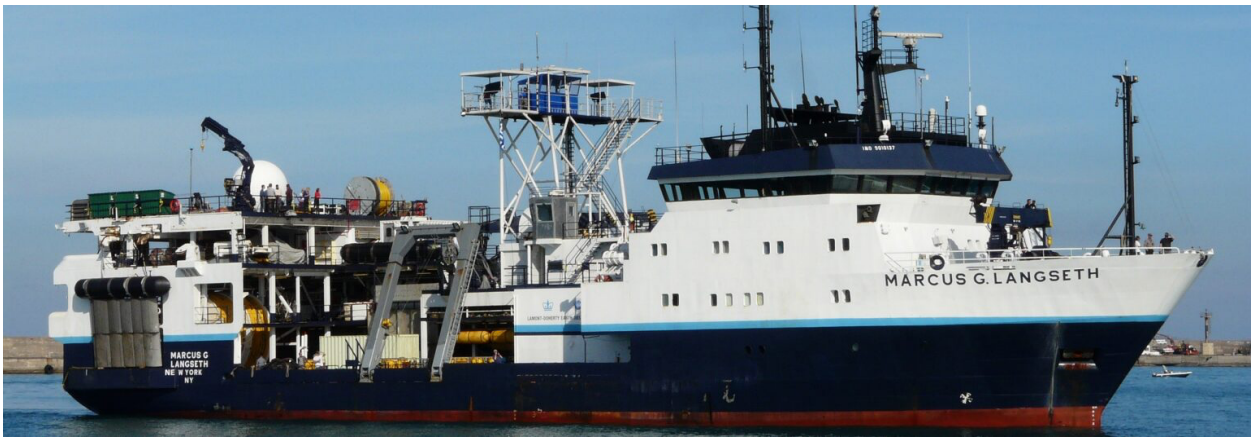
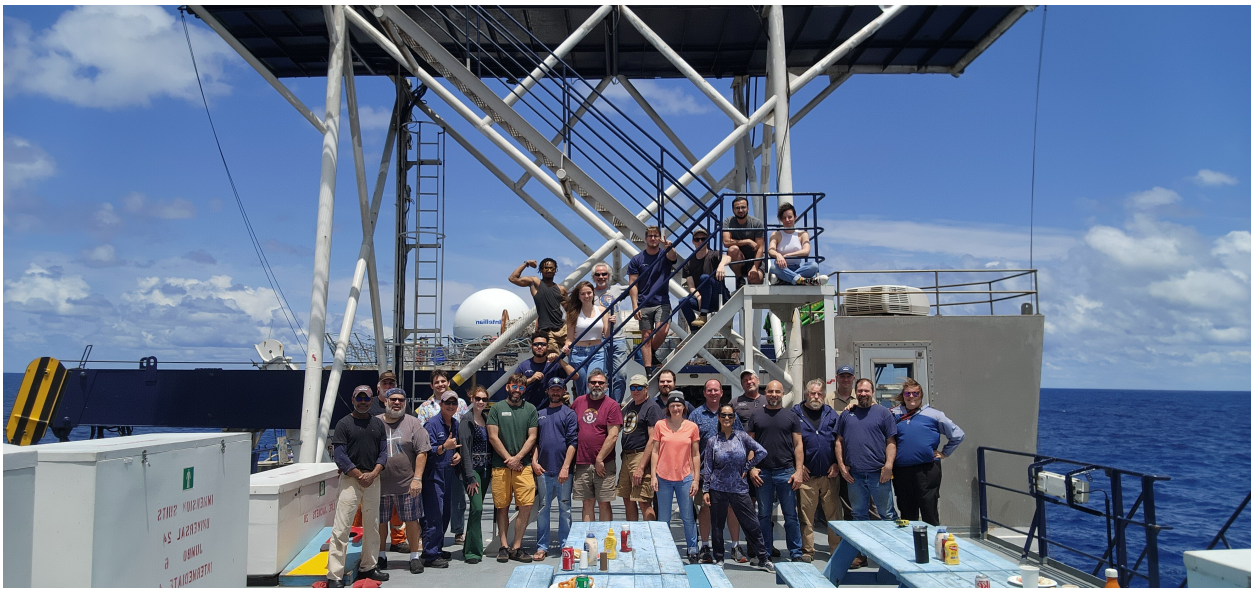
Cruise Report

Cape Fear research expedition

Cruises **MGL-2306**, *R/V Marcus Langseth*
MCS data





MGL2306 (MCS): Norfolk,VA – Morehead, NC
May 9 – June 2, 2023

Table of Contents

Cover ……..	1
Table of Contents ……...	2
1. Cruise Objectives ……	3-4
2. Cruise Summary …….	5-7
3. Daily Narrative ……...	8-14
4. Summary of multichannel seismic (MCS) data acquisition parameters	15-20
5. Summary of onboard MCS data analysis ……..……	21-34
6. Summary of acquisition parameters and processing of 3.5 kHz data ……	35-43
7. Summary of acquisition parameters and processing of multibeam ……..	44-78
8. Crew and Shipboard Scientific Party and Watches ……	79-82

Appendices:

Appendix A: Specifications on MCS equipment and acquisition parameters
Appendix B: Gravity and Magnetics data acquisition and processing
Appendix C: XBT: acquisition and onboard processing
Appendix D: More Information on data format
Appendix E: Marine Mammal Procedures and IHA

1. Cruise Objectives

We acquired a tightly spaced grid of high-resolution multichannel seismic (MCS) data, gravity and piston cores, and heat flow data inside and around the Cape Fear Slide (CFS; Hill et al., 2019) complex offshore North Carolina. In addition to the most recent mass transport deposits (MTDs), older, buried MTD complexes have been identified in seismic data, possibly as old as the late Oligocene. The widespread occurrence of MTDs throughout geologic time makes the region an ideal place to study the role slope failures play in building a passive margin, including failure frequency, spatial relationships between younger and antecedent failures, and processes that precondition or trigger failure, particularly shallow fluid migration.

Modern, deep penetration multi-channel seismic (MCS) data acquired aboard *R/V Marcus Langseth* in 2014-2015 as part of the NSF-GeoPRISMS Eastern North American Margin community seismic experiment (ENAM-CSE) and USGS-Law of the Sea project reveal previously unrecognized, yet massive MTD complexes buried below the CFS complex. The sparse existing seismic data provide rough estimates of the area and volume to be greater than ~16,400 km^2 with an average thickness of ~520 m. However, the estimated area and volume are quite speculative due to large regions without data coverage in the Northwest and Southeast. This cursory estimation of areal extent and volume indicate that this MTD complex is much larger than the CFS and Cape Lookout Slide combined, and among the largest MTD complexes identified worldwide (cf. Storegga: ~2400-3200 km^3; Haflidason et al., 2004). The identification of this MTD complex leads us to hypothesize that it provided controls on the failure location, trend and run-out distance of subsequent events in the Cape Fear Region. Another massive failure scarp was tentatively identified from newly released data from the Bureau of Ocean Energy Management (BOEM) by Hill et al. (2019), who postulated that the event is likely Upper Miocene in age. Numerous smaller, younger events are identifiable on all these seismic lines as well. Again, due to the large spacing between the existing modern seismic data, it is not possible to confidently map their size (i.e. areal extents, run-out distance, thickness), their trend (i.e. paths that the event(s) follow) and provide an estimate of their volume.

The Cape Fear region is a natural location for a study of submarine landslide history on the ENAM through the Neogene during passive margin evolution due to existing evidence of a long history of slope failure that is intricately linked with margin building processes. At the same time, the stratigraphic complexity evident in the ENAM-CSE data and the presence of salt diapirs create challenges for interpreting subsurface features. While a large amount of seismic data is available on the shelf and upper slope, the mid-slope and deeper areas have very sparse data coverage, which precludes any sort of detailed interpretation of the older MTDs apparent in the existing seismic data. This study represents a major step forward in our understanding of slope failure through time. The primary objectives of the proposed research are to (1) seismically image MTDs and associated stratigraphy in the Cape Fear region; (2) combine the new high-resolution MCS data with existing seismic data and ODP borehole data to interpret number of events, timing, source areas, volumes, areal extent and runout length, and bounding surfaces of MTDs and extract sediment physical properties for the uppermost MTDs; and (3) use interpretations of high-resolution

MCS data and analyses of sediment cores to assess and model internal characteristics of MTDs and surrounding sediments, including deformation style, present-day fluid flow, pore pressure and temperature distribution, and the presence of gas.

2. Cruise Summary

Cruises MGL2306 aboard the R/V Marcus G. Langseth lasted 33 days, departing Norfolk, VA on May 9, and returning to Port Canaveral on June 10, 2023.
MGL2306 achieved all the core data acquisition objective and was a success. During this first Leg, in total, we acquire 3666 km of multichannel seismic data along and across the slope and rise of the Eastern North America continental rifted margin, including within and outside the Cape Fear slide complex. In addition to seismic data, we also acquired a suite of other geophysical and oceanographic data (see Appendices).

Overview of cruise activities:
May 9: departure from Norfolk, VA at high tide (mid-day, local time)
May 11-June 2: Acquisition of multichannel seismic data
June 3: Day in Morehead, crew change.

MCS shooting:
After transiting to our survey area, we deployed the 6 km long streamer and the 2-string, 18 element, 3300 cu.in airgun array. Deployment went smoothly. After the gear was deployed, from May 11 to May 19, we shot continuously. We acquired data from Line MGL230601P01 to Line MGL2306019P17a. Because of a storm, which started on May 18, guns and streamer (especially birds) were having some technical issues. We waited for the storm to calm down and on May 20, we recovered both the streamer and guns, fixed them and redeployed them. Between May 20 and May 26, we acquired data from Line MG L2306020P14R to Line MGL2306048P40. At the end of Line P40, when the second storm had passed, we decided to recover the streamer because birds 9 to 16 were having some issues. Our thoughts are that we probably caught something such as fishing gear. From May 26 to June 2, we acquire the rest of the primary lines and some short contingency lines (from Line MGL2306049P41 to Line MGL2306059P51).
Overall, the data acquisition went well although we had numerous airgun issues, especially at the beginning of the cruise. Some of them could be due to (1) the lead-in interfering with the guns and in particular the first cluster on both strings as we were towing both the streamer and the guns at the same depth, (2) the fact they had not been used for several months. In addition, as expected, our study area is a challenging area to acquire MCS data because of the strong currents due to the gulf stream. The strong currents were affecting both our ability to maintain a constant speed and the streamer feathering. Our average speed when acquiring seismic data was 4.109 knots which is low for towing a 6 km long streamer.
As mentioned before, we experienced two storms with some high seas during data acquisition. During these storms (May 18-20, May 25), the quality of the data we acquired was lower with some strong swell noise on the streamer.
During the first leg, we had only one shutdown on Line MGL2306010P09 (SP44397-SP44480) due to a turtle sighting.

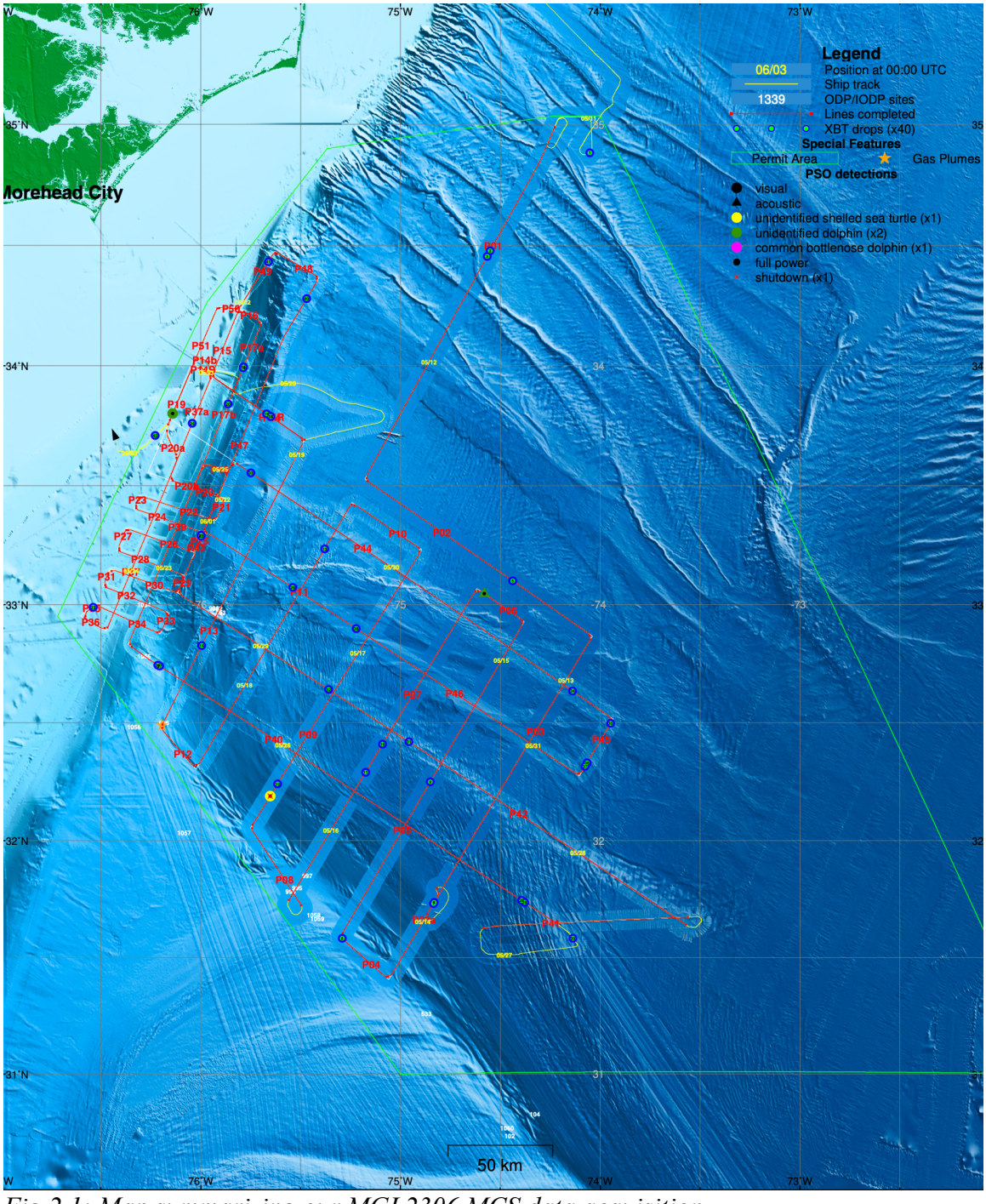
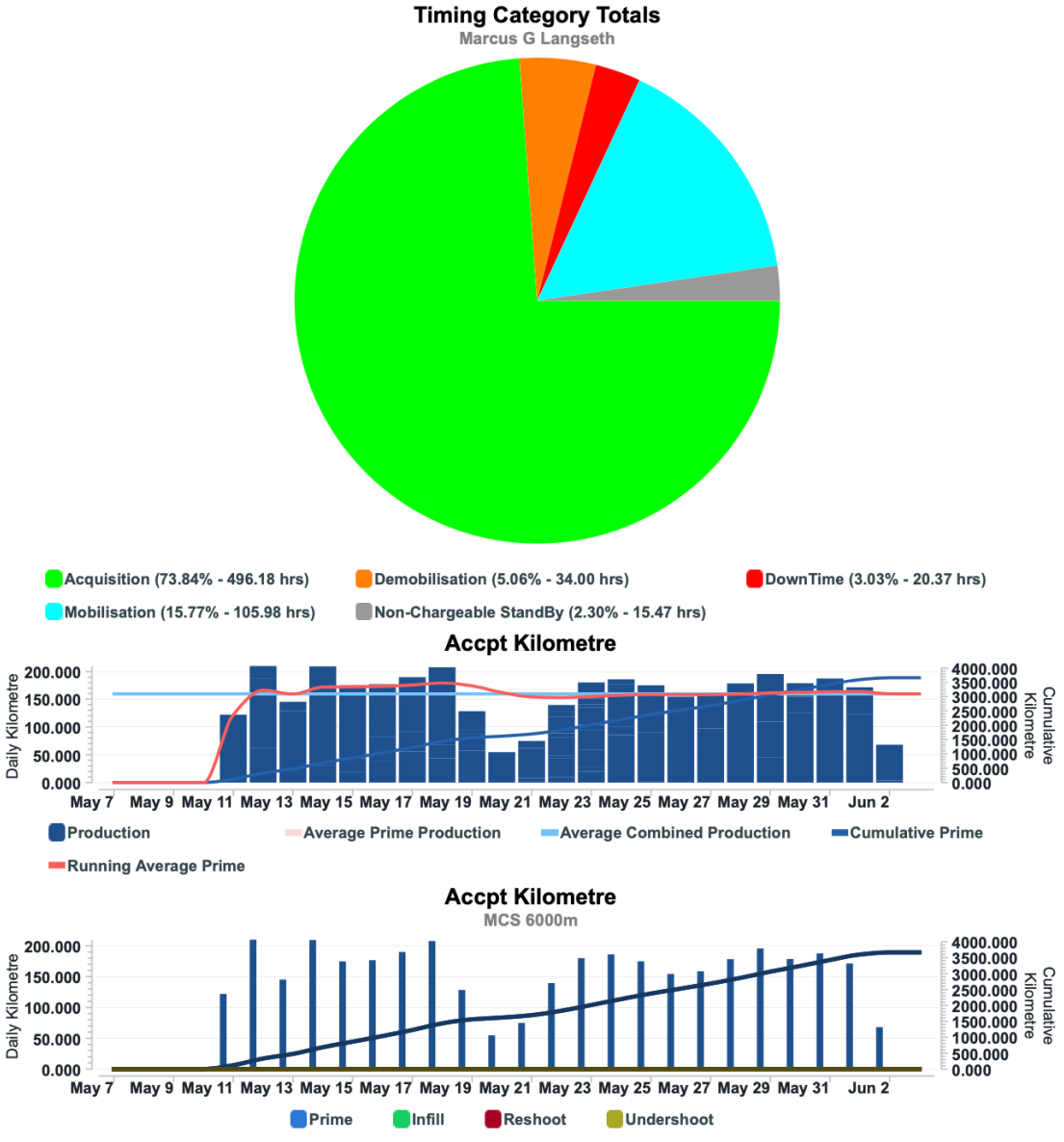


Fig.2.1: Map summarizing our MGL2306 MCS data acquisition



Timing categories for Leg 1.

3. Daily Narrative

Times are in UTC (local time = UTC time – 4hrs)

JD 129 (Tue. May 9). We left the NOAA dock in Norfolk at 16:59 as we had to wait for high tide. Weather was nice and seas were calm. Once we passed the Sea Gull pier and that the water depth was deep enough, we started to acquire chirp (Knudsen 3.5 kHz) data at 20:18 [*lat: 36.904268, long: -75.922490*] and multibeam bathymetry data at 21:30 [*lat: 36.777307, long: -75.922490*]. We continued transiting to our survey area until the end of the day.

JD 130 (Wed. May 10). From 00:00 to 10:00, we continued our transit to our survey area. At 10:06, we started deploying the tail buoy and the streamer. About half way through the deployment, we realized that we could not see GPS signal from the tail buoy and we had some issues with the streamer tail acquisition and power unit (TAPU) as well. Streamer and tail buoy were thus recovered. Tail buoy was back on deck at 16:30. At 17:31, tail buoy was ready with new antenna and at 18:35, the TAPU was replaced. At 21:57, the first Expendable Bathythermographs (XBT #1 T-5) was launched to measure velocity in the water column [*lat: 34.882335 long: -74.0530025*]. We continued deploying the streamer until the end of the day.

JD 131 (Thu. May 11). Continued deploying streamer. Head float was deployed at 03:16 and Passive Acoustic Monitoring (PAM) system at 04:06. Started deploying the source at 04:59 and finished deploying it at 05:40. Protected Species Observers started the pre-watch at 08:06 and we started the ramp up of the source of at 9:03. Ramp up was completed at 09:25. Start Of Line (SOL) MGL2306001P01 – Seq 1 – First good shot point (FGSP) 107 at 09:59. Magnetometer (Maggie) was deployed at 11:35. XBT (#2) was launched at 17:28 and as this one failed early, another one (#3) was launched at 17:47. Continued shooting until the end of the day.

JD 132 (Fri. May 12). Continued shooting MGL2306001P01 profile. End of the Line (EOL) was at 07:17 with the last good shot point (LGSP) being 7440. We started the acquisition of profile MGL2306002P02 (Seq 2 – FGSP: 8057) at 07:26. We launched a XBT T5 at 16:33. We ended MGL2306002P02 – Seq 2 – LGSP 13118 at 21:25. We started Profile MGL2306003P03 (Seq 3 – FGSP 14074) at 21:48. Continued shooting until the end of the day.

JD 133 (Sat. May 13). This is the day gun issues started to arose more and more… At 02:45, Gun 8 on string 2 (S2G8) started auto-firing. String 2 was thus disabled and we continued shooting with one string (1650 cu.in). Recovery of Array 2 started at 2:45. S2G8 was fixed and array 2 was redeployed at 4:15. We started acquiring data with full volume (3300 cu.in) at 04:30 (FGSP 16374). About half an hour later, at 04:59, Gun 1 on string/array 1 failed. Array 1 was disabled and we kept shooting string 2 only so with half the volume (1650 cu.in). Array 2 was recovered at 09:12, fixed and redeployed at 11:46. Array 2 was back online and we resumed shooting with full volume at 12:10 (FGSP = 18348). We launched an XBT T5 at 16:45 but as it failed so we launched another one at 16:50. Gun 2 on string 1 failed at 17:21, gun 2 string 1 was disabled at SP 19962 – new volume was 2940 cu.in until the decision was made to pick up the array 1 for repair of G2S1. Array was disabled for recovery at 17:52. We ended acquisition of MGL2306003P03 at 17:52 – Seq 3 – LGSP 20092 as we looped around. At 19:49, string 1 was in position and string 2 was being deployed. At 20:05, all strings were in position. We initiated ramp up at 20:32, ramp up was

complete at 20:55. At 20:56, string 1 was disabled to swap hydrophone card and was enabled again at 20:58. At 21;12, we started acquiring data on the rest of the profile 3 that we called line MGL2306004P03a (Seq 4 – FGSP 20579). At 22:26, an air-leak was detected at the head of gun string 1. Gun string 1 was disabled and we continued shooting with half the source volume (1650 cu.in) (SP 20865). Recovery of String 1 was initiated at 22:32 on May 13. At 22:53, the string 1 was on deck. Cluster (G1S1) was fixed and redeployment of string 1 started at 23:19. At 23:20, string 1 was fully redeployed and all string were in position. Started shooting with full volume at 23:34 (FGSP = 21129).

JD 134 (Sun. May 14). Continued shooting MGL2306004P03a profile. We finished acquiring data along profile MGL2306004P03a at 04:08 (Seq 4, LGSP 22491) at 4:02 and started acquiring data along profile MGL2306005P04 (Seq 5, FGSP 23066). XBT was launched at 07:27 (XBT#8). At 15:30, S2G1 started auto-firing. We disabled string 2 at 15:15 and kept shooting with a volume of 1650 cu.in. String 2 was recovered and fixed on deck. At 16:18, array 2 was redeployed. All strings were in position at 16:38 and string 2 was enabled at 16:39. Another XBT was launched that day at 16:48. Continued shooting until the end of the day.

JD 135 (Mon. May 15). At 01:16, Gun 2 string 2 (cluster) misfired due to a sensor line electrical leakage (SP 31 467). String 2 was disabled (SP 31501). Recovery of string 2 began at 01:31. String 2 was on deck for repairs at 01:50. String 2 was fixed and redeployed to stern at 2:24 for testing. First gun on the string 2 was enabled for testing (SP 31750 – new volume = 1650 +360) at 2:33. Gun 2 on string 2 was enabled for testing (SP 31751 – new volume 2370 cu.in). Gun 1 and 2 of string 2 were disabled – New volume was 1650 cu.in. Sensor card was swapped in GCU2. Gun 1 string 2 was enabled (volume of 2010 cu.in). Leakage was still spiking on String 2. Gun 2 on string 2 was enabled (SP 31768) (volume of 2370 cu.in). No change was observed. Gun 1 and 2 on string 2 were disabled (new volume of 1650 cu.in) at 2:39. At 2:42, string 2 was recovered again for the same leakage. At 02:52, string 2 was on deck for repair. Finished acquiring MGL2306006P5 (Seq 6, LGSP 31839) at 03:03 with half the volume (1650 cu.in). We started acquiring MGL2306007P06 (Seq 7 – FGSP 32042) at 03:18 also with half volume. Array 2 was fixed and started to be redeployed at 4:19. Array 2 was back in position and we started shooting with full volume at 04:34 (FGSP = 32882). We finished MGL2306007P06 profile (Seq 7 – LGSP 33030) at 07:31and started MGL2306008P07 (Seq 8 – FGSP = 33560) at 07:44. At 17:07, we launched a XBT (XBT #10) and another one at 19:09 (XBT #11). We continued shooting Profile 07 until the end of the day.

