	81.3722	-65.2894
Ellesmere	EITM054	2015-08-21	Arctic fox	Scat	9035477	461097	81.3717	-65.3234
Ellesmere	EITM055	2015-08-21	Unk mammal	Bone	9034514	460310	81.3628	-65.3680
Ellesmere	EITM056	2015-08-21	Unk mammal	Bone	9034795	459782	81.3651	-65.4001
Ellesmere	EITM057	2015-08-21	Lemming	Bone	9034795	459782	81.3651	-65.4001
Ellesmere	EITM058	2015-08-21	Unk mammal	Bone	9035397	460460	81.3708	-65.3612
Ellesmere	EITM059	2015-08-21	Arctic fox	Scat	9036321	461112	81.3793	-65.3245
Ellesmere	EITM060	2015-08-21	Arctic fox	Scat	9036663	461694	81.3825	-65.2905
Ellesmere	EITM061	2015-08-21	Arctic fox	Scat	9036663	461694	81.3825	-65.2905
Ellesmere	EITM062	2015-08-22	Wolf	Scat	9038028	462321	81.3950	-65.2563
Ellesmere	EITM063	2015-08-22	Unk mammal	Bone	9038528	462292	81.3995	-65.2592
Ellesmere	EITM064	2015-08-22	Caribou	Scat	9038782	462281	81.4017	-65.2604
Ellesmere	EITM065	2015-08-22	Snowy owl	Pellet	9038782	462281	81.4017	-65.2604
Ellesmere	EITM067	2015-08-22	Stoat	Scat	9039169	461982	81.4051	-65.2792
Ellesmere	EITM068	2015-08-22	Ptarmigan	Scat	9040373	461889	81.4158	-65.2876

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EITM069	2015-08-22	Unk mammal	Bone	9040373	461889	81.4158	-65.2876
Ellesmere	EITM070	2015-08-22	Goose	Feather	9040664	461743	81.4184	-65.2971
Ellesmere	EITM071	2015-08-22	Muskoxen	Bone	9040945	461756	81.4209	-65.2970
Ellesmere	EITM072	2015-08-22	Muskoxen	Bone	9041370	461739	81.4247	-65.2990
Ellesmere	EITM073	2015-08-22	Arctic fox	Scat	9041798	462128	81.4287	-65.2767
Ellesmere	EITM074	2015-08-22	Muskoxen	Scat	9041798	462128	81.4287	-65.2767
Ellesmere	EITM075	2015-08-22	Ptarmigan	Scat	9041798	462128	81.4287	-65.2767
Ellesmere	EITM076	2015-08-22	Arctic fox	Scat	9041798	462128	81.4287	-65.2767
Ellesmere	EITM077	2015-08-22	Muskoxen	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM078	2015-08-22	Hare	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM079	2015-08-22	Arctic fox	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM080	2015-08-22	Snowy owl	Pellet	9041868	462308	81.4294	-65.2660
Ellesmere	EITM081	2015-08-22	Ptarmigan	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM082	2015-08-22	Ptarmigan	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM083	2015-08-22	Ptarmigan	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM084	2015-08-22	Lemming	Bone	9041868	462308	81.4294	-65.2660
Ellesmere	EITM085	2015-08-22	Muskoxen	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM086	2015-08-22	snow bunting	Scat	9041868	462308	81.4294	-65.2660
Ellesmere	EITM087	2015-08-22	Arctic fox	Scat	9041972	462469	81.4303	-65.2566
Ellesmere	EITM088	2015-08-22	Ptarmigan	Scat	9041972	462469	81.4303	-65.2566
Ellesmere	EITM089	2015-08-22	Unk mammal	Bone	9042052	462588	81.4311	-65.2496
Ellesmere	EITM090	2015-08-22	Wolf	Scat	9042068	462727	81.4313	-65.2413
Ellesmere	EITM091	2015-08-22	Lemming	Scat	9042068	462727	81.4313	-65.2413
Ellesmere	EITM092	2015-08-22	Unk mammal	Bone	9042068	462727	81.4313	-65.2413
Ellesmere	EITM093	2015-08-22	Arctic fox	Scat	9042068	462727	81.4313	-65.2413
Ellesmere	EITM094	2015-08-22	Wolf	Scat	9042049	462917	81.4312	-65.2299
Ellesmere	EITM095	2015-08-22	Arctic fox	Scat	9042049	462917	81.4312	-65.2299
Ellesmere	EITM096	2015-08-22	Lemming	Bone	9042049	462917	81.4312	-65.2299
Ellesmere	EITM097	2015-08-22	Snowy owl	Pellet	9042049	462917	81.4312	-65.2299
Ellesmere	EITM098	2015-08-22	Hare	Carcass	9042229	463553	81.4330	-65.1921
Ellesmere	EITM099	2015-08-22	Arctic fox	Scat	9042229	463553	81.4330	-65.1921
Ellesmere	EITM100	2015-08-22	Unk mammal	Bone	9042183	463855	81.4327	-65.1738
Ellesmere	EITM101	2015-08-22	Hare	Bone	9042146	464200	81.4325	-65.1530
Ellesmere	EITM102	2015-08-22	Unk mammal	Bone	9042203	464361	81.4331	-65.1435
Ellesmere	EITM103	2015-08-22	Muskoxen	Bone	9041325	464492	81.4252	-65.1336
Ellesmere	EITM104	2015-08-22	Stoat	Scat	9040794	464379	81.4204	-65.1392
Ellesmere	EITM106	2015-08-22	Snowy owl	Pellet	9040734	464357	81.4199	-65.1404
Ellesmere	EITM107	2015-08-22	Arctic fox	Scat	9040734	464357	81.4199	-65.1404
Ellesmere	EITM108	2015-08-22	Lemming	Bone	9040734	464357	81.4199	-65.1404
Ellesmere	EITM109	2015-08-22	Muskoxen	Bone	9040734	464357	81.4199	-65.1404
Ellesmere	EITM110	2015-08-23	Muskoxen	Jaw	9043105	464736	81.4413	-65.1229
Ellesmere	EITM111	2015-08-23	Muskoxen	Antler	9042760	463705	81.4378	-65.1841
Ellesmere	EITM112	2015-08-24	Muskoxen	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM113	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM114	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM115	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Ellesmere	EITM116	2015-08-24	Hare	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM117	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM118	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM119	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM120	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM121	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM122	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM123	2015-08-24	Goose	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM124	2015-08-24	Goose	Feather	9039381	461546	81.4068	-65.3058
Ellesmere	EITM125	2015-08-24	Muskoxen	Scat	9039381	461546	81.4068	-65.3058
Ellesmere	EITM126	2015-08-24	Caribou	Scat	9039474	460806	81.4074	-65.3504
Ellesmere	EITM127	2015-08-24	Caribou	Scat	9039463	460980	81.4074	-65.3399
Ellesmere	EITM128	2015-08-24	Muskoxen	Scat	9039475	461541	81.4077	-65.3064
Ellesmere	EITM129	2015-08-24	Caribou	Scat	9039475	461541	81.4077	-65.3064
Ellesmere	EITM130	2015-08-24	Hare	Scat	9039475	461541	81.4077	-65.3064
Ellesmere	EITM131	2015-08-24	Hare	Scat	9039459	461585	81.4075	-65.3037
Ellesmere	EITM132	2015-08-24	Caribou	Scat	9039185	461896	81.4052	-65.2844
Ellesmere	EITM133	2015-08-24	Hare	Scat	9039185	461896	81.4052	-65.2844
Ellesmere	EITM134	2015-08-24	Goose	Scat	9037444	462721	81.3899	-65.2310
Hall	HallFD001	2015-08-04	Muskoxen	Scat	9060617	537789	81.5972	-60.6831
Hall	HallFD002	2015-08-04	Arctic fox	Scat	9060725	538599	81.5978	-60.6332
Hall	HallFD003	2015-08-04	Muskoxen	Scat	9060844	538900	81.5988	-60.6145
Hall	HallFD004	2015-08-04	Lemming	Carcass	9061323	539263	81.6029	-60.5910
Hall	HallFD005	2015-08-04	Stoat	Scat	9061328	539296	81.6030	-60.5890
Hall	HallFD006	2015-08-04	Hare	Scat	9061580	539274	81.6052	-60.5897
Hall	HallFD007	2015-08-04	Hare	Scat	9061642	539270	81.6058	-60.5898
Hall	HallFD008	2015-08-04	Ptarmigan	Scat	9061059	538358	81.6009	-60.6471
Hall	HallFD009	2015-08-04	Arctic fox	Scat	9061059	538358	81.6009	-60.6471
Hall	HallFD010	2015-08-04	Arctic fox	Scat	9060668	537565	81.5977	-60.6967
Hall	HallFD011	2015-08-05	Arctic fox	Fur	9061260	537726	81.6029	-60.6854
Hall	HallFD012	2015-08-05	Arctic fox	Scat	9061260	537726	81.6029	-60.6854
Hall	HallFD013	2015-08-05	Arctic fox	Scat	9061260	537726	81.6029	-60.6854
Hall	HallFD014	2015-08-05	Arctic fox	Scat	9061260	537726	81.6029	-60.6854
Hall	HallFD015	2015-08-05	Stoat	Scat	9061260	537726	81.6029	-60.6854
Hall	HallFD016	2015-08-05	Muskoxen	Scat	9061832	537805	81.6080	-60.6791
Hall	HallFD017	2015-08-05	Caribou	Scat	9061832	537805	81.6080	-60.6791
Hall	HallFD018	2015-08-05	Muskoxen	Scat	9061832	537805	81.6080	-60.6791
Hall	HallFD019	2015-08-05	Hare	Scat	9061832	537805	81.6080	-60.6791
Hall	HallFD020	2015-08-05	Arctic fox	Scat	9061832	537805	81.6080	-60.6791
Hall	HallFD021	2015-08-05	Hare	Scat	9061844	537879	81.6081	-60.6746
Hall	HallFD022	2015-08-05	Shorebird	Scat	9061844	537879	81.6081	-60.6746
Hall	HallFD023	2015-08-05	Lemming	Scat	9061844	537879	81.6081	-60.6746
Hall	HallFD025	2015-08-05	Caribou	Scat	9061858	537887	81.6082	-60.6740
Hall	HallFD026	2015-08-05	Arctic fox	Scat	9061869	537890	81.6083	-60.6738
Hall	HallFD027	2015-08-05	Shorebird	Scat	9061869	537890	81.6083	-60.6738
Hall	HallFD027	2015-08-05	Arctic fox	Fur	9062321	537858	81.6124	-60.6747

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallFD028	2015-08-05	Arctic fox	Scat	9062321	537858	81.6124	-60.6747
Hall	HallFD029	2015-08-05	Arctic fox	Scat	9062321	537858	81.6124	-60.6747
Hall	HallFD030	2015-08-05	Arctic fox	Scat	9062321	537858	81.6124	-60.6747
Hall	HallFD031	2015-08-05	Arctic fox	Scat	9062321	537858	81.6124	-60.6747
Hall	HallFD032	2015-08-05	Arctic fox	Scat	9062723	537932	81.6160	-60.6691
Hall	HallFD033	2015-08-05	Arctic fox	Scat	9062723	537932	81.6160	-60.6691
Hall	HallFD034	2015-08-05	Arctic fox	Scat	9062723	537932	81.6160	-60.6691
Hall	HallFD035	2015-08-05	Lemming	Fur	9062623	537932	81.6151	-60.6694
Hall	HallFD036	2015-08-05	Hare	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD037	2015-08-05	Ptarmigan	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD038	2015-08-05	Ptarmigan	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD039	2015-08-05	Snowy owl	Pellet	9062967	538934	81.6178	-60.6070
Hall	HallFD040	2015-08-05	Snowy owl	Pellet	9062967	538934	81.6178	-60.6070
Hall	HallFD041	2015-08-05	Snowy owl	Pellet	9062967	538934	81.6178	-60.6070
Hall	HallFD042	2015-08-05	Snowy owl	Pellet	9062967	538934	81.6178	-60.6070
Hall	HallFD043	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD044	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD045	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD046	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD047	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD048	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD049	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD050	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD051	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD052	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD053	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD054	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD055	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD056	2015-08-05	Arctic fox	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD057	2015-08-05	Stoat	Scat	9062967	538934	81.6178	-60.6070
Hall	HallFD058	2015-08-05	Caribou	Scat	9065453	538440	81.6402	-60.6311
Hall	HallFD059	2015-08-05	Hare	Scat	9065453	538440	81.6402	-60.6311
Hall	HallFD060	2015-08-05	Hare	Scat	9065453	538440	81.6402	-60.6311
Hall	HallFD061	2015-08-05	Arctic fox	Scat	9065453	538440	81.6402	-60.6311
Hall	HallFD062	2015-08-05	Hare	Bone	9066937	539329	81.6532	-60.5726
Hall	HallFD063	2015-08-05	Snowy owl	Pellet	9066969	539164	81.6535	-60.5826
Hall	HallFD064	2015-08-05	Snowy owl	Pellet	9066969	539164	81.6535	-60.5826
Hall	HallFD065	2015-08-05	Arctic fox	Fur	9066969	539164	81.6535	-60.5826
Hall	HallFD066	2015-08-05	Muskoxen	Fur	9066969	539164	81.6535	-60.5826
Hall	HallFD067	2015-08-05	Lemming	Bone	9066969	539164	81.6535	-60.5826
Hall	HallFD068	2015-08-05	Lemming	Bone	9066969	539164	81.6535	-60.5826
Hall	HallFD069	2015-08-05	Lemming	Bone	9066969	539164	81.6535	-60.5826
Hall	HallFD070	2015-08-05	Arctic fox	Scat	9066969	539164	81.6535	-60.5826
Hall	HallFD071	2015-08-07	Muskoxen	Skull	9060296	540853	81.5931	-60.4963
Hall	HallFD072	2015-08-07	Arctic fox	Scat	9060296	540853	81.5931	-60.4963
Hall	HallFD073	2015-08-07	Snowy owl	Pellet	9060275	542908	81.5921	-60.3706

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallFD075	2015-08-07	Arctic fox	Scat	9060275	542908	81.5921	-60.3706
Hall	HallFD076	2015-08-07	Muskoxen	Fur	9060275	542908	81.5921	-60.3706
Hall	HallFD077	2015-08-07	Caribou	Scat	9060275	542908	81.5921	-60.3706
Hall	HallFD078	2015-08-07	Snowy owl	Feather	9060367	543686	81.5926	-60.3227
Hall	HallFD079	2015-08-07	Snowy owl	Pellet	9060367	543686	81.5926	-60.3227
Hall	HallFD080	2015-08-07	Lemming	Bone	9060367	543686	81.5926	-60.3227
Hall	HallFD081	2015-08-07	Ptarmigan	Scat	9060367	543686	81.5926	-60.3227
Hall	HallFD082	2015-08-07	Muskoxen	Fur	9060746	544304	81.5958	-60.2838
Hall	HallFD083	2015-08-07	Snowy owl	Pellet	9060596	544756	81.5942	-60.2566
Hall	HallFD084	2015-08-07	Arctic fox	Scat	9060596	544756	81.5942	-60.2566
Hall	HallFD085	2015-08-07	Snow bunting	Scat	9060596	544756	81.5942	-60.2566
Hall	HallFD086	2015-08-07	Lemming	Skull	9060596	544756	81.5942	-60.2566
Hall	HallFD087	2015-08-07	Hare	Scat	9060596	544756	81.5942	-60.2566
Hall	HallFD088	2015-08-07	Wolf	Scat	9061878	547620	81.6044	-60.0774
Hall	HallFD089	2015-08-07	Arctic fox	Scat	9062853	548419	81.6128	-60.0253
Hall	HallFD090	2015-08-07	Snowy owl	Pellet	9062853	548419	81.6128	-60.0253
Hall	HallFD091	2015-08-07	Snowy owl	Pellet	9062771	548109	81.6122	-60.0446
Hall	HallFD092	2015-08-07	Snowy owl	Feather	9062771	548109	81.6122	-60.0446
Hall	HallFD093	2015-08-07	Lemming	Bone	9062771	548109	81.6122	-60.0446
Hall	HallFD094	2015-08-07	Muskoxen	Fur	9062771	548109	81.6122	-60.0446
Hall	HallFD095	2015-08-07	Goose	Scat	9062528	547822	81.6102	-60.0630
Hall	HallFD096	2015-08-07	Wolf	Scat	9061799	545157	81.6048	-60.2285
Hall	HallFD097	2015-08-07	Wolf	Scat	9061799	545157	81.6048	-60.2285
Hall	HallFD098	2015-08-07	Wolf	Scat	9061799	545157	81.6048	-60.2285
Hall	HallFD099	2015-08-07	Ptarmigan	Feather	9061483	542480	81.6031	-60.3935
Hall	HallFD100	2015-08-09	Wolf	Scat	9062962	537831	81.6181	-60.6748
Hall	HallFD101	2015-08-09	Goose	Scat	9059879	537575	81.5906	-60.6980
Hall	HallFD102	2015-08-09	Unk bird	Feather	9059879	537575	81.5906	-60.6980
Hall	HallFD103	2015-08-09	Goose	Scat	9059879	537575	81.5906	-60.6980
Hall	HallFD104	2015-08-09	Goose	Scat	9059879	537575	81.5906	-60.6980
Hall	HallFD105	2015-08-09	Goose	Scat	9059879	537575	81.5906	-60.6980
Hall	HallFD106	2015-08-09	Goose	Scat	9059879	537575	81.5906	-60.6980
Hall	HallFD107	2015-08-09	Goose	Scat	9059879	537575	81.5906	-60.6980
Hall	HallFD108	2015-08-10	Ptarmigan	Scat	9060272	542910	81.5921	-60.3705
Hall	HallFD109	2015-08-10	Muskoxen	Carcass	9060295	540855	81.5931	-60.4962
Hall	HallFD110	2015-08-10	Arctic fox	Scat	9060295	540855	81.5931	-60.4962
Hall	HallFD111	2015-08-12	Arctic fox	Fur	9057536	539640	81.5689	-60.5776
Hall	HallNL001	2015-08-04	Stoat	Scat	9060470	538151	81.5957	-60.6613
Hall	HallNL002	2015-08-04	Jaeger	Pellet	9034469	544377	81.3606	-60.3529
Hall	HallNL003	2015-08-04	Muskoxen	Scat	9034469	544377	81.3606	-60.3529
Hall	HallNL004	2015-08-04	Stoat	Scat	9034804	544362	81.3636	-60.3529
Hall	HallNL005	2015-08-04	Arctic fox	Scat	9036712	544305	81.3807	-60.3511
Hall	HallNL006	2015-08-04	Arctic fox	Scat	9061776	539668	81.6068	-60.5650
Hall	HallNL007	2015-08-04	Snowy owl	Pellet	9061776	539668	81.6068	-60.5650
Hall	HallNL008	2015-08-04	Snowy owl	Pellet	9061776	539668	81.6068	-60.5650
Hall	HallNL009	2015-08-04	Muskoxen	Fur	9034471	544321	81.3606	-60.3562

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Hall	HallNL010	2015-08-04	Muskoxen	Scat	9061776	539668	81.6068	-60.5650
Hall	HallNL011	2015-08-04	Stoat	Scat	9034471	544321	81.3606	-60.3562
Hall	HallNL012	2015-08-04	Arctic fox	Scat	9061491	539403	81.6044	-60.5820
Hall	HallNL013	2015-08-04	Jaeger	Pellet	9061491	539403	81.6044	-60.5820
Hall	HallNL020	2015-08-05	Stoat	Scat	9061816	537821	81.6079	-60.6782
Hall	HallNL021	2015-08-05	Jaeger	Pellet	9061816	537821	81.6079	-60.6782
Hall	HallNL022	2015-08-05	Arctic fox	Scat	9061899	537910	81.6086	-60.6725
Hall	HallNL023	2015-08-05	Arctic fox	Scat	9061871	538002	81.6083	-60.6670
Hall	HallNL024	2015-08-05	Muskoxen	Scat	9035149	543469	81.3670	-60.4052
Hall	HallNL025	2015-08-05	Stoat	Scat	9258272	533457	83.3678	-60.4044
Hall	HallNL026	2015-08-05	Arctic fox	Scat	9062435	537900	81.6134	-60.6718
Hall	HallNL027	2015-08-05	Lemming	Scat	9062552	538019	81.6144	-60.6642
Hall	HallNL028	2015-08-05	Ptarmigan	Scat	9062552	538019	81.6144	-60.6642
Hall	HallNL029	2015-08-05	Arctic fox	Fur	9062552	538019	81.6144	-60.6642
Hall	HallNL030	2015-08-05	Arctic fox	Scat	9062552	538019	81.6144	-60.6642
Hall	HallNL031	2015-08-05	Lemming	Scat	9062552	538019	81.6144	-60.6642
Hall	HallNL032	2015-08-05	Hare	Fur	9064922	538187	81.6355	-60.6480
Hall	HallNL033	2015-08-05	Unk mammal	Bone	9065552	538123	81.6412	-60.6504
Hall	HallNL034	2015-08-05	Arctic fox	Scat	9065552	538123	81.6412	-60.6504
Hall	HallNL035	2015-08-05	Hare	Scat	9065552	538123	81.6412	-60.6504
Hall	HallNL036	2015-08-05	Stoat	Scat	9065552	538123	81.6412	-60.6504
Hall	HallNL037	2015-08-05	Muskoxen	Fur	9069668	539105	81.6777	-60.5793
Hall	HallNL038	2015-08-05	Muskoxen	Scat	9069668	539105	81.6777	-60.5793
Hall	HallNL039	2015-08-05	Hare	Scat	9069668	539105	81.6777	-60.5793
Hall	HallNL040	2015-08-05	Ptarmigan	Scat	9069668	539105	81.6777	-60.5793
Hall	HallNL041	2015-08-05	Snowy owl	Pellet	9069668	539105	81.6777	-60.5793
Hall	HallNL042	2015-08-05	Wolf	Scat	9069668	539105	81.6777	-60.5793
Hall	HallNL043	2015-08-05	Hare	Scat	9069668	539105	81.6777	-60.5793
Hall	HallNL044	2015-08-05	Arctic fox	Scat	9069668	539105	81.6777	-60.5793
Hall	HallNL045	2015-08-05	Hare	Scat	9067015	540117	81.6536	-60.5238
Hall	HallNL046	2015-08-05	Hare	Fur	9067015	540117	81.6536	-60.5238
Hall	HallNL047	2015-08-05	Hare	Scat	9067015	540117	81.6536	-60.5238
Hall	HallNL048	2015-08-05	Muskoxen	Scat	9067015	540117	81.6536	-60.5238
Hall	HallNL049	2015-08-05	Wolf	Scat	9067015	540117	81.6536	-60.5238
Hall	HallNL050	2015-08-05	Hare	FUR	9067015	540117	81.6536	-60.5238
Hall	HallNL051	2015-08-05	Arctic fox	Scat	9067015	540117	81.6536	-60.5238
Hall	HallNL052	2015-08-05	Snow bunting	Scat	9067065	539849	81.6541	-60.5402
Hall	HallNL053	2015-08-05	Wolf	Scat	9067065	539849	81.6541	-60.5402
Hall	HallNL054	2015-08-05	Wolf	Scat	9067065	539849	81.6541	-60.5402
Hall	HallNL055	2015-08-05	Wolf	Fur	9067065	539849	81.6541	-60.5402
Hall	HallNL056	2015-08-05	Wolf	Scat	9067065	539849	81.6541	-60.5402
Hall	HallNL057	2015-08-05	Wolf	Scat	9067065	539849	81.6541	-60.5402
Hall	HallNL061	2015-08-06	Arctic fox	Scat	9060029	525821	81.5955	-61.4174
Hall	HallNL062	2015-08-06	Shorebird	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL063	2015-08-06	Arctic fox	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL064	2015-08-06	Arctic fox	Scat	9059908	535478	81.5916	-60.8263

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Hall	HallNL065	2015-08-06	Hare	Scat	9059682	535373	81.5896	-60.8332
Hall	HallNL066	2015-08-06	Hare	Scat	9059487	535251	81.5879	-60.8411
Hall	HallNL068	2015-08-06	Caribou	Bone	9059487	535251	81.5879	-60.8411
Hall	HallNL069	2015-08-06	Arctic fox	Scat	9059387	535821	81.5868	-60.8065
Hall	HallNL071	2015-08-06	Goose	Scat	9059380	535950	81.5867	-60.7986
Hall	HallNL072	2015-08-06	Hare	Scat	9059380	535950	81.5867	-60.7986
Hall	HallNL073	2015-08-06	Muskoxen	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL074	2015-08-06	Hare	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL075	2015-08-06	Shorebird	Scat	9057142	537548	81.5661	-60.7063
Hall	HallNL076	2015-08-06	Hare	Scat	9057142	537548	81.5661	-60.7063
Hall	HallNL077	2015-08-06	Caribou	Scat	9057310	537554	81.5676	-60.7055
Hall	HallNL078	2015-08-06	Caribou	Scat	9057006	537336	81.5650	-60.7196
Hall	HallNL079	2015-08-06	Goose	Feather	9057006	537336	81.5650	-60.7196
Hall	HallNL080	2015-08-06	Arctic fox	Scat	9057125	537169	81.5661	-60.7295
Hall	HallNL081	2015-08-06	Snowy owl	Pellet	9057125	537169	81.5661	-60.7295
Hall	HallNL082	2015-08-06	Hare	Scat	9057125	537169	81.5661	-60.7295
Hall	HallNL083	2015-08-06	Ptarmigan	Scat	9057125	537169	81.5661	-60.7295
Hall	HallNL084	2015-08-06	Hare	Fur	9056996	538128	81.5646	-60.6713
Hall	HallNL085	2015-08-06	Hare	Fur	9056996	538128	81.5646	-60.6713
Hall	HallNL085B	2015-08-06	Goose	Scat	9057353	538704	81.5676	-60.6352
Hall	HallNL086	2015-08-06	Muskoxen	Scat	9057353	538704	81.5676	-60.6352
Hall	HallNL087	2015-08-06	Wolf	Scat	9057530	539640	81.5688	-60.5776
Hall	HallNL089	2015-08-06	Snowy owl	Pellet	9057477	539878	81.5683	-60.5633
Hall	HallNL090	2015-08-06	Arctic fox	Scat	9057477	539878	81.5683	-60.5633
Hall	HallNL091	2015-08-06	Snow bunting	Bone	9057279	539187	81.5668	-60.6059
Hall	HallNL092	2015-08-06	Muskoxen	Bone	9057279	539187	81.5668	-60.6059
Hall	HallNL093	2015-08-06	Arctic fox	Scat	9057279	539187	81.5668	-60.6059
Hall	HallNL094	2015-08-06	Snowy owl	Pellet	9057530	539640	81.5688	-60.5776
Hall	HallNL095	2015-08-06	Ptarmigan	Scat	9057530	539640	81.5688	-60.5776
Hall	HallNL096	2015-08-06	Lemming	Scat	9057530	539640	81.5688	-60.5776
Hall	HallNL097	2015-08-06	Lemming	Carcass	9057530	539640	81.5688	-60.5776
Hall	HallNL098	2015-08-06	Arctic fox	Fur	9057530	539640	81.5688	-60.5776
Hall	HallNL099	2015-08-06	Hare	Scat	9057530	539640	81.5688	-60.5776
Hall	HallNL100	2015-08-06	Arctic fox	Scat	9057530	539640	81.5688	-60.5776
Hall	HallNL101A	2015-08-07	Snowy owl	Pellet	9057304	543422	81.5653	-60.3475
Hall	HallNL101B	2015-08-07	Wolf	Scat	9060291	538490	81.5940	-60.6410
Hall	HallNL111	2015-08-07	Arctic fox	Scat	9060480	542194	81.5943	-60.4137
Hall	HallNL112	2015-08-07	Snowy owl	Pellet	9060480	542194	81.5943	-60.4137
Hall	HallNL113	2015-08-07	Snowy owl	Pellet	9061035	542542	81.5991	-60.3909
Hall	HallNL115	2015-08-07	Snowy owl	Pellet	9060188	542776	81.5914	-60.3789
Hall	HallNL116	2015-08-07	Snow bunting	Scat	9060557	544758	81.5939	-60.2566
Hall	HallNL117	2015-08-07	Hare	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL118	2015-08-07	Muskoxen	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL119	2015-08-07	Arctic fox	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL121	2015-08-07	Lemming	Scat	9059908	535478	81.5916	-60.8263
Hall	HallNL122	2015-08-07	Stoat	Scat	9059908	535478	81.5916	-60.8263

