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Research Vessel CCGS *Hudson* expedition 2021126, July 22 to 27, 2021: glacial fan stratigraphy and sediment stability on the southwestern Scotian Slope, offshore Nova Scotia

E.L. King, K. Boggild, L. Broom, L. Campbell, T. Fralic, C. Greaves, P. Ingham, D. Manning, G. Nissen, P. Pledge, A. Robertson, and B.J. Todd

2022

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2022

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1.0 Background and Objectives

The shallow (upper 100s metres) stratigraphy and geologic features of the continental slope offshore SW Nova has witnessed perhaps less study than other former glaciated trough mouths along the Canadian margin. This area has only two glaciated shelf-crossing troughs, one at the mouth of Northeast Channel, between Browns and Georges banks, and a much smaller one between Baccaro and LaHave banks. The latter was the focus of this cruise. The data paucity is partly because the hydrocarbon interests have only more recently directed their attention here and partly because the highly dissected seabed on the upper slope recording multiple phases and events has precluded their understanding given only a few seismic traverses. This situation gradually changed with the collection of a large multibeam dataset (with 3.5 kHz sub-bottom profiler) by NOAA (National Oceanic and Atmospheric Administration), and acquisition of 3-D seismic blocks by the hydrocarbon industry.

The study area is the site of a deep-seated meteorite impact (Jansa et al. 1989) which also triggered large-scale sediment gravity failures about 50 Ma (Deptuck and Campbell 2012). Campbell et al. (2015) recognized a series of four distinct phases beginning with Late Cretaceous to Late Eocene gully and canyon development alternating with pelagic, hemipelagic and carbonate deposition, punctuated by the meteorite impact. The slope further eroded with Oligocene to Late Miocene gravity mass failure and along-slope bottom current reworking. From then until the glaciations amplified, they documented large current-driven contourites developed, largely building the slope stratigraphy. 3-D data enabled detailed characterization and broad age categorization of the near seabed "Barrington MTD" (mass transport deposit), which lies in the expedition survey area. It is blocky, with a 41 km runout across 8 km, involving over 12 km^3, and overlies other mass failure deposits (Mosher and Campbell 2011). As such, it is similar to many other MTDs in the study area.

Legacy data in the area include a 1987 GLORIA (Geological Long Range Inclined Asdic) sidescan survey which provided low resolution seabed backscatter imagery on part of the lower slope, highlighting the propensity of downslope processes. With continued interest in potential for hydrocarbon exploration and development in the area, the nature of the sediment and its stability needs addressing. GSC-A cruises in the past decades include 80-010, 90-002 and 90-015, 98-039, 2000-036, 2002-047, 2005-023 and 2006-042, representing about 4000 geophysical line km. Much of the legacy data were collected long the upper slope where a 10 km wide bank of intense seabed canyonization exists. This dissection precludes almost any continuity of shallow stratigraphy and similarly hampers the shelf-slope correlation. The exceptions are rare and only occur a limited locations within the two shelf-crossing troughs.

A comprehensive undergraduate thesis characterized the shallow geology (Robichaud 2006) of the shallow features and stratigraphy at the NE Channel mouth and slope (just west of the 2021126 cruise area). In it, seismic facies are differentiated and mapped, a tentative MIS 2, 4 and 6 ages assigned to regional seismic horizons in the upper ~100 m and several key correlative horizons identified in the upper few metres, based on cores. Robichaud also mapped broad geomorphic/facies zones, and recognized sandy overbank deposits post-dating the last glacial maximum. These will broaden and enhance findings in the 2021126 study area, immediately to the east.

Similarly, the area immediately bounding the 2021126 study area to the east has seen more work. About five times the GSC-Atlantic geophysical survey covers a similar slope area to the east, stretching to the slope area offshore Sable Island. Geohazard assessments of the shallow (Quaternary) geology conducted there (c.f. Campbell and MacDonald 2006) do not yet have analogues on the western Scotian Slope.

Many and diverse objectives were originally planned for the Hudson 2021126 expedition, spanning the entire outer Scotian Shelf and mid to inner shelf offshore SW Nova. With reduced survey time, the focus remained on the primary objective, namely the shelf-break and upper to mid continental slope offshore the Liverpool to Yarmouth area. This was motivated by a relatively recent acquisition of multibeam bathymetric data. This dataset is publically available, collected in 2019 under the auspices of NOAA as part of their "Deep Connections" expedition[(a)] with a focus on exploration and documentation of seabed habitats and biota in collaboration with Fisheries and Oceans Canada (DFO) and Natural Resources Canada [(b)].
We informally refer to the dataset, including simultaneously collected 3.5 kHz sub-bottom profiler transects, as the *Okeanos area* after the US government research vessel, *Okeanos Explorer*. The data helped identify multiple sediment mass transport features superimposed on a diverse suite of glacially-derived features.

The uppermost slope in the Okeanos area is dominated by a 10 km broad continuous shelf-break dissected by numerous canyons and their tributaries. Most canyons extend to below 1500 m water depth, some directly linked to multiple-style mass failures farther down-slope that dominate over 25% of the immediate seabed topography and 100% of the area if the shallow glacier-fed shallow stratigraphy is considered. The shelf-break canyons are partly interrupted by two glacial fans readily identified from the new multibeam and related images, combined with existing seismic data collected by GSC-A. Their locations and contrast with inter-fan areas presented the potential to better understand the glacial regimes that fed them, their timing, and the sediment behavior contrasts in terms of both sediment distribution and slope stability.

The opportunity to link glacial source and sink presented itself with the new multibeam data in combination with greatly improved shelf-based bathymetric imaging provided by OLEX images derived from mosaicking single beam echosounder transects. Pre-existing sub-bottom profiler and sparse deeper penetration seismic profiles across the slope area, along with several pre-existing sediment cores (some radiocarbon dated) demonstrated that the fans and inter-fan area could be mapped at both the seabed and more coarsely, in the sub-bottom, to substantially increase understanding of the surficial mass failures and the Late Cenozoic and glacial geologic evolution in general. The shelf and slope data combination allows far greater study potential towards understanding the shelf-based glaciation patterns and timing. Unfortunately, this concurrently evolving shelf-based understanding was one of the pre-cruise study objectives lost to the delays. Nevertheless the slope area is poised to provide a shallow 3-dimensional framework, and through this, better understanding of the potential roles in pre-glacial, glacial and interglacial and post-glacial sedimentation conditions.

(a) https://oceanexplorer.noaa.gov/okeanos/explorations/ex1905/welcome.html
(b) https://oceanexplorer.noaa.gov/okeanos/explorations/ex1905/logs/sept9/sept9.html

Given a pre-cruise preliminary understanding of the stratigraphy and geometry, the primary cruise goal was to develop a regional last glacial and post-glacial cycle chronological framework though coring. The fans themselves generally have a very thick post-glaciation blanket- too thick to reach more than the upper half of the geo-section by coring.

The general philosophy of the coring strategy in the slope area, given limited expected core numbers, was to sample from a proximal to distal and across-fan (strike direction) to build a regional chronological and stratigraphic event model. This can strongly augment the existing and ongoing successes of this nature by GSC-A colleagues in the areas immediately to the east and west. The cores should equally contribute to a nominal age dating of the numerous mass failures, despite only directly targeting a few failure features. Pre-cruise study confirmed a variable sediment blanket thickness over individual mass failures, as identified from sub-bottom profiler. This strongly suggest periodicity in the failure event timing which needs core-based radiocarbon or stratigraphic correlation timing to establish more absolute ages. The six cores collected make this goal attainable.

2.0 Support and Rationale

This cruise came as the first major opportunity to contribute new data to the Scotian Shelf component of a science program entitled Marine Geology for Marine Spatial Planning (MGMSP). This program is supported by Fisheries and Oceans Canada (DFO) and this expedition occurred in the penultimate of a 5-year program duration. The cruise had much greater aspirations with 33 sea-days anticipated. Accordingly a much broader and diverse data collection was planned, including biota-focused components, but as stated, vessel readiness eventually reduced this to the five days documented here. A brief account is included in a copy of the article supplied to the GSC-A newsletter “Below the Waterline” in the Appendices.

As study areas and scope diminished with expedition start delays, the focus was on the SW Nova slope where the greatest value-added potential could be realised because of the extensive multibeam coverage. This area represents one of the highest hydrocarbon potential blocks remaining in the present climate of diminishing offshore development interest. A long history of GSC-A research expeditions in the area have identified numerous and diverse sediment mass-failures in the area. However, without the recently available multibeam bathymetric imagery, a systematic identification of individual features, their failure style, extents, and periodicity has not been possible until this point. This warranted investigation for safe potential development reasons. Recent previous work in the area (2016 and 2018 Hudson cruises, Campbell 2016, Campbell and Normandeau 2016 and 2019) was driven by the NS provincial regulatory board and collaborators with a focus on so-called “cold seeps” (hydrocarbons) with their rich and unique microorganisms (e.g. Dong et al. 2020); this expedition did not follow those leads, focussing rather on a more regional framework development.

3.0 Cruise Participants and Reporting Credits

The Coast Guard vessel was lead by Commanding Officer Francey Fergus, with Chief Officer, Bill Naugle, Second Officer, Mariana Duque Rivera, Third Officer, Donald Moran, Chief Engineer, Chris Longley, and Bosun, Robert Costelo.

A shortened cruise duration and coronavirus restrictions dictated a small GSC-Atlantic staff, all with vital roles. Edward (Ned) King was chief scientist and Brian Todd assisted in planning, data interpretation, QC and recommendations. Seismic operations and data handling were by Desmond Manning, Peter Pledge and Kai Boggild. Desmond Manning and Kai Boggild each wrote seismic acquisition reports which were then merged. Tom Fralic, with GeoForce Group Ltd., operated the sparker towfish and topsides acquisition (often still referred to as the 'Huntec") and wrote all related reporting. Peter Pledge and Angus Robertson performed coring and seabed photography deck operations with Hudson crew, as well as AUV preparation, mission planning and deployment-recovery. Peter wrote the AUV operations summary. Angus wrote the seabed camera operations description and the sampling operations section. Lori Campbell and Laura Broom were responsible for all aspects of sampling processing and oversaw students. COOP students Grace Nissen, Cameron Greaves and Alex (Parker) Ingham provided vital seismic and/or core watchkeeping. All photographs of operations and personnel are credited to our unofficial enthusiast, COOP student Parker Ingham unless otherwise credited. Appendix VI further describes contributions including those that did not sail.

4.0 Results Highlights

The five-day expedition yielded results commensurate with such a short duration. Operations were not hampered by weather conditions with the minor exception of the AUV deployment plan which was altered accordingly. In fact, the exceptionally calm conditions afforded high quality seismic data and good coring conditions. Figure 1 shows the geophysical tracks and camera and sample stations.

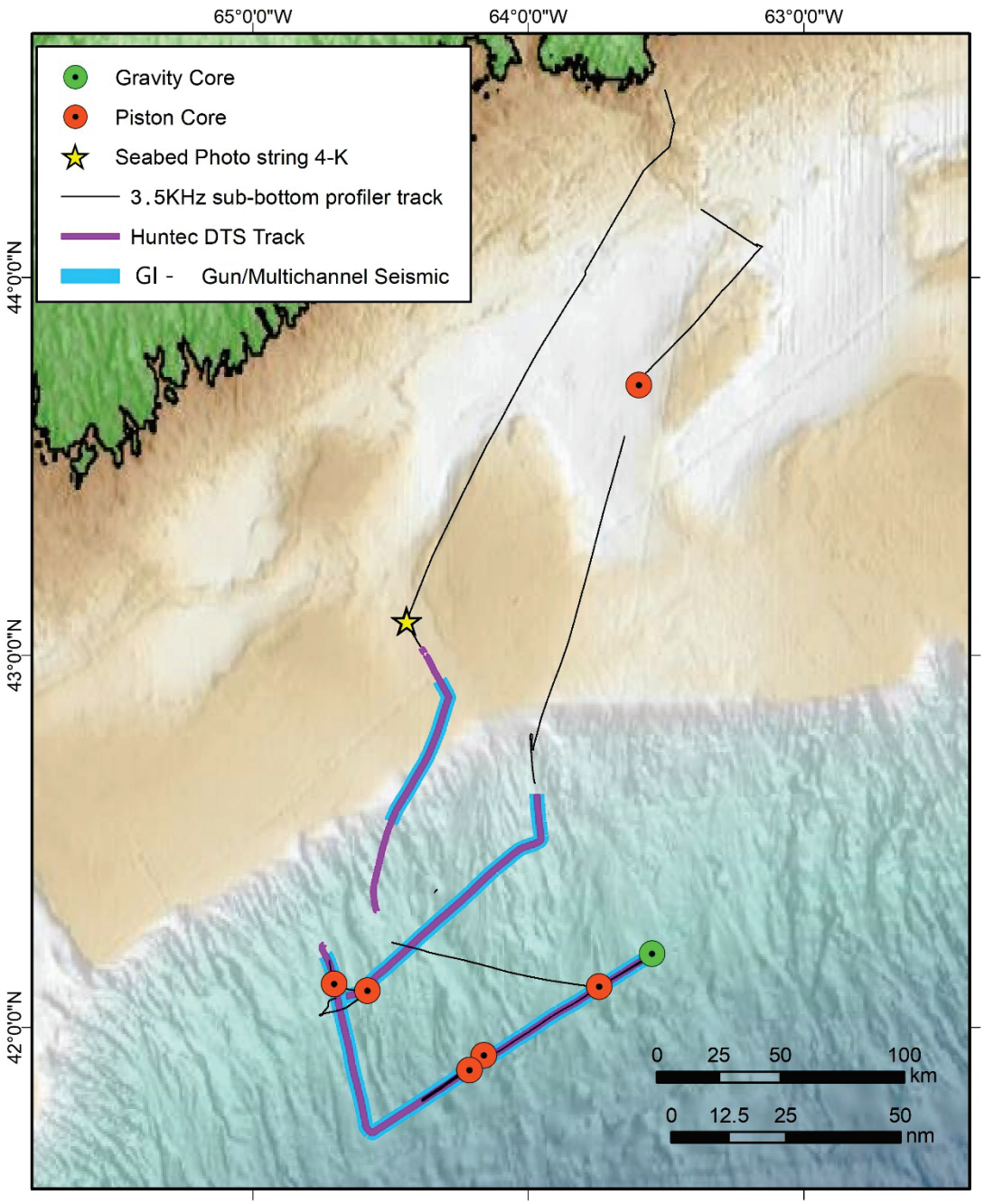


Figure 1. Geophysical survey and sample results (GEBCO bathymetry). Details of the SW Nova slope study area are shown in Fig. 4.

Figure 2 provides general laboratory and deck utilization and layout. The flight deck layout was especially modified to accommodate the multichannel streamer and AUV unit (Fig. 3).

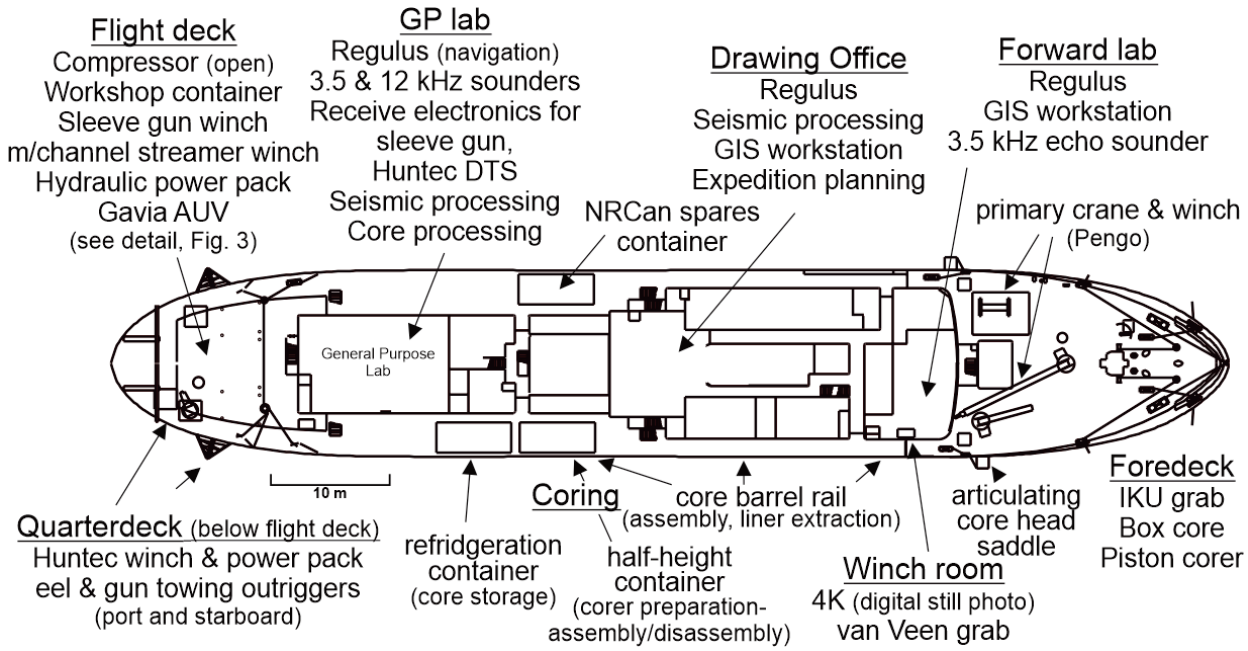


Figure 2. General laboratory and deck layout aboard CCGS Hudson for Expedition 2021126.

Figure 3. Flight deck (foreground) and afterdeck equipment layout aboard CCGS Hudson (photography by E. King. NRCan photo 2021-279).

4.1 Summary of Data Acquired

289 km of multichannel seismic reflection data of excellent (probably unprecedented) quality
240 km GeoForce Group Ltd. (Huntec) deep-towed sparker profiler of excellent quality
331 km of 3.5 kHz sub-bottom profiler of good quality

6 Piston Cores, all successful sediment recovery, most in over 2500 m water depth
1 Gravity core
1 Camera Station with 16 seabed photographs
1 Gavia Automated Underwater Vehicle (AUV) station located on northern Sambro Bank. AUV self-aborted its 2 hour mission only 18 minutes after beginning. Apparently the gradual decent to seabed timed-out, triggering mission termination. Recovery successful.

The weather conditions contributed to good quality 3.5 kHz data under transit to and from port; portions of this have very little legacy geophysical coverage.

The survey extent across the SW Nova (Okeanos) area was restricted to only half the planned survey area. The new data have the potential to accomplish many of the stated science goals. Figure 4 shows data collection details of the main study area.

This report documents the acquisition and early compilation efforts of the new data.

Details of cruise planning and results are further documented in the Appendices. Appendix I provides the documentation required of Coast Guard. Appendices II and III, the roles and cabin berths of GSC- staff, Appendix IV the specific log of (mainly geophysical) operations, Appendix V, a script developed for one step in the seismic processing, and an illustrated account of the cruise is in Appendix VI. An illustrated daily cruise narrative is provided in Appendix VII.

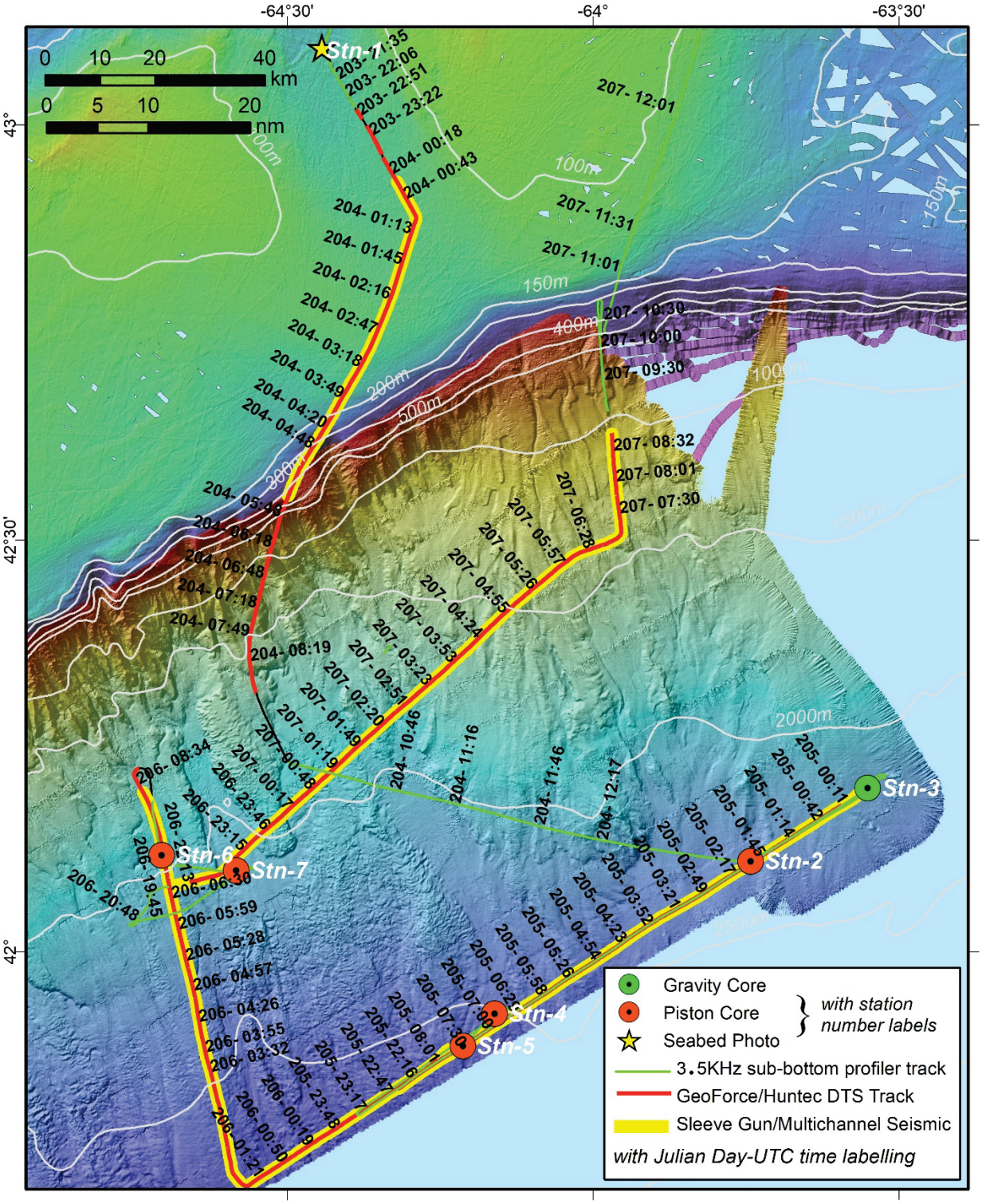


Figure 4. Geophysics and sampling in the main study area with OLEX (shelf area) and Okeanos bathymetric images (separate colour schemes) and Julian Day-UTC time stamps on the filenames allowing ready correlation with similarly stamped seismic filenames.

4.2 Summary of Geophysical Survey Results

Geophysical surveys included 12 kHz, 3.5 kHz, GeoForce deep tow and a sleeve-gun with multichannel streamer. Section 8 provides geophysical acquisition and processing details.
The 3.5 kHz, Regulus and GeoForce Group topsides displays are shown in Figure 5. The new 3.5 kHz sub-bottom profiler data complement the grid collected by NOAA simultaneously with the multibeam data (6 to 8 km line spacing). They are well suited to identify, and to a large degree, map the numerous mass failures and broadly differentiate their relative age based on thickness of stratified sediment cover. In contrast, the GeoForce (old Huntec) deep towed sparker profiles present superior resolution and at least twice the penetration. As do the legacy Huntec data in the area, they image an earlier phase of hemipelagic glacimarine sedimentation and mass failure. Initial study indicates that this sequence of mass failures is more extensive and thicker than the latter. It is unlikely that sufficient Huntec data coverage exist to map these in any detail. However, it is clear that this earlier phase strongly influences the present-day seabed topography, with the latest glacial downslope processes largely inheriting this topography. Consequently, many of the older, buried failures can be partially recognized in the multibeam image.

Figure 5. Sub-bottom profiler and Regulus (with multibeam image) displays in the General Purpose (GP) Lab. The MITS display, the left, is not shown. The Regulus monitor (right) also displayed the Electronic Log. A duplicate monitor facing the GeoForce setup (background) provided some topographic information to aid/anticipate steep slope-related triggering delay changes. (photography by C. Greaves. NRCan photo 2021-280).

The multichannel seismic utilized the 210 cubic inch GI gun and new GeoEel with two 50 m active sections, each with 8 channels and digibirds, controlled with Geometrics software and

preliminary processing (near trace and brute stack) in Vista 2020. The new system affords significant potential for post processing.

Four lines (298 km) were acquired, two with strike and two dip orientation, across the glacial fan emanating from Baccaro Channel, between Baccaro and LaHave banks (Fig. 4). A major course deviation (30 km) of the planned seismic transect at the mouth of Baccaro Channel, planned to cross the adjacent deep-sea sediment fan providing a continuous dip section, was not successful due to a very long sword-fish gear along the shelf break. Nevertheless, the new setup and calm sea resulted in perhaps the cleanest and highest S/N seismic data collected by GSC-A in decades. Figure 6 shows seismic illustration locations and Figures 7 to 9 provide an overview of the seismic images with very basic interpretations included.

All lines penetrated into deformed structure over deeply buried (>1.5 sec below sea floor) diapiric structures (Figs. 7 and 9), long known from underlying migration of Jurassic/Cretaceous salt (Jansa and Wade 1975). These are covered with classic stacked and migrating pre-glacial contourites (see Campbell et al. 2015, Campbell and Mosher 2016) followed by the transition to the glacial deposition regime characterized by a sharp increase in mass failures with a range in sizes. Even on the brute stack, a time-variable gain (TVG) helps image to over 5 seconds while resolution, especially near the seabed, is exceptional (Fig. 9). Even small failures are resolved scattered within the 20 m thick de-glacial stratified package at the seabed.

An experimental short overlap with a good quality 1990 line (Figs. 10 and 11) indicates nearly twice the penetration and improved resolution; the pulse signature is very sharp.

Overlap between profilers and air gun is exceptional as the deep towed sparker locally provided >100 ms penetration. Initial interpretation indicates that at least two glacial phases are recorded, the penultimate presenting the larger volume and failure magnitudes.

Table 1 has start and end times for the archived files. They are generally organized, not by line, but by Julian day and (UTC) time, concatenated to include up to 12 hour survey duration. Commonly these are only broken where data gaps or other survey parameter changes warrant. These are available in various formats but generally as SEGY and non-lossy SEGY-derived Jpeg2000 (.jp2 extension) images. Within NRCan they are on the GSC-A digital seismic archive, and externally available via email request to the chief scientist or general archivist (edward.king@nrcan-rncan.ca and kate.jarret@nrcan-rncan.ca).

All geophysical metadata, including 1 minute time-stamped latitude and longitude for each instrument are accessible through the NRCan Expedition database; https://ed.gdr.nrcan.gc.ca/index_e.php

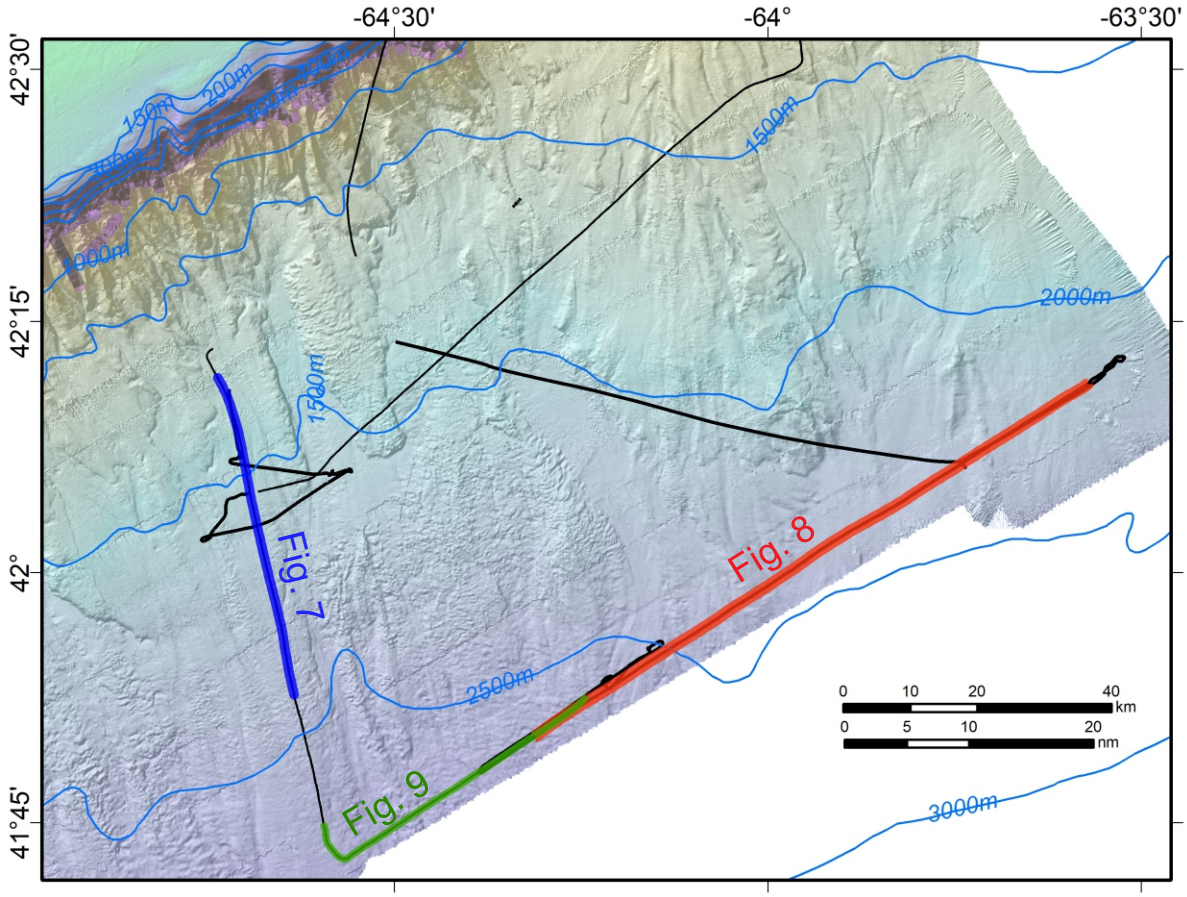


Figure 6. Multichannel sleeve gun profile illustration locations (coloured); other geophysics tracks are shown in black for reference.

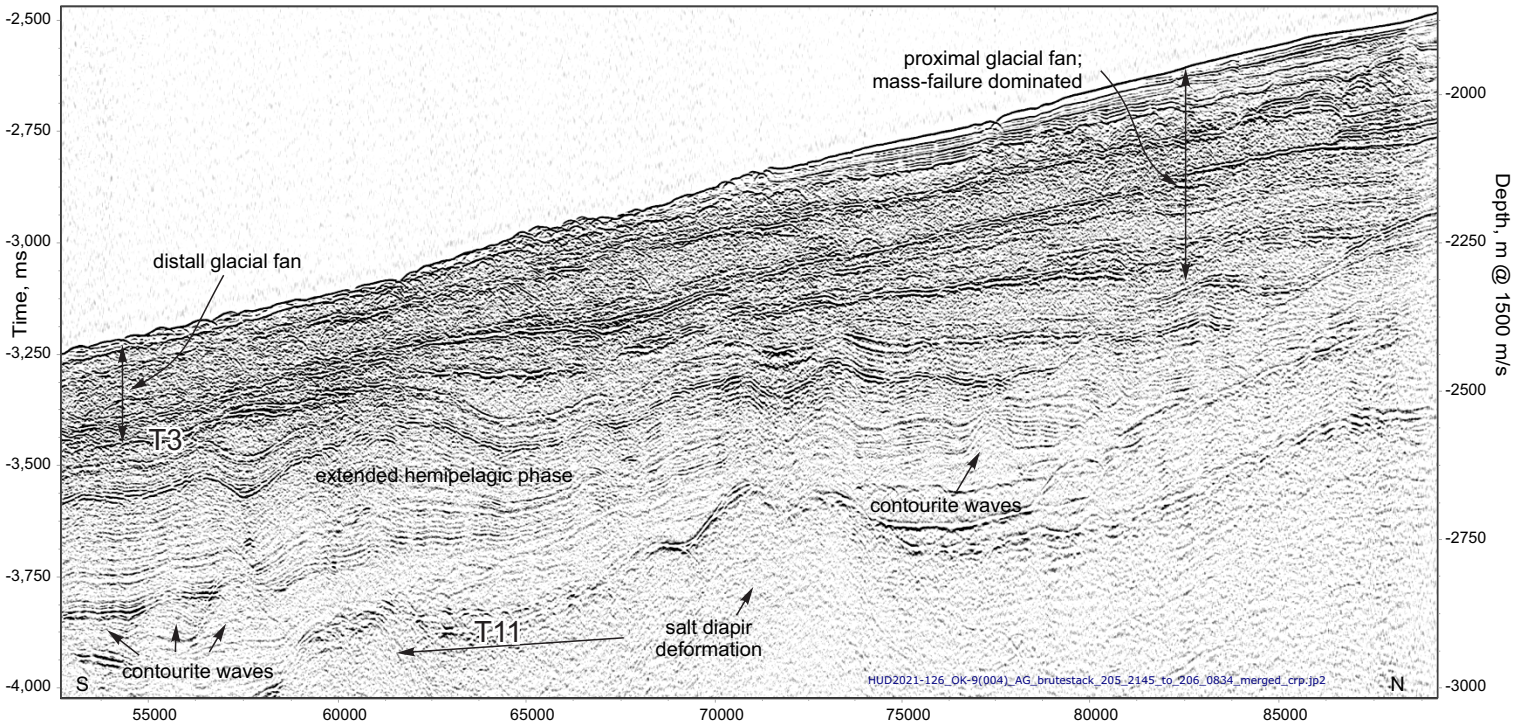


Figure 7. Multichannel sleeve gun profile along the western flank of the glacial fan supplied via Baccaro Channel. Much of the late Cenozoic section is imaged. The failure-dominated fan thins considerably distally. Horizons with T prefix are cross-correlated with Campbell et al. (2015). T11 marks a mid Miocene horizon, and they assign the erosive T3 to late Pliocene/Pleistocene. Profile location is the dip-line portion of line OK-9 (0004) in Fig. 6.

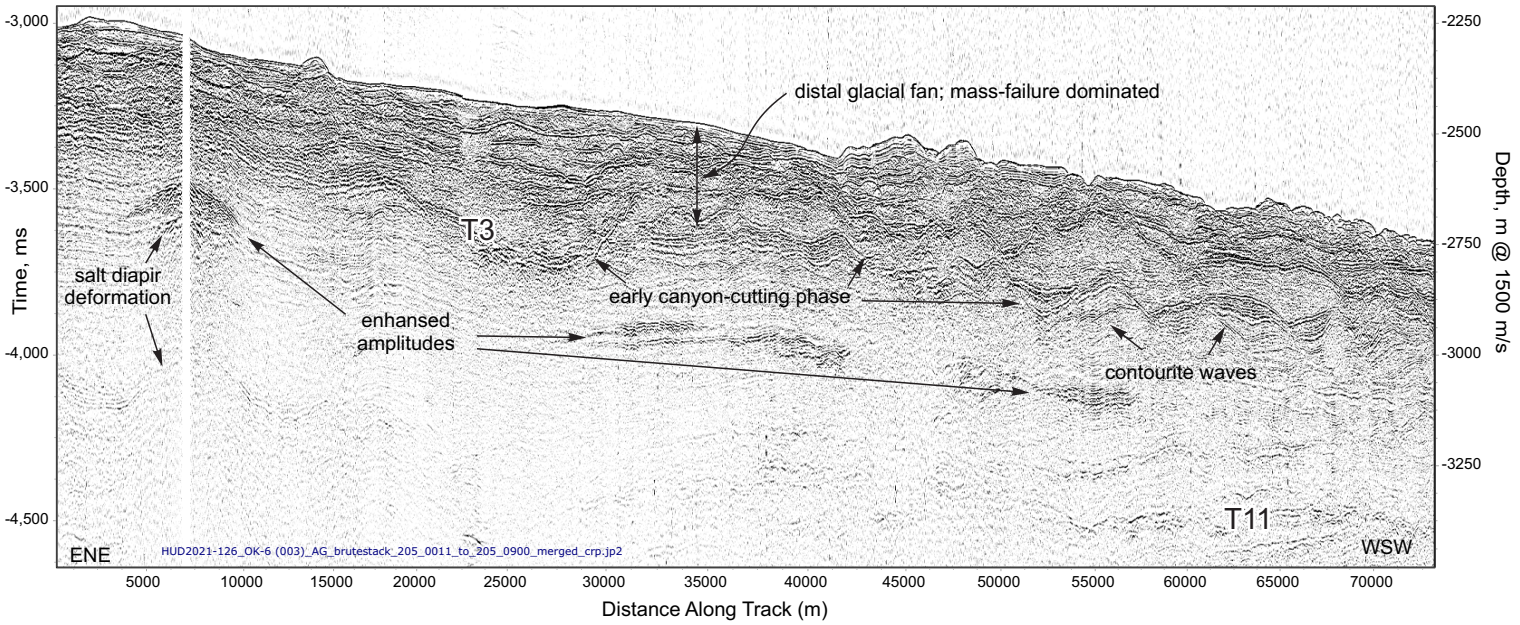


Figure 8. Multichannel sleeve gun profile along the mid to distal portion of the glacial fan supplied via Baccaro Channel. Horizon T-labels as per panel above. This approximate strike-line profile location is in Fig. 6.

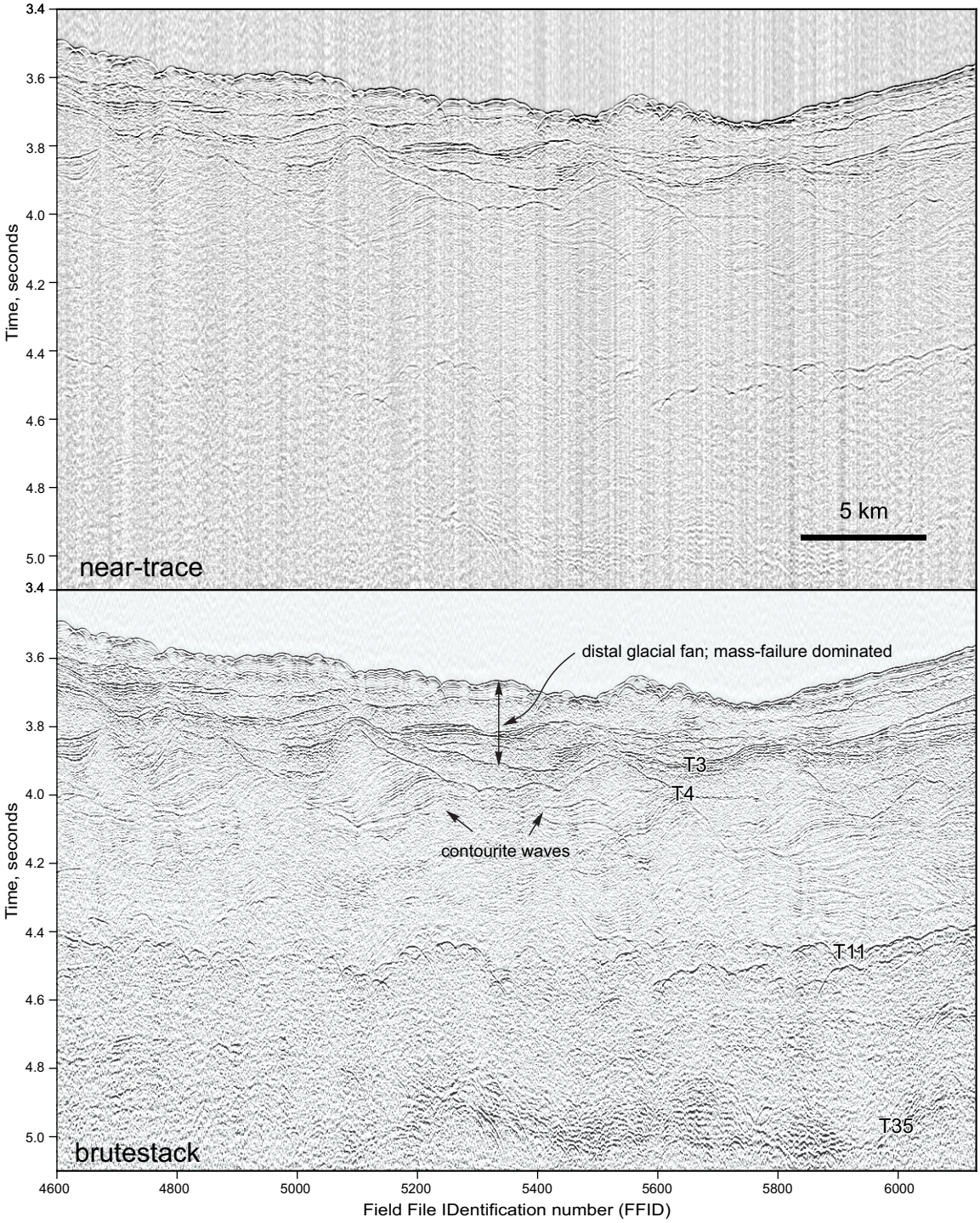
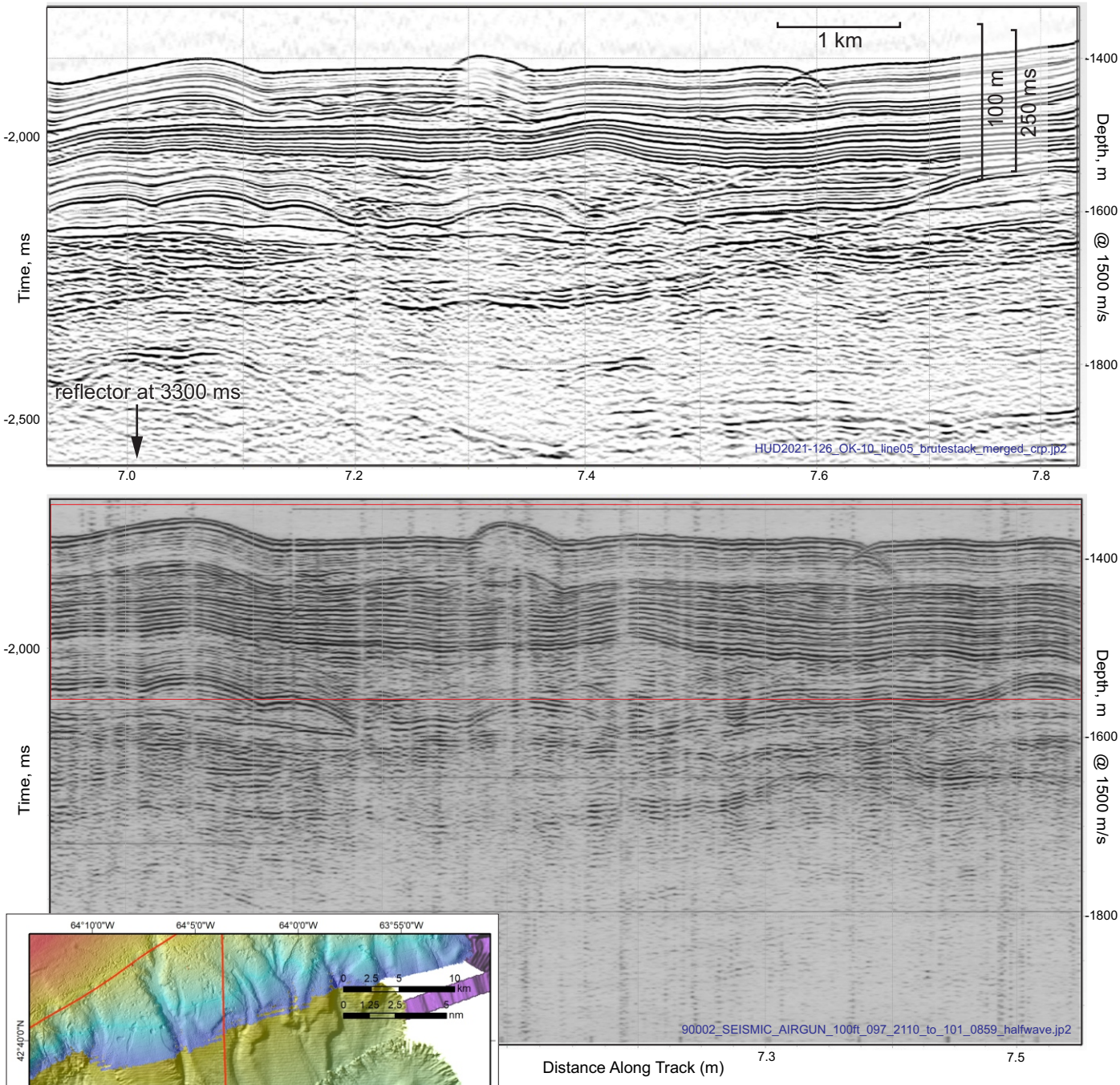


Figure 9. Multichannel sleeve gun profile along the distal and western flank of the glacial fan. The near trace and brute stack are contrasted. A time variable gain also enhances the deeper section compared to the previous illustrations where signal trails off below about 4 seconds. Horizons with T prefix are cross-correlated with Campbell et al. (2015). T35 approximately marks the Eocene-Oligocene contact. The others are identified in previous illustrations. Post-processing will further enhance these data. Profile location is in Fig. 6.