JD 136 (Tue. May 16). Continue shooting MGL2306008P07 profile. We finished profile MGL2306008P07 (Seq 8 – LGSP 40348) at 05:02. Compressor failed at 06:43 during the loop between P07 and 08 and source were disabled. We started the ramp-up at 7:00 and ended it at 7:23. Started MGL2306009P08 (Seq 9 – FGSP 41863) at 7:24 and ended this profile at 12:35 (EOL MGL2306009P08 - Seq 9 – LGSP 43455). Started acquiring data from MGL2306010P09 (Seq 10 – FGSP 44067) at 12:49. At 13:58, we had to shutdown for turtle seeing (source volume = 0 cu.in). We returned to full volume (3300 cu.in) at 14:14 (FGSP 44480). At 15:44, we launched an XBT (#12) Continued shooting until the rest of the day.

JD 137 (Wed. May 17). Finished acquiring data from profile MGL2306010P09 (Seq 10 – LGSP 50080) at 06:05. Started MGL2306011P10 (Seq 11 – FGSP 50563). At 6:18, LDS data logger

crashed and was restarted. At 11:03, we finished MGL2306011P10 (Seq 11 – LGSP 52010). And 10 min later, at 11:13, we started MGL2306012P11 (Seq 12 – 52358). At 14:13, an XBT (#13) was launched. At 14:28, the gun 4 on string 4 was disabled after multiple auto-fire, we continued without this 180 cu.in gun. New volume is 3120 cu.in (FGSP 53572). At 14:50, we disabled array 2 for recovery, new volume was thus 1650 cu.in. At 14:50, the array 2 was recovered and fixed. Array 2 was back in position at 16:48 and we were back to full volume (3300 cu.in) (FGSP 54112). AT 14:48, we lowered our speed through water to 4.8 knots due to weather. LSP of the day was 56453.

JD 138 (Thur. May 18). Finished MGL2603012P11 (Seq 12 – LGSP 58212) at 4:48. At 04:57, we started line MGL2306013P12 (Seq 13 – FGSP 58577). Ended line MGL2306013P12 (Seq 12 – LGSP 59508) at 07:40. Started line MGL230614P13 (Seq 14 – FGSP 60076) at 7:52. No chirp record between 8:52 and 09:32). Glas Flare was detected in the water column at 07:46. Made the water column team Jo and Louis-Marin very happy. At 12:25, we launched an XBT (#14). At 12:37, magnetometer was recovered because of rough seas. This is the beginning of a long chain of technical issues. Due to the bad weather and high seas, the streamer depth was set to 10m as it came almost to the surface. At 22:56, Gun 4 on string 1 failed to detect fire due to open sensor line. New volume 3120 cu.in (SP 65334). At 22:59, this gun was disabled. LSP of the day was 65690.

JD 139 (Fri. May 19). We ended line MGL2306014P13 (Seq 14, LGSP 65994) at 00:55. We started line MGL2306015P14 (Seq 15, FGSP 67066) at 1:03. We lost connection to the tail buoy at 3:26. High seas during the entire day; lot of noise on the streamer even it is still at 10m depth. LSP of the day was 65690. At 04:26, we switched the Tx Power of the Knudsen to 2 as we were reaching the slope. At 05:08, we switched the multibeam data system to medium mode as auto mode was not working. At 08:03, the multibeam system was disabled at it was having navigation issues. At 08:12, the multibeam system was back running and in medium mode. At 06:54, we ended MGL2306015P14 (Seq 15 – LGSP 69070). We started line MGL2306016P15 (Seq 16 – FGSP 69632) at 07:09. At 07:09, Gun4, string 1 was disabled, we were using a 17 element with a volume of 3120 cu.in. At 07:21, Gun 8 on string 1 was disabled after auto-firing. We continued shooting with a 2900 cu.in volume. At 07:27, array 1 was disabled because of the gun 8, string 1 (S1G8) auto-firing. At 09:44, multibeam system angle at starboard was changed to 60. At 10:15, multibeam system was switch to deep mode and with an angle of 68. At 09:57, we ended line MGL2306016P15 (Seq 16 – LGSP 70797) and array 1 was disable at the start of MGL2306017P16 profile (Seq 17 – FGSP 71105) at 09:57. At 11:16, we ended line MGL2306017P16 (Seq 17, LGSP 71450). We started MGL2306018P17 (Seq 18 – FGSP 71031) at 11:32 and immediately aborted it because of bad numbering (LSP 71034). Started a new line MGL2306019P17a (Seq 19 – FGSP 72044) at 11:38. We launched an XBT (#15) but it failed so we ended up deploying another one XBT#16 at 16:51. We ended line MGL2306019P17a (Seq 19 – LGSP 73370) at 19:53. At the same time, we did an internal firing of guns for testing before recovery (Source volume of 3300 cu.in). At 19:59, the testing was completed and all guns were disabled. At 20:20, we waited for turn completion to prevent the tangling of the lead-in and source during retrieval of source. At 20:43, we slowed down to 3.5 knots and we initiated recovery of string 2 for troubleshooting. At 21:07, the string 2 was on deck and we started the recovery of string 1. At 21:29, all strings were on deck. At 21:35, we prepared for the streamer recovery to be able to repair the tail buoy and slowed down to 3 knots. At 21:41, we commenced the recovery of the lead-in and at 21:42 we

recovered PAM cable. PAM was on deck at 21:49 and at 21:57, the streamer head float was on deck. At 21:58, we slowed down to 2 knots and started recovering the streamer. At 22:49, while recovering the streamer, we noticed that the bird 12 position was missing a SRD (streamer recovery device) (probably lost at sea). At 23:53, the streamer was onboard. At 23:54, we started lifting up the tail buoy on deck. Long day!

JD140 (Sat May 20). The tail buoy was on deck at 00:00. Trouble-shooting the Tail buoy until 05:22. We started redeploying the tail buoy at 05:22 followed by the streamer. The last bird was deployed at 08:42. At 9:25, we redeployed the magnetometer. At 09:04, the head float was redeployed and at 09:26 PAM was deployed. We started redeploying the airgun array at 9:39. PSO pre-watch started at 09:43. Continued deploying the airgun array, array 2 at 10:04. PSO pre-watch was completed at 10:14. At 10:39, all the sources were in position. We initiated the ramp up at 12:26 and it ended at 12:49. We started line MGL2306020P14R (Seq 20 – FGSP 74000) at 12:54. At 15:22, we launched a XBT (#17) but it failed so we relaunched another one (#18) and another one XBT (#19). At 19:11, the ping mode from the multibeam bathymetry system was set to auto. The medium mode auto was selected for this depth (CW pulse). Airleak on string 1 was detected. At 20:10, we disabled the string one. The now volume was 1650 cu.in. We started recovering string 1 at 20:16. String 1 was onboard at 20:35. Started deploying string 1 at 21:22 and finished deploying string 1 at 21:35. We enabled String 1 at 20:36 with now full volume of 3300 cu.in. Continued shooting for the rest of the day.

JD141 (Sun. May 21). We aborted line MGL2306020P14R (Seq 20) at 00:55 as we were moving very slowly. We reconfigure to shorter SP distance. We initiated MGL2306021P14S (Seq 21 – FGSP with a 8 m spacing). We ended this line early as we were not making progress (SOG of 0.2 knots) due to the 5.3 knots Gulf Stream currents. At 02:05, we ended MGL2306021P14S (Seq 21 – LGSP 78558). We cycled internally while reevaluating the plan. Eventually, the guns were disabled and compressor turned off at 03:12 while reevaluating the plan. We went back to Line 17. Started PSO pre-watch at 05:45 and ended the PSO pre-watch at 06:15. We started the ramp up at 06:16 and ended it at 06:38. We started line MGL2306022P17b (Seq 22 – FGSP 80130) at 07:00. At 22:17, we ended line MGL2306022P17b (Seq 22 – LGSP 82263). At 22:17, we cycling in internal mode at FSP 82264. We started line MGL2306023P20 (Seq 23 – FGSP 83041). At 23:07, we set speed targets to 5 knots (SOG/STW). The last shot point of the day was 83574.

JD142 (Mon. May 22). At 00:01, we ended line MGL2306023P20 (Seq 23 – LGSP 83576). We started line MGL2306024P21 (Seq 24 – FGSP 84045). At 00:20, String 1, gun 4 stopped firing (New volume of 3120 cu.in). At 00:20, the volume changed due to trouble shooting on String 1 gun 4, new volume is 3080 cu.in. At 00:23, we swapped string, 1 gun 3 and string 1, gun 4 in patch. String 1, gun 3 fired on Channel 4 (new volume of 3260 cu.in). At 00:26, we swapped string 1, gun 4 back (new volume of 3080 cu.in). At 00:44, we disabled string 1 (new volume of 1650 cu.in). At 00:48, we started recovering string 1. At 01:04, the string 1 was on deck for repairs. We ended Line MGL2306025P21 (Seq 24 – LGSP 84417) at 01:57 and started Line MGL2306025P22 (Seq 25 – FGSP 85064) at 02:05. At 02:31, we deployed string 1. At 02:41, the string 1 was back and all the guns were in position. At 02:44, the source 1 was enabled (SP 85253 – volume of 3300.cu.in). At 02:44, FGSP 85254 due to timing issues. We ended Line MGL2306025P22 (Seq 25 – LGSP 86465). At 06:55, we started MGL2306026P23 (Seq 26 – FGSP 87029). We ended Line MGL2306026P23 (Seq 26 – LGSP 87203) at 08:07. Started Line MGL2306027P24 (Seq 27

– FGSP 87537) at 08:21. At 12:49, the array 1 was disabled after end of the line for recovery, new volume is 1660 cu.in. We ended Line MGL2306027P24 (Seq 27 – LGSP 88811) at 12:49. At 13:09, we started the line MGL2306028P25 (Seq 28 – FGSP 89065) at 13:09. At 13:04, we started the recovery of array 1. At 13:42, we launched an XBT (#22). At 14:14, the string 1 was fixed and redeployed. Array 1 was back in position at 14:39. We ended Line MGL2306028P25 (Seq 28 – LGSP 89393). At 14:58, the array 1 was enabled at the start of internal cycling on the line change – we're back to full volume (3300 cu.in). At 15:13, we started Line MGL2306029P26 (Seq 29 – FGSP 90095). We ended the line MGL2306029P26 (Seq 29 – LGSP 91298) at 19:38. At 19:42, we started line MGL2306030P27 (Seq 30 – FGSP 92030) and ended it at 21:18 with LGSP 92398. At 22:32; we started line MGL2306031P28 (Seq 31 – FGSP 95048).

JD143 (Tue. May 23). We ended line MGL2306031P28 (Seq 31 – LGSP 94308) at 1:08. We started line MGL2306032P29 (Seq32 – FGSP 95048) at 01:16 and ended it at 02:24. We started line MGL2306033P30 (Seq 33 – FGSP 96045). At 05:52, we switched to external for improving water column quality for coring sites. We ended line MGL230633P30 (Seq 33 – LGSP 97305). At 07:13, we switched phase to 200 m for increasing resolution. At 07:29, we started line MGL2306034P31 (Seq 34 – FGSP 97587). We ended line MGL2306034P31 (Seq 34 – LGSP 97810) at 08:26. We started line MGL2306035P32 (Seq 35 – FGSP 98059) at 08:34. At 10:22, we were back on internal mode and 500 m range once crossing 1000 m. Multibeam was also switched to deep. At 12:08, we ended line MGL2306035P32 (Seq 35 – LGSP 99299). We started line MGL2306036P33 (Seq 36 – FGSP 99551) at 12:16. At 13:42, we ended Line MGL2306036P33 (Seq 36 – LGSP 99888). At 13:51, we started line MGL2306037P34 (Seq 37, FGSP 100060). At 15:36, we switch the Knudsen system to external mode. At 17:54, we ended line MGL2306037P34 (LGSP 101296). At 18:00, we started line MGL2306038P35 (Seq 38, FGSP 102018) and ended it at 19:32 (LGSP 102278). At 19:40, we started line MGL2306039P35 (Seq 38, FGS 103095) and ended it 20:57. At 21:04, we started line MGL2306039P36 (Seq 39, FGSP 103095) and ended it at 20:57 (LGSP 103512). We started line MGL2306040P37 (Seq 40, FGSP 104066) at 21:04.

JD144 (Wed. May 24). We ended line MGL2306040P37 (Seq 40 – LGSP 107485) at 06:00. At 06:09, we started MGL2306041P20a (Seq 41 – FGSP 108012). We ended line MGL2306041P20a (Seq 41 – LGSP 108012). At 07:22, the sea state changed to heavy seas. At 07:34, we started line MGL2306042P19 (Seq 42 – FGSP 109484). At 07:38, we turned off and recovered Maggie due to the rough seas. At 10:11, we ended line MGL2306042P19 (Seq 42 – LGSP 110092). At 10:23, we started lines MGL2306043P14b (Seq 43, LGSP 110692) and ended it at 11:45. We started line MGL2306044P37a (Seq 44 – FGSP 111042). At 15:38, we changed the scale of the Knudsen to 500m. At 20:10, we ended MGL1306044P37a (Seq 44 – LGSP 113037). We started Line MGL2306045P20b (Seq 45 – FGSP 114068). At 21:16, the Knudsen changed to internal triggering. We ended MGL2306045b (Seq 45 – LGSP 114921) at 22:36. At 22:36, we extended line change to shoot line 39 to the south. At 23:14, we ramped up following clearance at SP 114922. The ramp up was complete at 23:36 with full volume (3300 cu.in). At 23:37, we started line MGL2306046P18 (Seq 46 – FGSP 116001). Last SP of the Day was 116126.

JD145 (Thu. May 25). We ended Line MGL2306046P18 (Seq 46 – LGSP 116431) at 1:00. At 01:08, we raised the streamer back up at 10 m depth. We started Line MGL2306047P39 (Seq 47 – FGSP 120433) at 01:15. At 08:00, we disabled Gun 2 on string 2 after multiple failures (17 guns, 3120 cu.in). At 13:05, array 2 was disabled for recovery (9 guns, 1650 cu.in – FSP 121897). At

13:26, we recovered array 2. At 14:31, we ended Line MGL2306047P39 (Seq 47, LGSP 122150) with a volume of 1650 cu.in. At 14:45, we started Line MGL2306048040 (Seq 48, FGSP 123079) – 1650 cu.in at the start. At 14:51, we redeployed array 2 after replacing the broken pigtail. At 15:08, the array 2 was back in position and enabled (18 guns enabled). At 15:43, the streamer depth was set to 6m. At 17:02, the magnetometer was deployed and turned on. Kept shooting for the rest of the day.

JD146 (Fri. May 26). At 02:05, Streamer surfaced (birds 9-16) because we probably caught something (fishing gear?). At 03:23, the streamer was set to 8m (SOG was 6 knots). At 05:28, the SOG was back to 5 knots. At 13:30, the 10 shots (SP 13652-131661), array 2 failed to fire – 9 guns – 1650 cu.in. At 16:06, we recovered Maggie. We ended Line MGL2306048P40 (Seq 48 – LGSP 132628) at 16:10. At the same time, 16:10, the sources were disabled ahead of recovery. At 16:18, we were recovering array 2. At 16:35, the array 2 was onboard and we started recovering array 1. At 16:49, array 1 was onboard. At 17:04, PAM was onboard as well. At 17:10, we started to recover the front float. At 19:25, the tail buoy was at the stern, ready to be deployed. At 19:37, we started deploying the streamer.

JD147 (Sat. May 27). At 00:21, the streamer was fully deployed and was set to 15m. At 00:28, PAM was deployed. At 00:38, we deployed array 1. At 00:49, array 1 was fully deployed. At 00:50, the vessel was turning to line 41. At 01:23, we deployed array 2. At 02:16, we initiated ramp up (SP 132629) and at 02:38, the ramp up was complete (SP 132673 – full volume of 3300 cu.in). At 02:46, we started Line MGL2306049P41 (Seq 49 – FGSP 133632). At 03:19, we started deploying Maggy and at 03:24, it was fully deployed. We ended line 2306049P41 (Seq 49 – LGSP 137510). At 14:05, we recovered array 2 to look into rope and separation. At 14:29, the array 2 was back in position. We started ramp-up at 15:38. At 15:59, the ramp up was complete. We started line MGL2306050P42 (Seq 50 – FGSP 138761). At 23:56, the EM122 froze.

JD148 (Sun. May 28). At 00:02, the EM122 was back online. At 12:59, we launched an XBT (T5). At 19:01, we launched another XBT (T5). We continue shooting line MGL2306050P42 for the rest of the day.

JD149 (Mon. May 29 – BBQ and group photo day). We finished Line MGL2306050P42 (Seq 50, LGSP 150175) at 6:44. We started Line MGL2306051P43 (Seq 51, FGSP 151077) at 06:53. At 06:58, the array 1 was disabled before recovery to adjust separation (9 guns, 1650 cu.in, SP 151105). At 07:13, the array 1 was back online (18 guns, 3300 cu.in, SP 151196). 07:15, the array 2 was disabled before recovery to adjust separation (9 guns, 1650 cu.in). At 08:29, we turned starboard (~30°) to help recover array 2. At 09:28, the array 2 was back in position with a full volume of 3300 cu.in. At 13:51, we ended Line MGL2306051P43 (Seq 51, LGSP 153606). At 14:05, we started Line MGL2306052P44 (Seq 52, FGSP 154093). At 14:57, we launched an XBT (T5). At 18:51, the Knudsen (Chirp) stopped recording. At 19:21, we started a new line for the Knudsen. At 19:26, we put the Knudsen back into multi-ping mode (internal triggering). At 19:39, we stopped the Knudsen again as it stopped transmitting. At 20:20, we restarted it. At 20:06, the multi-ping was set to OFF.

JD150 (Tue. May 30). At 12:13, we launched an XBT (T5). At 13:24, the Knudsen received the signal out of sync with multi-ping enabled (noise on receive). We turned it off and started a new

file. It looked ok. At 13:43, the Knudsen is still not getting a good receive signal. We tried a restart of the controller and PC. We stopped the file recording. At 14:11, the Knudsen is still not getting a good receive signal. The topside controller was reset. Still not working properly. At 14:52, we ended Line MGL2306052P44 (Seq 52, LGSP 162560). At 14:53, the array 1 was disabled for recovery to address suspected leak (9 guns, 1650 cu.in). At 14:59, the Knudsen was back up and running, mutli-ping mode is off. It is recording data. At 15:01, we started Line MGL2306053P45 (Seq 53, FGSP 163060, 9 guns, 1650 cu.in). At 15:05, we launched an XBT (T5). At 15:19, we recovered array 1. At 16:28, the Knudsen was stopped for trouble shooting. At 16:28, we deployed string 1 following air leak repair. At 16:38, the string 1 was redeployed an enabled (FGSP 163435). At 18:24, we redeployed a XBT (T5), it failed re-launched another one (T5) at 18:38. At 18:45, the Knudsen was re-started. At 18:57, the Knudsen was stopped again. At 19:15, we ended Line MGL2306053P45 (Seq 53, LGSP 164200). We started Line MGL2306054P45 (Seq 54, FGSP165042. At 19:40, there was a broken rope on tail of string 1 (SP 165215). At 20:08, string 1 was disabled. At 20:13, we recovered string 1 due to broken depth rope. At 20:30, the Knudsen was re-started for trouble shooting. At 20:42, the Knudsen appeared to be working. At 21:00, we redeployed string 1. At 21:17, string 1 was in position and enabled (SP 165405). Continue shooting for the rest of the day.

JD151 (Wed. May 31). At 12:23, we launched an XBT (T5). At 17:30, we re-launched an XBT, T5. At 23:21, we ended line MGL2306054P46 (Seq 54, LGSP 173370). At 23:30, we started Line MGL2306055P47 (Seq 55, FGSP 175061).

JD152 (Thur. June 1). At 11:59, we set the Knudsen back to 500 (had been set to 100). We launched an XBT. At 13:25, we ended Line MGL2306055P47 (Seq 55, LGSP 180150). At 13:32, we started Line MGL2306056P48 (Seq 56, FGSP 181050). We ended Line MGL2306056P48 (Seq 56, LGSP 181899). At 18:42, we started Line MGL2306057P49 (Seq 57, FGSP 182021).

JD153 (Fri. June 2). At 00/53, we ended Line MGL2306057P49 (Seq 57, LGSP 183238). At 01:05, we started Line MGL2306058P50 (Seq 58, LGSP 184035). At 02:51, we ended Line MGL2306059P51 (Seq 58, FGSP 185023). At 12:52, the String 2, gun 1 was disabled after multiple timing errors (17 guns, 2940 cu.in, SP 186942). At 13:59, we ended Line MGL2306059P51 (Seq 59 – LGSP 187267). At 14:24, we recovered array 2. At 15:29, we started to recover PAM. At 15:35, it was the turn of Maggie to be recovered. PAM was fully recovered at 15:36, and Maggie at 15:43. Streamer head float was recovered at 16:09. At 16:24, we transferred to Reel 1. At 16:48, we recovered the RD sections on Reel 1. At 17:33, the streamer was transferred to reel 3, we changed to Seal V 1.1. At 17:50, we deployed streamer from reel 3. At 19:04, 7.5 km was deployed. We transferred to reel 2. At 19:33, we started to recover on Reel 2.

4. Summary of multichannel seismic data acquisition parameters

Here we briefly summarize the seismic acquisition parameters for the survey. Further detail is given in the Appendix A.

Source

- We used the 3300 cu.in, 2 string array of the *Langseth* towed at a 6 m depth. Each string includes 2 clusters (2 guns/cluster) and 5 individual airguns. The airgun array was towed 304 m behind the ship's navigational reference point (NRP [*Nav Reference Point*]-COS [*Center of Source*]). Source was fired at a pressure of ~1950 psi. 13 near field hydrophones were installed on top of each element of the array except for the 7th gun/6th element (60 cu.in) on string 2. The near field hydrophone data were available as separate SEGD files for each shot for the 5 first profiles (P01 to P05). For the rest of the lines, the hydrophone data were also included in the SEGD data as auxiliary traces. Calibration for each hydrophone can be found in the Appendix A.
- The airgun array is also equipped of 4 PosNet rGPS, 2 GPS per string, one forward and one in the middle. GPS data on the source array allowed us to derived the spacing between the 2 strings. The spacing between the 2 strings was variable and ranges between 6m and 30m, which is quite large.

Streamer

- We used the 6-km long, solid-state streamer of the *Langseth* towed at 6 m depth. Streamer includes 552 channels. To increase spatial resolution and signal to noise ratio, for the first 900 m of the streamer, we used the new high-resolution sections that have a channel spacing of 6.25 m. The first 144 channels (~900 m) were thus spaced every 6.25 m whereas for the rest of the streamer (channel 145 to 552), the channels were spaced every 12.5 m. The nominal distance between the center of the source and the first channel was 111.53 m.
- The nominal shot interval was 25 m.
- A sampling interval of 1 ms was used. The record length was 9.5 s. A SEGD standard polarity was used. A 3 Hz digital low-cut filter and a 400 Hz High cut filter with a slope of 370 dB/octave was applied to the data.
- For the first time on the R/V Langseth, we had access to the continuous data in SEGD format. Continuous data are stored in 5 min SEG Files.