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Hall	HallNL123	2015-08-07	Snowy owl	Pellet	9061129	547332	81.5979	-60.0973
Hall	HallNL124	2015-08-07	Muskoxen	Scat	9061118	547256	81.5978	-60.1020
Hall	HallNL125	2015-08-07	Hare	Scat	9061118	547256	81.5978	-60.1020
Hall	HallNL126	2015-08-07	Lemming	Scat	9061118	547256	81.5978	-60.1020
Hall	HallNL127	2015-08-07	Muskoxen	Scat	9061362	547311	81.6000	-60.0979
Hall	HallNL128	2015-08-07	Hare	Scat	9061362	547311	81.6000	-60.0979
Hall	HallNL129	2015-08-07	Muskoxen	Fur	9061671	547473	81.6027	-60.0870
Hall	HallNL130	2015-08-07	Hare	Scat	9061600	547322	81.6021	-60.0965
Hall	HallNL131	2015-08-07	Muskoxen	Scat	9061600	547322	81.6021	-60.0965
Hall	HallNL132	2015-08-07	Snowy owl	Pellet	9062098	547547	81.6064	-60.0812
Hall	HallNL133	2015-08-07	Arctic fox	Scat	9062098	547547	81.6064	-60.0812
Hall	HallNL134	2015-08-07	Muskoxen	Scat	9061600	547322	81.6021	-60.0965
Hall	HallNL135	2015-08-07	Arctic fox	Scat	9061852	547323	81.6043	-60.0956
Hall	HallNL136	2015-08-07	Hare	Scat	9061852	547323	81.6043	-60.0956
Hall	HallNL137	2015-08-07	Muskoxen	Scat	9061852	547323	81.6043	-60.0956
Hall	HallNL138	2015-08-07	Lemming	Scat	9061852	547323	81.6043	-60.0956
Hall	HallNL140	2015-08-07	Snowy owl	Pellet	9061320	544400	81.6009	-60.2763
Hall	HallNL141	2015-08-07	Snowy owl	Pellet	9061440	544540	81.6019	-60.2674
Hall	HallNL142	2015-08-07	Goose	Feather	9061440	544540	81.6019	-60.2674
Hall	HallNL143	2015-08-09	Arctic fox	Scat	9062335	537561	81.6126	-60.6929
Hall	HallNL144	2015-08-09	Muskoxen	Fur	9062335	537561	81.6126	-60.6929
Hall	HallNL145	2015-08-09	Snowy owl	Pellet	9058661	538830	81.5793	-60.6243
Hall	HallNL146	2015-08-09	Unk mammal	Bone	9058661	538830	81.5793	-60.6243
Hall	HallNL147	2015-08-09	Lemming	Scat	9058661	538830	81.5793	-60.6243
Hall	HallNL148	2015-08-09	Arctic fox	Scat	9058661	538830	81.5793	-60.6243
Hall	HallNL149	2015-08-09	Hare	Scat	9058661	538830	81.5793	-60.6243
Hall	HallNL150	2015-08-09	Snow bunting	Scat	9057671	539430	81.5702	-60.5901
Hall	HallNL151	2015-08-09	Snowy owl	Pellet	9057671	539430	81.5702	-60.5901
Hall	HallNL152	2015-08-09	Snowy owl	Pellet	9056958	539053	81.5639	-60.6149
Hall	HallNL153	2015-08-09	Goose	Feather	9056958	539053	81.5639	-60.6149
Hall	HallNL154A	2015-08-10	Snowy owl	Pellet	9059272	543306	81.5830	-60.3491
Hall	HallNL156	2015-08-10	Hare	Scat	9059272	543306	81.5830	-60.3491
Hall	HallNL157	2015-08-10	Ptarmigan	Feather	9059272	543306	81.5830	-60.3491
Hall	HallNL158	2015-08-10	Ptarmigan	Scat	9059272	543306	81.5830	-60.3491
Hall	HallNL159	2015-08-10	Ptarmigan	Scat	9059272	543306	81.5830	-60.3491
Hall	HallNL160	2015-08-10	Ptarmigan	Scat	9059272	543306	81.5830	-60.3491
Hall	HallNL161	2015-08-10	Arctic fox	Scat	9059272	543306	81.5830	-60.3491
Hall	HallNL162	2015-08-10	Ptarmigan	Feather	9059272	543306	81.5830	-60.3491
Hall	HallNL163	2015-08-10	Ptarmigan	Feather	9059272	543306	81.5830	-60.3491
Hall	HallNL164	2015-08-10	Muskoxen	Scat	9059272	543306	81.5830	-60.3491
Hall	HallNL165	2015-08-11	Goose	Feather	9060303	537484	81.5944	-60.7025
Hall	HallNL166	2015-08-10	Muskoxen	Bone	9059272	543306	81.5830	-60.3491
Hall	HallNL167	2015-08-11	Shorebird	Scat	9059272	543306	81.5830	-60.3491
Hall	HallNL168	2015-08-11	Shorebird	Scat	9060303	537484	81.5944	-60.7025
Hall	HallNL169	2015-08-11	Shorebird	Scat	9060303	537484	81.5944	-60.7025
Hall	HallNL172	2015-08-11	Shorebird	Scat	9060303	537484	81.5944	-60.7025

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Hall	HallNL173	2015-08-11	Shorebird	Scat	9060303	537484	81.5944	-60.7025
Hall	HallNL174	2015-08-11	Shorebird	Scat	9060303	537484	81.5944	-60.7025
Hall	HallNL175	2015-08-12	Lemming	Scat	9058005	538390	81.5736	-60.6528
Hall	HallNL176	2015-08-12	Stoat	Scat	9058005	538390	81.5736	-60.6528
Hall	HallNL177	2015-08-12	Lemming	Scat	9057947	538362	81.5730	-60.6546
Hall	HallNL178	2015-08-12	Lemming	Scat	9057949	538221	81.5731	-60.6632
Hall	HallNL179	2015-08-12	Lemming	Scat	9057645	538370	81.5703	-60.6549
Hall	HallNL179A	2015-08-12	Unk bird	Scat	9057646	538371	81.5703	-60.6548
Hall	HallNL180	2015-08-12	Lemming	Scat	9057646	538407	81.5703	-60.6526
Hall	HallNL181	2015-08-12	Lemming	Scat	9057267	538497	81.5669	-60.6481
Hall	HallNL182	2015-08-12	Muskoxen	Scat	9057267	538497	81.5669	-60.6481
Hall	HallNL184	2015-08-12	Lemming	Scat	9057088	539416	81.5650	-60.5924
Hall	HallNL185	2015-08-12	Ptarmigan	Scat	9057088	539416	81.5650	-60.5924
Hall	HallNL186	2015-08-12	Ptarmigan	Scat	9057023	539572	81.5643	-60.5831
Hall	HallNL187	2015-08-12	Long-tailed jaeger	Scat	9056882	540034	81.5629	-60.5553
Hall	HallNL190	2015-08-12	Hare	Scat	9057619	21 X 453460	81.5668	-59.8436
Hall	HallNL191	2015-08-12	Arctic fox	Scat	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP001	2015-08-04	Muskoxen	Scat	9060700	537087	81.5981	-60.7259
Hall	HallPP002	2015-08-04	Hare	Scat	9061097	537077	81.6017	-60.7255
Hall	HallPP003	2015-08-04	Lemming	Bone	9061880	536962	81.6088	-60.7307
Hall	HallPP004	2015-08-04	Unk bird	Scat	9062097	536972	81.6107	-60.7296
Hall	HallPP005	2015-08-04	Muskoxen	Scat	9062247	537007	81.6120	-60.7271
Hall	HallPP006	2015-08-04	Muskoxen	Scat	9062431	537095	81.6136	-60.7212
Hall	HallPP007	2015-08-04	Arctic fox	Scat	9062755	537301	81.6165	-60.7078
Hall	HallPP008	2015-08-04	Lemming	Scat	9062755	537301	81.6165	-60.7078
Hall	HallPP009	2015-08-04	Snowy owl	Pellet	9062755	537301	81.6165	-60.7078
Hall	HallPP010	2015-08-04	Lemming	Bone	9062755	537301	81.6165	-60.7078
Hall	HallPP011	2015-08-04	Stoat	Scat	9062755	537301	81.6165	-60.7078
Hall	HallPP012	2015-08-04	Ptarmigan	Scat	9062755	537301	81.6165	-60.7078
Hall	HallPP013	2015-08-04	Muskoxen	Scat	9062250	537802	81.6118	-60.6783
Hall	HallPP014	2015-08-04	Lemming	Scat	9062265	537811	81.6119	-60.6777
Hall	HallPP015	2015-08-04	Arctic fox	Scat	9062354	537863	81.6127	-60.6743
Hall	HallPP016	2015-08-04	Arctic fox	Scat	9062354	537863	81.6127	-60.6743
Hall	HallPP017	2015-08-04	Arctic fox	Scat	9062710	538016	81.6158	-60.6640
Hall	HallPP018	2015-08-04	Muskoxen	Scat	9062747	538032	81.6161	-60.6629
Hall	HallPP019	2015-08-04	Muskoxen	Fur	9062757	538044	81.6162	-60.6622
Hall	HallPP020	2015-08-04	Muskoxen	Scat	9063216	538231	81.6203	-60.6496
Hall	HallPP021	2015-08-04	Arctic fox	Scat	9063285	538280	81.6209	-60.6464
Hall	HallPP022	2015-08-04	Lemming	Scat	9063285	538280	81.6209	-60.6464
Hall	HallPP023	2015-08-04	Lemming	Scat	9064289	538977	81.6296	-60.6010
Hall	HallPP024	2015-08-04	Arctic fox	Scat	9064289	538977	81.6296	-60.6010
Hall	HallPP025	2015-08-04	Lemming	Bone	9064289	538977	81.6296	-60.6010
Hall	HallPP026	2015-08-04	Arctic fox	Scat	9064289	538977	81.6296	-60.6010
Hall	HallPP027	2015-08-04	Stoat	Scat	9064289	538977	81.6296	-60.6010
Hall	HallPP028	2015-08-04	Muskoxen	Scat	9064347	539025	81.6301	-60.5979
Hall	HallPP029	2015-08-04	Arctic fox	Scat	9064859	539677	81.6344	-60.5565

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallPP030	2015-08-04	Unk mammal	Fur	9065131	539977	81.6367	-60.5373
Hall	HallPP031	2015-08-04	Snowy owl	Pellet	9065166	540002	81.6370	-60.5357
Hall	HallPP032	2015-08-04	Snowy owl	Pellet	9065166	540002	81.6370	-60.5357
Hall	HallPP033	2015-08-04	Snowy owl	Pellet	9065166	540002	81.6370	-60.5357
Hall	HallPP034	2015-08-04	Snowy owl	Pellet	9065686	540217	81.6416	-60.5211
Hall	HallPP035	2015-08-04	Muskoxen	Scat	9065782	540276	81.6425	-60.5172
Hall	HallPP036	2015-08-04	Arctic fox	Scat	9066255	540720	81.6465	-60.4886
Hall	HallPP037	2015-08-04	Arctic fox	Scat	9066360	540854	81.6474	-60.4801
Hall	HallPP038	2015-08-04	Arctic fox	Scat	9066443	540974	81.6481	-60.4725
Hall	HallPP039	2015-08-04	Arctic fox	Scat	9067001	541181	81.6530	-60.4582
Hall	HallPP040	2015-08-04	Lemming	Scat	9067001	541181	81.6530	-60.4582
Hall	HallPP041	2015-08-04	Lemming	Scat	9066672	541209	81.6501	-60.4574
Hall	HallPP042	2015-08-04	Muskoxen	Carcass	9065973	540956	81.6439	-60.4748
Hall	HallPP043	2015-08-04	Arctic fox	Scat	9065973	540956	81.6439	-60.4748
Hall	HallPP044	2015-08-04	Arctic fox	Scat	9065744	540870	81.6419	-60.4808
Hall	HallPP045	2015-08-04	Arctic fox	Scat	9065635	540806	81.6409	-60.4850
Hall	HallPP046	2015-08-04	Arctic fox	Scat	9064714	540507	81.6328	-60.5058
Hall	HallPP047	2015-08-04	Snowy owl	Pellet	9064577	540420	81.6316	-60.5116
Hall	HallPP048	2015-08-04	Arctic fox	Scat	9064577	540420	81.6316	-60.5116
Hall	HallPP049	2015-08-04	Wolf	Skull	9064269	540388	81.6289	-60.5143
Hall	HallPP050	2015-08-04	Lemming	Skull	9064029	540411	81.6267	-60.5136
Hall	HallPP051	2015-08-04	Lemming	Bone	9064029	540411	81.6267	-60.5136
Hall	HallPP052	2015-08-04	Arctic fox	Scat	9064029	540411	81.6267	-60.5136
Hall	HallPP053	2015-08-04	Snowy owl	Pellet	9064029	540411	81.6267	-60.5136
Hall	HallPP054	2015-08-04	Arctic fox	Scat	9063942	540398	81.6259	-60.5146
Hall	HallPP055	2015-08-04	Hare	Carcass	9061877	538987	81.6080	-60.6065
Hall	HallPP056	2015-08-04	Arctic fox	Scat	9061057	538357	81.6009	-60.6472
Hall	HallPP057	2015-08-05	Arctic fox	Scat	9060748	536987	81.5986	-60.7319
Hall	HallPP058	2015-08-05	Arctic fox	Scat	9061437	536017	81.6051	-60.7897
Hall	HallPP059	2015-08-05	Arctic fox	Scat	9061437	536017	81.6051	-60.7897
Hall	HallPP060	2015-08-05	Unk bird	Scat	9061519	535905	81.6059	-60.7964
Hall	HallPP061	2015-08-05	Muskoxen	Scat	9062427	534123	81.6146	-60.9036
Hall	HallPP063	2015-08-05	Muskoxen	Scat	9063043	532972	81.6205	-60.9730
Hall	HallPP064	2015-08-05	Lemming	Skull	9063377	532539	81.6236	-60.9989
Hall	HallPP065	2015-08-05	Muskoxen	Scat	9063665	532212	81.6263	-61.0183
Hall	HallPP066	2015-08-05	Muskoxen	Scat	9064406	531200	81.6332	-61.0790
Hall	HallPP067	2015-08-05	Arctic fox	Scat	9065161	530326	81.6403	-61.1313
Hall	HallPP068	2015-08-05	Arctic fox	Scat	9065094	530314	81.6397	-61.1322
Hall	HallPP069	2015-08-05	Muskoxen	Scat	9064162	530588	81.6312	-61.1172
Hall	HallPP070	2015-08-05	Muskoxen	Carcass	9064070	530651	81.6304	-61.1135
Hall	HallPP071	2015-08-05	Unk mammal	Scat	9064070	530651	81.6304	-61.1135
Hall	HallPP072	2015-08-05	Arctic fox	Scat	9064021	530655	81.6299	-61.1133
Hall	HallPP073	2015-08-05	Muskoxen	Scat	9063909	530736	81.6289	-61.1086
Hall	HallPP074	2015-08-05	Muskoxen	Scat	9062901	531421	81.6197	-61.0685
Hall	HallPP075	2015-08-05	Lemming	Bone	9062769	531521	81.6185	-61.0627
Hall	HallPP076	2015-08-05	Arctic fox	Scat	9062769	531521	81.6185	-61.0627

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Hall	HallPP077	2015-08-05	Snowy owl	Pellet	9062769	531521	81.6185	-61.0627
Hall	HallPP079	2015-08-05	Muskoxen	Scat	9060964	534510	81.6014	-60.8832
Hall	HallPP080	2015-08-07	Lemming	Scat	9061775	538083	81.6074	-60.6622
Hall	HallPP081	2015-08-07	Caribou	Scat	9063520	535600	81.6239	-60.8104
Hall	HallPP082	2015-08-07	Arctic fox	Scat	9062969	537833	81.6182	-60.6746
Hall	HallPP083	2015-08-07	Caribou	Scat	9063092	537689	81.6193	-60.6832
Hall	HallPP084	2015-08-07	Muskoxen	Scat	9063159	537646	81.6200	-60.6856
Hall	HallPP085	2015-08-07	Snowy owl	Pellet	9063159	537646	81.6200	-60.6856
Hall	HallPP086	2015-08-07	Arctic fox	Scat	9063159	537646	81.6200	-60.6856
Hall	HallPP087	2015-08-07	Muskoxen	Scat	9063316	537772	81.6213	-60.6775
Hall	HallPP088	2015-08-07	Caribou	Scat	9063730	537594	81.6251	-60.6874
Hall	HallPP089	2015-08-07	Arctic fox	Scat	9064017	537524	81.6277	-60.6910
Hall	HallPP090	2015-08-07	Caribou	Scat	9064186	537568	81.6292	-60.6879
Hall	HallPP091	2015-08-07	Hare	Scat	9064388	537674	81.6309	-60.6809
Hall	HallPP092	2015-08-07	Muskoxen	Scat	9064388	537674	81.6309	-60.6809
Hall	HallPP093	2015-08-07	Caribou	Scat	9064388	537674	81.6309	-60.6809
Hall	HallPP094	2015-08-07	Hare	Scat	9064388	537674	81.6309	-60.6809
Hall	HallPP095	2015-08-07	Muskoxen	Scat	9064388	537674	81.6309	-60.6809
Hall	HallPP096	2015-08-07	Muskoxen	Fur	9064388	537674	81.6309	-60.6809
Hall	HallPP097	2015-08-07	Muskoxen	Scat	9064994	537686	81.6364	-60.6787
Hall	HallPP098	2015-08-07	Hare	Scat	9065228	537806	81.6384	-60.6707
Hall	HallPP099	2015-08-07	Snowy owl	Pellet	9065210	537844	81.6382	-60.6684
Hall	HallPP100	2015-08-07	Arctic fox	Scat	9065210	537844	81.6382	-60.6684
Hall	HallPP101	2015-08-07	Lemming	Bone	9065210	537844	81.6382	-60.6684
Hall	HallPP102	2015-08-07	Muskoxen	Scat	9065210	537844	81.6382	-60.6684
Hall	HallPP104	2015-08-07	Arctic fox	Scat	9065571	537986	81.6414	-60.6588
Hall	HallPP105	2015-08-07	Snowy owl	Pellet	9065571	537986	81.6414	-60.6588
Hall	HallPP106	2015-08-07	Muskoxen	Scat	9066404	538316	81.6488	-60.6363
Hall	HallPP108	2015-08-07	Lemming	Scat	9066915	538420	81.6533	-60.6286
Hall	HallPP109	2015-08-07	Caribou	Scat	9067009	538434	81.6541	-60.6275
Hall	HallPP110	2015-08-07	Hare	Bone	9067359	538079	81.6574	-60.6486
Hall	HallPP111	2015-08-07	Arctic fox	Scat	9067383	537988	81.6576	-60.6541
Hall	HallPP112	2015-08-07	Muskoxen	Scat	9067401	537449	81.6580	-60.6873
Hall	HallPP113	2015-08-07	Muskoxen	Scat	9067461	536920	81.6587	-60.7198
Hall	HallPP114	2015-08-07	Muskoxen	Fur	9067461	536920	81.6587	-60.7198
Hall	HallPP115	2015-08-07	Snowy owl	Pellet	9067504	536818	81.6591	-60.7260
Hall	HallPP116	2015-08-07	Arctic fox	Scat	9067504	536818	81.6591	-60.7260
Hall	HallPP117	2015-08-07	Muskoxen	Fur	9067279	536473	81.6573	-60.7478
Hall	HallPP118	2015-08-07	Snowy owl	Pellet	9067279	536099	81.6574	-60.7709
Hall	HallPP119	2015-08-07	Muskoxen	Scat	9067501	535527	81.6596	-60.8057
Hall	HallPP120	2015-08-07	Snowy owl	Pellet	9067416	535512	81.6588	-60.8068
Hall	HallPP121	2015-08-07	Muskoxen	Scat	9066121	535740	81.6471	-60.7958
Hall	HallPP122	2015-08-07	Arctic fox	Scat	9065831	535828	81.6445	-60.7910
Hall	HallPP123	2015-08-07	Arctic fox	Scat	9064651	536314	81.6338	-60.7639
Hall	HallPP124	2015-08-09	Stoat	Scat	9059894	538812	81.5903	-60.6223
Hall	HallPP125	2015-08-09	Muskoxen	Scat	9057832	539382	81.5716	-60.5926

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallPP126	2015-08-09	Unk mammal	Bone	9057742	539406	81.5708	-60.5914
Hall	HallPP127	2015-08-09	Lemming	Bone	9057523	539631	81.5688	-60.5782
Hall	HallPP128	2015-08-09	Ptarmigan	Scat	9057523	539631	81.5688	-60.5782
Hall	HallPP129	2015-08-09	Ptarmigan	Scat	9057523	539631	81.5688	-60.5782
Hall	HallPP130	2015-08-09	Ptarmigan	Scat	9057523	539631	81.5688	-60.5782
Hall	HallPP131	2015-08-09	Muskoxen	Carcass	9057666	538828	81.5704	-60.6269
Hall	HallPP131B	2015-08-09	Wolf	Scat	9057667	538829	81.5704	-60.6268
Hall	HallPP132	2015-08-10	Unk bird	Feather	9060207	541931	81.5919	-60.4306
Hall	HallPP133	2015-08-10	Hare	Scat	9060207	541931	81.5919	-60.4306
Hall	HallPP134	2015-08-10	Hare	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP135	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP136	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP138	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP139	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP140	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP141	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP142	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP143	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP144	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP145	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP146	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP147	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP148	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP149	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP150	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP151	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP152	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP153	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP154	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP155	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP156	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP157	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP158	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP159	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP160	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP161	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP162	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP163	2015-08-10	Lemming	Bone	9059658	542936	81.5866	-60.3706
Hall	HallPP164	2015-08-10	Unk bird	Bone	9060976	541999	81.5988	-60.4243
Hall	HallPP165	2015-08-10	Wolf	Scat	9060976	541999	81.5988	-60.4243
Hall	HallPP166	2015-08-09	Hare	Bone	9057523	539631	81.5688	-60.5782
Hall	HallPP167	2015-08-11	Caribou	Scat	9060640	540274	81.5964	-60.5309
Hall	HallPP168	2015-08-11	Lemming	Bone	9061023	541992	81.5992	-60.4246
Hall	HallPP169	2015-08-11	Snowy owl	Pellet	9061023	541992	81.5992	-60.4246
Hall	HallPP170	2015-08-11	Stoat	Scat	9061023	541992	81.5992	-60.4246
Hall	HallPP171	2015-08-11	Arctic fox	Scat	9061023	541992	81.5992	-60.4246

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallPP172	2015-08-11	Lemming	Bone	9061023	541992	81.5992	-60.4246
Hall	HallPP173	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP174	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP175	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP176	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP177	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP178	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP179	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP181	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP182	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP183	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP184	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP185	2015-08-11	Lemming	Skull	9061023	541992	81.5992	-60.4246
Hall	HallPP186	2015-08-11	Caribou	Scat	9060982	542303	81.5987	-60.4057
Hall	HallPP187	2015-08-11	Muskoxen	Scat	9060315	545287	81.5915	-60.2249
Hall	HallPP188	2015-08-11	Muskoxen	Fur	9060315	545287	81.5915	-60.2249
Hall	HallPP189	2015-08-11	Lemming	Scat	9060312	545646	81.5913	-60.2030
Hall	HallPP190	2015-08-11	Snowy owl	Pellet	9060312	545646	81.5913	-60.2030
Hall	HallPP191	2015-08-11	Hare	Scat	9060312	545646	81.5913	-60.2030
Hall	HallPP192	2015-08-11	Arctic fox	Bone	9060807	546926	81.5952	-60.1232
Hall	HallPP193	2015-08-11	Unk mammal	Bone	9060929	547089	81.5962	-60.1128
Hall	HallPP194	2015-08-11	Snowy owl	Pellet	9061133	547331	81.5979	-60.0974
Hall	HallPP195	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP196	2015-08-11	Hare	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP197	2015-08-11	Ptarmigan	Scat	9061133	547331	81.5979	-60.0974
Hall	HallPP198	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP199	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP200	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP201	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP202	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP203	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP204	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP205	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP206	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP207	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP208	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP209	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP210	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP211	2015-08-11	Lemming	Bone	9061133	547331	81.5979	-60.0974
Hall	HallPP212	2015-08-11	Wolf	Scat	9061059	547018	81.5974	-60.1168
Hall	HallPP213	2015-08-11	Hare	Scat	9061059	547018	81.5974	-60.1168
Hall	HallPP214	2015-08-11	Lemming	Bone	9061059	547018	81.5974	-60.1168
Hall	HallPP215	2015-08-11	Caribou	Scat	9061249	547203	81.5990	-60.1048
Hall	HallPP216	2015-08-11	Lemming	Skull	9061871	548085	81.6042	-60.0489
Hall	HallPP217	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP218	2015-08-11	Snowy owl	Pellet	9061871	548085	81.6042	-60.0489

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallPP219	2015-08-11	Snowy owl	Feather	9061871	548085	81.6042	-60.0489
Hall	HallPP220	2015-08-11	Ptarmigan	Scat	9061871	548085	81.6042	-60.0489
Hall	HallPP221	2015-08-11	Ptarmigan	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP222	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP223	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP224	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP225	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP226	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP227	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP228	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP229	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP230	2015-08-11	Lemming	Bone	9061871	548085	81.6042	-60.0489
Hall	HallPP231	2015-08-11	Goose	Scat	9062088	548176	81.6061	-60.0426
Hall	HallPP233	2015-08-11	Arctic fox	Scat	9062471	545938	81.6105	-60.1787
Hall	HallPP234	2015-08-11	Arctic fox	Bone	9062471	545938	81.6105	-60.1787
Hall	HallPP235	2015-08-11	Snowy owl	Pellet	9062471	545938	81.6105	-60.1787
Hall	HallPP236	2015-08-11	Lemming	Bone	9062471	545938	81.6105	-60.1787
Hall	HallPP237	2015-08-11	Lemming	Bone	9062471	545938	81.6105	-60.1787
Hall	HallPP238	2015-08-12	Unk bird	Egg	9060792	537201	81.5989	-60.7187
Hall	HallPP239	2015-08-12	Goose	Scat	9060792	537201	81.5989	-60.7187
Hall	HallPP240	2015-08-12	Ptarmigan	Feather	9061860	538151	81.6081	-60.6578
Hall	HallPP241	2015-08-12	Lemming	Skull	9061489	538152	81.6048	-60.6587
Hall	HallPP242	2015-08-12	Lemming	Skull	9061489	538152	81.6048	-60.6587
Hall	HallPP243	2015-08-12	Goose	Feather	9059931	537682	81.5910	-60.6913
Hall	HallPP244	2015-08-12	Lemming	Scat	9058020	538570	81.5736	-60.6417
Hall	HallPP245	2015-08-12	Ptarmigan	Scat	9058020	538570	81.5736	-60.6417
Hall	HallPP246	2015-08-12	Unk mammal	Bone	9058013	538420	81.5736	-60.6509
Hall	HallPP247	2015-08-12	Ptarmigan	Scat	9057895	538170	81.5726	-60.6665
Hall	HallPP248	2015-08-12	Lemming	Scat	9057637	538362	81.5703	-60.6554
Hall	HallPP249	2015-08-12	Ptarmigan	Scat	9057637	538362	81.5703	-60.6554
Hall	HallPP250	2015-08-12	Muskoxen	Bone	9057637	538362	81.5703	-60.6554
Hall	HallPP251	2015-08-12	Muskoxen	Scat	9057587	538502	81.5698	-60.6470
Hall	HallPP252	2015-08-12	Lemming	Scat	9057290	539053	81.5669	-60.6141
Hall	HallPP253	2015-08-12	Ptarmigan	Scat	9057325	539221	81.5672	-60.6037
Hall	HallPP254	2015-08-12	Ptarmigan	Scat	9056955	539549	81.5637	-60.5847
Hall	HallPP255	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP256	2015-08-13	Lemming	Skull	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP257	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP258	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP259	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP260	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP261	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP262	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP263	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP264	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP265	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallPP266	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP267	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP268	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP269	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP270	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP271	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP272	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP273	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP274	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP275	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP276	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP277	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP278	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP279	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP280	2015-08-13	Lemming	Bone	9057619	21 X 453460	81.5668	-59.8436
Hall	HallPP281	2015-08-06	Unk mammal	Bone	9058527	540020	81.5776	-60.5519
Hall	HallTM001	2015-08-08	Hare	Bone	9067734	545147	81.6579	-60.2116
Hall	HallTM002	2015-08-08	Unk mammal	Bone	9067734	545147	81.6579	-60.2116
Hall	HallTM003	2015-08-08	Muskoxen	Scat	9067379	545318	81.6547	-60.2021
Hall	HallTM004	2015-08-08	Ptarmigan	Scat	9067427	546084	81.6548	-60.1548
Hall	HallTM005	2015-08-08	Snowy owl	Pellet	9067427	546084	81.6548	-60.1548
Hall	HallTM006	2015-08-08	Lemming	Bone	9067185	545856	81.6527	-60.1695
Hall	HallTM007	2015-08-08	Arctic fox	Scat	9067185	545856	81.6527	-60.1695
Hall	HallTM008	2015-08-08	Lemming	Scat	9067185	545856	81.6527	-60.1695
Hall	HallTM009	2015-08-08	Muskoxen	Fur	9067119	545778	81.6522	-60.1746
Hall	HallTM010	2015-08-08	Arctic fox	Scat	9067066	545561	81.6518	-60.1881
Hall	HallTM011	2015-08-09	Arctic fox	Scat	9066997	545439	81.6512	-60.1958
Hall	HallTM012	2015-08-09	Hare	Scat	9066248	543784	81.6452	-60.2999
Hall	HallTM013	2015-08-09	Muskoxen	Scat	9066248	543784	81.6452	-60.2999
Hall	HallTM014	2015-08-09	Jaeger	Pellet	9066248	543784	81.6452	-60.2999
Hall	HallTM015	2015-08-09	Unk bird	Feather	9066248	543784	81.6452	-60.2999
Hall	HallTM016	2015-08-09	Snowy owl	Feather	9066086	543510	81.6439	-60.3173
Hall	HallTM017	2015-08-09	Snowy owl	Pellet	9065738	542954	81.6410	-60.3525
Hall	HallTM018	2015-08-09	Arctic fox	Scat	9065738	542954	81.6410	-60.3525
Hall	HallTM020	2015-08-09	Hare	Bone	9065738	542954	81.6410	-60.3525
Hall	HallTM021	2015-08-09	Snowy owl	Pellet	9064891	541671	81.6339	-60.4338
Hall	HallTM022	2015-08-09	Snowy owl	Pellet	9064672	541485	81.6321	-60.4458
Hall	HallTM023A	2015-08-09	Arctic fox	Scat	9064672	541485	81.6321	-60.4458
Hall	HallTM023B	2015-08-09	Snowy owl	Pellet	9064673	541486	81.6321	-60.4457
Hall	HallTM025	2015-08-09	Unk bird	Feather	9061845	538693	81.6078	-60.6246
Hall	HallTM026	2015-08-09	Snowy owl	Pellet	9066695	539165	81.6510	-60.5833
Hall	HallTM027	2015-08-09	Hare	Bone	9065821	537075	81.6440	-60.7142
Hall	HallTM028	2015-08-09	Arctic fox	Scat	9065570	534469	81.6426	-60.8753
Hall	HallTM029	2015-08-09	Snowy owl	Pellet	9065570	534469	81.6426	-60.8753
Hall	HallTM030	2015-08-09	Goose	Pellet	9063893	534046	81.6278	-60.9051
Hall	HallTM031	2015-08-10	Muskoxen	Fur	9059660	542592	81.5868	-60.3916