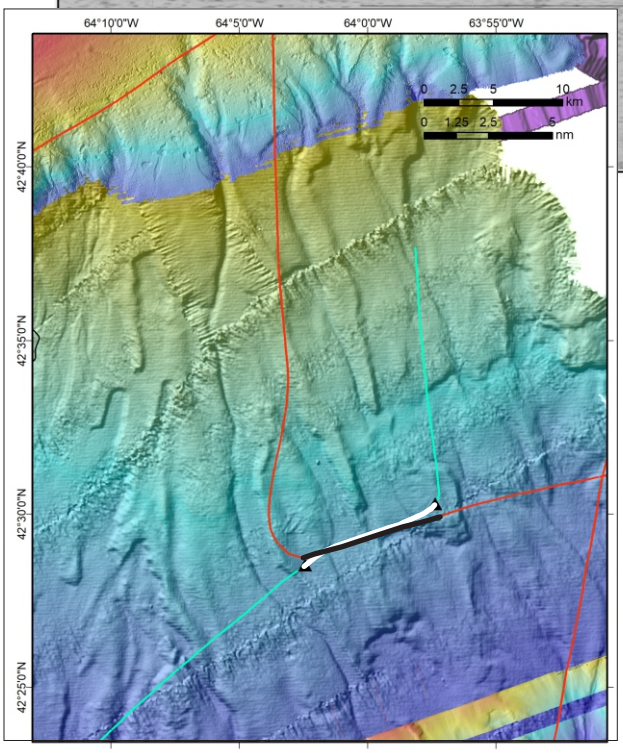


Figure 10. Comparison of air gun profiles across approximately the same transit. On the map at left, black is cruise 90002, and white is the 2021126 track. Note the disparate colour ranges on separate multibeam bathymetry shaded relief images and the prominent (but buried) downslope mass failure features. Upper panel is a brute stack from the 2021126 GI gun and multichannel streamer while the lower is from a 1990 cruise utilizing a 40 cubic inch air gun and 100 foot streamer. Strong reflections below ~2300 ms in the upper (2021) panel are much diminished in the lower (1990) which effectively attenuates by ~0.5 sec below seabed. A strong regional reflector at ~3300 ms (not shown) is well manifest on the newer survey line, indicating over twice the penetration. Vertically-exaggerated presentations of the red boxed area are in the following figure.

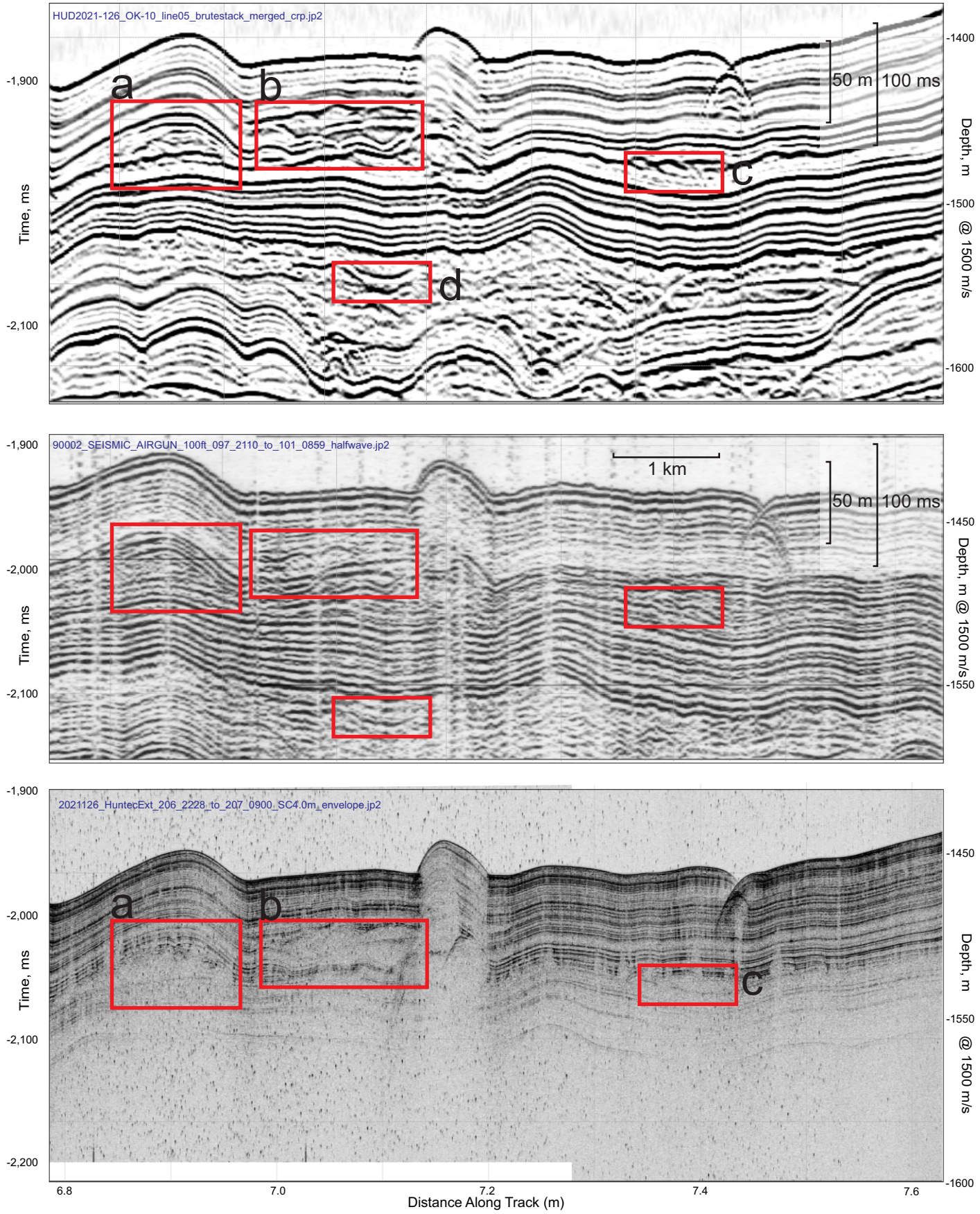


Figure 11. Comparison of the same two air gun profiles as in the preceding figure and the corresponding high resolution Huntec deep-towed sparker (lower panel), at the identical scales. These include only the shallower section (upper 300 ms). Note the features highlighted in red boxes. The amplitude and resolution in the new data allows recognition of individual mass transport events as opposed to their near-amalgamation in the older air gun line.

Table 1: Geophysical data listing

Start	End	Jpeg 2000 format filename; each with a corresponding concatenated SEGY format file with a similar name
12 kHz		
203_1232	204_0035	2021126_12KHZ_203_1232_to_204_0035_SC6.9m_envelope.jp2
204_0035	205_0308	2021126_12KHZ_204_0035_to_205_0308_SC2.6m_envelope.jp2
205_0308	205_1428	2021126_12KHZ_205_0308_to_205_1428_SC9.5m_envelope.jp2
205_1626	206_0244	2021126_12KHZ_205_1626_to_206_0244_SC6.3m_envelope.jp2
206_0245	207_0032	2021126_12 KHZ_206_0245_to_207_0032_SC7.0m_envelope.jp2
207_1535	207_1622	2021126_12 KHZ_207_1535_to_207_1622_envelope.jp2
207_1622	207_2247	2021126_12 KHZ_207_1622_to_207_2247_SC5.0m_envelope.jp2
3.5 kHz		
203_1232	203_2246	2021126_3.5KHZ_203_1232_to_203_2246_SC7.0m_envelope.jp2
204_1016	205_0308	2021126_3.5KHZ_204_1016_to_205_0308_SC1.8m_envelope.jp2
205_0308	205_1428	2021126_3.5KHZ_205_0308_to_205_1428_SC9.5m_envelope.jp2
205_2034	206_1915	2021126_3.5KHZ_205_2034_to_206_1915_SC0.9m_envelope.jp2
206_1915	207_1447	2021126_3.5KHZ_206_1915_to_207_1447_SC7.2m_envelope.jp2
207_1451	207_1622	2021126_3.5KHZ_207_1451_to_207_1622_envelope.jp2
207_1624	207_2247	2021126_3.5KHZ_207_1624_to_207_2247_SC5.0m_envelope.jp2
Deep-towed sparker; external streamer		
203_2251	203_2308	2021126_HuntecExt_203_2251_to_203_2308_SC0.7m_envelope.jp2
203_2322	204_0013	2021126_HuntecExt_203_2322_to_204_0013_SC0.7m_envelope.jp2
204_0018	204_0905	2021126_HuntecExt_204_0018_to_204_0905_SC2.5m_envelope.jp2
205_0031	205_0900	2021126_HuntecExt_205_0031_to_205_0900_SC4.8m_envelope.jp2
205_2201	206_0001	2021126_HuntecExt_205_2201_to_206_0001_SC4.8m_envelope.jp2
206_0001	206_0900	2021126_HuntecExt_206_0001_to_206_0900_SC4.8m_envelope.jp2
206_2228	207_0900	2021126_HuntecExt_206_2228_to_207_0900_SC4.0m_envelope.jp2
Deep-towed sparker; internal		
203_2251	203_2308	2021126_HuntecInt_203_2251_to_203_2308_SC0.7m_envelope.jp2
203_2322	204_0013	2021126_HuntecInt_203_2322_to_204_0013_SC0.7m_envelope.jp2
204_0018	204_0905	2021126_HuntecInt_204_0018_to_204_0905_SC2.5m_envelope.jp2
205_0031	205_0900	2021126_HuntecInt_205_0031_to_205_0900_SC4.8m_envelope.jp2
205_2201	206_0101	2021126_HuntecInt_205_2201_to_206_0101_SC4.8m_envelope.jp2
206_0001	206_0900	2021126_HuntecInt_206_0001_to_206_0900_SC4.8m_envelope.jp2
206_2228	207_0900	2021126_HuntecInt_206_2228_to_207_0900_SC4.0m_envelope.jp2
210" GI-air gun		
204_0043	204_0546	*HUD2021-126_BC-1(001_002)_AG_brutestack_204_0043_to_204_0546_merged_crp.jp2
204_0043	204_0546	HUD2021-126_BC-1(001_002)_AG_neartrace_204_0043_to_204_0546_merged_crp.jp2
205_0011	205_0900	HUD2021-126_OK-6 (003)_AG_brutestack_205_0011_to_205_0900_merged_crp.jp2
205_0011	205_0900	HUD2021-126_OK-6(003)_AG_neartrace_205_0011_to_205_0900_merged_crp.jp2
205_2145	206_0834	HUD2021-126_OK-9(004)_AG_brutestack_205_2145_to_206_0834_merged_crp.jp2
205_2145	206_0834	HUD2021-126_OK-9(004)_AG_neartrace_205_2145_to_206_0834_merged_crp.jp2
206_2213	207_0900	HUD2021-126_OK-10(005)_AG_brutestack_206_2213_to_207_0900_merged_crp.jp2
206_2213	207_0900	HUD2021-126_OK-10(005)_AG_neartrace_206_2213_to_207_0900_merged_crp.jp2

*alpha-numeric line numbers are field-assigned; bracketed numbers refer to post-processing line number assigned to the air gun data

5.0 Seabed Photography

The DFO 4k drop camera was used (as a test courtesy for an upcoming DFO mission) at one station being deployed from the winch room. The NRCan 4k camera was onboard as a spare. The same Canon Rebel Digital SLR and Canon flashes were used as in previous years powered by a 12 volt/80 Ahr Deep Sea Power & Light pressure compensated sea battery. A drift transect was run recovering 16 high quality still photos with a 12 kHz OIS pinger mounted on the camera sled being monitored for bottom trigger closure using the Knudsen 12 kHz in pinger mode.

A high powered 4000m Applied Acoustics beacon was also mounted on the sled to allow sub-sea positioning as it was tracked with the Trackpoint 3 USBL system from the GP lab moonpool.

The single seabed photography station targeted a small moraine at what was planned as the beginning of the seismic surveying. Figure 12 shows the series of photographs. Table 2 provides details and brief geological and biological descriptions. Both table and full resolution images are accessible through the NRCan Expedition database; https://ed.gdr.nrcan.gc.ca/index_e.php

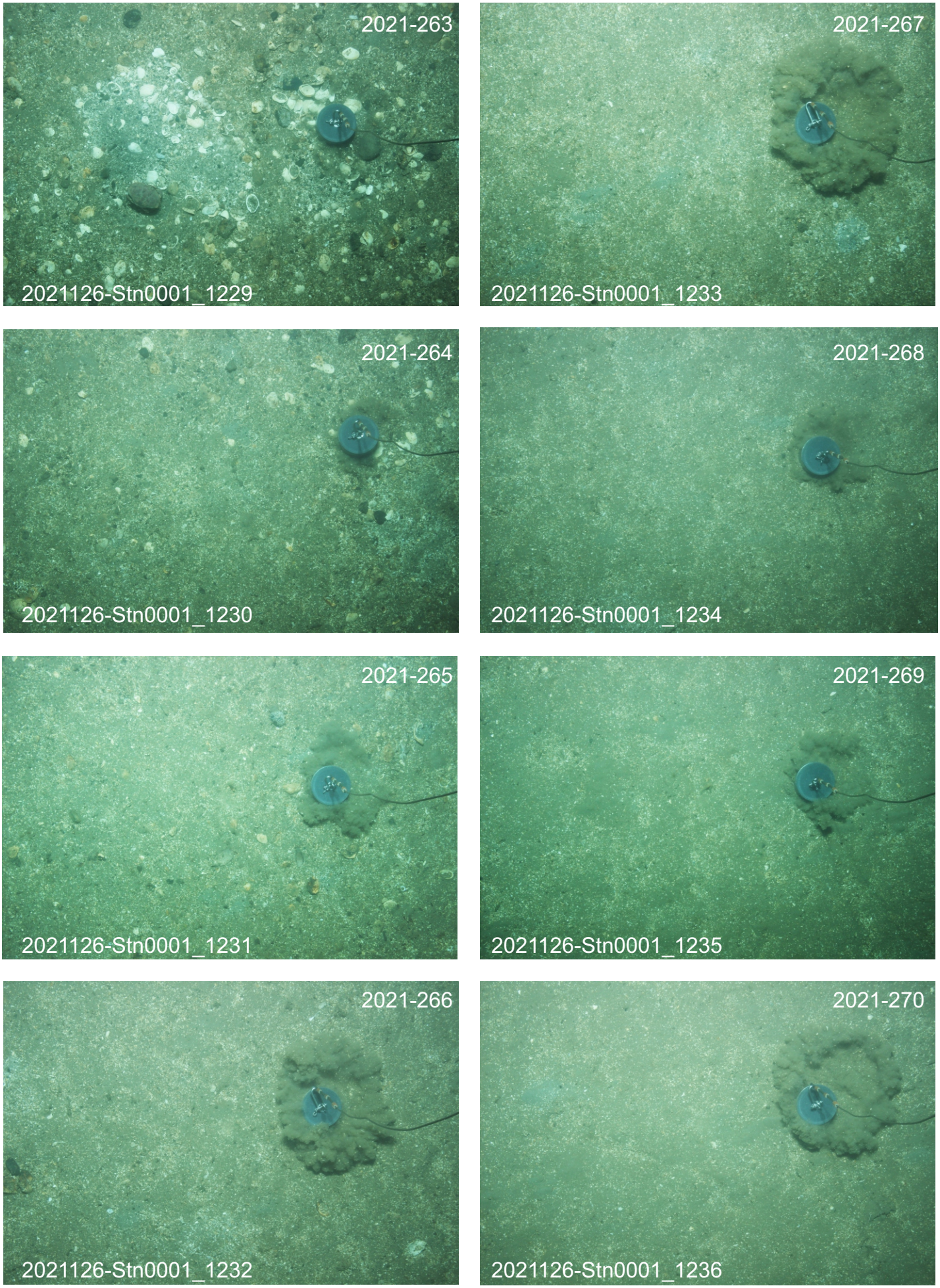
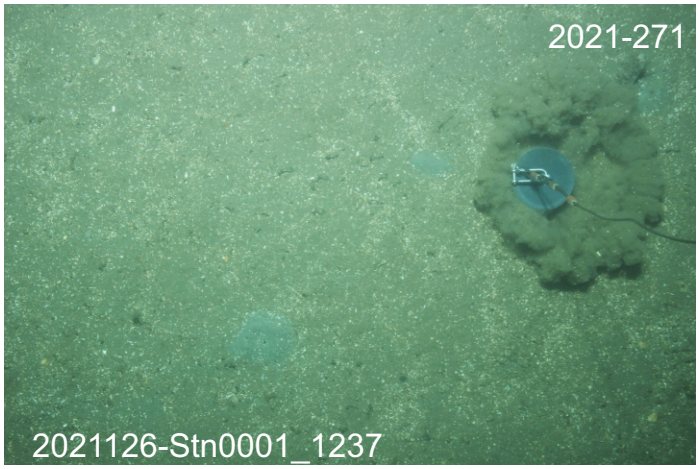
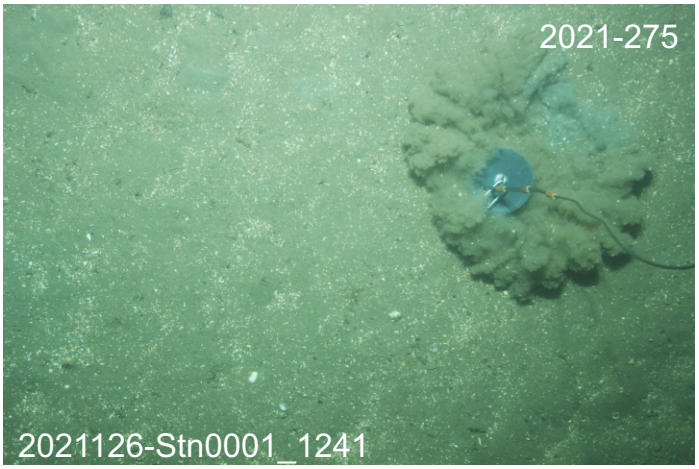
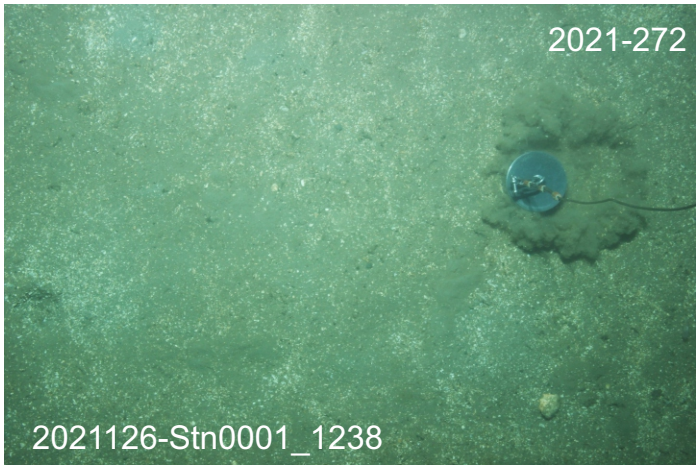
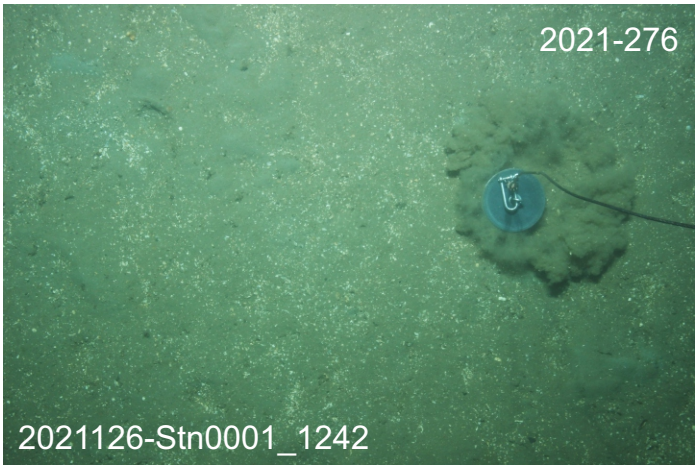


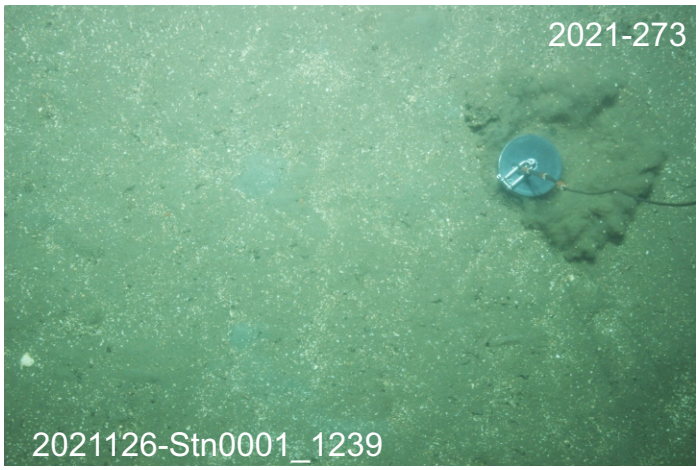
Figure 12. Station 0001 seabed photographs from the flank and south of a small moraine in Baccaro Channel.

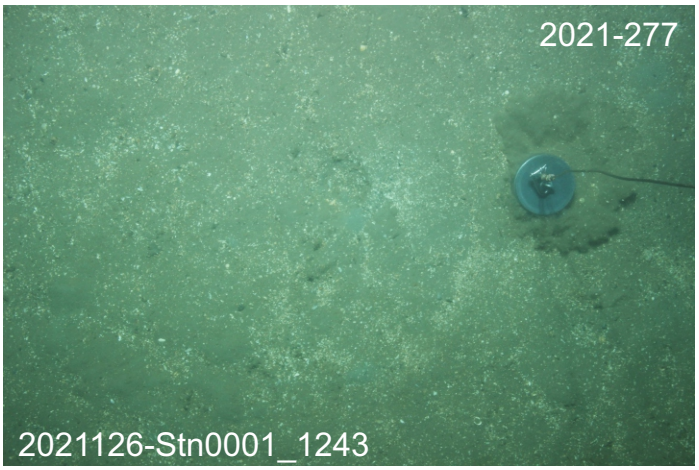


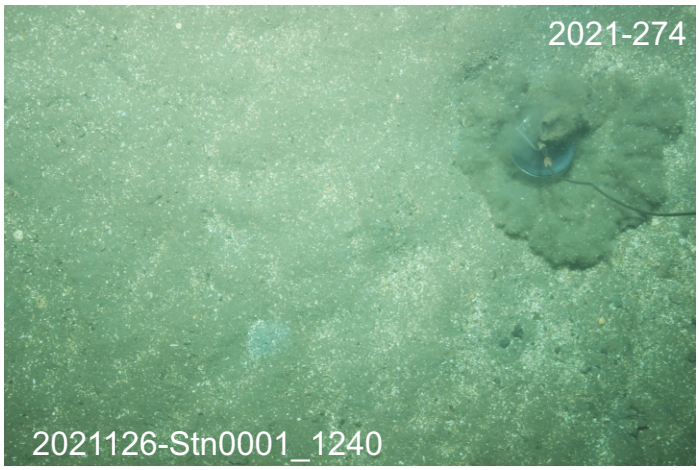












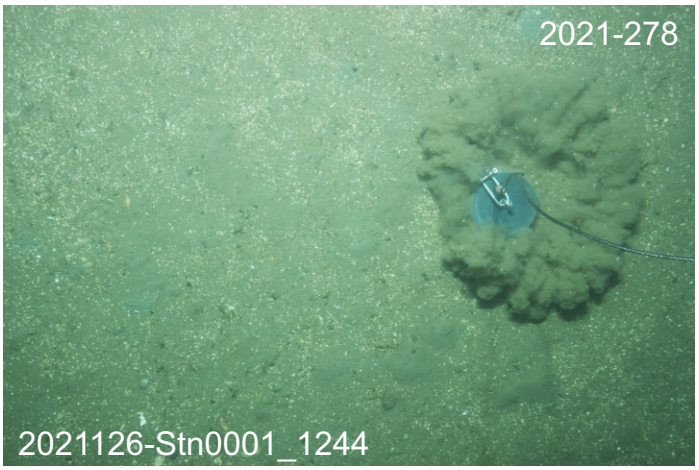


Figure 12, continued. Station 0001 seabed photographs (photography by A. Robertson; NRCan photo numbers in upper right corner).

Table 2: Descriptions of Seabed Photographs

Station Number	Water Depth, m	Filename	GEOLOGY	BIOLOGY
0001	128	2021126-Stn0001_1229.JPG	gravel lag with subrounded to rounded pebbles and rare cobbles of varied lithology with sand and abundant shell fragments and disarticulated shell valves, some marine life	Crab, disarticulated and fragmented bivalves of several species, unidentified soft bodies
0001	128	2021126-Stn0001_1230.JPG	thin sand with abundant shell hash and some disarticulated shell valves partially covering a gravel lag with subrounded to rounded pebbles	disarticulated and highly fragmented bivalves of several species, unidentified soft bodies
0001	128	2021126-Stn0001_1231.JPG	thin sand with abundant shell hash and some disarticulated shell valves partially covering a gravel lag with subrounded to rounded pebbles	disarticulated and highly fragmented bivalves of several species, some pebble encrustaion
0001	128	2021126-Stn0001_1232.JPG	thin fine sand with shell hash, few sub-rounded pebbles of varie lithology	disarticulated and highly fragmented bivalves of several unidentified species
0001	128	2021126-Stn0001_1233.JPG	fine to coarse sand with abundant small shell fragments, rare pebbles, several burrow mounds	shell hash, burrow mounds
0001	128	2021126-Stn0001_1234.JPG	fine to coarse sand with abundant small shell fragments, some grain sorting in poorly-developed bedforms	shell hash, few burrow holes and small associated mounds
0001	128	2021126-Stn0001_1235.JPG	fine to coarse sand with abundant small shell fragments, minor grain sorting in small poorly-developed bedforms, several burrow mounds	shell hash, few burrow holes and small associated mounds
0001	128	2021126-Stn0001_1236.JPG	fine sand with abundant small shell hash, several tracks and burrows	shell hash, few burrow holes and small associated mounds, unidentified piece of organic? matter in lower right
0001	128	2021126-Stn0001_1237.JPG	fine sand with abundant small shell hash, burrow holes with mounds, flocked organic? matter, disorganized shell hash sorting in degraded bedforms	shell hash, few burrow holes and small associated mounds, unidentified flocks of organic? matter
0001	128	2021126-Stn0001_1238.JPG	fine sand with abundant small shell hash, burrow holes with mounds, flocked organic? matter, disorganized shell hash sorting in degraded bedforms, rare pebbles	shell hash, few burrow holes and small associated mounds, unidentified flocks of organic? matter
0001	128	2021126-Stn0001_1239.JPG	fine sand with small shell hash, burrow holes with mounds, flocked organic? matter, disorganized shell hash sorting in degraded bedforms	shell hash, few burrow holes and small associated mounds, unidentified flocks of organic? matter
0001	128	2021126-Stn0001_1240.JPG	fine sand with some mud, abundant small shell hash, burrow holes with mounds, flocked organic? matter, disorganized shell hash sorting in degraded bedforms	shell hash, few burrow holes and small associated mounds, unidentified clump of organic? matter at drop weight
0001	128	2021126-Stn0001_1241.JPG	fine sand with some mud, abundant small shell hash, burrow holes with mounds, flocked organic? matter, disorganized shell hash sorting in degraded bedforms, rare pebbles	shell hash, few burrow holes and small associated mounds, rare, scattered flocked organic? matter
0001	128	2021126-Stn0001_1242.JPG	fine sand with some mud, abundant small shell hash, burrow holes with mounds, flocked organic? matter, disorganized shell hash sorting in degraded bedforms, rare pebbles	shell hash, few burrow holes and small associated mounds, scattered flocked organic? matter
0001	128	2021126-Stn0001_1243.JPG	fine sand with some mud, abundant small shell hash, burrow holes with mounds, flocked organic? matter, disorganized shell hash sorting in degraded bedforms	shell hash, few burrow holes and small associated mounds, scattered flocked organic? matter
0001	128	2021126-Stn0001_1244.JPG	fine sand with some mud, abundant small shell hash, burrow holes with mounds, flocked organic? matter	shell hash, few burrow holes and small associated mounds, scattered flocked organic? matter

all phtographs adjusted from raw by increasing contrast and exposure. Only those with seabed images included.
Target was a small moraine within Baccaro Channel as identified from OLEX bathymetric image; post processing indicates most of the sequence is from immediately south of the moraine.

6.0 Coring Operations and Results

The standard GSCA long piston coring system was used on the mission on eight stations. The corer was configured with a piston, trip-arm and trigger weight core on all but one station which was deployed as a giant gravity corer. Barrel assembly ranged from 3 to 4 barrels. The coring system tripped and operated properly on all stations (when rigged as a piston corer) with the piston splitting on all. The standard rotating core-head cradle, monorail, trolley and half-height core processing container were used for all operations. The tugger winches for raising the core string were not used on this mission as the foredeck Arva crane was able to recover the coring string to horizontal. It was noted that the pickup wire could have been 1 – 2 m shorter.

The piston core head used was a stainless steel model weighing 2750 lbs. The coring block had undergone a significant rebuild over the 2018 winter season and performed well. The cable counter worked on all piston core stations and the trip could be seen in the block but when the system was used as a gravity corer the counter stopped temporarily and there was obviously no trip seen so we inadvertently placed several metres of coring wire on the seabed before recovery (without damage).

The main Pengo winch performed fairly well during the trip after a refit with the coring wire having been re-spooled on in reverse order so the less used inner wire was now on outer winds. Spooling was quite uniform. There were some cooling issues but the engineering staff watched this closely and tried several intermediary repairs.

The trigger core worked well and we generally had good recovery. The pickup tugger winch had some serious hydraulic leak issues. Firstly, the installed pressure line leaked at the swage fittings and then the gearbox side of the winch suffered a breach whereby hydraulic fluid was flowing into the gearbox and then shooting out a breather vent. For the future a simple electric winch acquisition will be explored.

6.1 Coring Siting and Results

Table 3 summarizes the sample stations, including locations, targeting basis and rationale, recovery lengths and other relevant metadata. These data are also accessible through the NRCan Expedition database; https://ed.gdr.nrcan.gc.ca/index_e.php.

Figures 13 to 17 show locations and stratigraphic penetration depths in relation to the seabed bathymetric and profiler data. There, site specific goals and follow-up investigations are addressed in the figure captions. Only one core (0005) was considerably shorter than anticipated.

TABLE 3: Sample station summary

GSCA Station No.	Planned Station No.	Sample Type	Julian Day	Day / Time (UTC)	Latitude, DD*	Longitude, DD	Latitude, DM		Longitude, DM		Region: Scotian Shelf Sub-Region:	Target Seismic Record Cruise	Day/Time	Instr
0001	N/A	Camera 4K Start	203	20:24:59	43.093388	-64.443572	43	5.60330	-64	26.61434	Baccaro Channel	OLEX bathymetric image		
		Camera 4K Stop	203	20:51:49	43.089014	-64.438895	43	5.34085	-64	26.33370				
0002	OK-11	Piston Core**	204	16:23	42.109941	-63.742191	42	6.59648	-63	44.53147	Baccaro Fan	2019 Okeanus	229/19:12:05	3.5kHz Chirp
0003	OK-12	Gravity Core	204	20:41:31	42.198931	-63.550767	42	11.93587	-63	33.04605	Baccaro Fan	2019 Okeanus	229/18:01:59	3.5kHz Chirp
0004	OK-14	Piston Core	205	12:39:36	41.923996	-64.160761	41	55.43973	-64	9.64568	Baccaro Fan	2019 Okeanus	229/21:43:03	3.5kHz Chirp
0005	OK-18	Piston Core	205	17:14:23	41.884627	-64.212874	41	53.07763	-64	12.77244	Baccaro Fan	2021126	205/07:44:06	Huntec Ext.
0006	OK-10	Piston Core	206	11:33:52	42.117293	-64.705336	42	7.03757	64	42.32014	Baccaro Fan	2002046	234/22:35:01	Huntec Ext.
0007	OK-19	Piston Core	206	15:40:57	42.098662	-64.583695	42	5.91975	64	35.02172	Baccaro Fan	2002046	234/23:40:54	Huntec Ext.
0008	LH-1	Piston Core	207	16:06:57	43.716247	-63.598939	43	42.97480	63	35.93635	LaHave Basin	76016	175/05:13:00	Huntec Internal
0009	N/A	Gavia UAV	207	20:00:59	44.080524	-63.150852	44	4.83141	63	9.05115	Sambro Bank; Halifax Harbour Approaches	OLEX bathymetric image and bottom photographs		

*Positions from deck sheets **all PCs have an associated Trigger Weight Core not documented here

TABLE 3: Sample station summary, continued

GSCA Station No.	Water Depth (m)	Water Depth meth-od	Corer Length (ft)	App. Penn. (cm)	Core Length (cm)	No. of Sect-ions	Core Catcher sample?	Target/ Rationale	Comments
0001	128	12 kHz	Not Applicable: metadata, including positional coordinates embedded in individual photographs					small, inner channel moraine as identified from OLEX	In water: 20:24:59; On Bottom: 20:30:59; at surface: 20:51:49
0002	2301	12 kHz	30	~970	667.0	5	N	thick distal fan debrite with 6m stratified sediment cover	In water: 15:04; On Bottom: 16:23; no accurate wire out display; at surface: 1722
0003	2183	12 kHz	30	~850	475.0	5	Y	thick distal fan debrite with 4m stratified sediment cover	deployed: 19:49:32; recovered: 21:39:12; Piston Core without piston installed; butterfly valve instead
0004	2501	12 kHz	40	~600	361.0	3	N	central recent broad failure chute; distal fan area	In water: 12:14:59; at surface: 13:41:45
0005	2579	3.5kHz	40	~450	232.0	2	N	undisturbed stratified sediment near chute flank; control for distal fan glacmarine sedimentation chronology	In water: 16:20:35; at surface: 18:20:53; very sandy top; no subsample for constant volume or shear strength
0006	1952	12 kHz	30	~900	513.5	6	Y	GM sediment over nearby debris flows; addresses age of adjacent debrites; provides mid slope control for chrono framework	In water: 10:49:15; at surface: 12:31:42; mud on TWC weitght so likely toppled on impact. Lost nose cone sapmle on recovery
0007	2083	12 kHz	30	~750	528.5	5	N	control for midslope GM chronology; reached bottom half of section	In water: 14:59:15; at surface: 16:36:21
0008	214	12 kHz	30	~640	308.0	2	Y	glacimarine mud-covered moraine-top unconformity on the southeast flank of LaHave Basin; potential for penetration to near base of the post-moraine mud	First attempt failed to trigger; second attempt successful. In water: 16:02:47; at surface: 16:21:31. cutter nose cone bagged after hydraulic extraction.
0009	<150	CHS chart						"Russian hat" sponge colonies	in water at surface 19:46:45; Mission start 20:19:25 44 04.83141063 63 05.114581; Gavia back on surface (iridium) message received: 20:19:25 (44 08.783 63 16.6917); and 20:55:03 (44 05.162 63 10.0976; mission plan was shortened to ~1.5 hrs from original 3-4 hrs) but was self-aborted after ~18 min.

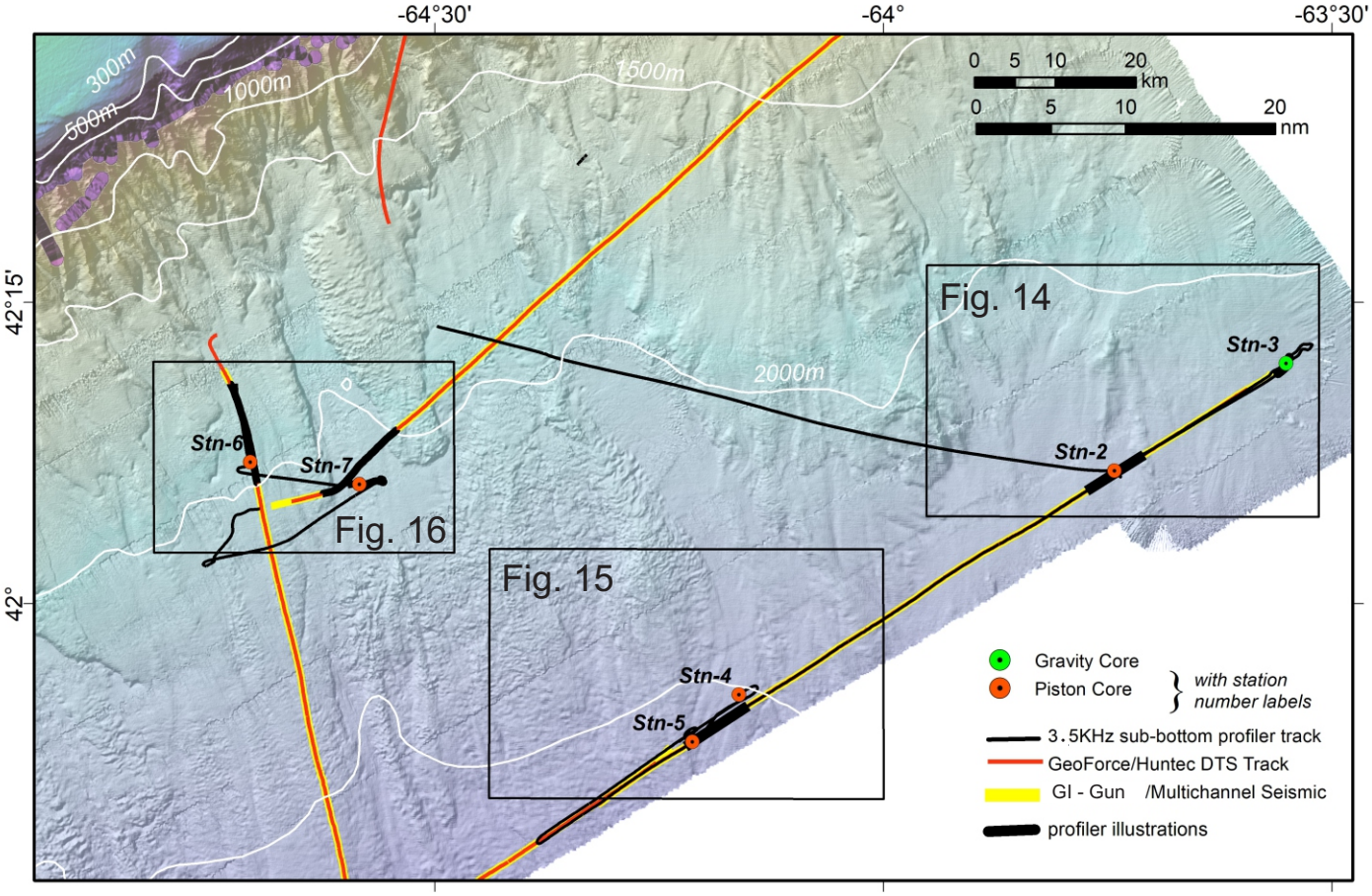


Figure 13. Multibeam bathymetric image showing the following core-related illustration locations.