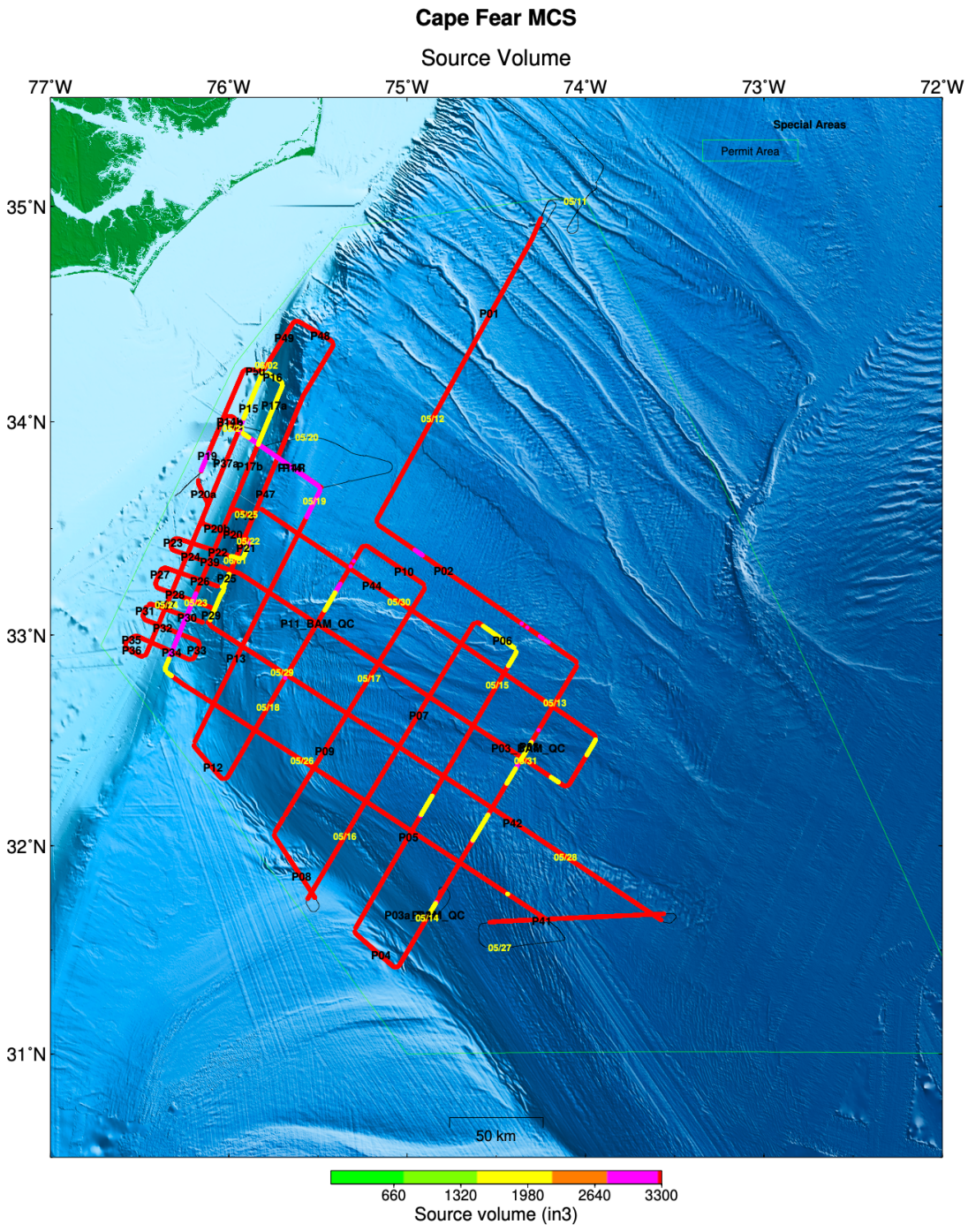
Here is a brief summary of the challenges that occurred during the survey. More information can be found in the Obs and Nav logs for each line, which are not part of the cruise report.

Challenges

Airgun array

We had some airgun issues throughout the survey. When a gun issue arose, we usually kept acquiring data with 1 gun string (half volume of 1650 cu.in) while fixing the other string. We also had some gun issues during bad weather windows. During these bad weather windows, the seas were too high to be able to recover the gun strings and fix them. We would thus wait for the bad weather to be over to pick up the string and fix them.

Here is a list of the lines where we encountered gun issues:
MGL2306002P02: small pieces with a volume of 3120 cu.in
MGL2306003P03: Recovered array 2 first and then later on array 1
MGL2306003P03a: problem with array 1
MGL2306006P05: Recovered array 2 two times during this line
MGL2306007P06: Array 2 disabled and fixed;
MGL2306012P11: Array 2 disabled and fixed;
MGL230614P13: from SP 65334 to EOL, the volume was 3120 cu.in
MGL2306015P14: S1G4 disabled – the all line was shot with a volume of 3120 cu.in;
MGL2306016P15: started with volume of 3120 cu.in (S1G4, disabled), later on Array 1 was disabled; Unable to recover array 1 in rough sea to fix it.
MGL2306017P16: half volume for the entire line;
MGL2306019P17a: half volume for the entire line;
MGL2306020P14R: SP75823-75979 with half volume
MGL2306022P17b: SP 80748-81665 – Misfire gun 9, string 1, between 2.1-2.3 ms early;
MGL2306023P20: Misfire gun 9 on string 1 at the beginning of line
MGL2306024P21: from SP 84074 to EOL SP 84203,
MGL2306025P22: from SP85064 to SP 85254, issue with string 1
MGL2306027P24: from SP 88717 to EOL SP 84177, array 1 recovered at the end of the line
MGL2306028P25: Array 1 disabled at start of line, half volume for the entire line
MGL2306047P39: S2Gun2 disabled after SP 120433, Array 2 disabled after SP 121896
MGL2306048P40: Started with Array 1 only, Array 2 was back in position for SP123194
MGL2306051P43: Array 1 then array 2 disabled shortly after the beginning of line to adjust separation
MGL2306053P45: Array 1 was recovered not far from the beginning of the line (airleak repair)
MGL2306059P51: String 2, gun 1 was disabled after multiple timing error (2940 cu.in)



Map Credit: Gilles Guérin

Streamer depth

Because of rough and high seas, we had to increase the depth of the streamer for some profiles.

MGL2306014P13: Streamer was set to 10m after ~SP 62100 (JD37, 13:29)

MGL2306015P14: streamer was set to 10 m from start to end of line

MGL2306016P15: Streamer was then set to 10m.Tail of the streamer was near the surface during turn. The front of the streamer was lowered to 15 m while trying to stabilize it.

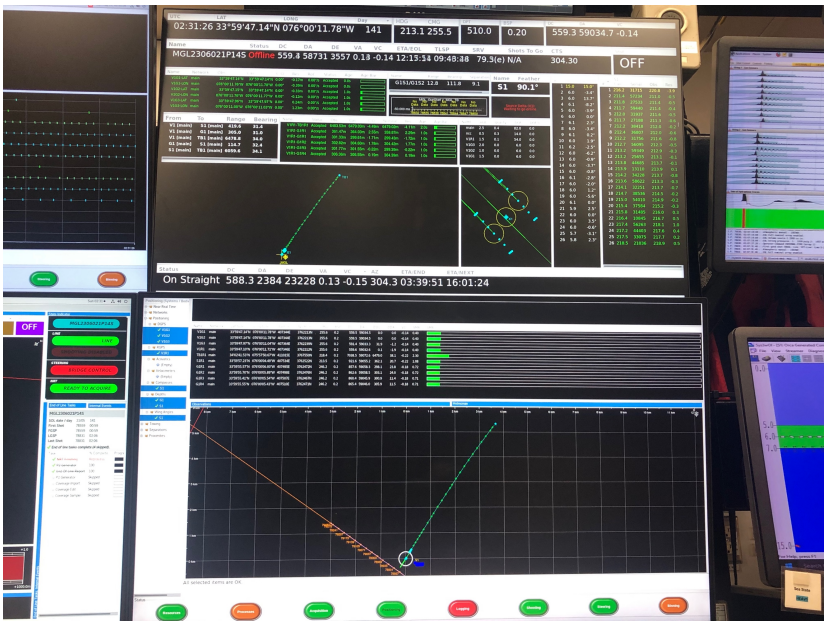
MGL2306017P16: Streamer was set to a 10m depth
MGL2306019P17a: Strong currents from aft were affecting vessel steering and streamer depths
MGL2306043P14b: The streamer depth set to 8m early in line, then to 10m then 9m –
MGL2306044P37a: The streamer was set to 7-8m.
MGL2306045P20b: The streamer was set to 8m. (SOL through SP114350, the streamer was on the Surface from DB10 to DB 19)
MGL2306046P18: The streamer was set to 15m, increasing sea state causing erratic trim on the streamer SOL – EOL.
MGL2306047P39: The streamer was set to 10m

Tail Buoy (TB1)
We lost connection to the tail buoy at 3:26 on JD 139 while acquiring Line MGL2306015P14. We had no tail buoy signal for Line MGL2306016P15, MGL2306017P16, MGL2306018P17, MGL2306019P17a. After this profile, tail buoy was recovered and fixed (JD140 between 00:00 and 05:22).

Change of shot spacing
Due to the strong Gulf stream currents, some lines were acquired with a different shot spacing.
For Line MGL2306021P14s – we used a shot spacing of 8 m instead of 25 m due to the slow shooting speed because of the strong currents. Note that this sequence 21 is a continued reshoot of Seq 15, line MGL2306015P14.
For Line MGL2306016P15, we did not change the shot spacing although the speed over ground was over 6kts. Most of the SPs have overlap.
For lines MGL2306041P20a, MGL2306042P19, MGL2306034P14b, we used a shot spacing of 50m due to the fast shooting.
For line MGL2306048P40, the shot spacing was not changed but we have a lot of overlap between shots in the middle of the profile.

GPS on the source
For line MGL2306008P07, the G1R2 RGPS data slightly noisy at times.
Starting on Line MGL2306022P17b (JD141), the forward GPS on gun string #1 was intermittent. Continued for Lines MGL20306023P20, MGL2306024P21. GPS was fixed starting during acquisition of MGL2306025P22.
The forward GPS on gun string 1 started again to be intermittent for MGL2306027P24 and MGL2306028P25.

Gulf stream – large feather angle
Strong currents in the area of the Gulf Stream created a high feather angle. The profiles that were shot in the high current area were:
MGL2306022P17b (strong head current, SOG ~1.5 kts at beginning of line), MGL2306025P22, MGL2306026P23 (Short line consisting mostly of turn with currents causing high number of compass reading rejection),
MGL2306027P24, MGL2306027P24, MGL2306028P25, MGL230628P26, MGL23030P27, MGL2603031P28.



Example of 90° feathering on line 14R.

Digibirds

For MGL2306001P01, S1C19 causing depth keeping issues, flying shallow
For MGL2306002P02, Digibird 7 appears to have something caught on it, going deep and shallow (SP 12412), back to normal at SP 12670
Bird 1 became intermittent since the streamer was redeployed on JD140.
For MGL23040P37, SP 10580 – digibirds were trending up, we placed fixed wing angle to drive them down.
For MGL2306043P14b, the birds went wild.
Bird sea state was changed to heavy sea on May 24 at 07:22 UTC
Bird 10-14 not working properly between MGL2306046P18 and MGL2306048P41. We picked up the streamer at the end of MGL2306048P40 to fix them.

Near Field hydrophone

Near Field Hydrophone 2-6 (string 2, element #6) was not working for Lines MGL2306001P01 and MGL2306002P02.
Near Field Hydrophones 1-6 and 2-6 were not working for Lines MGL2306003P03 to the last profile.
During acquisition of MGL2306012P11, hydrophone 2-1 was damaged on deployment and was disabled
Auxiliary Integrated NFH channels are omitting for Gun 7 on both strings due to a limitation in the electrical junction box?
For Lines MGL2306007P06, MGL2306008P07, MGL2306009P08, MGL2306010P09, the auxiliary channels were mapped incorrectly. Correct mapping as follows: Ch1/NFH-11, Ch2/NFH-12, Ch3/NFH-9, Ch4/NFH-10, Ch5/NFH-7, Ch6/NFH--8m; Ch7/NFH-5, Ch8/NFH-6, Ch9/NFH-3, Ch10/NFH-4, Ch11/NFH-1, Ch12/NFH—2.

Bad or weak traces on the streamer

From Line MGL2306001P01 to Line MGL2306019P17a: channel #192 was weak and channel #481 was dead.
From Line MGL2306020P14R to Line: channel #192 was weak and channels # 145 and 481 were dead.
From Line MGL2306xxxPxx to the

Compressor failures

For MGL2306009P08, at the SOL, SP until SP 41862 were edited due to compressor failure (pressure drop) at SOL. FGSP: 41863

Separation between the two gun strings

Nominal separation was 6m. We looked at the GPS data and computed the separation for each shot point along all the profiles. We realized the separation is variable; ranging from 6m to 33m. MGL2306049P41: Reduced separation between sources during part of the line because of broken steering rope for array 2. Separation was adjusted at the beginning of Line MGL2306051P43.

5. MGL2306 Multichannel Seismic Acquisition and Processing

MCS Acquisition

During the MGL2306 seismic experiment, approximately 3,544 km of multichannel seismic data were acquired in the vicinity of the Cape Fear slide using the R/V *Marcus G. Langseth* airgun source and streamer. The system was configured in a two-string array consisting of 18 elements with a capacity of 3,300 cubic inches (nominal pressure of 1950 psi ± 100 psi), and a 6-km-long streamer consisting of 552 receiver groups (144 near groups spaced at 6.25 meters and 408 far groups spaced at 12.5 meters). The source arrays and streamer were towed at 6-10 meters.

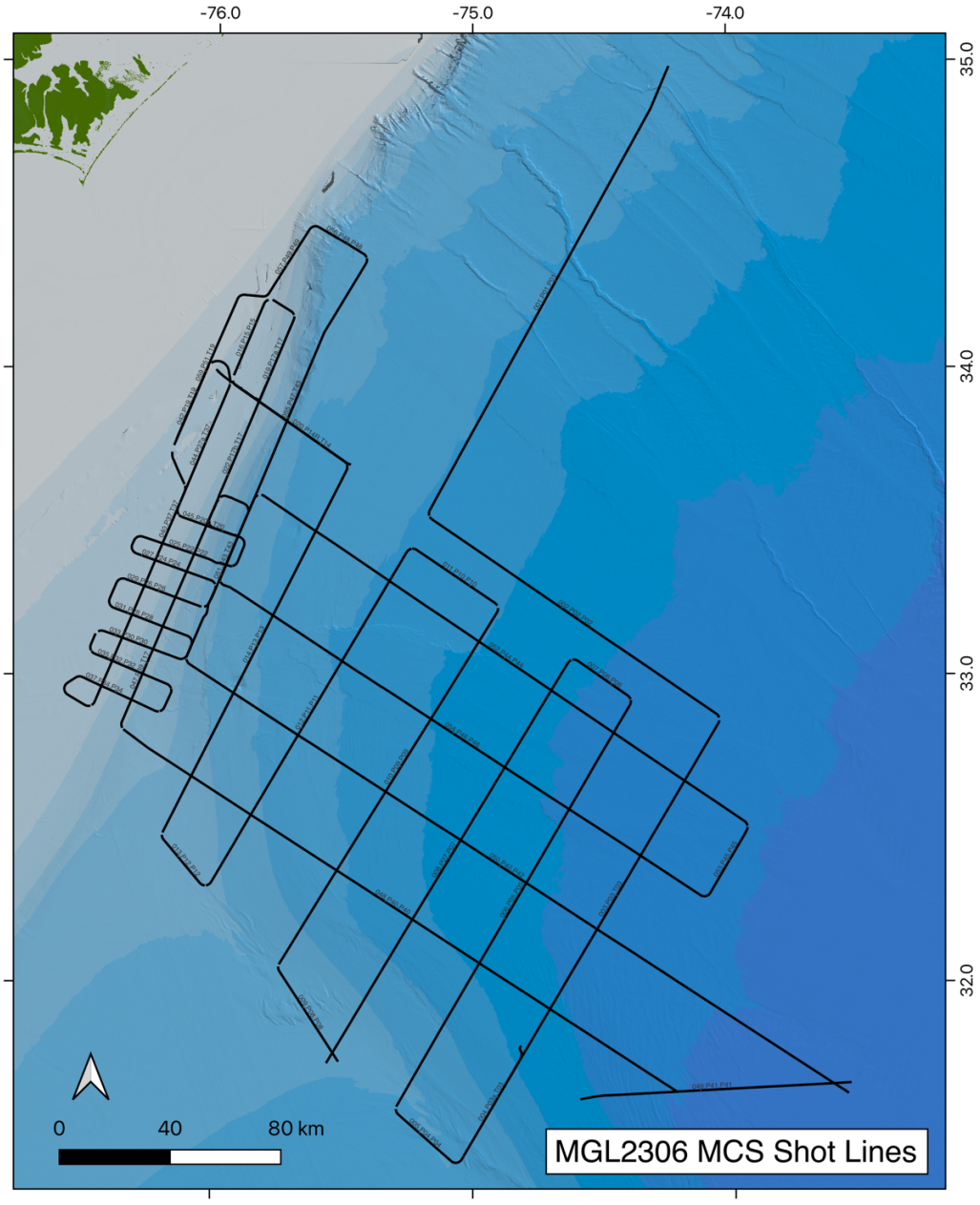


Figure1. MCS shot lines occupied during MGL2306.

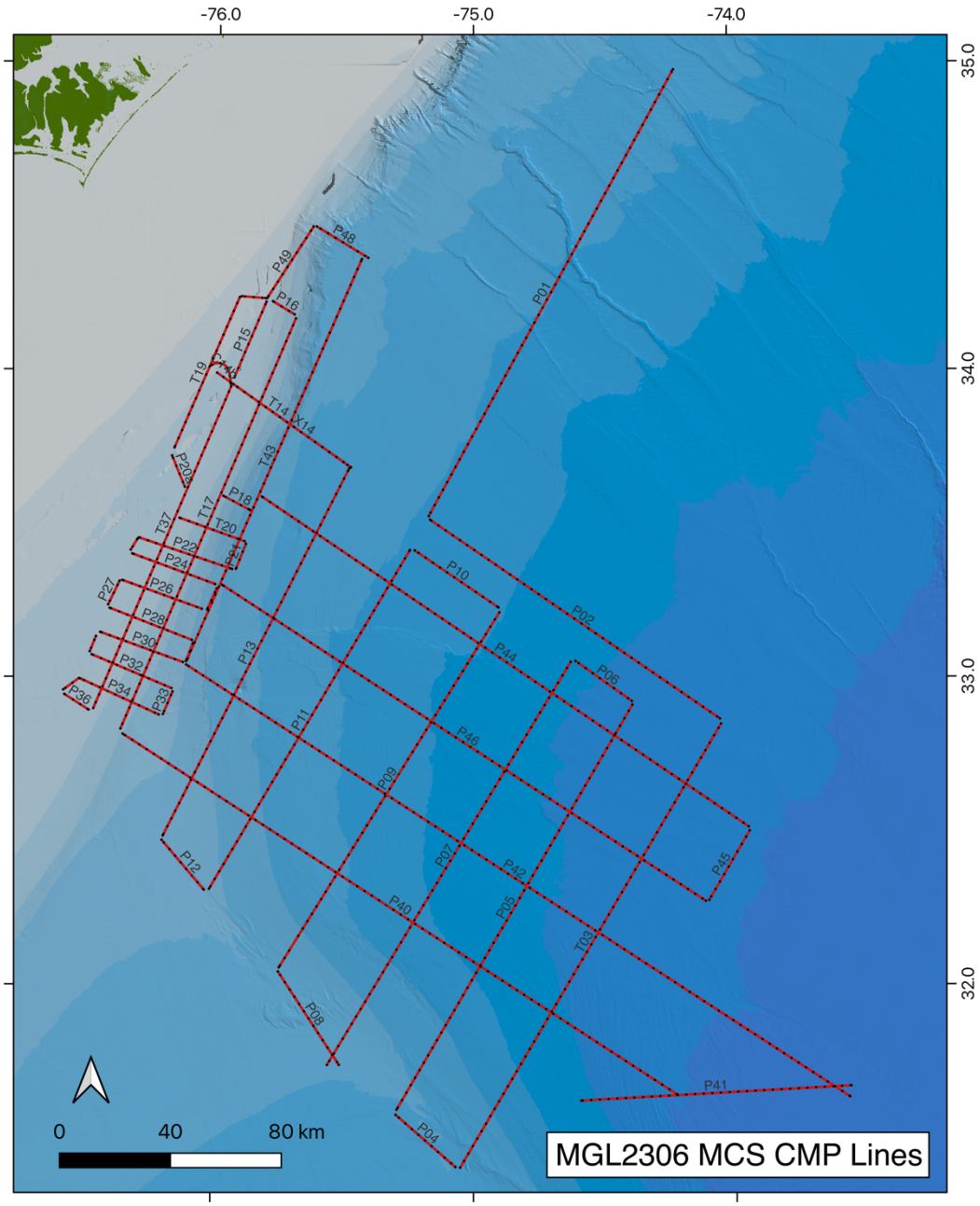


Figure 2. Tracklines of CMP profiles processed during MGL2306.

MGL2306Seismic Configuration by sequence acquired with offsets

Sequence	line name	Shot spacing (m)	Number of active channels	sample rate	record length	source sub-array used	source depth	streamer depth	NBP-COS	COS-CMG	comment
001	MGL2306001P01	25	552	1	9.5	2 Arrays used	6	6	304	111	First Line of the Cruise
002	MGL2306002P02	25	552	1	9.5	2 Arrays used	6	6	304	111	
003	MGL2306003P03	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
004	MGL2306004P03a	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
005	MGL2306005P04	25	552	1	9.5	2 Arrays used	6	6	304	111	
006	MGL2306006P05	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
007	MGL2306007P06	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
008	MGL2306008P07	25	552	1	9.5	2 Arrays used	6	6	304	111	
009	MGL2306009P08	25	552	1	9.5	2 Arrays used	6	6	304	111	
010	MGL2306010P09	25	552	1	9.5	2 Arrays used	6	6	304	111	
011	MGL2306011P10	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
012	MGL2306012P11	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
013	MGL2306013P12	25	552	1	9.5	2 Arrays used	6	6	304	111	
014	MGL2306014P13	25	552	1	9.5	2 Arrays used	6	10	304	111	
015	MGL2306015P14	25	552	1	9.5	2 Arrays used	6	10	304	111	Source repairs during line, only 1 array operational at times
016	MGL2306016P15	25	552	1	9.5	1 Array used	6	10	304	111	Source repairs during line, only 1 array operational at times
017	MGL2306017P16	25	552	1	9.5	1 Array used	6	10	304	111	Source repairs during line, only 1 array operational at times
018	MGL2306018P17	25	552	1	9.5	1 Array used	6	10	304	111	Source repairs during line, only 1 array operational at times
019	MGL2306019P17a	25	552	1	9.5	1 Array used	6	10	304	111	Source repairs during line, only 1 array operational at times
020	MGL2306020P14R	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
021	MGL2306021P14S	8	552	1	9.5	2 Arrays used	6	6	304	111	Shot point spacing was changed to 8 meters
022	MGL2306022P17b	25	552	1	9.5	2 Arrays used	6	6	304	111	
023	MGL2306023P20	25	552	1	9.5	2 Arrays used	6	6	304	111	
024	MGL2306024P21	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
025	MGL2306025P22	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
026	MGL2306026P23	25	552	1	9.5	2 Arrays used	6	6	304	111	
027	MGL2306027P24	25	552	1	9.5	2 Arrays used	6	6	304	111	
028	MGL2306028P25	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
029	MGL2306029P26	25	552	1	9.5	2 Arrays used	6	6	304	111	
030	MGL2306030P27	25	552	1	9.5	2 Arrays used	6	6	304	111	
031	MGL2306031P28	25	552	1	9.5	2 Arrays used	6	6	304	111	
032	MGL2306032P29	25	552	1	9.5	2 Arrays used	6	6	304	111	
033	MGL2306033P30	25	552	1	9.5	2 Arrays used	6	6	304	111	
034	MGL2306034P31	25	552	1	9.5	2 Arrays used	6	6	304	111	
035	MGL2306035P32	25	552	1	9.5	2 Arrays used	6	6	304	111	
036	MGL2306036P33	25	552	1	9.5	2 Arrays used	6	6	304	111	
037	MGL2306037P34	25	552	1	9.5	2 Arrays used	6	6	304	111	
038	MGL2306038P35	25	552	1	9.5	2 Arrays used	6	6	304	111	
039	MGL2306039P36	25	552	1	9.5	2 Arrays used	6	6	304	111	
040	MGL2306040P37	25	552	1	9.5	2 Arrays used	6	6	304	111	
041	MGL2306041P20a	50	552	1	9.5	2 Arrays used	6	6	304	111	
042	MGL2306042P19	50	552	1	9.5	2 Arrays used	6	6	304	111	
043	MGL2306043P14b	50	552	1	9.5	2 Arrays used	6	6-8-10-9	304	111	
044	MGL2306044P37a	25	552	1	9.5	2 Arrays used	6	8	304	111	
045	MGL2306045P20b	25	552	1	9.5	2 Arrays used	6	8 (bad)	304	111	
046	MGL2306046P18	25	552	1	9.5	2 Arrays used	6	15	304	111	
047	MGL2306047P39	25	552	1	9.5	2 Arrays used	6	10	304	111	Source repairs during line, only 1 array operational at times
048	MGL2306048P40	25	552	1	9.5	2 Arrays used	6	10 and 6	304	111	Source repairs during line, only 1 array operational at times
049	MGL2306049P41	25	552	1	9.5	2 Arrays used	6	6	304	111	
050	MGL2306050P42	25	552	1	9.5	2 Arrays used	6	6	304	111	
051	MGL2306051P43	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
052	MGL2306052P44	25	552	1	9.5	2 Arrays used	6	6	304	111	
053	MGL2306053P45	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
054	MGL2306054P46	25	552	1	9.5	2 Arrays used	6	6	304	111	Source repairs during line, only 1 array operational at times
055	MGL2306055P47	25	552	1	9.5	2 Arrays used	6	6	304	111	
056	MGL2306056P48	25	552	1	9.5	2 Arrays used	6	6	304	111	
057	MGL2306057P49	25	552	1	9.5	2 Arrays used	6	6	304	111	
058	MGL2306058P50	25	552	1	9.5	2 Arrays used	6	6	304	111	
059	MGL2306059P51	25	552	1	9.5	2 Arrays used	6	6	304	111	

Table 1. *R/V Marcus Langseth* seismic system acquisition parameters by sequence for MGL2306.