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Hall	HallTM032	2015-08-10	Snowy owl	Pellet	9059851	542846	81.5884	-60.3756
Hall	HallTM033	2015-08-10	Snowy owl	Pellet	9059837	542998	81.5882	-60.3663
Hall	HallTM034	2015-08-10	Arctic fox	Scat	9059837	542998	81.5882	-60.3663
Hall	HallTM035	2015-08-10	Unk mammal	Bone	9059837	542998	81.5882	-60.3663
Hall	HallTM036	2015-08-10	Lemming	Bone	9059837	542998	81.5882	-60.3663
Hall	HallTM037	2015-08-10	Hare	Bone	9059334	542313	81.5839	-60.4096
Hall	HallTM038	2015-08-10	Wolf	Scat	9059334	542313	81.5839	-60.4096
Hall	HallTM039	2015-08-10	Arctic fox	Scat	9059334	542313	81.5839	-60.4096
Hall	HallTM040	2015-08-11	Snowy owl	Pellet	9063165	537650	81.6200	-60.6854
Hall	HallTM041	2015-08-11	Shorebird	Scat	9063550	538866	81.6230	-60.6097
Hall	HallTM042	2015-08-11	Shorebird	Scat	9063796	538919	81.6252	-60.6058
Hall	HallTM043	2015-08-11	Caribou	Scat	9069042	538962	81.6721	-60.5898
Hall	HallTM044	2015-08-11	Caribou	Scat	9064288	539016	81.6296	-60.5986
Hall	HallTM045	2015-08-11	Caribou	Scat	9064288	539016	81.6296	-60.5986
Hall	HallTM046	2015-08-11	Snow bunting	Scat	9065090	539230	81.6367	-60.5834
Hall	HallTM047	2015-08-11	Caribou	Scat	9063423	543955	81.6199	-60.2975
Hall	HallTM048	2015-08-11	Wolf	Scat	9063749	544635	81.6225	-60.2548
Hall	HallTM049	2015-08-11	Snowy owl	Pellet	9063749	544635	81.6225	-60.2548
Hall	HallTM050	2015-08-11	Ptarmigan	Scat	9063531	544473	81.6206	-60.2654
Hall	HallTM051	2015-08-11	Lemming	Scat	9063531	544473	81.6206	-60.2654
Hall	HallTM052	2015-08-11	Lemming	Scat	9063531	544473	81.6206	-60.2654
Hall	HallTM053	2015-08-11	Unk mammal	Bone	9061144	542517	81.6001	-60.3921
Washington	WaPP001	2015-08-15	Goose	Scat	8911450	542213	80.2603	-60.7643
Washington	WaPP002	2015-08-15	Lemming	Scat	8911450	542213	80.2603	-60.7643
Washington	WaPP003	2015-08-15	Arctic fox	Scat	8911475	542331	80.2605	-60.7580
Washington	WaPP004	2015-08-15	Hare	Scat	8911458	542361	80.2603	-60.7565
Washington	WaPP005	2015-08-15	Muskoxen	Scat	8911468	542399	80.2604	-60.7545
Washington	WaPP006	2015-08-15	Goose	Scat	8911468	542399	80.2604	-60.7545
Washington	WaPP007	2015-08-15	Hare	Fur	8911505	542551	80.2607	-60.7463
Washington	WaPP008	2015-08-15	Arctic fox	Scat	8911557	542599	80.2611	-60.7437
Washington	WaPP009	2015-08-15	Hare	Carcass	8911557	542599	80.2611	-60.7437
Washington	WaPP010	2015-08-15	Arctic fox	Scat	8911626	542690	80.2617	-60.7387
Washington	WaPP011	2015-08-15	Goose	Scat	8911626	542690	80.2617	-60.7387
Washington	WaPP012	2015-08-15	Hare	Scat	8911729	542761	80.2626	-60.7348
Washington	WaPP013	2015-08-15	Goose	Scat	8911836	543122	80.2634	-60.7154
Washington	WaPP014	2015-08-15	Arctic fox	Scat	8911836	543122	80.2634	-60.7154
Washington	WaPP015	2015-08-15	Muskoxen	Scat	8911881	543367	80.2637	-60.7024
Washington	WaPP016	2015-08-15	Muskoxen	Fur	8911881	543367	80.2637	-60.7024
Washington	WaPP017	2015-08-15	Snow bunting	Feather	8912010	543519	80.2648	-60.6941
Washington	WaPP018	2015-08-15	Hare	Scat	8912010	543519	80.2648	-60.6941
Washington	WaPP019	2015-08-15	Arctic fox	Scat	8912010	543519	80.2648	-60.6941
Washington	WaPP020	2015-08-15	Muskoxen	Scat	8912010	543519	80.2648	-60.6941
Washington	WaPP021	2015-08-15	Goose	Scat	8912049	543869	80.2651	-60.6755
Washington	WaPP022	2015-08-15	Hare	Bone	8912260	544057	80.2669	-60.6651
Washington	WaPP023	2015-08-15	Hare	Scat	8912839	544208	80.2720	-60.6558
Washington	WaPP024	2015-08-15	Lemming	Bone	8912921	544325	80.2727	-60.6495

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaPP025	2015-08-15	Arctic fox	Scat	8912921	544325	80.2727	-60.6495
Washington	WaPP026	2015-08-15	Ptarmigan	Scat	8912921	544325	80.2727	-60.6495
Washington	WaPP027	2015-08-15	Unk mammal	Bone	8912921	544325	80.2727	-60.6495
Washington	WaPP028	2015-08-15	Hare	Scat	8912921	544325	80.2727	-60.6495
Washington	WaPP029	2015-08-15	Arctic fox	Scat	8912858	544619	80.2720	-60.6340
Washington	WaPP030	2015-08-15	Hare	Bone	8912747	544760	80.2710	-60.6268
Washington	WaPP031	2015-08-15	Lemming	Bone	8912747	544760	80.2710	-60.6268
Washington	WaPP032	2015-08-15	Hare	Bone	8912747	544760	80.2710	-60.6268
Washington	WaPP033	2015-08-15	Hare	Bone	8912747	544760	80.2710	-60.6268
Washington	WaPP034	2015-08-15	Lemming	Bone	8912747	544760	80.2710	-60.6268
Washington	WaPP035	2015-08-15	Hare	Bone	8912747	544760	80.2710	-60.6268
Washington	WaPP036	2015-08-15	Hare	Scat	8912747	544760	80.2710	-60.6268
Washington	WaPP037	2015-08-15	Muskoxen	Scat	8912612	544941	80.2697	-60.6175
Washington	WaPP038	2015-08-15	Goose	Scat	8912481	545211	80.2684	-60.6035
Washington	WaPP039	2015-08-15	Lemming	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP040	2015-08-15	Hare	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP041	2015-08-15	Hare	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP042	2015-08-15	Unk mammal	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP043	2015-08-15	Lemming	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP044	2015-08-15	Lemming	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP045	2015-08-15	Lemming	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP046	2015-08-15	Lemming	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP047	2015-08-15	Lemming	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP049	2015-08-15	Unk mammal	Bone	8912462	545362	80.2682	-60.5955
Washington	WaPP050	2015-08-15	Goose	Scat	8912068	546108	80.2644	-60.5569
Washington	WaPP051	2015-08-15	Goose	Scat	8912068	546108	80.2644	-60.5569
Washington	WaPP052	2015-08-15	Lemming	Bone	8912017	546085	80.2640	-60.5582
Washington	WaPP053	2015-08-15	Unk mammal	Bone	8912017	546085	80.2640	-60.5582
Washington	WaPP054	2015-08-15	Unk mammal	Bone	8912017	546085	80.2640	-60.5582
Washington	WaPP055	2015-08-15	Unk mammal	Bone	8912017	546085	80.2640	-60.5582
Washington	WaPP056	2015-08-15	Arctic fox	Scat	8911741	545087	80.2619	-60.6117
Washington	WaPP057	2015-08-15	Arctic fox	Scat	8911734	545076	80.2618	-60.6123
Washington	WaPP058	2015-08-15	Unk bird	Bone	8911734	545076	80.2618	-60.6123
Washington	WaPP059	2015-08-15	Lemming	Bone	8911734	545076	80.2618	-60.6123
Washington	WaPP060	2015-08-15	Hare	Scat	8911734	545076	80.2618	-60.6123
Washington	WaPP061	2015-08-15	Snowy owl	Pellet	8911734	545076	80.2618	-60.6123
Washington	WaPP062	2015-08-15	Unk mammal	Bone	8911904	544760	80.2634	-60.6286
Washington	WaPP063	2015-08-15	Lemming	Bone	8911820	544469	80.2628	-60.6442
Washington	WaPP064	2015-08-15	Unk mammal	Bone	8911943	544421	80.2639	-60.6465
Washington	WaPP065	2015-08-15	Unk mammal	Bone	8911943	544421	80.2639	-60.6465
Washington	WaPP066	2015-08-15	Lemming	Bone	8911943	544421	80.2639	-60.6465
Washington	WaPP067	2015-08-15	Lemming	Skull	8911943	544421	80.2639	-60.6465
Washington	WaPP068	2015-08-15	Arctic fox	Scat	8911943	544421	80.2639	-60.6465
Washington	WaPP069	2015-08-15	Arctic fox	Scat	8911716	543925	80.2621	-60.6732
Washington	WaPP070	2015-08-15	Unk bird	Bone	8911716	543925	80.2621	-60.6732
Washington	WaPP071	2015-08-15	Unk mammal	Bone	8911716	543925	80.2621	-60.6732

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaPP072	2015-08-15	Lemming	Skull	8911716	543925	80.2621	-60.6732
Washington	WaPP073	2015-08-15	Lemming	Bone	8911716	543925	80.2621	-60.6732
Washington	WaPP074	2015-08-17	Ptarmigan	Scat	8912745	542585	80.2717	-60.7420
Washington	WaPP075	2015-08-17	Lemming	Skull	8912760	542617	80.2719	-60.7403
Washington	WaPP076	2015-08-17	Unk mammal	Bone	8912940	542850	80.2734	-60.7276
Washington	WaPP077	2015-08-17	Ptarmigan	Scat	8913377	543159	80.2772	-60.7103
Washington	WaPP078	2015-08-17	Arctic fox	Scat	8913377	543159	80.2772	-60.7103
Washington	WaPP079	2015-08-17	Jaeger	Pellet	8913377	543159	80.2772	-60.7103
Washington	WaPP080	2015-08-17	Ptarmigan	Scat	8914557	544590	80.2873	-60.6319
Washington	WaPP081	2015-08-17	Ptarmigan	Scat	8914614	544640	80.2877	-60.6291
Washington	WaPP082	2015-08-17	Arctic fox	Scat	8914614	544640	80.2877	-60.6291
Washington	WaPP083	2015-08-17	Unk mammal	Bone	8914993	544770	80.2911	-60.6214
Washington	WaPP084	2015-08-17	Ptarmigan	Scat	8915656	545338	80.2968	-60.5898
Washington	WaPP085	2015-08-17	Ptarmigan	Scat	8915923	545894	80.2990	-60.5597
Washington	WaPP086	2015-08-17	Snow bunting	Feather	8915671	545844	80.2968	-60.5629
Washington	WaPP087	2015-08-17	Unk bird	Bone	8914711	545462	80.2883	-60.5853
Washington	WaNL001	2015-08-15	Wolf	Scat	8911458	542361	80.2603	-60.7565
Washington	WaNL002	2015-08-15	Hare	Scat	8911458	542399	80.2603	-60.7545
Washington	WaNL003	2015-08-15	Wolf	Scat	8911557	542599	80.2611	-60.7437
Washington	WaNL005	2015-08-15	Goose	Feather	8911626	542680	80.2617	-60.7393
Washington	WaNL006	2015-08-15	Goose	Bone	8911836	543122	80.2634	-60.7154
Washington	WaNL007	2015-08-15	Arctic fox	Scat	8911836	543122	80.2634	-60.7154
Washington	WaNL008	2015-08-15	Muskoxen	Scat	8911836	543122	80.2634	-60.7154
Washington	WaNL009	2015-08-15	Snow bunting	Scat	8912010	543519	80.2648	-60.6941
Washington	WaNL010	2015-08-15	Ptarmigan	Scat	8912010	543519	80.2648	-60.6941
Washington	WaNL011	2015-08-15	Arctic fox	Scat	8911996	543796	80.2646	-60.6794
Washington	WaNL012	2015-08-15	Muskoxen	Scat	8912575	544171	80.2697	-60.6584
Washington	WaNL013	2015-08-15	Snow bunting	Scat	8912921	544325	80.2727	-60.6495
Washington	WaNL014	2015-08-15	Snowy owl	Pellet	8912921	544325	80.2727	-60.6495
Washington	WaNL015	2015-08-15	Stoat	Scat	8912921	544325	80.2727	-60.6495
Washington	WaNL016	2015-08-15	Arctic fox	Scat	8912921	544325	80.2727	-60.6495
Washington	WaNL017	2015-08-15	Arctic fox	Scat	8912921	544325	80.2727	-60.6495
Washington	WaNL018	2015-08-15	Jaeger	Pellet	8912854	544676	80.2720	-60.6310
Washington	WaNL019	2015-08-15	Wolf	Scat	8912854	544676	80.2720	-60.6310
Washington	WaNL020	2015-08-15	Ptarmigan	Scat	8912854	544676	80.2720	-60.6310
Washington	WaNL021	2015-08-15	Snow bunting	Scat	8912747	544760	80.2710	-60.6268
Washington	WaNL022	2015-08-15	Arctic fox	Scat	8912747	544760	80.2710	-60.6268
Washington	WaNL023	2015-08-15	Jaeger	Pellet	8912670	544807	80.2703	-60.6245
Washington	WaNL024	2015-08-15	Snowy owl	Feather	8912670	544807	80.2703	-60.6245
Washington	WaNL025	2015-08-15	Snow bunting	Scat	8912670	544807	80.2703	-60.6245
Washington	WaNL027	2015-08-15	Arctic fox	Scat	8912613	544947	80.2697	-60.6172
Washington	WaNL027B	2015-08-15	Hare	Scat	8912613	544947	80.2697	-60.6172
Washington	WaNL028	2015-08-15	Lemming	Scat	8912613	544947	80.2697	-60.6172
Washington	WaNL029	2015-08-15	Snow bunting	Scat	8912613	544947	80.2697	-60.6172
Washington	WaNL030	2015-08-15	Arctic fox	Scat	8912613	544947	80.2697	-60.6172
Washington	WaNL031	2015-08-15	Muskoxen	Scat	8912613	544947	80.2697	-60.6172

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaNL032	2015-08-15	Snowy owl	Pellet	8912456	545362	80.2682	-60.5955
Washington	WaNL033	2015-08-15	Snowy owl	Pellet	8912456	545362	80.2682	-60.5955
Washington	WaNL034	2015-08-15	Arctic fox	Scat	8912456	545362	80.2682	-60.5955
Washington	WaNL035	2015-08-15	Stoat	Scat	8912456	545362	80.2682	-60.5955
Washington	WaNL036	2015-08-15	Muskoxen	Scat	8912456	545362	80.2682	-60.5955
Washington	WaNL037	2015-08-15	Hare	Scat	8912456	545362	80.2682	-60.5955
Washington	WaNL038	2015-08-15	Jaeger	Pellet	8912456	545362	80.2682	-60.5955
Washington	WaNL039	2015-08-15	Jaeger	Pellet	8912456	545362	80.2682	-60.5955
Washington	WaNL041	2015-08-15	Arctic fox	Scat	8912456	545362	80.2682	-60.5955
Washington	WaNL042	2015-08-15	Snowy owl	Feather	8912456	545362	80.2682	-60.5955
Washington	WaNL043	2015-08-15	Goose	Scat	8912376	545669	80.2673	-60.5795
Washington	WaNL044	2015-08-15	Goose	Feather	8912376	545669	80.2673	-60.5795
Washington	WaNL045	2015-08-15	Wolf	Scat	8912068	546108	80.2644	-60.5569
Washington	WaNL046	2015-08-15	Arctic fox	Scat	8911941	545461	80.2635	-60.5914
Washington	WaNL047	2015-08-15	Snow bunting	Scat	8911741	545087	80.2619	-60.6117
Washington	WaNL048	2015-08-15	Arctic fox	Scat	8911741	545087	80.2619	-60.6117
Washington	WaNL049	2015-08-15	Snow bunting	Scat	8911741	545087	80.2619	-60.6117
Washington	WaNL050	2015-08-15	Jaeger	Pellet	8911943	544621	80.2638	-60.6359
Washington	WaNL051	2015-08-15	Snowy owl	Pellet	8911943	544621	80.2638	-60.6359
Washington	WaNL052	2015-08-15	Arctic fox	Scat	8911908	544444	80.2636	-60.6453
Washington	WaNL053	2015-08-15	Ptarmigan	Scat	8911908	544444	80.2636	-60.6453
Washington	WaNL054	2015-08-15	Lemming	Skull	8911908	544444	80.2636	-60.6453
Washington	WaNL055	2015-08-15	Wolf	Scat	8911746	544089	80.2623	-60.6645
Washington	WaNL056	2015-08-15	Hare	Fur	8911746	544089	80.2623	-60.6645
Washington	WaNL057	2015-08-15	Arctic fox	Scat	8911631	543612	80.2614	-60.6899
Washington	WaNL058	2015-08-15	Wolf	Scat	8911626	543349	80.2615	-60.7039
Washington	WaFD000	2015-08-14	Unk bird	Feather	8911228	541626	80.2585	-60.7958
Washington	WaFD001	2015-08-14	Wolf	Scat	8912063	546029	80.2644	-60.5611
Washington	WaFD002	2015-08-14	Hare	Carcass	8912063	546029	80.2644	-60.5611
Washington	WaFD003	2015-08-15	Arctic fox	Scat	8912485	545044	80.2685	-60.6123
Washington	WaFD004	2015-08-15	Unk mammal	Bone	8911788	543146	80.2630	-60.7143
Washington	WaFD005	2015-08-15	Arctic fox	Scat	8911788	543146	80.2630	-60.7143
Washington	WaFD006	2015-08-15	Arctic fox	Scat	8911788	543146	80.2630	-60.7143
Washington	WaFD007	2015-08-15	Arctic fox	Scat	8911451	542488	80.2602	-60.7498
Washington	WaFD008	2015-08-15	Hare	Skin	8911413	542210	80.2600	-60.7646
Washington	WaFD009	2015-08-15	Hare	Fur	8912124	542017	80.2664	-60.7733
Washington	WaFD010	2015-08-15	Hare	Fur	8912124	542017	80.2664	-60.7733
Washington	WaFD011	2015-08-15	Lemming	Scat	8912303	542468	80.2678	-60.7491
Washington	WaFD012	2015-08-15	Unk mammal	Bone	8912294	542360	80.2678	-60.7548
Washington	WaFD013	2015-08-16	Hare	Bone	8911985	541864	80.2652	-60.7817
Washington	WaFD014	2015-08-16	Ptarmigan	Scat	8911985	541864	80.2652	-60.7817
Washington	WaFD016	2015-08-16	Ptarmigan	Scat	8912529	542635	80.2698	-60.7398
Washington	WaFD017	2015-08-16	Hare	Bone	8912494	542919	80.2694	-60.7248
Washington	WaFD018	2015-08-16	Ptarmigan	Feather	8912573	543400	80.2699	-60.6992
Washington	WaFD019	2015-08-16	Lemming	Skull	8912552	543535	80.2697	-60.6921
Washington	WaFD020	2015-08-16	Goose	Scat	8912362	543786	80.2679	-60.6792

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaFD021	2015-08-16	Goose	Scat	8912362	543786	80.2679	-60.6792
Washington	WaFD022	2015-08-16	Goose	Scat	8912233	544010	80.2667	-60.6676
Washington	WaFD023	2015-08-16	Goose	Scat	8912233	544010	80.2667	-60.6676
Washington	WaFD024	2015-08-16	Hare	Bone	8911155	543839	80.2571	-60.6789
Washington	WaFD025	2015-08-16	Muskoxen	Fur	8910805	543464	80.2541	-60.6995
Washington	WaFD026	2015-08-16	Unk mammal	Bone	8910749	543240	80.2536	-60.7115
Washington	WaFD027	2015-08-16	Muskoxen	Fur	8910736	542685	80.2537	-60.7408
Washington	WaNL059	2015-08-16	Arctic fox	Scat	8911227	541353	80.2586	-60.8103
Washington	WaNL060	2015-08-16	Arctic fox	Scat	8911227	541353	80.2586	-60.8103
Washington	WaNL061	2015-08-16	Lemming	Scat	8911227	541353	80.2586	-60.8103
Washington	WaNL062	2015-08-16	Hare	Scat	8911227	541353	80.2586	-60.8103
Washington	WaNL063	2015-08-16	Arctic fox	Scat	8911504	541353	80.2611	-60.8097
Washington	WaNL064	2015-08-16	Hare	Scat	8911504	541353	80.2611	-60.8097
Washington	WaNL065	2015-08-16	Hare	Scat	8911504	541353	80.2611	-60.8097
Washington	WaNL066	2015-08-16	Hare	Scat	8911504	541353	80.2611	-60.8097
Washington	WaNL067	2015-08-16	Hare	Fur	8911970	541331	80.2652	-60.8100
Washington	WaNL068	2015-08-16	Arctic fox	Scat	8911970	541331	80.2652	-60.8100
Washington	WaNL069	2015-08-16	Hare	Scat	8911970	541331	80.2652	-60.8100
Washington	WaNL070	2015-08-16	Arctic fox	Scat	8911970	541331	80.2652	-60.8100
Washington	WaNL071	2015-08-16	Arctic fox	Scat	8911970	541331	80.2652	-60.8100
Washington	WaNL072	2015-08-16	Ptarmigan	Scat	8911970	541331	80.2652	-60.8100
Washington	WaNL073	2015-08-16	Muskoxen	Scat	8911970	541331	80.2652	-60.8100
Washington	WaNL074	2015-08-16	Arctic fox	Scat	8911970	541331	80.2652	-60.8100
Washington	WaNL075	2015-08-16	Snowy owl	Pellet	8911970	541331	80.2652	-60.8100
Washington	WaNL076	2015-08-16	Snow bunting	Scat	8912053	541281	80.2660	-60.8124
Washington	WaNL077	2015-08-16	Ptarmigan	Scat	8912053	541281	80.2660	-60.8124
Washington	WaNL078	2015-08-16	Arctic fox	Scat	8912053	541281	80.2660	-60.8124
Washington	WaNL079	2015-08-16	Snowy owl	Pellet	8912053	541281	80.2660	-60.8124
Washington	WaNL080	2015-08-16	Unk mammal	bone	8912053	541281	80.2660	-60.8124
Washington	WaNL081	2015-08-16	Ptarmigan	Scat	8912053	541281	80.2660	-60.8124
Washington	WaNL082	2015-08-16	Hare	Scat	8912053	541281	80.2660	-60.8124
Washington	WaNL084	2015-08-16	Hare	Scat	8912053	541281	80.2660	-60.8124
Washington	WaNL085	2015-08-16	Snow bunting	Scat	8912513	541342	80.2701	-60.8083
Washington	WaNL086	2015-08-16	Arctic fox	Scat	8912513	541342	80.2701	-60.8083
Washington	WaNL087	2015-08-16	Hare	Scat	8912513	541342	80.2701	-60.8083
Washington	WaNL088	2015-08-16	Hare	Fur	8912513	541342	80.2701	-60.8083
Washington	WaNL089	2015-08-16	Hare	Scat	8912513	541342	80.2701	-60.8083
Washington	WaNL090	2015-08-16	Arctic fox	Scat	8912513	541342	80.2701	-60.8083
Washington	WaNL091	2015-08-16	Muskoxen	Carcass	8912725	541195	80.2720	-60.8157
Washington	WaNL092	2015-08-16	Muskoxen	Bone	8912725	541195	80.2720	-60.8157
Washington	WaNL093	2015-08-16	Ptarmigan	Scat	8912742	541157	80.2722	-60.8176
Washington	WaNL094	2015-08-16	Hare	Fur	8912768	541090	80.2725	-60.8211
Washington	WaNL095	2015-08-16	Arctic fox	Scat	8912768	541090	80.2725	-60.8211
Washington	WaNL096	2015-08-16	Snow bunting	Scat	8912809	541075	80.2728	-60.8219
Washington	WaNL097	2015-08-16	Arctic fox	Scat	8912839	541055	80.2731	-60.8229
Washington	WaNL098	2015-08-16	Hare	Fur	8912959	540994	80.2742	-60.8258

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaNL099	2015-08-16	Arctic fox	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL100	2015-08-16	Hare	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL103	2015-08-16	Snow bunting	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL104	2015-08-16	Arctic fox	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL105	2015-08-16	Ptarmigan	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL106	2015-08-16	Ptarmigan	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL107	2015-08-16	Snow bunting	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL108	2015-08-16	Hare	Bone	8913246	540671	80.2769	-60.8424
Washington	WaNL109	2015-08-16	Wolf	Scat	8913246	540671	80.2769	-60.8424
Washington	WaNL110	2015-08-16	Snow bunting	Scat	8913244	540624	80.2769	-60.8449
Washington	WaNL111	2015-08-16	Arctic fox	Scat	8913244	540624	80.2769	-60.8449
Washington	WaNL112	2015-08-16	Snow bunting	Scat	8912912	540552	80.2739	-60.8494
Washington	WaNL113	2015-08-16	Hare	Scat	8912912	540552	80.2739	-60.8494
Washington	WaNL114	2015-08-16	Hare	Scat	8912912	540552	80.2739	-60.8494
Washington	WaNL115	2015-08-16	Arctic fox	Scat	8912739	540381	80.2724	-60.8588
Washington	WaNL116	2015-08-16	Hare	Scat	8912739	540381	80.2724	-60.8588
Washington	WaNL117	2015-08-16	Ptarmigan	Scat	8912739	540381	80.2724	-60.8588
Washington	WaNL118	2015-08-16	Snowy owl	Pellet	8912747	540458	80.2725	-60.8547
Washington	WaNL119	2015-08-16	Ptarmigan	Scat	8912747	540458	80.2725	-60.8547
Washington	WaNL120	2015-08-16	Hare	Fur	8912729	540459	80.2723	-60.8546
Washington	WaNL121	2015-08-16	Hare	Scat	8912729	540459	80.2723	-60.8546
Washington	WaNL122	2015-08-16	Hare	Scat	8912569	540352	80.2709	-60.8606
Washington	WaNL123	2015-08-16	Ptarmigan	Scat	8912569	540352	80.2709	-60.8606
Washington	WaNL124	2015-08-16	Arctic fox	Scat	8912569	540352	80.2709	-60.8606
Washington	WaNL125	2015-08-16	Ptarmigan	Scat	8912569	540352	80.2709	-60.8606
Washington	WaNL126	2015-08-16	Hare	Scat	8912569	540352	80.2709	-60.8606
Washington	WaNL127	2015-08-16	Ptarmigan	Scat	8912569	540352	80.2709	-60.8606
Washington	WaNL128	2015-08-16	Hare	Scat	8912569	540352	80.2709	-60.8606
Washington	WaNL129	2015-08-16	Hare	Scat	8912344	540245	80.2689	-60.8667
Washington	WaNL130	2015-08-16	Arctic fox	Scat	8912344	540245	80.2689	-60.8667
Washington	WaNL131	2015-08-16	Unk mammal	bone	8912202	540155	80.2677	-60.8718
Washington	WaNL132	2015-08-16	Arctic fox	Scat	8912202	540155	80.2677	-60.8718
Washington	WaNL133	2015-08-16	Hare	Scat	8912202	540155	80.2677	-60.8718
Washington	WaNL134	2015-08-16	Snow bunting	Feather	8912154	540137	80.2673	-60.8728
Washington	WaNL135	2015-08-16	Snow bunting	Scat	8912154	540137	80.2673	-60.8728
Washington	WaNL136	2015-08-16	Arctic fox	Scat	8912154	540137	80.2673	-60.8728
Washington	WaNL137	2015-08-16	Arctic fox	Scat	8912154	540137	80.2673	-60.8728
Washington	WaNL138	2015-08-16	Snowy owl	Feather	8912154	540137	80.2673	-60.8728
Washington	WaNL139	2015-08-16	Snow bunting	Feather	8912154	540137	80.2673	-60.8728
Washington	WaNL140	2015-08-16	Arctic fox	Scat	8912154	540137	80.2673	-60.8728
Washington	WaNL141	2015-08-16	Snow bunting	Feather	8912154	540137	80.2673	-60.8728
Washington	WaNL142	2015-08-16	Ptarmigan	Scat	8912154	540137	80.2673	-60.8728
Washington	WaNL143	2015-08-16	Snow bunting	Scat	8912146	540175	80.2672	-60.8708
Washington	WaNL144	2015-08-16	Snow bunting	Feather	8912146	540175	80.2672	-60.8708
Washington	WaNL145	2015-08-16	Hare	Scat	8912146	540175	80.2672	-60.8708
Washington	WaNL146	2015-08-16	Snow bunting	Feather	8912146	540175	80.2672	-60.8708