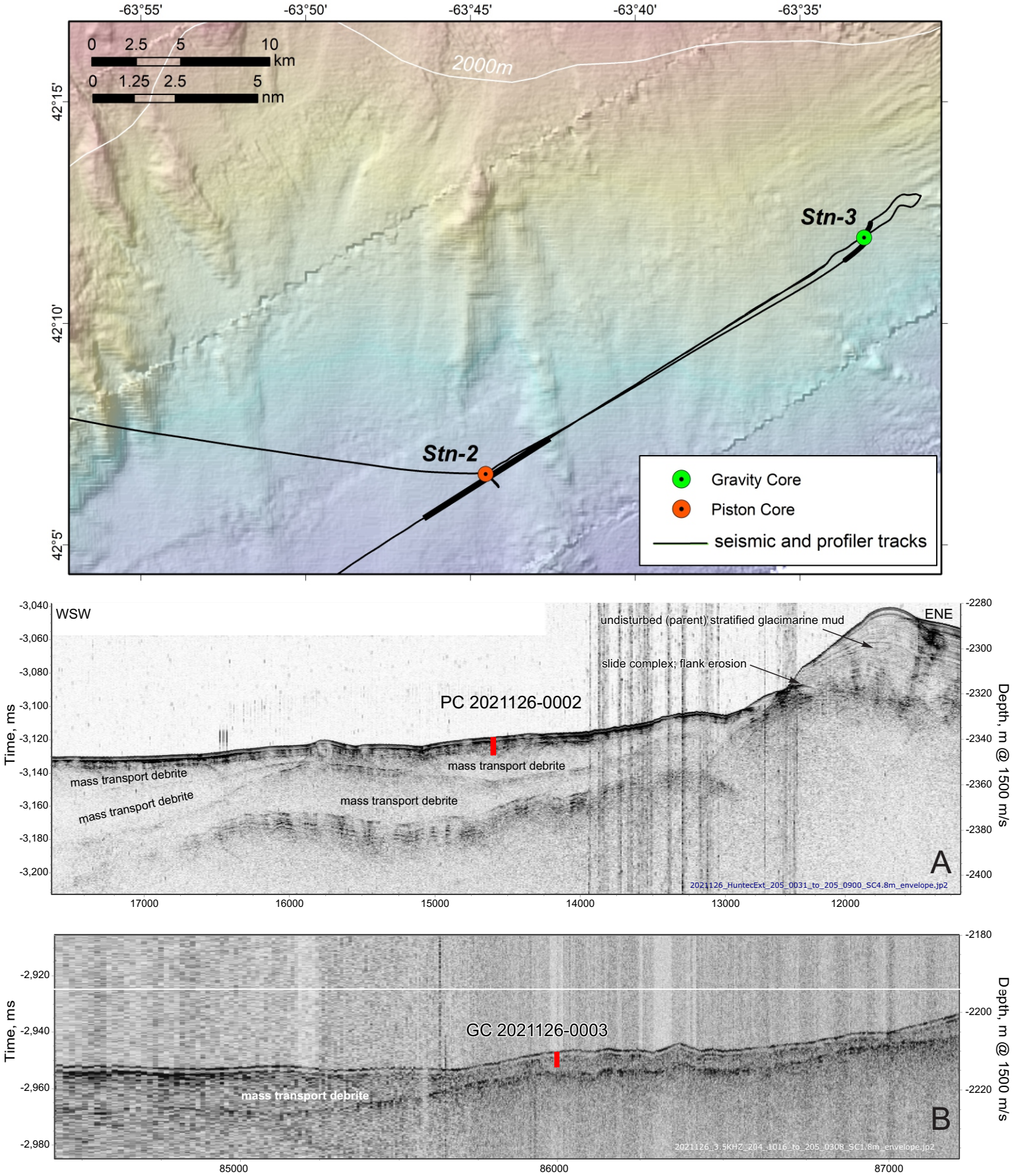


Figure 14. Multibeam bathymetric image (Panel A) spanning 1925 m to 2410 m water depth. Sparker deep towed profiles, panels B and C, with piston core (PC) stations 2 & 3 respectively. Positions and penetration depths projected. Core 2 penetrates to the debris flow material below several metres of post-failure stratified mud overlying stacked mass failure debrites. Core 3 penetrates much of the stratified blanket over a large slide complex deposit. It also strtigraphically brackets a much smaller nearby debrite.

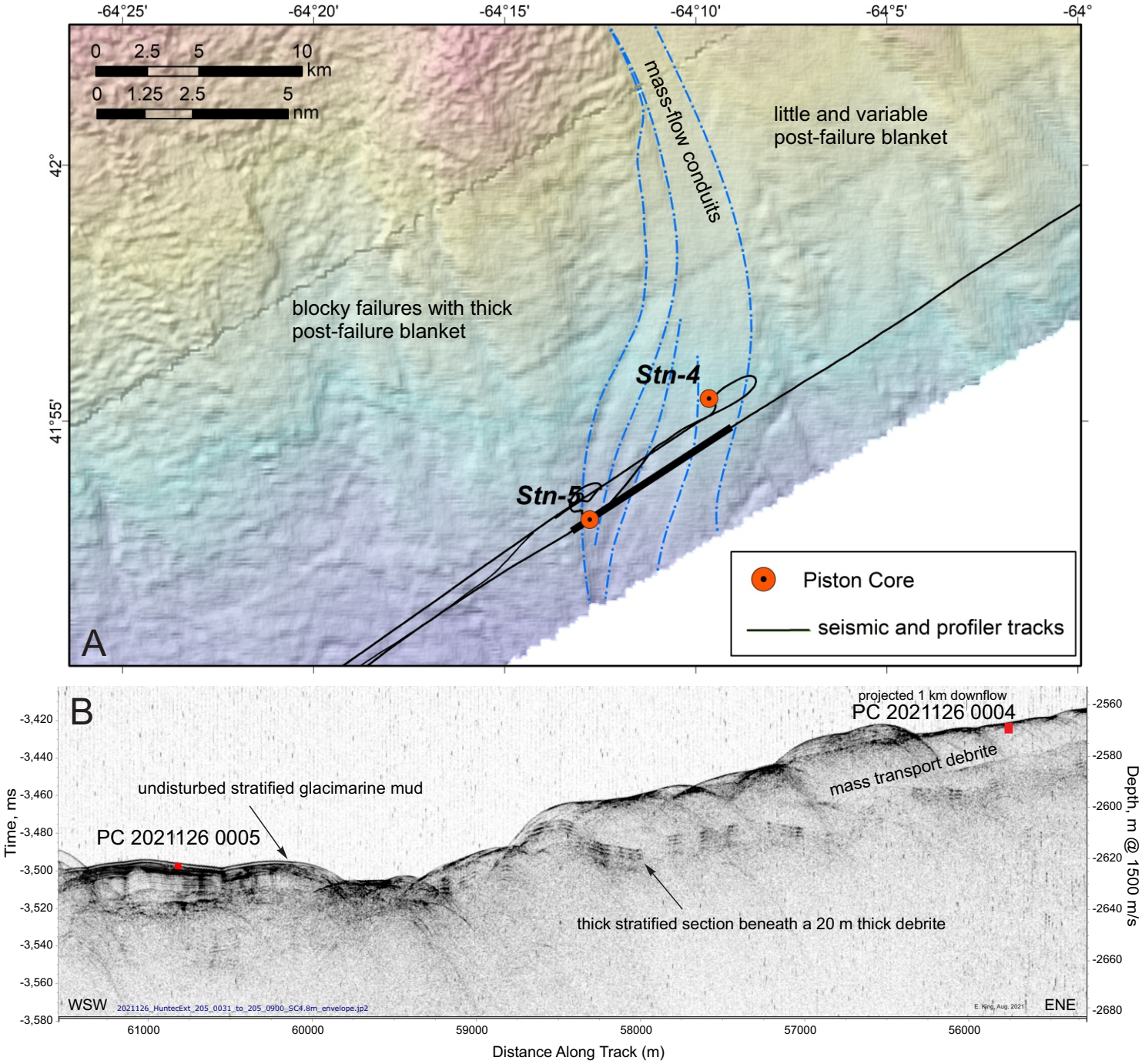


Figure 15. Multibeam image and sparker deep towed profile in about 2100 m to 2700 m water depth (panel A) depicting multiple mass failure features visible at the seabed despite variable post-event stratified sediment cover thickness. Thick black line indicates location of the profile panel. The blocky slide on the west of this image typically has 10 to 15 m cover; at the Stn. 0005 coresite it is 11 m thick (panel below). In contrast, the gravity flow features to the east have lesser sediment cover. The goal for Stn 0005 piston core was to reach as much of the stratified cover as possible, providing potential for dating failures in the area once an age model versus thickness was established. The limited recovery (shown in red column) will require considerable downward extrapolation, limiting precision for all but the younger failures. Sedimentologic study will attempt correlative ties with ongoing core studies to the east (Jenner et al in prep.) and may identify key horizons dated elsewhere as well as possible overbank processes. Core 0004 location targeted a large debrite with limited post-event cover. In this profile illustration, its position is projected over 1 km downflow according to the flow lineation and contact traces in blue dashed lines. The corresponding 3.5 kHz profile at the core site has an identical seabed signature but no further penetration to the base of the debrite such as identified here.

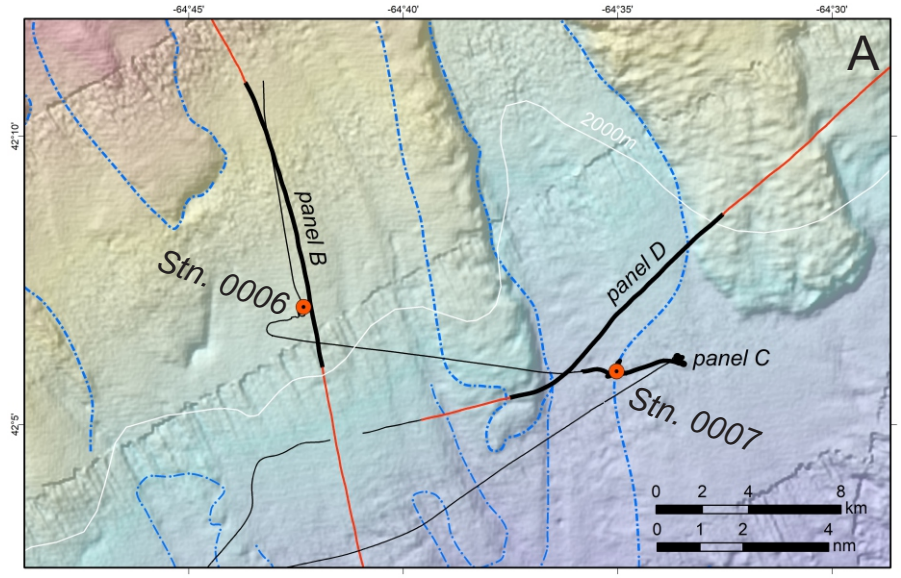
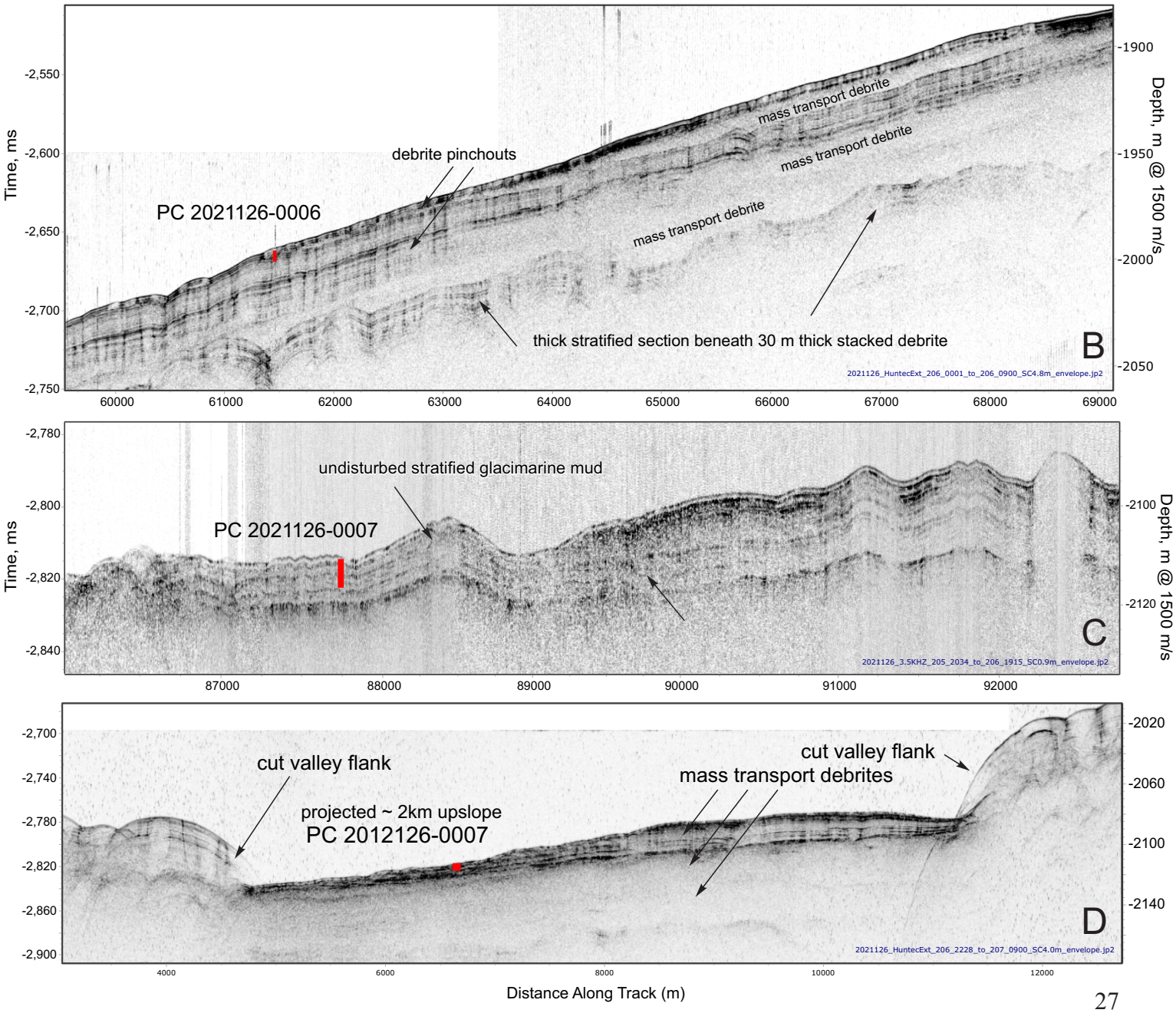


Figure 16. Multibeam bathymetric image (panel A) showing profile locations with respect to numerous mass failure features, some highlighted here by blue dashed lines. Deep-towed sparker (panels B and D) and 3.5 kHz sub-bottom profiler (panel C) in about 2000 m water depth, with piston core (PC) stations 6 & 7 positions and penetration depths projected. Core 6 will potentially allow dating of a slightly buried debrite which pinches out immediately up-slope and characterize its downslope equivalents. Core 7 sampled much of the buried post-failure stratifed cover in a broad valley cut much earlier (flanking scarps in panel D) and also brackets a debrite lens within the valley seen in panel D.



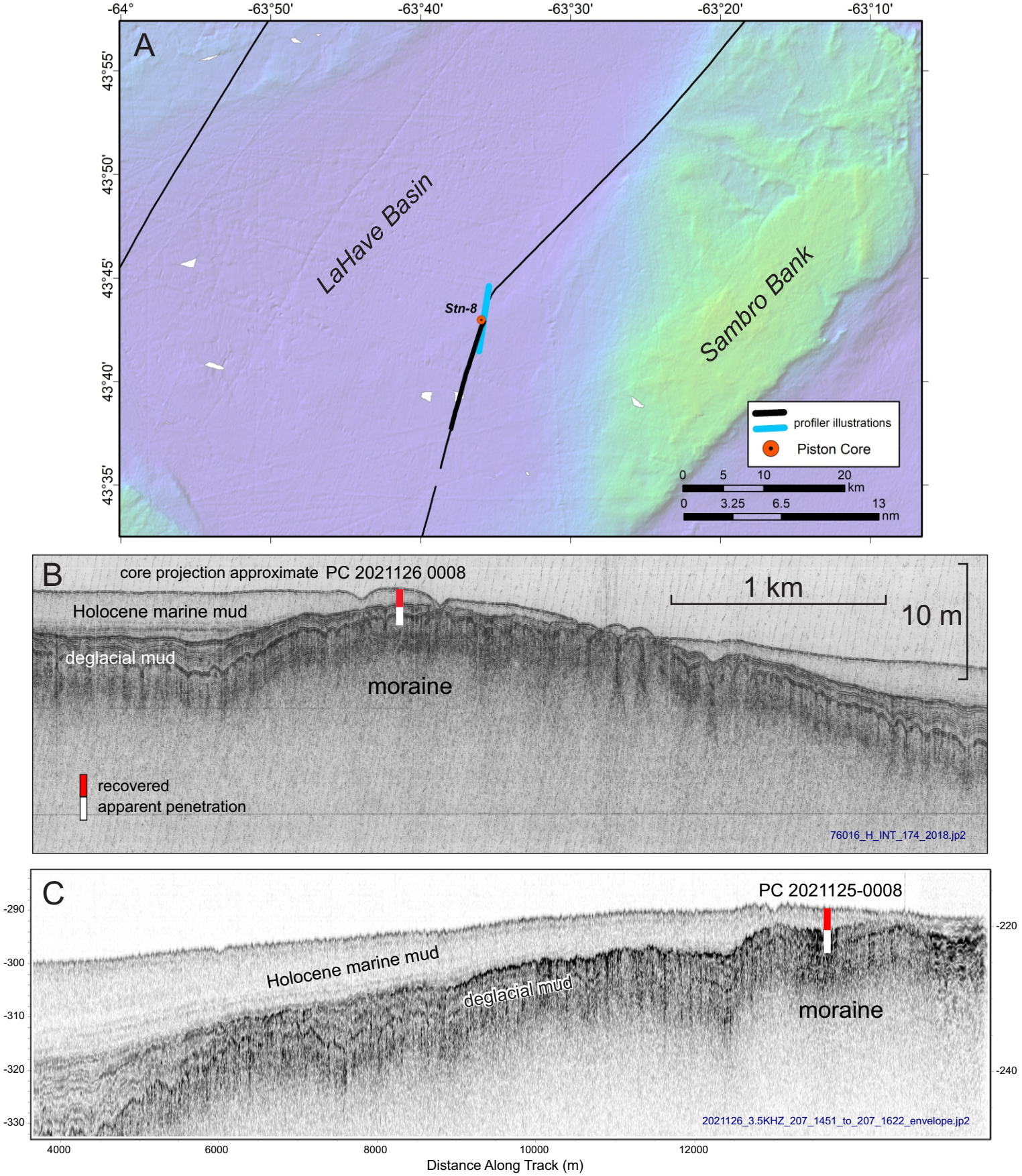


Figure 17. OLEX bathymetric image of eastern LaHave Basin and Sambro Bank (panel A) showing core location on a buried moraine and location of the two profiler panels, Huntec DTS (thick blue line and panel B) and 3.5 kHz (thick black line, and panel C). The goal was largely to sample the overlying mud for dating purposes. The core penetration was apparently sufficient to penetrate one half of the stratified glacimarine mud section but recovery was only half of this. Unless core and trigger weight examination indicates otherwise, the upper Holocene mud unit was sampled but little of the glacimarine mud blanket overlying the moraine.

7.0 Open Water GAVIA AUV Sea-trials

The GAVIA AUV (Autonomous Underwater Vehicle) was used on the cruise to investigate the launch and recovery challenges from larger survey vessels. Prior to participating in the Hudson mission, the vehicle had been used successfully in shore based missions.

7.1 GAVIA General Specifications:

Length: 12' (8" diameter); Weight: 250lbs (air), 2lbs positive buoyancy in water; Depth Rating: 1000m; Survey Speed: 3 knots

The purpose of the sea trial was to investigate any challenges associated with deployment and recovery from a larger vessel such as CCGS Hudson. The Proposed launch/recovery procedure consisted of the following:

Launch

1. Weather conditions permitting (to be determined and assessed for both the deployment and expected recovery times)
2. Check sea water density in the survey area. Ballast vehicle accordingly.
3. Launch CCGS Hudson FRC (Fast Rescue Craft).
4. Lift the GAVIA from the Hudson using lifting straps (fore/aft) and lower the AUV to the waiting FRC.
5. Disconnect AUV from Hampton crane and escort the AUV (tied alongside the FRC) to the mission execution site.
6. Confirm ballast of the vehicle and execute mission.
7. Return FRC to the CCGS Hudson and standby for an Iridium signal from the AUV at the end of the mission.

Recovery

1. Launch the FRC prior to the AUV mission estimated recovery time.
2. Standby on location with the FRC for Iridium message of mission completion and position. Relay position to the FRC for recovery.
3. Bring the AUV alongside the FRC and return to CCGS Hudson.
4. Connect lifting straps from the Hampton crane to the AUV and transfer to CCGS Hudson.

7.2 Mission #1 (Aborted due to weather)

July 26, 2021 an area suitable for AUV survey was selected for the first GAVIA deployment. The survey area was in approximately 700m water depth and would take approximately 5 hours. The vehicle was prepared in the morning for mission. The pre-dive took approximately 30 minutes. Weather conditions during the pre-dive process were not ideal and deteriorating. The weather conditions were discussed with the CS/Capt and AUV operators. Finally, the decisions was made by the Captain to abort due to thunderstorms and lightning. The launch and recovery operations both involve personnel in the FRC and this was deemed a risk. As such the CCGS Hudson resumed other science objectives.

7.3 Mission #2

As the vessel transited to its next science objective, the weather conditions improved. As such, it was decided to perform an AUV survey in an area near Sambro Bank in about 135 m water depth. The mission had been pre-planned for 5 hours duration, but was modified to 1.5 hours duration due to daylight recovery constraint. The AUV had recently been pre-dived and was quickly brought online for the INS (inertial navigation system) to align. At approximately (1900hrs UTC) the watchkeepers in the GP lab were notified to be on standby (AUV iridium watch) while Angus Robertson and Peter Pledge embarked on the FRC. Des Manning was standing by with the ships crew to deploy the GAVIA from the flight deck to the waiting FRC with the Hampton crane.

The AUV launch procedure was executed as planned at approximately 2000hrs UTC. The sea conditions were approximately 1m confused sea (waves coming from multiple directions). While the Hudson is quite stable in these sea conditions, a smaller FRC is significantly more lively. Immediately, there were difficulties in releasing the AUV from the Hampton crane hook. The lifting straps between the AUV and crane had been bound with zip ties. This resulted in extra time disconnecting the AUV from the crane while the FRC operator (Chief Mate) tried to hold position with the FRC. The rise and fall of the FRC and lines to the GAVIA AUV resulted in the vehicle being momentarily snagged beneath the FRC and raising the FRC bow from the water. Cosmetic damage to the AUV was noted. Once the AUV was released from the crane, the straps were used to hold the AUV alongside the FRC as the FRC escorted the AUV to the start of the mission.

Once in vicinity of the start of mission, the buoyancy verification of the AUV commenced. It was extremely difficult to perform the buoyancy check, the check involves verifying that the vehicle has the correct attitude in the water (slightly positive pitch) and approximately 2 lbs of positive buoyancy. The liveliness of the FRC relative to the AUV made this challenging. After several minutes of observation we believed that the buoyancy looked correct, but could not evaluate the pitch attitude. The decision was made to execute the mission as the ultimate test of pitch is whether or not the vehicle could dive. The vehicle was given a “shove” towards start of line and immediately dove into an oncoming wave. This meant we had to wait briefly for the AUV to surface (or at least the tower to break the surface) so that the mission execute command could be delivered (WiFi is used). When the tower broke the surface, the mission was executed, the system confirmed and the vehicle dove immediately. The FRC remained in the area for

approximately 5 minutes to confirm that the vehicle had not aborted and then we returned to the Hudson.

Approximately 30 minutes into the mission, a message was received on the Iridium Satellite phone from the AUV ("unsafe to navigate position"). The meaning of the message was unknown as we had never seen this message before in operations, however, it was clear that the AUV was on the surface (early) and not on mission. The FRC was scrambled, the Iridium position was input into the navigation system and then we went to recover the AUV. Once on location of the last known position (approximately 15 minutes had elapsed) we began searching for the AUV. The seas were still confused and it made it difficult to find the AUV, in fact we couldn't see it at all. After some time, Hudson radioed an updated position from the Iridium AUV (system is programmed to update every 15 minutes or so) and we proceeded in a new direction. After 15 minutes we were able to see the flashing strobe and recover the AUV to the FRC. The FRC then escorted the AUV back to Hudson. Hudson deployed the Hampton crane and we were able to reconnect the lifting straps to the crane and it was hoisted aboard Hudson. The FRC returned to the Hudson. At this time, no attempt was made to determine the cause of the abort (post mission analysis) as there was no time perform another mission (end of cruise party!).

Post mission analysis was performed when we returned to BIO. The AUV mission records have a complete history of sensor information and vehicle state (black box data recorder).

1. Mission abort (unsafe to navigate position). In the hopes of understanding the mission abort, we contacted Teledyne GAVIA in Iceland. We described the scenario and also sent them the mission files for analysis. Iceland's response was very simple. The AUV did not dive quickly enough. The mission plan that was made used our typical dive plan of (dive point, lead in line and survey grid). This works well for a shallow shore based launch (our practice conditions) but does not work for open-water dives. The issues is the INS/DVL. The GAVIA is equipped with an IXSEA C5 INS system which is couple to a DVL. The range of the DVL is approximately 20m. What this means is that if the vehicle does not come within 20m of the seabed within 20 minutes, the INS system's position error estimate exceeds a tolerance and the vehicle aborts the mission.
2. Further scrutiny of the mission files, replaying at BIO also showed a curious thing. The vehicle surfaced when the INS aborted the mission. However, when it reacquired GPS position it resumed the mission and dove. This is why we could not find the AUV in the FRC at the first location. The vehicle dove and then aborted a second time. The second abort was a message that we are familiar with (failed to track depth). This message typically means that the vehicle was unable to dive due to buoyancy or trim (pitch). Examining the CTD water density collected by the vehicle we could see the density increasing from 1021 (surface) to 1027 (80m depth).

7.4 AUV Operations Recommendations

1. The strap setup on the crane needs to be quick to release from the FRC side.
2. Tag lines for handling the AUV as it goes over the side and returns (very little clearance between A-frame).
3. Assessing the sea conditions for safe operation of the vehicles needs to consider the sea state of the FRC. Buoyancy assessment is critical and difficult in waves and confused sea, and trim is almost impossible.
4. Improving how the FRC escorts the AUV. The FRC has a rigid hull beneath the inflatable floatation. The gavial can be easily damaged on this rigid hull. Perhaps towing would be a preferred option or using fenders or some other method.
5. Open-water diving mission plan. Teledyne GAVIA in Iceland recommend the use of the following when diving: a) dive point with set depth b) vertical lawn-mower pattern to quickly dive the vehicle (zero meters line spacing set to altitude mode with an appropriate number of lines to get the AUV to the seabed as quickly as possible) c) standard mission lawn-mower pattern for seabed survey.
6. Utilizing USBL in truly deep dives to update the INS position from the surface with the ACOMS so that the INS does not drift sufficiently to abort before reaching the seabed.
7. Investigation better methods of assessing the vehicle pitch and positive buoyancy while at sea.

8.0 Seismic Acquisition

8.1 Multichannel Seismic (MCS) Reflection

8.1.1 Highlights

This operation represents the first multichannel data collected by GSCA on the east coast for decades. This and a long duration since seismic data collection aboard CCGS Hudson contributed to challenging mobilization and start-up. Despite this, outcome was excellent.

The seismic source consisted of a Sercel 210 inch gun suspended from a Norwegian buoy at a depth of 1.5 – 2 m below the sea surface and fired every ten seconds triggered by the GSCA-Multi-Instrument Timing System (MITS). Signal was received though a Geometrics GeoEel with two active sections each configured for 8 channels (total of 16). Digital signal was conveyed to the deck over Ethernet. Streamer depth and leveling was controlled by three attached and interactive vanes from DigiBIRD.

Seismic reflection data were acquired along four survey lines centered on the southwest slope and shelf-break (Fig. 18). A summary of these lines is given in Table 4. In total, 289 km of seismic reflection data were acquired comprising 12153 individual shot gathers. Calm conditions experienced during surveying facilitated acquisition of excellent quality data with minimal downtime.

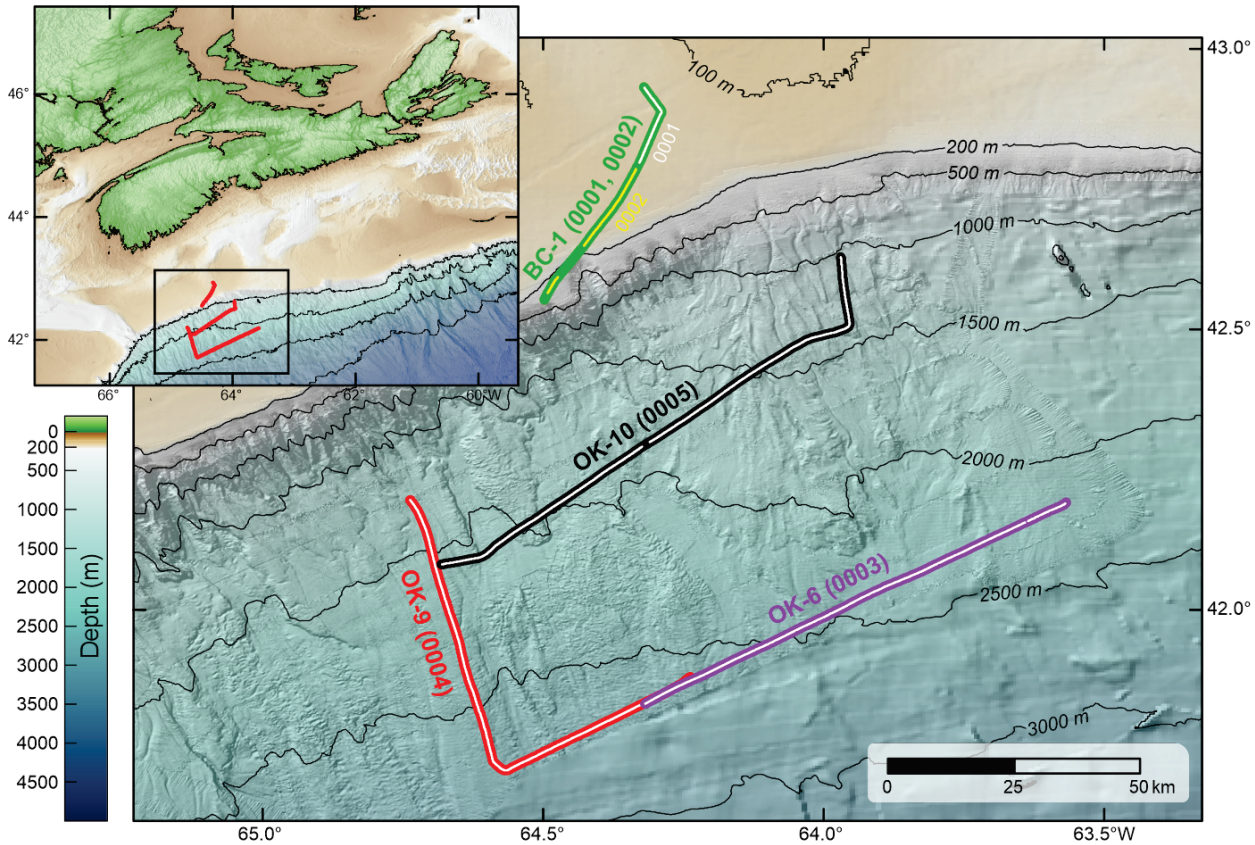


Figure 18. Distribution of seismic reflection data acquired during HUD2021-126. Bold lines indicate the four survey lines. Thin white and yellow lines indicate segments of continuous acquisition, labelled according to GeoEel line numbering. The "OK" refers to Okeanos Explorer, the NOAA vessel which collected multibeam bathymetry in 2019, shown here along with bathymetry from GEBCO 2020. "BC" stands for Baccaro Channel where it started in the north, with the intent to follow SE along its axis and across the deep water fan, but was diverted due to extensive fishing activity at the shelf break.

Table 4. Line information for seismic reflection data acquired during HUD2021-126

Line	GeoEel Line #	SOL (UTC)	EOL (UTC)	Start FFID	End FFID	Shot gathers	Line-km
BC1	0001	204 00:42:55	204 02:28:17	233	846	614	15.94
BC1	0002	204 02:36:48	204 05:46:53	734*	1777	1044	20.52
OK-6	0003	205 00:11:30	205 09:00:38	1778	4559	3079†	73.43
OK-9	0004	205 21:45:24	206 08:34:25	4560	8276	3717	89.19
OK-10	0005	206 22:13:31	207 09:00:09	8277	11975	3699	89.64
					Total:	**12153**	**288.73**

**controller restarted under new line caused reset of file number iteration (see below)*
†controller crash during line caused reset of file number iteration within same line, so total number of records exceeds start/end difference (see below)

8.1.2 Multichannel Seismic Acquisition Details

Figure 19 shows the Flight Deck equipment layout and Figure 20 shows the multichannel equipment towing configuration. For context, see the overall deck layout in Fig. 2

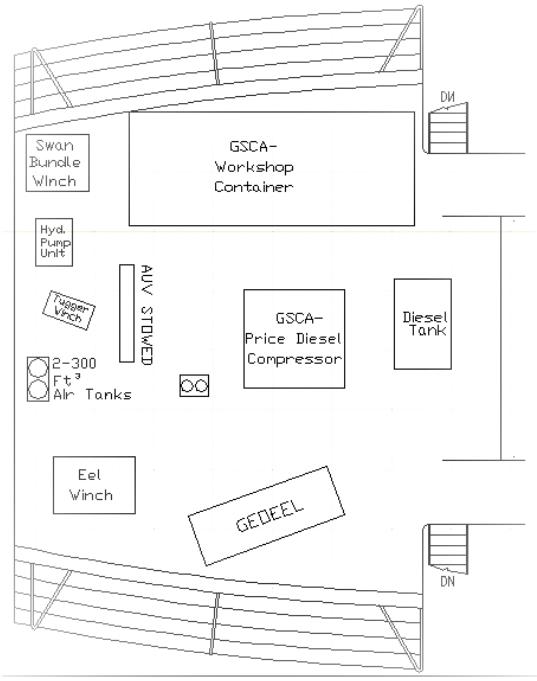


Figure 19. Hudson flight deck equipment layout for this cruise.

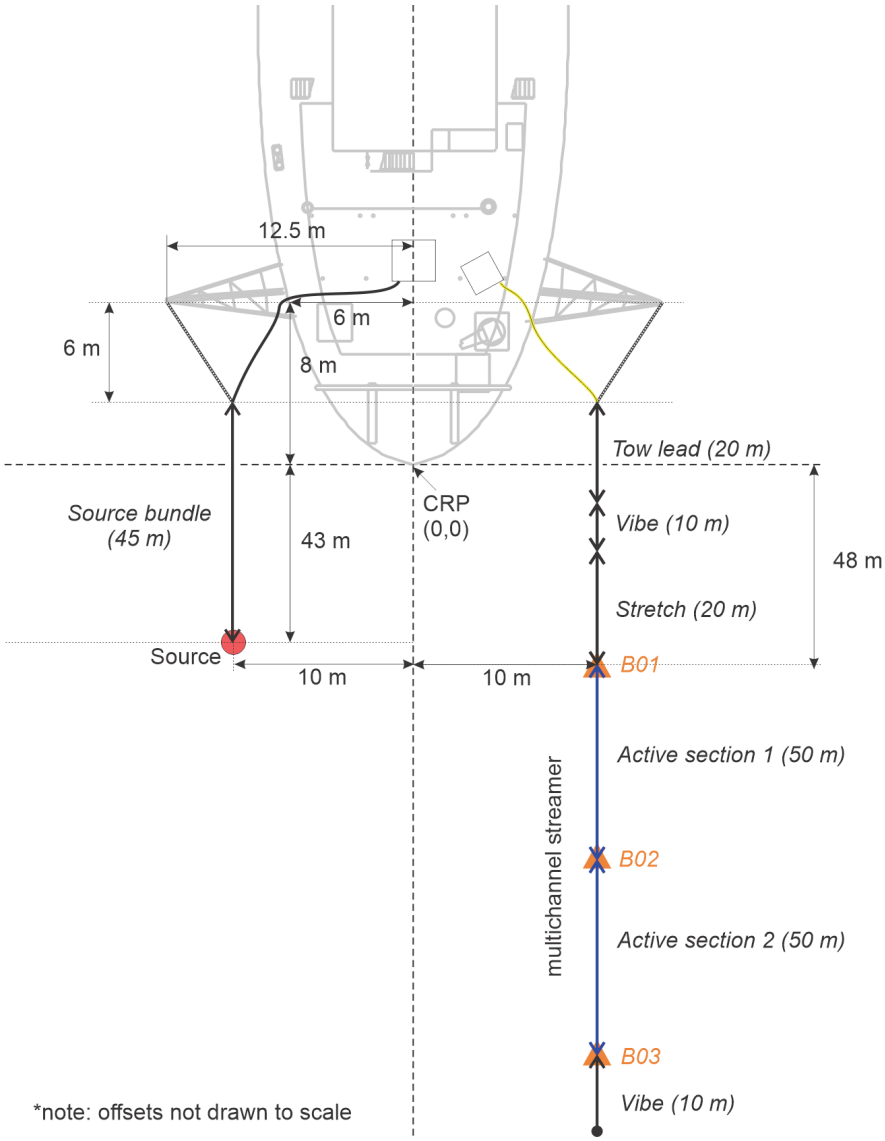


Figure 20. Approximate plan-view towing configuration of the seismic source and hydrophone streamer used during HUD2021-126. Actual positions of the source and streamer may have varied by up to an estimated ± 5 m during acquisition due to changes in speed through water (log speed), heading, and/or variable sea-state.

8.1.2.1 Seismic Source

The Sercel 210 cubic inch GI gun is essentially two guns in one. The primary gun, the generator, is fired before the second gun, the injector, is fired. The timing of the firing of the injector inhibits the collapse of the initial bubble. A LongShot Seismic Source Controller controls the firing, and associated delays, of both guns. The timed triggers are sent to a Four Shot Solenoid Power Supply which generates the required firing pulse voltages.

A single GI gun was towed from an outrigger (Ironing board) on the port side of the quarterdeck, approximately 43 m aft of the stern and 10 m port of the centre-line. This ensured separation of the seismic source and the Huntec Deep Tow being towed from the center hanger of the A-Frame. It was suspended from an I-beam and towed at a depth of 1.5 – 2 meters and fired every 10 seconds at a pressure of 2000 psi. In previous surveys the shot interval was as low as 6 seconds using this source, but difficulties with our compressor prevented running faster than 1350 rpm. 2000 psi was maintained throughout.

8.1.2.2 Gun Floatation

A no. 6 Norwegian buoy was used for primary floatation with a small secondary buoy used to keep the slack deployment and recovery line away from the gun during the survey (Fig. 21). The smaller float was removed early on in the survey.

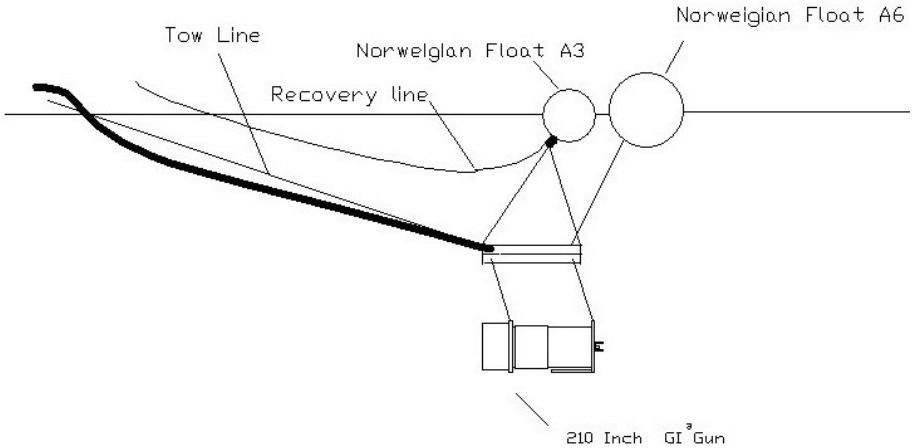


Figure 21. Towing configuration. 210 cu in GI Gun. A3 float later removed.

8.1.2.3 Compressed Air Supply

High pressure air for the seismic source was supplied by a W2 Air Master four stage reciprocating compressor built by the Price Compressor Company in Houston Texas. The compressor is powered by a Detroit Allison In-line Six diesel engine and is capable of delivering 200 SCF per

minute at 2000 psi. The engine was rebuilt in 2011 and at the time of this survey had only 12 hours use.

This compressor had not seen use since 2008. On the first night of use, a leak developed at the crank shaft seal of the third/fourth stage block. The leak was managed for the duration of the mission with a few quick shut downs for oil level checks. The temperature at both seals was checked regularly and did not rise appreciably during that time. Engine speed was limited to 1350 rpm. To maintain 2000psi, shot intervals were limited to 10 seconds. Reported data quality was satisfactory.

Price Compressor (Houston, Tx) closed its doors with the retirement of Don Price in 2016. Though the remaining inventory of parts was purchased by another company, availability of parts for the two W2 Air Masters NRCan owns is uncertain. NRCan owns two W2 Air Gun Master compressors. These units are generally reliable, but their age, and the unsure access to support might make them a liability moving forward.