		Start of line						End of line						Start		End		Sample	Sample	
Line #	Seq #	Date	Time (UTC)	Latitude*	Latitude*	Longitude*	Longitude*	Date	Time (UTC)	Latitude*	Latitude*	Longitude*	Longitude*	file#	shot#	file#	shot#	Rate	Length	# Channels
				whole degrees	decimal minutes	whole degrees	decimal minutes			whole degre	decimal min	whole degre	decimal minutes					ms	seconds	
MGL2306001P01	001	2023-05-11	9:59	34	59.13833	-74	13.75817	2023-05-12	7:17	33	31.68483	-75	10.19150	1	107	7334	7440	1	9.5	552
MGL2306002P02	002	2023-05-12	7:26	33	31.08600	-75	09.79933	2023-05-12	21:24	32	52.02833	-74	02.96133	7335	8057	12396	13118	1	9.5	552
MGL2306003P03	003	2023-05-12	21:37	32	51.00567	-74	03.04600	2023-05-13	17:52	31	41.03383	-74	52.04017	12397	14074	18416	20093	1	9.5	552
MGL2306004P03a	004	2023-05-13	21:12	31	47.66450	-74	49.17850	2023-05-14	4:02	31	25.06483	-75	03.89667	18417	20579	20329	22491	1	9.5	552
MGL2306005P04	005	2023-05-14	4:08	31	25.11583	-75	04.35150	2023-05-14	7:35	31	35.53100	-75	17.65350	20330	23066	23066	24207	1	9.5	552
MGL2306006P05	006	2023-05-14	7:46	31	36.42133	-75	17.30517	2023-05-15	3:03	32	55.42400	-74	23.36467	21472	25087	28224	31839	1	9.5	552
MGL2306007P06	007	2023-05-15	3:18	32	56.04150	-74	23.60783	2023-05-15	7:33	33	03.45917	-74	36.79117	28225	32042	29213	33030	1	9.5	552
MGL2306008P07	008	2023-05-15	7:44	33	03.17317	-74	37.57750	2023-05-16	5:02	31	44.60350	-75	33.58033	29214	33560	36002	40348	1	9.5	552
MGL2306009P08	009	2023-05-16	6:43	31	43.51967	-75	29.89883	2023-05-16	12:35	32	03.31283	-75	44.68600	36003	41863	37595	43455	1	9.5	552
MGL2306010P09	010	2023-05-16	12:50	32	04.12750	-75	44.32383	2023-05-17	6:05	33	13.50583	-74	54.15433	37596	44067	43528	50080	1	9.5	552
MGL2306011P10	011	2023-05-17	6:19	33	14.37233	-74	54.60267	2023-05-17	11:03	33	25.16783	-75	34.04483	43529	50563	44976	52010	1	9.5	552
MGL2306012P11	012	2023-05-17	11:13	33	25.03583	-75	14.72667	2023-05-18	4:48	32	19.16033	-76	01.38633	44977	52538	50651	58212	1	9.5	552
MGL2306013P12	013	2023-05-18	4:58	32	19.20933	-76	02.16600	2023-05-18	7:40	32	28.85283	-76	11.71283	50652	58577	51538	59508	1	9.5	552
MGL2306014P13	014	2023-05-18	7:52	32	29.72933	-76	11.38950	2023-05-19	0:55	33	41.56050	-75	29.43467	51584	60076	57502	65994	1	9.5	552
MGL2306015P14	015	2023-05-19	1:03	33	42.07400	-75	29.88167	2023-05-19	6:54	33	57.76517	-75	56.36467	57503	67076	59507	69070	1	9.5	552
MGL2306016P15	016	2023-05-19	7:09	33	59.24300	-75	55.86667	2023-05-19	9:43	34	13.61050	-75	48.07000	59508	69632	60673	70797	1	9.5	552
MGL2306017P16	017	2023-05-19	9:57	34	13.45783	-75	46.79883	2023-05-19	11:17	34	10.81283	-75	42.18450	60674	71105	61019	71450	1	9.5	552
MGL2306018P17	018	2023-05-19			00.00000		00.00000	2023-05-19			00.00000		00.00000					1	9.5	552
MGL2306019P17a	019	2023-05-19	11:38	34	10.12000	-75	42.04950	2023-05-19	19:52	33	53.52033	-75	50.20517	61024	72044	62350	73370	1	9.5	552
MGL2306020P14R	020	2023-05-20	12:54	33	41.63150	-75	28.94967	2023-05-21	0:53	33	58.86667	-75	59.01867	62351	74000	64601	76250	1	9.5	552
MGL2306021P14S	021	2023-05-21	1:01	33	58.93750	-75	59.11567	2023-05-21	2:05	33	59.77133	-76	00.13700	64610	78567	64873	78830	1	9.5	552
MGL2306022P17b	022	2023-05-21	7:00	33	56.51983	-75	48.75867	2023-05-21	22:17	33	29.73050	-76	01.51733	64874	80130	67007	82263	1	9.5	552
MGL2306023P20	023	2023-05-21	22:24	33	29.39600	-76	01.28200	2023-05-22	0:01	33	26.40783	-76	53.37333	67008	83041	67543	83576	1	9.5	552
MGL2306024P21	024	2023-05-22	0:05	33	26.10267	-75	53.28633	2023-05-22	1:56	33	21.58067	-75	55.95883	67544	84045	67916	84417	1	9.5	552
MGL2306025P22	025	2023-05-22	2:05	33	21.55850	-75	56.55517	2023-05-22	6:47	33	27.02400	-76	18.19067	67917	85064	69318	86465	1	9.5	552
MGL2306026P23	026	2023-05-22	6:55	33	26.87867	-76	18.48067	2023-05-22	8:07	33	24.66783	-76	19.45400	69319	87029	69493	87203	1	9.5	552
MGL2306027P24	027	2023-05-22	8:21	33	24.26150	-76	19.22467	2023-05-22	12:49	33	18.06700	-76	00.05150	69494	87537	70768	88811	1	9.5	552
MGL2306028P25	028	2023-05-22	13:09	33	17.31267	-75	59.87483	2023-05-22	14:57	33	13.55400	-76	02.41550	70769	89065	71087	89383	1	9.5	552
MGL2306029P26	029	2023-05-22	15:13	33	13.65133	-76	03.59183	2023-05-22	19:34	33	18.81367	-76	21.96250	71088	90095	72291	91246	1	9.5	552
MGL2306030P27	030	2023-05-22	19:42	33	18.62050	-76	22.41383	2023-05-22	21:17	33	13.97117	-76	24.53500	72292	92030	72660	92398	1	9.5	552
MGL2306031P28	031	2023-05-22	21:25	33	13.57217	-76	24.27533	2023-05-23	1:09	33	07.05750	-76	05.39633	72661	93040	73929	94308	1	9.5	552
MGL2306032P29	032	2023-05-23	1:16	33	06.63167	-76	05.28450	2023-05-23	2:24	33	03.38500	-76	07.18750	73930	95048	74197	95256	1	9.5	552
MGL2306033P30	033	2023-05-23	2:33	33	03.28117	-76	07.73333	2023-05-23	7:07	33	08.53400	-76	27.00283	74198	96045	75458	97305	1	9.5	552
MGL2306034P31	034	2023-05-23	7:29	33	07.75367	-76	27.85500	2023-05-23	8:26	33	04.80283	-76	28.70267	75459	97587	75682	97810	1	9.5	552
MGL2306035P32	035	2023-05-23	8:34	33	04.49167	-76	28.26950	2023-05-23	12:08	33	57.60100	-76	10.03583	75683	98059	76923	99299	1	9.5	552
MGL2306036P33	036	2023-05-23	12:16	32	57.09883	-76	09.92600	2023-05-23	13:43	32	53.05983	-76	12.45933	76924	99551	77261	99888	1	9.5	552
MGL2306037P34	037	2023-05-23	13:52	32	52.99950	-76	13.19500	2023-05-23	17:53	32	59.62717	-76	31.39767	77262	100060	78498	101296	1	9.5	552
MGL2306038P35	038	2023-05-23	18:00	32	59.55800	-76	31.77167	2023-05-23	19:31	32	56.99383	-76	34.75583	78501	102018	78759	102278	1	9.5	552
MGL2306039P36	039	2023-05-23	19:40	32	56.57567	-76	34.59467	2023-05-23	20:57	32	53.96933	-76	28.65850	78760	103095	79177	103512	1	9.5	552
MGL2306040P37	040	2023-05-23	21:04	32	54.33000	-76	27.98717	2023-05-24	6:00	33	37.16117	-76	07.24100	79178	104066	82597	107485	1	9.5	552
MGL2306041P20a	041	2023-05-24	6:09	33	37.83283	-76	07.59467	2023-05-24	7:19	33	43.84033	-76	10.32517	82598	108012	82749	108163	1	9.5	552
MGL2306042P19	042	2023-05-24	7:34	33	45.50283	-76	09.73700	2023-05-24	10:12	34	00.65067	-76	02.06350	82750	109484	83358	110092	1	9.5	552
MGL2306043P14b	043	2023-05-24	10:23	34	01.44150	-76	00.95967	2023-05-24	11:45	33	57.34550	-75	56.97117	83359	110505	83546	110692	1	9.5	552
MGL2306044P37a	044	2023-05-24	11:55	33	56.76883	-75	57.10950	2023-05-24	20:10	33	31.59700	-76	08.75300	83547	111042	85542	113037	1	9.5	552
MGL2306045P20b	045	2023-05-24	20:18	33	31.19367	-76	08.29000	2023-05-24	22:35	33	27.66250	-75	55.18100	85543	114068	86396	114921	1	9.5	552
MGL2306046P18	046	2023-05-24	23:37	33	32.84600	-75	52.45417	2023-05-25	0:59	33	35.00933	-75	58.92683	86397	116001	86827	116431	1	9.5	552
MGL2306047P39	047	2023-05-25	1:15	33	34.22200	-75	59.62733	2023-05-25	14:31	32	49.76167	-76	21.23333	86828	118599	90379	122150	1	9.5	552
MGL2306048P40	048	2023-05-25	14:51	32	49.20750	-76	20.60033	2023-05-26	16:10	31	38.82367	-74	13.18200	90380	123079	99929	132628	1	9.5	552
MGL2306049P41	049	2023-05-27	2:43	31	37.59150	-74	34.98917	2023-05-27	13:53	31	40.42300	-73	33.44850	99930	133613	103827	137510	1	9.5	552
MGL2306050P42	050	2023-05-27	16:14	31	38.56733	-73	34.41283	2023-05-29	6:44	33	03.25917	-76	06.49800	103828	138761	115242	150175	1	9.5	552
MGL2306051P43	051	2023-05-29	6:53	33	04.03200	-76	06.36483	2023-05-29	13:51	33	35.43683	-75	50.21533	115243	151077	117772	153606	1	9.5	552
MGL2306052P44	052	2023-05-29	14:05	33	35.39650	-75	48.94500	2023-05-30	14:52	32	30.80267	-73	56.67350	117773	154094	126240	162560	1	9.5	552
MGL2306053P45	053	2023-05-30	15:01	32	30.14217	-73	56.73233	2023-05-30	19:50	32	17.10167	-74	06.44450	126241	163060	127381	164200	1	9.5	552
MGL2306054P46	054	2023-05-30	19:22	32	17.07683	-74	06.84583	2021-05-31	23:21	33	18.46150	-75	58.71733	127382	165042	135701	173370	1	9.5	552
MGL2306055P47	055	2023-05-31	23:30	33	19.13267	-75	58.77817	2021-06-01	13:25	34	21.83467	-75	25.05167	135702	175061	140791	180150	1	9.5	552
MGL2306056P48	056	2023-06-01	13:32	34	22.34300	-75	25.33367	2021-06-01	18:14	34	28.06700	-75	37.34333	140792	181050	141641	181848	1	9.5	552
MGL2306057P49	057	2023-06-01	18:42	34	28.00417	-75	37.72467	2021-06-02	0:09	34	14.35650	-75	48.83517	141642	181910	142859	183093	1	9.5	552
MGL2306058P50	058	2023-06-02	1:05	34	14.27017	-75	49.28667	2021-06-02	2:52	34	14.42733	-75	54.67267	142869	184035	143188	184363	1	9.5	552
MGL2306059P51	059	2023-06-02	3:01	34	14.18017	-75	55.08167	2023-06-02	14:00	33	46.25450	-75	09.34033	143189	185023	145433	187267	1	9.5	552

Table 2. MGL2306 shot sequence information table.

Geometry Line	First CMP	Last CMP	Line Length KM	Sequence Manifest	Geometry Line	First CMP	Last CMP	Line Length KM	Sequence Manifest
MGL2306_P01	1552	60316	183	001.P01.P01	MGL2306_P28	1830	12019	31.8	031,P28,P28
MGL2306_P02	1799	42368	126	002.P02.P02	MGL2306_P29	1845	4098	7.04	032,P29,P29
MGL2306_P04	1498	10656	28.6	005.P04.P04	MGL2306_P30	1822	11980	31.7	033,P30,P30
MGL2306_P05	1720	55832	169	006.P05.P05	MGL2306_P31	1589	3493	5.95	034,P31,P31
MGL2306_P06	1558	9532	24.9	007.P06.P06	MGL2306_P32	1847	11843	31.2	035,P32,P32
MGL2306_P07	1463	55823	169	008.P07.P07	MGL2306_P33	1639	4451	8.79	036,P33,P33
MGL2306_P08	1510	14384	40.2	009,P08,P08	MGL2306_P34	1552	11516	31.1	037,P34,P34
MGL2306_P09	1731	49964	150	010,P09,P09	MGL2306_P35	1677	3919	7.01	038,P35,P35
MGL2306_P10	1477	13172	36.5	011,P10,P10	MGL2306_P36	1807	5140	10.4	039,P36,P36
MGL2306_P11	1679	47140	142	012,P11,P11	MGL2306_P40	1687	78124	238	048,P40,P40
MGL2306_P12	1581	9123	23.5	013,P12,P12	MGL2306_P41	1852	33088	97.6	049,P41,P41
MGL2306_P13	1813	49288	148	014,P13,P13	MGL2306_P42	1668	93095	285	050,P42,P42
MGL2306_C14b	102	4054	12.3	043,P14b,C14b	MGL2306_P44	1876	69731	212	052,P44,P44
MGL2306_X14	3433	19551	50.3	015,P14,X14	MGL2306_P45	1558	10843	29	053,P45,P45
MGL2306_P15	1827	11318	29.6	016,P15,P15	MGL2306_P46	1749	68467	208	054,P46,P46
MGL2306_P16	1859	4776	9.12	017,P16,P16	MGL2306_P48	1491	8442	21.7	056,P48,P48
MGL2306_P18	1710	5220	10.9	046,P18,P18	MGL2306_P49	1732	11574	30.7	057,P49,P49
MGL2306_P20a	1696	5585	12.1	041,P20a,P20a	MGL2306_P50	1633	4370	8.56	058,P50,P50
MGL2306_P21	1878	4980	9.7	024,P21,P21	MGL2306_T03	2115	61568	168	003,P03,T03; 004,P03a,T03
MGL2306_P22	1915	13255	35.4	025,P22,P22	MGL2306_T14	1137	20053	59.1	020,P14R,T14; 021,P14S,T14
MGL2306_P23	1592	3102	4.72	026,P23,P23	MGL2306_T17	1383	52862	160	019,P17a,T17; 022,P17b,T17; 047,P39,T17
MGL2306_P24	1829	12028	31.8	027,P24,P24	MGL2306_T19	1828	20737	59.1	042,P19,T19; 059,P51,T19
MGL2306_P25	1842	4505	8.33	028,P25,P25	MGL2306_T20	1851	9834	24.9	023,P20,T20; 045,P20b,T20
MGL2306_P26	1874	11624	30.4	029,P26,P26	MGL2306_T37	2276	42676	126	040,P37,T37; 044,P37a,T37
MGL2306_P27	1539	4581	9.51	030,P27,P27	MGL2306_T43	1794	52267	157	055,P47,T43; 051,P43,T43

Table 3. MGL2306 processed MCS CMP geometry line information table.

MCS Processing

Onboard MCS processing during MGL2306 was conducted using Shearwater Reveal (version 5.2-2023-1-23). The basic flow consisted of raw SEG-D data import, single channel gather export, initial shot qc and trace editing, p190 navigation import and qc, source, receive, midpoint geometry calculation, CMP line creation and binning, bandpass-filtering, and constant velocity brute stack. Additional processing conducted for 18 second records included noise reduction filtering, 1-D velocity model creation, and post-stack time migration. Details for each processing phase follow.

Basic diagnostic flow:

1) Raw SEG-D data were imported by sequence for 9 second cut records and continuously recorded files in parallel. During import of the 9 second records, a gather of receiver channel two was exported for initial sequence qc. After import, continuous shot records were concatenated by channel within sequences, then cut to 18 second records using microsecond shot timing. Shot gathers from each sequence were inspected for quality control, including detection of noisy or dead channels, comparison of direct arrival timing at near traces to the nominal source to near group distance used in acquisition.

2) Processed p190 navigation data were imported by sequence, generating databases containing source, receiver, and midpoint coordinates, source to receiver offsets, source and receiver depths, and timing for all traces. Navigation data for each sequence were inspected for quality control using the Reveal crossplot utility which allows for integrated visual inspection of navigational reference point, source, and receiver geometry. A generalized line was calculated for each sequence using the average midpoint coordinates for every 50th source point gather and written to a database file.

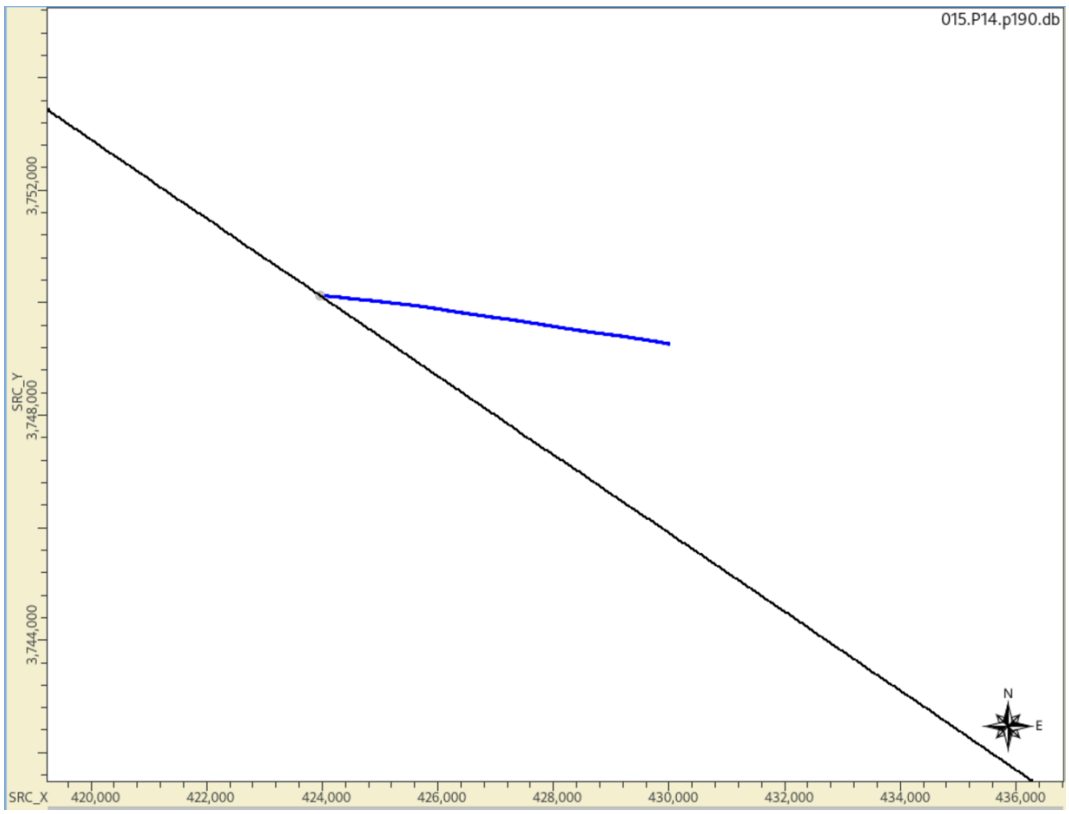


Figure 3. Example of source and receiver navigation qc in Reveal cross plot, illustrating extreme streamer feather associated with crossing the Gulf Stream Current.

3) Straight CMP binning geometry lines were defined for each sequence using the origin coordinates and nominal azimuth of the generalized midpoint line created previously. Composite geometry lines were also created to encompass multiple aligned sequences so that they could be combined into larger transects. CMP bins were created at 3.125 m along the defined geometry lines.

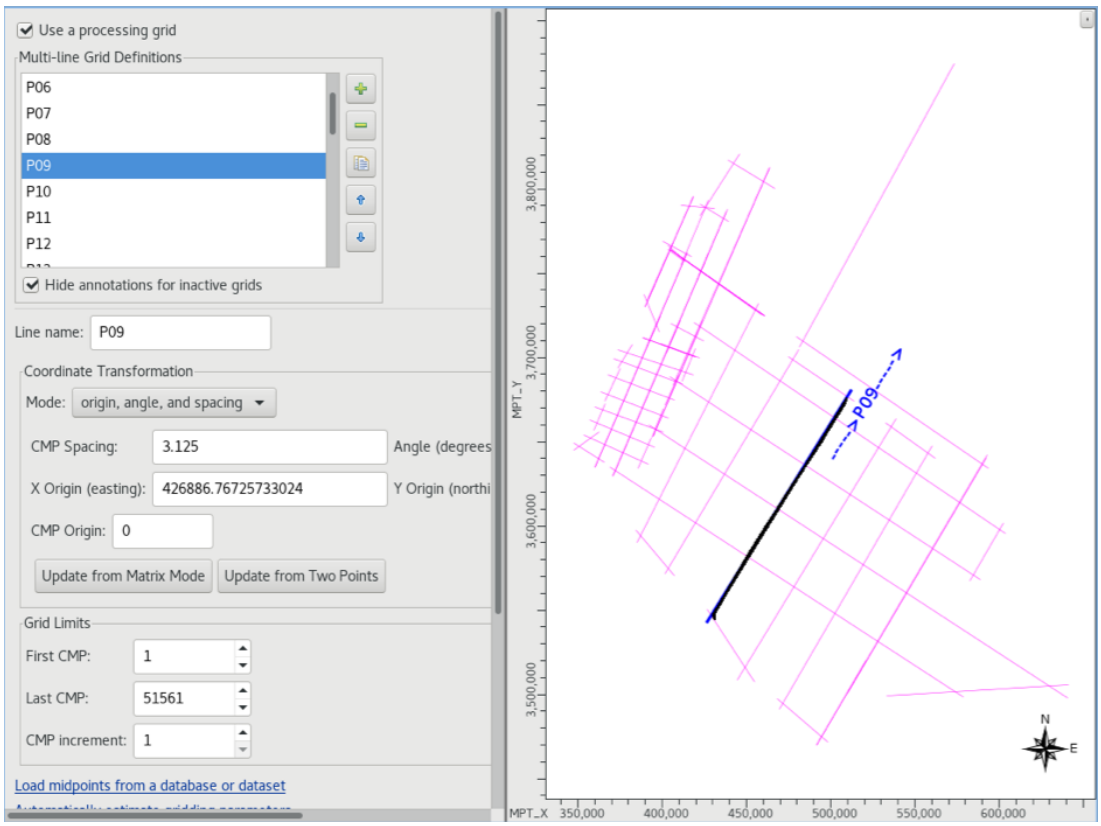


Figure 4. Example of the Reveal project grid editor illustrating geometry line definition in the origin, angle and spacing mode (left), and the MGL2306 project grid (right)

4) The p190 databases for each sequence were merged with the CMP binning geometry to associate source, receive, and midpoint coordinates with CMP bins, and assign CMP bin coordinates to the navigation database. The complete navigation databases were then merged with their respective trace sequences. As a first order product, the raw traces with header navigation and geometry were exported to SEG-Y files.