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaNL147	2015-08-16	Arctic fox	Scat	8912146	540175	80.2672	-60.8708
Washington	WaNL148	2015-08-16	Hare	Scat	8912146	540175	80.2672	-60.8708
Washington	WaNL149	2015-08-16	Hare	Bone	8912146	540175	80.2672	-60.8708
Washington	WaNL151	2015-08-16	Arctic fox	Scat	8912146	540175	80.2672	-60.8708
Washington	WaNL152	2015-08-16	Arctic fox	Scat	8912146	540175	80.2672	-60.8708
Washington	WaNL153	2015-08-16	Hare	Fur & Skin	8912146	540175	80.2672	-60.8708
Washington	WaNL154	2015-08-16	Arctic fox	Scat	8912106	540098	80.2669	-60.8750
Washington	WaNL155	2015-08-16	Hare	Scat	8912106	540098	80.2669	-60.8750
Washington	WaNL156	2015-08-16	Ptarmigan	Scat	8912106	540098	80.2669	-60.8750
Washington	WaNL157	2015-08-16	Snow bunting	Feather	8912106	540098	80.2669	-60.8750
Washington	WaNL158	2015-08-16	Snow bunting	Scat	8912106	540098	80.2669	-60.8750
Washington	WaNL159	2015-08-16	Hare	Bone	8912106	540098	80.2669	-60.8750
Washington	WaNL160	2015-08-16	Arctic fox	Fur	8912106	540098	80.2669	-60.8750
Washington	WaNL161	2015-08-16	Ptarmigan	Scat	8912106	540098	80.2669	-60.8750
Washington	WaNL162	2015-08-16	Snow bunting	Scat	8912106	540098	80.2669	-60.8750
Washington	WaNL163	2015-08-16	Hare	Scat	8912106	540098	80.2669	-60.8750
Washington	WaNL164	2015-08-16	Arctic fox	Scat	8912066	539948	80.2666	-60.8830
Washington	WaNL165	2015-08-16	Hare	Fur	8912100	540090	80.2668	-60.8754
Washington	WaNL166	2015-08-16	Hare	Scat	8911956	540076	80.2655	-60.8764
Washington	WaNL167	2015-08-16	Arctic fox	Scat	8911560	540857	80.2617	-60.8359
Washington	WaNL168	2015-08-17	Hare	Fur	8910377	541863	80.2508	-60.7850
Washington	WaNL169	2015-08-17	Hare	Scat	8910377	541863	80.2508	-60.7850
Washington	WaNL170	2015-08-17	Snow bunting	Scat	8910377	541863	80.2508	-60.7850
Washington	WaNL171	2015-08-17	Ptarmigan	Scat	8910192	541995	80.2491	-60.7784
Washington	WaNL172	2015-08-17	Snow bunting	Scat	8910192	541995	80.2491	-60.7784
Washington	WaNL173	2015-08-17	Arctic fox	Scat	8910192	541995	80.2491	-60.7784
Washington	WaNL174	2015-08-17	Arctic fox	Scat	8909818	542047	80.2457	-60.7764
Washington	WaNL175	2015-08-17	Muskoxen	Scat	8909488	542128	80.2427	-60.7728
Washington	WaNL176	2015-08-17	Muskoxen	Scat	8909407	541981	80.2421	-60.7807
Washington	WaNL177	2015-08-17	Arctic fox	Scat	8909407	541981	80.2421	-60.7807
Washington	WaNL178	2015-08-17	Snowy owl	Pellet	8909407	541981	80.2421	-60.7807
Washington	WaNL179	2015-08-17	Hare	Fur	8909407	541981	80.2421	-60.7807
Washington	WaNL180	2015-08-17	Wolf	Scat	8909407	541981	80.2421	-60.7807
Washington	WaNL181	2015-08-17	Arctic fox	Scat	8909407	541981	80.2421	-60.7807
Washington	WaNL182	2015-08-17	Arctic fox	Scat	8909178	541984	80.2400	-60.7810
Washington	WaNL183	2015-08-17	Hare	Bone	8909265	543122	80.2404	-60.7208
Washington	WaNL184	2015-08-17	Muskoxen	Scat	8909265	543122	80.2404	-60.7208
Washington	WaNL185	2015-08-17	Jaeger	Pellet	8909265	543122	80.2404	-60.7208
Washington	WaNL186	2015-08-17	Arctic fox	Scat	8909265	543122	80.2404	-60.7208
Washington	WaNL187	2015-08-17	Snowy owl	Pellet	8908753	543106	80.2358	-60.7227
Washington	WaNL188	2015-08-17	Sandpiper	Wing	8908407	543013	80.2328	-60.7283
Washington	WaNL189	2015-08-17	Hare	Leg	8908407	543013	80.2328	-60.7283
Washington	WaNL190	2015-08-17	Snowy owl	Feather	8908084	542941	80.2299	-60.7328
Washington	WaNL191	2015-08-17	Muskoxen	Scat	8908084	542941	80.2299	-60.7328
Washington	WaNL192	2015-08-17	Arctic fox	Scat	8908084	542941	80.2299	-60.7328
Washington	WaNL191b	2015-08-17	Lemming	Scat	8908084	542941	80.2299	-60.7328

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaNL193	2015-08-17	Lemming	Fur	8908084	542941	80.2299	-60.7328
Washington	WaNL194	2015-08-17	Muskoxen	Scat	8908084	542941	80.2299	-60.7328
Washington	WaNL195	2015-08-17	Muskoxen	Fur	8908084	542941	80.2299	-60.7328
Washington	WaNL196	2015-08-17	Wolf	Scat	8907268	540447	80.2234	-60.8659
Washington	WaNL197	2015-08-17	caribou	Scat	8907268	540447	80.2234	-60.8659
Washington	WaNL198	2015-08-17	Arctic fox	Scat	8908230	538467	80.2327	-60.9685
Washington	WaNL199	2015-08-17	Wolf	Scat	8908230	538467	80.2327	-60.9685
Washington	WaNL200	2015-08-17	Snow bunting	Scat	8908230	538467	80.2327	-60.9685
Washington	WaNL201	2015-08-17	Snow bunting	Scat	8909057	537375	80.2404	-61.0247
Washington	WaNL202	2015-08-17	Snow bunting	Feather	8909057	537375	80.2404	-61.0247
Washington	WaNL203	2015-08-17	Lemming	Scat	8909655	539065	80.2453	-60.9343
Washington	WaNL204	2015-08-17	Muskoxen	Scat	8909740	539075	80.2460	-60.9336
Washington	WaNL205	2015-08-17	Muskoxen	Scat	8909740	539075	80.2460	-60.9336
Washington	WaNL206	2015-08-17	Goose	Scat	8909740	539075	80.2460	-60.9336
Washington	WaNL207	2015-08-17	Unk mammal	bone	8909740	539075	80.2460	-60.9336
Washington	WaTM002	2015-08-15	Wolf	Scat	8911625	543986	80.2612	-60.6702
Washington	WaTM003	2015-08-15	Hare	Scat	8911625	543986	80.2612	-60.6702
Washington	WaTM004	2015-08-15	Muskoxen	Bone	8911584	544041	80.2608	-60.6673
Washington	WaTM005	2015-08-15	Arctic fox	Scat	8911584	544041	80.2608	-60.6673
Washington	WaTM006	2015-08-15	Hare	Bone	8911599	544192	80.2609	-60.6593
Washington	WaTM007	2015-08-15	Hare	Bone	8911587	544628	80.2607	-60.6363
Washington	WaTM008	2015-08-15	Snowy owl	Pellet	8911599	544775	80.2607	-60.6285
Washington	WaTM009	2015-08-15	Hare	Bone	8911613	544845	80.2608	-60.6247
Washington	WaTM010	2015-08-15	Lemming	Scat	8911613	544845	80.2608	-60.6247
Washington	WaTM011	2015-08-15	Ptarmigan	Scat	8911613	544845	80.2608	-60.6247
Washington	WaTM012	2015-08-15	Snowy owl	Pellet	8911613	544845	80.2608	-60.6247
Washington	WaTM013	2015-08-15	Snowy owl	Pellet	8911613	544845	80.2608	-60.6247
Washington	WaTM014	2015-08-15	Arctic fox	Scat	8911613	544845	80.2608	-60.6247
Washington	WaTM015	2015-08-15	Ptarmigan	Scat	8911613	544845	80.2608	-60.6247
Washington	WaTM016	2015-08-15	Snowy owl	Pellet	8911630	544944	80.2609	-60.6195
Washington	WaTM017	2015-08-15	Ptarmigan	Scat	8911630	544944	80.2609	-60.6195
Washington	WaTM018	2015-08-15	Hare	Fur	8911630	544944	80.2609	-60.6195
Washington	WaTM019	2015-08-15	Goose	Feather	8911630	544944	80.2609	-60.6195
Washington	WaTM020	2015-08-15	Unk mammal	Bone	8912677	545186	80.2702	-60.6044
Washington	WaTM021	2015-08-15	Hare	Bone	8911588	542482	80.2614	-60.7498
Washington	WaTM022	2015-08-16	Arctic fox	Scat	8911182	541860	80.2580	-60.7836
Washington	WaTM023	2015-08-16	Arctic fox	Scat	8911053	542037	80.2568	-60.7745
Washington	WaTM024	2015-08-16	Arctic fox	Scat	8911053	542037	80.2568	-60.7745
Washington	WaTM025	2015-08-16	Arctic fox	Scat	8910973	542107	80.2560	-60.7709
Washington	WaTM026	2015-08-16	Muskoxen	Scat	8910973	542107	80.2560	-60.7709
Washington	WaTM027	2015-08-16	Arctic fox	Scat	8910973	542107	80.2560	-60.7709
Washington	WaTM028	2015-08-16	Muskoxen	Scat	8910973	542107	80.2560	-60.7709
Washington	WaTM029	2015-08-16	Arctic fox	Scat	8910973	542107	80.2560	-60.7709
Washington	WaTM030	2015-08-16	Muskoxen	Scat	8910949	542468	80.2557	-60.7519
Washington	WaTM031	2015-08-16	Arctic fox	Scat	8910949	542468	80.2557	-60.7519
Washington	WaTM032	2015-08-16	Snowy owl	Pellet	8910904	542508	80.2553	-60.7498

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaTM033	2015-08-16	Lemming	bone	8910904	542508	80.2553	-60.7498
Washington	WaTM034	2015-08-16	Arctic fox	Scat	8910904	542508	80.2553	-60.7498
Washington	WaTM035	2015-08-16	Ptarmigan	Scat	8910904	542508	80.2553	-60.7498
Washington	WaTM036	2015-08-16	Jaeger	Pellet	8910904	542508	80.2553	-60.7498
Washington	WaTM037	2015-08-16	Hare	Scat	8910930	542594	80.2555	-60.7452
Washington	WaTM038	2015-08-16	Lemming	bone	8910930	542594	80.2555	-60.7452
Washington	WaTM039	2015-08-16	Arctic fox	Scat	8910920	542763	80.2553	-60.7363
Washington	WaTM040	2015-08-16	Ptarmigan	Scat	8910913	542806	80.2553	-60.7341
Washington	WaTM041	2015-08-16	Muskoxen	Scat	8910925	542845	80.2554	-60.7320
Washington	WaTM042	2015-08-16	Arctic fox	Scat	8911050	543180	80.2564	-60.7140
Washington	WaTM043	2015-08-16	Arctic fox	Scat	8911050	543180	80.2564	-60.7140
Washington	WaTM044	2015-08-16	Arctic fox	Scat	8911082	543235	80.2566	-60.7110
Washington	WaTM046	2015-08-16	Snowbunting	Scat	8911082	543235	80.2566	-60.7110
Washington	WaTM047	2015-08-16	Lemming	bone	8911082	543234	80.2566	-60.7111
Washington	WaTM048	2015-08-16	Lemming	bone	8911082	543234	80.2566	-60.7111
Washington	WaTM049	2015-08-16	Lemming	bone	8911082	543234	80.2566	-60.7111
Washington	WaTM050	2015-08-16	Lemming	bone	8911082	543234	80.2566	-60.7111
Washington	WaTM051	2015-08-16	Arctic fox	Scat	8911166	543415	80.2573	-60.7013
Washington	WaTM052	2015-08-16	Ptarmigan	Scat	8911166	543415	80.2573	-60.7013
Washington	WaTM053	2015-08-16	Hare	Scat	8911166	543415	80.2573	-60.7013
Washington	WaTM054	2015-08-16	Ptarmigan	Scat	8911166	543415	80.2573	-60.7013
Washington	WaTM055	2015-08-16	Arctic fox	Scat	8911388	543636	80.2592	-60.6892
Washington	WaTM056	2015-08-16	Lemming	Bone	8911388	543636	80.2592	-60.6892
Washington	WaTM057	2015-08-16	Snowbunting	Scat	8911388	543636	80.2592	-60.6892
Washington	WaTM058	2015-08-16	Snowy owl	Pellet	8911388	543636	80.2592	-60.6892
Washington	WaTM059	2015-08-16	Ptarmigan	Scat	8911416	543721	80.2594	-60.6846
Washington	WaTM060	2015-08-16	Arctic fox	Scat	8911416	543721	80.2594	-60.6846
Washington	WaTM061	2015-08-16	Lemming	Bone	8911416	543721	80.2594	-60.6846
Washington	WaTM062	2015-08-16	Arctic fox	Scat	8911421	543748	80.2595	-60.6832
Washington	WaTM063	2015-08-16	Lemming	Bone	8911466	543821	80.2599	-60.6792
Washington	WaTM064	2015-08-16	Muskoxen	Scat	8911628	544110	80.2612	-60.6636
Washington	WaTM065	2015-08-16	Arctic fox	Scat	8911584	544187	80.2608	-60.6596
Washington	WaTM066	2015-08-16	Hare	Bone	8911584	544187	80.2608	-60.6596
Washington	WaTM067	2015-08-16	Snowy owl	Pellet	8911584	544187	80.2608	-60.6596
Washington	WaTM068	2015-08-16	Lemming	Bone	8911584	544187	80.2608	-60.6596
Washington	WaTM069	2015-08-16	Lemming	Bone	8911584	544187	80.2608	-60.6596
Washington	WaTM070	2015-08-16	Snowy owl	Pellet	8911770	544629	80.2623	-60.6358
Washington	WaTM071	2015-08-16	Arctic fox	Scat	8911770	544629	80.2623	-60.6358
Washington	WaTM072	2015-08-16	Ptarmigan	Scat	8911770	544629	80.2623	-60.6358
Washington	WaTM073	2015-08-16	Hare	Pellet	8911879	544898	80.2632	-60.6214
Washington	WaTM074	2015-08-16	Unk mammal	Bone	8911750	545000	80.2620	-60.6162
Washington	WaTM075	2015-08-16	Arctic fox	Scat	8911750	545000	80.2620	-60.6162
Washington	WaTM076	2015-08-16	Ptarmigan	Scat	8911750	545000	80.2620	-60.6162
Washington	WaTM077	2015-08-16	Arctic fox	Scat	8911654	545166	80.2611	-60.6077
Washington	WaTM088	2015-08-16	Arctic fox	Scat	8911647	545234	80.2610	-60.6041
Washington	WaTM089	2015-08-16	Snowy owl	Pellet	8911520	545538	80.2597	-60.5883

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Site	Sample	Date	Species	Type	North	East	Lat	Long
Washington	WaTM090	2015-08-16	Arctic fox	Scat	8911520	545538	80.2597	-60.5883
Washington	WaTM091	2015-08-16	Lemming	Scat	8911520	545538	80.2597	-60.5883
Washington	WaTM092	2015-08-16	Muskoxen	Scat	8911487	545926	80.2593	-60.5678
Washington	WaTM093	2015-08-16	Snowbunting	Scat	8911493	546025	80.2593	-60.5626
Washington	WaTM094	2015-08-16	Arctic fox	Scat	8911493	546025	80.2593	-60.5626
Washington	WaTM095	2015-08-16	Hare	Carcass	8911537	546180	80.2596	-60.5543
Washington	WaTM096	2015-08-16	Muskoxen	Scat	8911537	546180	80.2596	-60.5543
Washington	WaTM097	2015-08-16	Wolf	Scat	8911621	546278	80.2603	-60.5489
Washington	WaTM098	2015-08-16	Goose	Scat	8911621	546278	80.2603	-60.5489
Washington	WaTM099	2015-08-16	Goose	Feather	8911621	546278	80.2603	-60.5489
Washington	WaTM100	2015-08-16	Arctic fox	Scat	8911621	546278	80.2603	-60.5489
Washington	WaTM101	2015-08-16	Goose	Scat	8911621	546278	80.2603	-60.5489
Washington	WaTM102	2015-08-16	Goose	Scat	8911621	546278	80.2603	-60.5489
Washington	WaTM103	2015-08-16	Goose	Scat	8911621	546278	80.2603	-60.5489
Washington	WaTM104	2015-08-16	Arctic fox	Scat	8912822	545590	80.2714	-60.5827
Washington	WaTM105	2015-08-16	Muskoxen	Scat	8912822	545590	80.2714	-60.5827
Washington	WaTM106	2015-08-16	Wolf	Scat	8912822	545590	80.2714	-60.5827
Washington	WaTM107	2015-08-16	Muskoxen	Scat	8912879	545556	80.2719	-60.5843
Washington	WaTM108	2015-08-16	Lemming	Bone	8912879	545556	80.2719	-60.5843
Washington	WaTM109	2015-08-16	Snowbunting	Scat	8912879	545556	80.2719	-60.5843
Washington	WaTM110	2015-08-16	Snowy owl	Pellet	8912879	545556	80.2719	-60.5843
Washington	WaTM111	2015-08-16	Arctic fox	Scat	8913402	544899	80.2768	-60.6180
Washington	WaTM112	2015-08-16	Ptarmigan	Scat	8913402	544899	80.2768	-60.6180
Washington	WaTM113	2015-08-16	Arctic fox	Scat	8912896	543508	80.2728	-60.6928
Washington	WaTM114	2015-08-16	Arctic fox	Scat	8912407	543161	80.2685	-60.7122
Washington	WaTM115	2015-08-16	Hare	Scat	8912407	543161	80.2685	-60.7122
Washington	WaTM116	2015-08-16	Hare	Bone	8913367	543122	80.2771	-60.7123
Washington	WaTM116	2015-08-16	Arctic fox	Scat	8913367	543122	80.2771	-60.7123
Washington	WaTM117	2015-08-16	Muskoxen	Scat	8911466	542207	80.2604	-60.7646
Washington	WaTM118	2015-08-16	Hare	Scat	8911388	541962	80.2598	-60.7777
Washington	WaTM119	2015-08-17	Hare	Scat	8909661	538555	80.2455	-60.9612
Washington	WaTM120	2015-08-17	Unk mammal	Bone	8910243	540893	80.2499	-60.8366

Table TB-7. Location (UTM Zone 20N and Lat/Long), altitude, depth (cm) and collection date for soil samples.

Site	Date	Core site	Northing	Easting	Lat	Long	Alt	Depth
Hall	2015-08-07	Core1	9061075	546978	81.5975	-60.1192	299	5
Hall	2015-08-07	Core1	9061075	546978	81.5975	-60.1192	299	15
Hall	2015-08-07	Core1	9061075	546978	81.5975	-60.1192	299	25
Hall	2015-08-07	Core1	9061075	546978	81.5975	-60.1192	299	35
Hall	2015-08-07	Core1	9061075	546978	81.5975	-60.1192	299	50
Hall	2015-08-09	Core2	9057530	537831	81.5695	-60.6881	90	5
Hall	2015-08-09	Core2	9057530	537831	81.5695	-60.6881	90	13
Hall	2015-08-09	Core2	9057530	537831	81.5695	-60.6881	90	25
Hall	2015-08-09	Core2	9057530	537831	81.5695	-60.6881	90	35
Hall	2015-08-09	Core3	9057530	539640	81.5688	-60.5776	133	0
Hall	2015-08-09	Core3	9057530	539640	81.5688	-60.5776	133	5
Hall	2015-08-09	Core3	9057530	539640	81.5688	-60.5776	133	15
Hall	2015-08-09	Core4	9057275	539192	81.5667	-60.6056	131	0
Hall	2015-08-09	Core4	9057275	539192	81.5667	-60.6056	131	10
Hall	2015-08-09	Core4	9057275	539192	81.5667	-60.6056	131	20
Hall	2015-08-10	Core5	9060274	542910	81.5921	-60.3705	111	5
Hall	2015-08-10	Core5	9060274	542910	81.5921	-60.3705	111	15
Hall	2015-08-10	Core5	9060274	542910	81.5921	-60.3705	111	25
Hall	2015-08-10	Core6	9059658	542938	81.5866	-60.3705	136	5
Hall	2015-08-10	Core6	9059658	542938	81.5866	-60.3705	136	15
Hall	2015-08-10	Core6	9059658	542938	81.5866	-60.3705	136	25
Hall	2015-08-11	Core7	9061024	541988	81.5992	-60.4249	95	5
Hall	2015-08-11	Core7	9061024	541988	81.5992	-60.4249	95	15
Hall	2015-08-11	Core7	9061024	541988	81.5992	-60.4249	95	25
Hall	2015-08-11	Core8	9061971	548085	81.6051	-60.0486	155	5
Hall	2015-08-11	Core8	9061971	548085	81.6051	-60.0486	155	5
Hall	2015-08-11	Core8	9061971	548085	81.6051	-60.0486	155	15
Hall	2015-08-11	Core8	9061971	548085	81.6051	-60.0486	155	25
Hall	2015-08-11	Core9	9062852	548420	81.6128	-60.0253	124	5
Hall	2015-08-11	Core9	9062852	548420	81.6128	-60.0253	124	15
Hall	2015-08-11	Core10	9062468	545931	81.6105	-60.1791	123	5
Hall	2015-08-11	Core10	9062468	545931	81.6105	-60.1791	123	15
Hall	2015-08-11	Core10	9062468	545931	81.6105	-60.1791	123	25
Hall	2015-08-11	Core10	9062468	545931	81.6105	-60.1791	123	35
Hall	2015-08-11	Core10	9062468	545931	81.6105	-60.1791	123	50
Hall	2015-08-06	Core11	9061847	537882	81.6081	-60.6744	88	10
Hall	2015-08-06	Core11	9061847	537882	81.6081	-60.6744	88	20
Hall	2015-08-06	Core11	9061847	537882	81.6081	-60.6744	88	30
Hall	2015-08-06	Core11	9061847	537882	81.6081	-60.6744	88	40
Hall	2015-08-06	Core11	9061847	537882	81.6081	-60.6744	88	55
Hall	2015-08-06	Core12	9061902	537922	81.6086	-60.6718	86	10
Hall	2015-08-06	Core12	9061902	537922	81.6086	-60.6718	86	25
Hall	2015-08-06	Core12	9061902	537922	81.6086	-60.6718	86	40
Hall	2015-08-06	Core12	9061902	537922	81.6086	-60.6718	86	55
Washington	2015-08-15	Core13	8912461	545362	80.2682	-60.5955	297	5

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Site	Date	Core site	Northing	Easting	Lat	Long	Alt	Depth
Washington	2015-08-15	Core13	8912461	545362	80.2682	-60.5955	297	15
Washington	2015-08-15	Core13	8912461	545362	80.2682	-60.5955	297	25
Washington	2015-08-15	Core13	8912461	545362	80.2682	-60.5955	297	35
Washington	2015-08-15	Core13	8912461	545362	80.2682	-60.5955	297	45
Hall	2015-08-04	H2-1	9061090	539232	81.6009	-60.5935	90	5
Hall	2015-08-04	H2-2	9061328	539296	81.6030	-60.5890	92	5
Hall	2015-08-04	H2-3	9061579	539277	81.6052	-60.5895	90	5
Hall	2015-08-04	H2-4	9061829	539240	81.6075	-60.5911	91	5
Hall	2015-08-04	H2-5	9062081	539214	81.6097	-60.5921	80	5
Hall	2015-08-12	H4-1	9063561	538785	81.6231	-60.6147	97	5
Hall	2015-08-12	H4-2	9063796	538918	81.6252	-60.6059	99	5
Hall	2015-08-12	H4-3	9064042	538962	81.6274	-60.6026	103	5
Hall	2015-08-12	H4-4	9064288	539016	81.6296	-60.5986	106	5
Hall	2015-08-12	H4-5	9064534	539069	81.6317	-60.5947	109	5
Hall	2015-08-05	H5-1	9066970	538862	81.6536	-60.6013	123	5
Hall	2015-08-05	H5-2	9069668	539105	81.6777	-60.5793	116	5
Hall	2015-08-05	H5-3	9066938	539353	81.6532	-60.5711	123	5
Hall	2015-08-05	H5-4	9066922	539605	81.6529	-60.5556	123	5
Hall	2015-08-05	H5-5	9066907	539851	81.6527	-60.5405	120	5
Hall	2015-08-09	H6-1	9063481	534010	81.6241	-60.9082	93	5
Hall	2015-08-09	H6-2	9063219	534117	81.6217	-60.9022	96	5
Hall	2015-08-09	H6-3	9062966	534118	81.6194	-60.9027	85	5
Hall	2015-08-09	H6-4	9062717	534132	81.6172	-60.9024	85	5
Hall	2015-08-09	H6-5	9062467	534141	81.6150	-60.9024	82	5
Hall	2015-08-10	H9-1	9059910	542869	81.5889	-60.3740	132	5
Hall	2015-08-10	H9-2	9059766	542619	81.5877	-60.3897	124	5
Hall	2015-08-10	H9-3	9059621	542531	81.5864	-60.3955	129	5
Hall	2015-08-10	H9-4	9059560	542275	81.5860	-60.4113	130	5
Hall	2015-08-10	H9-5	9059465	542045	81.5852	-60.4256	127	5
Hall	2015-08-12	H12-1	9063312	543656	81.6190	-60.3162	133	5
Hall	2015-08-12	H12-2	9063422	543955	81.6199	-60.2975	135	5
Hall	2015-08-12	H12-3	9063520	544190	81.6206	-60.2828	140	5
Hall	2015-08-12	H12-4	9063664	544395	81.6218	-60.2698	144	5
Hall	2015-08-12	H12-5	9063749	544635	81.6225	-60.2548	147	5
Hall	07/08/2015	H13-1	9059908	535478	81.5916	-60.8263	192	5
Hall	07/08/2015	H13-2	9061118	547256	81.5978	-60.1020	238	5
Hall	07/08/2015	H13-3	9061362	547311	81.6000	-60.0979	161	5
Hall	07/08/2015	H13-4	9061600	547322	81.6021	-60.0965	138	5
Hall	07/08/2015	H13-5	9061852	547323	81.6043	-60.0956	137	5
Hall	2015-08-08	H14-1	9067334	545114	81.6544	-60.2148	95	5
Hall	2015-08-08	H14-2	9067386	545370	81.6547	-60.1989	94	5
Hall	2015-08-08	H14-3	9067449	545617	81.6552	-60.1835	107	5
Hall	2015-08-08	H14-4	9067474	545869	81.6553	-60.1679	101	5
Hall	2015-08-08	H14-5	9067457	546122	81.6550	-60.1523	107	5
Hall	06/08/2015	H17-1	9059908	535478	81.5916	-60.8263	75	5
Hall	06/08/2015	H17-2	9059682	535373	81.5896	-60.8332	72	5