8.1.2.4 Trigger Timing

Triggering for both the seismic system and the Huntec DTS, with any delay required, was supplied by the GSCA- Multi-Instrument Timing System (MITS). This allows multiple systems to operate simultaneously without interfering with one another by applying timing delays. The system is accurate to one millisecond.

A simultaneous trigger was sent to the GeoEel system, the LongShot Seismic Controller, and the ION Geophysical, Position Control System. This will be changed in future expeditions so that the GeoEel is receiving the trigger from the central time break (CNT) from the Longshot controller. This would eliminate the need to post-process firing delays; particularly in instances where they are modified during acquisition. To make this change, the BNC cable between the Longshot and the GeoEel SPSU can be switched so that it is being output from the Clock Time Break output on the Longshot rather than the T-junction with the MITS input.

GeoEel data taken into the acquisition computer was time stamped through NavNet. Data was later merged with navigation data.

The firing interval for the GI gun was gradually reduced to 10 seconds, limited by the performance of the compressor. The timing delay was set to 50 ms outside of a short time while the gun was being tuned in. The injector delay was set to 55ms.

8.1.2.5 Streamer

A Geometrics GeoEel multi-channel streamer was originally acquired for use in the Arctic. In this deployment it was towed approximately 48 m aft of the stern and 10 m starboard of the centre-line (Fig. 20). This streamer is modular. Fifty meter active sections each contain eight channels with six and one half meter spacing. Ten meter “vibe” sections may be added to isolate

the active sections from ships noise. Twenty-five meter stretch sections will allow ten percent lengthening under strain without permanent damage isolating the active sections from the heave of the ship in heavy weather.

At the head of each active section an A/D module digitizes the data from the eight channels of that section, and amplifies the data from the modules of active sections further down the line. Digital packets are sent up the line over Ethernet. At every hundred meters (can be less) between the head of the first active and the Deck Control Unit a repeater must be added for signal amplification (Figure 22).

Figure 22. General arrangement of modular sections for the Geometrics GeoEel

The configuration for this project from the acquisition computer and deck control unit to the outboard end of the streamer hydrophone was as follows:

CNT-2 acquisition computer and Deck Control Unit	
Deck lead (Deck unit to winch)	50 m
Repeater	---
Tow lead (first element on winch)	100 m
Repeater	---
Stretch section	25 m
Vibe section – with depth control	10 m
A/D converter	---
Active section	50 m
A/D converter	---
Active section– with depth control	50 m
Vibe section – with depth control	10 m

Sections/modules are mechanically joined with keyed male and female connectors seen in Figure 23. The connectors are threaded, tightened, and wrapped to inhibit water ingress.
Any leakage is detected and displayed at the Deck Control Unit.

Figure 23. Keyed, threaded connectors link sections/modules (photography by D. Manning. NRCan photo 2021-281).

There was leakage in at least one of these connections while the streamer was deployed. No appreciable increase in overall current could be seen. We continued to collect data with satisfactory results.

Using more aggressive waterproofing of connections may fix the issue of leakage. Geometrics has moved away from the use of the Glenair connectors seen above. This may just have been a supply issue and will be investigated further.

A Teledyne single channel streamer used in previous years was taken along as a backup for this cruise.

8.1.2.6 Streamer Depth Control

It was not known at the start of the survey whether any difference in sea-water density, as compared to the Arctic, might make the streamer difficult to balance. This turned out not to be an issue. Depth control birds, which could not be used under Arctic ice when the streamer was first purchased, were used during this survey.

Active sections and vibe sections each contain “bird coils”. ION Geophysical 5010 depth control birds, similarly equipped with coils, were clipped to the streamer as seen in Figure 24.

The ION Position Control System is connected to the Deck Control Unit for two way communication with the birds. Streamer depth/attitude can be monitored, or changed, in real time.

At the start of the cruise the Data Management Unit of the PCS failed. We had to use the old Digicourse bird modem and software. Much of the functionality of the Digicourse software was unavailable. Two way communication was still possible and the depth of the streamer was maintained at approximately two meters.

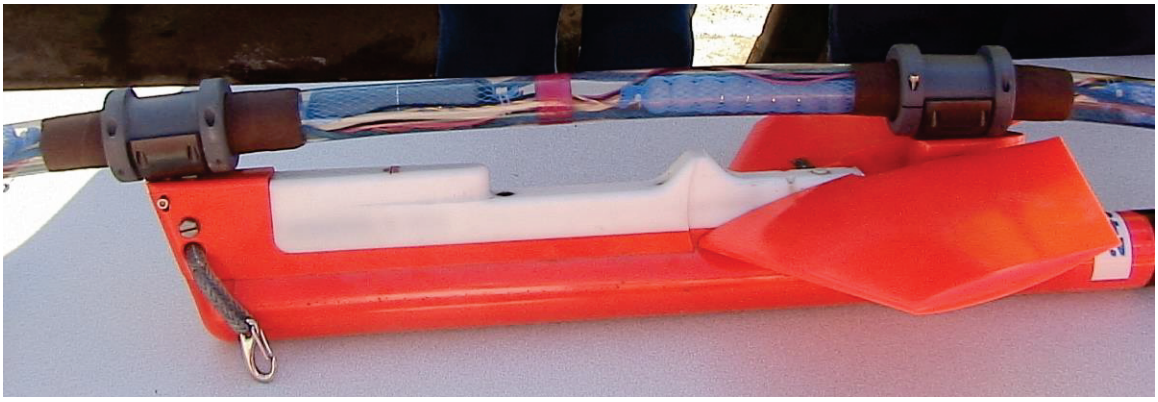


Figure 24. ION Geophysical 5010 depth control bird clipped in position at coil (photography by D. Manning. NRCan photo 2021-282).

The multi-channel streamer was towed from the starboard outrigger with a towing geometry shown in Fig. 20.

8.1.2.7 Deployment

The GI Gun was deployed the over the port quarter using a snatch block hanging from the ship’s crane in tandem with a Pullmaster M7 winch on the flight deck. The deployment/recovery wire was let out until tension was taken up by the main tow wire attached to the port side outrigger. Air and electrical lines were bound to the tow line as the gun was let out. The steamer was deployed from a winch located at the starboard rail of the quarter-deck and towed from the port-side ironing board. The flight deck arrangement is illustrated in Figure 19.

8.1.2.8 GeoEel Acquisition Parameters

Seismic signals digitized in the streamer were sent via Ethernet connection to a Geometrics GeoEel SPSU unit connected to a desktop PC (i5-3570 CPU @ 3.40 GHz; 8.00 Gb RAM; Windows 10 v20H2) running the GeoEel Controller software (v5.64). Acquisition parameters used by the GeoEel controller software are summarized in Table 5. Prior to starting the GeoEel software an instance of the GSCA NavNet NMEA formatter was set up to broadcast the common reference point (CRP) position as a simulated $GPGGA sentence over virtual serial port COM4 which was received by the GeoEel controller software. Captured $GPGGA sentences were used for resetting GPS time and logged to the GeoEel navigation log file.

The Geometrics controller software was set to write data in two locations simultaneously for redundancy: on the local drive of the controller computer (E:\\HUD2021126) and on the network NAS drive (Z:\\Data). With each new line, the software incremented the line number and created a new subdirectory on the data drives named by line number. Note these incremented line numbers differ from the alphanumeric line names used for science planning (see Table 5). Shot gathers were recorded in SEG-D 8058 Revision 1 format (extension '.sgd') and incremented in file name (see section 1.3 for file-naming errors). Log files generated by the GeoEel controller software (including navigation strings captured for each file and error messages) were written to the local C drive.

Table 5. Acquisition parameters used by the GeoEel controller software (v 5.64)

Parameter	Value
Sampling interval	0.5 ms
Record length	7 s
Recording delay	0 s
Recording format	SEG-D Rev. 1 8058
Active channels	16
Reset file timestamp to GPS time	True
Preamp gains	18 db
Peak noise threshold	15 µbar
Noise average threshold	3 µbar
Noise low cut freq.	8 Hz

8.1.3 Shipboard MCS processing

Preliminary processing of airgun data was completed in Vista 2020 using a field laptop located in the GP lab (Lenovo Thinkpad T480; i5-8350U CPU @ 1.70 1.90 GHz; 16 Gb RAM; Windows 10 v20H2). Shipboard processing consisted of removal of the firing delay, resampling, debias, butterworth highpass filter, and gain correction for spherical divergence exporting near-trace and brute-stack profiles. An example of a preliminary processed section was shown in Section 4.0, Figure 9. Final processing is to be completed post-cruise.

Upon completion of each line, preliminary processed sections were exported from Vista in SEG-Y format and merged with navigation of the using hourly logs retrieved from the GSCA NavNet server. To accomplish this a Python script called 'mergenav.py' (Appendix V) was used to parse hourly offset logs and join the closet fix of the common reference point (CRP) to the trace header of the SEG-Y files based on start time. SEG-Ys with merged navigation were then converted to JPEG2000 format using SegyJP2 for use in daily science planning.

8.1.3.1 Processing details and issues

File numbering problems were encountered as a result of crashes of the controller software. In some cases the GeoEel software reset the FFID number and file naming (a) at the start of a new line; or (b) within a line. By default the controller software writes files in separate directories according to line number, so number resets at the beginning of a new line caused file names with identical file names but in separate directories (e.g., '…/0001/734.sgd', '…/0002/734.sgd'). If the reset continued within the same line, file names are given an alphabetic prefix (e.g. 'a1778.sgd', 'a1779.sgd', 'a1780.sgd', etc.). Because of these safeguards, the file naming issues did not result in any loss of data, however will require extra care when processing since the FFID numbers may be used to sort data for processing. Since gather files were neatly organized into subdirectories by default, no attempt was made at sea to renumber or edit the original field records at sea. Further processing onshore should include renumbering the files and FFID trace headers sequentially.

A source firing delay of 50 ms was used for most lines, with the exception of line 0001 (BC-1) where it was changed between 40 and 65 ms. Shot gather files recorded by the GeoEel start at each trigger point generated by the MITS and do not apply any recording delay, so this firing delay must be removed and start times shifted prior to further processing.
A summary of line-by-line processing notes is given below:

Line 0001 (BC-1):

Firing delay was modified during acquisition after troubleshooting the gun phone. The following lists the firing delays used for each segment of the line:

- FFIDs 233 – 602: 40 ms
- FFIDs 603 – 607: 60 ms
- FFIDs 608 – 622: 55 ms
- FFIDs 623 – 846: 50 ms

Line 0002 (BC-1):

Crash of controller software led to reset of the FFID (734) and new line started (0002) Guns disabled for compressor maintenance at end of line: FFIDs 1709 to 1777 (no signal).

Line 0003 (OK-6):

Injector gun not working at beginning of line (FFIDs 1778 – 2137). This is visible in the source signature and as a faint bubble pulse ~100 ms below the seafloor reflection. Crash of controller software led to reset of the FFID midway through line after FFID 2071. As a result FFID 2072 was saved as 'a1778.sgd'.

Second reset after FFID 2248 reset to 2247 resulting in two alphanumeric filenames ('a2247.sgd, 'a2248.sgd')

Line 0005 (OK-10):

Guns shut down briefly for compressor maintenance at 3:00 UTC – FFIDs 9906 - 9957 have no signal

8.1.4 Seismic Acquisition Conclusions, Issues and Recommendations

Despite the long lead up time to this very short cruise, multiple issues hounded the seismic portion. These issues would likely not have been diagnosable outside of full on operations. The Seismic suite has not been used since 2016.

Compressor:

The shaft seal on the high pressure stages failed causing heavy leaking. This required significant management to ensure the oil was caught, the oil never got too low, and that overheating did not become an issue. The shaft seals will need to be replaced. The age of the compressor and parts availability will need to be considered in the future.

Air Control/Delivery:

Airline, Reservoir bottles, Gauges, valves, Air slip rings, and connections. No leaks. Three gauges will require replacement.

LongShot/SureShot:

Worked well. Early into the cruise an electrical line broke, so the bubble pulse could not be monitored through the blast phone. The flashing of the solenoid indicators ensured the generator and injector were firing in proper sequence with no apparent time variations. Monitoring of air pressure showed no leaks at the gun. Subsequent processing of the data showed excellent data quality. Time, and a lack of personnel did not allow for a line swap out.

GI Gun:

Performed well. An extension was put in place for a firing line (electrical) that was too short. A weak connection caused an interruption to the firing of the injector gun for a short period. This was corrected and there were no further issues

Position Control System:

The Data Management Unit (DMU), an integral part of the system, failed. Efforts to bring the unit back on line were unsuccessful and we used the old Digicourse DOS based system. The software was not fully functional, but direct DigiBird commands and responses were possible. Streamer depth was maintained for the duration of the cruise. The ION Geophysical DMU has been returned to the manufacturer for diagnosis/repair.

GeoEel Streamer:

The GeoEel streamer work well although there was leakage at least one connection. More robust waterproofing would first and least expensive solution. Other users have had similar difficulties and have had sections/modules retrofitted with other connectors. The connectors the system is presently fitted with are no longer used by Geometrics.

Acquisition Computer/Software:

There were several glitches with the present CNT-2 software. Inconsistent behaviour of the GeoEel controller software (v5.64) caused several issues during acquisition. Software crashes resulted brief downtime of the logger interface during lines 0001 and 0003 during which a few shots were not logged. When restarting the line after a crash on line 0003, only one of the two designated data write folders was actually being populated (despite settings remaining unchanged). As a result manual backups had to be made during that line to ensure redundancy of data storage. Restarting the line also caused naming to become out of sequence (see section 8.1.3). The software would easily become unresponsive and crash when modifying display parameters of the interface causing breaks in acquisition. Before next field season, further testing of this software is necessary, in addition to contacting Geometrics for bug fixes and updated versions. This version of the software was used since it was compatible with Windows 10, which was a requirement to connect and write to the NAS via the network. We will be in contact with Geometrics on this.

The sample rate set in the GeoEel controller software was set higher than required since the frequency content of the seismic source had not been measured. Quick analysis of the first reflection and direct wave show a peak frequency of ~120 Hz with energy up to ~300 Hz. A longer sample interval would therefore be sufficient for this source while reducing file sizes (e.g. 1 ms). Even at the higher sample rate, however, the ample storage space on the hard-disk and NAS drives was more than adequate for storage.

Improvement in Onboard Seismic Displays:

The waterfall display of the GeoEel controller is very basic and should be improved or supplemented with a separate display for future surveys. The GeoEel display is generally adequate to ensure data are being written, however the limited options for display make it difficult to achieve meaningful images for watchkeeping purposes. Options for automated processing and display of incoming data should be evaluated so watchkeepers can get a better sense of data quality and underlying geology. In addition to streamlining QC, this would enable quicker decision-making for on-the-fly route planning and sample site selection.

A designated large monitor in the GP lab for seismic processing would be beneficial. The limited resolution of the field laptop used for processing was quite small and not ideal for display of some software (e.g. Vista and SegyJP2Viewer). A separate display could be mounted in the aft or forward part of the lab for better display of data. A nearby network connection should be made available for data transfer of the processing computer.

8.1.5 Seismic Acquisition Acknowledgments

We would like to thank the Chief Engineer, Senior Engineer and 1st engineer for supplying cooling water and diesel fuel to the compressor. They also provided much in the way of technical support and advice for our many mechanical needs.

Thanks go to the Bosun and Deck Crew for their professionalism in ensuring the safe and timely deployment and recovery of all equipment.

8.2 GeoForce Group Deep-Towed Sparker Acquisition

8.2.1 Introduction

This report is a review of the Geoforce Deep Tow System (DTS) operations on board the Canadian Coast Guard Ship Hudson during the Geological Survey of Canada-Atlantic Region (GSCA) mission Hudson 2021-126. The scientific objective of this mission was to investigate the marine geology of the southwestern Scotian Slope between the shelf break at 200 m to a depth of about 2500m. In support of the scientific objective the DTS was used in sparker mode to collect high resolution sub bottom seismic data. The mission took place from June 22 to June 27, 2021 under the direction of Chief Scientist Edward (Ned) King.

Geoforce Group Limited provided senior technician Tom Fralic under the standing offer contract #7000002753 to supervise the installation, operation and maintenance of the DTS system during the field program.

This was the first complete NRCan survey with the newly acquired Geoforce DTS. Geoforce was granted a Built in Canada Innovation Program (BCIP) contract (UT849-208463/001/SC) in 2019 to cover the costs of development of an upgraded DTS, previously known as the Huntec system. The most notable improvements from the legacy system are: hydrophone digitizer housed inside the DTS; long range ethernet network communications from topside to DTS; the ability to swap between Boomer or Sparker "on-the-fly" by use of topside software; a newly designed tow-cable Junction Box which utilizes subsea connectors, and a software based waterfall data visualizer/recorder.

8.2.2 Equipment

8.2.3 Digital Deep Tow System

Geoforce Group Limited of Dartmouth, NS is contracted under Standing Offer to supervise the operation, maintenance and ongoing engineering development of the NRCan's Deep Tow Seismic (DTS) systems. The DTS system is a deep towed, high resolution, sub-bottom profiling system complete with two acoustic sources (Boomer/Sparker), high voltage Energy Storage Unit (ESU), Digital Acquisition Unit (DAU), and two receiving hydrophones housed in an underwater tow fish (Fig. 25). This system is complimented with a custom data acquisition software known as

Figure 25. Geoforce DTS (photography by T. Fralic. NRCan photo 2021-283).

Cerebella and a purpose-built Topside Control Unit (TCU) for both receiving DTS telemetry and providing low voltage and high voltage to the DTS.

DTS SN3004 system was primarily used on this mission. The maximum power output of this system is 1000 Joules with an ED10F/C Boomer and a twenty-tip mini sparker source. For this mission, the internal single element GF16 hydrophone was recorded as "Internal Channel". The externally towed Geoforce GF15/10P streamer hydrophone was recorded as "External Channel" (overall streamer length 15 feet, single channel with a combined 10-foot active section, total of 10 AQ-16 elements with an effective spacing of 12 inches).

The ED10/FC Boomer source (Fig. 26) is depth compensated and outputs a highly repeatable broadband pulse, capable of resolving 10 centimeters. Peak output intensity at 480 Joules is 212 dB/1µPa @ 1m, with a pulse duration of 160µs, the output frequency is centered at roughly 3.5 kHz with a frequency band of 500 Hz - 10kHz.

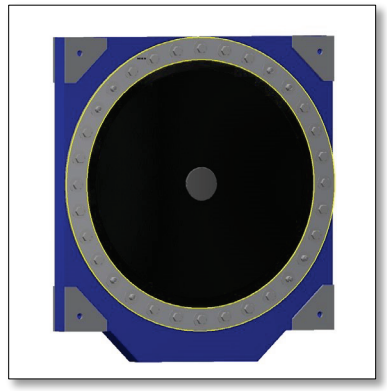


Figure 26. ED10/FC Boomer

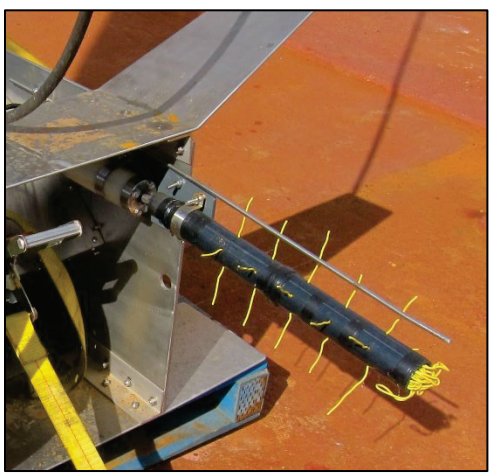


Figure 27. 20 tip mini-sparker (photography by T. Fralic. NRCan photo 2021-284)

The sparker source (Fig. 27) consists of twenty exposed #18 AWG solid core tips. The peak output intensity at 125m depth, 480 Joules is 210 dB/1µPa @ 1m. Acoustic output is centered at approximately 2000 Hz, with a bandwidth of 600 Hz – 6 kHz. Unlike the Boomer, the Sparker output characteristics are directly affected by atmospheric water pressure, the acoustical values are depth dependent, and because the system was towed at a variety of depths, these are not static values. The sparker source was used exclusively on this mission.

The towfish was deployed from the A-Frame deck (Fig. 28) from a Hawboldt oceanographic winch (Fig 29), which includes an Alpha multi-way slip ring and a 600-meter, fourteen-conductor, armored tow cable. The tow cable is handled by a 36-inch diameter roller cluster (Fig. 30) rigged on the center position of the aft A-frame.

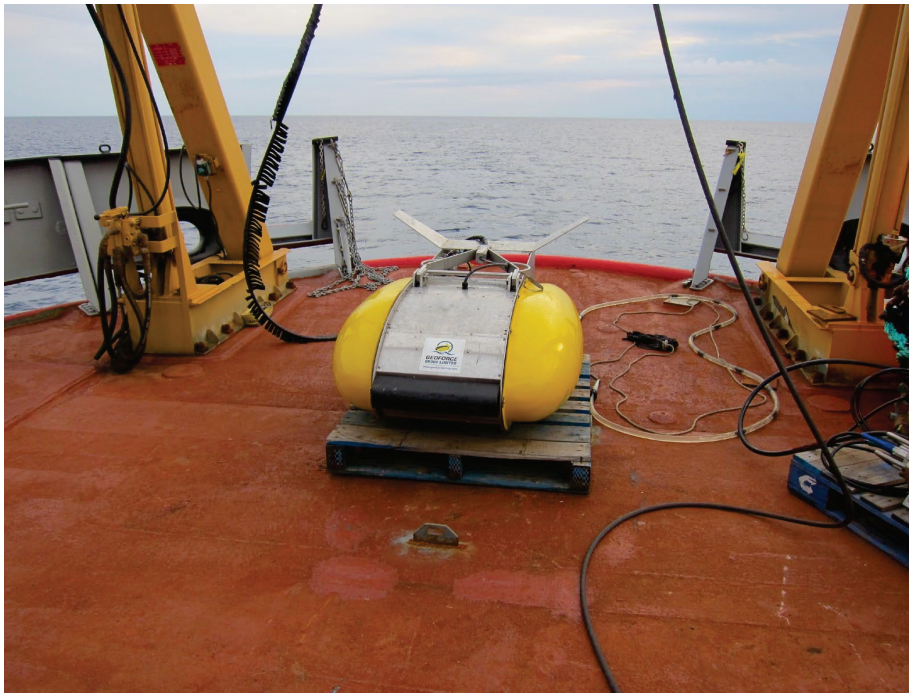


Figure 28. DTS on deck (photography by T. Fralic. NRCan photo 2021-285).

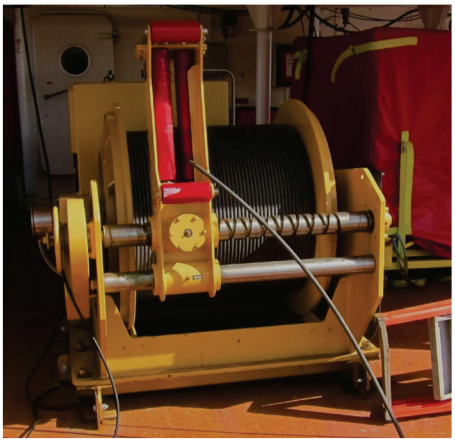


Figure 29. Hawboldt Winch and Tow Cable (photography by T. Fralic. NRCan photo 2021-287).

Figure 30. Roller Cluster (photography by T. Fralic. NRCan photo 2021-286).

Figure 31. Lab equipment in operation (photography by T. Fralic. NRCan photo 2021-288).

The lab instrumentation consists of a Windows 10 PC running Cerebella logging software, a Geoforce TCU, a Huntec Mk III PCU, and a Huntec low pass filter unit (Fig 31).

8.2.4 Recording Systems

A Geoforce Cerebella acquisition system was used as the digital recording device. This software is designed specifically to communicate with the Geoforce DTS and was a large portion of the BCIP contract. This software incorporates a waterfall view which can be viewed on a separate screen with a primary purpose of providing data quality assurance to the operator, but in certain scenarios can also be used to interpret on the fly. The software also includes displays showing the DTS depth, attitude (pitch and roll), ambient water temperature, leak sensor indicators, trigger options, and TCU status.

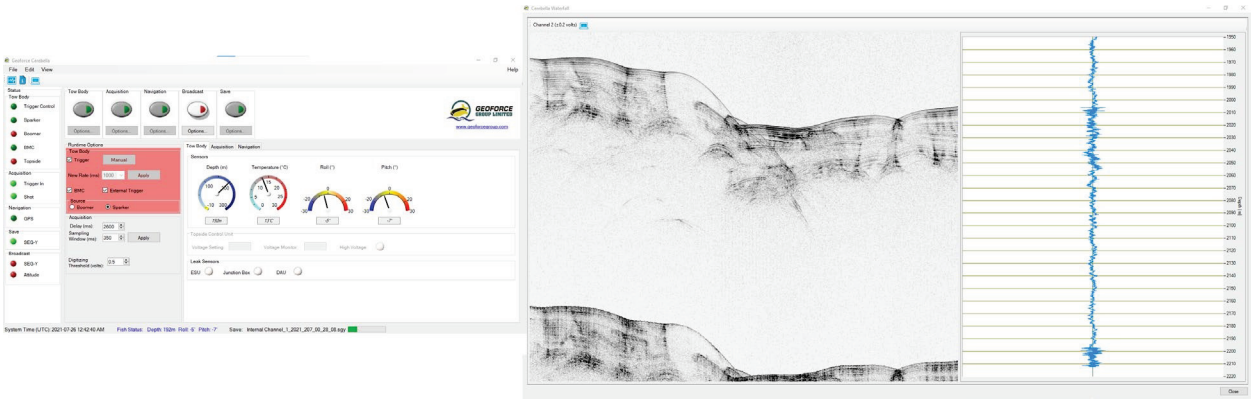


Figure 32. Geoforce Cerebella software in operation

8.2.5 Spares

A spares kit was assembled which included some compatible parts from legacy GSCA Huntec systems AGC#2 and AGC#3. An official spares kit for the Geoforce DTS in its current form has not been acquired by GSCA. No components were used.

8.2.6 Operations; Recording Parameters

Cerebella Digital Recorder
Software: Geoforce Cerebella v1.3.8.0
Format: SEG-Y
Storage Medium: Internal Hard Disk Drive
Sample Rate: 25.6 kHz
Record Length: 350 ms
Trigger I/P: MITS External Trigger
Analog I/P 1: DTS Internal Raw
Analog I/P 2: DTS External Raw
File Break: 1 Hour
Navigation: Ship's position embedded on SEG-Y files

Figure 32 shows the Cerebella software windows in operation.

8.2.7 Equipment Performance

System preparation began on June 4, 2021, the equipment was set up and tested by June 18, at this time it was noticed that the TCU high voltage output was intermittent, it would only partially charge the ESU to roughly 1/3 of the desired voltage. After a series of tests and contact with the manufacturer of the HV module, it was determined the High Voltage output section had failed. The workaround for this was to use the Huntec PCU and line filter, this solution worked for the duration of the mission.

During pre-cruise testing it was observed that the external trigger provided by MITS would cause the Cerebella software to go into an error of receiving triggers, but not saving SEGY traces. Through phone and email communication with the Cerebella software developer, the bug causing this issue was fixed with a new version of Cerebella.

System operation began on July 22, 2021 and DTS performed well for the duration of the cruise, providing clean streamer data with no unplanned recoveries. Two minor glitches are logged on the data in Figures 33 and 34.

On the evening of July 24, collecting line OK-9, the DTS was temporarily unattended and the Sparker failed to fire for ~6 minutes. This can happen for a variety of reasons including a sudden change of salinity. Without a power reset this causes the HV power supply to "load down" in a loop until it is power cycled.

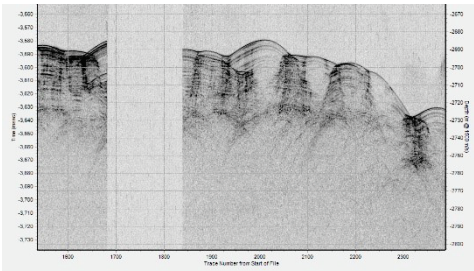


Figure 33. Sparker not firing

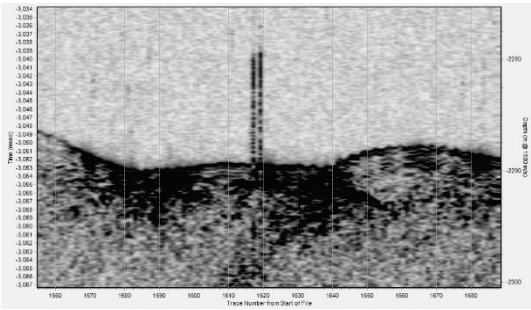


Figure 34. Bad SEGY traces

There was an occasional, unexplained glitch which produced a "bad" SEGY trace – the software would register an unwanted trigger very shortly after an expected trigger, it was not determined if this was a problem with hardware or software. The result can be seen in Figure 34. These bad traces could be "dissected" from the record in post-processing if they interfered with interpretation.

The GeoForce watchkeeper log, documenting most parameter settings and changes, is provided in Table 6.

WATCHKEEPER'S LOG - GEOFORCE DEEP TOW PROFILER

22/Jul/21			27/Jul/21				CCGS Hudson						
Time		Data Annotation	Environmental				DTS Profiler Settings				Graphic Recorder		Comments
Julian Day	Time UTC	Line #	WD	Log Spd.	Fish Depth	Sea State	Source BM.	Source SP.	Fire Rate	PCU KV	Sweep Speed	Print Delay	
203	22:40		122 m	2 kn		2	x		500 ms	2 kV	500 ms	100 ms	Launch DTS
204	00:03	BC_approach_first_line	124 m	2.6 kn	53 m	1	x		500 ms	4 kV	350 ms	100 ms	Dialing in settings since launch - tested sparker @ 4kV
204	00:18	BC1	120 m	5 kn	45 m	1		x	500 ms	4 kV	350 ms	100 ms	SOL BC1 – Sparker mode – Pitch over 20 deg
204	00:28	BC1	123 m	5 kn	45 m	1		x	500 ms	4 kV	350 ms	100 ms	Increase MITS Ch1 delay (DTS) to 300ms
204	01:51	BC1	124 m	3.6 kn	46 m	1		x	1000 ms	4 kV	350 ms	100 ms	Decrease fire rate to 1000ms
204	04:10	BC1	150 m	4 kn	45 m	1		x	1000 ms	4 kV	350 ms	100 ms	Increase MITS Ch1 delay (DTS) to 600ms
204	04:34	BC1	183 m	4 kn	62 m	1		x	1000 ms	4 kV	350 ms	180 ms	Lower DTS – Increase delay
204	05:29	BC1	247 m	4 kn	87 m	1		x	1000 ms	4 kV	350 ms	300 ms	Lower DTS – Increase delay
204	05:55	BC1	329 m	4.1 kn	97 m	1		x	1000 ms	4 kV	350 ms	380 ms	Lower DTS – Increase delay
204	06:26	BC1	884 m	4.1 kn	111 m	1		x	1500 ms	4 kV	350 ms	940 ms	Going over shelf, decrease firing rate, increase delays
204	06:58	BC1	1292 m	4.1 kn	186 m	1		x	2000 ms	4 kV	350 ms	1640 ms	Going over shelf, decrease firing rate, increase delays – lower DTS
204	09:05	BC1	1660 m										EOL BC1
204	09:22		0 m										Gear onboard
204	19:10												Tow Bridal changed to middle position
204	11:33		2166 m	2 kn	54 m	1	x		2250 ms	4 kV	350 ms	2160 ms	Launch DTS – 6 deg nose up @ 2kn
204	11:48		2180 m	2 kn						4 kV			Restart Cerebella PC before getting on line – Blue wheeled 2 times
205	00:32	OK-6	2173 m	4.4 kn	178 m	1		x	2250 ms	4 kV	350 ms	2880 ms	SOL OK-6 – Cerebella Blue wheeled once despite restart – not missing shots
205	00:45	OK-6	2200 m	4.5 kn	172 m	1		x	2225 ms	4 kV	350 ms	2880 ms	Bridge shut off depth sounder – cleaned up record – pitch @ 0 deg – takes more cable out
205	01:00	OK-6	2230 m	4.5 kn	189 m	1		x	2960 ms	4 kV	350 ms		Broke SEGY File – Check for sounder interference – not HV
205	01:23	OK-6	2290 m	4.5 kn	169 m	1		x	2000 ms	4 kV	350 ms	2960 ms	Broke SEGY File – Sparker double shooting – Bridge called saying lightning strike
205	01:33	OK-6	2252 m	4.5 kn	169 m	1		x	2000 ms	4 kV	350 ms	2950 ms	Trigger Rate 2s, Air gun trigger 10s, noise controlled.
205	02:07	OK-6	2301 m	4.5 kn	165 m	1		x	2000 ms	4 kV	350 ms	3060 ms	Vessel going 6kn COG, slowed to 4.5kn
205	02:50	OK-6	2334 m	3.7 kn	191 m	1		x	2000 ms	4 kV	350 ms	3060 ms	Disabled Cerebella log file, no more blue wheeling/freezing up
205	05:50	OK-6	2428 m	4.5 kn	187 m	1		x	2100 ms	4 kV	350 ms	3240 ms	Decrease fire rate to 2100ms – Divisble of airgun 10500ms
205	09:00	OK-6	2648 m	4.3 kn	186 m	1		x	2100 ms	4 kV	350 ms	3400 ms	EOL OK-6
205	09:19	OK-6	2650 m	2 kn	0 m	1		x					Gear onboard – all SEGY files moved to RAID
205	19:30												Add cable fairing – Change top tailfin trim to 0 deg
205	21:35	OK-9	2600 m	2 kn	23 m	1	x		2100 ms		350 ms	3400 ms	Launch DTS
205	22:01	OK-9	2602 m	4.5 kn	181 m	1		x	2100 ms	4 kV	350 ms	3200 ms	SOL OK-9 – DTS 6 deg nose down
205	23:06	OK-9	2686 m	4.5 kn	200 m	1		x	2100 ms	4 kV	350 ms	3500 ms	Lost spark for ~5 min
206	07:18	OK-9	1982 m	4.5 kn	189 m	1		X	1750 ms	4 kV	350 ms	2600 ms	Change trigger rate – some air gun walking until good value was found
206	06:00	OK-9	1766 m	4.5 kn	200 m	1		x	1500 ms	4 kV	350 ms	2300 ms	EOL OK-9
206	06:20		1821 m	2 kn	0 m	1							Gear onboard – all SEGY files moved to RAID
206	22:27	OK-10	2040 m	4.5 kn	190 m	1		x	1750 ms	4 kV	350 ms	2700 ms	SOL OK-10
207	03:05	OK-10	1865 m	4.6 kn	194 m	1		x	1500 ms	4 kV	350 ms	2400 ms	Increase Firing Rate to 1500ms (Delay 800ms)
207	03:09	OK-10	1861 m	4.5 kn	195 m	1		x	1500 ms	4 kV	350 ms	2400 ms	Decrease MITS delay to 600ms
207	04:10	OK-10	1702 m	4.5 kn	186 m	1		x	1500 ms	4 kV	350 ms	2300 ms	Lost spark two times
207	05:12	OK-10	1538 m	4.5 kn	180 m	1		x	2100 ms	4 kV	350 ms	1950 ms	Reduce firing rate
207	06:00	OK-10	1050 m	4.5 kn	200 m	1		x	2100 ms	4 kV	350 ms	1400 ms	EOL OK-10
207	06:26												Gear onboard – DTS operations completed

8.3 Knudsen Sounder

The Knudsen 3260 is a dual 12 kHz/ 3.5Khz stand-alone system. The Transducer used by the 12 kHz is mounted on the ram at the forward end of the ship and is typically used for depth, or for tracking target depth/distance, and bottom contact using "pinger" mode. No targets were tracked during this cruise.

The 3.5 kHz functions as a sub-bottom profiler and is connected to a 4 x 4 element array mounted directly to the inside of the hull of the ship. The 3.5 kHz sounder is not used when the Huntec collecting sub-bottom data.

The system gets its time from the time server (ship's equipment). It receives a position string and outputs one depth string for each channel.

9.0 Recommendations

The acquisition of multichannel seismic data represents a new phase for GSC-A field operations. Its success should dictate this as standard operating procedure. Of course, some modifications can improve this. Specific recommendations for AUV operations are in Section 7.4. and for seismic acquisition and display are in Section 8.14.

Alternate to Geophysical Paper Log:

Paper-based (hand-written) serial logging of the geophysical operations has always been the standard operation. Together with the electronic log, this provides necessary redundancy of operation parameters. It can be tedious and challenging to keep up with events, especially when these parameters change rapidly. We suggest an alternate operation that is entirely digital yet not subject to potential (though rare) electronic failure or loss. Screen grabs immediately written to a different disk (network-connected RAID or local external disk) or a phone camera capture could achieve this with adequate data redundancy.

10.0 References

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Appendices

Appendix I: Coast Guard Pre- and Post-sailing documents; Forms B, C1 and C2

Appendix II: Hudson 2021126 Duty Roster

Appendix III: Hudson 2021126 Cabin Assignments

Appendix IV: Digital General Log *Also provided as separate text file*

Appendix V: Python script "mergenav.py", to merge navigation from hourly NAVNet logs and insert at common reference point (CRP) in the SEG-Y trace header (Kai Boggild) *Also provided as separate text file*

Appendix VI: Post-Cruise GSC-Atlantic Newsletter Article

Appendix VII: Cruise Narrative

Appendix I: Coast Guard Pre- and Post-sailing documents; Forms B, C1 and C2

VOYAGE PLAN **NRCan Mission Maritimes Region** **FORM "B" Version July 21**

SHIP: CCGS *Hudson*	VOYAGE NUMBER: HUD2021126

Overall Objective:

The mission is to collect geoscience data within defined areas on the Scotian Shelf and Slope. *Limited ship time means that certain target areas will have to be dropped*.

Daytime hours will involve geological sampling (focus on piston cores, but grabs and/or camera stations may be necessary also) and deployment and retrieval of the Gavia AUV. Overnight hours involved seismic surveys with Huntec Deep-Tow-Seismic and sleevegun systems.

Proposed Itinerary:

- *Note: Limited ship time means that certain target areas will have to be dropped compare to earlier Form B submissions and the included map figure*. *The primary objective is the shelf-break and continental slope offshore Shelburne and NE Channel* (southern Scotian Slope; SSS area, polygon in the map figure).
- Depart BIO on Thursday, July 22, 2021
- Operations in the SSS area; AUV and coring during daytime and seismics during nighttime. Depending on time of BIO departure, transit may be optimized to start seismic operation (~1800 hrs) or full, or partial day in that area should there be ample time for coring. AUV operations require most of the daytime shift while coring in relatively deep water will require several hours at each site. Should timing be poor for the SSS transit, then geoscience activities commencement will be considered on the inner shelf between St. Margaret's Bay, Mahone Bay and Emerald Basin. Specific but approximate coordinates are supplied on the last page.
- Operate *at least* 2 to 4 nights and 3 to 4 days in SSS area.
- Operate remainder of time on mid to inner shelf; Roseway to Emerald Basins and northern flanks
- Return to BIO on Tuesday AM July 27, 2021

Summary of Operations:

Prior to sailing, NRCan and Hudson crew will work together to ensure that the deck space requirements for all science gear and containers will be met.

The mission is to collect geoscience data within defined areas on the Scotian Shelf and Slope.

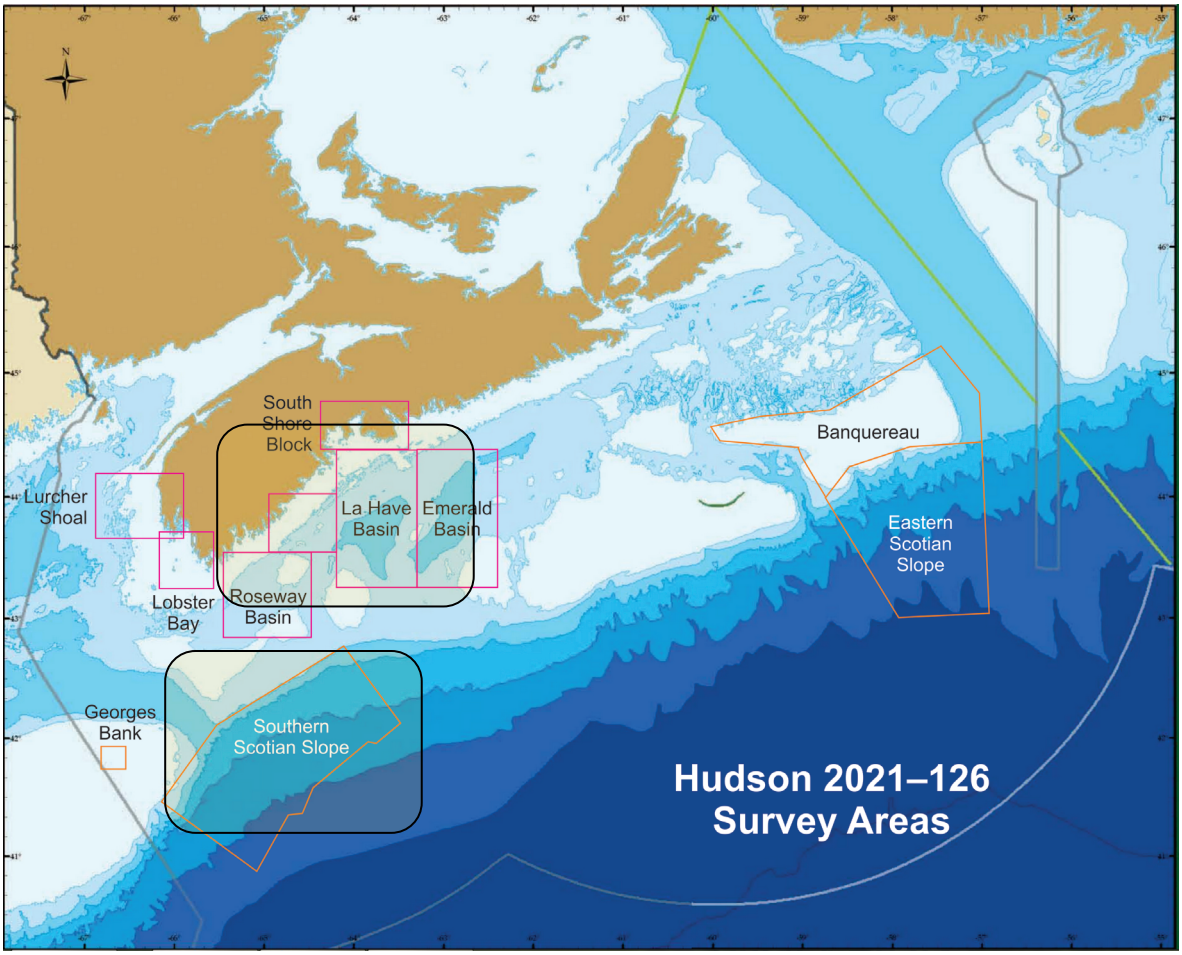
Daytime hours will involve geological sampling (piston cores, possibly grabs, camera stations) and deployment and retrieval of the Gavia AUV. Overnight hours involved seismic surveys with Huntec Deep-Tow-Seismic and sleevegun systems.