5) Finally, a high-pass Butterworth filter (6-Hz, 4 corners), an offset dependent spherical divergence correction (1510 m/s), and constant velocity normal moveout correction (1510 m/s), were each applied to trace sequence data prior to creating a brute CMP stack using the near 144, 6.25-meter spaced channel groups.

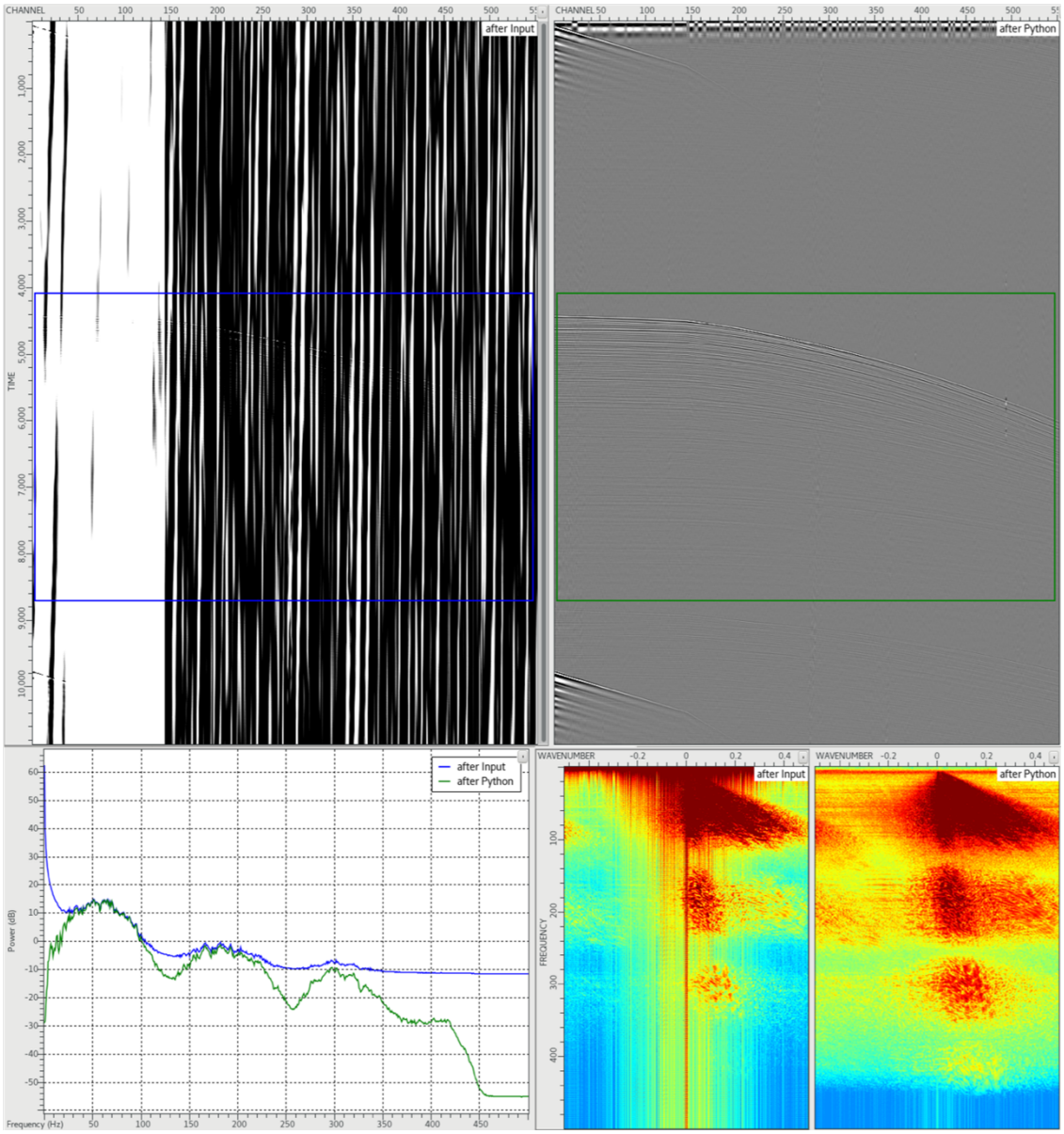


Figure 5. Example shot gather illustrating the highpass filter applied to the data. Traces before and after filter (top, left and right), pre and post raw power – frequency spectra (bottom left), and pre and post filter FK spectra are (bottom right) displayed.

Noise reduction:

6) Noise reduction processing was intended to be minimal and limited to discrete noise problems identified during shot qc. In preparation, the delay times between the direct arrival of current and next shot in the 18 second records were calculated and saved to a database file.

7) The first noise reduction flow consisted of eliminating 5 traces (145, 192, 481, 482, and 540) that were either dead, noisy, or weak, applying a high-pass Butterworth filter (6-Hz, 4 corners), and conducting spike removal to reduce the effects of several periods of

source auto fire. Linear moveout (3000 m/s) was applied in preparation for FK filtering, which was conducted on the 6.25- and 12.5-meter group sections (channels 1-144 and 145-552, respectively) separately. The FK filter was intended to reduce noise associated with the direct arrival of the subsequent shot. Individual polygon mutes were designed for the trace subsets and the filters were applied below a horizon defined (buffered above by a 200 ms taper) by the calculated time of the subsequent direct arrival. Filtered traces were remerged into gathers, the linear moveout was removed, and top (30 ms) and bottom (100 ms) tapered mutes were applied, prior to output.

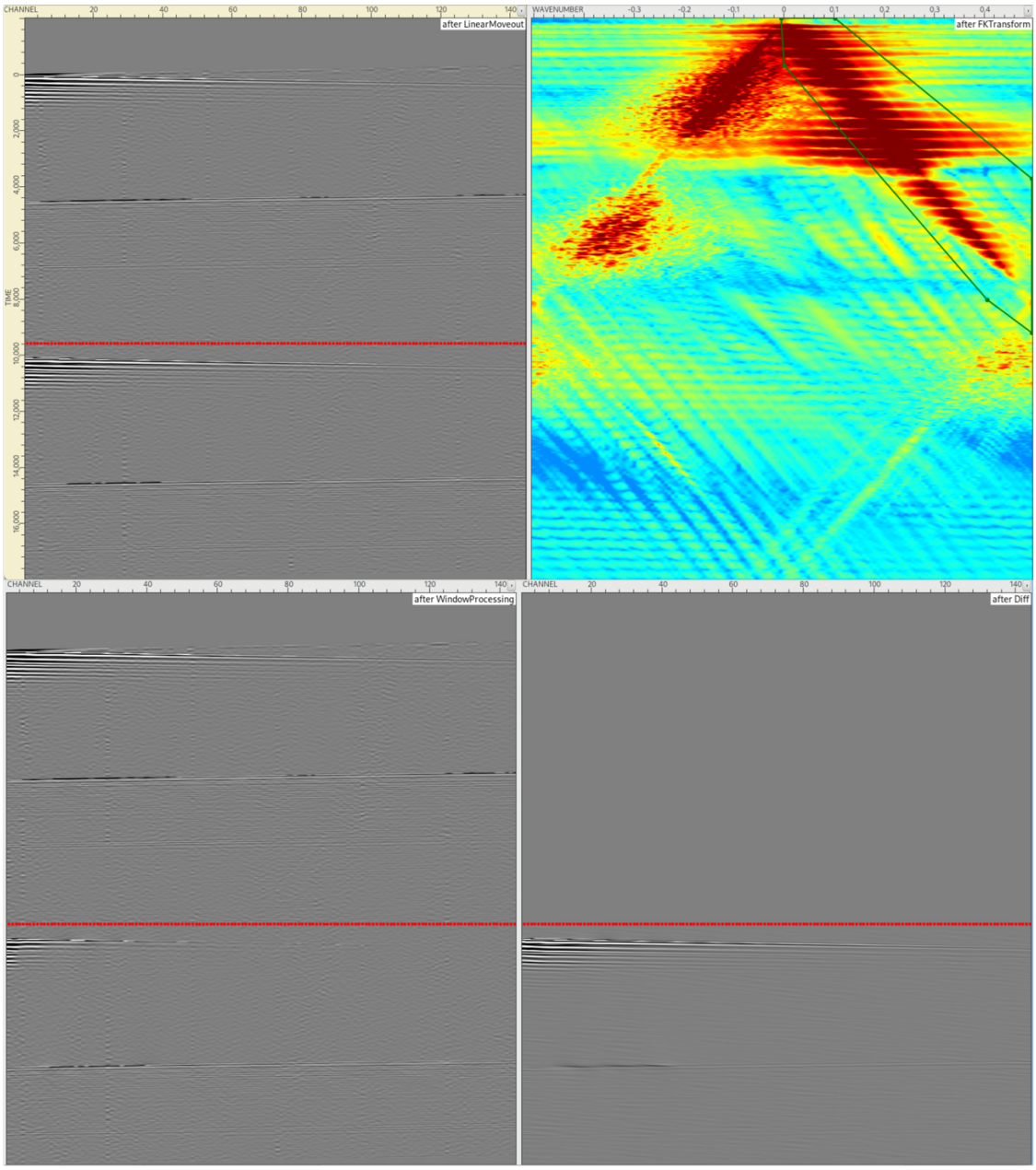


Figure 6. Example of FK filtering of the near 144 group section, within an interactive Reveal probe illustrating the polygon picking, trace before and after filtering, and the filtered noise.

8) FX Swell filtering was applied in the second flow (borrowed from the Reveal Venezuela 2D processing example) over three separate passes in the common channel domain. The first was designed to reduce broad noise bursts at frequencies between 0 and 125 Hz, the second to target local noise between 0 and 5 Hz, and the third to target broad noise bursts between 8-12 Hz. These filters were effective for reducing noise associated with ocean swell and streamer tug.

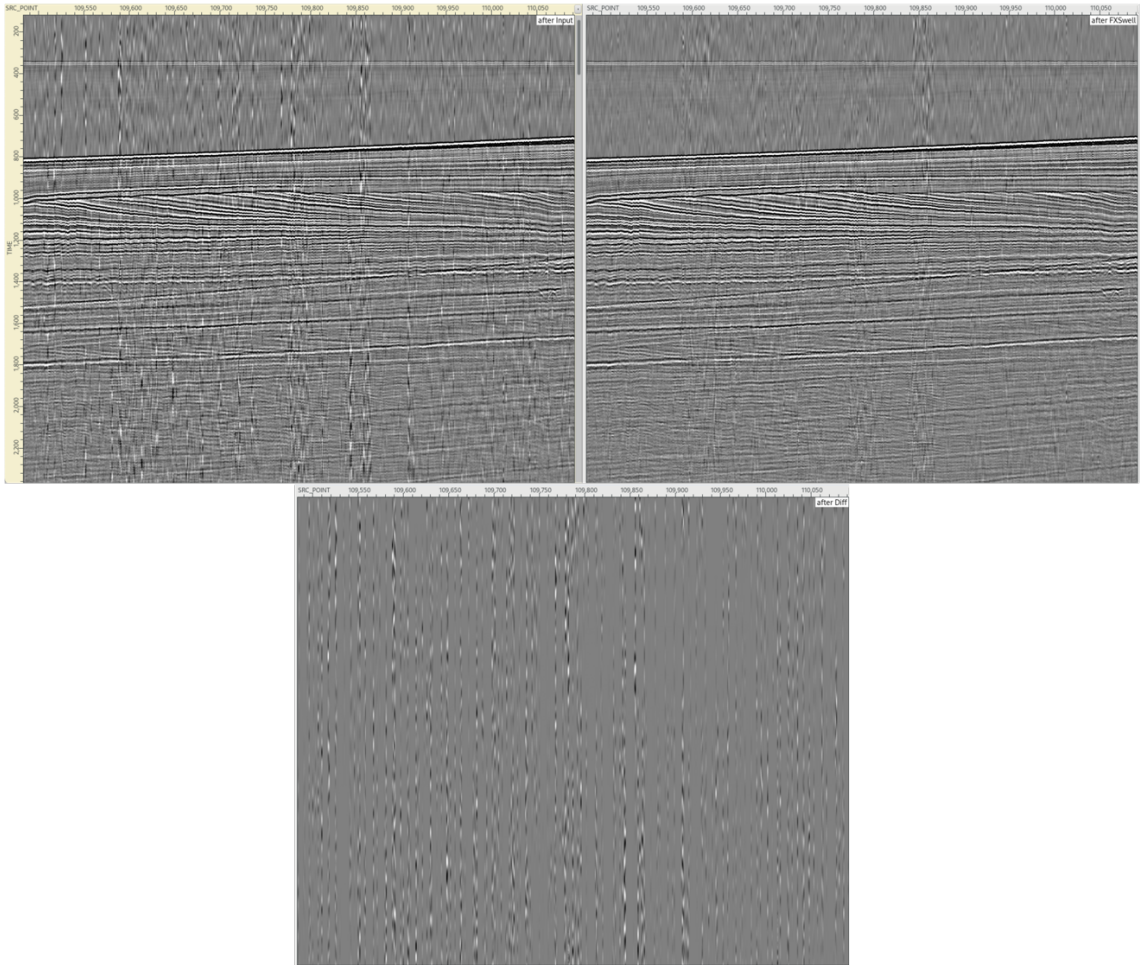


Figure 7. Example of FXSwell filter results, illustrating the traces before and after filtering, and the filtered noise.

Velocity and migration:

9) We decided to utilize a 1-D velocity model loosely based on data collected during MGL1407 and MGL1408 nearby on the margin as a starting point for velocity processing. In preparation, a stack (near 144 channels) of the 18 second geometry line profiles and the center beam depth of the EM122 MBES, included in the p190 navigation files, were used as inputs to pick sea floors for all lines. The Obspy z-detect method was used to pick the seafloor reflection at times within a window around the center beam depth value based on an amplitude threshold value. The picks were written to a table, reviewed and edited for accuracy.

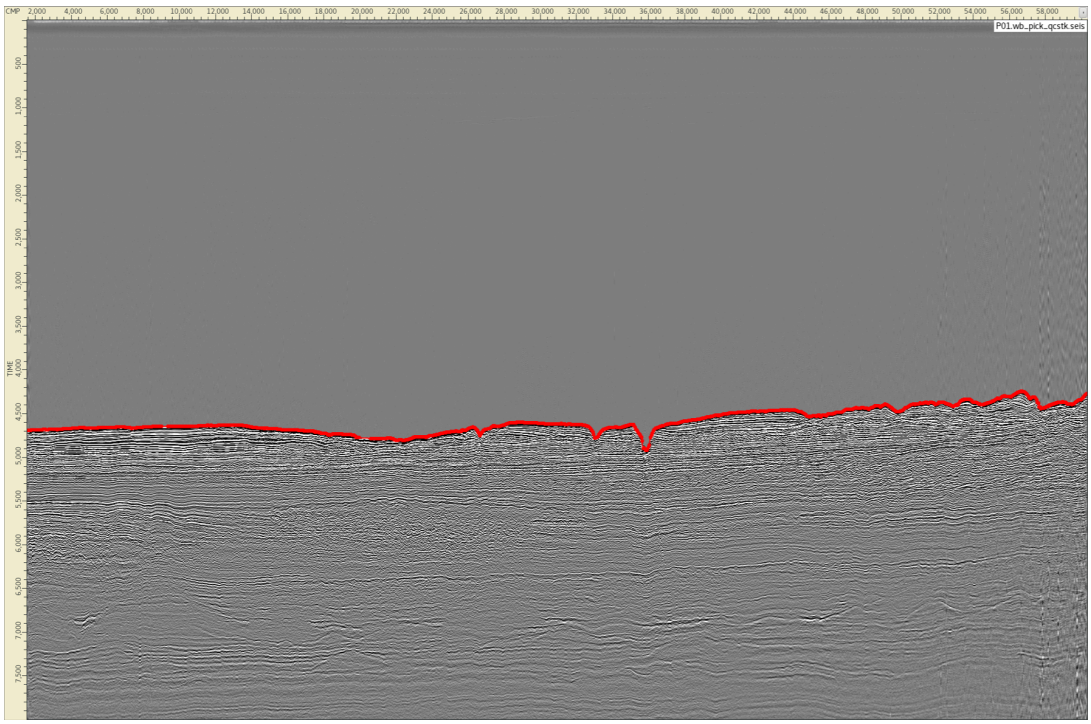


Figure 8. Example review of water bottom picked using the Obspy z-detect method.

10) Using the sea floor picks and domains CMP domains of the geometry lines, the 1-D interval velocity model was “hung” from the seafloor to produce a model over the same domain as the input CMP range and trace lengths. The time interval velocity model was converted to time RMS and written to a database table and a CMP stack (near 144 channels) was produced using the initial model.

11) To refine the 1-D model the Reveal residual semblance and semblance autopicker tools were utilized. The final denoise data for each geometry line were input along with the sea floor pick table, and an offset dependent spherical divergence correction and normal moveout were applied using the initial 1-D velocity model prior to picking. The picking function was run on 7 CMP supergathers and residual velocity percentage tables were produced for each geometry line.

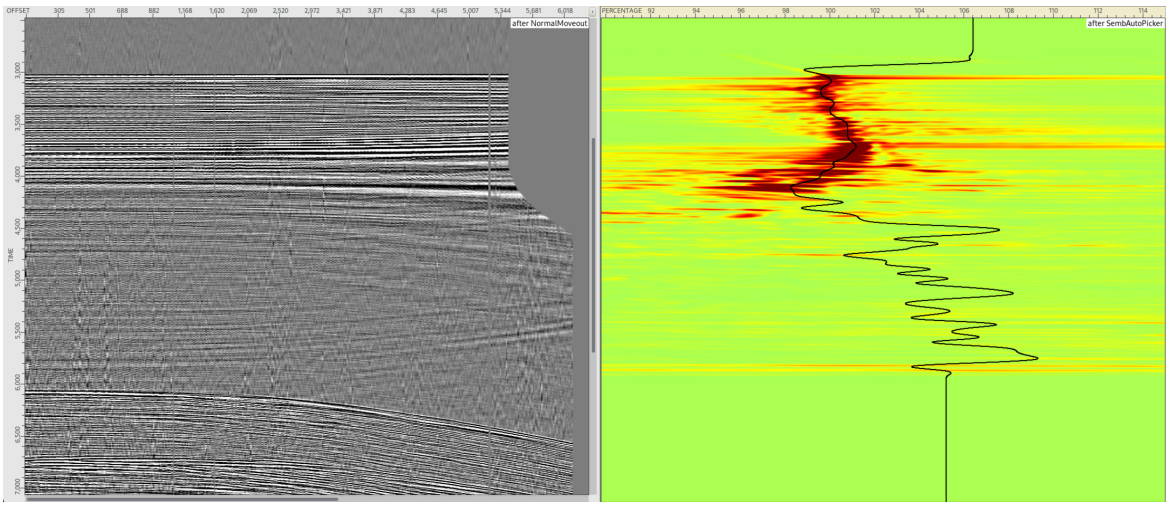


Figure 9. Example review of CMP supergather and residual semblance picks used to refine the 1-D velocity function used for CMP stacking and post-stack migration.

12) The initial 1-D velocity tables we multiplied by their residual velocity percentage tables and written to updated velocity tables, which were then used to produce new CMP stack (near 144 channels) for each geometry line.

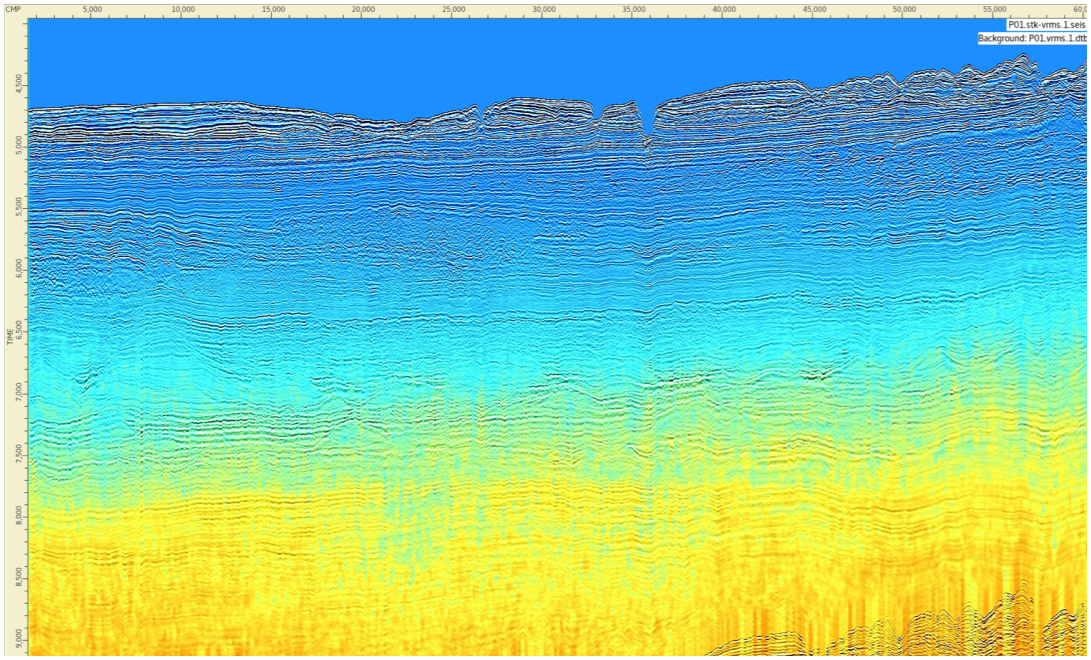


Figure 10. Example CMP stack of geometry line P01 and its associated 1-D velocity model after adjustment using the residual semblance percentages.

13) Finally, the preliminary CMP stacks with velocity and 1-D velocity tables were used to conduct post-stack phase-shift time migration, using 3.125 m bin spacing and preserving maximum frequencies of 440 Hz.