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Site	Date	Core site	Northing	Easting	Lat	Long	Alt	Depth
Hall	06/08/2015	H17-3	9059449	535273	81.5876	-60.8399	71	5
Hall	06/08/2015	H17-4	9059225	535167	81.5856	-60.8469	83	5
Hall	06/08/2015	H17-5	9058984	535090	81.5835	-60.8521	74	5
Hall	06/08/2015	H18-1	9059908	535478	81.5916	-60.8263	99	5
Hall	06/08/2015	H18-2	9057142	537548	81.5661	-60.7063	84	5
Hall	06/08/2015	H18-3	9057006	537336	81.5650	-60.7196	84	5
Hall	06/08/2015	H18-4	9056901	537106	81.5641	-60.7338	90	5
Hall	06/08/2015	H18-5	9056875	536857	81.5640	-60.7491	86	5
Washington	16/08/2015	Wa1-1	8912493	542378	80.2696	-60.7535	342	5
Washington	16/08/2015	Wa1-2	8912514	542625	80.2697	-60.7404	328	5
Washington	16/08/2015	Wa1-3	8912526	542880	80.2697	-60.7268	332	5
Washington	16/08/2015	Wa1-4	8912539	543135	80.2697	-60.7133	338	5
Washington	16/08/2015	Wa1-5	8912558	543391	80.2698	-60.6997	327	5
Washington	2015-08-17	Wa2-1	8911625	539950	80.2626	-60.8837	352	5
Washington	2015-08-17	Wa2-2	8911637	539691	80.2628	-60.8974	358	5
Washington	2015-08-17	Wa2-3	8911647	539439	80.2630	-60.9107	359	5
Washington	2015-08-17	Wa2-4	8911607	539187	80.2627	-60.9242	361	5
Washington	2015-08-17	Wa2-5	8911565	538935	80.2624	-60.9376	364	5
Washington	16/08/2015	Wa3-1	8912267	544054	80.2669	-60.6652	297	5
Washington	16/08/2015	Wa3-2	8912014	544025	80.2647	-60.6673	286	5
Washington	16/08/2015	Wa3-3	8911764	544010	80.2625	-60.6686	308	5
Washington	16/08/2015	Wa3-4	8911513	543999	80.2602	-60.6697	320	5
Washington	16/08/2015	Wa3-5	8911260	543982	80.2580	-60.6712	351	5
Washington	2015-08-15	Wa4-1	8911744	545089	80.2619	-60.6115	298	5
Washington	2015-08-15	Wa4-2	8911993	545072	80.2641	-60.6119	297	5
Washington	2015-08-15	Wa4-3	8912273	545058	80.2666	-60.6120	297	5
Washington	2015-08-15	Wa4-4	8912503	545026	80.2687	-60.6132	295	5
Washington	2015-08-15	Wa4-5	8912749	544991	80.2709	-60.6146	300	5
Washington	2015-08-17	Wa5-1	8910161	538668	80.2499	-60.9543	368	5
Washington	2015-08-17	Wa5-2	8909917	538614	80.2477	-60.9576	369	5
Washington	2015-08-17	Wa5-3	8909662	538555	80.2455	-60.9612	359	5
Washington	2015-08-17	Wa5-4	8909383	538487	80.2430	-60.9653	362	5
Washington	2015-08-17	Wa5-5	8909101	538357	80.2405	-60.9727	373	5
Washington	2015-08-17	Wa6-1	8914907	545040	80.2902	-60.6073	439	5
Washington	2015-08-17	Wa6-2	8914873	544790	80.2900	-60.6206	438	5
Washington	2015-08-17	Wa6-3	8914868	544533	80.2901	-60.6342	418	5
Washington	2015-08-17	Wa6-4	8914821	544284	80.2897	-60.6475	442	5
Washington	2015-08-17	Wa6-5	8914770	544039	80.2894	-60.6607	434	5
Washington	2015-08-17	Wa7-1	8907422	540002	80.2250	-60.8891	529	5
Washington	2015-08-17	Wa7-2	8907202	539814	80.2231	-60.8994	533	5
Washington	2015-08-17	Wa7-3	8907181	539532	80.2230	-60.9143	537	5
Washington	2015-08-17	Wa7-4	8907191	539287	80.2231	-60.9272	541	5
Washington	2015-08-17	Wa7-5	8907166	539038	80.2230	-60.9404	544	5
Washington	2015-08-17	Wa8-1	8907575	542760	80.2254	-60.7434	529	5
Washington	2015-08-17	Wa8-2	8907422	543674	80.2237	-60.6955	517	5
Washington	2015-08-17	Wa8-3	8907422	543674	80.2237	-60.6955	492	5

Cruise Report

Site	Date	Core site	Northing	Easting	Lat	Long	Alt	Depth
Washington	2015-08-17	Wa8-4	8907422	543519	80.2238	-60.7037	492	5
Washington	2015-08-17	Wa8-5	8907422	543674	80.2237	-60.6955	488	5
Washington	2015-08-17	Wa9-1	8916673	545864	80.3057	-60.5596	443	5
Washington	2015-08-17	Wa9-2	8916423	545864	80.3035	-60.5601	439	5
Washington	2015-08-17	Wa9-3	8916168	545863	80.3012	-60.5608	416	5
Washington	2015-08-17	Wa9-4	8915918	545885	80.2990	-60.5601	415	5
Washington	2015-08-17	Wa9-5	8915672	545843	80.2968	-60.5629	406	5
Washington	2015-08-17	Wa10-1	8909440	536043	80.2443	-61.0943	572	5
Washington	2015-08-17	Wa10-2	8909213	536050	80.2422	-61.0944	574	5
Washington	2015-08-17	Wa10-3	8908965	536068	80.2400	-61.0938	577	5
Washington	2015-08-17	Wa10-4	8908716	536074	80.2378	-61.0940	580	5
Washington	2015-08-17	Wa10-5	8908467	536114	80.2355	-61.0923	582	5
Ellesmere	2015-08-20	EI11-1	9043507	461362	81.4437	-65.3268	302	5
Ellesmere	2015-08-20	EI11-2	9043459	461107	81.4432	-65.3420	294	5
Ellesmere	2015-08-20	EI11-3	9043427	460876	81.4428	-65.3558	279	5
Ellesmere	2015-08-20	EI11-4	9043455	460612	81.4430	-65.3718	270	5
Ellesmere	2015-08-20	EI11-5	9043410	460364	81.4425	-65.3866	258	5
Ellesmere	2015-08-22	EI5-1	9037428	457436	81.3878	-65.5468	289	5
Ellesmere	2015-08-22	EI5-2	9037681	457466	81.3901	-65.5457	298	5
Ellesmere	2015-08-22	EI5-3	9037931	457486	81.3923	-65.5452	300	5
Ellesmere	2015-08-22	EI5-4	9038181	457503	81.3946	-65.5448	295	5
Ellesmere	2015-08-22	EI5-5	9038432	457313	81.3967	-65.5568	296	5
Ellesmere	2015-08-23	EI20-1	9041322	465256	81.4255	-65.0878	224	5
Ellesmere	2015-08-23	EI20-2	9041279	465007	81.4250	-65.1026	233	5
Ellesmere	2015-08-23	EI20-3	9041291	464739	81.4250	-65.1187	179	5
Ellesmere	2015-08-23	EI20-4	9041261	464521	81.4247	-65.1318	166	5
Ellesmere	2015-08-23	EI20-5	9041261	464259	81.4246	-65.1475	162	5
Ellesmere	2015-08-20	EI14-1	9037035	462043	81.3860	-65.2706	175	5
Ellesmere	2015-08-20	EI14-2	9037152	462249	81.3871	-65.2585	173	5
Ellesmere	2015-08-20	EI14-3	9037277	462475	81.3883	-65.2453	173	5
Ellesmere	2015-08-20	EI14-4	9037435	462697	81.3898	-65.2324	170	5
Ellesmere	2015-08-20	EI14-5	9037568	462882	81.3911	-65.2216	168	5
Ellesmere	2015-08-20	EI10-1	9039569	460814	81.4082	-65.3501	206	5
Ellesmere	2015-08-20	EI10-2	9039535	461063	81.4080	-65.3351	202	5
Ellesmere	2015-08-20	EI10-3	9039449	461302	81.4073	-65.3206	199	5
Ellesmere	2015-08-20	EI10-4	9039317	461520	81.4062	-65.3072	209	5
Ellesmere	2015-08-20	EI10-5	9039190	461737	81.4052	-65.2939	204	5
Ellesmere	2015-08-21	EI4-1	9043502	463818	81.4445	-65.1790	311	5
Ellesmere	2015-08-21	EI4-2	9043251	463756	81.4422	-65.1822	283	5
Ellesmere	2015-08-21	EI4-3	9043008	463743	81.4401	-65.1824	262	5
Ellesmere	2015-08-21	EI4-4	9042759	463705	81.4378	-65.1841	258	5
Ellesmere	2015-08-21	EI4-5	9042509	463654	81.4356	-65.1866	244	5
Ellesmere	2015-08-22	EI15-1	9034762	464420	81.3665	-65.1235	146	5
Ellesmere	2015-08-22	EI15-2	9034727	464481	81.3662	-65.1198	139	5
Ellesmere	2015-08-22	EI15-3	9034477	464481	81.3639	-65.1193	133	5
Ellesmere	2015-08-22	EI15-4	9034219	464549	81.3616	-65.1146	147	5
Ellesmere	2015-08-22	EI15-5	9033966	464458	81.3593	-65.1195	174	5

MM – Marine Mammal and Seabird Observations

During the *Petermann 2015 Expedition* a marine mammal and seabird observation program occurred on the *IB Oden*. The intent of the program was to 1) implement required marine mammal monitoring and mitigation measures during seismic profiling operations and 2) systematically collect data on the presence and behavior of marine mammals and seabirds in and around PF and surrounding waters.

Prior to the start of the expedition a Marine Mammal Observation and Management Plan (MMOMP) was prepared to identify measures to minimize and avoid potential adverse effects (i.e., disturbance) on marine mammals during seismic and vessel operations. Marine mammal monitoring and mitigation measures in the MMOMP were specifically designed to address potential effects of seismic sound and protection of marine mammals following guidelines developed by the Government of Canada in the Statement of Canadian Practice (<http://www.dfo-mpo.gc.ca/oceans/management-gestion/integratedmanagement-gestionintegree/seismic-sismique/index-eng.asp>).

On 28 July 2015 the Nunavut Impact Review Board issued a NIRB Screening Decision Report (NIRB File No.: 15YN018) defining Project-Specific Terms and Conditions (pursuant to Section 12.4.4(a) of the Nunavut Land Claims Agreement) and authorized activities of the *Petermann 2015 Expedition* in the Qikiqtani Region. All project specific terms and conditions relative to marine based seismic surveys, marine mammal and seabird monitoring were followed according to the aforementioned NIRB Screening Report.

This field report summarizes results of the marine mammal and seabird sightings, observation effort, environmental conditions, and mitigation measures associated with seismic operations in Canadian/Nunavut waters. The reporting period is for between 30 July and 30 August 2015.

Methods

During the associated marine mammal and seabird observation program one marine mammal observer (MMO) collected marine mammal and seabird occurrence and distribution data via daily vessel-based visual observation. Observations occurred from the portside bridge with eye height 32 m above sea level for approximately 10 hours (hr) each day. During the duration of the project (30 July–30 August) daylight hours occurred 24 hr/day, thus observations occurred throughout all periods of day and night. Observations occurred all days from 30 July through 30 August 2015 from the *IB Oden*. Additional observations occurred from the *RV Skidbladner* on 22, 23 and 27 August by the assistance of the seafloor mapping team during small boat operations in nearshore areas. During *RV Skidbladner* operations marine mammal and seabird sighting records were hand collected recorded on excel spreadsheets and incorporated into the final data set upon return to the *IB Oden*.

During data collection on the *IB Oden* the biologist systematically scanned waters alternating between the naked eye, handheld Fujinon 10×50 reticle binoculars and Celestron 25×100 tripod-mounted binoculars, recording sighting and environmental data on a PC running *Mysticetus* Observation Software linked to the vessel Global Positioning System (GPS). *Mysticetus* software allowed for efficiency and accuracy of observations by instantly displaying positions and distances to marine mammal sightings based on bearing

and binocular reticle or estimated visual distance. Marine mammal observations focused forward and to the sides of the vessel in an arc of $\sim 180^\circ$, but the observer also regularly checked for marine mammals astern of the vessel. All sighted marine mammals were recorded and when possible photographed for identification purposes.

Seabird observations focused 300 m forward and to the sides of the vessel in an arc of $\sim 180^\circ$, but the observer also regularly checked for seabirds ship following astern of the vessel.

Upon sighting a marine mammal or seabird (or group of animals) the observer recorded the following information:

- **Environmental data:** Beaufort sea state, ice cover (10% increments in $\sim 180^\circ$ observation area), visibility (km), and sun glare (in % of $\sim 180^\circ$ observation area). Environmental data were recorded at the start and end of each watch and when there was an obvious change in one or more of the environmental variables.
- **Marine mammal sighting data:** species, minimum/maximum/best estimate of group size, number of juveniles/calves, behavior state (Table MM-1), individual behavioral events, bearing and distance of the animal(s) relative to the vessel, sighting cue (what aspect of the animal drew the attention of the observer, i.e., body, blow, etc.), and person who sighted the animal.
- **Seabird sighting data:** species, minimum/maximum/best estimate of flock size, species composition (adult, male, female, juvenile, mixed), behavior state (flying, sitting, searching, feeding, ship-following), bearing and distance of the animal(s) relative to the vessel, and person who sighted the animal.

Table MM-1. Definition of marine mammal behavior states.

Behavior State	Definition (e.g., per Encyclopedia of Marine Mammals)
Rest	>50% of group exhibiting little or no forward movement (<1 km/hr) remaining at the surface in the same location or drifting/traveling slowly with no wake
Travel	>50% of group swimming with an obvious consistent orientation (directional) and speed, no surface activity
Mill	>50% of group swimming with no obvious consistent orientation (non-directional) characterized by asynchronous headings, circling, changes in speed, and no surface activity, includes feeding/foraging
Surface Active Travel/Mill	>50% of group engaging in travel or mill behavior states (see above) with surface activity (i.e. porpoising, splashing, rapid dives)
Hauled Out	Pinniped hauled out on ice or land, considered a resting behavior
Unknown	Not able to determine behavior state. (e.g., animals out of sight, too far to determine, on a dive, etc.)

Results consisting of the total observation effort in hours (hr) and kilometers (km), marine mammal sightings (Table MM-2), mitigation measures (Table MM-3), and seabird observations (Table MM-4) during the 30 July to 30 August 2015 project field period are summarized below.

Operations

Visual Observations

A total of 282.8 hr (2,210.2 km) of observation effort were conducted from the IB *Oden* during the *Petermann 2015 Expedition* (Table MM-1). Seismic effort hours included ~4.7 hrs of observation effort in Canadian/Nunavut waters and 22.2 hours in Greenland waters. Seismic effort hours in Canadian/Nunavut waters includes observation during all seismic operations and the time associated with clearing the 1000 m zone 30 minutes prior to the start of operations.

Table MM-2. Total number of observation effort hours by vessel activity during the 30 July–30 August 2015 project duration.

Vessel Activity Type	Observation Effort (hrs)
Observation effort during non-seismic periods	255.9
Observation effort during seismic periods	22.2
Greenland waters	
Observation effort during seismic periods	4.7
Canadian/Nunavut waters	
Total	282.8

Seismic Operations Requiring Mammal Operations

Seismic operations during the *Petermann 2015 Expedition* included the use of small sound sources (45 cu in airgun and sparker). In Canadian/Nunavut waters seismic operations occurred on three separate days (11, 17 and 27 August) for a total of 4.7 hours (Table MM-3).

Prior to commencing seismic operations in Canadian/Nunavut waters the marine mammal observer established (i.e., cleared) a safety zone of 1000 meters (m) measured from the center of the seismic source (i.e., airgun or sparker) for all marine mammals and colonies of seabirds. The MMO continued to monitor for marine mammals approaching or within the 1000 m safety zone for the duration of seismic operations.

The 1000 m safety zone was visible during all seismic operations. There were no marine mammals observed approaching or within the 1000 m zone thus no shut down procedures or additional mitigation measures were required. The IB *Oden* maintained a minimum distance of 100 m from all marine mammals.

Table MM-3. Dates and duration of observation during seismic operations in Canadian/Nunavut waters including associated sightings and mitigation measures.

Date	Start Seismic Observation	End Seismic Observation	Total Duration	No. Sightings	No. Mitigation Measures
8/11/2015	06:16:33	08:12:39	1:56:06	0	0
8/17/2015	12:32:48	13:10:23	0:37:35	0	0
	21:32:49	21:51:18	0:18:29	0	0
8/27/2015	10:46:09	11:25:23	0:39:14	0	0
8/28/2015	04:10:25	5:23:38	1:13:14	0	0
TOTAL			4:44:37	0	0

Shipboard Results

Marine Mammal Observation

A total of 315 groups (~344 individuals) of marine mammals were observed during the project (Table MM-4). Ringed seals were the most commonly observed marine mammals with 205 groups (~217 individuals). Bearded seals were also commonly observed with 77 groups (~84 individuals). Other marine mammals observed included 8 groups (~15 individuals) of harp seals, 11 groups (~12 individuals) of hooded seals and 3 polar bears. There were 11 groups (13 individuals) of pinnipeds that were not identified to species due to distance from vessel when observed.

The most common observed behavior (Figure MM-1) recorded by all seal species combined was mill. Ringed seals were most frequently (78%) observed exhibiting mill behavior, followed by travel (13%) and hauled out on ice (6%). Bearded seals were most frequently observed hauled out (77%) followed by mill (17%) and travel (6%). All three polar bear sightings were on ice.

The distribution of Marine Mammal sightings sighted are in Figure MM-2 and Figure MM-3, and example photographs of species sighted are in Figures MM4–9.

Table MM-4. Total number of groups and estimated individual marine mammals observed during the 30 July to 30 August 2015 project duration.

Species	Scientific name	No. of Groups	No. of Estimated Individuals
Bearded seal	<i>Erignathus barbatus</i>	77	84
Harp seal	<i>Pagophilus groenlandicus</i>	8	15
Hooded seal	<i>Cystophora cristata</i>	11	12
Polar bear	<i>Ursus maritimus</i>	3	3
Ringed seal	<i>Pusa hispida</i>	205	217
Unidentified pinniped	<i>Pinnipedia Sp.</i>	11	13
TOTAL		315	344

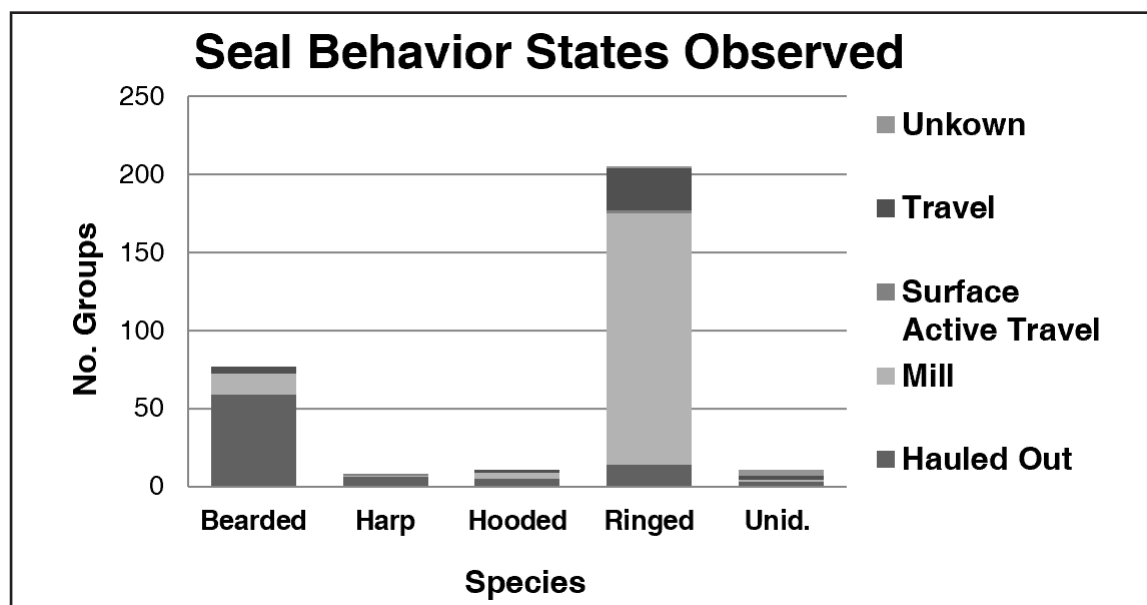


Figure MM-1. Seal behavior states by species and number of groups observed.

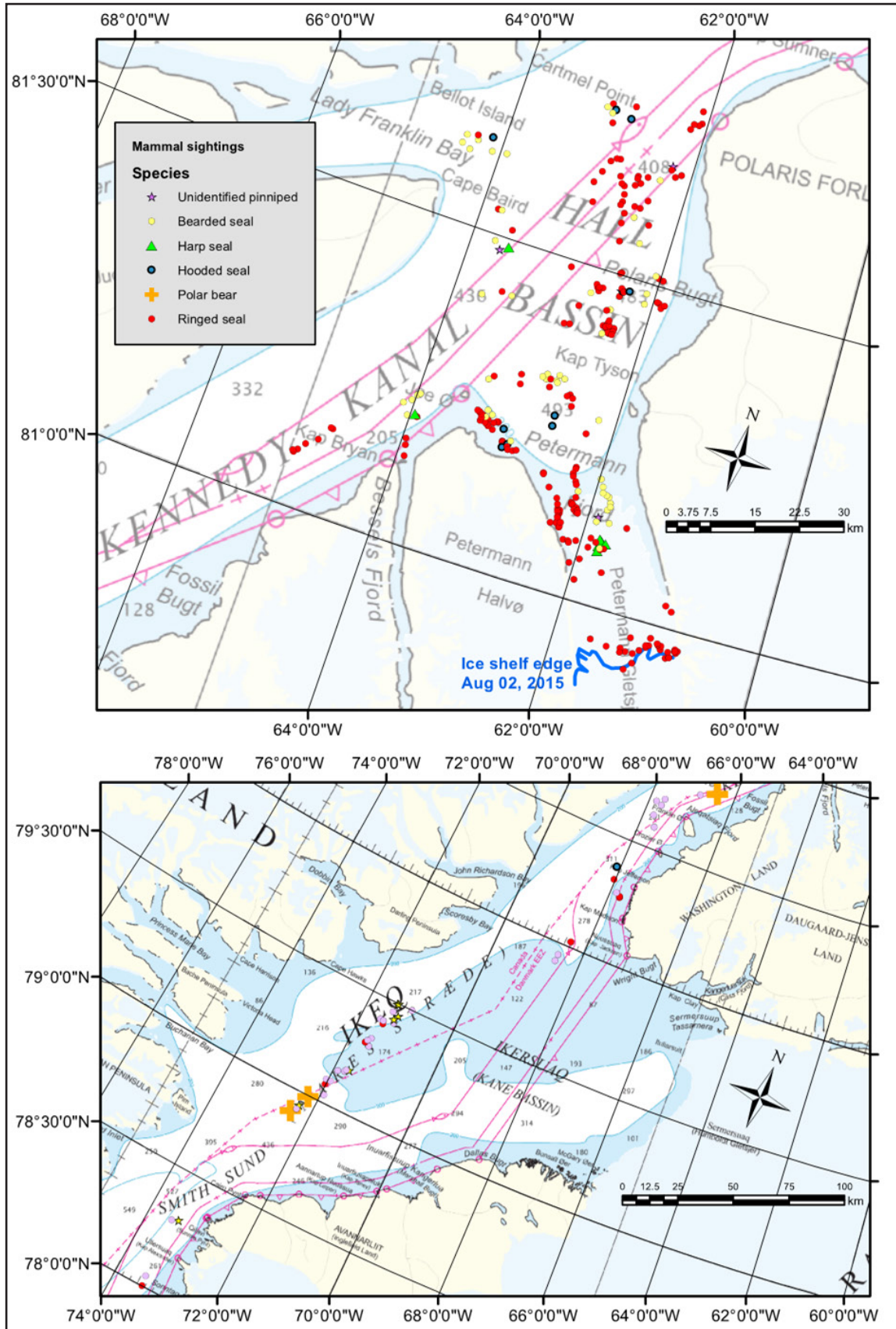


Figure MM-2. All marine mammal sightings during the 30 July to 30 August 2015 project duration.

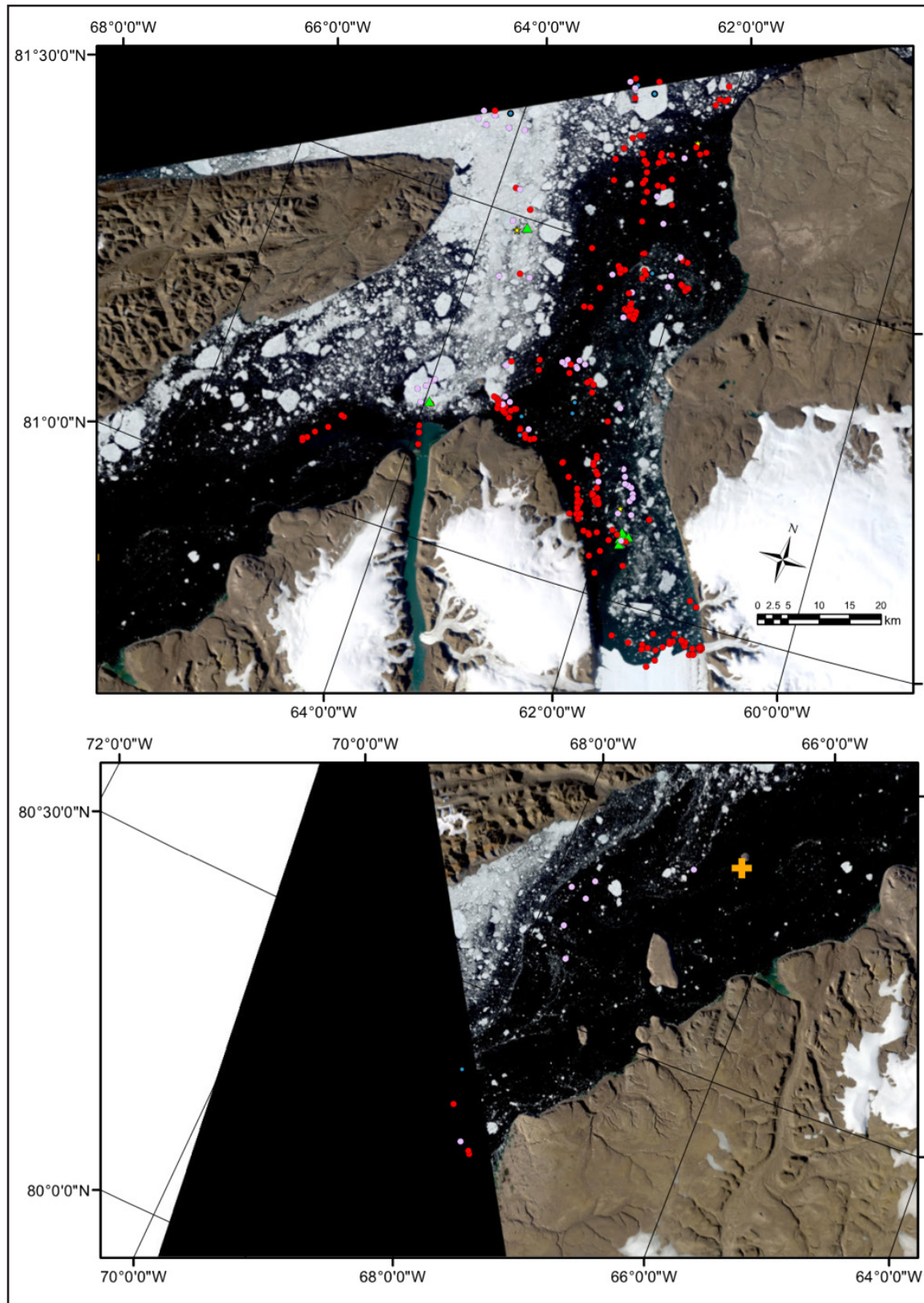


Figure MM-3. All marine mammal sightings with 12 August satellite image depicting ice coverage.



Figure MM-4. Hooded seal (*Cystophora cristata*) hauled out on ice in NS 02 August 2015.
Photo: Kate Lomac-MacNair



Figure MM-5. Ringed seal (*Pusa hispida*) hauled out on Petermann Glacier 05 August 2015.
Photo: Kate Lomac-MacNair



Figure MM-6. Bearded seal (*Erignathus barbatus*) hauled out on ice near 20 August 2015.
Photo: Kate Lomac-MacNair



Figure MM-7. Harp seals (*Pagophilus groenlandicus*) surface active behavior (porpoising) outside PF 17 August 2015. Photo: Kate Lomac-MacNair



Figure MM-8. Polar bear (*Ursus maritimus*) observed on 04 August 2015.
Photo: Martin Jakobsson



Figure MM-9. Ringed seal (*Pusa hispida*) swimming in Petermann Fjord, 05 August 2015.
Photo: Kate Lomac-MacNair

Seabird Observation

A total of 389 groups (673 individuals) of seabirds were observed during the project (Table MM-5). The most frequently observed species was the black guillemot (*Cepphus grylle*) with 125 groups (213 individuals) followed by the Glaucous gull (*Larus hyperboreus*) with 112 groups (137 individuals). Other seabird species frequently recorded included Arctic and long-tailed skuas often in mixed flocks (*Stercorarius parasiticus* and *Stercorarius longicaudus*), Ivory gull (*Pagophila eburnea*) and northern fulmar (*Fulmarus glacialis*). Unexpected sightings included the snowy owl (*Bubo scandiacus*) and Sabine's gull (*Larus sabini*). The distribution of seabird sightings are in Figure MM-10.