Staff:

Twelve science staff will participate. Duty roster is provided as a separate single Excel file. Cabin assignments are similarly attached.

VOYAGE ITINERARY REQUIRED: (start, stop, port call(s), track chart. Coordinates represent **start** of operation).

- Depart BIO on Friday July 21 2021
- Head directly to southern Scotian Slope area (SSS beige rectangle, see map) and begin operations unless departing time offers efficiencies for some operation in the mid to inner shelf study area on the map. Several days (*at least* half the available cruise time) in the SSS area
- Remainder of cruise time on operations in the mid and inner shelf areas of beige rectangle on map.
- Tentative return data to BIO on Tuesday July 27 2021
- No other port calls.



This map related to the original cruise plan. Operations for the renewed plan (July 21, 2021 start) include only those areas in the beige rectangles.

CHIEF SCIENTIST:

Edward (Ned) King, Geological Survey of Canada-Atlantic, Natural Resources Canada, Bedford Institute of Oceanography, 1 Challenger Drive, Dartmouth, NS, Canada, B2Y 4A2
edward.king@canada.ca, 902- 292-6059 nedking222@gmail.com

SCIENTIFIC STAFF LIST: (include affiliation) (Attach Next-of-kin List)

Each staff member will be assigned to their own cabin as a preventative measure to mitigate the spread of Covid-19.

	Name	Affiliation	Next of Kin, telephone
1	Robertson, Angus	GSCA	Removed
2	Boggild, Kai	GSCA	Removed
3	Broom, Laura	GSCA	Removed
4	Fralic, Tom	Geoforce Group Ltd.	Removed
5	Campbell, Lori	GSCA	Removed
6	Greaves, Cameron	GSCA (Student)	Removed
7	Ingham, Parker	GSCA	Removed
8	King, Edward	GSCA	Removed
9	Manning, Desmond	GSCA	Removed
10	Nissen, Grace	GSCA (Student)	Removed
11	Pledge, Peter	GSCA	Removed
12	Todd, Brian	GSCA	Removed
13			

EQUIPMENT TO BE USED:

1. EQUIPMENT SUPPLIED BY MARINE SERVICES (excluding winches):

2. EQUIPMENT SUPPLIED BY GEOLOGICAL SURVEY OF CANADA

Sampling Equipment (Daytime operations):

- Piston core
- IKU grab
- Box core

Seafloor imagery (Daytime operations):

- Seafloor still/video camera
- GAVIA AUV

Geophysical profiling (Nighttime operations):

- Sleeve gun seismic refection system (compressor and guns)
- For sleeve gun: diesel compressor which will be on the flight deck as well as a diesel day running tank. Note that tank will need to be re-fueled (daily) from the engine room.
- Huntec Deep Tow System (Operated by Geoforce Group Ltd personnel)

Navigation:

- 2-4 Regulus and/or Alderbaran navigation computers (NRCan)
- Will require access to ship's navigation data (3 feeds: GPS: $GPGGA, $GPZDA; Gyro: $HEHDT; Sounder: $SDDBT or $SDDBK; NMEA feed).

Refrigerators, Freezers, Storage Containers:

- Containers:
- Half Height core process container (20') starboard side forward
- Reefer for core storage on starboard side aft
- Spares container (20') port side aft
- Compressor container (2x20') flight deck

Laboratory Equipment:

Chemicals/Hazardous Materials/Other:

*Material Safety Data Sheets (MSDS) will accompany all hazardous material.

3. EQUIPMENT FROM OTHER SOURCES:

4. EXPLOSIVES:

5. WINCH AND WIRE REQUIREMENTS:

- Pengo winch
- Hydrowire winch

SCIENTIFIC OR SURVEY OBJECTS:

1. Obtain geophysical profiles within defined areas on the Scotian Shelf and Slope.
2. Obtain geological samples within defined areas on the Scotian Shelf and Slope.
3. Obtain photographs and video within defined areas on the Scotian Shelf and Slope.

VOYAGE PROCEDURES AND STATION PATTERN REQUIRED:

Daytime geological sampling and nighttime geophysical surveying operations will take place in areas outlined on Scotian Shelf and Slope map. A detailed expedition plan comprising latitude and longitude of sample stations is not available prior to sailing; sampling locations will be decided each day (0600–1800) depending upon interpretation of previous nighttime geophysical survey (1800–0600). Geophysical survey lines for the *first night* will be determined prior to sailing and provided at the start of the expedition.
As per the plan noted above, operations will most likely start at the shelf break immediately south of LaHave Bank, ca. 64W, 42 45N with an AUV dive *OR* along a seismic survey line starting between LaHave and Baccaro Banks, no farther south than ~ 41 48 N, 64 12.5 W, with a survey line extending south into deep water.
Should operations alternatively commence on the inner shelf, daytime operations would be located ~44 21 N, 63 36 W (off Pennant Pt) if the AUV is deployed, OR 44 10N, 63 29 W should we start with seismic surveying.

Department of Fisheries and Oceans
Canadian Coast Guard
Bedford Institute of Oceanography
Dartmouth, Nova Scotia

Atlantic Zone Science Vessel Operation Report
Form C-1 (page 1 of 4)
SCIENTIFIC MISSION SUMMARY
To be completed by Senior Scientist

Mission No.: HUD2021126 **Ship: CCGS HUDSON**

Dates: July 21 to 27, 2021

Mission Title (if any): SW Nova Slope Studies

Sponsoring agency/group(s): Under a much broader agreement than the specific cruise, Natural Resources Canada (NRCan) and Fisheries and Oceans Canada (DFO) cooperate on studies addressing various defined Areas of Interest.

Staff: All science participants are affiliated with NRCan, Geological Survey of Canada-Atlantic. Note that long departing delays necessitated several changes in NRCan participants; only those that sailed are included here.

Master: Fergus Francey
*Senior Scientist(s): Edward (Ned) King, NRCan
Scientific project leader(s): Brian Todd, Calvin Campbell, NRCan

List of participants for HUD2021126.

	Name	Affiliation	Duty	Shift
1	King, Edward (Ned)	NRCan/GSC-A	Chief Scientist	
2	Boggild, Kai	NRCan/GSC-A	Seismic watchkeeping	
3	Broom, Laura	NRCan/GSC-A	Sampling watchkeeping	
4	Campbell, Lori	NRCan/GSC-A	Sampling watchkeeping	
5	Fralic, Tom	Geoforce Group Ltd.	Huntec DTS watchkeeping	
6	Greaves, Cameron	GSC-A (Student)	Sampling and seismic watchkeeping	
7	Ingham, Parker	GSC-A (Student)	Sampling and seismic watchkeeping	
8	Manning, Desmond	NRCan/GSC-A	Seismic lead and watchkeeping	
9	Nissen, Grace	GSC-A (Student)	Sampling and seismic watchkeeping	
10	Pledge, Peter	NRCan/GSC-A	Sampling, AUV watchkeeping	
11	Robertson, Angus	NRCan/GSC-A	Sampling, AUV watchkeeping	
12	Todd, Brian	NRCan/GSC-A	Science planning and interpretation	

Area(s) of Operation: (Geographical location and coordinates)

Shelf break and upper slope offshore Shelburne, SW Nova, Scotian Shelf with minor operations on mid Scotian Shelf offshore St Margaret's Bay. See map.

Summary of Purpose:

The main objectives of the mission were many, across six geographic study areas but only one area was covered. The sub-objectives for this area were:

Primary: Seismic and sampling in the upper slope area of SW Nova towards a surficial geology and stratigraphic and age framework in which to place major seabed and buried sediment mass failures

Additional:
1. Assess the timing and behavior of past glaciations and their pre-conditioning to potential geohazards.
2. Test new Geoforce Deep towed system in a program-determined area, Test new GAVIA AUV in a program-determined

Type of Data Collected:

multichannel seismic (small sleeve gun ~ 150 Hz), GeoForce (formerly Huntec) deep towed sparker (~ 3 kHz), sub-bottom profiler (3.5 kHz), Piston cores, camera, Automated Underwater Vehicle (AUV) attempt.

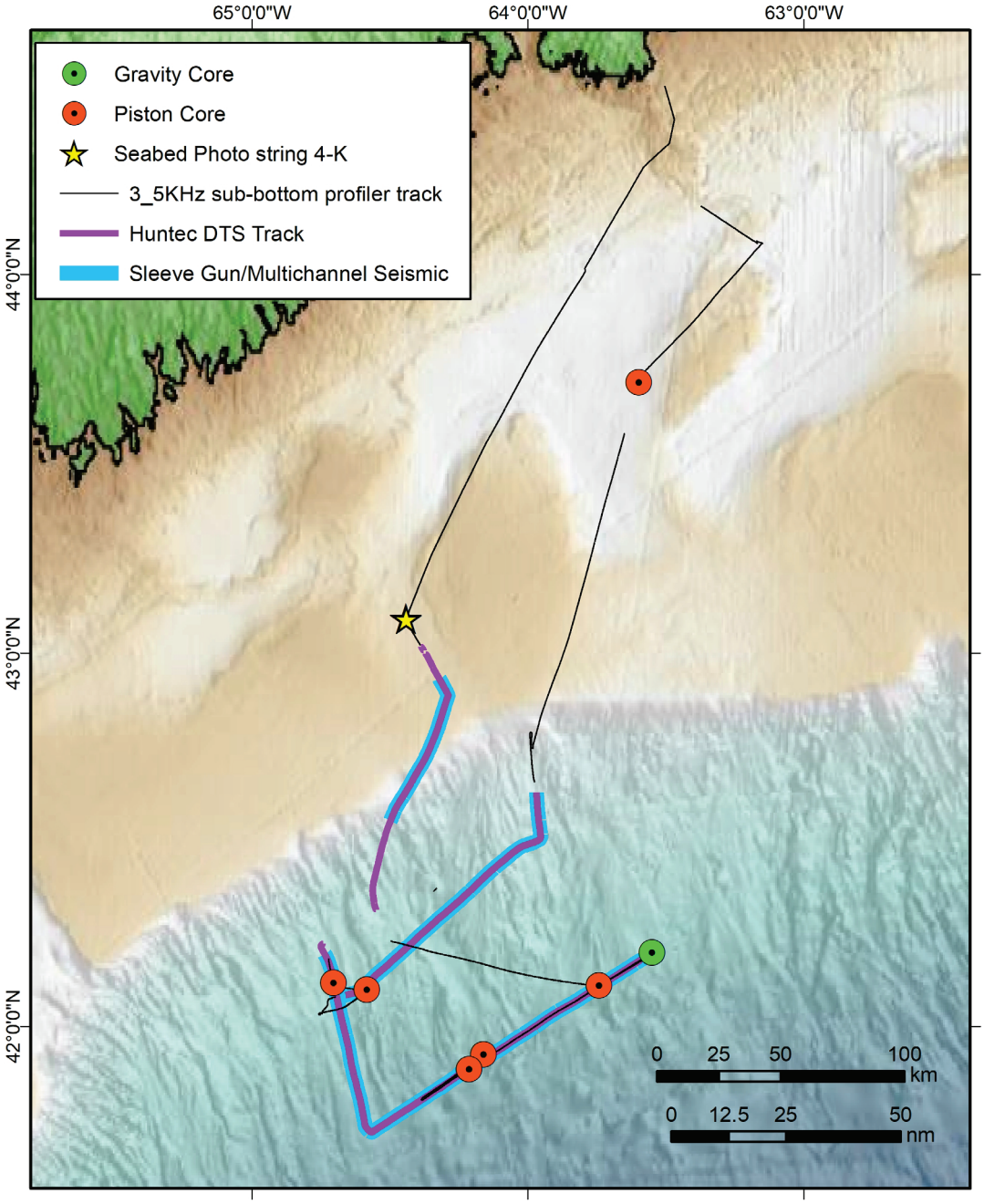
Research Project Allocation:
Changes from Scientific Staff List Shown on Form "B":

No changes to final (July 21, 2021) edition

Itinerary Accomplished (Including Actual Track Chart):

As stated elsewhere, the delays and cancellations strongly curtailed the potential accomplishments against original plans. Nevertheless, the short cruise did accomplish science objectives in one half of the area of one of the original 6 planned study areas.

Figure 1. Mission track for HUD2021126


65°0'0"W
64°0'0"W
63°0'0"W
44°0'0"N
43°0'0"N
42°0'0"N
Gravity Core
Piston Core
Seabed Photo string 4-K
3_5KHz sub-bottom profiler track
Huntec DTS Track
Sleeve Gun/Multichannel Seismic
0 25 50 100
km
0 12.5 25 50
nm

Scientific or Survey Accomplishments:
(with brief statements explaining failures to achieve objectives)

New data Acquired:
289 km of multichannel seismic reflection data of excellent (probably unprecedented) quality
240 km GeoForce (Huntec) deep-towed sparker profiler of excellent quality
331 km of 3.5 kHz sub-bottom profiler of good quality

6 Piston Cores, all successful sediment recovery, most in over 2500 m water depth
1 Gravity core
1 Camera Station with 16 seabed photographs
1 Gavia Automated Underwater Vehicle (AUV) station located on northern Sambro Bank. AUV self-aborted its 2 hour mission only 18 minutes after beginning. Reasons as yet unclear. Recovery successful.

The seismic and samples will be the basis for a shallow geologic framework in which to place multiple and large past sediment mass failures.

Problems Encountered - Suggested Improvements, etc.:

A major course deviation of the planned seismic transect at the mouth of Baccaro Channel, planned to cross the adjacent deep-sea sediment fan, was not successful due to a very long sword-fish gear along the shelf break. This was unavoidable and largely unforeseeable by all parties.

ATLANTIC ZONE -- VESSEL OPERATION REPORT

MISSION NUMBER: 2021126 **DATE: July 21 to 27, 2021**
VESSEL:

Form C (2 of 3) To be completed by ships personnel and Senior Scientist in co-operation

Section to be filled out by Ship's Personnel			
1. OPERATIONS PROFILE	**DAYS**	**TOTAL TIME**	**COMMENTS**
Total Time Allotted	**33 days**	**5 days at sea** 15%	**Long and repeated cruise start delays characterized the mission. This included full cruise cancellation but also an unprecedented rescheduling at a later date. Most delays were ship's condition and equipment-related. A brief account of these is reported separately below. Once the mission was re-scheduled for a July 21 date, a short delay (<1day) resulted from ship's crew shortages and the CG-prescribed pre-sailing duty of a newly recruited officer's familiarization with the vessel.**
On Task		95%	**Minimal "dead" time, largely as driven by CS; always related to the transition from nighttime-dominated seismic operations and daytime-dominated sampling operations. Several occasions required personnel shift adjustments which were readily accommodated by the CO.**
In Transit to/from Task Area	**20 hr 0.83 days**	16%	**Some science operations while underway to and from the main study area minimized effective transit time (core and UAV). Short transits between sample stations are not included here. Sub-bottom profiler data collection while under transit is not included here as it does not contribute directly to the mission goal but nevertheless is a product that NRCan archives.**
SAR Mission		0 %	
Other Sea Time (specify)		0%	
Turnaround/Provisioning		0%	
Directed Alongside		85%	**Percentage is based on planned vs actual days at sea**
Weatherbound		0 %	
Other (specify)		%	

Sections 2, 3 and 4 to be filled out by Senior Scientist					
2. OPERATION	**EXCEEDS**	**MEETS**	**ACCEPT**	**UNACCEPT**	**COMMENTS**
Program Fulfilled				**X**	**See section 4; Vessel performance; At least 85% of the planned program was not achieved as the vessel remained along-side for repairs. However, the short time at sea was successful and met or exceeded program operations.**
Program-related Assistance by Ship's Officers/Crew	**X**				**Good interactions, support, advise and fulfillment of goals**
3. VESSEL CONDITION					
Accommodation		**X**			**Numerous start-up shortcomings in two cabins, plumbing and cooling-related. Dealt with promptly. However a persistent drain sink leak necessitated a cabin shift for one member, mid-cruise, volunteered by ship's staff.**
Food	**X**				**Diversity, including significant attention to specific participant's dietary wishes and needs, good quality and presentation, good**

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					spirited staff interaction, attention to wishes and needs of participants on irregular shifts were all superior to most past missions in the CS's experience. Contributed to a satisfying experience.
Laboratories		**X**			**The General Purpose (aft) lab and the Forward Lab and the Drawing Room were largely NRCan-occupied; others were unused. Minor heating and plumbing cases were inconsequential and handled immediately by crew. Renovations/inspections in the drawing room floor prior to sailing required general clean-up and floor painting. Our extended presence there while awaiting sailing notice hampered painting operations but ship's staff made accommodations for this. Nevertheless, paint fume ventilation from both indoor and outdoor maintenance were not adequate. Implications were, again, relatively inconsequential.**
Deck Space		**X**			**Very tight hanger deck equipment and container layout but functioned well**
Hook-ups					**Adequate network, no problems. Power outage on de-mob shut down all computers, of course, but consequences were minor from a science standpoint.**
Boarding Craft					**N/A**
Other (specify)		**X**			**FRC operations during AUV deployment and recovery**

4. VESSEL PERFORMANCE

Did the vessel and vessel equipment (including fishing gear) function satisfactorily, and are any repairs necessary?

Does any scientific equipment need servicing or repairs?

Pengo hydraulics cooling pump repaired underway. Little or no lost mission time.

Any improvements which would help to deliver your program requirements?
The most vital improvement that must be made is to improve the dependability of the vessel so that science can be delivered to the Government of Canada. The five days of this expedition falls far, far short of what was required to deliver meaningful science.

From April until July, this expedition was beset with scheduling changes, major delays, and eventual cancellation followed by an unprecedented re-start. All these changes resulted in significant staff effort being used for planning changes, documentation revisions, and personnel uncertainties and adjustments. The negative effect on staff was considerable and scientific productivity was lost in the misery of recurring disappointment. It was made apparent that some staff will likely avoid any future Hudson commitments. Alternative vessels may well have to be investigated.

Equipment: The clear shortcoming is an old vessel that requires an inordinate servicing effort to effect a science plan. A persistent and continuous list of various equipment shortcomings prevented at-sea operations for 28 of 33 planned sailing days.

Communications: A crew change that occurred between the July cancellation and the re-scheduled NRCan time slot (unprecedented in our experience) clearly caused communication confusion among all parties, at all hierarchical levels with which we had any communication. Once a tentative sailing date was re-set this cleared to normal, acceptable levels. NRCan and Coast Guard both had challenges meeting staff/crew components but with ultimate success. As stated above, final mobilization, sailing, and at sea operations went very acceptably for the shortened (5-day) time slot.

ATLANTIC ZONE -- VESSEL OPERATION REPORT

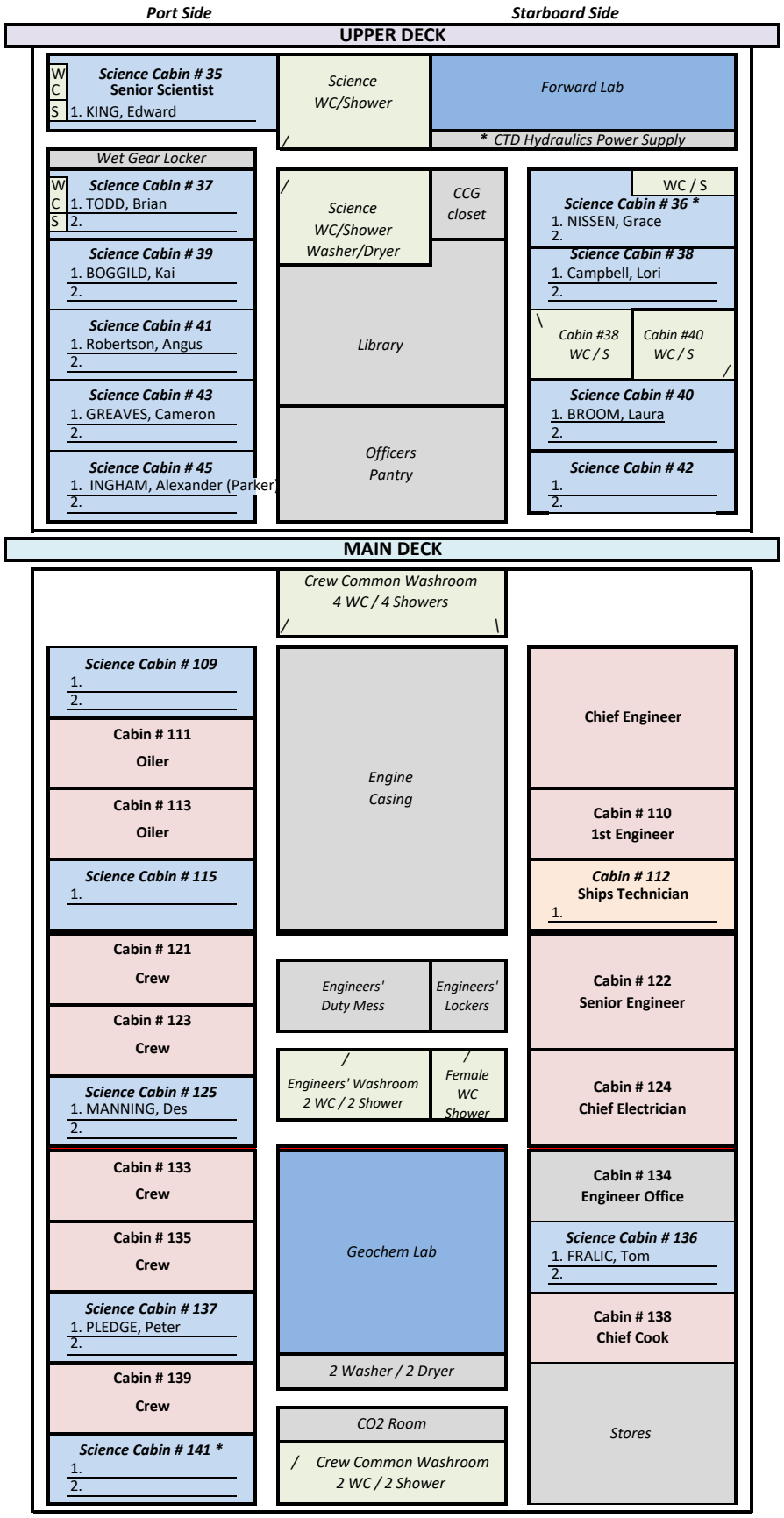
MISSION NUMBER: 2021126 **DATE: July 21 to 27, 2021**
VESSEL:

CLIENT DEPARTMENT	OPERATING DEPARTMENT	
Program Representative: Date:	Captain: _____ Date: _____	Additional Comments:

Appendix II: Hudson 2021126 Duty Roster

Time	0000–0100	0100–0200	0200–0300	0300–0400	0400–0500	0500–0600	0600–0700	0700–0800	0800–0900	0900–1000	1000–1100	1100–1200	1200–1300	1300–1400	1400–1500	1500–1600	1600–1700	1700–1800	1800–1900	1900–2000	2000–2100	2100–2200	2200–2300	2300–2400
12-hour Activity	**Nighttime geophsyics**						**Daytime sampling, photography, Gavia**												**Nighttime geophysics**					
	Nissen				Greaves				Ingham				Nissen				Greaves				Ingham			
Watchkeeping 24 hour: Elog, log, data backups	Boggild																							
Chief Scientist							King																	
Expediton planning							King,Todd																	
Navigation, GIS							King, Broom, with assistance from Pledge and Boogild																	
Curation							Campbell, Broom, with input from Watchkeepers																	
Sampling							Robertson, Pledge, Broom, Campbell and students																	
Sample processing							Broom, Campbell and students																	
Gavia and image processing							Pledge, Robertson																	
Huntec Deep-Tow Seismic	Fralic																							
Seismic system (and Gavia)	Manning																		Fralic					
Hudson deck crew							Gear in	Sampling, imagery and Gavia with GSCA staff										Gear out	Manning					

Appendix III: Hudson 2021126 Science Cabin Assignments Jul-21



Appendix IV: Digital General Log

Digital version includes several pre-sailing days NOT shown here

/File created with LabVIEW version 8.5 by William MacKinnon-GSC(A);
/General Cruise Logging Software- Version 2;
/MAY 2008;
/File format:

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
203	10:55:18		4440.8661	N	6336.8237	W	T0004.9	T0009.0	0	208.60T	0	0.1										Gangway up
203	10:59:59		4440.8668	N	6336.8242	W	T0004.9	T0009.0	200	209.51T	0	0.1										
203	11:10:58		4440.612	N	6336.6686	W	T0010.0	T0018.4	111	110.26T	3.9	3.7										Lines away. Sailing to SOL
203	11:14:59		4440.5127	N	6336.2033	W	T0009.8	T0018.0	105	104.58T	5.9	6										
203	11:29:59		4439.5159	N	6334.5582	W	T0009.9	T0018.2	125	124.99T	6.3	6.2										
203	11:45:00		4438.0445	N	6333.1774	W	T0011.3	T0020.7	181	181.48T	8.4	8.3										
203	12:00:00		4435.8188	N	6332.2145	W	T0009.8	T0018.0	160	160.80T	10.1	9.7										
203	12:06:13		4434.96515	N	6331.98627	W	T0015.8	T0028.9	181	174.62T	8.3	8.2										
203	12:15:00		4433.07456	N	6331.81968	W	T0011.1	T0020.3	176	174.62T	13.5	13.2										
203	12:30:00		4429.85007	N	6330.47283	W	T0028.9	T0052.9	160	174.62T	13.1	13.1										
203	12:44:59		4426.69652	N	6329.13247	W	T0029.6	T0054.1	165	174.62T	13.2	13.1										
203	12:59:59		4423.5077	N	6328.34665	W	T0049.5	T0090.7	192	174.62T	13.2	13.1										
203	13:15:00		4420.31719	N	6329.46401	W	T0028.0	T0051.3	225	174.62T	13.2	13.1										
203	13:30:00		4418.04405	N	6332.98583	W	T0048.8	T0089.3	226	174.62T	13.8	13.3										
203	13:45:00		4415.37284	N	6335.99461	W	T0067.7	T0124.0	210	174.62T	14	13.1										
203	14:00:00		4412.36723	N	6338.38132	W	T0070.6	T0129.2	211	174.62T	9.7	8.7										
203	14:15:00		4410.97381	N	6339.54033	W	T0072.5	T0132.7	212	174.62T	6.3	5.5										
203	14:30:00		4409.55926	N	6340.73453	W	T0075.6	T0138.3	209	174.62T	10.6	9.7										
203	14:44:59		4406.53937	N	6343.13823	W	T0083.5	T0152.8	209	174.62T	14	12.9										
203	14:59:59		4403.48951	N	6345.55818	W	T0089.4	T0163.6	209	174.62T	14	13										
203	15:06:11		4402.24197	N	6346.56865	W	T0103.9	T0190.2	211	174.62T	14	13.1										Phase shift to 150-250
203	15:14:59		4400.45134	N	6347.53432	W	T0099.7	T0182.5	199	174.62T	13.2	12.3										
203	15:16:08		4400.22156	N	6347.70778	W	T0102.2	T0187.1	210	174.62T	13.9	12.8										Power change to 3; Gain change to 20dB
203	15:27:09		4358.0304	N	6349.60769	W	T0097.2	T0178.0	213	174.62T	14	12.9										Change power to 4
203	15:30:00		4357.46451	N	6350.0943	W	T0095.9	T0175.5	212	174.62T	13.9	12.8										Gaun changed to
203	15:31:40		4357.13864	N	6350.38943	W	T0096.0	T0175.7	213	174.62T	14.1	13										Gain changed to 20
203	15:45:00		4354.51101	N	6352.6535	W	T0096.4	T0176.5	211	174.62T	13.8	12.9										
203	16:00:00		4351.55106	N	6355.16259	W	T0103.8	T0190.1	211	174.62T	13.8	12.9										
203	16:15:00		4348.60162	N	6357.66793	W	T0110.3	T0202.0	212	174.62T	13.8	12.9										
203	16:29:22		4345.72291	N	6359.89722	W	T0122.4	T0224.0	209	174.62T	13.7	12.9										Phase change to 200-300
203	16:30:00		4345.59861	N	6359.99338	W	T0122.7	T0224.6	209	174.62T	13.4	12.7										
203	16:44:40		4342.65464	N	6402.18552	W	T0001.9	T0003.6	209	174.62T	13.6	12.9										change gain to 22dB
203	16:45:00		4342.58864	N	6402.23596	W	T0002.3	T0004.3	209	174.62T	13.5	12.5										
203	16:58:07		4339.93226	N	6404.18818	W	T0002.9	T0005.4	208	174.62T	13.9	12.9								3.5KHz	12KHz	
203	16:59:36		4339.62892	N	6404.40766	W	T0002.9	T0005.3	208	174.62T	13.8	13								3.5KHz	12KHz	Phase change to 150-250; gain value changed to 20dB
203	16:59:59		4339.55136	N	6404.46522	W	T0002.6	T0004.8	208	174.62T	13.8	13								3.5KHz	12KHz	
203	17:14:59		4336.85555	N	6406.45357	W	T0111.83	T0204.52	208	207.01T	13.9	12.9								3.5KHz	12KHz	
203	17:29:59		4333.85932	N	6408.76318	W	T0000.00	T0000.00	210	208.82T	13.5	12.9								3.5KHz	12KHz	
203	17:32:20		4333.39682	N	6409.11767	W	T0109.90	T0200.98	207	204.98T	13.5	12.9								3.5KHz	12KHz	
203	17:44:59		4330.82753	N	6410.86316	W	T0108.42	T0198.27	206	205.59T	13.9	12.9								3.5KHz	12KHz	
203	17:59:59		4327.75457	N	6412.94513	W	T0098.65	T0180.42	206	204.07T	13.7	12.8								3.5KHz	12KHz	
203	18:14:59		4324.67108	N	6415.03088	W	T0096.37	T0176.25	206	203.79T	13.8	12.9								3.5KHz	12KHz	
203	18:29:59		4321.54497	N	6417.10132	W	T0098.74	T0180.57	206	204.88T	14	13								3.5KHz	12KHz	
203	18:44:59		4318.43294	N	6419.16813	W	T0088.53	T0161.90	206	205.52T	13.8	13								3.5KHz	12KHz	
203	18:50:58		4317.19244	N	6419.98751	W	T0082.31	T0150.52	207	205.82T	13.8	12.9								3.5KHz	12KHz	phase change 100-200
203	18:59:59		4315.33048	N	6421.17812	W	T0069.30	T0126.74	199	197.48T	13.3	12.6								3.5KHz	12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pres-sure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
203	19:14:59		4312.20671	N	6422.89399	W	T0066.56	T0121.72	202	200.47T	13.4	12.9								3.5KHz	12KHz	
203	19:29:59		4309.09828	N	6424.5739	W	T0073.51	T0134.43	203	202.81T	13.4	13.1								3.5KHz	12KHz	
203	19:44:59		4306.04122	N	6426.28187	W	T0071.48	T0130.72	207	207.95T	13.2	12.9								3.5KHz	12KHz	
203	19:59:59		4305.6611	N	6426.23238	W	T0069.96	T0127.94	332	323.52T	7.9	8.2								3.5KHz	12KHz	
203	20:09:54		4305.72006	N	6426.75954	W	T0056.80	T0103.88	78	164.58T	0.6	-0.6								3.5KHz	12KHz	Setting up for camera stationm
203	20:14:59		4305.70195	N	6426.7067	W	T0072.35	T0132.32	140	203.58T	0.5	0.4								3.5KHz		
203	20:23:18		4305.61884	N	6426.62895	W	T0070.25	T0128.47	138	195.88T	0.7	0								3.5KHz		Ram lowered; 12 kHz turned off
203	20:29:59		4305.56519	N	6426.57617	W	T0069.97	T0127.96	164	208.43T	0.6	0.6								3.5KHz		
203	20:34:52		4305.50786	N	6426.53358	W	T0071.36	T0130.50	137	199.89T	0.8	0.3								3.5KHz		Camera at bottom
203	20:44:59		4305.41875	N	6426.41355	W	T0071.80	T0131.31	150	213.82T	0.8	0.5								3.5KHz		
203	20:56:19		4305.2937	N	6426.25249	W	T0070.41	T0128.77	122	172.64T	1.1	0.1								3.5KHz		Camera stop @ surface; ram raised
203	20:59:59		4305.25197	N	6426.16769	W	T0070.88	T0129.63	131	175.71T	1.3	0.4								3.5KHz	12KHz	
203	21:14:59		4304.63154	N	6425.92446	W	T0069.86	T0127.76	156	176.23T	1.6	1.2								3.5KHz	12KHz	
203	21:29:59		4304.1373	N	6425.7093	W	T0068.18	T0124.69	161	178.58T	2.5	2.2								3.5KHz	12KHz	
203	21:44:59		4303.68838	N	6425.28622	W	T0069.67	T0127.40	158	177.62T	2	1.5								3.5KHz	12KHz	
203	21:59:59		4303.04556	N	6424.81084	W	T0069.18	T0126.51	154	161.98T	2.9	2.4								3.5KHz	12KHz	
203	22:14:59		4302.41511	N	6424.31195	W	T0069.52	T0127.14	152	157.14T	2.6	2.3								3.5KHz	12KHz	
203	22:29:59		4301.85697	N	6423.86481	W	T0068.06	T0124.47	151	151.41T	2.7	2.4								3.5KHz	12KHz	
203	22:44:59		4301.31519	N	6423.39658	W	T0068.18	T0124.70	155	157.09T	2.4	2.4								3.5KHz	12KHz	
203	22:59:59		4300.75703	N	6422.93522	W	T0068.04	T0124.42	144	149.64T	2.5	2.6									12KHz	
203	23:14:59		4300.20298	N	6422.45826	W	T0068.04	T0124.42	147	154.64T	2.9	3.1									12KHz	
203	23:29:59		4259.64504	N	6421.96294	W	T0068.04	T0124.42	144	158.86T	2.6	2.6							Boomer		12KHz	
203	23:44:59		4259.07088	N	6421.53611	W	T0068.04	T0124.42	156	167.82T	2.6	2.6			40	1	5000		Boomer		12KHz	
203	23:59:59		4258.46949	N	6421.11353	W	T0068.04	T0124.42	158	172.07T	2.8	2.7			210	1	0		Boomer		12KHz	
204	00:14:59		4257.81115	N	6420.70871	W	T0068.04	T0124.42	160	170.12T	3.6	3.2			210	1	0		Boomer		12KHz	
204	00:29:59		4256.81539	N	6419.96805	W	T0068.04	T0124.42	152	158.09T	4.8	4			210	1	0		Boomer		12KHz	
204	00:41:38	BC 1	4255.99191	N	6419.30515	W	T0068.04	T0124.42	150	151.77T	4.9	3.9			210	1	0		Boomer		12KHz	SOL
204	00:44:59	BC 1	4255.7549	N	6419.11586	W	T0068.04	T0124.42	148	150.09T	5	4			210	1	0		Boomer		12KHz	
204	00:59:59	BC 1	4254.62324	N	6418.27381	W	T0068.04	T0124.42	149	144.15T	5.2	4	1800	6000	210	1	0	Sparker			12KHz	
204	01:14:59	BC 1	4253.52951	N	6417.46734	W	T0068.04	T0124.42	151	144.97T	4.9	3.9	1800	7000	210	1	0	Sparker			12KHz	
204	01:29:59	BC 1	4252.4316	N	6417.73642	W	T0068.04	T0124.42	198	201.00T	4.7	3.9	1800	7000	210	1	0	Sparker			12KHz	
204	01:45:00	BC 1	4251.30202	N	6418.23506	W	T0068.04	T0124.42	198	200.61T	4.8	3.8	1800	7000	210	1	0	Sparker			12KHz	
204	02:00:00	BC 1	4250.16231	N	6418.7227	W	T0068.04	T0124.42	197	199.27T	4.9	3.6	1800	8000	210	1	0	Sparker			12KHz	
204	02:14:59	BC 1	4248.94088	N	6419.22897	W	T0068.04	T0124.42	197	200.62T	5.3	3.9	1800	8000	210	1	0	Sparker			12KHz	
204	02:29:59	BC 1	4247.69684	N	6419.77879	W	T0068.04	T0124.42	200	200.34T	5.2	3.8	1800	8000	210	1	0	Sparker			12KHz	
204	02:44:59	BC 1	4246.46504	N	6420.43242	W	T0068.04	T0124.42	201	200.25T	5.4	4.1	1800	8000	210	1	0	Sparker			12KHz	
204	02:59:59	BC 1	4245.26364	N	6421.09869	W	T0068.04	T0124.42	203	201.63T	5.3	3.9	1800	8000	210	1	0	Sparker			12KHz	
204	03:14:59	BC 1	4244.01839	N	6421.82475	W	T0068.04	T0124.42	202	199.06T	5.5	4	1800	8000	210	1	0	Sparker			12KHz	
204	03:29:59	BC 1	4242.84829	N	6422.6346	W	T0068.04	T0124.42	213	209.70T	5.2	4	1800	8000	210	1	0	Sparker			12KHz	
204	03:45:00	BC 1	4241.7379	N	6423.50976	W	T0068.04	T0124.42	212	206.23T	5.4	4.2	1800	8000	210	1	0	Sparker			12KHz	
204	03:59:59	BC 1	4240.66332	N	6424.35357	W	T0068.04	T0124.42	212	206.98T	4.9	4	1800	8000	210	1	0	Sparker			12KHz	
204	04:14:59	BC 1	4239.61646	N	6425.1489	W	T0068.04	T0124.42	211	209.33T	4.7	3.9	1800	8000	210	1	0	Sparker			12KHz	
204	04:20:50	BC 1	4239.20651	N	6425.4567	W	T0068.04	T0124.42	207	204.67T	4.9	4	1800	8000	210	1	0	Sparker			12KHz	Huntec delay A status changed to 600ms
204	04:25:25	BC 1	4238.88508	N	6425.70109	W	T0068.04	T0124.42	208	204.83T	4.8	3.9	1800	8000	210	1	0	Sparker			12KHz	Shutdown airgun 1
204	04:29:59	BC 1	4238.56858	N	6425.97058	W	T0083.07	T0151.92	212	209.27T	5	3.9	1800	8000	210	1	0	Sparker			12KHz	
204	04:31:15	BC 1	4238.47826	N	6426.04552	W	T0085.46	T0156.29	210	210.04T	4.9	4.1	1800	8000	210	1	0	Sparker			12KHz	WD Met and WD Fath have been wrong since the huntec was deployed @22:38:27
204	04:38:35	BC 1	4237.96058	N	6426.47062	W	T0099.32	T0181.64	211	211.46T	4.9	4	1800	8000	210	1	0	Sparker			12KHz	Phase changed to 150-250/ Gain changed to 26dB
204	04:44:59	BC 1	4237.5148	N	6426.83564	W	T0110.92	T0202.84	211	210.35T	4.9	4	1800	8000	210	1	0	Sparker			12KHz	
204	04:51:56	BC 1	4237.04022	N	6427.22271	W	T0123.75	T0226.32	213	211.30T	4.7	3.9	1800	8000	210	1	0	Sparker			12KHz	phase change to 200-300
204	04:59:59	BC 1	4236.48701	N	6427.71483	W	T0125.48	T0229.48	214	212.44T	4.9	4.2	1800	8000	210	1	0	Sparker			12KHz	
204	05:12:41	BC 1	4235.58705	N	6428.44659	W	T0000.00	T0000.00	208	208.29T	4.8	3.9	1800	8000	210	1	0	Sparker			12KHz	Compresser back on/ redused fire rate to 9000ms
204	05:14:59	BC 1	4235.42705	N	6428.57479	W	T0121.16	T0221.59	211	211.02T	4.7	3.8	1800	8000	210	1	0	Sparker			12KHz	
204	05:29:59	BC 1	4234.35574	N	6429.25447	W	T0130.79	T0239.19	202	199.13T	4.7	4.3	1800	8000	210	1	0	Sparker			12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
204	05:37:42	BC 1	4233.81283	N	6429.56626	W	T0137.46	T0251.38	200	197.82T	4.6	4.1	1800	8000	210	1	0	Sparker			12KHz	oil seel is gone in the compresser shuting down gun
204	05:44:59	BC 1	4233.27826	N	6429.84686	W	T0146.09	T0267.17	203	202.81T	4.7	4	1800	8000	210	1	0	Sparker			12KHz	
204	05:48:25	BC 1	4233.02337	N	6429.98092	W	T0149.28	T0273.01	203	203.17T	4.8	4.2	1800	8000	210	1	0	Sparker			12KHz	Airgun 1 trigger disabled - FFIDs 1709 to 1777 are blank (compressor shut down)/ Phase change 250-350
204	05:57:04	BC 1	4232.38727	N	6430.31872	W	T0191.51	T0350.22	202	201.24T	4.9	4.1	1800	8000	210	1	0	Sparker			12KHz	Phase change 300-400; SOL
204	05:59:59	BC 1	4232.17635	N	6430.4334	W	T0202.49	T0370.32	200	199.74T	4.6	3.9	1800	8000	210	1	0	Sparker			12KHz	
204	06:01:19	BC 1	4232.08076	N	6430.48109	W	T0211.05	T0385.96	199	197.99T	4.6	3.9	1800	8000	210	1	0	Sparker			12KHz	Phase change 350-450
204	06:04:38	BC 1	4231.83439	N	6430.60893	W	T0245.62	T0449.19	202	199.35T	4.9	4.2	1800	8000	210	1	0	Sparker			12KHz	phase change 400-500
204	06:07:51	BC 1	4231.57629	N	6430.71403	W	T0272.70	T0498.71	196	193.88T	5	4.2	1800	8000	210	1	0	Sparker			12KHz	phase change 450-550
204	06:10:44	BC 1	4231.35141	N	6430.81339	W	T0297.83	T0544.68	199	196.46T	4.9	4.2	1800	8000	210	1	0	Sparker			12KHz	phase change 500-600
204	06:13:43	BC 1	4231.12023	N	6430.9123	W	T0000.00	T0000.00	194	188.22T	4.8	4.2	1800	8000	210	1	0	Sparker			12KHz	phase change 600-700
204	06:14:59	BC 1	4231.02027	N	6430.94447	W	T0373.09	T0682.31	193	187.72T	4.9	4.3	1800	8000	210	1	0	Sparker			12KHz	
204	06:16:17	BC 1	4230.91672	N	6430.97814	W	T0381.39	T0697.48	194	189.01T	4.9	4.3	1800	8000	210	1	0	Sparker			12KHz	phase change 650-750
204	06:20:22	BC 1	4230.59688	N	6431.09118	W	T0370.83	T0678.18	195	190.42T	4.8	4.2	1800	8000	210	1	0	Sparker			12KHz	Phase change back to 600-700
204	06:22:54	BC 1	4230.39889	N	6431.16724	W	T0389.02	T0711.44	198	192.62T	4.9	4.3	1800	8000	210	1	0	Sparker			12KHz	phase change 650-750
204	06:27:28	BC 1	4230.0419	N	6431.30822	W	T0478.72	T0875.48	198	192.14T	4.9	4.3	1800	8000	210	1	0	Sparker			12KHz	phase change 850-950/power change 4/ gain value 30dB
204	06:29:59	BC 1	4229.84544	N	6431.3887	W	T0000.00	T0000.00	196	189.59T	5	4.3	1800	8000	210	1	0	Sparker			12KHz	
204	06:30:53	BC 1	4229.77427	N	6431.4179	W	T0489.21	T0894.66	198	191.41T	4.9	4.5	1800	8000	210	1	0	Sparker			12KHz	huntec decrease fire to 1500 ms
204	06:37:43	BC 1	4229.26538	N	6431.62576	W	T0462.66	T0846.12	194	188.24T	4.6	4.1	1800	8000	210	1	0	Sparker			12KHz	phase change 800-900/ gain value changed to 40dB
204	06:44:59	BC 1	4228.74112	N	6431.80842	W	T0468.24	T0856.33	194	189.65T	4.3	3.8	1800	8000	210	1	0	Sparker			12KHz	
204	06:50:40	BC 1	4228.34582	N	6431.95	W	T0514.08	T0940.15	193	188.50T	4.4	4	1800	8000	210	1	0	Sparker			12KHz	phase change 850-950
204	06:52:50	BC 1	4228.18928	N	6431.99662	W	T0567.32	T1037.52	193	190.08T	4.5	3.9	1800	8000	210	1	0	Sparker			12KHz	phase change 1000-1100
204	06:58:29	BC 1	4227.77733	N	6432.13051	W	T0709.20	T1296.98	192	188.99T	4.6	4	1800	8000	210	1	0	Sparker			12KHz	phase change 1250-1350
204	06:59:59	BC 1	4227.66543	N	6432.16132	W	T0714.36	T1306.43	193	190.67T	4.6	3.9	1800	8000	210	1	0	Sparker			12KHz	
204	07:06:32	BC 1	4227.18362	N	6432.32547	W	T0732.44	T1339.48	193	185.04T	4.6	3.9	1800	8000	210	1	0	Sparker			12KHz	Phase change 1300-1400
204	07:14:59	BC 1	4226.55878	N	6432.52182	W	T0734.22	T1342.74	193	184.94T	4.5	3.9	1800	8000	210	1	0	Sparker			12KHz	Gain adjusted to 45dB
204	07:29:03	BC 1	4225.53111	N	6432.85485	W	T0680.65	T1244.78	195	185.54T	4.4	4.2	1800	8000	210	1	0	Sparker			12KHz	Phase change 1200-1300m
204	07:29:04	BC 1	4225.52995	N	6432.85505	W	T0680.65	T1244.78	195	185.53T	4.4	4.2	1800	8000	210	1	0	Sparker			12KHz	
204	07:29:59	BC 1	4225.46657	N	6432.87509	W	T0682.70	T1248.53	193	185.36T	4.2	4.1	1800	8000	210	1	0	Sparker			12KHz	
204	07:38:17	BC 1	4224.9247	N	6433.0491	W	T0704.87	T1289.06	195	186.38T	3.9	3.9	1800	8000	210	1	0	Sparker			12KHz	Phase change 1250-1350m
204	07:44:11	BC 1	4224.559	N	6433.1732	W	T0721.74	T1319.92	191	183.60T	3.9	3.8	1800	8000	210	1	0	Sparker			12KHz	Phase change 1300m-1400m
204	07:44:59	BC 1	4224.50766	N	6433.18691	W	T0725.69	T1327.14	191	183.63T	3.9	3.8	1800	8000	210	1	0	Sparker			12KHz	
204	07:54:36	BC 1	4223.89135	N	6433.38782	W	T0758.72	T1387.55	197	187.49T	4.4	4.1	1800	8000	210	1	0	Sparker			12KHz	Phase change 1350-1450m
204	07:56:15	BC 1	4223.77217	N	6433.43209	W	T0000.00	T0000.00	193	183.36T	4.6	4.6	1800	8000	210	1	0	Sparker			12KHz	Phase change 1400-1500m
204	07:58:22	BC 1	4223.61074	N	6433.48242	W	T0818.79	T1497.41	194	185.62T	4.8	4.6	1800	8000	210	1	0	Sparker			12KHz	Phase change 1450-1550m
204	08:00:00	BC 1	4223.48926	N	6433.52757	W	T0823.85	T1506.66	196	187.64T	4.6	4.4	1800	8000	210	1	0	Sparker			12KHz	
204	08:05:30	BC 1	4223.09867	N	6433.64273	W	T0831.92	T1521.42	184	177.18T	4.3	4.1	1800	8000	210	1	0	Sparker			12KHz	Phase change 1500-1600m
204	08:14:02	BC 1	4222.47909	N	6433.71546	W	T0825.23	T1509.18	185	175.29T	4.5	4.2	1800	8000	210	1	0	Sparker			12KHz	Phase change 1450-1550m
204	08:14:59	BC 1	4222.40809	N	6433.7247	W	T0825.24	T1509.19	186	176.07T	4.5	4.2	1800	8000	210	1	0	Sparker			12KHz	
204	08:29:59	BC 1	4221.3071	N	6433.70117	W	T0826.16	T1510.88	176	165.22T	4.3	4.3	1800	8000	210	1	0	Sparker			12KHz	
204	08:36:39	BC 1	4220.82213	N	6433.63557	W	T0834.31	T1525.79	172	160.67T	4.3	4.4	1800	8000	210	1	0	Sparker			12KHz	Phase change 1500-1600m
204	08:43:15	BC 1	4220.35871	N	6433.5192	W	T0862.73	T1577.77	169	159.45T	4.3	4.5	1800	8000	210	1	0	Sparker			12KHz	Phase change 1550-1650m
204	08:44:59	BC 1	4220.23657	N	6433.48878	W	T0877.56	T1604.87	170	161.18T	4.4	4.5	1800	8000	210	1	0	Sparker			12KHz	
204	08:49:41	BC 1	4219.90245	N	6433.42326	W	T0908.17	T1660.87	172	163.66T	4.2	4.5	1800	8000	210	1	0	Sparker			12KHz	Phase change 1650-1750
204	08:50:51	BC 1	4219.82193	N	6433.40725	W	T0906.54	T1657.87	169	159.35T	4.1	4.5	1800	8000	210	1	0	Sparker			12KHz	Phase change 1600-1700
204	08:59:59	BC 1	4219.20919	N	6433.20704	W	T0905.08	T1655.21	163	156.16T	4.1	4.3	1800	8000	210	1	0	Sparker			12KHz	
204	09:05:35	BC 1	4218.8424	N	6433.03713	W	T0910.26	T1664.69	162	156.31T	4.1	4.4	1800	8000	210	1	0	Sparker			12KHz	End of line
204	09:08:25	BC 1	4218.65883	N	6432.96006	W	T0916.75	T1676.56	163	156.95T	4.1	4.3	1800	8000	210	1	0	Sparker			12KHz	Phase change 1650-1750
204	09:10:08	BC 1	4218.54974	N	6432.91149	W	T0919.34	T1681.28	161	155.61T	4	4.3	1800	8000	210	1	0	Sparker			12KHz	EOL
204	09:14:59		4218.23857	N	6432.75167	W	T0929.19	T1699.31	156	152.55T	4.2	4.4									12KHz	
204	09:19:27		4217.93949	N	6432.58725	W	T0936.40	T1712.50	159	156.41T	4.4	4.6									12KHz	Huntec on board
204	09:24:41		4217.5799	N	6432.39496	W	T0946.35	T1730.68	155	153.67T	4.4	4.5									12KHz	Phase change 1700-1800m