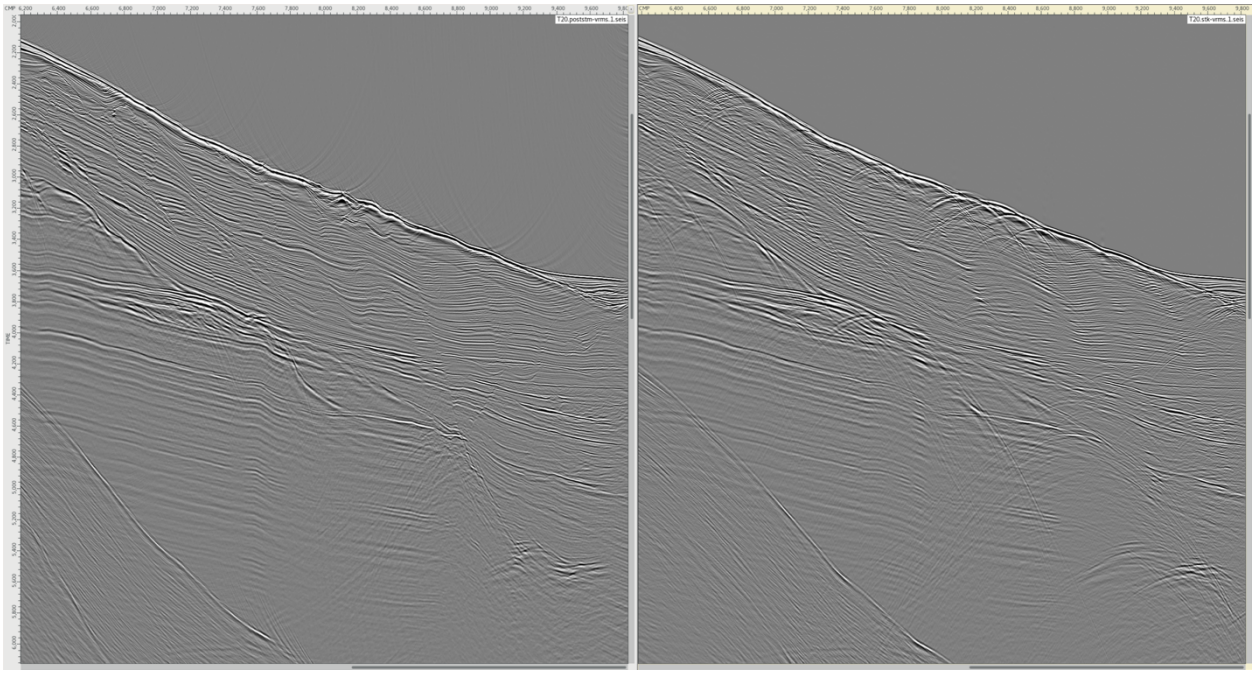


Figure 11. Example of post-stack phase shift time migration results (before and after, right and left panels, respectively) for a portion of geometry line T20, illustrating improved imaging of compaction related faults.

Known Problems

Several challenges were encountered during MCS acquisition and processing during MGL2306. With respect to acquisition, one challenge expected during cruise planning was conducting survey operations within and adjacent to the Gulf Stream current. As expected, periods of extreme streamer feathering occurred (nearing 90° at times) and along track "crab" of the survey vessel. At some points the current caused abandonment of planned tracks due to reduced ability to maneuver, or extreme changes in speed over ground, which caused required changes to shot spacing. Some of these events required reshoots of some line segments at alternate times and courses. Several periods of inclement weather also caused problematic navigation and noise in the recorded data, at times forcing the source and streamer to be towed at depth up to 10 meters.

Periodic source issues caused auto fires and required maintenance and operating for periods with only half of the array active. These events are noted in the observer and navigation logs and are mostly evident in the raw and shipboard processed data. The source outages also complicated shipboard processing of p190 navigation within the Orca navigation software. Outputs file processed in the presence of only one active source string contained inaccurate streamer positions over the time period of the source interruption. Additional navigation processing issues stemmed from the loss of tail buoy function during sequence 19. Eventually all navigation issues were rectified through use of an alternate software for processing.

With respect to processing, we think the shipboard stacks could be improved considerably through additional noise reduction work, including but not limited to tuning of the FK filter strategy, particularly for data acquired along the outer shelf and upper slope. While our velocity

and migration strategy clearly sharpened imaging of the relatively shallow sediments and fault traces, additional velocity work (possibly through streamer tomography) could improve the treatment of more rugose elements (mass transport deposit and basement surface) and the clarity of deeper sediment layers.

Data Summary and recommendations

Data type (format)	Trace length	Comment
Level 0 SEG-D	9-s	Raw data 9-s, continuous, and gun link
Level 0 Seismic (Seis)	9 and 18-s	Raw data converted in Reveal
Level 0 Navigation (p190)	N/A	Processed navigation
Level 1 Seismic (Seis)	9 and 18-s	Shot sorted gathers with merged header navigation and geometry
Level 1 Seismic (SEG-Y)	18-s	Sea-surface swell filtered static shifted Shot sorted gathers with merged header navigation and geometry
Level 2 Seismic (SEG-Y)	18-s	Preliminary CMP stack processed through post-stack, phase-shift time migration using 1-D velocity model hung from the seafloor.
Level 2 browse image (PNG)	18-s	Seismic Unix plot of migrated stack
GIS (SQL db, Esri shape, and ASCII CSV)	N/A	CMP trackline, 1000 CMP interval points, and shot points.

Table 4. Summary of raw and processed data.

Overall, the quality of MCS data collected during MGL2306 was quite good considering some of the challenges experienced. The addition of the 6.25 m groups to the layout and ability to acquire continuous data a 1-ms sample rate allowed for increased resolution and extended trace lengths. As such, we recommend that subsequent parties begin data copying early in the survey to keep up. Reading and writing the continuous data was also challenging for the computer systems and should be considered for those interested in working with the continuous records.

Acknowledgements

The quality of the MCS data acquired during MGL2306 would not have been possible if not for attentiveness of the marine technician crew including navigation and acquisition personnel, Cody Bahlau, Alan Delong, Giles Guerin, Jared Gursslin, Koray Ergun, and Riley Lopez; as well as the operational sound source and handling personnel, Joshua Kasinger, Brian Agee, Ray Hatton, and Malcom Moody.

Prepared by:

Wayne E. Baldwin, USGS, Woods Hole, MA wbaldwin@usgs.gov
David S. Foster, USGS, Woods Hole, MA dfoster@usgs.gov
Nathaniel C. Miller, Woods Hole, MA ncmiller@usgs.gov

6. MGL2306 Knudsen 3.5 kHz Chirp Acquisition and Processing

David S. Foster, USGS, Woods Hole, MA dfoster@usgs.gov
Wayne E. Baldwin, USGS, Woods Hole, MA wbaldwin@usgs.gov

System and GPS to transducer offsets

Chirp data were collected using a Knudsen Engineering Limited (KEL) 3260 Chirp echosounder. The 3260 is configured with a four-by-four, array of sixteen 3.5 kHz Massa TR-1075 transducers. The transducer array is in the sonar pod of the *R/V Langseth* adjacent to the EM122 multibeam transducers. The transducers are 20.2 m forward of the navigation reference point NRP) and C-Nav GPS antenna.

Knudsen Chirp Acquisition

KEL SounderSuite (v.4.12) software was used to record the data. Table 1 summarizes the parameters used in the SounderSuite software. The chirp data are acquired continuously along the cruise track and recorded within a window of 200 m, 500 m window depending on water depth. A manual deep-water delay was applied to keep the seafloor and subbottom reflections within the data window. Ping rates were variable depending on water depth. The chirp system was usually triggered internal, particularly in deep water. On steep slopes or shallow water, the internal ping trigger resulted in noise and loss of bottom tracking of the EM122 MBES. To mitigate this issue, the ping rate was set by external trigger from the EM122 MBES. This resulted in good spatial resolution of the chirp in shallow water and was a compromise on the slopes. Raw data consist of (a) KEL Binary (KEB) envelope detected trace data, (b) KEL ASCII (KEA), and (c) SEG-Y format trace data, which were recorded on the acquisition computer hard drive. SEG-Y files recorded the correlate (match filtered) trace data. These files are remotely copied via rsync to the *Langseth* network file server. Next, these files were copied with rsync from the server to a Synology NAS where they could be accessed from the processing workstation. KEB files can be played back or converted to SEG-Y format using KEL Postsurvey software (https://knudseneng.com). KEA files recorded user selected attributes and for this cruise include RecNum, ddmmyyyy, hhmmss.sss, Freq, Depth, SigType, EnvDet, TxPwr, RxGain, Pulse, TxBlank, SDepth, EDepth, Freq,Depth, SigType, EnvDet, TxPwr, RxGain, Pulse, TxBlank, SDepth, EDepth, SndSpd, Lat/Y, Long/X, GPSMode.

Table 1. SounderSuite Echo Control Client (v. 4.12) settings

Transmit Parameters	Settings
Tx Pulse	8, 16, and 32.0 ms (longer pulse length with depth)
Tx Power	Variable 1-3 (Generally Powers 1on the shelf, 2on the slope, 3 for deep > 3000 m)
Gain Mode	Manual
Gain Value	Variable 10-48 dB
TVG Mode	None
Process Shift	1 – not applied in manual gain mode
Draft	None
Tx Blanking	25.0 m
Global Tx	Mixed

Range (data window)	200 m (266 ms), 500 m (666 ms), 1000 m (1333 ms)
Phase (deep-water delay)	Manual (depth dependent)
Depth Limits	0-9000 m
Multiple Pings	Enabled or not enabled
Sound Speed	1500 m/s
Ping Rate	Both internal and external triggering
Echogram	Uncompressed
Sync Mode	Internal or External (slave to EM122)
Waveform	Chirp: Envelope Detect Square Law
Center Frequency Band	3.5 kHz
Frequency Bandwidth	3 kHz
SEG-Y Carrier Type	Filtered (match filtered – correlate)

Processing

Processing and QA/QC of the KEL Chirp data was accomplished using a series of flows that utilize Shearwater Reveal seismic processing software. PNG images of the processed data were created with SeismicUnix (github.com/JohnStockwellJr/SeisUnix). The following process steps were applied and Reveal Seis format or SEG-Y files written as described below.

1) A Reveal flow named *101_ReadKELSegy Input* one or more correlate SEG-Y files that coincided with transit or MCS lines (Table 2?). All traces from these files were sorted into one large gather. Original FFIDs were renumbered sequentially starting at one by setting FFID equal to the gather trace number. The original FFID numbers in the SEG-Y trace headers and KEA files do not match the renumbered FFIDs. Geographic coordinates (arc seconds) were read from the SEG-Y trace headers (source X and Y) and converted (module UTM2LatLon) to decimal degrees. These coordinates represent the position of the NRP. No offset corrections were applied to these coordinates. The geographic coordinates were converted to UTM Zone 18 North (WGS 84) with the module UTM2LatLong. The raw SEG-Y files have varying deep-water delays as well as different trace lengths. The flow rectified different delay times by setting the trace length and start and end two-way travel time (TWT) the same for all input SEG-Y files, which resulted in traces that were padded with zero sample values outside of the original data window (Figure 1). Some files that had total padded trace lengths that exceeded the SEG-Y format maximum number of samples (65,536) had to be resampled so as not to exceed this limitation. The delay header was then set to a common minimum delay from all the input files. Traces were then sorted by FFID. A Reveal Seis format trace file was written for the correlate traces with common delay and trace length. The Reveal module CTAN was used to apply a Hilbert Transform to convert traces data to envelope and written to a new Seis file. The Reveal headers (NRP_X, NRP_Y, NRP_LON, NRP_LAT, TRACENO [FFID], YEAR, DAY, HOUR, MINUTE) were written to CSV files to be used with GIS.

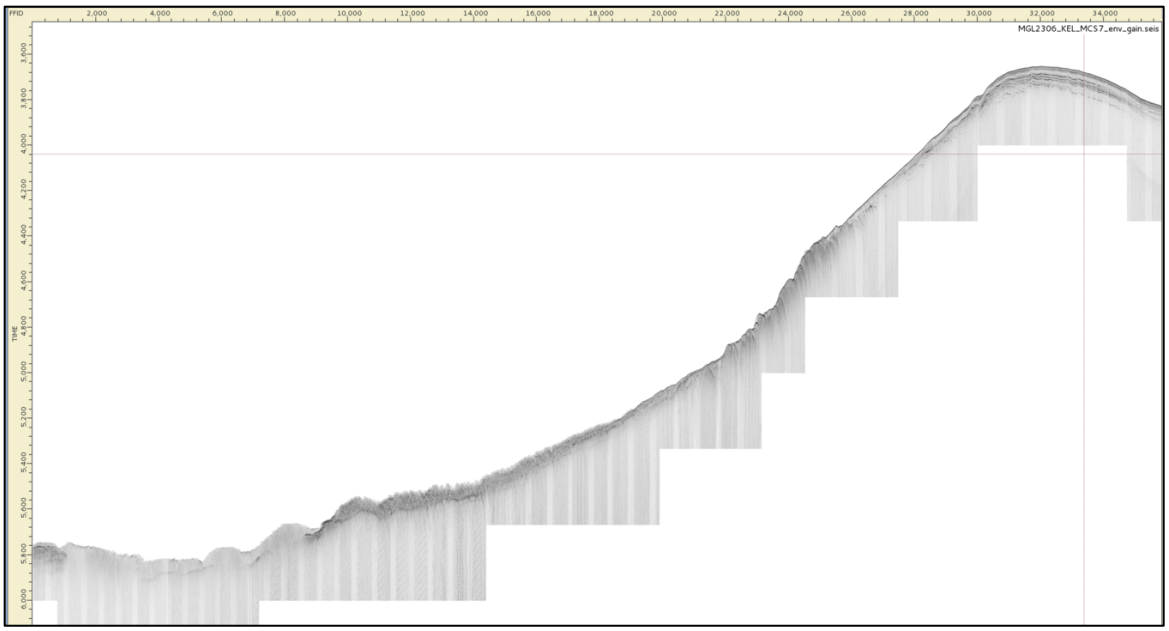


Figure 1. An envelope chirp profile (MGL2306_KEL_MCS7_env_gain) consisting of concatenated raw SEG-Y files that were static shifted, and samples were padded to a common trace start and end time. This profile, which coincides with MCS P7, had to be resampled before writing a SEG-Y file, because the number of samples per trace exceeded the SEG-Y format limit.

2) A Reveal flow named *102_OPWBPickTable* read the envelope trace data created in the previous flow. A custom Python Obspy module written by Nathan Miller was used to pick the seafloor by finding the maximum amplitude for a set data window and a threshold value to prevent picking values above and below the seafloor (Figure 2). The data window was set by picking a guide table as the top of the window (above the seafloor) and the bottom of the window was 10 ms below the guide table. The picked seafloor was saved as a header and subsequently written to a table to be used in the next processing step. Some seafloor picks required editing spurious picks from the table file before further processing.

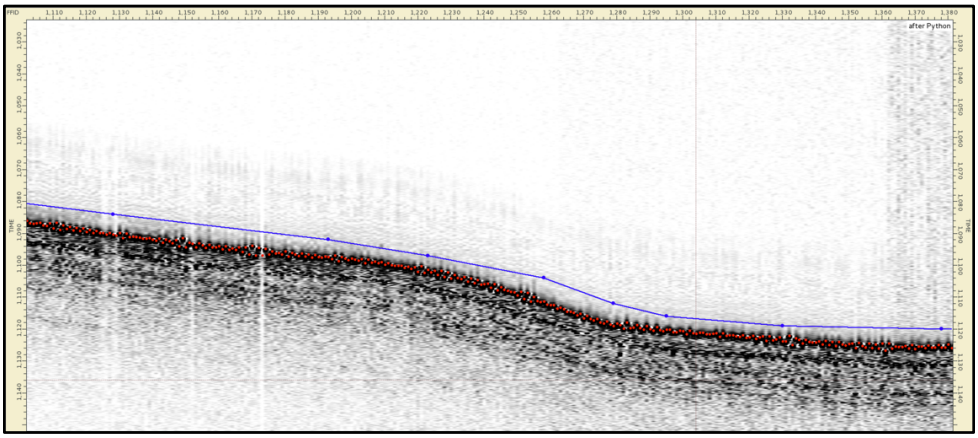


Figure 2. Chirp profile showing Obspy picking (red dots) the seafloor with swell (heave). The blue line is the upper guide that is digitized to constrain the picks below the guide.

3) The Reveal flow *103_SwellStatGain* smoothed the seafloor picks from the previous step to filter sea-surface swell (heave) from the correlate trace data. When the seafloor picks were sufficiently sampled the sea-surface swell without spatial aliasing, a static shift value was applied by subtracting the original seafloor pick header from a smoothed seafloor header value and applying the difference as a static shift. The static shifted traces resulted in significant improvement in the resolution of the data (Figure 3). A time-varying gain was applied to the trace amplitudes that started from the smoothed seafloor header values and increased exponentially with increasing TWT. If no smoothed seafloor header was available, then the manually picked guide table was used to start the gain TWT. The processed traces were written to correlate and envelope Reveal Seis files.

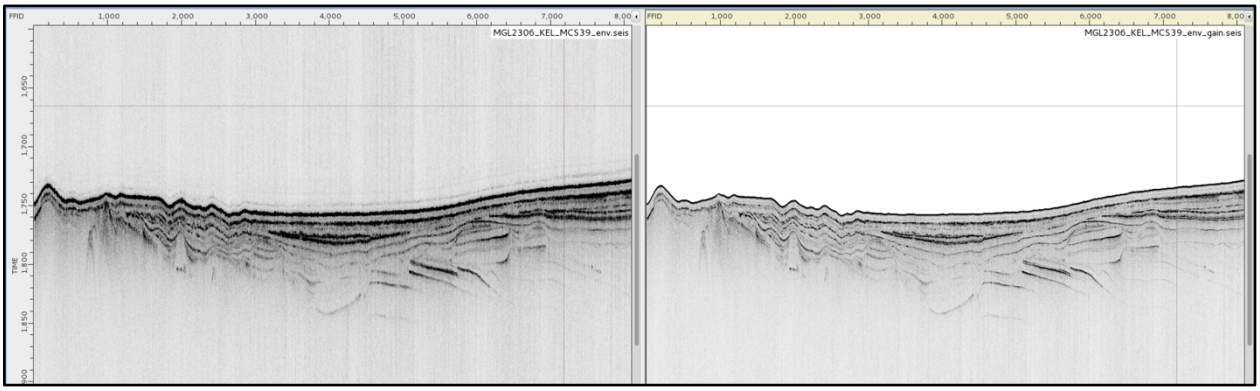


Figure 3. Left profile, a subset of a processed chirp file MGL2306_KEL_MCS39 after application of common deep-water delay and padding trace data to a common length. Right profile, the same profile after application of a 11-point swell filter to apply a static correction to the traces to remove vessel heave and a time-varying gain initiated from the sea floor.

4) A Reveal flow *104_WriteSegy* input the full waveform Reveal Seis files from the previous step. Tracelength was used to set a common start and end time of the traces to eliminate excessive water column in the data. A common delay was set to the beginning of the traces. Traces were down sampled when the number of samples per trace was exceeded as allowed by the SEG-Y standard. A SEG-Y file was written for full waveform and another for envelope traces. General information is in the EBCDIC headers, for example:

> MGL2306 - R/V Marcus G. Langseth
> U.S. Geological Survey Field Activity 2023-007-FA
>
> Knudsen Engineering Ltd. (KEL) 3260 3.5 kHz Chirp
> SEG-Y file: MGL2306_KEL_MCS1_real_gain.sgy
>
> Processing: SwellGain
> Filenames containing "env" indicates envelope traces,
> "real" indicates full waveform
>
> Positioning from Langseth navigation reference point (NRP), no offset correction`
> Coordinates stored NRP_X (bytes 181-184), NRP_Y (bytes 185-188)
> 32-bit IEEE float, UTM zone 18 North (WGS 84)
> FFID and Delay are in standard SEG-Y trace headers

5) The CSV files from step 1 were imported to a SQL database using a Python script written by Wayne Baldwin. The SQL database contains unique shot and coordinates, shot and coordinates for 100-m shot intervals and beginning and end shots and coordinates, and tracklines (polylines) with associated attributes. The SQL database was imported to QGIS and plotted before exporting tracklines and 100-shot interval points to Esri shapefiles.
6) A Kingdom Suite (v. 2017, SQL 2014) project was created to QA/QC the processed SEG-Y files and identify data gaps and any navigation issues. The project was also useful in aiding the selection of coring sites for MGL2307.
7) Seismic Unix was used to plot 8-bit gray scale PNG images of the envelope and padded trace data. The images are annotated with shot number along the horizontal axis with 100 shot interval ticks that coincide with SQL and shapefile shot navigation (Figure 4). These images are useful for browsing trace data from each file and creating preliminary figures.

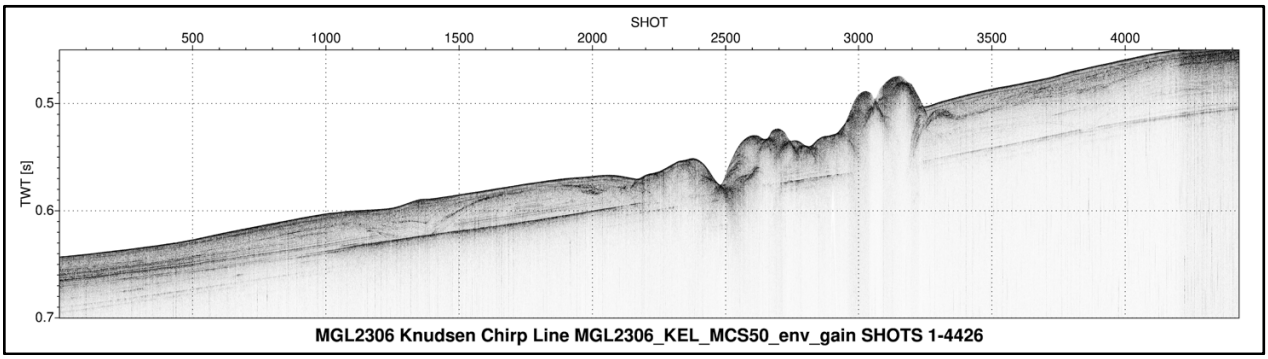


Figure 4. Example of a Seismic Unix plot.

Known Problems

The overall quality of the KEL chirp data was good with a few exceptions. Coherent zero to low-amplitude trace segments are present throughout the chirp data (Figure 5). These trace segments are noticeable when zoomed in but do not significantly degrade the data. They have been observed in previous *Langseth* cruises and attributed to interference from the EM122 MBES.

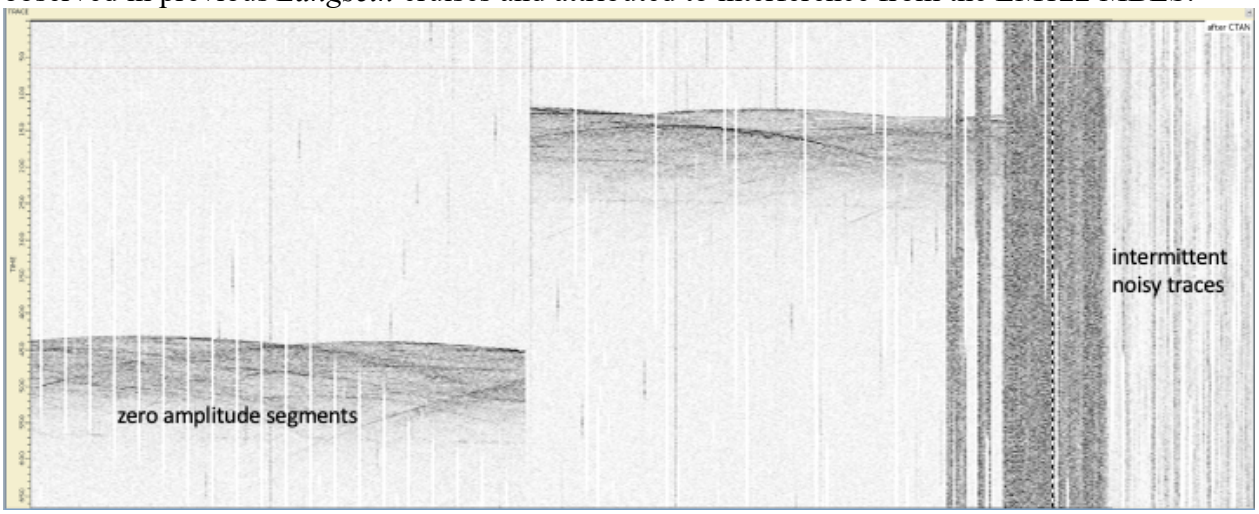


Figure 5. A raw envelope chirp profile without delay adjustment showing types of noise seen in the data.

Intermittent noisy traces occurred during Julian days 150 and 151 while MCS lines 44, 45, and 46 were being shot. The noise completely masked the trace data. Portions of these lines were not recorded due to transceiver shutdowns and troubleshooting. A call with Knudsen support resulted in resetting the acquisition software to default values. This seemed to help, but the noise did return after no changes in acquisition parameters. The noise ended during MCS Line 46; however, the cause was not determined. Possibilities include ship or electronic induced interference. The use of multi-ping mode was suspected, but not confirmed. Multi-ping mode was not used for the remainder of the cruise.