Table MM-5. Total number of groups and estimated individual seabirds observed during the 30 July to 30 August 2015 project duration.

Species	Scientific Name	No. of Groups	No. of Estimated Individuals
Arctic Skua (Parasitic Jaeger)	<i>Stercorarius parasiticus</i>	63	212
Black Guillemot	<i>Cepphus grylle</i>	125	213
Glaucous Gull	<i>Larus hyperboreus</i>	112	137
Ivory Gull	<i>Pagophila eburnea</i>	40	47
Little Auk (Dovekie)	<i>Alle alle</i>	3	3
Long-tailed Skua (Long-tailed Jager)	<i>Stercorarius longicaudus</i>	27	34
Northern Fulmar	<i>Fulmarus glacialis</i>	13	19
Red Phalarope	<i>Phalaropus fulicarius</i>	2	3
Red-necked Phalarope	<i>Phalaropus lobatus</i>	1	1
Sabine's Gull	<i>Larus sabini</i>	1	1
Snowy Owl	<i>Bubo scandiacus</i>	1	1
Unidentified seabird		1	1
TOTAL		389	673

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Public Engagement & Outreach

Personnel: Saskia Madlener, Laurence Dyke, Alan Mix, Martin Jakobsson.

Goals

We aimed to produce educational, relevant, and dynamic content via a blog site, www.petermannsglacialhistory.wordpress.com, with blog posts, photos, short HD videos, and linked Twitter and Instagram accounts that were directly embedded on the site for seamless posts (@Petermann_ice, #Petermann2015). Our objective was to educate the public on the specific operations and goals of the Petermann 2015 research expedition, and to reach broader audiences by producing image-heavy and narrative-based content.

This project culminated in a series of short character-driven documentary films about the importance of achieving more informed and accurate projections of Greenland ice-loss and future sea level rise. Shot in cinema vérité style, the film will reveal the personalities behind the research – including the scientists, students, various technicians, and crew – and highlight their motivations regarding their field of expertise and contribution to this research. Footage may also be licensed to CBS, NSF, NASA, Vice-Motherboard, or others.

Methods

Due to limited internet access aboard the IB *Oden* during the cruise, we appointed two helpers on shore who posted to our blog, social media, and vimeo accounts. The specific strategies for each account types are outlined below. Large image and video files were uploaded via an .ftp site established onboard, then sent daily via the public drive – we had a folder for each day that included a text file identifying which contact should receive which files. The Swedish Polar Research Secretariat's onshore team would then send the files to the appropriate contact who would be given instructions as to how to use the images or videos.

The operation also included a visit to the ship, and onshore filming, but a CBS-60 minutes camera crew.

Output Streams

Blog

The blog had several pages – Posts, Background, Updates from Co-Chief Scientist Alan Mix, Videos, and Resources. Different members of the scientific teams wrote pieces for the Posts page. We established a posting schedule prior to departure and the scientists committed to a date – we aimed for two posts per week, 3–4 paragraphs, with enough coverage from most of the working groups (we did not include the ecology team as they weren't listed in the original scope of work). The outreach coordinators wrote 2 pieces for the Background page to provide context for why we are doing research on the Petermann Glacier system and which operations will be conducted aboard the IB *Oden* in order to achieve the goals laid out by the research. Each working group also provided content for background pages about their specific operations and goals. Alan would provide semi-daily logs for his personal blog page, providing some context for the scientific operations and conveying the day-to-day routine of working at sea and conducting multi-disciplinary work. The Resources page lists links to information on Petermann Glacier (namely NASA sites) and to other relevant

blogs, i.e. Icy Seas, which is managed by Andreas Muenchow. The Videos page was set up to post videos that were meant to be produced during the cruise, but we experienced some difficulty getting videos edited in time and we had problems sending larger file sizes back onshore, so this will be tackled post-cruise.

One onshore contact managed the blog posts from the different working groups. We would send the images via .ftp as described above and provide text in the body of an email with indications of where to place the images. The contact had direct access to our blog site and would post according to our instructions, including image placement, captions, and titling. A separate contact managed the Chief Scientist's blog in the same fashion; this contact, Abby Metzger, is the head of public relations for the College of Earth, Ocean, and Atmospheric Sciences at OSU and had vested interest to promote our outreach efforts. She also provided us with analytics to help us gauge our readership, which will be discussed in the Results section.

Social Media

We ran Twitter and Instagram (IG) accounts using the handle, "Petermann_ice." Our twitter account focused on Daily posts with updates about operations aboard and on land or the ice, accomplishments throughout the cruise, and interesting facts about Petermann Glacier, the IB *Oden*, or other relevant topics. These were often accompanied by images. We would also post a link to any new blog posts via our Twitter account. IG included daily posts with beautiful images of the surrounding land & seascape, scientific operations, or of the IB *Oden*, with detailed and educational captions describing the relevance of the image. For example, a picture of the sidewalls of the fjord allowed us to discuss sedimentary rocks and surface indications of ice retreat through striations.

We sent images via email (jpg size of <150kb) with the accompanying. We sent a separate email for each account every evening for the following day, with the subject line "IG – Day, date" or "Twitter – Day, date." We logged the text and images for both Twitter and IG in a single document on the public drive, set up as an outline – the caption, followed by the name of the image file (for our onshore contact) and a thumbnail of the picture itself so colleagues aboard the *Oden* could track our posts.

We set up a gmail account to manage these accounts, as well as a Facebook account to ensure coverage of all social media, but we did not use Facebook for outreach.

Videos

We gathered footage throughout the trip based on the operations of the day – we wanted to capture the breadth of this expedition, which required knowing the daily plan and asking permission to shoot certain operations, especially where safety was a concern.

We gathered interviews from each working group, roughly two representatives from each group (differing backgrounds and ages), throughout the cruise. It was important to stagger these so as not to interfere with operations, and to get a sense of the progress and accomplishments along the way.

We edited together a couple of short videos, one on how and why we obtain a geological record to understand the past ice extent of Petermann Glacier, and one outlining why we are studying this iconic system in particular. These videos remained in the roughcut stages during the cruise and were not posted on the blog site, they were tackled post-cruise instead, which will be discussed under results.

We did compile a couple of 15-second videos to be posted on IG, which we sent via our .ftp site to one of our onshore helpers along with descriptive captions.

Shipboard Results

Our outreach efforts were successful, considering our inability to access the internet and post directly to our various accounts. The following Results are separated into Metrics (pulled from the Analytics features from various accounts), a Discussion of these metrics, Lessons Learned, and Continued Efforts, in the hopes that researchers will return to Petermann and can build upon the momentum we garnered this summer, 2015.

Metrics

These are an aggregate of values between July 1 and September 7, 2015.

Twitter (@Petermann_ice)

- Followers: 203
- Posts: 115
- Profile visits: 6.2k
- Favorites: 177
- Retweets: 184
- Tweet impressions (potential views): 78.8k
- Link clicks: 1.0k

Instagram (@Petermann_ice)

- Followers: 117
- Posts: 60
- Likes: 1,282
- Comments: 22

Blog (www.petermannnsglacialhistory.wordpress.com)

- Blog posts: 46 (Most popular: ‘Updates from co-chief scientist Alan Mix’ with 2,738 views)
- Page views: 10,472 (Top 3 countries: USA, 6,501; Sweden, 971; UK , 778)
- Comments: 11

Although our following for Twitter and IG was a little low (203 and 117, respectively), we were able to get a lot of views, page visits, and “impressions” (potential views due to reposting and showing up in searches) over a two-month period. The Twitter account could have been managed better; retweeting and directing posts to specific followers and other relevant users helps to garner a stronger following and keeps people engaged. Twitter is more about compiling information on a broad topic and engaging followers, not just posting about your own work and progress. This is discussed in Lessons Learned.

IG was successful with the amount of “likes” we got, and it’s a relatively easy platform to gain a following as the public is generally driven by images – the captions provided a great opportunity to provide just enough scientific content so that the viewer could walk away better informed about our research.

Our blog was pretty successful, with 10,472 page views, which is promising considering this is the platform with the most thorough scientific information. It is difficult to tease out how we gained this readership, but it's very telling that Alan's semi-daily logs got the most views – this could be a product of how he advertised the blog amongst friends, family, and colleagues, or it could be due to people's interest in hearing directly from a co-chief scientist or hearing about the daily workings of an expedition.

Lessons Learned for successful shipboard outreach

Not having access to the internet posed many problems and it is important to have experienced and devoted partners on shore who are willing to work with us to maintain our outreach efforts:

- Set up social media accounts well in advance to gather a strong following – Twitter could be populated by retweets of relevant findings, publications, and news articles having to do with the Greenland ice sheet and the Arctic overall. IG could be populated by pictures taken on past expeditions that can provide some general overview of what we can expect on this expedition. We would have liked to have more of a following on these accounts so as to direct them to the extensive content provided on our blog.
- A seasoned “tweeter” who knows how to retweet relevant and complementary posts from other accounts, and point to other followers when discussing certain topics should manage twitter, would have helped to increase our following. We were unable to do this ourselves from the ship, so it is important to have an experienced tweeter manage this on shore.
- It's important to share more videos with the public during the expedition, and this was lacking because there was not enough time to edit videos together. In the future, it would be nice to post very short (15-second videos for IG) videos that cover very general topics and tell the tale of the expedition – what we are accomplishing that week, where we are in the schedule or geographically, maybe some initial findings. This could be better achieved if there were a separate outreach officer and a filmmaker.

Outreach Products

Web Pages and Public Media

- Petermann's Glacial History - Deciphering Past Climate at the Ice-Ocean Boundary.
- <https://petermannsglacialhistory.wordpress.com>
- Public Facing educational web page, with scientific bac.

Twitter

- PetermannGlacier.
- https://twitter.com/Petermann_ice
- Twitter feed with rapid updates on expedition progress and scientific results: 795 followers.

Instagram

- Petermann_Ice.
- https://www.instagram.com/petermann_ice
- Instragram feed with expedition photos, available to public and press.

CBS 60 Minutes

- Greenland.
- <https://www.cbsnews.com/news/greenland-60-minutes-climate-change>
- Episode of CBS 60 MINUTES broadcast, with outreach information about Greenland ice and climate, developed in Collaboration with the Petermann Glacier Research Team. CBS estimates viewership at several million people.

Data Submissions

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<https://arcticdata.io>. submitted, urn:uuid:6ec5773d-boda-4a5f-9d27-219f02a38c01. (Physical Collection, Metadata)

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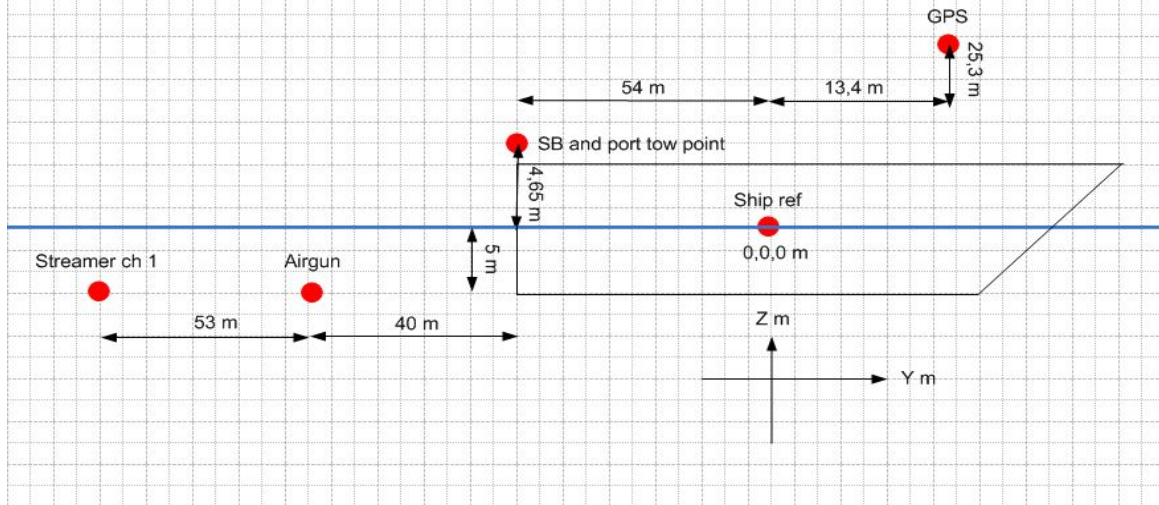
Stoner, J., Mix, A.C., Walczak, M. PF Sediment Core collection
– <http://osu-mgr.org/collections> [physical collection]

GM – Geophysical Mapping

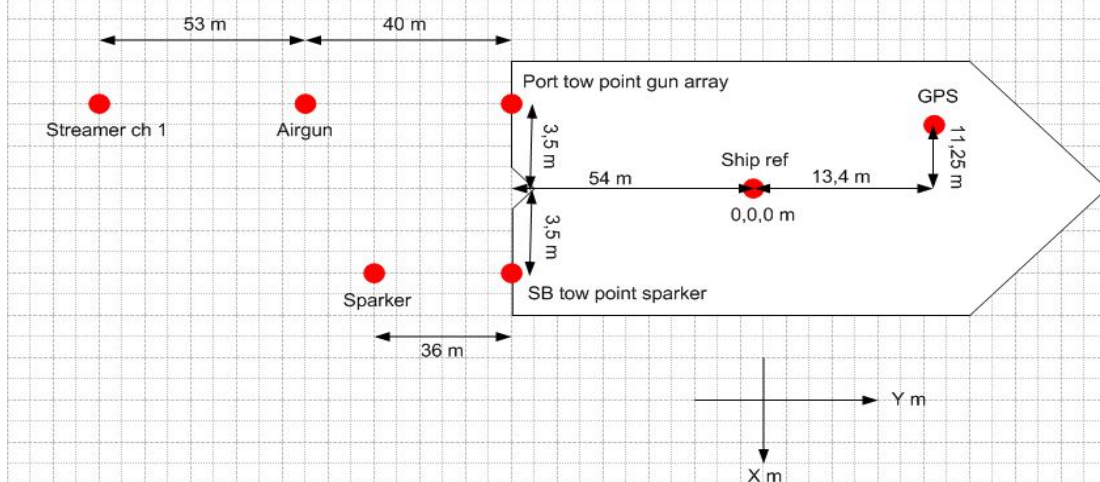
Appendix I | Marine Survey general information

Date:	10 to 12-08-2015		 Marine Survey - General Information						Line:	0004 to 0007				
Cruise:			Petermann 2015		Ship:		IB Oden		Location:			Petermann fjord		
GPS antenna		Reipoint ship		Gyro		100 Mb repeater		Length Tow cable		10 Mb repeater, quick coupling		Length stretch section (m)		
X (m)	-11.5	X (m)	0.00	X (m)	0.00	NN	40	1080	53	Length section (m)	50	Length section (m)	50	
Y (m)	13.4	Y (m)	0.00	Y (m)	0.00	Serial no. A/D converter (front of section)	1674		1480	1478	1150	1479	1172	
Z (m)	25.3	Z (m)	0.00	Z (m)	0.00	Serial no. depth transducer 6.25 m section	5008		5022	5013	5009	5002	5001	
Streamer Ch1		BB tow point		Airgun		Location of depth transducer with respect to ch no		1	9	24	32	33	48	
X (m)	0.00	X (m)	-3.50	X (m)	0.00	Navigation:		Transformation parameters:						
Y (m)	93.00	Y (m)	-54.00	Y (m)	-40.00	Software:	NaviPac ver 3.8.2		Semimajor axis (m):		6378137		Longitude at Origin	-63° 0' 0.0"
Z (m)	-3.00	Z (m)	4.65	Z (m)	-6.00	Projection:	UTM north, Zone 20		Inverse flattening:		298.25722		Latitude at Origin	81° 00' 0.0"
Towpoint used :		Tow point used:		Tow point used:		Datum:	WGS84		Scale at Origin		0.9998		False easting (m):	500000
BB tow point		BB tow point		BB tow point						False northing (m):		0		
Seismic Energy Source:														
Type 1:	Sercel GI gun		Seismic Instruments:											
Serial no. GI-Gun:	44212		Type:	Geometrics GeoEel controller										
Volume G (cu.inch):	105		Lowcut filter (Hz):	out										
Volume I (cu.inch):	105		Lowcut filt. (dB/Oct):	out										
Injector delay	45mS		Highcut filter (Hz):	anti-alias										
Discharge port	603_120, Medium		Highcut filt. (dB/Oct):	anti-alias										
Delay	0 mS		Gain Setting (dB):	0										
Pressure (bar):	140		Sample Rate (ms):	0.250										
Planned depth (m):	5		Record Length (ms):	3000										
Type 2 (no delay)			No of recording chs:	48										
Sledge			Software version	5.84										
Power supply			No of auxiliary chs:	8										
Energy			Nearfield hydrophone	AUX 1										
Remarks:														
Airgun positions calculated in NaviPac as drag from the BB towpoint Streamer depth scanned on every shot. Events set to time trigger, every 5 sec Serial string from NaviPac to SEG-D header, "Time, Event, X, Y (airgun), X, Y (sparker), Center beam (Kongsberg, water depth from sea surface)". navi event: start byte 142 i6 airgun utm x : start byte 148 f9.2 airgun utm y : start byte 158 f10.2 sparker utm x : start byte 169 f9.2 sparker utm y : start byte 179 f10.2 cent beam water depth : start byte 190 f7.2														

Seismic setup Oden 2015, vertical view

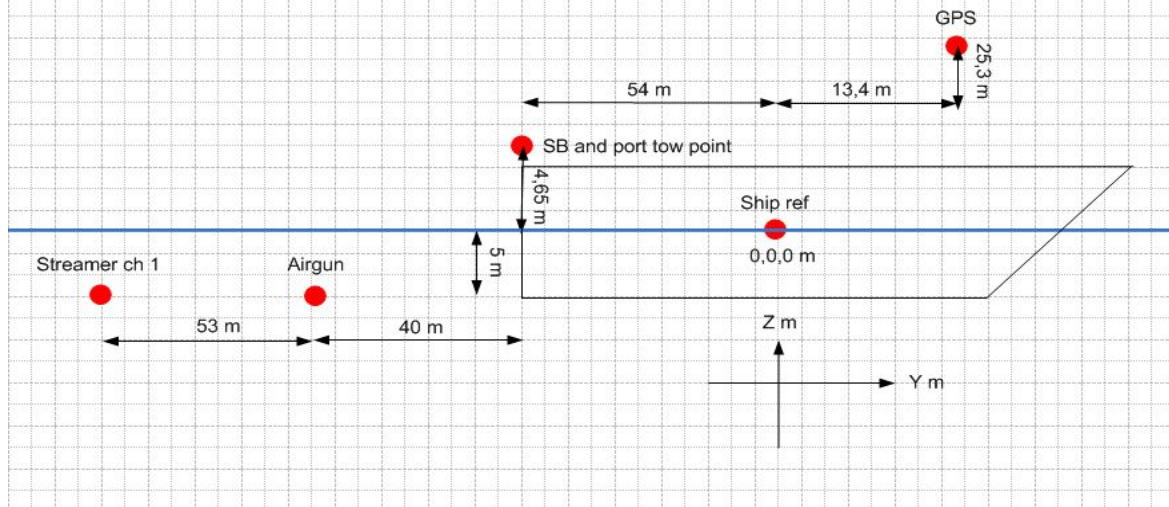


Seismic setup Oden 2015, plan view

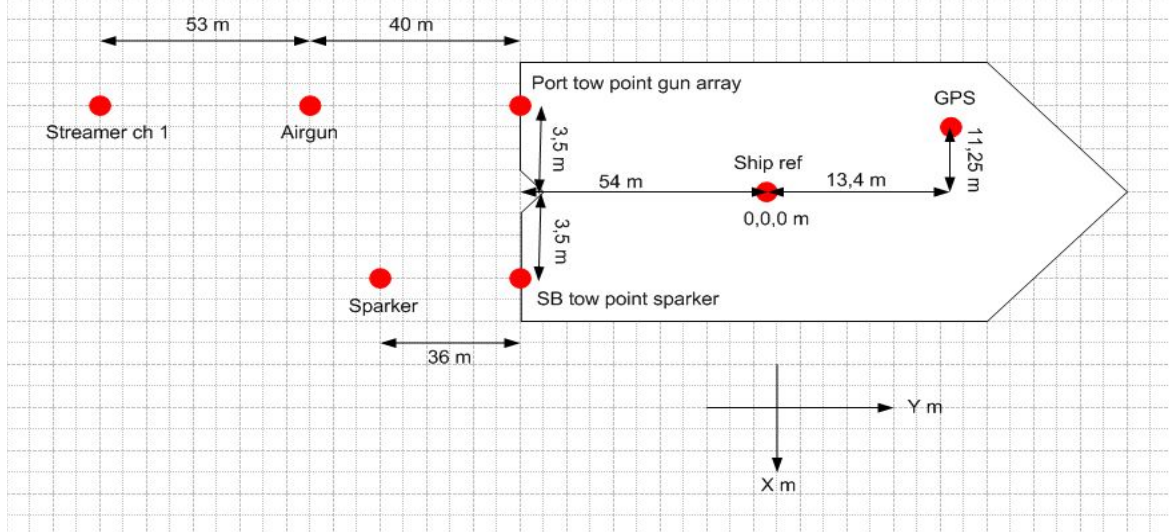


Date:	2015-08-17		 Marine Survey - General Information				 Line:		0008 to 0009			
Cruise:	Petermann 2015		Ship:		IB Oden		Location:				Petermann fjord	
GPS antenna	Refpoint ship	Gyro	100 Mb repeater	Length Tow cable	10 Mb repeater, quick coupling	Length stretch section (m)	Length section (m)	Length section (m)	Length section (m)	Length section (m)	Length section (m)	Length section (m)
X (m)	-11.5	X (m)	0.00	NN	40	53	50	50	50	50	50	50
Y (m)	13.4	Y (m)	0.00	Serial no. A/D converter (front of section)		1674	1480	1478	1150	1479	1172	
Z (m)	25.3	Z (m)	0.00	Serial no. depth transducer 6.25 m section		5008	5022	5013	5009	5002	5001	
			Location of depth transducer with respect to ch no		1	9	24	32	33	48		
Streamer Ch1	BB tow point	Airgun										
X (m)	0.00	X (m)	-3.50	X (m)	0.00	Navigation:						
Y (m)	-70.00	Y (m)	-54.00	Y (m)	-15.00	Software:	NaviPac ver 3.8.2					
Z (m)	-3.00	Z (m)	4.65	Z (m)	-6.00	Projection:	UTM north, Zone 20					
Towpoint used :			Tow point used:		Datum:							
BB tow point			BB tow point		WGS84							
Seismic Energy Source:												
Type 1:	Sercel G1 gun		Seismic Instruments:									
Serial no. G1-Gun:	44212		Type:	Geometrics GeoEel controller								
Volume G (cu.inch):	105		Lowcut filter (Hz):	out								
Volume I (cu.inch):	105		Lowcut filt. (dB/Oct):	out								
Injector delay	44ms		Highcut filter (Hz):	anti-alias								
Discharge port	603_120, Medium		Highcut filt. (dB/Oct):	anti-alias								
Delay	0 mS		Gain Setting (dB):	0								
Pressure (bar):	140		Sample Rate (ms):	0.250								
Planned depth (m):	6		Record Length (ms):	3000								
Type 2 (no delay)			No of recording chs:	48								
Sledge			Software version	5.84								
Power supply			No of auxiliary chs:	8								
Energy			Nearfield hydrophone	AUX 1								
Remarks:												
Airgun positions calculated in NaviPac as drag from the BB towpoint												
Streamer depth scanned on every shot.												
Events set to time trigger, every 5 sec												
Serial string from NaviPac to SEG-D header, "Time, Event, X, Y (airgun), X, Y (sparker), Center beam (Kongsberg, water depth from sea surface)".												
navi event: start byte 142 i6												
airgun utm x : start byte 148 f9.2												
airgun utm y : start byte 158 f10.2												
sparker utm x : start byte 169 f9.2												
sparker utm y : start byte 179 f10.2												
cent beam weater depth : start byte 190 f7.2												

Seismic setup Oden 2015, vertical view

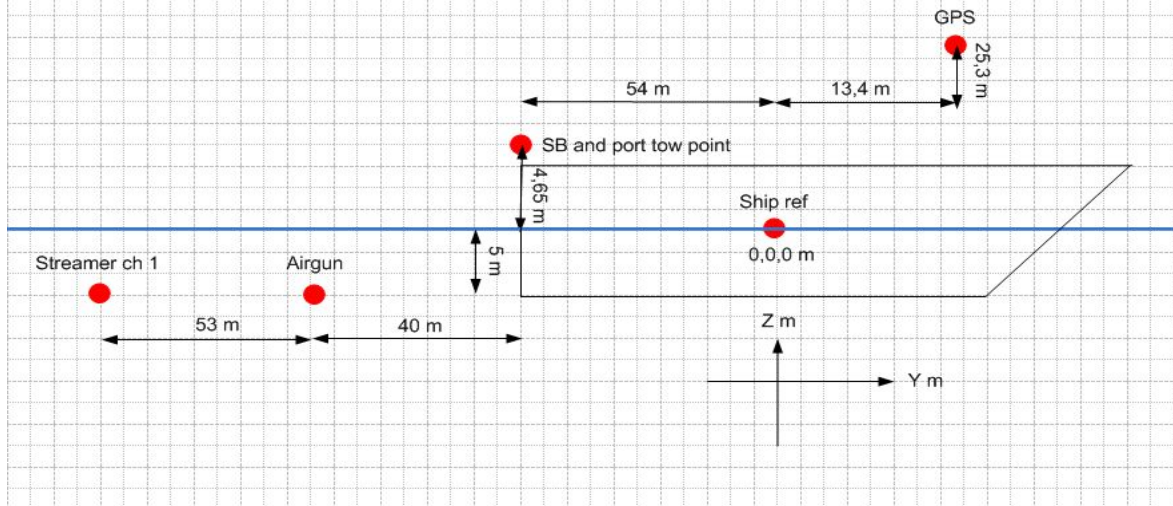


Seismic setup Oden 2015, plan view

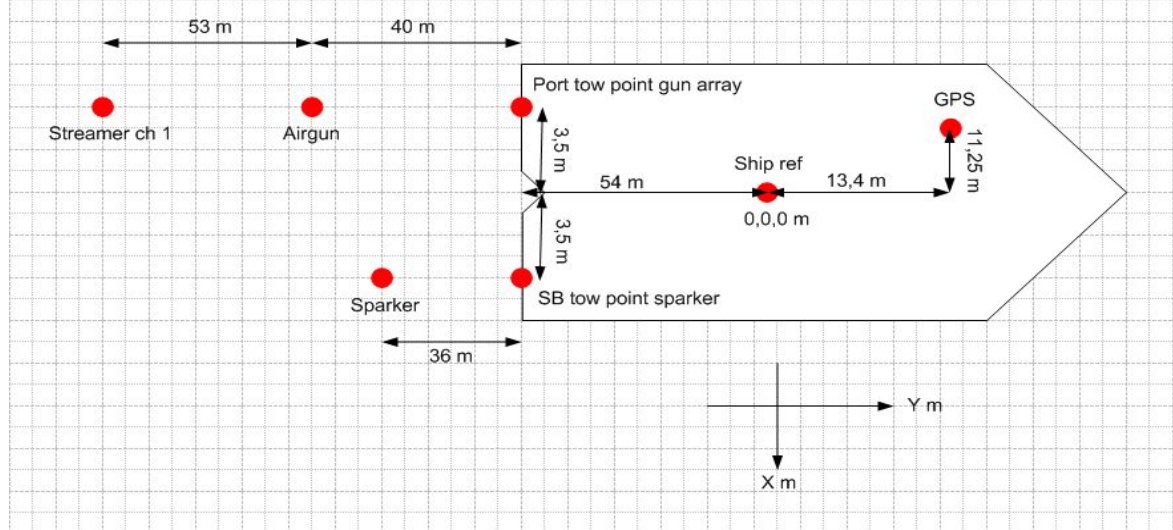


Date:	2015-08-17		 Marine Survey - General Information				 Line:		0010 to 0013			
Cruise:	Petermann 2015		Ship:		IB Oden		Location:				Petermann fjord	
GPS antenna	Refpoint ship	Gyro	100 Mb repeater	Length Tow cable	10 Mb repeater, quick coupling	Length stretch section (m)	Length section (m)	Length section (m)	Length section (m)	Length section (m)	Length section (m)	Length section (m)
X (m)	-11.5	X (m)	0.00	X (m)	0.00	53	50	50	50	50	50	
Y (m)	13.4	Y (m)	0.00	Y (m)	0.00	Serial no. A/D converter (front of section)	1674	1480	1479	1172		
Z (m)	25.3	Z (m)	0.00	Z (m)	0.00	Serial no. depth transducer 6.25 m section	5008	5022	5002	5001		
						Location of depth transducer with respect to ch no	1	9	17	32		
Streamer Ch1	BB tow point	Airgun										
X (m)	0.00	X (m)	-3.50	X (m)	0.00	Navigation:						
Y (m)	-70.00	Y (m)	-54.00	Y (m)	-15.00	Software:	NaviPac ver 3.8.2					
Z (m)	-3.00	Z (m)	4.65	Z (m)	-6.00	Projection:	UTM north, Zone 20					
Towpoint used :		Tow point used:				Datum:	WGS84					
BB tow point		BB tow point										
Seismic Energy Source:												
Type 1:	Sercel G1 gun		Seismic Instruments:									
Serial no. G1-Gun:	44212		Type:		Geometrics GeoEel controller							
Volume G (cu.inch):	105		Lowcut filter (Hz):		out							
Volume I (cu.inch):	105		Lowcut filt. (dB/Oct):		out							
Injector delay	44ms		Highcut filter (Hz):		anti-alias							
Discharge port	603_120, Medium		Highcut filt. (dB/Oct):		anti-alias							
Delay	0 mS		Gain Setting (dB):		0							
Pressure (bar):	140		Sample Rate (ms):		0.250							
Planned depth (m):	6		Record Length (ms):		3000							
Type 2 (no delay)			No of recording chs:		32							
Sledge			Software version		5.84							
Power supply			No of auxiliary chs:		8							
Energy			Nearfield hydrophone		AUX 1							
Remarks:												
Airgun positions calculated in NaviPac as drag from the BB towpoint												
Streamer depth scanned on every shot.												
Events set to time trigger, every 5 sec												
Serial string from NaviPac to SEG-D header, "Time, Event, X, Y (airgun), X, Y (sparker), Center beam (Kongsberg, water depth from sea surface)".												
navi event: start byte 142 i6												
airgun utm x : start byte 148 f9.2												
airgun utm y : start byte 158 f10.2												
sparker utm x : start byte 169 f9.2												
sparker utm y : start byte 179 f10.2												
cent beam weater depth : start byte 190 f7.2												