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
204	09:29:59		4217.21746	N	6432.16966	W	T0966.51	T1767.55	149	147.05T	4.6	4.6									12KHz	
204	09:35:25		4216.84263	N	6431.92133	W	T0979.34	T1791.02	154	149.33T	4.7	4.5									12KHz	Phase change 1750-1850m
204	09:44:05		4216.23032	N	6431.51439	W	T1002.14	T1832.71	154	149.30T	4.6	4.7									12KHz	Phase change 1800-1900
204	09:44:59		4216.16757	N	6431.47153	W	T1008.96	T1845.18	152	147.93T	4.7	4.9									12KHz	
204	09:59:59		4215.08718	N	6430.77745	W	T1020.52	T1866.33	156	150.99T	4.9	4.6									12KHz	
204	10:09:03		4214.4115	N	6430.33717	W	T1027.70	T1879.45	159	154.35T	5.1	4.8									12KHz	Phase change 1850-1950
204	10:14:59		4213.96464	N	6430.04383	W	T1034.62	T1892.11	153	149.48T	5.1	5.2									12KHz	
204	10:16:36		4213.81692	N	6429.88794	W	T1038.43	T1899.09	128	118.57T	8.5	8.4								3.5KHz	12KHz	All gear recovered
204	10:27:03		4213.31587	N	6427.24585	W	T1061.82	T1941.86	107	104.74T	12.1	11.6								3.5KHz	12KHz	Phase change 1900-2000m
204	10:29:59		4213.17067	N	6426.47667	W	T1054.90	T1929.19	105	103.07T	12	11.8								3.5KHz	12KHz	
204	10:44:59		4212.4775	N	6422.87546	W	T1074.48	T1965.02	106	102.18T	4.6	4.9								3.5KHz	12KHz	
204	10:49:23		4212.41592	N	6422.59877	W	T1078.37	T1972.12	109	099.49T	1.9	2.3								3.5KHz	12KHz	Phase change 1950-2050m
204	10:59:59		4212.25832	N	6422.02055	W	T1083.81	T1982.08	106	104.23T	10.3	10								3.5KHz	12KHz	
204	11:14:59		4211.55632	N	6418.05719	W	T0000.00	T0000.00	102	101.26T	12.5	11.7								3.5KHz	12KHz	
204	11:29:59		4210.87992	N	6413.89875	W	T1126.19	T2059.57	104	103.73T	12.8	11.5								3.5KHz	12KHz	
204	11:44:59		4210.08068	N	6409.70859	W	T1109.15	T2028.42	105	099.74T	12.7	11.8								3.5KHz	12KHz	phase change made to 2000-2100
204	11:59:59		4209.22652	N	6405.58839	W	T1124.67	T2056.80	107	102.11T	12.6	11.1								3.5KHz	12KHz	
204	12:14:59		4208.49395	N	6401.43176	W	T1130.89	T2068.17	102	097.30T	12.7	11.7								3.5KHz	12KHz	phase change at the start of the new time sectino to 2050-2150
204	12:27:16		4207.96984	N	6357.96688	W	T1162.16	T2125.35	101	097.19T	13	12.1								3.5KHz	12KHz	phase shift 2100-2200
204	12:29:59		4207.86656	N	6357.19208	W	T1163.92	T2128.58	101	099.65T	12.9	12								3.5KHz	12KHz	
204	12:32:30		4207.76343	N	6356.48018	W	T1187.75	T2172.16	102	100.21T	12.9	12.1								3.5KHz	12KHz	phase shift 2150-2250
204	12:44:59		4207.33914	N	6352.96813	W	T1227.84	T2245.47	99	099.29T	12.6	12.2								3.5KHz	12KHz	
204	12:59:59		4206.87224	N	6348.67524	W	T1256.45	T2297.79	97	098.03T	13.1	11.9								3.5KHz	12KHz	
204	13:14:59		4206.62345	N	6344.62033	W	T1256.07	T2297.10	84	088.34T	5.9	5								3.5KHz	12KHz	
204	13:29:59		4206.62126	N	6344.48289	W	T1258.55	T2301.64	275	259.83T	0.6	1.5								3.5KHz	12KHz	
204	13:44:59		4206.61665	N	6344.52033	W	T1257.99	T2300.61	169	216.02T	0.3	1								3.5KHz	12KHz	
204	13:59:59		4206.66369	N	6344.55454	W	T1255.85	T2296.70	346	281.69T	0.6	1.1								3.5KHz	12KHz	
204	14:14:59		4206.64869	N	6344.47973	W	T1256.26	T2297.45	143	238.60T	0.2	1.2								3.5KHz	12KHz	
204	14:29:59		4206.60224	N	6344.50971	W	T1257.08	T2298.94	208	255.69T	0.1	1.1								3.5KHz	12KHz	
204	14:44:59		4206.613	N	6344.50497	W	T1257.09	T2298.97	40	277.60T	0.2	1.1								3.5KHz	12KHz	
204	14:59:59		4206.55859	N	6344.40719	W	T1257.54	T2299.79	143	243.17T	0.6	0.7								3.5KHz	12KHz	0002 core
204	15:14:45		4206.36011	N	6344.16011	W	T1260.20	T2304.66	134	169.81T	1.5	1								3.5KHz	12KHz	0002 PC deployed
204	15:14:59		4206.35607	N	6344.15494	W	T1260.22	T2304.68	136	171.78T	1.4	0.9								3.5KHz	12KHz	
204	15:29:59		4206.3782	N	6344.23558	W	T1259.47	T2303.33	312	292.15T	0.5	1.1								3.5KHz	12KHz	
204	15:44:59		4206.50207	N	6344.38692	W	T1258.35	T2301.28	326	302.04T	0.6	1.3								3.5KHz	12KHz	
204	15:59:59		4206.58374	N	6344.48508	W	T1257.39	T2299.51	335	295.55T	0.3	0.9								3.5KHz	12KHz	
204	16:14:59		4206.5965	N	6344.52072	W	T1257.78	T2300.23	327	292.53T	0.1	0.8								3.5KHz	12KHz	
204	16:23:15		4206.59648	N	6344.53147	W	T1258.32	T2301.22	193	296.13T	0.1	0.7								3.5KHz	12KHz	0002 PC @bottom
204	16:29:59		4206.59761	N	6344.52455	W	T1259.19	T2302.80	27	283.22T	0.1	0.6								3.5KHz	12KHz	
204	16:44:59		4206.59725	N	6344.52495	W	T1257.53	T2299.76	199	285.26T	0.2	0.5								3.5KHz	12KHz	
204	16:59:59		4206.60031	N	6344.52135	W	T1257.14	T2299.05	96	282.38T	0.1	0.6								3.5KHz	12KHz	
204	17:14:59		4206.59547	N	6344.50553	W	T1257.72	T2300.13	200	274.29T	0.2	0.4								3.5KHz	12KHz	
204	17:22:31		4206.61882	N	6344.47164	W	T1257.07	T2298.92	45	332.21T	0.7	1.2								3.5KHz	12KHz	0002 PC Return to surface
204	17:30:00		4206.71504	N	6344.31856	W	T1256.21	T2297.36	54	013.00T	1.4	0.7								3.5KHz	12KHz	
204	17:45:00		4206.88388	N	6343.95218	W	T1254.73	T2294.65	65	019.70T	1.2	0.7								3.5KHz	12KHz	
204	17:59:59		4207.37816	N	6342.79099	W	T1233.33	T2255.52	62	057.99T	6.2	5.8								3.5KHz	12KHz	
204	18:14:59		4208.3857	N	6340.43001	W	T1228.77	T2247.17	58	056.38T	11.5	10.7								3.5KHz	12KHz	
204	18:22:53		4209.18638	N	6338.64773	W	T1215.01	T2222.01	58	055.99T	11.7	11.2								3.5KHz	12KHz	Phase Change 2200-3300
204	18:25:34		4209.45298	N	6338.04375	W	T1200.18	T2194.89	59	055.31T	11.6	11								3.5KHz	12KHz	Phase change 2150-2250
204	18:29:59		4209.88131	N	6337.05865	W	T1191.55	T2179.11	61	057.23T	11.4	11								3.5KHz	12KHz	
204	18:44:59		4211.3468	N	6333.78642	W	T1192.68	T2181.16	55	052.18T	11.3	11								3.5KHz	12KHz	
204	18:59:59		4211.92254	N	6332.93247	W	T1195.05	T2185.51	279	277.74T	0.5	0.6								3.5KHz	12KHz	
204	19:14:59		4211.91823	N	6333.06153	W	T1191.85	T2179.66	267	280.57T	0.3	0.5								3.5KHz	12KHz	
204	19:29:59		4211.93192	N	6333.03351	W	T1191.77	T2179.50	62	341.37T	0.4	-0.7								3.5KHz	12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
204	19:44:59		4211.9319	N	6333.01835	W	T1191.21	T2178.49	323	279.46T	0.2	0.7								3.5KHz	12KHz	
204	19:49:32		4211.96369	N	6333.0203	W	T1193.14	T2182.01	358	305.65T	0.6	0.5								3.5KHz	12KHz	0003 GC deployed
204	19:59:59		4211.94418	N	6333.02885	W	T1193.78	T2183.19	163	246.74T	0.2	0.8								3.5KHz	12KHz	
204	20:14:59		4211.94189	N	6333.03836	W	T1190.69	T2177.54	169	260.40T	0.2	0.5								3.5KHz	12KHz	
204	20:29:59		4211.93659	N	6333.0438	W	T1190.97	T2178.04	203	279.13T	0.2	0.4								3.5KHz	12KHz	
204	20:41:31		4211.93587	N	6333.04605	W	T1193.57	T2182.81	172	290.08T	0.1	-0.2								3.5KHz	12KHz	GC on bottom
204	20:44:59		4211.93739	N	6333.04512	W	T1191.56	T2179.12	295	276.60T	0.1	0.5								3.5KHz	12KHz	
204	20:59:59		4211.97915	N	6332.99423	W	T1193.18	T2182.09	13	337.15T	0.3	0.6								3.5KHz	12KHz	
204	21:14:59		4212.09801	N	6332.94476	W	T1190.37	T2176.94	341	303.77T	0.3	0.5								3.5KHz	12KHz	
204	21:29:59		4212.23396	N	6332.86453	W	T1189.20	T2174.81	1	306.31T	0.5	0.5								3.5KHz	12KHz	
204	21:39:12		4212.33781	N	6332.78489	W	T1185.35	T2167.76	51	016.50T	1.2	0.8								3.5KHz	12KHz	0003 GC at surface
204	21:44:59		4212.4066	N	6332.63725	W	T1185.15	T2167.40	56	024.50T	1.4	0.9								3.5KHz	12KHz	
204	21:59:23		4212.64017	N	6332.26889	W	T1177.76	T2153.89	35	002.66T	1.4	1.1								3.5KHz	12KHz	Phase change 2100-2200m
204	21:59:59		4212.65128	N	6332.25844	W	T1176.31	T2151.24	35	000.16T	1.3	0.9								3.5KHz	12KHz	
204	22:14:59		4212.88284	N	6331.96714	W	T1173.02	T2145.22	58	016.44T	1.2	0.7								3.5KHz	12KHz	
204	22:29:59		4212.90007	N	6331.71229	W	T1175.53	T2149.80	93	016.28T	0.7	0.3								3.5KHz	12KHz	
204	22:44:59		4212.92063	N	6331.49507	W	T1178.31	T2154.90	89	015.39T	0.6	0.2								3.5KHz	12KHz	
204	22:59:59		4212.88351	N	6331.32998	W	T1177.38	T2153.19	97	324.85T	0.3	0.2								3.5KHz	12KHz	
204	23:14:59		4212.64175	N	6331.56497	W	T1178.50	T2155.24	235	272.34T	1.1	1.2								3.5KHz	12KHz	
204	23:29:59		4212.56568	N	6332.07601	W	T1177.56	T2153.53	207	226.32T	2.2	2	1650	5000	210	1	0	Sparker			12KHz	
204	23:30:06		4212.56199	N	6332.07883	W	T1177.72	T2153.82	208	226.53T	2.2	2	1650	5000	210	1	0	Sparker			12KHz	huntec in the watyer at 23:29:18
204	23:44:59		4212.21459	N	6332.5394	W	T1188.52	T2173.56	236	249.45T	2.2	2.5	1650	5000	210	1	0	Sparker			12KHz	
204	23:59:48		4211.85367	N	6333.29714	W	T1189.33	T2175.05	240	248.40T	2.8	2.8	1650	5000	210	1	0	Sparker			12KHz	phase change to 2150-2250
205	00:00:00		4211.84875	N	6333.30843	W	T1189.42	T2175.20	240	247.56T	2.9	2.8	1650	5000	210	1	0	Sparker			12KHz	
205	00:06:01	ok-6	4211.67456	N	6333.62864	W	T1190.29	T2176.81	242	252.89T	3.3	3.3	1650	5000	210	1	0	Sparker			12KHz	coming on to line - speedig up to 4. 5 knots, SOL
205	00:06:46	ok-6	4211.65843	N	6333.68257	W	T1189.70	T2175.73	249	255.98T	3.5	3.4	1650	5000	210	1	0	Sparker			12KHz	air gun rep fire rate -> 1000 ms
205	00:14:59	ok-6	4211.27049	N	6334.28958	W	T1188.81	T2174.09	237	246.91T	4.2	4.2	1650	5000	210	1	0	Sparker			12KHz	
205	00:17:08	ok-6	4211.19344	N	6334.46047	W	T1188.60	T2173.71	233	237.73T	4.2	4.3	1650	5000	210	1	0	Sparker			12KHz	12 khz switched off for testing reasons
205	00:29:59	ok-6	4210.6949	N	6335.55775	W	T1188.60	T2173.71	246	252.93T	4.5	4.3	1650	5000	210	1	0	Sparker			12KHz	
205	00:44:59	ok-6	4210.09859	N	6336.89456	W	T1188.60	T2173.71	236	245.11T	4.7	4.5	1650	5000	210	1	0	Sparker			12KHz	
205	00:59:59	ok-6	4209.4856	N	6338.15675	W	T1188.60	T2173.71	235	249.45T	4.2	4.1	1650	5000	210	1	0	Sparker			12KHz	BRIDGE turned off depth sounder that was interfering with the huntec at 00:47 am
205	01:14:59	ok-6	4208.90027	N	6339.40021	W	T1221.54	T2233.96	239	255.70T	4.6	4.4	1650	5000	210	1	0	Sparker			12KHz	
205	01:29:59	ok-6	4208.27227	N	6340.74313	W	T1229.29	T2248.12	241	258.48T	4.8	4.5	1650	5000	210	1	0	Sparker			12KHz	
205	01:39:13	ok-6	4207.88362	N	6341.59206	W	T1233.54	T2255.89	238	252.51T	4.8	4.3	1650	10000	210	1	0	Sparker			12KHz	both air guns are working again. in the log book. I recorded the gun size as 105 since only 1 of the 2 guns were working. this was not changed on the digital general log.

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-12 khz sounder was swithced back on

- forgc 000 on digital log- had been updated on paper

205	01:40:34	ok-6	4207.82561	N	6341.71617	W	T1233.53	T2255.89	237	250.63T	4.9	4.3	1650	10000	210	1	0	Sparker			12KHz	phase shift of the the 12kHz sounder to 2250-2350
205	01:45:00	ok-6	4207.63086	N	6342.12653	W	T1231.43	T2252.04	242	254.64T	4.8	4.2	1650	10000	210	1	0	Sparker			12KHz	
205	02:00:00	ok-6	4206.91913	N	6343.62436	W	T1253.81	T2292.98	239	251.53T	5.7	4.9	1650	10000	210	1	0	Sparker			12KHz	
205	02:14:59	ok-6	4206.22164	N	6345.04768	W	T1258.95	T2302.37	239	251.39T	4.8	3.7	1650	10000	210	1	0	Sparker			12KHz	
205	02:23:13	ok-6	4205.90422	N	6345.75234	W	T1261.46	T2306.95	242	251.57T	4.3	3.3	1650	10000	210	1	0	Sparker			12KHz	des had to cycle the geometrics software because the geo eel is not responding
205	02:29:59	ok-6	4205.63356	N	6346.33241	W	T1263.13	T2310.02	240	247.68T	4.4	3.2	1650	10000	210	1	0	Sparker			12KHz	
205	02:44:59	ok-6	4205.02983	N	6347.61683	W	T1272.53	T2327.20	234	237.06T	4.6	3.2	1650	10000	210	1	0	Sparker			12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pres-sure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
205	02:48:24	ok-6	4204.89088	N	6347.90081	W	T1276.29	T2334.08	237	240.85T	4.4	3.2	1650	10000	210	1	0	Sparker			12KHz	SPSU redtart - CNT crash
205	02:49:56	ok-6	4204.8338	N	6348.03357	W	T1277.17	T2335.69	242	243.70T	4.5	3.3	1650	10000	210	1	0	Sparker			12KHz	phase change of sounder to 2300-2400
205	02:59:59	ok-6	4204.41372	N	6348.86698	W	T1281.18	T2343.01	236	237.61T	4.5	3.5	1650	10000	210	1	0	Sparker			12KHz	
205	03:14:59	ok-6	4203.83611	N	6350.14626	W	T1288.20	T2355.86	243	241.10T	4.4	3.2	1650	10000	210	1	0	Sparker			12KHz	
205	03:29:59	ok-6	4203.29066	N	6351.45307	W	T1287.86	T2355.24	241	236.17T	4.2	3	1650	10000	210	1	0	Sparker			12KHz	
205	03:44:59	ok-6	4202.73885	N	6352.76257	W	T1296.57	T2371.16	241	236.93T	4.5	3.5	1650	10000	210	1	0	Sparker			12KHz	
205	03:52:34	ok-6	4202.47075	N	6353.43393	W	T1297.14	T2372.22	238	229.95T	4.7	3.5	1650	10000	210	1	0	Sparker			12KHz	Phase change 2350-2450
205	03:59:59	ok-6	4202.16761	N	6354.04818	W	T1302.32	T2381.69	238	231.01T	4.4	3.3	1650	10000	210	1	0	Sparker			12KHz	
205	04:14:59	ok-6	4201.60118	N	6355.2572	W	T1309.71	T2395.20	238	232.40T	4.1	3.4	1650	10000	210	1	0	Sparker			12KHz	
205	04:29:59	ok-6	4201.01292	N	6356.45629	W	T1319.42	T2412.95	236	227.65T	4.3	3.7	1650	10000	210	1	0	Sparker			12KHz	
205	04:39:05	ok-6	4200.60979	N	6357.19701	W	T1327.34	T2427.43	236	230.27T	4.5	3.9	1650	10000	210	1	0	Sparker			12KHz	Phase change 2400-2500
205	04:44:59	ok-6	4200.35311	N	6357.6742	W	T1329.61	T2431.59	232	226.39T	4.5	3.9	1650	10000	210	1	0	Sparker			12KHz	
205	04:59:59	ok-6	4159.73839	N	6358.92302	W	T1345.95	T2461.47	235	231.20T	4.5	4.3	1650	10000	210	1	0	Sparker			12KHz	
205	05:08:20	ok-6	4159.39254	N	6359.61245	W	T1343.96	T2457.83	240	232.88T	4.4	4.6	1650	10000	210	1	0	Sparker			12KHz	Huntec decrease delay to 500ms
205	05:14:59	ok-6	4159.12588	N	6400.16147	W	T1340.03	T2450.65	238	232.96T	4.4	4.8	1650	10000	210	1	0	Sparker			12KHz	
205	05:29:59	ok-6	4158.52771	N	6401.43425	W	T1323.80	T2420.97	243	235.09T	4.5	4.7	1650	10000	210	1	0	Sparker			12KHz	
205	05:44:59	ok-6	4157.93247	N	6402.71063	W	T1339.57	T2449.80	237	232.51T	4.4	4.5	1650	10000	210	1	0	Sparker			12KHz	
205	05:47:24	ok-6	4157.83541	N	6402.92011	W	T1332.43	T2436.74	238	232.37T	4.6	4.7	1650	10000	210	1	0	Sparker			12KHz	chaging airgun fire rate to 10.5 sec
205	05:49:47	ok-6	4157.73494	N	6403.11976	W	T1329.64	T2431.65	234	228.75T	4.5	4.6	1650	10000	210	1	0	Sparker			12KHz	Changing Huntec fire rate 2100 ms
205	06:00:00	ok-6	4157.29493	N	6403.96467	W	T1351.97	T2472.49	235	231.75T	4.4	4.5	1650	10000	210	1	0	Sparker			12KHz	
205	06:05:34	ok-6	4157.05948	N	6404.43468	W	T1355.72	T2479.34	236	231.88T	4.7	4.6	1650	10000	210	1	0	Sparker			12KHz	Phase change 2450-3550
205	06:14:59	ok-6	4156.68228	N	6405.22424	W	T1358.01	T2483.53	235	230.68T	4.6	4.5	1650	10000	210	1	0	Sparker			12KHz	
205	06:29:59	ok-6	4156.07369	N	6406.48509	W	T1364.42	T2495.26	237	233.04T	4.6	4.6	1650	10000	210	1	0	Sparker			12KHz	
205	06:39:56	ok-6	4155.68603	N	6407.34072	W	T1381.73	T2526.91	234	230.36T	4.4	4.3	1650	10000	210	1	0	Sparker			12KHz	Phase change 2500-2600
205	06:44:59	ok-6	4155.49319	N	6407.75999	W	T1370.55	T2506.47	237	232.45T	4.5	4.5	1650	10000	210	1	0	Sparker			12KHz	
205	07:00:00	ok-6	4154.89062	N	6409.04883	W	T1375.91	T2516.27	238	233.61T	4.6	4.6	1650	10000	210	1	0	Sparker			12KHz	
205	07:14:59	ok-6	4154.26927	N	6410.32879	W	T1390.49	T2542.93	234	230.39T	4.5	4.2	1650	10000	210	1	0	Sparker			12KHz	
205	07:27:01	ok-6	4153.7632	N	6411.33669	W	T1406.43	T2572.09	236	232.68T	4.6	4.3	1650	10000	210	1	0	Sparker			12KHz	Phase change 2550-2650m
205	07:29:59	ok-6	4153.63419	N	6411.58453	W	T1413.97	T2585.86	235	232.29T	4.5	4.3	1650	10000	210	1	0	Sparker			12KHz	
205	07:44:59	ok-6	4153.02139	N	6412.85626	W	T1411.27	T2580.93	237	231.52T	4.5	4.2	1650	10000	210	1	0	Sparker			12KHz	
205	07:49:37	ok-6	4152.84453	N	6413.25494	W	T1416.13	T2589.81	240	232.12T	4.5	4.2	1650	10000	210	1	0	Sparker			12KHz	Phase change 2500-2600m
205	07:58:31	ok-6	4152.49825	N	6414.02362	W	T1413.31	T2584.67	242	233.86T	4.5	4.3	1650	10000	210	1	0	Sparker			12KHz	Phase change 2550-2650m
205	07:59:59	ok-6	4152.44488	N	6414.15447	W	T1414.20	T2586.28	240	232.35T	4.6	4.3	1650	10000	210	1	0	Sparker			12KHz	
205	08:08:19	ok-6	4152.12735	N	6414.86948	W	T1416.16	T2589.88	236	229.36T	4.4	4.3	1650	10500	210	1	0	Sparker			12KHz	Note: The firing rate was not updated in the E-Log - but there is an entry of when it was changed (See log entry at 05:47). Now updating the value in the E-log.
205	08:14:59	ok-6	4151.86015	N	6415.43255	W	T1429.10	T2613.53	239	231.62T	4.5	4.3	1650	10500	210	1	0	Sparker			12KHz	
205	08:29:59	ok-6	4151.23972	N	6416.6935	W	T1433.20	T2621.03	232	228.51T	4.5	4.3	1650	10500	210	1	0	Sparker			12KHz	
205	08:39:22	ok-6	4150.83687	N	6417.46995	W	T1445.01	T2642.64	234	230.70T	4.6	4.3	1650	10500	210	1	0	Sparker			12KHz	Phase change 2600-2700m
205	08:44:59	ok-6	4150.59069	N	6417.93974	W	T1445.74	T2643.97	234	231.07T	4.6	4.4	1650	10500	210	1	0	Sparker			12KHz	
205	08:59:59	ok-6	4149.92837	N	6419.15033	W	T1445.94	T2644.34	238	235.04T	4.4	4.5	1650	10500	210	1	0	Sparker			12KHz	
205	09:00:09	ok-6	4149.92161	N	6419.16395	W	T1445.74	T2643.97	237	234.82T	4.4	4.5	1650	10500	210	1	0	Sparker			12KHz	EOL
205	09:14:59		4149.34151	N	6420.34304	W	T1451.74	T2654.95	235	235.15T	4.4	4.6									12KHz	
205	09:15:23		4149.32491	N	6420.37584	W	T1450.52	T2652.72	236	235.61T	4.4	4.5									12KHz	Huntec retreived
205	09:29:59		4148.70401	N	6421.61986	W	T1469.40	T2687.24	232	233.07T	4.7	4.9									12KHz	
205	09:33:37		4148.53823	N	6421.93681	W	T1462.52	T2674.65	236	236.31T	4.8	4.9								3.5KHz	12KHz	3.5KHz turned on
205	09:44:59		4148.00198	N	6422.94979	W	T1469.26	T2686.98	235	235.07T	4.9	5								3.5KHz	12KHz	
205	10:00:00		4149.28903	N	6421.12377	W	T1455.88	T2662.52	56	053.61T	5.5	5								3.5KHz	12KHz	
205	10:14:59		4150.10185	N	6419.47181	W	T1441.12	T2635.53	58	054.09T	6	5.6								3.5KHz	12KHz	
205	10:29:59		4150.94568	N	6417.84505	W	T1443.73	T2640.30	54	054.42T	5.6	5.4								3.5KHz	12KHz	
205	10:44:59		4151.8195	N	6416.1969	W	T1420.02	T2596.93	56	055.29T	9.7	9.4								3.5KHz	12KHz	
205	10:45:55		4151.91504	N	6416.01058	W	T1417.85	T2592.96	55	054.33T	11.2	10.9								3.5KHz	12KHz	Phase change 2550-2650m
205	10:57:51		4153.11189	N	6413.73929	W	T1395.69	T2552.43	55	055.32T	9.4	9								3.5KHz	12KHz	Phase change 2500-2600m
205	10:59:59		4153.3538	N	6413.24191	W	T1397.70	T2556.12	57	055.84T	13.5	13								3.5KHz	12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
205	11:11:15		4154.78869	N	6410.33123	W	T1381.82	T2527.08	56	053.81T	14	13.4								3.5KHz	12KHz	Testing CNT interface - unresponsive. Error said to cycle SPSU. SPSU turned off and turned on again.
205	11:14:59		4155.07412	N	6409.70405	W	T1372.67	T2510.33	74	068.30T	5.3	4.8								3.5KHz	12KHz	
205	11:29:59		4155.4322	N	6409.59418	W	T1367.28	T2500.48	357	308.18T	0.4	0.7								3.5KHz	12KHz	
205	11:44:59		4155.50107	N	6409.55063	W	T1366.97	T2499.91	63	297.24T	0.3	0.5								3.5KHz	12KHz	
205	11:46:59		4155.50473	N	6409.5397	W	T1366.06	T2498.25	68	291.68T	0.3	0.4								3.5KHz	12KHz	0004 PC in water
205	11:59:59		4155.41118	N	6409.58867	W	T1367.82	T2501.46	237	258.42T	0.6	1.1								3.5KHz	12KHz	
205	12:14:59		4155.44332	N	6409.63479	W	T1367.47	T2500.84	242	276.52T	0.1	0.9								3.5KHz	12KHz	
205	12:30:00		4155.44265	N	6409.64772	W	T1367.71	T2501.26	226	278.10T	0.1	0.8								3.5KHz	12KHz	
205	12:39:26		4155.43973	N	6409.64568	W	T1367.66	T2501.18	355	294.12T	0.1	0.7								3.5KHz	12KHz	0004 PC core on bottom
205	12:44:59		4155.45626	N	6409.65788	W	T1366.87	T2499.73	326	293.68T	0.2	0.9								3.5KHz	12KHz	
205	12:59:59		4155.49228	N	6409.64928	W	T1366.65	T2499.32	73	320.04T	0.3	0.5								3.5KHz	12KHz	
205	13:14:59		4155.46129	N	6409.61105	W	T1366.85	T2499.70	250	297.24T	0.2	0.8								3.5KHz	12KHz	
205	13:29:59		4155.48621	N	6409.55955	W	T1366.33	T2498.74	75	324.63T	0.1	0.8								3.5KHz	12KHz	
205	13:41:45		4155.48649	N	6409.56237	W	T1365.97	T2498.09	252	305.13T	0.1	0.6								3.5KHz	12KHz	0004 PC at surface
205	13:44:59		4155.4794	N	6409.56962	W	T1366.00	T2498.14	208	301.74T	0.2	0.6								3.5KHz	12KHz	
205	13:59:59		4155.39977	N	6409.52346	W	T1369.38	T2504.31	139	314.43T	0.6	-0.4								3.5KHz	12KHz	
205	14:14:59		4155.73786	N	6408.39152	W	T1364.71	T2495.79	201	212.95T	5.1	4.7								3.5KHz	12KHz	
205	14:29:59		4154.56662	N	6410.89066	W	T1386.88	T2536.32	244	252.03T	4.3	4.4								3.5KHz	12KHz	
205	14:44:59		4153.58218	N	6412.03009	W	T0000.00	T0000.00	220	226.20T	5	4.6								3.5KHz	12KHz	
205	14:59:59		4153.05037	N	6412.69717	W	T0000.00	T0000.00	265	296.20T	0.9	0.9								3.5KHz	12KHz	
205	15:14:58		4153.04809	N	6412.8227	W	T1413.16	T2584.39	159	347.98T	0.1	0.6								3.5KHz	12KHz	3.5KHz gain value 40dB/ phase 2550-2650 12KHz gain value 45dB/ phase 2550-2650
205	15:14:59		4153.04811	N	6412.82268	W	T1413.16	T2584.39	158	348.19T	0.1	0.6								3.5KHz	12KHz	
205	15:29:59		4153.06944	N	6412.74127	W	T1413.16	T2584.38	243	352.37T	0.1	0.5								3.5KHz	12KHz	
205	15:37:43		4153.06401	N	6412.75168	W	T1410.54	T2579.59	267	347.25T	0.2	0.7								3.5KHz	12KHz	3.5 KHz gain adjusted to 30dB
205	15:44:59		4153.06961	N	6412.75896	W	T1410.71	T2579.91	256	355.55T	0.1	0.6								3.5KHz	12KHz	
205	15:59:59		4153.08157	N	6412.75273	W	T1410.35	T2579.24	308	351.45T	0.3	0.5								3.5KHz	12KHz	
205	16:14:59		4153.07948	N	6412.73642	W	T1410.10	T2578.79	78	057.61T	0.3	0.6								3.5KHz	12KHz	
205	16:20:35		4153.05222	N	6412.7339	W	T1410.33	T2579.22	160	082.43T	0.3	0.5								3.5KHz	12KHz	0005PC in water
205	16:29:59		4153.05931	N	6412.75104	W	T1410.41	T2579.36	337	030.72T	0.2	0.4								3.5KHz	12KHz	
205	16:44:59		4153.06777	N	6412.76306	W	T1410.50	T2579.52	324	037.67T	0.1	0.6								3.5KHz	12KHz	
205	16:59:59		4153.07289	N	6412.79518	W	T1410.89	T2580.23	210	057.50T	0.2	-0.1								3.5KHz	12KHz	
205	17:14:23		4153.07763	N	6412.77244	W	T1410.26	T2579.08	202	096.72T	0.2	0.5								3.5KHz	12KHz	0005PC @ bottom
205	17:14:59		4153.07596	N	6412.77389	W	T1410.50	T2579.52	210	104.73T	0.2	0.4								3.5KHz	12KHz	
205	17:29:59		4153.04496	N	6412.85786	W	T1411.08	T2580.59	262	123.79T	0.4	0.2								3.5KHz	12KHz	
205	17:44:59		4153.04256	N	6412.88433	W	T1411.64	T2581.60	64	085.02T	0.6	0.9								3.5KHz	12KHz	
205	17:59:59		4153.06688	N	6412.77151	W	T1410.52	T2579.56	81	095.94T	0.1	0.4								3.5KHz	12KHz	
205	18:14:59		4153.066	N	6412.82109	W	T1411.47	T2581.30	280	133.15T	0.3	0								3.5KHz	12KHz	
205	18:20:53		4153.07764	N	6412.8671	W	T1415.43	T2588.53	295	154.55T	0.4	0.1								3.5KHz	12KHz	0005 PC @ surface
205	18:29:59		4153.11884	N	6412.94276	W	T1408.44	T2575.76	318	196.70T	0.5	-0.2								3.5KHz	12KHz	
205	18:44:59		4153.18741	N	6412.97075	W	T1411.12	T2580.65	303	274.42T	0.2	-0.1								3.5KHz	12KHz	
205	18:51:59		4153.20287	N	6412.98069	W	T1402.02	T2564.01	17	261.59T	0.2	0								3.5KHz	12KHz	3.5 KHz gain changed to 35 dB
205	18:59:59		4153.23346	N	6412.98221	W	T1402.15	T2564.25	359	236.37T	0.1	0								3.5KHz	12KHz	
205	19:14:59		4153.25361	N	6412.97055	W	T1403.93	T2567.51	266	277.92T	0.1	0.2								3.5KHz	12KHz	
205	19:29:59		4153.25316	N	6413.01252	W	T1401.82	T2563.65	28	232.47T	0.1	0.1								3.5KHz	12KHz	
205	19:44:59		4153.25346	N	6413.0352	W	T1400.39	T2561.04	233	273.07T	0.1	0.1								3.5KHz	12KHz	
205	19:59:59		4153.23868	N	6413.12633	W	T1405.96	T2571.22	255	273.47T	0.5	0.2								3.5KHz	12KHz	
205	20:10:10		4153.61223	N	6413.15928	W	T1397.57	T2555.88	55	058.56T	9.2	9								3.5KHz	12KHz	Phase change 2500-2600m
205	20:14:59		4153.75903	N	6412.48187	W	T1402.22	T2564.39	157	169.84T	2.9	3								3.5KHz	12KHz	
205	20:29:59		4153.6565	N	6412.56274	W	T1405.67	T2570.69	221	214.38T	1.4	1.5								3.5KHz	12KHz	
205	20:44:59		4153.43526	N	6412.86053	W	T1406.72	T2572.62	278	252.09T	0.4	0.4								3.5KHz	12KHz	
205	20:59:59		4153.44416	N	6412.95942	W	T1401.46	T2562.99	272	285.00T	0.4	0.2								3.5KHz	12KHz	
205	21:14:59		4153.4904	N	6412.95792	W	T1415.39	T2588.46	211	210.74T	2.6	2.8								3.5KHz	12KHz	
205	21:29:59		4153.10691	N	6413.6761	W	T1408.02	T2574.98	236	232.75T	2.1	2.4								3.5KHz	12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
205	21:32:30		4153.05693	N	6413.77433	W	T1401.83	T2563.66	234	226.37T	2.1	2									12KHz	Huntec in water
205	21:41:13	OK-9	4152.88691	N	6414.09718	W	T1401.83	T2563.66	241	230.09T	2.1	2.3									12KHz	SOL
205	21:45:00	OK-9	4152.80461	N	6414.25225	W	T1401.83	T2563.66	227	220.33T	2.6	2.6		10500	210	1	0	Sparker			12KHz	
205	21:56:33	OK-9	4152.28663	N	6414.91636	W	T1401.83	T2563.66	223	215.75T	4.4	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase change 2550-2650m
205	21:59:59	OK-9	4152.1049	N	6415.15495	W	T1401.83	T2563.66	222	215.33T	4.5	4.6	2000	10500	210	1	0	Sparker			12KHz	
205	22:02:03	OK-9	4151.99829	N	6415.3086	W	T1401.83	T2563.66	230	222.93T	4.6	4.5	2000	10500	210	1	0	Sparker			12KHz	Huntec logging
205	22:14:59	OK-9	4151.43081	N	6416.33421	W	T1425.82	T2607.54	231	225.57T	4.4	4.5	2000	10500	210	1	0	Sparker			12KHz	
205	22:22:04	OK-9	4151.1411	N	6416.86952	W	T1442.66	T2638.34	237	232.98T	4.6	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase change 2600-2700m
205	22:29:59	OK-9	4150.82609	N	6417.52403	W	T1442.05	T2637.23	240	232.59T	4.4	4.3	2000	10500	210	1	0	Sparker			12KHz	
205	22:44:59	OK-9	4150.20996	N	6418.78915	W	T1447.20	T2646.63	233	230.53T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	
205	22:59:59	OK-9	4149.60327	N	6420.05462	W	T1445.79	T2644.07	234	229.37T	4.5	4.3	2000	10500	210	1	0	Sparker			12KHz	
205	23:06:35	OK-9	4149.32557	N	6420.58619	W	T1442.84	T2638.67	237	235.16T	4.4	4.3	2000	10500	210	1	0	Sparker			12KHz	huntec wasnt triggering for a few minutes.
205	23:14:59	OK-9	4148.97569	N	6421.27998	W	T1456.09	T2662.91	234	234.81T	4.3	4.5	2000	10500	210	1	0	Sparker			12KHz	
205	23:29:59	OK-9	4148.35131	N	6422.53242	W	T1461.93	T2673.58	236	236.73T	4.4	4.3	2000	10500	210	1	0	Sparker			12KHz	
205	23:44:59	OK-9	4147.75376	N	6423.79216	W	T1475.28	T2697.99	236	235.66T	4.5	4.3	2000	10500	210	1	0	Sparker			12KHz	
205	23:59:59	OK-9	4147.12324	N	6425.04231	W	T1474.74	T2697.01	236	236.34T	4.3	3.9	2000	10500	210	1	0	Sparker			12KHz	
206	00:14:59	OK-9	4146.53448	N	6426.31491	W	T1491.48	T2727.62	241	236.04T	4.4	3.9	2000	10500	210	1	0	Sparker			12KHz	
206	00:29:59	OK-9	4145.92951	N	6427.5723	W	T0000.00	T0000.00	239	233.51T	4.5	3.7	2000	10500	210	1	0	Sparker			12KHz	
206	00:44:59	OK-9	4145.32273	N	6428.81322	W	T1482.85	T2711.84	239	236.28T	4.6	3.9	2000	10500	210	1	0	Sparker			12KHz	
206	00:59:59	OK-9	4144.69898	N	6430.06176	W	T1493.06	T2730.50	237	234.46T	4.5	3.9	2000	10500	210	1	0	Sparker			12KHz	
206	01:14:59	OK-9	4144.07471	N	6431.32636	W	T1504.23	T2750.93	238	235.21T	4.5	4.1	2000	10500	210	1	0	Sparker			12KHz	
206	01:29:59	OK-9	4143.48407	N	6432.58841	W	T1483.83	T2713.63	235	232.64T	4.4	4.1	2000	10500	210	1	0	Sparker			12KHz	
206	01:44:59	OK-9	4142.8505	N	6433.79011	W	T1470.49	T2689.23	243	246.13T	4.3	4.1	2000	10500	210	1	0	Sparker			12KHz	
206	01:59:59	OK-9	4143.38848	N	6434.98219	W	T1454.84	T2660.60	321	319.80T	4.6	4.4	2000	10500	210	1	0	Sparker			12KHz	
206	02:14:59	OK-9	4144.38294	N	6435.53264	W	T1448.83	T2649.63	354	350.64T	4.3	4.3	2000	10500	210	1	0	Sparker			12KHz	
206	02:29:59	OK-9	4145.47883	N	6435.81113	W	T1418.92	T2594.92	350	348.94T	4.4	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	02:44:59	OK-9	4146.58952	N	6436.09609	W	T1400.71	T2561.62	349	346.40T	4.5	4.1	2000	10500	210	1	0	Sparker			12KHz	
206	02:59:59	OK-9	4147.67659	N	6436.39618	W	T1397.12	T2555.05	347	338.49T	4.2	4.3	2000	10500	210	1	0	Sparker			12KHz	
206	03:03:35	OK-9	4147.93154	N	6436.45621	W	T1388.50	T2539.30	355	343.61T	4.4	4.6	2000	10500	210	1	0	Sparker			12KHz	PHASE CHANGE 2500-2600
206	03:14:59	OK-9	4148.76419	N	6436.70871	W	T1371.30	T2507.82	353	342.73T	4.5	4.7	2000	10500	210	1	0	Sparker			12KHz	
206	03:15:39	OK-9	4148.8128	N	6436.71974	W	T1367.41	T2500.73	349	339.59T	4.4	4.7	2000	10500	210	1	0	Sparker			12KHz	phase change 2450-2550
206	03:29:59	OK-9	4149.82267	N	6437.09079	W	T1348.47	T2466.08	344	338.89T	4.4	4.6	2000	10500	210	1	0	Sparker			12KHz	
206	03:30:58	OK-9	4149.89187	N	6437.11676	W	T1346.69	T2462.83	345	340.41T	4.4	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase change 2400-2500
206	03:44:59	OK-9	4150.88536	N	6437.42401	W	T1331.11	T2434.33	339	335.13T	4.4	4.7	2000	10500	210	1	0	Sparker			12KHz	
206	03:59:59	OK-9	4151.95908	N	6437.81713	W	T1312.28	T2399.90	347	345.32T	4.5	4.8	2000	10500	210	1	0	Sparker			12KHz	
206	04:00:14	OK-9	4151.9776	N	6437.82262	W	T1320.32	T2414.60	347	345.57T	4.6	4.8	2000	10500	210	1	0	Sparker			12KHz	Phase change 2350-2450
206	04:14:59	OK-9	4153.06955	N	6438.17157	W	T1313.73	T2402.55	347	345.60T	4.5	4.6	2000	10500	210	1	0	Sparker			12KHz	
206	04:23:09	OK-9	4153.67403	N	6438.34653	W	T1289.09	T2357.49	346	345.01T	4.4	4.3	2000	10500	210	1	0	Sparker			12KHz	Phase change 2300-2400
206	04:29:59	OK-9	4154.17095	N	6438.48764	W	T1284.25	T2348.64	352	350.26T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	04:45:00	OK-9	4155.26409	N	6438.74685	W	T1268.62	T2320.05	351	348.01T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	04:45:22	OK-9	4155.29129	N	6438.75202	W	T1268.80	T2320.37	352	348.59T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	phase change 2250-2350
206	04:59:59	OK-9	4156.35792	N	6438.97462	W	T1253.75	T2292.85	349	339.90T	4.5	4.3	2000	10500	210	1	0	Sparker			12KHz	
206	05:14:59	OK-9	4157.4449	N	6439.29837	W	T1238.22	T2264.46	347	338.99T	4.5	4.6	2000	10500	210	1	0	Sparker			12KHz	
206	05:15:07	OK-9	4157.45471	N	6439.30143	W	T1237.05	T2262.31	346	338.91T	4.5	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase shift 2200-2300
206	05:29:59	OK-9	4158.54345	N	6439.65808	W	T1210.71	T2214.14	344	337.60T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	05:34:19	OK-9	4158.85819	N	6439.76152	W	T1203.60	T2201.14	345	338.31T	4.4	4.5	2000	10500	210	1	0	Sparker			12KHz	Phase change 2150-2250
206	05:44:59	OK-9	4159.61886	N	6440.0315	W	T1191.24	T2178.54	347	341.75T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	05:59:59	OK-9	4200.69398	N	6440.37	W	T1177.24	T2152.94	348	340.69T	4.5	4.6	2000	10500	210	1	0	Sparker			12KHz	
206	06:00:04	OK-9	4200.70002	N	6440.37166	W	T1178.61	T2155.43	348	340.78T	4.5	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase Change 2100-2200
206	06:14:59	OK-9	4201.79457	N	6440.71878	W	T1152.69	T2108.03	349	342.26T	4.6	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	06:15:02	OK-9	4201.79829	N	6440.71996	W	T1152.43	T2107.56	349	342.48T	4.6	4.5	2000	10500	210	1	0	Sparker			12KHz	phase shift 2050-2150
206	06:29:59	OK-9	4202.90071	N	6441.06849	W	T1135.99	T2077.50	346	338.66T	4.5	4.3	2000	10500	210	1	0	Sparker			12KHz	
206	06:44:59	OK-9	4203.9976	N	6441.37902	W	T1118.03	T2044.65	346	337.32T	4.5	4.3	2000	10500	210	1	0	Sparker			12KHz	
206	06:47:50	OK-9	4204.20598	N	6441.44952	W	T1116.84	T2042.47	346	338.87T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	Phase change 2000-2100