Spatial aliasing prevented swell filtering when trace spacing exceeded the sea-surface wave lengths, due to slower ping rates and deeper water depths. This problem was minimized by using internal triggering and using the SounderSuite multi-ping option.

Data Summary

A total of 4,430-line kilometers (Figure 6) of KEL Chirp profiles were acquired and processed.

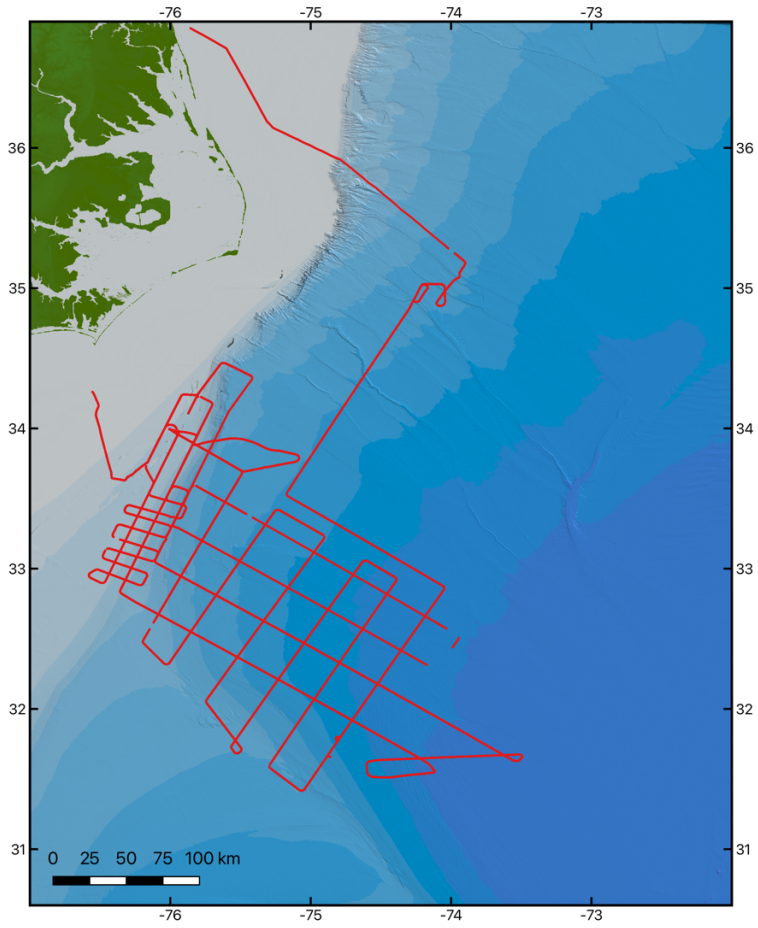


Figure 6. Map showing trackline locations of KEL Chirp profiles for MGL2306.

Information about raw file names, shot range, trace length, date, and time are in Table 2. Table 3 summarizes the data types from raw to output from various process steps. Processed KEL Chirp files named in relation to MCS lines, renumbered shot (FFID) starting at 1, ending shot number, beginning trace time in milliseconds (common delay), start and end day and time, line length (km). Note this was the acquisition computer time, which could be slightly different than UTC if the Knudsen computer was not synced to a time server. Navigation data are the definitive attribute for locating and correlating with other datasets. The Excel spreadsheet MGL2306_KEL_FileLog.xlsx, included with the data, has details of which raw SEG-Y files were input to reveal and their attributes.

Table 2.

LineName	Shot_init	Shot_end	Delay	UTCDT_init	UTCDT_end	Length_km
MGL2306_KEL_Transit2	1	15799	0	129:20:43:09	130:00:15:56	72.790
MGL2306_KEL_Transit3	1	12176	0	130:00:17:42	130:03:00:02	58.290
MGL2306_KEL_Transit4	1	5231	0	130:03:00:05	130:04:09:50	24.042
MGL2306_KEL_Transit5	1	814	266	130:04:09:59	130:04:23:50	4.530
MGL2306_KEL_Transit6	1	1224	1200	130:04:24:14	130:06:50:22	45.274
MGL2306_KEL_Transit7	1	221	3100	130:06:51:55	130:07:26:38	9.960
MGL2306_KEL_Transit8	1	233	3300	130:07:27:07	130:08:04:34	10.900
MGL2306_KEL_Transit9	1	1011	3600	130:08:06:42	130:10:53:45	31.009
MGL2306_KEL_Transit10	1	140	4300	130:11:52:32	130:11:57:37	0.425
MGL2306_KEL_Transit11	1	15377	4300	130:11:57:54	130:20:25:58	44.842
MGL2306_KEL_Transit12	1	9091	4300	130:20:27:49	131:01:21:23	31.484
MGL2306_KEL_Transit13	1	10825	4100	131:01:21:27	131:07:00:24	27.379
MGL2306_KEL_Transit14	1	5693	4100	131:07:00:36	131:09:58:57	21.697
MGL2306_KEL_MCS1	1	37243	4200	131:09:59:00	132:07:17:22	184.226
MGL2306_KEL_MCS2	1	20400	4600	132:07:26:16	132:21:58:04	131.865
MGL2306_KEL_MCS3	1	29299	4900	132:21:58:09	133:18:39:15	151.608
MGL2306_KEL_MCS3A	1	12760	3900	133:20:53:29	134:04:08:05	52.051
MGL2306_KEL_MCS4	1	7121	3900	134:04:08:11	134:07:35:20	28.785
MGL2306_KEL_MCS5	1	30539	3800	134:07:46:10	135:03:19:13	170.432
MGL2306_KEL_MCS6	1	5989	5700	135:03:19:16	135:07:32:57	24.954
MGL2306_KEL_MCS7	1	35857	3500	135:07:33:07	136:05:04:07	171.730
MGL2306_KEL_Transit20	1	4768	3700	136:05:05:47	136:07:24:31	18.096
MGL2306_KEL_MCS8	1	13568	3400	136:07:24:34	136:13:38:26	47.357
MGL2306_KEL_MCS9	1	28604	3500	136:13:38:29	137:06:05:43	144.984
MGL2306_KEL_MCS10	1	7852	4500	137:06:19:41	137:11:03:31	36.531
MGL2306_KEL_MCS11	1	31914	3000	137:11:13:28	138:04:48:17	142.806
MGL2306_KEL_MCS12	1	4647	2800	138:04:57:50	138:07:40:14	23.559
MGL2306_KEL_MCS13	1	2191	2800	138:07:40:16	138:08:52:37	10.680
MGL2306_KEL_MCS13A	1	28557	2800	138:09:32:11	139:01:00:52	134.882
MGL2306_KEL_MCS14	1	12035	700	139:01:00:56	139:07:05:01	53.529
MGL2306_KEL_MCS15	1	2713	500	139:08:24:56	139:09:43:47	15.294
MGL2306_KEL_MCS16	1	2354	500	139:09:57:34	139:11:17:17	9.204
MGL2306_KEL_MCS17	1	12187	600	139:11:31:58	139:19:27:42	34.882
MGL2306_KEL_Transit15	1	4384	1400	139:19:27:47	139:21:59:49	18.358
MGL2306_KEL_Transit16	1770*	31220	3600	139:21:59:51	140:13:00:03	100.085
MGL2306_KEL_MCS14R	1	24144	500	140:13:00:06	141:00:57:54	56.336
MGL2306_KEL_MCS14S	1	2922	600	141:00:57:57	141:02:15:51	2.476
MGL2306_KEL_Transit17	1	10433	600	141:02:15:54	141:07:01:05	20.732

MGL2306_KEL_MCS17B	1	24924	1300	141:07:01:09	141:22:24:16	55.098
MGL2306_KEL_MCS20	1	3233	1800	141:22:24:21	142:00:08:31	14.623
MGL2306_KEL_MCS21	1	4284	3333	142:00:08:35	142:02:03:41	10.238
MGL2306_KEL_MCS22	1	8816	666	142:02:03:42	142:06:48:32	35.859
MGL2306_KEL_MCS23	1	2652	800	142:06:55:34	142:08:07:43	4.743
MGL2306_KEL_MCS24	1	8502	800	142:08:07:48	142:12:28:49	31.150
MGL2306_KEL_MCS25	1	4443	2600	142:12:28:52	142:14:58:12	12.366
MGL2306_KEL_MSC26	1	9067	700	142:14:58:14	142:19:42:27	33.191
MGL2306_KEL_MCS27	1	3803	800	142:19:42:31	142:21:26:01	10.408
MGL2306_KEL_MCS28	1	3731	800	142:22:01:19	142:23:57:43	17.095
MGL2306_KEL_MCS29	1	4868	1600	142:23:57:47	143:02:33:42	18.969
MGL2306_KEL_MCS30	1	7107	800	143:02:33:45	143:07:07:46	32.041
MGL2306_KEL_MCS31	1	1097	900	143:07:29:18	143:08:26:29	5.886
MGL2306_KEL_MCS32	1	1997	900	143:08:26:35	143:10:21:58	16.828
MGL2306_KEL_MCS32A	1	3090	1400	143:10:22:08	143:12:08:28	15.657
MGL2306_KEL_MCS33	1	3227	2300	143:12:16:44	143:13:43:42	8.881
MGL2306_KEL_MCS34	1	5084	800	143:13:53:16	143:17:53:52	31.161
MGL2306_KEL_MCS35	1	1729	900	143:18:00:52	143:19:33:14	7.221
MGL2306_KEL_MCS36	1	1468	666	143:19:41:04	143:21:05:34	12.148
MGL2306_KEL_MCS37	1	9351	800	143:21:05:38	144:06:00:55	85.830
MGL2306_KEL_MCS20a	1	1620	666	144:06:09:26	144:07:19:31	12.322
MGL2306_KEL_MCS19	1	4077	500	144:07:34:47	144:10:12:27	30.764
MGL2306_KEL_MCS14B	1	2794	500	144:10:12:30	144:11:45:52	14.589
MGL2306_KEL_MCS37A	1	10391	700	144:11:55:38	144:20:02:58	50.973
MGL2306_KEL_MCS20B	1	5624	666	144:20:03:01	144:23:37:36	34.953
MGL2306_KEL_MCS18	1	2602	1500	144:23:37:40	145:01:11:07	13.156
MGL2306_KEL_MCS39	1	19507	1600	145:01:15:58	145:14:32:01	90.736
MGL2306_KEL_MCS40A	1	20362	1700	145:14:32:04	146:01:02:29	96.795
MGL2306_KEL_MCS40B	1	22789	4500	146:01:02:31	146:16:10:43	145.332
MGL2306_KEL_Transit18	1	14319	5500	146:16:10:49	147:02:43:02	73.385
MGL2306_KEL_MCS41	1	14458	5600	147:02:43:07	147:13:48:46	98.242
MGL2306_KEL_Transit19	1	3833	6780	147:13:48:52	147:16:14:02	18.414
MGL2306_KEL_MCS42A	1	11386	6400	147:16:14:04	148:01:00:00	72.308
MGL2306_KEL_MCS42B	1	17583	5500	148:01:00:03	148:13:27:18	93.274
MGL2306_KEL_MCS42C	1	19898	4200	148:13:27:23	149:01:05:01	87.029
MGL2306_KEL_MCS42D	1	11349	2500	149:01:06:48	149:06:44:01	40.679
MGL2306_KEL_MCS43	1	13444	2500	149:06:44:05	149:13:52:18	65.438
MGL2306_KEL_MCS44A	1	9125	3500	149:14:05:17	149:18:43:21	40.095
MGL2306_KEL_MCS44B	1	4243	4500	149:19:20:45	150:03:01:58	66.276
MGL2306_KEL_MCS44C	1	3756	5400	150:03:02:06	150:11:02:28	68.725
MGL2306_KEL_MCS44D	1	1760	6200	150:11:02:36	150:13:42:26	21.094
MGL2306_KEL_MCS45	1	617	6400	150:14:57:38	150:16:24:55	8.561
MGL2306_KEL_MCS46A	1	2834	6000	150:20:38:53	151:03:02:02	36.627
MGL2306_KEL_MCS46B	1	3144	5333	151:03:02:10	151:10:00:02	59.173
MGL2306_KEL_MCS46C	1	7383	3000	151:10:00:09	151:23:22:08	106.496
MGL2306_KEL_MCS47	1	10121	3000	151:23:22:12	152:13:25:54	128.810
MGL2306_KEL_MCS48	1	4243	1666	152:13:32:35	152:18:33:48	21.659
MGL2306_KEL_MCS49	1	12206	500	152:18:42:45	153:00:54:30	31.083
MGL2306_KEL_MCS50	1	4426	450	153:00:54:31	153:02:52:33	9.248
MGL2306_KEL_MCS51	1	21988	400	153:03:01:42	153:14:03:54	57.229
MGL2306_KEL_Transit21	1	21346	300	153:14:04:00	154:02:01:14	47.220

MGL2306_KEL_Transit22	1	963	200	154:02:01:15	154:02:26:55	4.432
MGL2306_KEL_Transit23	1	10464	0	154:02:26:58	154:07:18:18	50.839

*MGL2306_KEL_Transit16 starts at shot 1770 (no shots are missing)

Table 3. Summary of raw and processed data.

Data type (format)	Trace length	Deep water Delay	Comment
Level 0 Seismic (KEB)	Variable	Variable	Read or convert with KEL software
Level 0 Seismic (SEG-Y)	Variable	Variable	Correlate (match filtered) traces.
Level 0 Attribute (KEA)	N/A	N/A	Select attributes in ASCII format.
Level 1Seismic (Seis)	Common	Common	Padded traces with common delay and trace length. Separate envelope and full waveform traces.
Level 2 Seismic (Seis)	Common	Common	Sea-surface swell filtered static shifted
Level 3 Seismic (Seis)	Common	Common	Time-varying gain applied below the seafloor picks.
Chirp profile (PNG)	Common	Common	Seismic Unix plot
GIS (SQL db, Esri shape, and ASCII CSV)	N/A	N/A	Trackline, Unique shot point, and 100 shot-point intervals

Recommendations

Internal triggering and multi-ping capabilities significantly improved data resolution, for example, the data processed in 2019 (MGL1903). Multi-ping was discontinued after noisy trace data developed during Julian days 150 and 151, because it was thought to be a possible contributor to the noise. However, the noise did occur again without muti-ping enabled and without user interaction with acquisition settings. The source of the noisy traces and solution should be investigated. The use of muti-ping mode would contribute to collection of higher quality chirp profiles.

A consideration that would negate the need for processing heave removal would be to use the heave data from the IMU. This would require that the Knudsen acquisition computer to be always synced to GPS time. Also, the Knudsen SounderSuite could take the heave correction.

Acknowledgements

The quality of the chirp profiles acquired during MGL2306 would not have been possible if not for the attentive watch standing by Louis-Marin Bodiguel-Dupuis, Mason Farnsworth, Emma Le Gall, and Ali Mohammed with assistance by Bill Danforth, Celine Grall, and James Gibson.

7. Summary of multibeam bathymetry acquisition parameters and analysis (including water column data)

William Danforth, USGS Woods Hole, MA bdanforth@usgs,gov
James Gibson, LDEO, New York, NY jgibson@ldeo.columbia.edu

Acquisition

Bathymetry and backscatter data were collected using a Kongsberg EM-122 multibeam echo sounder and SIS (v4.3.2) PC acquisition software. The system consists of two hull-mounted transducer arrays (Figure 1): A transmit array is located along the ship centerline that forms a 150° athwartship and a 1° alongship transmit beam that has up to 9 pitch, roll, and yaw compensated sectors in deep waters (> 1000 m) centered at 12 kHz (10.5 – 13.0 kHz). A receive array that forms 1° athwartship x 30° alongship beams is located forward of the transmit transducer array and oriented athwartships. The system forms a swath of 288 receive beams that produce an across-track profile of 432 high density, equidistant bathymetric soundings.



Figure 1. View of the Kongsberg EM122 transmit (EM122 Tx) and receive arrays (EM122 Rx) prior to installation.

Motion and position of the vessel was measured using a Seapath 330 integrated inertial/GNSS system and sent to the SIS acquisition software in real time. The Seapath 330 inertial motion reference unit (MRU) measures and records heave, pitch, and roll data, and the heading is determined by a dual antenna setup. Position comes from the system primary antenna. These data are sent to the SIS acquisition software via serial cables.

The origin or zero offset of the mapping system frame of reference is the Navigation Reference Point (NRP), which was reset during the 2023 Multibeam Advisory Committee (MAC http://mac.unols.org) quality assurance test (QAT) conducted in February 2023. For the MGL2306 survey the NRP was referenced to the top of the IMU bottle within the Seapath 330 MRU located in the main deck dry lab, and linear offsets between the multibeam arrays and the NRP for both the Seapath 330 and POS MV inertial navigation systems were updated onboard the Langseth (Fig 2) during the MGL2301 QAT survey. Built in self tests (BIST) were also conducted by the MAC and found the EM122 system in very good health. As stated in the QAT executive summary: "*The EM122 has been in service for 16 years using the original TX array (2007) and slightly newer RX array (2010); the topside electronics are generally original and appear to be functioning well, though the system is beyond the service life of ~10 years typically seen among other deepwater Kongsberg multibeam systems. Dockside Built-In Self-Tests (BISTs) indicated acceptable impedance levels with four TX element failures and one RX element failure; these results are proxies for hardware health and should be corroborated with direct*

impedance measurements (e.g., using a Cypher impedance analyzer, available from Kongsberg)."

EM122, POS MV, and Seapath configuration updates outlined in the MAC QAT resulted in a unified mapping system reference frame with the origin at the Seapath MRU target (translated from Frame 1/centerline/keel using the February 2023 Westlake Consultants, Inc survey results.). Also updated were GNSS antenna baseline calibrations for the Seapath system (dockside) as well as POS MV GPS Azimuth Measurement System (GAMS) heading calibrations.

A patch test is required to measure any residual MRU angular offsets latencies remaining after installation, and the last full patch test was done in 2012. An updated patch test was therefore conducted by the MAC during the February 2023 QAT, and angular offsets for pitch, roll, and heading (yaw) were subsequently updated for both the Seapath MRU and POS MV IMU (Fig 2).

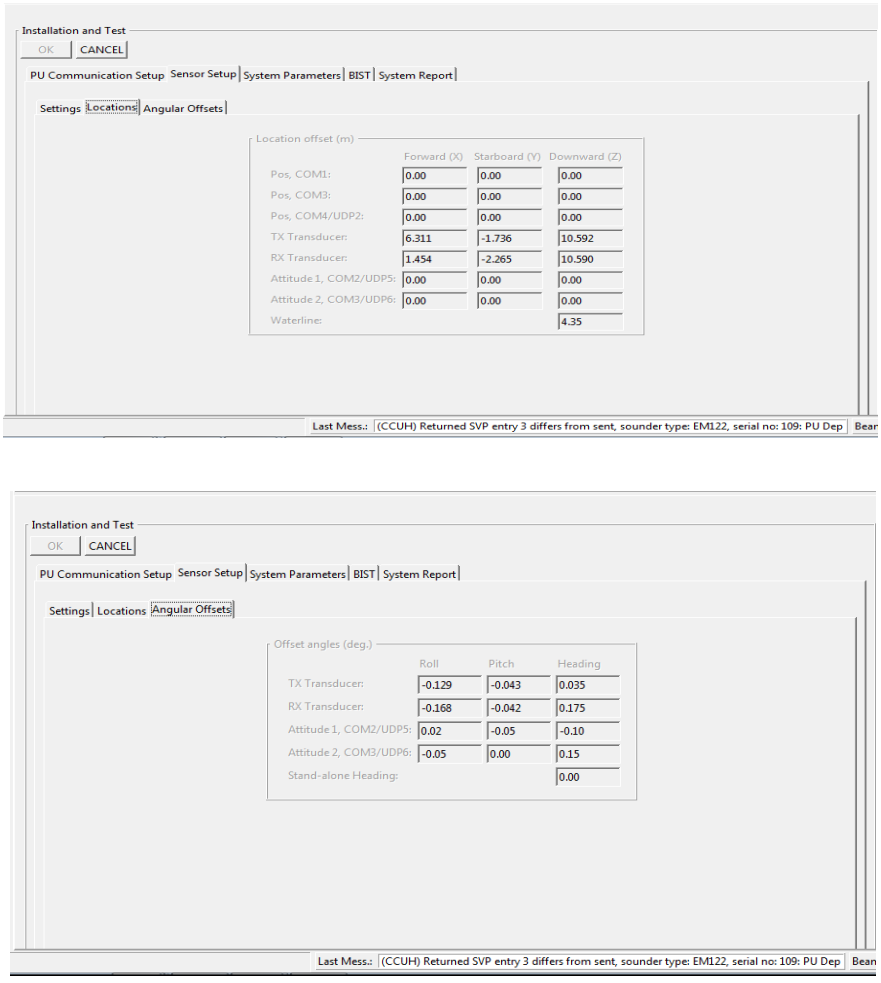


Figure 2. Location and angular offsets of the transmit (tx) and receive (rx) arrays relative to the Seapath 330 MRU

The SIS software processes the EM122 sonar range/angle data from each ping during acquisition, merging position, motion sensor and hull mounted sound velocity data, as well as the current sound velocity profile to derive 432 sounding solutions compensated for vessel motion and water column sound velocity variations in a swath athwart-ships for each transmitted ping. The EM122 was operated in dynamic dual-swath mode, resulting in a total of 864 soundings per ping. Within SIS, the slope, aeration, and interference filters were turned on to enable better bottom detects by compensating for hull bubble washdown, Knudsen 3.5 kHz transmit signals, and false inward changes in slope across track. Water column returns were gained up using a 30logR curve to ensure the intensity range was above the -65 dB lower limit set by SIS, and a 10 degree from normal incidence angle for was chosen to avoid high specular returns at nadir influencing angle dependent backscatter variations. Lambert's law compensation was left off as the QPS FM Geocoder program accounts for spreading loss while processing the EM122 backscatter (Fig 3).

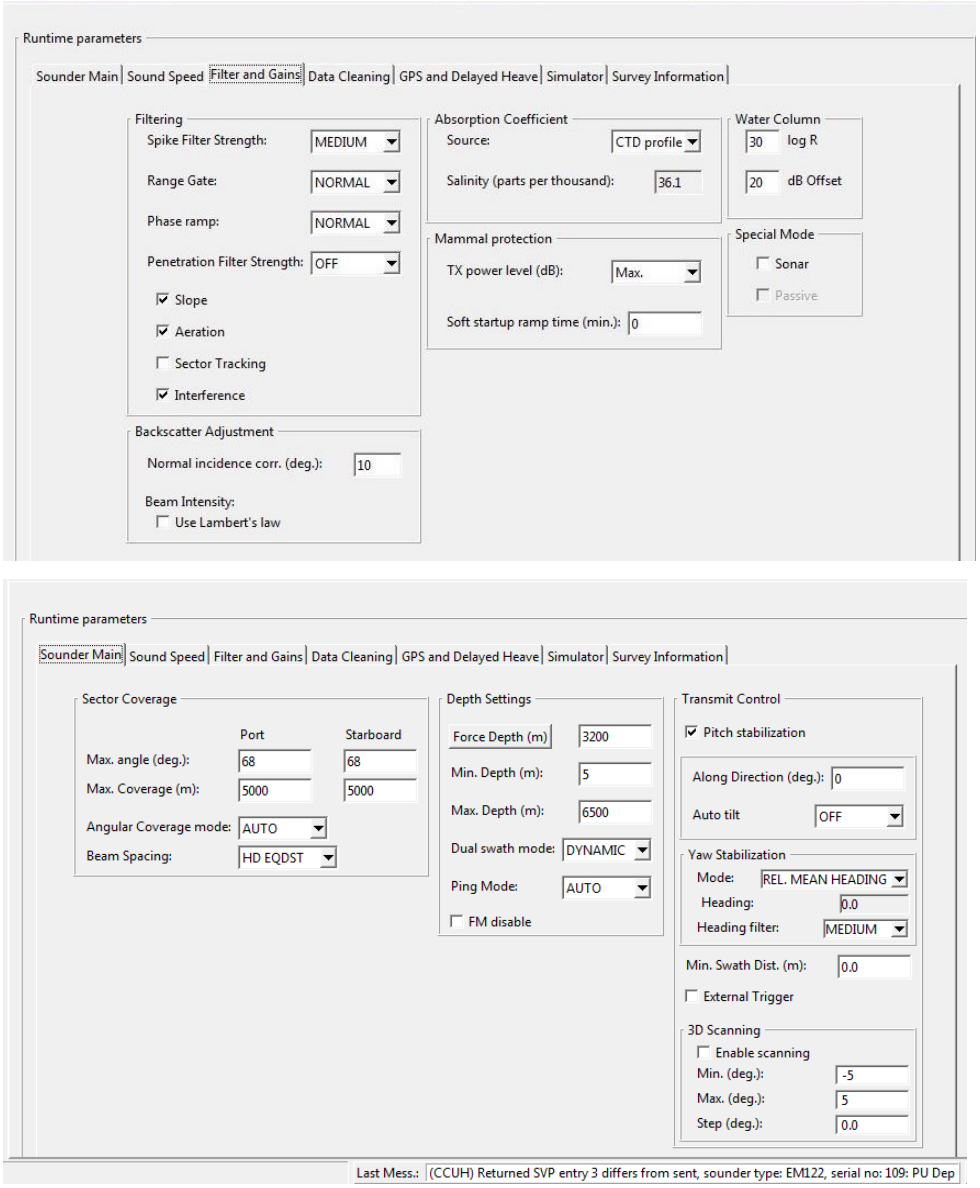


Figure 3. Main runtime parameters controlling swath width, ping modes, pitch, and yaw stabilization, and real-time filters applied.