Seismic setup Oden 2015, vertical view

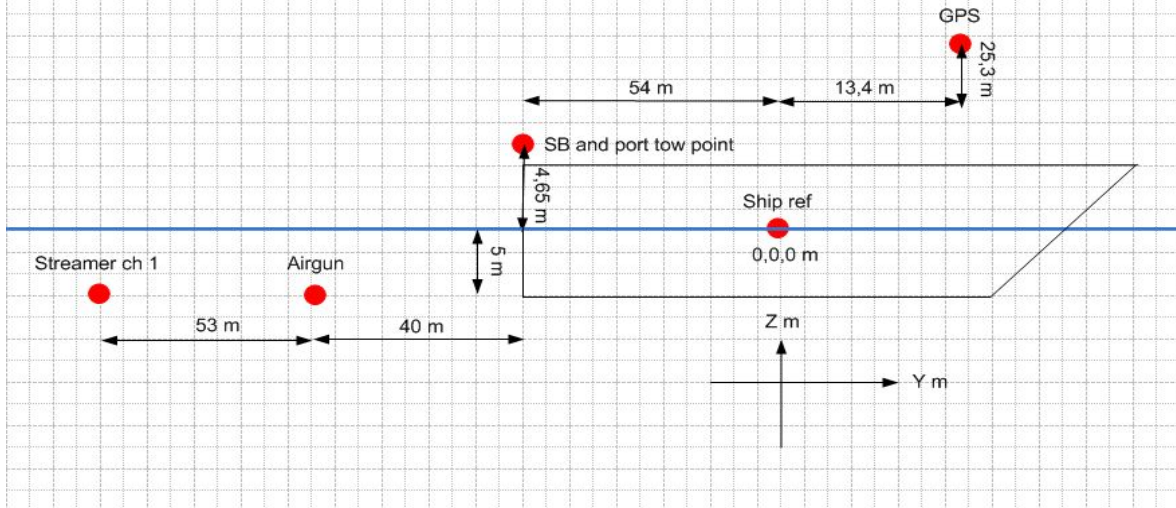


Seismic setup Oden 2015, plan view

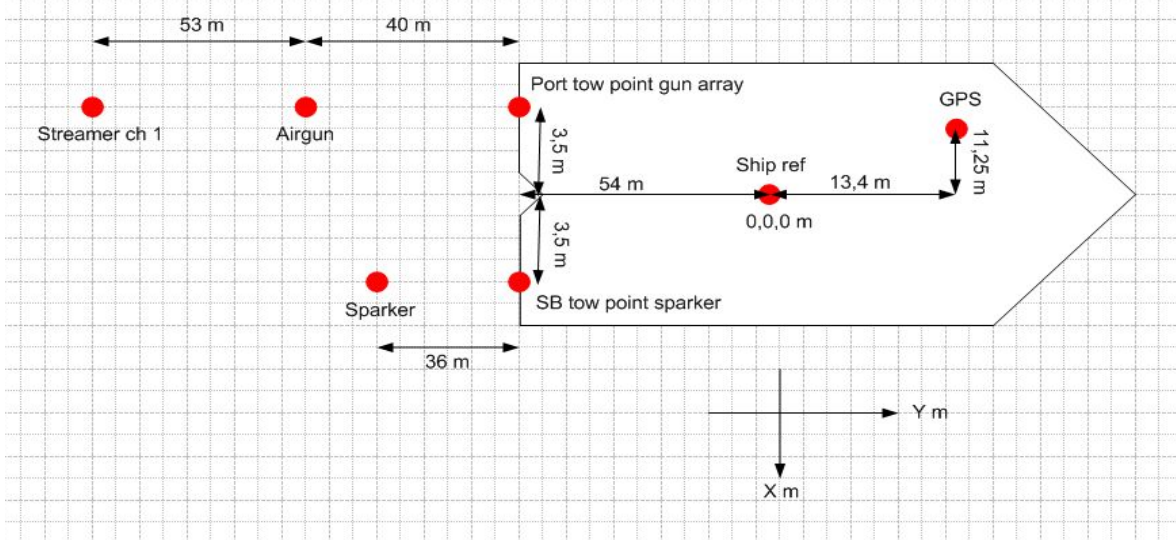


Date:		27 to 29-08-2015		Marine Survey - General Information						Line:		0014 to 0020	
Cruise:		Petermann 2015		Ship:		IB Oden		Location:		Petermann fjord			
GPS antenna		Refpoint ship		Gyro		100 Mb repeater		Length tow cable		10 Mb repeater, quick coupling		Length stretch section (m)	
X (m)	-11.5	X (m)	0.00	X (m)	0.00	NN	40	1080	53	50	50	50	50
Y (m)	13.4	Y (m)	0.00	Y (m)	0.00	Serial no. A/D converter (front of section)	1674	1480	1479	1497	1143		
Z (m)	25.3	Z (m)	0.00	Z (m)	0.00	Serial no. depth transducer 6.25 m section	5008	5022	5002	5015	5016		
Streamer Ch1		BB tow point		Airgun		Location of depth transducer with respect to ch no		1		9		17	
X (m)	0.00	X (m)	-3.50	X (m)	0.00	Navigation:				Transformation parameters:			
Y (m)	-70.00	Y (m)	-54.00	Y (m)	-15.00	Software:		NaviPac ver 3.8.2		Semimajor axis (m):		6378137	
Z (m)	-3.00	Z (m)	4.65	Z (m)	-6.00	Projection:		UTM north, Zone 20		Inverse flattening:		298.25722	
Towpoint used :		Tow point used:		Tow point used:		Datum:		WGS84		Scale at Origin		0.9996	
BB tow point		BB tow point		BB tow point						False easting (m):		500000	
										False northing (m):		0	
Seismic Energy Source:													
Type 1:		Sercel G1 gun		Type:		Geometrics GeoEel contoller		Type:		Geometrics GeoEel			
Serial no. G1-Gun:	44212	Lowcut filter (Hz):		out		Length of tow section (m):		40+50 (tow + vib)					
Volume G (cu.inch):	105	Lowcut filt. (dB/Oct):		out		Length of live section (m):		300.0					
Volume I (cu.inch):	105	Highcut filter (Hz):		anti-alias		No. of live sections:		5					
Injector delay	44mS	Highcut filt. (dB/Oct):		anti-alias		No. of channels:		40					
Discharge port	603, 120, Medium	Gain Setting (dB):		0		No. of channels/live section:		8					
Delay	0 mS	Sample Rate (ms):		0.250		No. of AUX channels:		8					
Pressure (bar):	140	Record Length (ms):		3000		channel interval (m):		6.25					
Planned depth (m):	6	No of recording chs:		32		No. of hydrophones/channel:		8					
Type 2 (no delay)		Software version		5.84		Hydrophone type		Geopoint					
Sledge		No of auxilliary chs:		8		Planned depth (m):		6					
Power supply		Nearfield hydrophone		AUX 1									
Energy													
Remarks:													
Airgun positions calculated in NaviPac as drag from the BB towpoint													
Streamer depth scanned on every shot.													
Events set to time trigger, every 5 sec													
Serial sting from NaviPac to SEG-D header, "Time, Event, X, Y (airgun), X, Y (sparker), Center beam (Kongsberg, water depth from sea surface)".													
navi event: start byte 142 16													
airgun utm x : start byte 148 f9.2													
airgun utm y : start byte 158 f10.2													
sparker utm x : start byte 169 f9.2													
sparker utm y : start byte 179 f10.2													
cent beam weater depth : start byte 190 f7.2													

Seismic setup Oden 2015, vertical view



Seismic setup Oden 2015, plan view



Appendix I | Marine Survey general information

Metadata table

Line name	Acoustic source	Start X (UTM 20N)	Start Y (UTM 20N)	End X (UTM 20N)	End Y (UTM 20N)	First record	Last record	Length (km)	Acquisition date (dd-mm-yyyy)	Acquisition start time	Acquisition end time	Total acquisition time
pm15_0001	Sparker	530549.6	8998167.5	531864.2	8998770.4	1191.sgd	2177.sgd		06/08/2015	01:06	03:01	01:55
pm15_0002	Sparker	495922.7	9027132.7	525018.3	9000351.6	2178.sgd	2280.sgd		06/08/2015	03:14	03:23	00:09
pm15_0003	Sparker	521486.0	8997963.6	528323.2	9004776.6	2281.sgd	6443.sgd	60.25	06/08/2015	03:53	09:03	05:10
pm15_0004	Airgun	514561.5	9011028.8	512417.0	9080336.4	7001.sgd	14844.sgd	86.00	10/08/2015 to 11/08/2015	22:46	09:40	10:54
pm15_0005	Airgun	514132.7	9079462.4	472393.1	9010210.2	14845.sgd	20484.sgd	83.15	11/08/2015	09:58	18:01	08:03
pm15_0006	Airgun	472115.9	9008451.2	479319.2	9022258.2	20485.sgd	22199.sgd	18.26	11/08/2015	18:14	20:36	02:22
pm15_0007	Airgun	479895.7	9022591.6	507113.7	9063057.4	22200.sgd	26942.sgd	61.71	11/08/2015 to 12/08/2015	20:42	03:17	06:35
pm15_0008	Airgun	478378.1	9008181.9	478383.7	9009237.2	27001.sgd	28935.sgd	27.69	17/08/2015	10:58	13:39	02:41
pm15_0009	Airgun	478209.4	9007554.0	486891.6	9020134.8	28936.sgd	31173.sgd	29.49	17/08/2015	13:46	16:53	03:07
pm15_0010	Airgun	488681.4	9020851.4	476946.5	9036157.7	31183.sgd	32725.sgd	19.61	17/08/2015	20:20	22:29	02:09
pm15_0011	Airgun	476896.6	9037016.1	492683.8	9046395.2	32726.sgd	34346.sgd	18.55	17/08/2015 to 18/08/2015	22:35	00:50	02:15
pm15_0012	Airgun	492600.8	9047138.0	513807.1	9026631.6	34351.sgd	36735.sgd	36.11	18/08/2015	00:55	04:14	03:19
pm15_0013	Airgun	514459.3	9027650.0	518413.4	9006746.2	36736.sgd	39440.sgd	41.76	18/08/2015	04:28	08:13	03:45
pm15_0014	Airgun	470803.8	9009320.6	453339.0	8988182.4	40001.sgd	41675.sgd	31.70	27/08/2015 to 28/08/2015	22:29	00:49	02:20
pm15_0015	Airgun	424939.3	8960636.4	425751.7	8961480.8	41676.sgd	45720.sgd	51.47	28/08/2015	07:16	12:53	05:37
pm15_0016	Airgun	424219.2	8956436.8	399616.1	8917020.7	45731.sgd	48656.sgd	53.09	28/08/2015 to 29/08/2015	20:33	00:36	04:03
pm15_0017	Airgun	398625.1	8916466.3	423071.8	8951663.9	48657.sgd	52734.sgd	67.53	29/08/2015	00:41	06:21	05:40
pm15_0018	Airgun	423511.6	8951348.5	402190.2	8918438.0	52735.sgd	54424.sgd	40.35	29/08/2015	06:24	08:44	02:20
pm15_0019	Airgun	401956.4	8917285.9	407633.0	8881869.0	54425.sgd	57153.sgd	42.24	29/08/2015	08:51	12:38	03:47
pm_15_020	Airgun	406612.0	8888806.0	397674.0	8888367.0	57201.sgd	57797.sgd	8.97	29/08/2015	20:39	21:29	00:50
TOTAL								777.94				77:01

Vessel: IB Oden

Sparker/Airgun

Nav file names:	
Custom log	_C.npd
General log	_G.npd
Survey log	_S.npd

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Per Trinhammer

KAH
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PT



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

<u>Date</u> dd-mm-yyyy	<u>UTC</u> hh:mm	<u>FILE</u> no	<u>EVENT</u> no.	<u>nav file name</u> yyyy_hhmmss C and G and S	<u>sparker</u>	<u>Airgun</u>	<u>Ship's heading</u>	<u>comments and (Mammals observation)</u>	<u>initialed</u>
06-08-2015	03:53	2281			yes	no	261	SOL, sparker settings: 2000 J and preamp gain 8 pb, no birds on streamer, streamer length 150m, speed = 5.8	
	03:58	2387					235	change shot interval to double of SBP	
	03:58	2397						0 db, water depth 456m	
	04:04	2455					162	turn finished, speed 4,3 kn, water depth 420 m	
	04:18	2686					115	turn	
	04:25	2787					65	turn finished, speed 5,3 kn, water depth 465 m	
	04:43	2945					85	change shot interval: same as SBP; speed: 5,4 kn; depth: 1140 m	
	04:47	2984					84	streamers mostly at 1,3; 1,7 and 3,6 m from closest to the ship to furthest	
	05:36	3553					156	Turned 45 degrees to starboard	
	05:52	3754					186	turn start: 5,2 kn	
	05:58	3838					252	turn finished: 5,9 kn	
	06:51	4612					295	start turn	
	06:56	4713					336	finished turn	
	06:58	4761					336	stop propeller starboard side; multibeam still on	
	07:05	4903					336	restart of starboard propeller	
	07:07	4963					334	Switch off of SBP. Multibeam and EK80 still on	
	07:13	5052					333	Switch off of SBP and multibeam. EK80 is still on	
	07:17							Switch off of SBP, multibeam and EK80. Loss of trigger, no recording	
	07:21	5062					326	restart recording, but without sparker pulse	
	07:28	5166					334	restart sparker	
	08:02	5757					74	finished turn (turn was made approx. 50 shots before this file)	
	08:16	5916					25	speed = 7,2 kn	
	08:19	5963					7	turn of multibeam = loss of trigger	
		6056					348	power supply on again	
	08:52	6298					125	turning, speed = 6,8 kn	
	09:02							EOL, switching off equipment	
	09:03	6443						EOL, switching off equipment	
Nav file names:									
Custom log _C.npd									
General log _G.npd									
Survey log _S.npd									
Initials:									
Katrien An Heirman KAH									
Egon Nørmark EN									
Søren Thesbjerg Andersen STA									
Per Trinhammer PT									

Line name : 0004



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Airgun

<u>Date</u> dd-mm-yyyy	<u>UTC</u> hh:mm	<u>FILE</u> no	<u>EVENT</u> no	<u>nav file name</u> yyyy_hhmmss_C and_G and_S	<u>sparker</u>	<u>Airgun</u>	<u>Ship's</u> <u>heading</u>	<u>comments and (Mammals observation)</u>	<u>initialer</u>
10-08-2015	22:46	7001	7002	20150810_224650_G.NDP	no	yes		SOL: gun (105 cu i) at ca. 5 m below surface; 40m behind stern; shooting rate 5s	
	22:59	7156	7157					running only on starboard side propellor	
	23:02	7185	7186				61	streamer at 8,38; 10,2; 13,34; 15,91; 15,93; 19,2m depth	
	23:06	7238	7239				61	speed increased to 5 kn: streamer depth all ca. 1 m higher (8,1; 9,88; 13,25; 15,62; 15,67; 17,94 m)	
	23:13	7315	7316				57	speed increased to 5,2 kn: streamer depth all ca. 1 m higher (7,91; 9,18; 12,03; 14,51; 14,61; 17,33 m)	
	23:15	7340	7341				56	passing seismic line	
	23:16	7356	7357				57	reducing speed to 5 kn (decreasing noise)	
	23:20	7405	7406				56	start turn to line along axis	
	23:40	7643	7644				253	Petermann fiord	
	23:46	7719	7120				322	crossed line	
								on line, slight deviation due to ice; speed 4,9 kn	
11-08-2015	00:09	7988	7989				328	ice berg along side, causing reflection; speed 5,4 kn	
	00:29	8241	8242				318	speed 4,7 kn; water depth: 723 m	
	00:39	8363	8364				319	Streamer uplift: 6.36 m, 7.09 m, 9.06 m, 10.70 m, 10.75 m, 12.94 m	STAVEN
	01:24	8890	8891				294	Deviating from planned line, approx. started 3 miles ago do to ice. No sharp turns.	
	02:05	9393	9394				349	Passed a big ice floe	

03:17	10260	10261				341	Back on planned line, speed shifting between 4,7 kn and 5,1 kn.	
04:06	10850	10851				328	Speed is now between 4,1 kn and 4,5 kn	
04:23	11055	11056				350	Streamer has dropped to 7.42 m, 8.46 m, 10.43 m, 12.69 m, 12.71 m, 15.07 m	
04:54	11422	11423				323	Streamer at 6.93 m, 8.01 m, 10.39 m, 12.67 m, 12.55 m, 14.39 m	
05:13	11655	11656				327	Streamer at 7.30 m, 8.46 m, 11.14 m, 13.61 m, 13.29 m, 15.69 m	
05:21	11745	11746				328	Speed is now between 3,8 kn and 4,1 kn	
05:24	11783	11784				328	Streamer at 7.09 m, 8.13 m, 10.02 m, 11.87 m, 11.93 m, 13.73 m	
	11950	11951				330	Streamer at 7.30 m, 8.13 m, 9.55 m, 11.14 m, 11.18 m, 12.61 m	
05:50	12096	12097				357	Speed is now between 3,1 kn and 3,7 kn	
05:57	12180	12181				312	Speed increased, and now between 3,8 kn and 4,5 kn	
06:23	12485	12486				355	50 deg starboard side deviation (ice), 3,5 kn speed	
06:52	12827	12828				47	speed: 4,4 kn; streamer at 7,38; 8,88; 10,72; 12,17; 12,38; 13,65 m	
07:42	13425	13426				45	speed 4,0, streamer, 7,7, 9,11, 11,12, 12,67, 12,74 and 14,2 m	
08:21	13900	13901				32	Canadian waters: will be moving in and out of them during current transect: speed: 4,7 kn	
09:04	14408	14409				39	Speed: 4 kn	
09:16	14550	14551				29	speed: 4 kn; streamer depth: 6,9; 7,6; 8,2; 9,1; 9,1; 9,7 m	
09:38	14827	14828				35	speed 4,2 kn; streamer depth 6,44; 6,56; 7,05; 9,19; 8,97; 11,38 m	
09:40	14844	14845				37	EOL	

Nav file names:
 Custom log _C.npd
 General log _G.npd
 Survey log _S.npd

Initials:

Katrien An Heirman
 Egon Nørmark
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 Per Trinhhammer

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 EN
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 PT

Line name : 0005



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

<u>Date</u> dd-mm-YYYY	<u>UTC</u> hh:mm	<u>FILE</u> no	<u>EVENT</u> no.	<u>nav file name</u> YYYY_hhmmss_C and_G and_S	<u>sparker</u>	<u>Airgun</u>	<u>Ship's heading</u>	<u>comments and (Mammals observation)</u>	<u>initialer</u>
11-08-2015	09:58	14845	14848	20150811_095847_G_NDP	no	yes	217	SOL; 105 cu i airgun; Greenland waters	PT
	10:02	14896	14899				219	speed: 5,2 kn; streamer depth: 6,45; 7,13; 9,23; 10,62; 10,93; 12,66 m	
	10:09	14975	14978				226	speed: 4,9 kn; streamer depth: 7,03; 7,83; 11,47; 13,90; 14,04; 16,53 m	
	11:14	15749	15752				218	speed: 5,2 kn; streamer depth: 7,74; 8,69; 10,35; 12,74; 12,52; 15,89 m	
	11:40	16065	16068				222	speed: 5,8 kn; streamer depth: 7,92 ; 9,11; 11,15; 13,44; 13,43; 15,04 m depth	
	12:51	16930	16933				199	Gate change in one compressor needed, shooting with 115-125 bar.	STA
	13:18	17252	17255				197	Gate change completed, back around 140 bar.	
		17721	17724					Start of gun problem: Gun controller only shoots every 4th shot	
	14:12	17764	17901				192	Gun problem observed: Gun controller terminated (harddisk was filled on gun controller)	
	14:16	17766	17947				200	Gun controller reactivated	
	14:44	18129	18286				203	speed: 5.5 kn; streamer at: 7.98 m, 9.45 m, 12.38 m, 14.61 m, 14.96 m, 17.57 m	
	18:02	20484	20641				220	EOL	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

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Line name : 0006

Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

[illegible]

Nav file names:

Custom log
General log
Survey log

Initials:

Katrien An Heirman
Egon Nørmark
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Per Trinhammer

KAH	EN	STA	PT
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Line name : 0007



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date dd-mm-yyyy	UTC hh:mm	FILE no	EVENT no.	nav file name yyyy hhmmss C and G and S	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initialer
11-08-2015	20:42	22200	22359	20150811 204217	no	yes	70	SOL, no mammals in sight of 1000m	
	23:09	23970	24130				75	Deviating do to ice floes	
	23:33	24255	24415					FAULT: compressor 2	
	23:35	24280	24440					switching off power of compressor interface panel (current pressure 121 bar)	
	23:42	24359	24519				60	both compressors back on (back 150 bar) (accidental power switch off to compressor 2)	
12-08-2015	01:25	25600	25760				350	approach north going line (0008), continue without break	
	01:36	25730	25890				341	On right course	
	03:18	26942						Turning 10 degrees starboard	
								EOL	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

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Marine survey - Line log



Line name : 0008

Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date dd-mm-yyyy	UTC hh:mm	FILE no	EVENT no.	nav file name yyyy_hhmmss_C and_G and_S	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initials
17-08-2015	10:58	27001	27001	20150817_105815_G.NDP	no	yes	143	SOL, no mammals in sight of 1000m	
	11:12	27126	27127				221	streamer depth: 8,04; 7,35, 9,17; 10,03; 10,03; 11,19 m; speed = 7,4 kn	
	11:23	27306	27307				276	start turn	
	12:13	27908	27909				326	Deviating (ice floes)	
	12:27	28080	28081				349	Planned line aborted (due to bad ice conditions). Deviating and turning 90 degrees into the other planned line.	
	12:57	28434	28435				112	Sharp turn towards south	
	13:22	28737	28738				136	Observation: Injector delay set to 16 ms. Should have been 44 ms	
	13:35	28893	28899				150	Injector delay changed to 44 ms. Bubbl pulse disappeared	
	13:40	28935	28941					EOL	
								FROM Line 0008 we run	
								with both SB and BB propeller	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

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Line name : 0009



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date dd-mm-yyyy	UTC hh:mm	FILE no	EVENT no.	nav file name yyyy hhmmss C and G and S	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initials
17-08-2015	13:46	28936	28943	20150817 134654 G.NDP	no	yes	213	SOL, no mammals in sight of 1000m	
	13:51	28989	28997				277	leakage fault streamer	
	14:09	29211	29219				53	another leakage fault streamer: reseted	
	14:53	29741	29749				44	Start turning north to get on new line	
	15:15	29992	3000				332	On line and righth course	
	15:58	30511	30519				14	start turn	
	16:06	30610	30618				102	end turn: on course of new line	
	16:52	31173						ch 43 noisy	
								EOL	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

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Per Trinhhammer

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Marine survey - Line log

Line name : 0010

Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

[illegible]

Nav file names:

	Custom log	General log	Survey log
C.npd			
G.npd			
S.npd			

Initials:

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Per Trinhammer

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Marine survey - Line log



Line name : 0011

Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date	UTC	FILE	EVENT	nav file name	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initials
dd-mm-yyyy	hh:mm	no	no	YVV hhmms C and G and S					
17-08-2015	22:36	32726	32729	20150817_223551	no	yes	45	SOL, no mammals in sight of 1000m	
	23:01	33045	33048				55	Turning towards next waypoint	
	00:47	34317	34320				36	Turning portside, preparing EOL	
	00:50	34346	34349				24	EOL	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

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Per Trinhammer

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Marine survey - Line log



Line name : 0012

Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date	UTC	FILE	EVENT	nav file name	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initials
dd-mm-yyyy	hh:mm	no	no	YVV hhmms C and G and S					
18-08-2015	00:55	34352	34353	20150817_223551	no	yes	10	SOL, starts with 270 degree port side turn, no mammals in sight of 1000m	
	01:10	34534	34535				116	End of sharp port side turn, now on line	
	01:55	35074	35075				153	Minor deviations do to ice floes	
	03:21	36094	36095				94	starboard turn because of ice ahead, cannot stay on originally planned line	
	03:45	36386	36387				182	on line; speed: 5,9 kn	
	04:14	36735	36736				142	EOL	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

Katrien An Heirman
Egon Nørmark
Søren Thesbjerg Andersen
Per Trinhammer

KAH
EN
STA
PT

Sparker/Airgun

Nav file names:	Initials:	
Custom log	Katrien An Heirman	KAH
General log	Egon Nørmark	EN
Survey log	Søren Thesbjerg Andersen	STA
	Per Trinhammer	PT

Marine survey - Line log

Sparker/Airgun

Nav file names:	Initials:	
Custom log	Katrien An Heirman	KAH
General log	Egon Nørmark	EN
Survey log	Søren Thesbjerg Andersen	STA
	Per Trinhammer	PT

Line name : 0015



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

<u>Date</u> dd-mm-yyyy	<u>UTC</u> hh:mm	<u>FILE</u> no	<u>EVENT</u> no.	<u>nav file name</u> yyyy_hhmmss_C and G and S	<u>sparker</u>	<u>Airgun</u>	<u>Ship's heading</u>	<u>comments and (Mammals observation)</u>	<u>initialer</u>
28-08-2015	07:17	41678	41680	20150828_071641	no	yes	72	SOL, no mammals in sight of 1000m,	
		41870	41872				40	turn to port side	pt
	07:46	42030	42032				234	180 turn ended	
		42436						30 degree to sb side	
	09:11	43058	43060				216	entering area with higher ice concentration	
	09:37	43365	43368				208	start starboard turn, turn back to crossline and zig-zag back	
	10:15	42826	43829				43	turn to port side	
	10:45	44183	44185				335	close to Canadian border	
	11:07	44455	44460				39	turn to starboard side	
	11:25	44660	44661					entering greenlandic waters	
	12:04	45133	45137					turn to port side	
	12:33	45483	45485				0	turn to starboard side	
	12:53	45720	45722				90	EOL	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

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Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

[illegible]

Nav file names:

	Custom log	General log	Survey log
Custom log	1	0	0
General log	0	1	0
Survey log	0	0	1

Initials:

Katrien An Heirman
Egon Nørmark
Søren Thesbjerg Andersen
Per Trinhammer

KAH
EN
STA
PT

Line name : 0017



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date	UTC	FILE	EVENT	nav file name	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initialer
dd-mm-YYYY	hh:mm	no	no.	yyy_hhmmss_C and _G and _S					
29-08-2015				20150829_004141_G.NDP	no	yes		SOL, no mammals in sight of 1000m, starting with starboard turn	
	00:54	48814	48816				65	Turn ended. Due to ice, Oden had to go south of the planned line	
	01:00							Wind speed 22 m/s from 035	
	01:22	49158	49160				60	turn on an extra engine, to keep down the prob wash	
	01:27	49212	49214				46	Turning to port side to connect with planned line	
	01:49	49476	49478				77	Now following planned line	
	03:05	50385	50387				55	start port turn, rather heavy weather and shallow waters	
	03:14	50495	50497				318	turn completed	
	04:22	51311	51313				293	breaking off of line due to heavy ice, start turn, going north	
	04:41	51540	51542				20	turning starboard, too much ice to reach the planned start of line	
	06:19	52706	52708				75	turn to starboard, start southerly course	
	06:21	52734	52736				112	EOL	

Nav file names:

Custom log _C.npd
General log _G.npd
Survey log _S.npd

Initials:

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Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

[illegible]

Nav file names:

Custom log
General log
Survey log

Initials:

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Line name : 0019



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date	UTC	FILE	EVENT	nav file name	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initialer
dd-mm-yyyy	hh:mm	no	no.	yyyy_hhmmss_C and_G and_S					
29-08-2015	08:51	54425	54430	20150829_085109_G.NDP	no	yes	191	SOL, no mammals in sigh of 1000m, starting with starboard turn	
	11:59	56685	56691				176	90 degrees turn to port	
	12:07	56780	56787				105	turn ended	
	12:39	57153	57159					EOL	

Nav file names:

_C.npd
_G.npd
_S.npd

Initials:

Katrien An Heirman
Egon Nørmark
Søren Thesbjerg Andersen
Per Trinhammer

KAH
EN
STA
PT

Line name : 0020



Marine survey - Line log



Project : Petermann2015

Vessel: IB Oden

Sparker/Airgun

Date	UTC	FILE	EVENT	nav file name	sparker	Airgun	Ship's heading	comments and (Mammals observation)	initialer
dd-mm-yyyy	hh:mm	no	no.	yyyy_hhmmss_C and_G and_S					
29-08-2015	20:40	57201	57201	20150829_203951	no	yes	265	SOL, no mammals in sigh of 1000m	
	21:29	57797	57797					EOL	

Nav file names:

_C.npd
_G.npd
_S.npd

Initials:

Katrien An Heirman
Egon Nørmark
Søren Thesbjerg Andersen
Per Trinhammer

KAH
EN
STA
PT

GM – Appendix II | Seismic source signature test

IV.1 Test motivation

The signature of a seismic source has great impact on quality of seismic recordings and the results of the following processing. It was therefore decided to do far field tests of the seismic sources used during the expedition. The sources will here be referred to as 'Sparker' and 'GI Gun'. Detailed information on those sources can be found in section 1.1 and Appendix I.E.