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pres-sure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
206	06:59:59	OK-9	4205.09411	N	6441.66626	W	T1107.04	T2024.55	351	339.39T	4.4	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	07:06:58	OK-9	4205.60023	N	6441.7998	W	T1095.61	T2003.66	350	339.84T	4.5	4.5	2000	10500	210	1	0	Sparker			12KHz	Phase change 1950-2050m
206	07:14:59	OK-9	4206.18809	N	6441.94826	W	T1082.75	T1980.14	347	337.09T	4.4	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	07:24:34	OK-9	4206.8886	N	6442.11961	W	T1072.66	T1961.68	349	338.90T	4.4	4.5	2000	10500	210	1	0	Sparker			12KHz	phase change 1900-2000
206	07:29:59	OK-9	4207.27655	N	6442.20845	W	T1062.54	T1943.17	352	340.79T	4.3	4.5	2000	10500	210	1	0	Sparker			12KHz	
206	07:44:59	OK-9	4208.36943	N	6442.51065	W	T1045.07	T1911.22	345	336.85T	4.4	4.6	2000	10500	210	1	0	Sparker			12KHz	
206	07:46:02	OK-9	4208.44473	N	6442.53712	W	T1042.92	T1907.30	346	337.56T	4.4	4.7	2000	10500	210	1	0	Sparker			12KHz	Phase change 1850-1950m
206	07:59:59	OK-9	4209.42851	N	6442.92701	W	T1028.14	T1880.26	339	336.31T	4.6	5	2000	10500	210	1	0	Sparker			12KHz	
206	08:09:50	OK-9	4210.13878	N	6443.22632	W	T1015.90	T1857.87	339	336.41T	4.5	4.8	2000	10500	210	1	0	Sparker			12KHz	Phase change 1800-1900m
206	08:14:59	OK-9	4210.49538	N	6443.40835	W	T1012.12	T1850.96	341	341.51T	4.4	4.9	2000	10500	210	1	0	Sparker			12KHz	
206	08:28:43	OK-9	4211.409	N	6443.99043	W	T1001.95	T1832.36	333	340.57T	4.5	5.2									12KHz	Compressor issue; shut down early
206	08:29:59	OK-9	4211.4935	N	6444.04837	W	T1000.57	T1829.84	333	340.53T	4.5	5.2									12KHz	
206	08:35:33	OK-9	4211.85593	N	6444.33335	W	T0991.09	T1812.51	330	340.66T	4.3	5.4									12KHz	Air gun 1 turned off
206	08:39:20	OK-9	4212.09663	N	6444.50761	W	T0984.79	T1800.98	331	339.00T	4.4	5.4									12KHz	Phase change 1750-1850m
206	08:44:59	OK-9	4212.47596	N	6444.77965	W	T0978.79	T1790.00	332	337.85T	4.6	5.6									12KHz	
206	08:59:59	OK-9	4213.38082	N	6444.50648	W	T0965.54	T1765.77	78	068.81T	4.7	4.8									12KHz	
206	09:01:29	OK-9	4213.38879	N	6444.34677	W	T0968.91	T1771.93	91	080.56T	4.8	4.8									12KHz	Huntec turned off
206	09:14:41	OK-9	4212.70769	N	6443.47825	W	T0987.31	T1805.60	172	169.18T	5	3.9									12KHz	Huntec out of water
206	09:14:59	OK-9	4212.68312	N	6443.47393	W	T0988.37	T1807.53	173	169.67T	5	3.9									12KHz	
206	09:29:59	OK-9	4211.40715	N	6443.30906	W	T1005.31	T1838.51	176	167.57T	5.1	3.9									12KHz	
206	09:34:38	OK-9	4211.06263	N	6443.26962	W	T1008.63	T1844.59	174	164.85T	4	3.2								3.5KHz	12KHz	Phase change 1800-1900m
206	09:44:59	OK-9	4210.42052	N	6443.24039	W	T1014.60	T1855.50	179	170.72T	4.2	3.4								3.5KHz	12KHz	
206	09:51:09	OK-9	4209.2949	N	6442.96736	W	T1034.19	T1891.32	170	167.87T	13.1	11.9								3.5KHz	12KHz	Phase change 1850-1950m; 3.5 KHz gain changed to 30 dB
206	09:59:59	OK-9	4207.53129	N	6442.57521	W	T1060.41	T1939.29	172	169.19T	7.4	6								3.5KHz	12KHz	
206	10:00:28	OK-9	4207.47732	N	6442.56433	W	T1061.18	T1940.68	171	163.78T	6.7	5.4								3.5KHz	12KHz	Phase change 1900-2000m
206	10:14:59	OK-9	4207.0416	N	6442.38695	W	T1066.98	T1951.30	261	307.64T	0.9	1.4								3.5KHz	12KHz	
206	10:29:59	OK-9	4206.94982	N	6442.29327	W	T1067.87	T1952.93	355	350.07T	0.7	1.6								3.5KHz	12KHz	
206	10:44:59	OK-9	4207.00555	N	6442.3083	W	T1068.12	T1953.37	44	024.98T	0.1	0.9								3.5KHz	12KHz	
206	10:49:15	OK-9	4207.00451	N	6442.29398	W	T1067.15	T1951.61	121	039.13T	0.2	1.1								3.5KHz	12KHz	0006 PC in the water
206	10:59:59	OK-9	4207.02541	N	6442.30357	W	T1066.90	T1951.14	105	026.38T	0.1	0.9								3.5KHz	12KHz	
206	11:14:59	OK-9	4207.04115	N	6442.29305	W	T1068.31	T1953.72	165	094.55T	0.5	0.9								3.5KHz	12KHz	
206	11:29:59	OK-9	4207.03715	N	6442.31932	W	T1067.42	T1952.10	326	041.48T	0.1	0.8								3.5KHz	12KHz	
206	11:33:52	OK-9	4207.03757	N	6442.32014	W	T1067.30	T1951.88	186	051.81T	0.1	0.9								3.5KHz	12KHz	0006 pc core on bottom
206	11:44:59	OK-9	4206.92894	N	6442.36122	W	T1069.14	T1955.25	238	149.00T	1.1	-0.2								3.5KHz	12KHz	
206	11:59:59	OK-9	4206.855	N	6442.46761	W	T1069.64	T1956.15	263	194.87T	0.5	0								3.5KHz	12KHz	
206	12:14:59	OK-9	4206.85153	N	6442.60243	W	T1072.46	T1961.31	136	090.81T	0.2	0.7								3.5KHz	12KHz	
206	12:29:59	OK-9	4206.8058	N	6442.74643	W	T1073.96	T1964.06	274	165.96T	0.6	-0.4								3.5KHz	12KHz	
206	12:31:42		4206.80635	N	6442.76866	W	T1074.70	T1965.42	268	171.46T	0.6	-0.2								3.5KHz	12KHz	0006 PC at surface
206	12:44:59		4206.77701	N	6442.98426	W	T1076.48	T1968.66	257	203.11T	0.8	0.4								3.5KHz	12KHz	
206	12:59:59		4206.47716	N	6442.57451	W	T1079.79	T1974.72	100	097.41T	8.3	8.6								3.5KHz	12KHz	
206	13:14:59		4206.18879	N	6439.48855	W	T0000.00	T0000.00	95	094.76T	9.5	9.5								3.5KHz	12KHz	
206	13:29:59		4205.89628	N	6436.56762	W	T1140.49	T2085.73	94	089.35T	5.3	5.7								3.5KHz	12KHz	
206	13:44:59		4205.92771	N	6435.30421	W	T1139.36	T2083.66	117	111.73T	2.1	2.4								3.5KHz	12KHz	
206	13:59:59		4205.83003	N	6435.23026	W	T1141.09	T2086.83	97	102.33T	0.8	0.7								3.5KHz	12KHz	
206	14:14:59		4205.91066	N	6435.03937	W	T1138.46	T2082.02	316	088.82T	0.1	0.7								3.5KHz	12KHz	
206	14:29:59		4205.90981	N	6435.03393	W	T1140.43	T2085.61	181	130.52T	0.3	1								3.5KHz	12KHz	
206	14:44:59		4205.92235	N	6435.02563	W	T1138.45	T2082.00	217	130.50T	0.2	0.6								3.5KHz	12KHz	
206	14:59:15		4205.91238	N	6435.03499	W	T1142.96	T2090.25	302	146.63T	0.3	0.2								3.5KHz	12KHz	0007 PC in water
206	14:59:59		4205.91324	N	6435.03701	W	T1140.33	T2085.43	332	147.56T	0.1	0.4								3.5KHz	12KHz	
206	15:14:59		4205.91744	N	6435.03606	W	T1142.85	T2090.04	332	144.06T	0.1	0.5								3.5KHz	12KHz	
206	15:29:59		4205.92069	N	6435.02929	W	T1140.14	T2085.08	31	153.94T	0.1	0.6								3.5KHz	12KHz	
206	15:40:57		4205.91975	N	6435.02173	W	T1138.96	T2082.94	46	192.19T	0	0.7								3.5KHz	12KHz	0007 PC @ bottom
206	15:44:59		4205.91399	N	6435.03538	W	T1141.29	T2087.20	213	189.52T	0.2	0.7								3.5KHz	12KHz	
206	15:59:59		4205.8966	N	6435.05738	W	T1141.15	T2086.94	240	225.29T	0.4	0.7								3.5KHz	12KHz	
206	16:14:59		4205.91475	N	6435.04628	W	T1139.43	T2083.78	43	205.86T	0.5	0.6								3.5KHz	12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pres-sure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
206	16:29:59		4205.99901	N	6434.94799	W	T1138.97	T2082.95	321	241.94T	0.2	0.7								3.5KHz	12KHz	
206	16:36:21		4206.0324	N	6434.99209	W	T1137.82	T2080.85	309	277.59T	0.6	0.9								3.5KHz	12KHz	0007 PC @ surface
206	16:44:59		4206.07271	N	6434.96201	W	T1139.12	T2083.22	257	092.33T	0.1	-0.6								3.5KHz	12KHz	
206	16:59:59		4206.0498	N	6435.00044	W	T1136.20	T2077.88	206	199.03T	2.9	3.3								3.5KHz	12KHz	
206	17:14:59		4206.10395	N	6433.99518	W	T1130.95	T2068.28	71	088.73T	3.5	3								3.5KHz	12KHz	
206	17:29:59		4206.17157	N	6433.53232	W	T1127.74	T2062.41	259	226.28T	0.4	1.4								3.5KHz	12KHz	
206	17:44:59		4206.18892	N	6433.64713	W	T1128.99	T2064.71	23	283.73T	0.9	-1								3.5KHz	12KHz	
206	17:59:59		4206.16568	N	6433.49427	W	T1127.37	T2061.74	334	277.68T	0.4	1								3.5KHz	12KHz	
206	18:14:59		4206.17688	N	6433.54344	W	T1127.83	T2062.57	275	250.25T	2	2.8								3.5KHz	12KHz	
206	18:29:59		4206.09172	N	6433.55508	W	T1129.32	T2065.31	279	265.54T	4.4	4.7								3.5KHz	12KHz	
206	18:44:59		4206.16304	N	6433.51443	W	T1127.95	T2062.80	67	128.10T	1.3	0.9								3.5KHz	12KHz	
206	18:59:59		4206.17189	N	6433.4976	W	T1127.91	T2062.72	87	210.53T	0.1	1.1								3.5KHz	12KHz	
206	19:14:59		4205.42681	N	6435.21912	W	T1146.83	T2097.31	239	236.63T	9.4	10								3.5KHz	12KHz	
206	19:29:59		4204.11236	N	6437.91347	W	T1143.87	T2091.91	233	233.94T	9.7	10.3								3.5KHz	12KHz	
206	19:44:59		4202.88658	N	6440.70954	W	T1137.98	T2081.13	252	252.68T	9.7	10.1								3.5KHz	12KHz	
206	19:59:59		4202.34802	N	6443.86263	W	T1129.74	T2066.07	258	256.77T	9.4	10								3.5KHz	12KHz	
206	20:14:59		4201.86817	N	6445.31907	W	T1128.42	T2063.66	103	083.99T	0.6	0.1								3.5KHz	12KHz	
206	20:29:59		4201.91846	N	6445.16432	W	T1132.12	T2070.42	61	059.61T	0.4	0.2								3.5KHz	12KHz	
206	20:44:59		4201.95548	N	6445.07334	W	T1130.89	T2068.18	72	026.92T	0.5	0.2								3.5KHz	12KHz	
206	20:59:59		4202.03518	N	6444.87973	W	T1133.45	T2072.86	56	330.15T	0.7	0								3.5KHz	12KHz	
206	21:14:59		4202.21327	N	6444.77954	W	T1131.13	T2068.62	354	349.70T	2.6	2.6								3.5KHz	12KHz	
206	21:29:59		4204.03921	N	6443.51668	W	T1114.15	T2037.56	11	005.88T	6.7	6.7								3.5KHz	12KHz	
206	21:30:06		4204.05212	N	6443.51307	W	T1114.12	T2037.51	11	006.37T	6.7	6.7								3.5KHz	12KHz	Phase change 2000-2100m
206	21:44:59		4204.56997	N	6442.63484	W	T1107.69	T2025.74	60	043.78T	2.5	2								3.5KHz	12KHz	
206	21:59:22		4204.70933	N	6441.82051	W	T1110.20	T2030.33	77	067.53T	2.8	2.2								3.5KHz	12KHz	Huntec in the water
206	21:59:59		4204.71515	N	6441.78245	W	T1111.13	T2032.04	79	068.62T	2.8	2.4								3.5KHz	12KHz	
206	22:03:40		4204.76397	N	6441.56189	W	T1106.54	T2023.64	65	056.93T	2.9	2.6									12KHz	3.5 KHz turned off
206	22:11:56	OK-10	4204.84122	N	6441.02624	W	T1108.89	T2027.94	81	076.00T	3.3	3.3	2000	10500	210	1	0	Sparker			12KHz	SOL
206	22:14:59	OK-10	4204.87053	N	6440.79582	W	T1109.79	T2029.59	81	071.69T	3.7	3.3	2000	10500	210	1	0	Sparker			12KHz	
206	22:29:59	OK-10	4205.12396	N	6439.36591	W	T1116.50	T2041.85	77	069.76T	4.5	3.9	2000	10500	210	1	0	Sparker			12KHz	
206	22:44:59	OK-10	4205.39992	N	6437.90745	W	T1120.78	T2049.68	74	066.22T	4.6	4.1	2000	10500	210	1	0	Sparker			12KHz	
206	22:59:59	OK-10	4205.72701	N	6436.50429	W	T1142.08	T2088.63	57	044.18T	4.3	4.1	2000	10500	210	1	0	Sparker			12KHz	
206	23:14:59	OK-10	4206.50624	N	6435.46365	W	T1131.75	T2069.75	43	031.08T	4.6	5	2000	10500	210	1	0	Sparker			12KHz	
206	23:29:59	OK-10	4207.37035	N	6434.37693	W	T1118.64	T2045.77	43	032.49T	4.5	5	2000	10500	210	1	0	Sparker			12KHz	
206	23:44:59	OK-10	4208.13933	N	6433.32747	W	T1117.22	T2043.17	47	038.56T	4	4.5	2000	10500	210	1	0	Sparker			12KHz	
207	00:00:00	OK-10	4208.83154	N	6432.26878	W	T1077.23	T1970.05	52	044.66T	4.1	4.5	2000	10500	210	1	0	Sparker			12KHz	
207	00:14:59	OK-10	4209.51248	N	6431.1476	W	T1058.61	T1935.99	51	042.62T	4.4	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	00:29:59	OK-10	4210.2525	N	6430.05484	W	T1087.41	T1988.66	43	040.13T	4.4	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	00:44:59	OK-10	4211.01256	N	6428.95306	W	T1072.60	T1961.57	49	042.48T	4.3	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	00:59:59	OK-10	4211.68906	N	6427.90261	W	T1077.70	T1970.89	48	040.57T	4.3	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	01:14:59	OK-10	4212.41305	N	6426.83785	W	T1062.76	T1943.57	45	040.75T	4.3	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	01:29:59	OK-10	4213.15481	N	6425.72983	W	T1062.46	T1943.02	49	042.43T	4.6	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	01:45:00	OK-10	4213.89953	N	6424.64201	W	T1055.71	T1930.68	45	041.18T	4.3	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	01:59:59	OK-10	4214.67103	N	6423.58966	W	T1059.09	T1936.87	46	046.35T	4.5	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	02:14:59	OK-10	4215.42234	N	6422.44264	W	T1063.54	T1945.00	49	047.99T	4.3	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	02:29:59	OK-10	4216.12204	N	6421.37292	W	T1032.16	T1887.61	46	048.82T	3.9	4.5	2000	10500	210	1	0	Sparker			12KHz	
207	02:44:59	OK-10	4216.83076	N	6420.31794	W	T1024.22	T1873.10	47	048.83T	4.4	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	02:59:59	OK-10	4217.56962	N	6419.21971	W	T1025.03	T1874.58	50	055.46T	4.6	4.8	2000	10500	210	1	0	Sparker			12KHz	
207	03:07:35	OK-10	4217.94437	N	6418.62254	W	T1022.32	T1869.62	51	055.70T	4.6	5	2000	10500	210	1	0	Sparker			12KHz	Guns reenabled
207	03:14:59	OK-10	4218.27797	N	6418.05435	W	T1011.37	T1849.59	52	056.23T	4.3	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	03:21:46	OK-10	4218.60259	N	6417.5521	W	T0996.45	T1822.32	49	055.33T	4.5	4.8	2000	10500	210	1	0	Sparker			12KHz	Phase Change 1750-1850
207	03:29:59	OK-10	4219.01461	N	6416.93201	W	T0983.62	T1798.84	51	053.24T	4.5	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	03:45:00	OK-10	4219.77511	N	6415.76195	W	T0960.82	T1757.15	46	049.89T	4.8	4.6	2000	10500	210	1	0	Sparker			12KHz	
207	03:45:12	OK-10	4219.78594	N	6415.74633	W	T0962.35	T1759.94	47	050.49T	4.8	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase change 1700-1800
207	03:59:59	OK-10	4220.57348	N	6414.512	W	T0938.29	T1715.95	47	047.47T	5	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	04:02:08	OK-10	4220.70247	N	6414.34327	W	T0935.37	T1710.60	43	045.69T	5	4.7	2000	10500	210	1	0	Sparker			12KHz	Phase change 1650-1750

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
207	04:14:59	OK-10	4221.4321	N	6413.30439	W	T0923.31	T1688.55	47	047.33T	4.9	4.5	2000	10500	210	1	0	Sparker			12KHz	
207	04:29:59	OK-10	4222.25147	N	6412.06552	W	T0906.10	T1657.08	47	046.39T	4.9	4.5	2000	10500	210	1	0	Sparker			12KHz	
207	04:30:05	OK-10	4222.25705	N	6412.05743	W	T0904.29	T1653.76	48	046.07T	4.9	4.5	2000	10500	210	1	0	Sparker			12KHz	Phase change 1600-1700
207	04:44:59	OK-10	4223.13446	N	6410.87069	W	T0875.70	T1601.48	47	048.99T	5.2	4.6	2000	10500	210	1	0	Sparker			12KHz	
207	04:45:09	OK-10	4223.14429	N	6410.85646	W	T0873.45	T1597.36	47	048.80T	5.2	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase shift 1550-1650
207	04:59:59	OK-10	4224.03589	N	6409.59381	W	T0875.43	T1600.98	45	049.76T	5.1	4.5	2000	10500	210	1	0	Sparker			12KHz	
207	05:03:33	OK-10	4224.25016	N	6409.30712	W	T0854.32	T1562.38	47	054.43T	5.1	4.5	2000	10500	210	1	0	Sparker			12KHz	Phase change 1500-1600
207	05:11:29	OK-10	4224.71625	N	6408.61652	W	T0839.26	T1534.83	48	054.48T	5.4	4.9	2000	10500	210	1	0	Sparker			12KHz	Huntec fire rate changed to 2100ms
207	05:14:59	OK-10	4224.91913	N	6408.30773	W	T0825.37	T1509.43	46	051.28T	5.1	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	05:15:10	OK-10	4224.92991	N	6408.2924	W	T0823.20	T1505.46	46	051.53T	5.1	4.7	2000	10500	210	1	0	Sparker			12KHz	phase change 1450-1550
207	05:29:59	OK-10	4225.74201	N	6407.03143	W	T0795.20	T1454.27	52	060.36T	5	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	05:32:10	OK-10	4225.85849	N	6406.84067	W	T0814.86	T1490.21	48	055.66T	5	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase Change 1400-1500
207	05:41:03	OK-10	4226.35556	N	6406.06572	W	T0783.22	T1432.35	48	056.98T	5.2	4.5	2000	10500	210	1	0	Sparker			12KHz	Huntec delay 800ms/phase change 1350-1450
207	05:44:59	OK-10	4226.57727	N	6405.70293	W	T0767.57	T1403.72	54	061.18T	5.3	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	05:59:59	OK-10	4227.4345	N	6404.30183	W	T0760.96	T1391.64	51	056.35T	5.3	5	2000	10500	210	1	0	Sparker			12KHz	
207	06:14:59	OK-10	4228.24565	N	6402.95465	W	T0760.86	T1391.46	53	058.68T	5.1	4.7	2000	10500	210	1	0	Sparker			12KHz	
207	06:16:02	OK-10	4228.30008	N	6402.85856	W	T0753.96	T1378.83	53	059.15T	5.1	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase change 1300-1400
207	06:29:59	OK-10	4228.90082	N	6401.74716	W	T0742.92	T1358.65	59	069.56T	4.1	3.9	2000	10500	210	1	0	Sparker			12KHz	
207	06:44:59	OK-10	4229.29209	N	6400.39825	W	T0749.95	T1371.51	72	081.07T	4.3	4.1	2000	10500	210	1	0	Sparker			12KHz	
207	06:46:19	OK-10	4229.32163	N	6400.27784	W	T0753.40	T1377.81	71	080.44T	4.2	4	2000	10500	210	1	0	Sparker			12KHz	Phase change 1350-1450
207	06:59:59	OK-10	4229.63014	N	6359.0562	W	T0749.57	T1370.81	75	083.23T	4.2	4.1	2000	10500	210	1	0	Sparker			12KHz	
207	07:14:59	OK-10	4230.05821	N	6357.77633	W	T0750.40	T1372.34	59	063.50T	4.3	4.1	2000	10500	210	1	0	Sparker			12KHz	
207	07:22:30	OK-10	4230.43769	N	6357.27111	W	T0742.03	T1357.03	21	019.70T	4.3	3.9	2000	10500	210	1	0	Sparker			12KHz	Phase change 1300-1400m
207	07:29:59	OK-10	4230.97325	N	6357.27517	W	T0729.10	T1333.39	354	351.94T	4.3	3.7	2000	10500	210	1	0	Sparker			12KHz	
207	07:44:59	OK-10	4232.01536	N	6357.43959	W	T0713.51	T1304.87	354	349.86T	4.3	3.6	2000	10500	210	1	0	Sparker			12KHz	
207	07:45:43	OK-10	4232.06835	N	6357.44913	W	T0712.03	T1302.16	352	348.26T	4.4	3.8	2000	10500	210	1	0	Sparker			12KHz	Phase change 1250-1350m
207	07:59:59	OK-10	4233.18802	N	6357.65555	W	T0694.11	T1269.38	352	348.63T	4.6	4.3	2000	10500	210	1	0	Sparker			12KHz	
207	08:01:59	OK-10	4233.33987	N	6357.68687	W	T0691.07	T1263.83	353	351.04T	4.6	4.3	2000	10500	210	1	0	Sparker			12KHz	Phase change 1200-1300m
207	08:11:47	OK-10	4234.07638	N	6357.78453	W	T0660.79	T1208.45	354	349.41T	4.5	4.3	2000	10500	210	1	0	Sparker			12KHz	Phase change 1150-1250m
207	08:14:59	OK-10	4234.3133	N	6357.81973	W	T0651.06	T1190.66	352	347.92T	4.4	4.4	2000	10500	210	1	0	Sparker			12KHz	
207	08:23:46	OK-10	4234.97207	N	6357.90804	W	T0630.63	T1153.30	353	349.03T	4.6	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase change 1100-1200m
207	08:29:59	OK-10	4235.45215	N	6357.97127	W	T0621.01	T1135.70	354	349.21T	4.7	4.6	2000	10500	210	1	0	Sparker			12KHz	
207	08:40:13	OK-10	4236.24389	N	6358.02997	W	T0605.32	T1107.00	357	349.42T	4.7	4.6	2000	10500	210	1	0	Sparker			12KHz	Phase change 1050-1150m
207	08:44:59	OK-10	4236.61457	N	6358.06098	W	T0596.32	T1090.55	355	347.66T	4.6	4.5	2000	10500	210	1	0	Sparker			12KHz	
207	08:58:41	OK-10	4237.66001	N	6358.16211	W	T0573.95	T1049.65	354	348.51T	4.6	4.5	2000	10500	210	1	0	Sparker			12KHz	Phase change 1000-1100m
207	08:59:59	OK-10	4237.76079	N	6358.17537	W	T0571.14	T1044.51	355	350.39T	4.7	4.6	2000	10500	210	1	0	Sparker			12KHz	
207	09:00:07	OK-10	4237.7712	N	6358.17659	W	T0568.44	T1039.56	355	350.95T	4.7	4.6	2000	10500	210	1	0	Sparker			12KHz	EOL
207	09:00:45		4237.82106	N	6358.18177	W	T0572.08	T1046.21	356	350.83T	4.7	4.6									12KHz	Air gun 1 turned off
207	09:11:50		4238.67611	N	6358.31294	W	T0547.23	T1000.77	351	349.70T	4.5	4.5									12KHz	Phase change 950-1050m
207	09:14:59		4238.9092	N	6358.38381	W	T0548.25	T1002.64	345	349.02T	4.6	4.5									12KHz	
207	09:19:28		4239.25462	N	6358.48574	W	T0527.32	T0964.37	347	350.10T	4.9	4.6									12KHz	Huntec out of the water
207	09:20:27		4239.33247	N	6358.51373	W	T0519.09	T0949.31	344	348.03T	4.9	4.8								3.5KHz	12KHz	Phase change 900-1000m
207	09:27:54		4239.9463	N	6358.72575	W	T0487.25	T0891.08	348	350.68T	5.3	5								3.5KHz	12KHz	Phase change 850-950m
207	09:29:59		4240.12689	N	6358.78172	W	T0478.84	T0875.70	349	354.65T	5.3	5								3.5KHz	12KHz	
207	09:40:54		4241.04499	N	6358.92687	W	T0428.21	T0783.11	350	356.45T	4.4	4								3.5KHz	12KHz	Phase change 750-850m
207	09:45:00		4241.32356	N	6358.97561	W	T0412.46	T0754.32	355	002.07T	3.8	3.5								3.5KHz	12KHz	
207	09:46:15		4241.43045	N	6358.99308	W	T0409.78	T0749.41	353	357.05T	6.8	6.3								3.5KHz	12KHz	Phase change 700-800m
207	09:49:57		4242.11348	N	6359.08971	W	T0380.13	T0695.18	355	356.92T	12.3	11.9								3.5KHz	12KHz	Phase change 650-750m
207	09:52:23		4242.48995	N	6359.12879	W	T0349.85	T0639.81	356	359.06T	7.8	7.3								3.5KHz	12KHz	Phase change 600-700m
207	09:57:33		4243.05802	N	6359.18919	W	T0308.57	T0564.32	356	000.05T	6.1	5.4								3.5KHz	12KHz	Phase change 550-650m
207	09:59:37		4243.26319	N	6359.21113	W	T0301.58	T0551.54	356	359.42T	5.9	5.4								3.5KHz	12KHz	Phase change 500-600m
207	09:59:59		4243.29935	N	6359.21453	W	T0295.87	T0541.09	356	359.92T	5.9	5.3								3.5KHz	12KHz	
207	10:03:50		4243.67743	N	6359.25333	W	T0273.89	T0500.89	354	357.03T	5.9	5.2								3.5KHz	12KHz	Phase change 450-550m
207	10:08:51		4244.17557	N	6359.30468	W	T0242.91	T0444.24	355	356.77T	6	5.2								3.5KHz	12KHz	Phase change 400-500m