IV.2 Test setup

The tests were conducted after completion of seismic line 7 in the morning of august 12th. The GI-gun was tested at four depths, with different injector delays. The Sparker was tested with varying energy and filter settings. The signatures were recorded with a Reson TC4034 hydrophone, situated at a depth of approximately 67.4 m below sea level. The reflection seismic crew handled the sources, a crewmember of Oden handled the A-frame and Lawrence Meyer handled the hydrophone and recording computer. The ship engines were shut off, but the Multibeam and Subbottom Profiler systems were running. Pressure-relieve valves for Oden's fuel heating system were running, and have possibly caused noise on the recordings. Figure IV.1 and IV.2 shows the setup for the GI gun and Sparker tests respectively. 10 shots were recorded for each setup, and in all 11 different setups were tested. Setup specifications are listed in table IV.1.

Fig. IV.1: The GI Gun signature was tested at 3m, 6m, 9m and 20m below sea level. At 20m the gun was tested with two different injector delays. The recording hydrophone was situated at a depth of approx. 67,4m with approx. 10m of lateral distance to the gun.

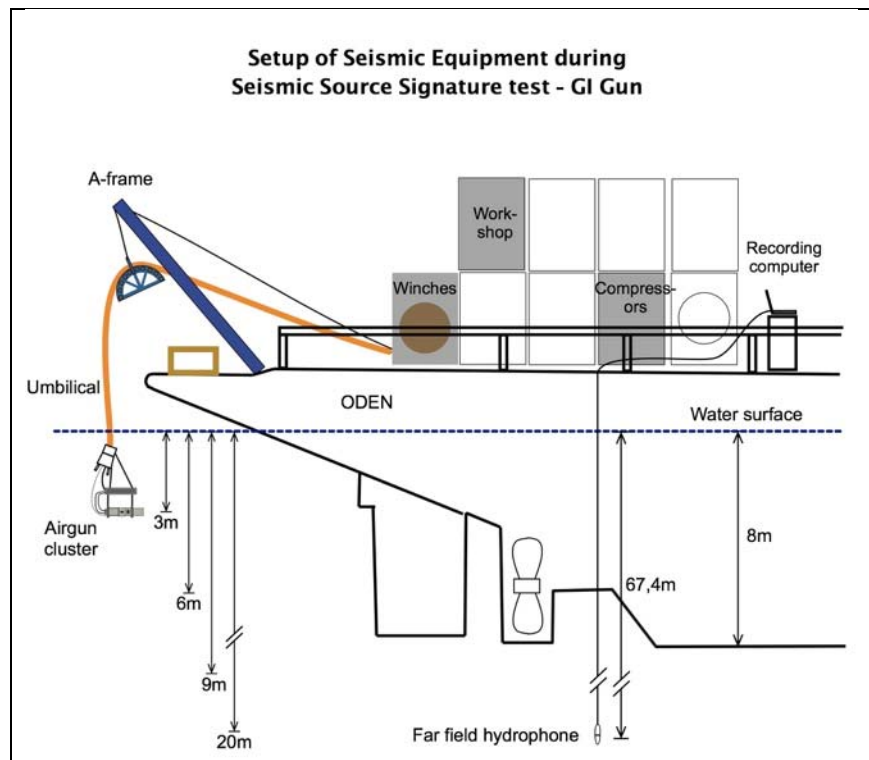
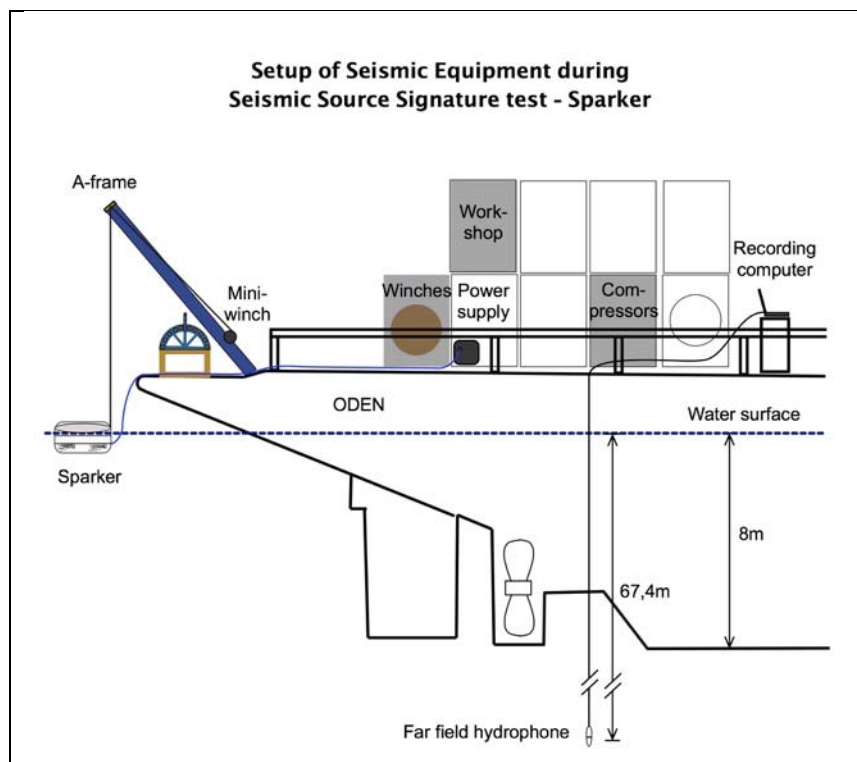


Fig. IV.2: The Sparker signature was tested at constant depth of approx. 0.3m below sea level. The hydrophone position was the same as for the gun tests. 6 different energy outputs were tested (100, 500, 1000, 1250, 2000 and 2400 Joule). The output power was low for the test at 1000 Joule, and high for all other.



Time (UTC)	Source type	Source size	Pressure (bar)	Depth (m)	Injector delay (mS)	Number of shots
04:18 – 04:26	GI gun	105/105	140	3	52	10
04:26 – 04:29	GI gun	105/105	140	6	44	10
04:30 – 04:33	GI gun	105/105	140	9	38	10 (8 recorded)
04:34 – 04:37	GI gun	105/105	140	20	38	10
04:37 – 04:41	GI gun	105/105	140	20	16	10 (8 recorded)
Time (UTC)	Source type	Output Power	Energy (J)	Depth (m)		Number of shots
05:12 – 05:15	Sparker	High	2400	0,3		10
05:15 – 05:18	Sparker	High	2000	0,3		10
05:18 – 05:19	Sparker	High	1250	0,3		10
05:19 – 05:20	Sparker	High	500	0,3		10
05:25 – 05:26	Sparker	High	100	0,3		10
05:29 – 05:30	Sparker	Low	1000	0,3		10
Pre-amp setting	GI gun		Sparker		Filter change @ 05:25	
Filter	10 Hz to 30 kHz		10 Hz to 30 kHz		300 hz to 10 kHz	
Gain	x100		x200			
Type	Low noise		Low noise			
Input type	AC coupled		AC coupled			
Hydrophone						
Type		Renson TC4034				
Cable length		87 m				
Cable on deck		Approx. 15 m				
Cable over railing		Approx. 72 m				
Railing to sea surface		4.6 m				
Hydrophone Depth		Approx. 67.4 m				
Sparker spec						
Power supply type		CSP-D2400				
Squid 2000, number of tips		8 x 15 = 120				

Table IV.1: This table contains all test setup specifications.

IV.3 Test results

The recorded data is here presented with as little processing as possible. A Fast Fourier Transform has been applied on time intervals of the signatures, to obtain a rough idea of the amplitude-spectra.

GI GUN

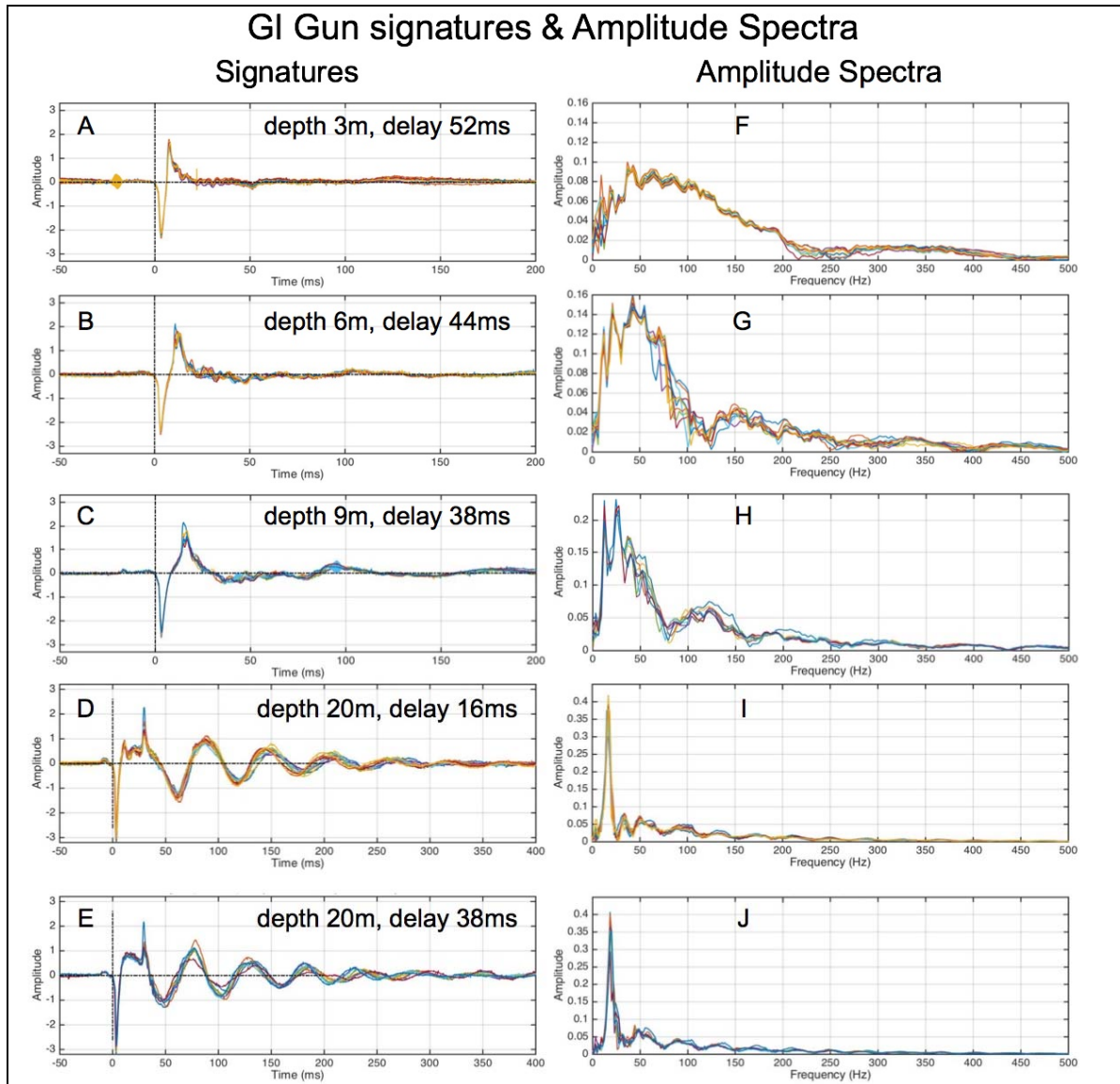


Fig. IV.3: A-E shows the recorded signatures. The recordings for each setup has all been plotted, which shows that the source is reliable. A-C is plotted for 200ms, while the ringing of the 20m tests yielded a plot of 400ms. F-J shows the amplitude spectra. These clearly show that the frequencies of the signature get more confined to the low end of the spectra, when the depth of the source is increased.

Signatures and amplitude spectra for GI Gun tests can be seen in figure IV.3. These shows that the pulse is compressed the most at the shallowest of the four test depths, and the frequency band is also wider. It gets harder for the injector to dampen the bubble pulse when the source is deeper situated. This is clearly seen by the ringing signature at 20 m depth. This also results in dominant low frequent energy.

SPARKER

Figure IV.4 shows the results from the Sparker test. The amplitude of the Sparker signature increases with increased energy. The delay of the bubble pulse is also increased with increased energy. The signatures and spectra only show minor differences when the energy gets above 1500 Joule. The bandwidths of the signatures are more or less the same for all setups. The power was set to “low” at 1000 Joule, and it is seen, that the signature here differs from the other power setting (all at “high” power).

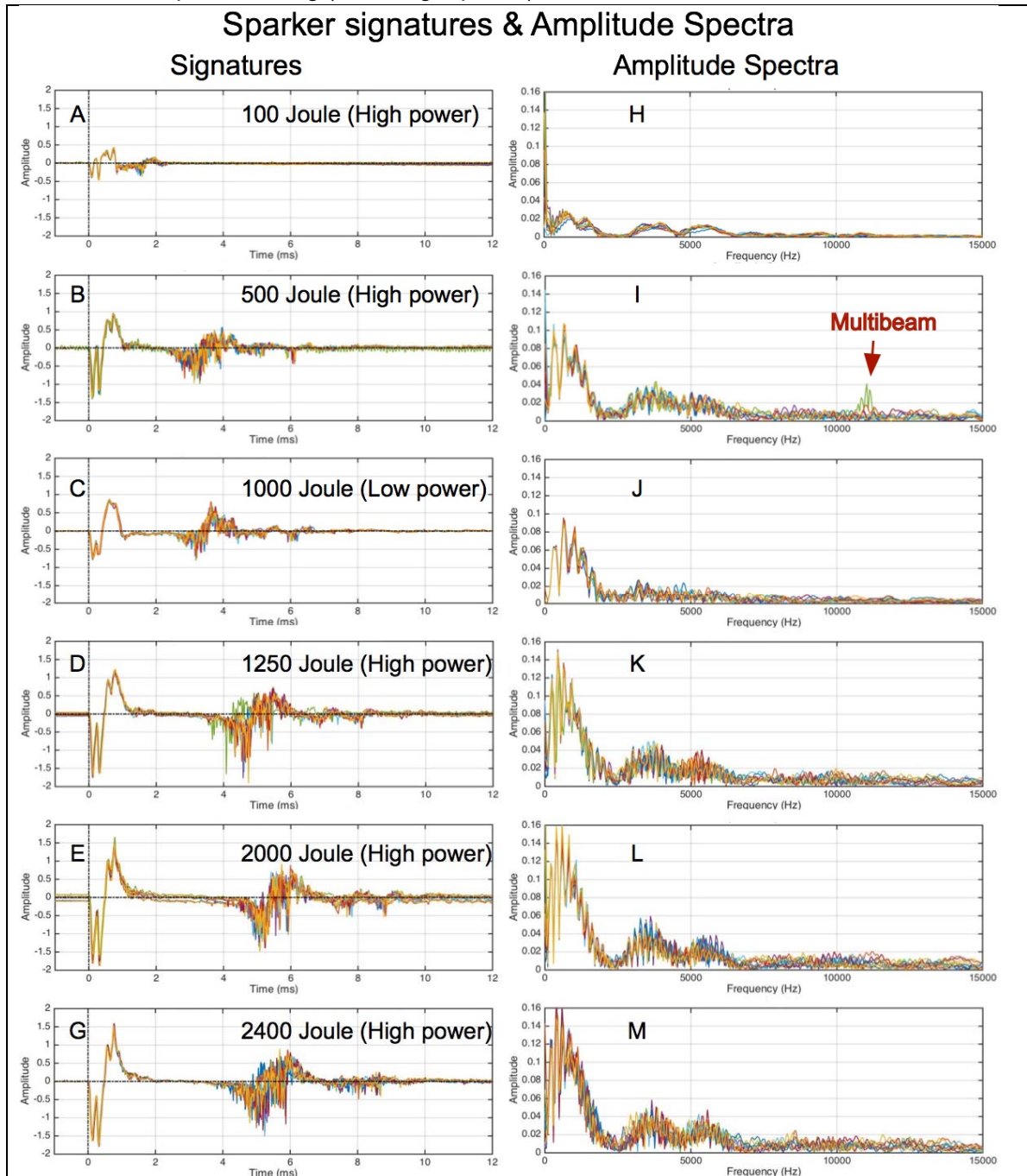
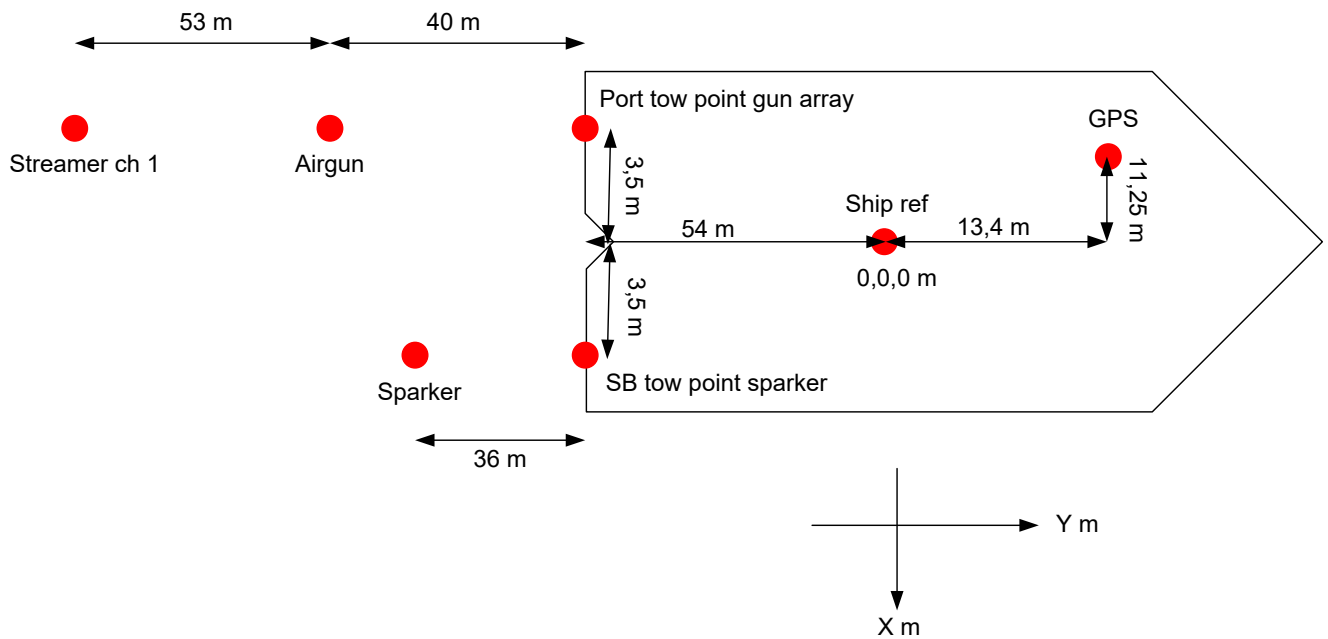


Fig. IV.4: A-G show that increased energy gives stronger amplitude and the bubble is further delayed. The frequency band is more or less constant. A low power output (C), gives a weaker amplitude compared to the high power output. The amplitude increase and bubble delay is not very apparent at energies above 2000 Joule.

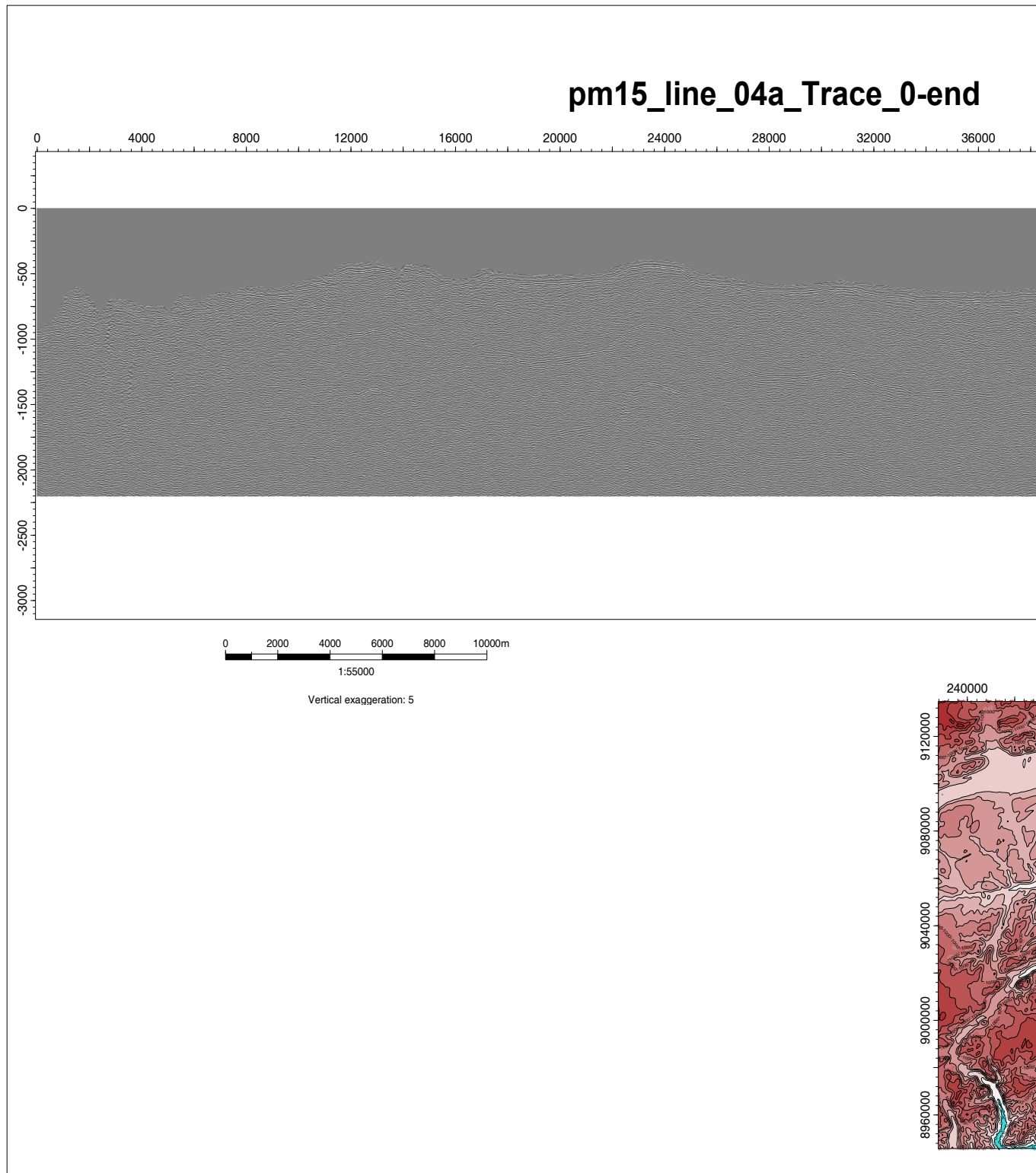
GM – Appendix III | Definition of offset points #1 and #2

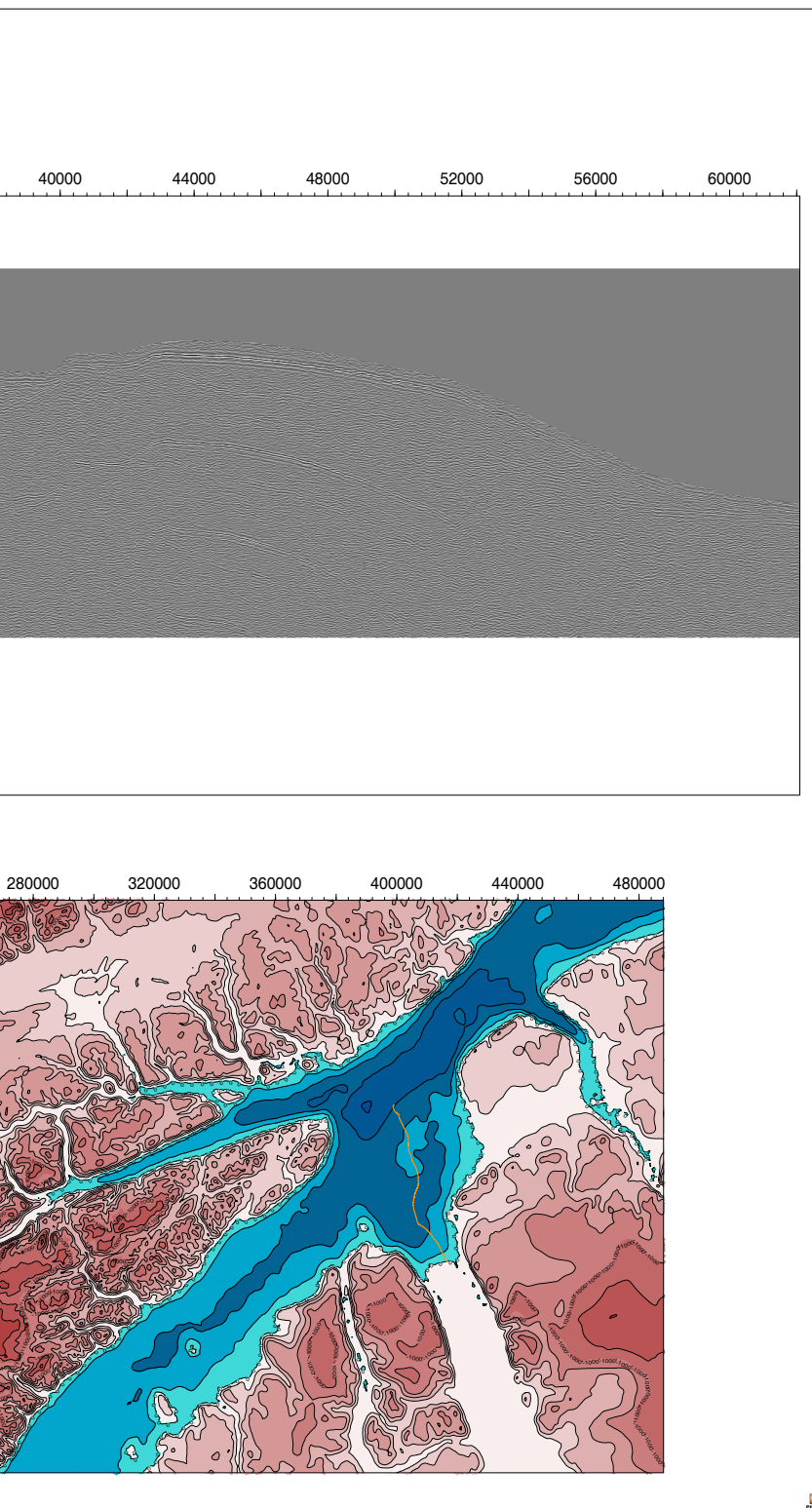
Seismic setup Oden 2015, plain view



GM – Appendix IV | Seismic line

pm15_line_04a_Trace_0-end







POLARFORSKNINGS SEKRETARIATET

SWEDISH POLAR RESEARCH SECRETARIAT

Polarforskningssekretariatet är en statlig myndighet som främjar och samordnar svensk polarforskning. Det innebär bland annat att följa och planera forsknings- och utvecklingsarbete samt att organisera och leda forskningsexpeditioner till Arktis och Antarktis.



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