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
207	10:14:59		4244.80351	N	6359.37726	W	T0217.22	T0397.25	353	355.36T	6.3	5.1								3.5KHz	12KHz	
207	10:16:53		4245.00315	N	6359.39368	W	T0223.18	T0408.15	359	001.36T	6.3	5.2								3.5KHz	12KHz	Phase change 350-450m
207	10:20:44		4245.41512	N	6359.4231	W	T0191.69	T0350.56	355	355.77T	6.5	5.4								3.5KHz	12KHz	Phase change 300-400m
207	10:25:52		4245.96952	N	6359.47233	W	T0161.53	T0295.41	357	359.25T	6.4	5.4								3.5KHz	12KHz	Phase change 250-350m
207	10:29:59		4246.41006	N	6359.49591	W	T0143.45	T0262.35	356	356.18T	6.4	5.3								3.5KHz	12KHz	
207	10:30:46		4246.4938	N	6359.5053	W	T0146.81	T0268.49	355	355.76T	6.4	5.4								3.5KHz	12KHz	Phase change 200-300m
207	10:35:21		4246.98614	N	6359.54049	W	T0116.15	T0212.42	358	359.30T	6.5	5.3								3.5KHz	12KHz	3.5 KHz gain changed to 20dB; 12 KHz gain changed to 40dB
207	10:44:59		4246.60664	N	6359.1742	W	T0131.31	T0240.15	184	181.92T	10.8	11.5								3.5KHz	12KHz	Phase change 150-250m
207	10:45:31		4246.51064	N	6359.18359	W	T0135.30	T0247.44	184	181.35T	10.8	11.6								3.5KHz	12KHz	Phase change 200-300m
207	10:48:51		4245.91148	N	6359.2247	W	T0163.88	T0299.70	184	180.91T	10.8	11.6								3.5KHz	12KHz	Phase change 250-350m
207	10:51:25		4245.44555	N	6359.25436	W	T0187.24	T0342.42	183	181.21T	10.9	11.6								3.5KHz	12KHz	Phase change 300-400m
207	10:54:21		4245.08944	N	6359.2879	W	T0205.66	T0376.12	185	179.64T	4.8	5.5								3.5KHz	12KHz	Phase change 350-450m
207	10:57:22		4244.94964	N	6359.25989	W	T0212.51	T0388.64	146	145.69T	1.7	2.6								3.5KHz	12KHz	3.5 KHz gain changed to 15 dB
207	10:59:59		4244.89876	N	6359.1837	W	T0216.98	T0396.82	141	152.16T	3.6	4.5								3.5KHz	12KHz	
207	11:02:38		4244.8576	N	6358.86025	W	T0229.18	T0419.13	39	025.53T	8.6	8.2								3.5KHz	12KHz	Phase change 400-500m
207	11:06:43		4245.62904	N	6358.77415	W	T0181.87	T0332.60	18	018.76T	12.9	12								3.5KHz	12KHz	Phase change 300-400m
207	11:08:39		4246.03605	N	6358.61474	W	T0158.55	T0289.95	16	017.23T	13.3	12.3								3.5KHz	12KHz	Phase change 250-350m
207	11:11:38		4246.67973	N	6358.37864	W	T0133.18	T0243.56	16	017.23T	13.6	12.3								3.5KHz	12KHz	Phase change 200-300m
207	11:14:59		4247.41847	N	6358.10022	W	T0117.78	T0215.39	14	014.72T	13.7	12.6								3.5KHz	12KHz	
207	11:16:49		4247.82142	N	6357.95674	W	T0104.86	T0191.77	16	016.09T	13.6	12.5								3.5KHz	12KHz	Phase change 150-250m
207	11:22:19		4248.63361	N	6357.65023	W	T0081.97	T0149.91	18	018.31T	9.2	8								3.5KHz	12KHz	Phase change 100-200m
207	11:29:59		4250.37387	N	6357.01151	W	T0066.75	T0122.07	17	017.30T	14.3	13.3								3.5KHz	12KHz	
207	11:44:59		4253.81215	N	6355.37421	W	T0061.56	T0112.58	21	018.42T	14.8	13.6								3.5KHz	12KHz	
207	11:59:59		4257.25616	N	6353.63149	W	T0060.58	T0110.79	22	019.36T	14.6	13.6								3.5KHz	12KHz	
207	12:14:59		4300.62152	N	6351.97303	W	T0056.36	T0103.08	21	018.24T	14.1	13.4								3.5KHz	12KHz	
207	12:29:59		4303.98122	N	6350.54978	W	T0058.04	T0106.15	16	012.69T	14.1	13.6								3.5KHz	12KHz	
207	12:44:59		4307.34813	N	6349.29103	W	T0054.18	T0099.09	15	015.35T	13.7	13.5								3.5KHz	12KHz	
207	12:59:59		4310.64716	N	6348.04082	W	T0062.93	T0115.09	15	011.67T	13.7	13.5								3.5KHz	12KHz	
207	13:14:59		4313.9344	N	6346.82635	W	T0078.05	T0142.74	14	013.88T	13.7	13.3								3.5KHz	12KHz	
207	13:29:59		4317.28444	N	6345.6275	W	T0097.76	T0178.79	15	013.18T	13.9	13.4								3.5KHz	12KHz	
207	13:44:59		4320.69222	N	6344.41088	W	T0103.38	T0189.05	15	015.60T	14.3	13.6								3.5KHz	12KHz	
207	13:59:59		4324.10023	N	6343.16703	W	T0118.41	T0216.55	15	014.52T	14.1	13.5								3.5KHz	12KHz	
207	14:14:59		4327.48888	N	6341.81612	W	T0117.73	T0215.31	15	011.74T	14.2	13.5								3.5KHz	12KHz	
207	14:29:59		4330.8756	N	6340.52418	W	T0115.46	T0211.16	15	012.24T	14	13.4								3.5KHz	12KHz	
207	14:44:59		4334.26451	N	6339.24669	W	T0124.28	T0227.28	12	012.99T	14	13.4								3.5KHz	12KHz	
207	14:59:59		4337.61385	N	6338.01676	W	T0118.86	T0217.37	17	015.64T	13.9	13.5								3.5KHz	12KHz	
207	15:14:59		4340.93282	N	6336.71545	W	T0121.31	T0221.84	15	013.57T	13.8	13.4								3.5KHz	12KHz	
207	15:29:59		4342.94363	N	6335.77098	W	T0117.68	T0215.22	334	269.99T	0.1	0								3.5KHz	12KHz	
207	15:44:59		4342.96172	N	6335.78961	W	T0117.69	T0215.23	298	209.04T	0.1	-0.4								3.5KHz	12KHz	
207	15:48:34		4342.96889	N	6335.81294	W	T0118.98	T0217.60	260	222.95T	0.6	0.3								3.5KHz	12KHz	3.5KHz gain value 20 dB/Power 2
12kHz gain value 20 dB/ Power 2																						
207	15:57:28		4343.02962	N	6335.81426	W	T0117.31	T0214.54	98	330.38T	1.2	-1								3.5KHz	12KHz	0008PC in water
207	15:59:59		4342.99357	N	6335.77892	W	T0118.29	T0216.33	163	349.60T	1	-0.8								3.5KHz	12KHz	
207	16:00:02		4342.99271	N	6335.77873	W	T0117.44	T0214.78	164	349.16T	1	-0.9								3.5KHz	12KHz	0008 PC bottom?
207	16:02:49		4342.97052	N	6335.74316	W	T0119.95	T0219.36	102	359.33T	0.6	-0.3								3.5KHz	12KHz	0008 PC in water (second attempt)
207	16:06:57		4342.9747	N	6335.73639	W	T0117.02	T0214.01	359	293.16T	0.3	0.5								3.5KHz	12KHz	0008PC @ botto
m 2nd Attempt																						
207	16:14:59		4343.08569	N	6335.70073	W	T0116.55	T0213.15	18	343.39T	1.6	0.9								3.5KHz	12KHz	
207	16:21:31		4343.22037	N	6335.64791	W	T0116.94	T0213.85	9	325.14T	0.9	0.8								3.5KHz	12KHz	0008PC @ surface
207	16:29:59		4343.34073	N	6335.60968	W	T0121.10	T0221.47	19	327.31T	0.9	0.6								3.5KHz	12KHz	
207	16:44:59		4344.18617	N	6335.26264	W	T0122.34	T0223.73	29	028.51T	6.4	6.3								3.5KHz	12KHz	
207	16:59:59		4345.37287	N	6333.76553	W	T0125.83	T0230.12	44	042.86T	6.5	6.3								3.5KHz	12KHz	
207	17:14:59		4346.50286	N	6332.2166	W	T0120.58	T0220.51	42	039.46T	6.3	6.3								3.5KHz	12KHz	
207	17:29:59		4347.6211	N	6330.68008	W	T0118.07	T0215.93	46	042.59T	6.2	6.4								3.5KHz	12KHz	
207	17:44:59		4349.51455	N	6328.13398	W	T0109.83	T0200.86	43	041.09T	11.9	11.7								3.5KHz	12KHz	

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
207	18:00:00		4351.62092	N	6325.23299	W	T0092.09	T0168.41	46	043.13T	11.8	11.9								3.5KHz	12KHz	
207	18:01:41		4351.86034	N	6324.92088	W	T0092.18	T0168.57	40	037.98T	11.7	11.6								3.5KHz	12KHz	Phase change 150-250
207	18:13:42		4353.62918	N	6322.74617	W	T0077.84	T0142.36	40	036.45T	11.8	11.9								3.5KHz	12KHz	Phase change 100-200m
207	18:14:59		4353.8198	N	6322.51629	W	T0077.67	T0142.04	42	039.37T	11.8	11.8								3.5KHz	12KHz	
207	18:29:59		4356.07456	N	6319.8856	W	T0075.10	T0137.34	38	035.11T	11.7	11.9								3.5KHz	12KHz	
207	18:44:59		4358.35504	N	6317.09633	W	T0085.26	T0155.92	47	043.35T	13.3	13.3								3.5KHz	12KHz	
207	18:59:59		4400.82748	N	6313.99363	W	T0093.31	T0170.65	40	036.85T	13.3	13.4								3.5KHz	12KHz	
207	19:14:59		4403.34969	N	6311.00544	W	T0073.23	T0133.91	39	037.46T	13.2	13.1								3.5KHz	12KHz	
207	19:29:59		4404.84742	N	6309.03511	W	T0073.24	T0133.94	83	084.30T	0.5	0.7								3.5KHz	12KHz	
207	19:44:59		4404.81074	N	6308.97172	W	T0071.24	T0130.29	255	219.06T	0.1	-0.6								3.5KHz	12KHz	
207	19:46:45		4404.80954	N	6308.9715	W	T0071.40	T0130.58	306	223.11T	0.2	-0.7								3.5KHz	12KHz	Gavia in the water
207	19:52:21		4404.82153	N	6309.00012	W	T0071.51	T0130.78	273	263.07T	0.3	0.4										3.5 KHz and 12 KHz turned off
207	19:59:59		4404.82949	N	6309.05515	W	T0071.69	T0131.10	184	050.48T	0.4	-0.1										
207	20:00:59		4404.83141	N	6309.05115	W	T0071.69	T0131.10	27	047.42T	0.3	0.9										Gavia mission started
207	20:14:59		4404.83258	N	6308.87003	W	T0071.69	T0131.10	49	077.46T	0.2	0.2										
207	20:29:59		4404.80989	N	6308.70848	W	T0071.69	T0131.10	125	106.33T	1.5	1.2										Gavia mission ended
207	20:44:59		4404.98118	N	6309.67714	W	T0071.69	T0131.10	295	293.87T	6.7	6.4										
207	20:55:03		4405.16235	N	6310.09763	W	T0071.69	T0131.10	292	287.67T	2.6	2.8										Gavia retrieved
207	20:59:59		4405.17606	N	6310.17563	W	T0071.69	T0131.10	316	281.89T	0.4	-0.1										
207	21:03:13		4405.1847	N	6310.23257	W	T0076.85	T0140.54	262	256.46T	2	1.9								3.5KHz	12KHz	3.5 and 12 KHz turned back on
207	21:14:59		4404.96499	N	6310.15658	W	T0079.79	T0145.92	101	093.33T	0.6	0.9								3.5KHz	12KHz	
207	21:29:59		4404.91135	N	6310.08837	W	T0079.01	T0144.50	190	117.76T	0.3	0.4								3.5KHz	12KHz	
207	21:45:00		4405.24949	N	6310.97066	W	T0077.45	T0141.64	301	301.55T	7.5	7.2								3.5KHz	12KHz	
207	21:59:59		4406.42534	N	6313.48138	W	T0097.38	T0178.10	304	303.03T	10	9.5								3.5KHz	12KHz	
207	22:01:54		4406.59985	N	6313.8487	W	T0098.19	T0179.56	303	303.14T	9.9	9.3								3.5KHz	12KHz	3.5 KHz gain change 15 dB
207	22:14:59		4407.79952	N	6316.32201	W	T0077.78	T0142.24	303	302.74T	10	9.3								3.5KHz	12KHz	
207	22:23:22		4408.56649	N	6317.92782	W	T0085.63	T0156.59	303	303.36T	10	9.3								3.5KHz	12KHz	Gain change 10db (3.5KHz)
207	22:29:59		4409.16344	N	6319.18034	W	T0082.66	T0151.17	304	304.88T	9.6	9.1								3.5KHz	12KHz	
207	22:33:21		4409.46811	N	6319.80622	W	T0101.02	T0184.74	304	303.91T	9.7	9.1								3.5KHz	12KHz	Phase change 150-250m
207	22:36:56		4409.78154	N	6320.48135	W	T0080.29	T0146.83	302	303.24T	9.8	9.1								3.5KHz	12KHz	Phase change 100-200m
207	22:44:59		4410.50348	N	6321.99562	W	T0068.21	T0124.75	303	302.47T	9.7	9.1								3.5KHz	12KHz	
207	22:59:59		4411.76643	N	6324.85856	W	T0063.03	T0115.27	301	300.24T	9.6	9.1										
207	23:14:59		4413.04789	N	6327.71161	W	T0063.03	T0115.27	302	301.14T	9.6	9.2										
207	23:29:59		4414.37836	N	6330.55374	W	T0063.03	T0115.27	302	301.08T	9.7	9.5										
207	23:44:59		4415.47062	N	6332.83926	W	T0063.03	T0115.27	307	305.91T	6.2	5.6										
207	23:59:59		4416.40436	N	6334.53049	W	T0063.03	T0115.27	309	305.92T	6.1	5.5										
208	00:14:59		4417.31971	N	6336.24115	W	T0063.03	T0115.27	306	300.20T	6.1	5.4										
208	00:29:59		4418.18797	N	6337.95518	W	T0063.03	T0115.27	307	300.81T	6	5.6										
208	00:44:59		4418.72992	N	6338.81802	W	T0063.03	T0115.27	320	287.59T	1.9	1.1										
208	00:59:59		4419.11718	N	6339.38761	W	T0063.03	T0115.27	303	285.21T	3.3	2.8										
208	01:14:59		4419.59167	N	6340.44321	W	T0063.03	T0115.27	302	284.51T	3.6	3										
208	01:29:59		4420.05949	N	6342.05223	W	T0063.03	T0115.27	286	276.90T	6	5.8										
208	01:44:59		4419.78549	N	6344.01117	W	T0063.03	T0115.27	249	244.85T	6.1	6.3										
208	01:59:59		4419.29389	N	6346.01551	W	T0063.03	T0115.27	255	251.73T	5.9	6.2										
208	02:14:59		4418.80664	N	6348.05033	W	T0063.03	T0115.27	253	250.68T	6	6										
208	02:29:59		4418.35941	N	6350.07695	W	T0063.03	T0115.27	255	254.88T	6.2	6.3										
208	02:44:59		4417.93464	N	6352.02517	W	T0063.03	T0115.27	252	251.64T	6.1	6.1										
208	02:59:59		4417.47305	N	6354.03472	W	T0063.03	T0115.27	251	250.41T	5.8	5.8										
208	03:14:59		4417.03931	N	6356.02993	W	T0063.03	T0115.27	253	251.24T	6	6.1										
208	03:29:59		4416.59993	N	6358.00656	W	T0063.03	T0115.27	252	249.14T	6	6.3										
208	03:44:59		4416.1377	N	6359.97898	W	T0063.03	T0115.27	250	247.54T	5.8	6										
208	03:59:59		4415.72155	N	6401.89957	W	T0063.03	T0115.27	254	247.94T	5.9	6.3										
208	04:14:59		4415.62025	N	6401.35812	W	T0063.03	T0115.27	27	024.35T	7.1	6.5										
208	04:29:59		4416.26707	N	6359.42745	W	T0063.03	T0115.27	73	075.43T	5.8	5.3										
208	04:44:59		4416.4904	N	6357.41558	W	T0063.03	T0115.27	95	098.54T	5.9	5.4										
208	04:59:59		4416.35901	N	6355.36369	W	T0063.03	T0115.27	96	095.15T	5.9	5.4										

J Day	UTC	Line#	Lat	N/S	Long	E/W	Water Depth(fathoms)	Water Depth, meters	COG	Heading	SOG	LOG, Kts,	Air gun Pressure	Firing rate, ms	Gun size	# of guns	Delay, ms	Spark-er	Boom-er	3.5KHz	12KHz	Comments
208	05:14:59		4416.20223	N	6353.33277	W	T0063.03	T0115.27	95	093.54T	6	5.5										
208	05:29:59		4416.05897	N	6351.30169	W	T0063.03	T0115.27	93	088.26T	5.9	5.3										
208	05:45:00		4415.94341	N	6349.2231	W	T0063.03	T0115.27	97	092.48T	6.1	5.6										
208	06:00:00		4415.81605	N	6347.18257	W	T0063.03	T0115.27	94	087.98T	5.6	5.2										
208	06:14:59		4415.70381	N	6345.18012	W	T0063.03	T0115.27	94	088.61T	6.3	6										
208	06:29:59		4415.57547	N	6343.07571	W	T0063.03	T0115.27	94	089.76T	6.1	5.6										
208	06:44:59		4415.42795	N	6340.98292	W	T0063.03	T0115.27	95	091.51T	6.1	5.7										
208	06:59:59		4415.29542	N	6338.8861	W	T0063.03	T0115.27	95	090.14T	6	5.6										
208	07:14:59		4415.16453	N	6336.80905	W	T0063.03	T0115.27	94	091.85T	6.1	5.9										
208	07:29:59		4415.01681	N	6334.48063	W	T0063.03	T0115.27	96	093.47T	7.1	6.9										
208	07:44:59		4415.12056	N	6332.0903	W	T0063.03	T0115.27	58	054.56T	6.9	7										
208	08:00:00		4415.97244	N	6329.95785	W	T0063.03	T0115.27	55	051.77T	6.9	7										
208	08:14:59		4417.06824	N	6328.08498	W	T0063.03	T0115.27	52	048.79T	7	7										
208	08:29:59		4418.21503	N	6326.29853	W	T0063.03	T0115.27	46	045.51T	6.9	7.1										
208	08:44:59		4419.39039	N	6324.50048	W	T0063.03	T0115.27	45	043.71T	7	7.1										
208	08:59:59		4420.78772	N	6323.3438	W	T0063.03	T0115.27	1	001.51T	7.1	7.2										
208	09:14:59		4422.77431	N	6323.46871	W	T0063.03	T0115.27	331	330.74T	9.4	9.3										
208	09:29:59		4425.39132	N	6325.36941	W	T0063.03	T0115.27	332	329.14T	12.1	11.9										
208	09:44:59		4427.6528	N	6327.05345	W	T0063.03	T0115.27	327	323.20T	10.9	10.6										
208	09:59:59		4430.00123	N	6329.16573	W	T0063.03	T0115.27	327	323.93T	11.2	11										
208	10:14:59		4432.36399	N	6331.33226	W	T0063.03	T0115.27	331	329.96T	11.3	11										
208	10:29:59		4435.10682	N	6331.96375	W	T0063.03	T0115.27	355	354.06T	11.3	11.2										
208	10:44:59		4437.7024	N	6333.31853	W	T0063.03	T0115.27	332	331.53T	8.8	8.4										
208	10:59:59		4439.48068	N	6334.47245	W	T0063.03	T0115.27	308	302.63T	7.8	7.3										
208	11:14:59		4440.57274	N	6336.39421	W	T0063.03	T0115.27	285	283.86T	5	3.7										
208	11:29:59		4440.85959	N	6336.8045	W	T0063.03	T0115.27	19	202.19T	0.4	-0.2										
208	11:44:59		4440.8655	N	6336.82282	W	T0063.03	T0115.27	80	207.44T	0	-0.4										
208	11:59:59		4440.86526	N	6336.82307	W	T0063.03	T0115.27	212	207.29T	0	-0.2										
208	12:14:59		4440.86551	N	6336.82297	W	T0063.03	T0115.27	61	207.54T	0	-0.1										
208	12:29:59		4440.86569	N	6336.82275	W	T0063.03	T0115.27	150	207.52T	0	0										
208	12:42:58		4440.86577	N	6336.82281	W	T0063.03	T0115.27	168	207.49T	0	0.5										Tied up at BIO as of ~1130 UTC

Appendix V: SEGy navigation merge from ship's NAVNET
Kai Boggild, July 2021

```
# -*- coding: utf-8 -*-
"""
Created on Fri Jun 25 10:53:13 2021

Script for merging the CRP navigation from GSCA Navnet hourly logfiles with the output SEGY files
(based on starttime)

@author: kboggild
"""
import os
import re
from datetime import datetime, timedelta as td
import dateutil.parser as dp
from obspy.core import read
import pandas as pd
import numpy as np
import argparse

parser = argparse.ArgumentParser(add_help = True, \
                                 prog = 'mergenav',
                                 description = "Script for merging navigation from GSCA NavNet lo
gfiles with preliminary SEG-Y files (according to FFID in the headers). Writes output SEG-
Y to same directory as the input segy, so only work on copies.")
parser.add_argument('inputSEGY', metavar = 'inputSEGY', type=str,
                    help = 'Path to segy file to merge navigation with' )
parser.add argument('inputNavFolder', metavar = 'inputNavFolder',
                    type = str,
                    help = "Path to folder with copy of NavNet log files (use '.' if current fold
er)." )
parser.add_argument('-offset', action = 'store_true',
                    help = 'Add this flag to apply offset to source position.')
args = parser.parse_args()

#input filename
inputSEGY_filename = args.inputSEGY
inputNavFolder = args.inputNavFolder
apply_source_offset = args.offset

#check for offset flag and set file suffix based on whether it is applied
suffix = '_merged_crp.sgy'
if apply_source_offset == True:
    from pyproj import Geod
    g = Geod(ellps='WGS84')
    suffix = '_merged_src_position.sgy'

#source offset from CRP
gps_x = -10 #positive direction is in starboard direction
gps_y = 43 #positive direction is in aft direction
gps_distance = np.sqrt(gps_x**2 + gps_y**2)
gps_azimuth_corr = np.rad2deg(np.arctan(gps_x/gps_y))

#find the offset files from the navnet archive (copied locally)
file_list = []
for root, dirs, files in os.walk(inputNavFolder, topdown=True):
    for name in files:
        file_list.append(os.path.join(root, name))
offset_matching = [s for s in file_list if "Offset.txt" in s]

#read seismic data and get start and end times (date range)
st = read(inputSEGY_filename, unpack_trace_headers = True)
d1 = st[0].stats.starttime.date
d2 = st[-1].stats.starttime.date
delta = d2 - d1
rng=[]
for i in range(delta.days + 1):
    rng.append(str(d1 + td(days=i)))
```

```
#Sample path list to contain only paths to data within the desired date range
matching2=[]
for i in rng:
    day_string = i
    tmp = [s for s in offset_matching if day_string in s]
    matching2.extend(tmp)

#get CRP positions from matching files
offset_timestamp = []; crp_lat = []; crp_lon = []; crp_heading = []
for i in matching2:
    f = open(i, 'r')
    lines = f.readlines()
    f.close()
    for line in lines:
        if 'CRP' in line:
            lstrip = line.strip()
            words = lstrip.split('|')
            offset_timestamp.append(dp.isoparse(words[4]))
            nav_temp = re.split(':   |,|:  ', words[5])
            crp_lat.append(float(nav_temp[1]))
            crp_lon.append(float(nav_temp[3]))
            crp_heading.append(float(nav_temp[-1]))

posix_time = [x.timestamp() for x in offset_timestamp]
df_crp = pd.DataFrame({'offset_timestamp': offset_timestamp,
                       'posix_time': posix_time,
                       'crp_lat': crp_lat,
                       'crp_lon':crp_lon,
                       'crp_heading': crp_heading})

for i in st:
    start_time = i.stats.starttime
    trace_posix_time = start_time.timestamp

    #get index of closest timestamp
    idx = df_crp['posix_time'].sub(trace_posix_time).abs().idxmin()

    #use index to get closest nav fixes
    y = df_crp['crp_lat'][idx]
    x = df_crp['crp_lon'][idx]

    if apply_source_offset == True:
        closest_heading = df_crp['crp_heading'][idx]
        closest_heading_corrected_for_antenna = closest_heading + gps_azimuth_corr
        back_azimuth = closest_heading_corrected_for_antenna - 180.
        x, y, _ = g.fwd(x, y, back_azimuth, gps_distance)

    #use this index to write the navigation to the trace headers and set the coordinate types
    i.stats['segy']['trace_header']['source_coordinate_y'] = int(round(y*3600000))
    i.stats['segy']['trace_header']['source_coordinate_x'] = int(round(x*3600000))
    i.stats['segy']['trace_header']['coordinate_units'] = 2
    i.stats['segy']['trace_header']['scalar_to_be_applied_to_all_coordinates'] = -1000

#append suffix to input filename
outputSEGY = inputSEGY_filename.split('.s')[0] + suffix
#write output segy
st.write(outputSEGY, format = 'SEGY')
print('Done!')
```

Appendix VI: Post-Cruise GSC-Atlantic Newsletter Article (October 2021)

Hudson Cruise 2021126: The continental slope offshore SW Nova

A similar version of this cruise account was released internal to NRCan, October. 2021 as part of their quarterly GSC-Atlantic Newsletter "Below The Waterline" available only on NRCan intranet

Finally, a relatively long expedition aboard CCGS Hudson and a return to the Scotian Shelf shallow geology seemed to be a reality. A change in DFO plans meant an offer of 33 days ship time towards the major field program for the Nova Scotian portion of the MGMSP (Marine Geology for Marine Spatial Planning) program, not the original 17 days toward which Brian Todd had been planning for months. He brought in Ned King to share responsibilities and two cruise legs were anticipated. At the suggestions of several of our scientists that couldn't make one or the other leg, a plan developed to cover most of the full expanse of the shelf, east to west, with a significant new look at St Margaret's Bay and a large chunk of the mid to inner shelf along the NS South Shore. Then, the study would stretch from the sand dunes of Georges Bank, the glacial fans and sediment mass failures off the Shelburne slope, possible iceberg scour-triggered slumps on the upper slope off Halifax, to the thick sea-level rise generated sand sheets and canyons of Banquereau. We even envisioned wetting the new Autonomous Underwater Vehicle "Gavia" in its first science missions, anticipating centimetre-scale resolution of soft sponge colonies, hard corals on the "Stone Fence" and the multiple "cookie bites" at the head of newly discovered canyons. This was also to be the first science-driven test of the multichannel seismic system and the greatly upgraded GeoForce (the old Huntec) deep towed system.

Now, most seagoing expeditions don't go exactly to plan, but this was the great exception… and not in the good sense! The well-known foibles of our dear OLD ship were about to multiply and flourish. We'll skip umpteen disappointments and plan adjustments that iteratively shrunk from the potential of 33 days to the reality of only five. This included a full cancellation of Brian's, then Ned's leg, only to resurrect in an unprecedented re-scheduling; a revised Hudson crew, some major adjustments to our own staff and suddenly we were back on for a short cruise! We were sorry to loose some key staff with the schedule change but back in business as others offered to hop off the shortened Amundsen cruise to join us.

With all the components and technicalities in mobilizing and realizing a cruise such as this, it is impressive how the GSC-A team musters to assemble a working machinery. This includes those who don't even get to sail. Thanks for planning and mobilizing to Jordan Eamer, Alex Normandeau, Mike Li, Genevieve Philibert, Robbie Bennet, Paul Fraser, Scott Hayward, Jenna Higgins and Kate Jarrett, most of whom would have sailed but for scheduling conflicts and Tom Carson, Patrick Meslin and George Tanski, for mob efforts and to Calvin Campbell who actually entertained a break in project leadership for a sea voyage during the scramble for our crew.

With a "gift" of new multibeam and sub-bottom profiler coverage from NOOA across a large area of the slope offshore Shelburne/Yarmouth area together with hydrocarbon interest blocks of proprietary continuous high resolution bathymetry and pre-multibeam GSC-A seismic and core data amassed over the years, largely under David Piper and Calvin Campbell's direction, we headed for that area. We recognized the potential for establishing a rough stratigraphic and chronologic framework for glacial fans and dozen's of mappable large and smaller submarine avalanches of varied style.

Well five days, including transit, is short - but while ship and equipment held up despite some initial challenges, the fantastic warm and calm weather helped enormously. A few good cores (longest over 7 m) and nearly 300 km of geophysics tracks in the study area marked a successful cruise. We were quite enthused by results from the new multichannel streamer; an overlap with some legacy data demonstrated perhaps twice the penetration with improved resolution, even with a single, relatively small gun. All lines imaged deeply buried (>1.5 sec below sea floor) diapiric structures from underlying salt, classic pre-glacial contourites, the transition to the glacial deposition regime, and multiple large mass failures. Overlap between profilers and air gun is exceptional as the deep towed sparker locally provided >100 ms penetration. Initial interpretation indicates that at least two glacial phases are recorded, the penultimate presenting the larger volume and failure magnitudes. Transit timing on the way home allowed a core on a major glacial retreat moraine and we were also charged about the first science-driven attempt at an AUV survey, targeting soft sponges on Canso Bank, but it unexpectedly aborted its own mission quite prematurely - at least we gained some deployment/recovery experience.

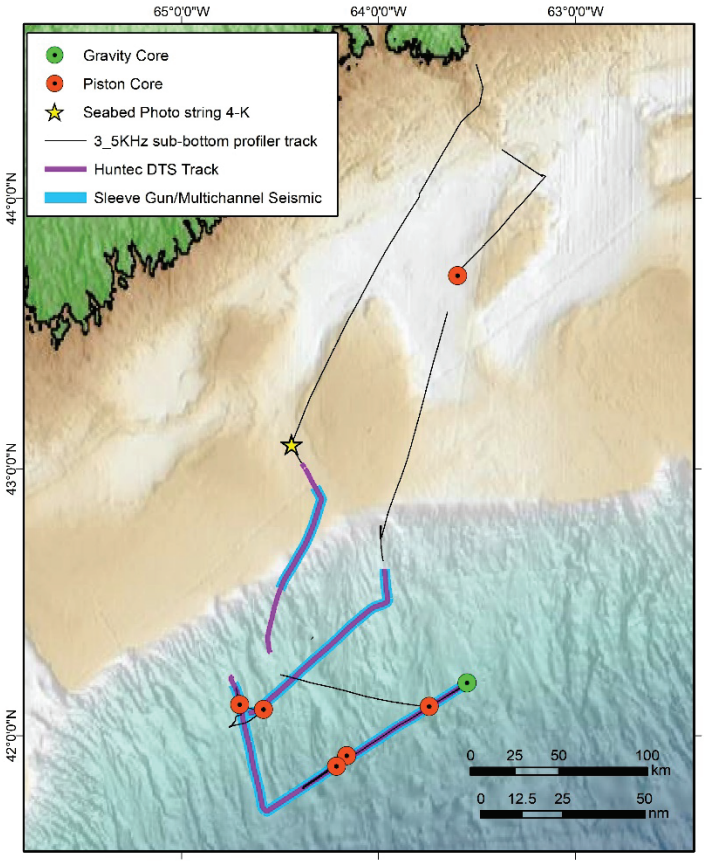

Figure 35. Hudson 2021126 tracks and samples.

As always, we are glad to have our students join, and in fact, quite dependant on their watchkeeping skills, but with the flat calm and "T-shirt with shorts" conditions we experienced, they may have come ashore with a slightly skewed sea-going impression. Thanks Parker, Grace and Cameron. Parker was the photography enthusiast and credited with all the images shown.

Hearty acknowledgments to Tom Fralic for the great GeoForce survey, to Captain Francey and all the bridge crew, boatswain Rob Costelo and his crew, logistics officer, Chantal Davis, the engineering team under Chris Longley (though we hardly ever saw their faces!), Flo Pardy and her galley folks for exceptional fare, Becky Newcombe for her ever-cheerful stewarding services, just a few of the 30-some Hudson crew who make our studies feasible.

Many thanks to all GSC-A folks who sailed; Kai Boggild, Laura Broom, Cameron Greaves. Lorie Campbell, Parker Ingham, Des Manning, Grace Nissen, Peter Pledge, Angus Robertson, and Brian Todd

Ned King

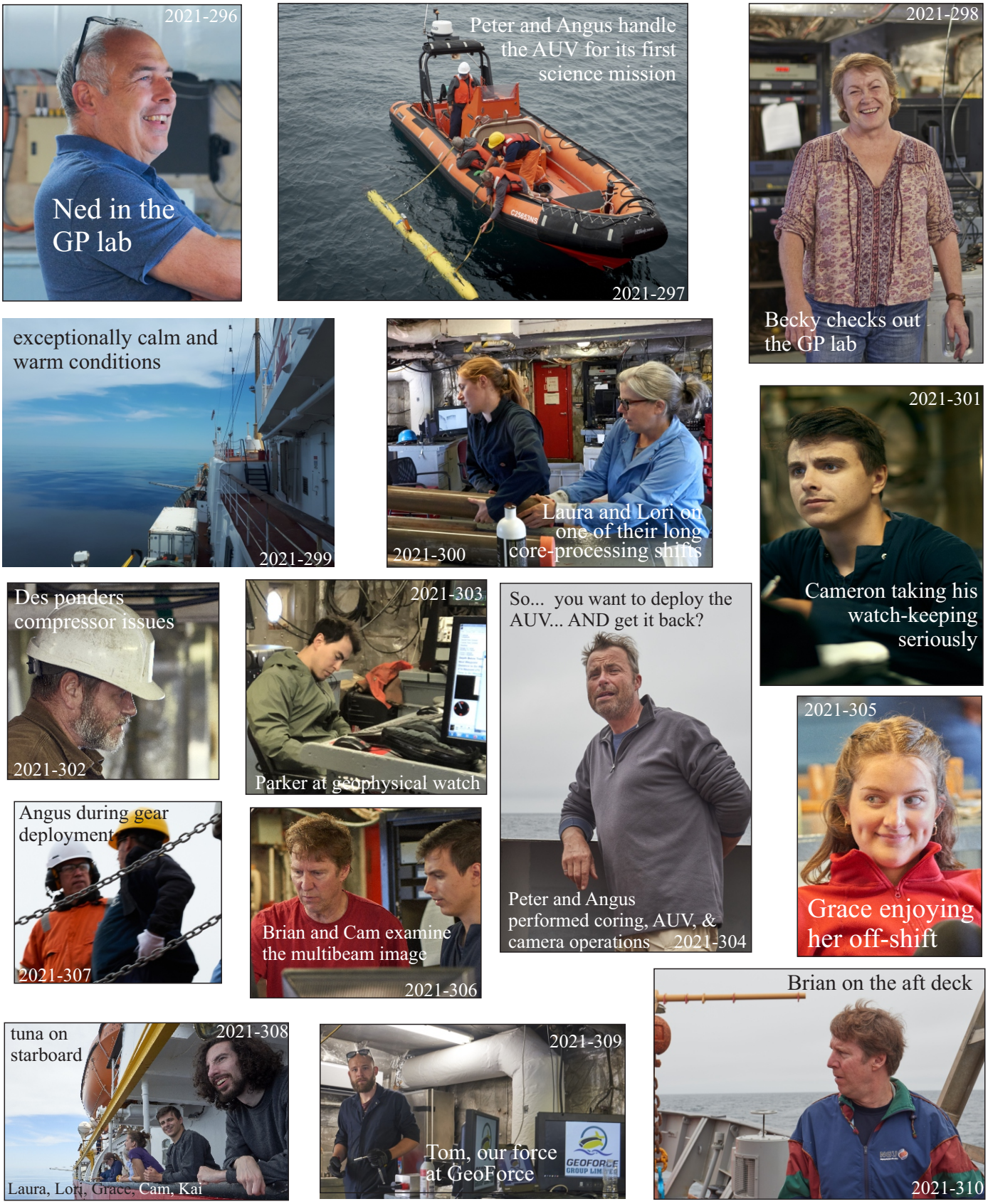

Figure 36. Photo collage from the cruise. (photography by A. Parker; NRCan photo numbers in corners).

Appendix VII: Cruise Narrative

Julian Day 203, Thursday July 22
Sailed at 0800 local; 11:00 UTC. All times are UTC unless otherwise stated or bracketed.
No harbour or basin trials; sailed directly out to Harbour approaches; Fog, light breeze SW, forecast slight wind increase. Operating 3.5 kHz; watches start. Considerable overtime for many GSC-A staff, especially the seismic crew. Nevertheless, occasional off-shift camaraderie (Fig. 37).
~1400 hrs; Lifeboat Drill while underway in Harbour Approaches area. Steam SE ~13 to 14 kts toward shelf-break for planned seismic SOL.

Good quality 3.5 kHz data during transit to study area. Good progress time-wise, so took decision to deploy camera near SOL site and begin geophysical operations at shift change (1800). Took slightly longer than expected for various reasons. Regulus (navigation input/display) in winch room not recording event positions so communicated via phones to GP lab. SSE drift established so positioned north of the target (small moraine) and took ca. 10-12 shots. Tracking of position relative to the OLEX target was effective but tedious. Need to install the OLEX and Okeanos (SW Nova multibeam) images in all Regulus machines (restricted to Mercator world projection parameters). Some bridge confusion about camera position nearby the planned SOL, because the SOL points had been inadvertently shifted in Bridge's Alderbaren (bridge navigation input/display). Successful flight but data not downloaded until next day because survey starting.

Figure 37. Grace, Laura and Kai sporting their new Hudson sweatshirts (photography by A. Parker. NRCan photo 2021-289).

Decision to start survey farther from the shelf break than planned simply because the shift timing was better. Start seismic deployment at 2100 (1800) JD203. First eel then GeoForce/Huntec, followed by guns. Ca. 1 kt. New helmsman (Coleen) training by Bill Naugle (2nd Officer). Plan is to extend the transit to the first coresite in the morning for at least an hour. Deployment took ca. 2.5 hrs.
Typical minor problems with air gun but apparently running well after 1st hour (by 0030 UTC). Some electrical leakage apparent on the streamer but won't know if record is critically affected until midnight shift and initial processing is done. Warm coolant water on the compressor necessitated slower fire rate.

GeoForce/Huntec performing well, but geology is very hard bottom. 3.5 kHz registration is about the same.

Added a coloured multibeam-3-D seismic coloured bathymetry record into Regulus display in the General Purpose (GP) lab for guidance in deep and rough terrain.

The goal of the first seismic line was to transit a dip line down the sediment fan axis while avoiding most failure scarps. However, at ca. 0100 UTC, sword fishing activity dead ahead (13 nM) was communicated by VHF. A rather cryptic message which took a bit to sort out when it was determined that the fishing line had beacons which eventually were recognized (beacon 02) on the radar on one end of the line as they came into distance range. Twenty mile long gear string so had to AC and divert from planned seismic line by over 20 nM. Line was consequently altered more than 20 n miles before re-altering course after passing the hazard. This placed the vessel relatively far from the morning core target, OK-11.

Post-processing display of air gun data (Boggild) proved the data were excellent. Some discussions about recording parameters (high sample rate and 7 sec long window) and decided to keep as is.

JD 204, Friday July 23
Sea is calm (Fig. 38). Steamed after gear recovery toward Okeanos 11 PC planned core site. Rigged and ready by 1400 UTC. Pengo winch pump leakage but repairs allowed continued use. Pump replacement planned for this evening. Successful core. Slow steam to next coresite following full core dissembly. Whales sited (Fig. 40). Coresite OK-12 on location at 1900 hrs UTC. Some delay invoked a change to GC to save ca. ½ hr and permit recovery around supper time.

Figure 38. Extreme calm on morning of JD 204 (photography by A. Parker. NRCan photo 2021-290).

GI gun needed blast hydrophone replacement and supply line need extension. This carried out before Des' shift started (OT). Deployment was a bit late and core processing extended beyond the 2000 hrs shift change.

Figure 39. Whale activity on the bow in calm waters, JD 204 (photography by A. Parker. NRCAN photo 2021-291).

JD 205, Saturday July 24
Initial seismic gear deployment (Fig. 40) and successful strike line collected at the distal Bacarro Channel Fan. Gear recovery at 0900 before re-rigging of the piston core. Long core (0002) recovery within a wide mass-failure chute with some surficial sand. Adjacent "control" core (0003) was short despite a well-stratified seismic signature. Recovery and processing by 2000 UTC followed by seismic deployment at shift change (2100). Gear deployed by 2200 UTC, extending the distal fan strike line westward followed by an up-hill dip line to the next day's core sites. Piston corer rigged and ready for morning.

Figure 40. Geophysics gear deployment (photography by A. Parker. NRCan photo 2021-292).

JD 206 Sunday July 25, 2021
Excellent weather holds; warm and extremely calm.

Successful night survey. Exceptional quality. Over 5 sec penetration. Very good overlap between Huntec and sleeve gun data. Weather flat calm. Forecast improving for Monday. Smooth operations with coring and improved efficiency with familiarization. Stations 6, 7 and 8 yielded successful and relatively long cores.

Two good piston cores recovered, one targeting two debris flow event ages and the other the base of the thick glacimarine section, generally exceeding 20 m thick, but at this location the lower half was exhumed along an undulating but near horizontal failure plane.

Figure 41. Whales spotted off the port side during some rest hours for some of Hudson's crew (photography by A. Parker. NRCan photo 2021-293).

JD 207 Monday July 26, 2021

Calm and warm weather continues (Fig 41). Some probability of windier (20 kts) conditions forecast for later in the day. Seismic deployment (Fig. 42) and successful seismic survey from previous night, covering more than planned due to good conditions and elevated survey speed. A strike line across the mid Baccaro Channel Fan produced very high resolution in the upper ½ second, allowing full overlap with equally good Huntec. Acoustic penetration to the multiple (over 3 seconds showed deep unconformities and salt diaper effects and a stark contrast to the glacial regime in the upper 100s milliseconds.

The plan to deploy the Gavia AUV (Fig. 43) on a multibeam-identified small but relatively recent failure was put in jeopardy as wind and waves rapidly increased. Though an early morning deployment was possible, the uncertainty of conditions worsening (as forecast) during the 5 hour mission raised concern. This was the first offshore, first science and first deep water deployment for the instrument and operation with borderline conditions was not ideal. With a wind forecast not ameliorating until too late in the day for the planned 5 hr deployment and thunderstorms in the immediate vicinity hampering FRC operations for a few hours, the Gavia plan was foregone

after much science and captain/crew deliberation. Rather, we began the transit to BIO with some science objectives underway.

Figure 42. Early evening seismic gear deployment underway on the afterdeck and flight deck. Angus, left and Des, right (and unidentified, centre) on the flight deck and Rob, our boatswain, below (photography by A. Parker. NRCan photo 2021-294).

Figure 43. Gavia Autonomous Underwater Vehicle (AUV) (photography by C. Greeves. NRCan photo 2021-295).

Core 0008, situated on a glacimarine mud-covered moraine-top unconformity on the south flank of LaHave Basin (previously unmapped) yielded 308 cm on the second triggering attempt.
At the Captain's suggestion, given that we had now transited out of the poor weather conditions, we resurrected the Gavia AUV deployment concept and selected one of the pre-planned missions on Sambro Bank, the "Russian hat" sponge colony site. The operation consists of FRC launch, crane lowering to the surface and man-handled transfer of the sling straps to the FRC. This is followed by manual ballasting (weighting) to achieve required minor positive floatation (only 3 lbs on a ~ 800 lb instrument), before the mission start. The AUV mission was shortened significantly (5 to 2 hours) due to daylight recovery constraints. The instrument dove at ~2000 hrs UTC. After only ~20 min an iridium signal was received indicating a self-aborted mission. Position was ca 1 nm distant. FRC deployed and instrument sighted and recovered after an updated position was radioed to the FRC. (~2045 UTC). FRC alongside at 2055.

Steamed homeward. Overnighted outside the Halifax Harbour approaches to arrive dockside in the morning (208). Demobilization began immediately. Most data (seismics, navigation, camera, cores) were processed in terms of completeness, quality control, and double redundancy copies before disembarking.