All runtime parameters applied during EM122 multibeam data acquisition for the MGL2306 survey are shown in Figure 3. Surface sound velocity (SV) information was automatically transmitted to the SIS software from the Applied Micro Systems Micro SV mounted on the transducer gondola, and a total of 42 expendable bathy thermograph (XBT) probes deployed throughout the cruise were manually transmitted to the SIS software using the Sound Speed Manager. All the XBT profiles were processed using the Sound Speed Manager to augment cast data with values from the World Ocean Atlas (2009) at the same coordinates, extending profiles to 12 km depth before sending them to the SIS acquisition system.

Multibeam data were collected nearly continuously throughout the cruise, effectively mapping the seafloor along the course of the ship's track. Kongsberg raw sonar data (.all), water column (*.wcd) files, and raw Sippican XBT files were copied from the *Langseth* network file server to a local computer for processing (Table 1). A total of 4861.1 line-kilometers of multibeam echo sounder, backscatter, and water column data were collected between May 9th and June 9th.

Table 1. Summary of raw and processed data.

Data type	Comment
Raw Kongsberg sonar (*.all) and water column data (*.wcd)	Direct import to QPS Qimera
Sippican XBT (*.EDF/RDF) profile data	Qimera imports Sippican XBT stored in *.all files, can import EDF
Qimera Project	Requires QPS Qimera software
FMGT Backscatter Project	Requires QPS FMGT software
Grid and Raster Exports	32 bit GeoTIFF grid, GMT grid, sonar GSF files for FMGT (Geocoder) backscatter processing, 8 bit backscatter GeoTIFF files.

Processing

QPS Qimera (v2.5.3) was used to post-process the bathymetric data (Fig 4). The measurement offsets between the multibeam transducers and the inertial measurement unit (IMU), and angular offsets (roll, pitch, and heading) of the transducer and IMU were imported from the Kongsberg

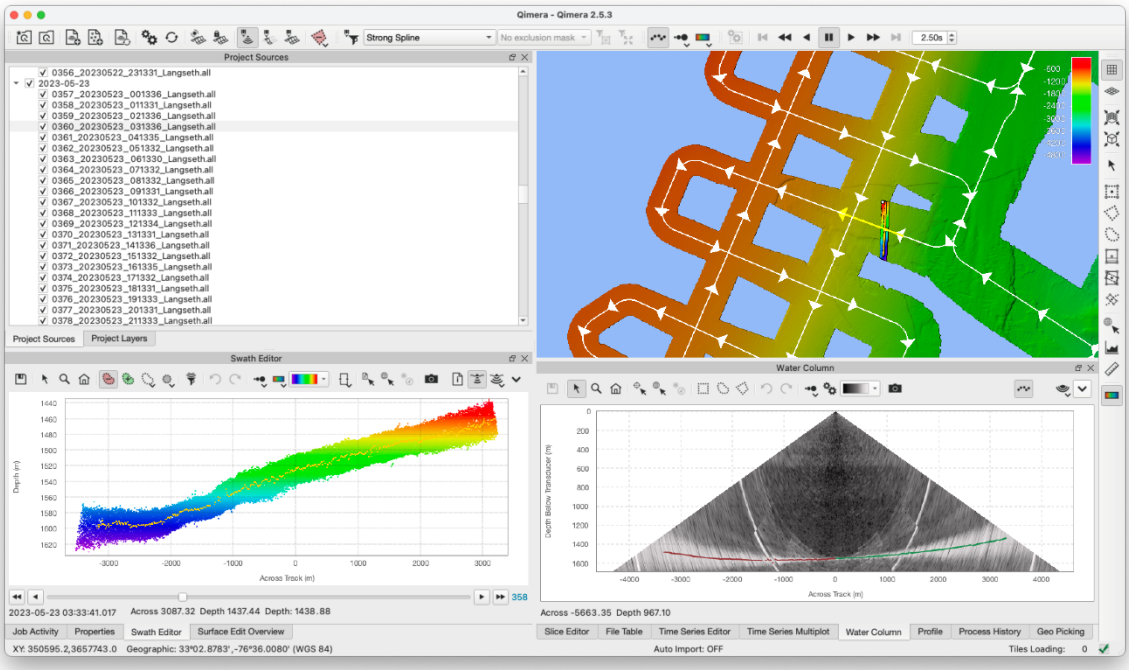


Figure 4. Main Qimera interface. Used for swath editing, water column QC, and gridding.

raw sonar (.all) files. Though this information was used to calculate the sounding positions and depths in SIS, it is also necessary in Qimera for subsequent calculation of total propagated uncertainty (TPU) and application of sound velocity corrections to the raw range/angle data.

The processing flow consisted of first using Qimera to add Kongsberg (.all) files into the project database, where Qimera creates an internal QPD format. Navigation was visually inspected, soundings were referenced to instantaneous sea level at the time of observation, and sound velocity information was re-applied. A strong spline filter was applied to the converted sonar files to remove erroneous soundings overall. Data from each file were then added to a dynamic surface with a 50-meter node spacing using a combined uncertainty and bathymetric estimator (CUBE) algorithm. Manual selection and rejecting of soundings were then done using the Qimera swath editor and 2D/3D editor tools.

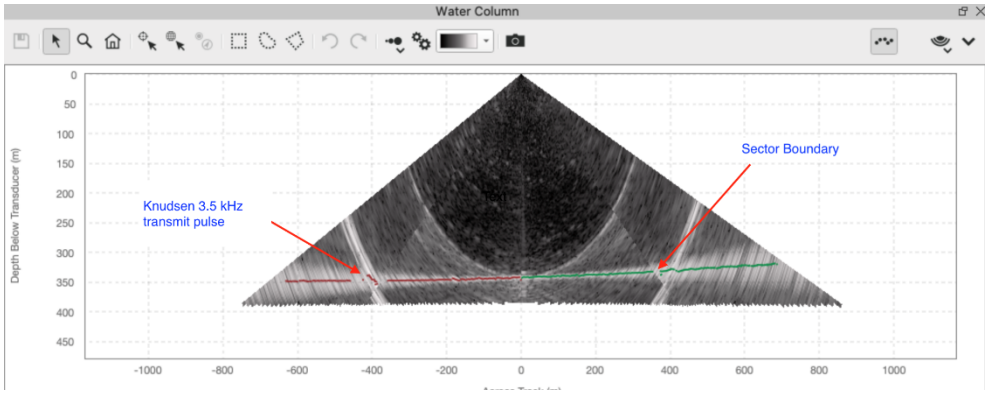


Figure 5

There was intermittent noise present in the swaths at all water depths that had to be visually edited. The noise was due to a combination of noise from the Knudsen Chirp 3.5 kHz transmit pulse and transmit sector boundaries in the first sectors across track away from nadir (Fig 5). Noise in the multibeam was also encountered in rough seas where hull bubble washdown became problematic. The transmit signal is dispersed by the bubbles resulting in very low amplitude returns signals (Fig 6). Most of this noise was cleaned from the data without adverse effects on the gridded surface. After cleaning, a final dynamic grid surface was created in Qimera that was exported as 32-bit GeoTIFF grid that represents depths based on instantaneous water heights. A second 32-bit GeoTIFF was created using the ellipsoidal heights recorded by the Seapath 330 system to calculate orthometric heights using the Geoid-18 model published by the National Geodetic Service (https://geodesy.noaa.gov/GEOID/GEOID18/).

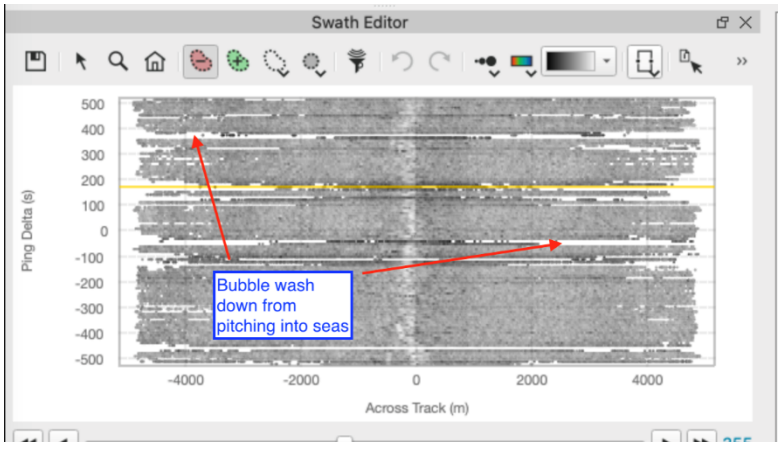


Figure 6

The QPS Fledermaus Geocoder Toolbox (FMGT v7.10.2, Fig 7) was used to post-process the backscatter data. Data were imported from the edited Kongsberg raw (.all) files that were converted to GSF files in Qimera, and the automatic processing option was utilized with the EM122 beam time series selected as the backscatter source. A multi-tile mosaic was computed using a 25 m per pixel resolution, and the histogram of the resulting image was manually stretched to accentuate the contrast between zones of high and low backscatter.

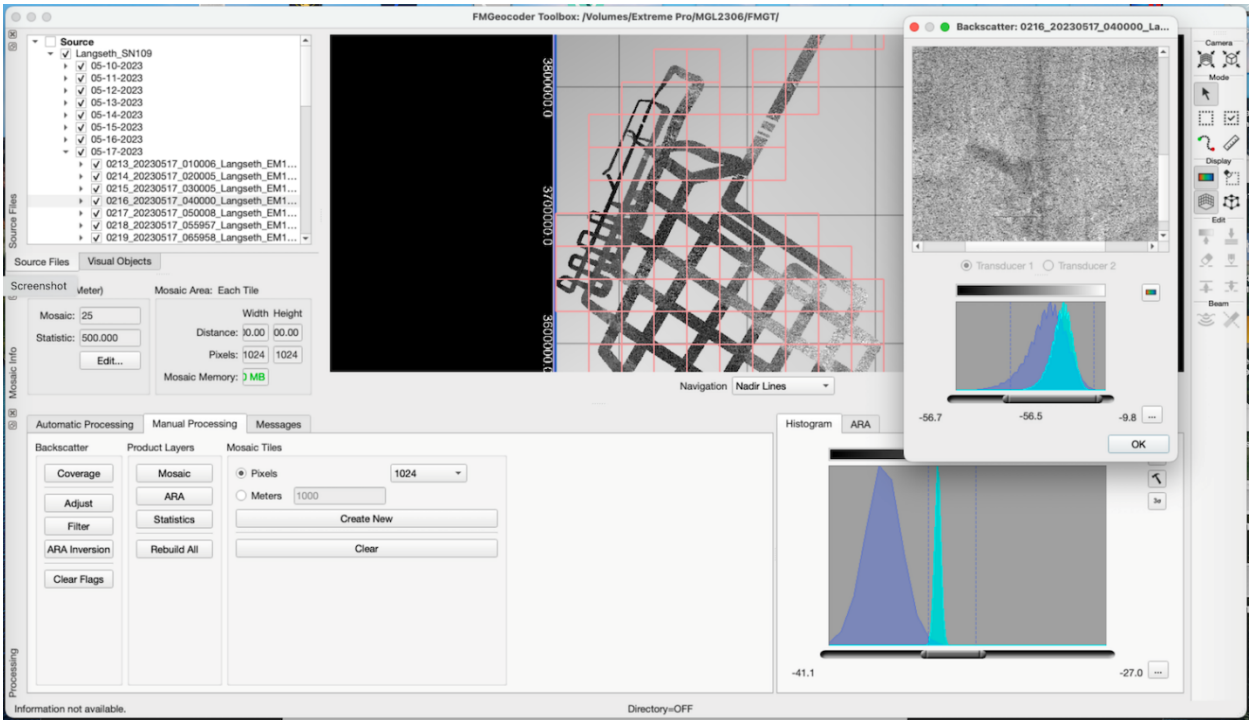


Figure 7

Water column data was not systematically processed, though the data were viewed in the Qimera water column dock window for quality control (Figs 4, 5). Most of the water column showed cross talk from the Knudsen chirp where the Knudsen was pinging internally, and side-lobe/sector boundary interference.

Analysis

Kongsberg EM122 data occasionally exhibit a “washboard” artifact on the outer edges of the swaths due to a lack of consistent sound velocity profiles in this dynamic environment so close to the gulf stream (Fig 8). The artifact worsened as sea state increased and is more noticeable as the swath width widens. Without accurate sound velocity profiles, the acquisition and/or processing programs are not able to properly ray trace each return beam throughout the water column resulting in offset bottom detects at the outer edges of swaths. While noticeable on sun-illuminated, vertically exaggerated surfaces, the error induced by this artifact is less than one percent of the depth.

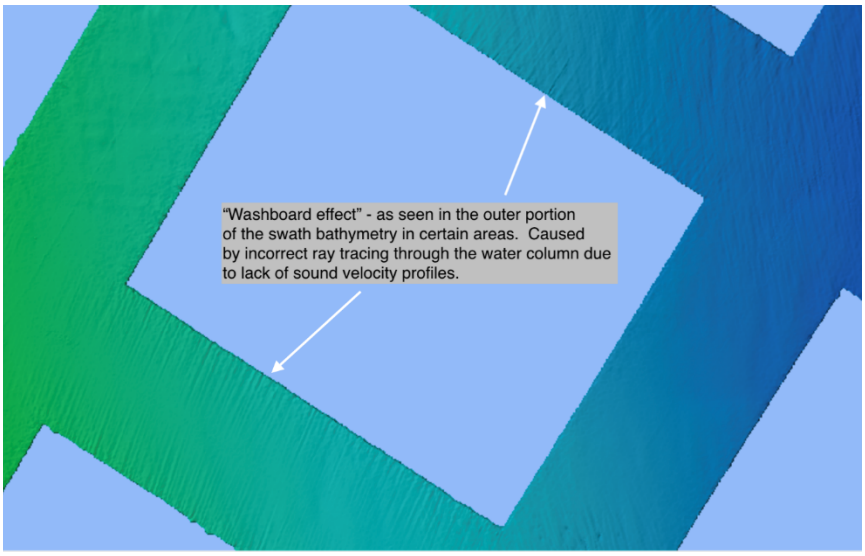


Figure 8

Artifacts and false bottom detects caused by the Knudsen Chirp transmit pulse is an issue for both the backscatter and multibeam data, however setting the interference filter during acquisition helped to minimize false bottom detects due to the higher intensity chirp transmit signals. The outgoing Knudsen transmit pulse is not noticeable in the EM122 mosaiced backscatter.

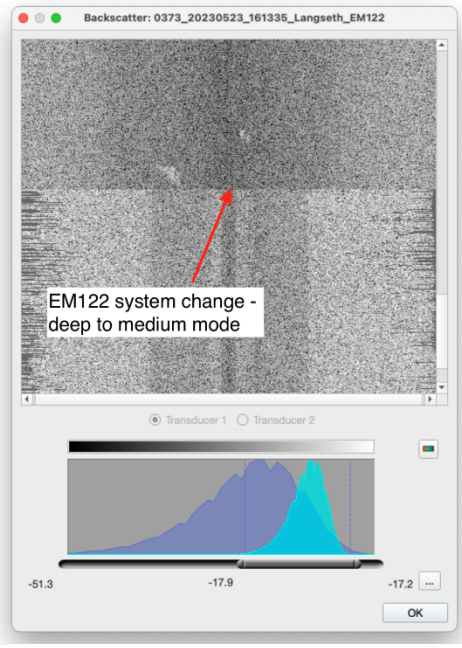


Figure 9

Artifacts in the backscatter caused by setting the transmit mode to Auto in the SIS software can be alleviated by setting the water depth modes manually if desired. The various transmit modes for the EM122 (shallow, medium, deep, very deep) have differing transmit sectors and frequencies, thus the received backscatter response will vary from mode to mode (Fig 9). This can be compensated for during acquisition by requesting a custom “bscorr.txt” file from Simrad that is based on data previously collected using the system in all modes. However, the backscatter variations encountered using different modes can also be empirically compensated for in the QPS FMGT software (Fig 10). During the majority (>90%) of the cruise in waters deeper than 1000 meters, we kept the EM122 in “deep” mode to avoid these variations in the received backscatter time series data.

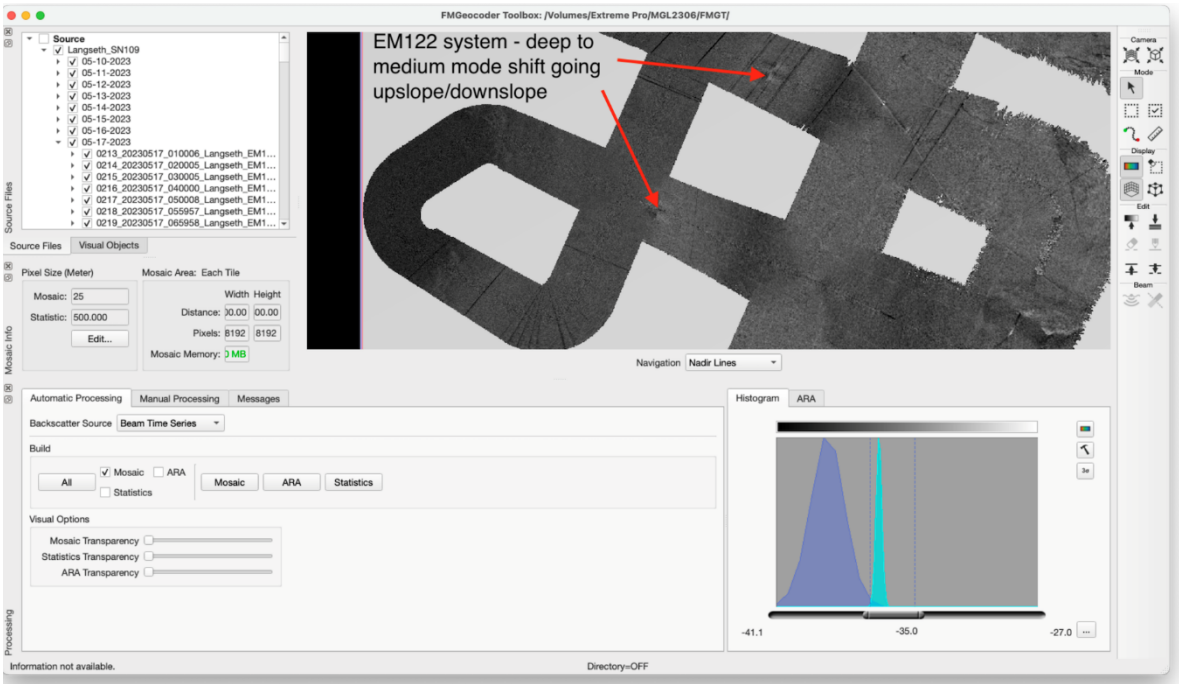


Figure 10

Depth accuracy of soundings digitized by the EM122 system were analyzed using the Qimera Cross Check tool. Cross Check performs a statistical analysis of individual beam footprint values referenced to a selected Dynamic or Static Surface. The tool will run the check based on the selected IHO or LINZ hydrographic standards and prepares the output shown below. Of note is that statistics gathered for individual beams from the raw files with respect to the gridded surface are below the Kongsberg stated sounding accuracy of 0.5% water depth and within the IHO Special Order 1 standard.

Cross Check Report:

Project: /Volumes/Extreme Pro/MGL2306/Qimera
Time of Report: 2023-06-09 10:44:23
Username: bwd

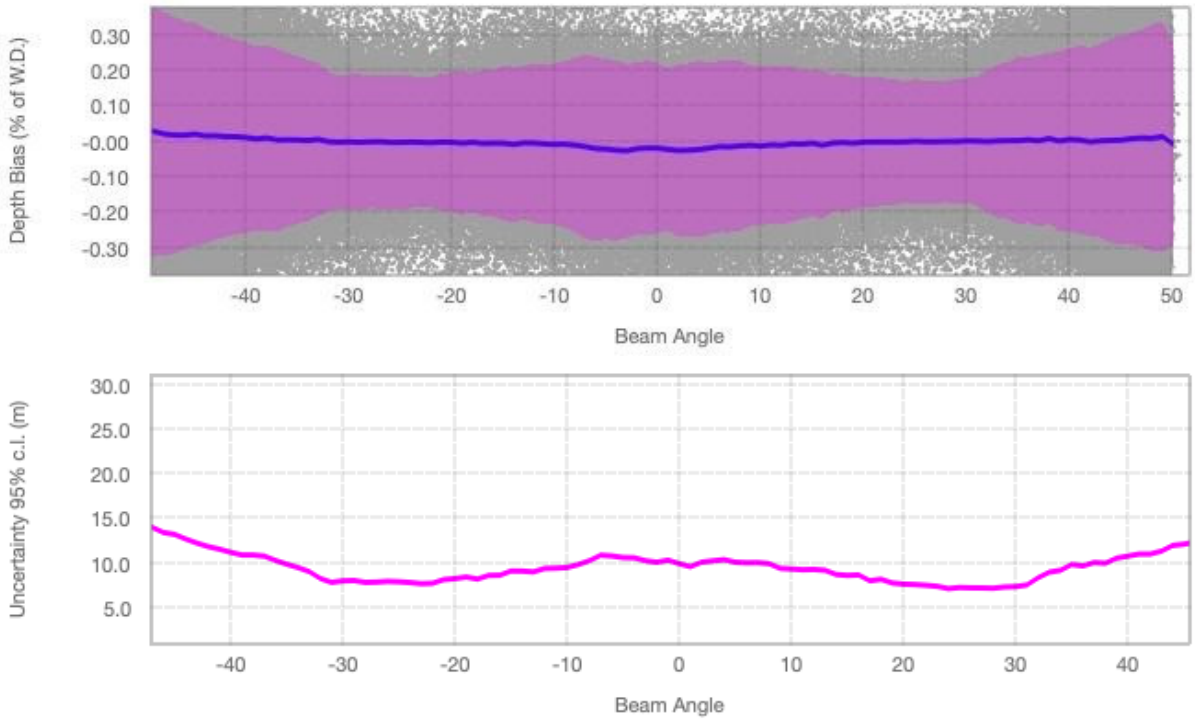
Raw Files Used in Cross Check:

0494_20230528_140158_Langseth.all
0179_20230515_145956_Langseth.all
0493_20230528_130151_Langseth.all
0495_20230528_150151_Langseth.all
0180_20230515_160001_Langseth.all

Reference Surface Used in Cross Check:

MGL2306_Grid_Geoid18

Plots of soundings referenced to the gridded surface showing the Langseth EM122 multibeam system sounding accuracy statistics as a percentage of water depth (top plot, meters), and sounding uncertainty within two standard deviations (bottom plot, 95% CI). These statistics are based on soundings collected at 4200 meters water depth using five raw files.



Cross Check Summary

Survey Order: IHO S-44 Order 1

Statistic	Value
Error Limit	54.3512
Number Rejected	0
P-Statistic	0
Test	ACCEPTED
Number Of Points	982235
Grid Cell Size	50.000
Difference Mean	0.055
Difference Median	0.178
Difference Std. Dev	5.258
Difference Range	[-41.460, 32.675]
Mean + 2*Stddev	10.570
Median + 2*Stddev	10.693
Data Mean	-4180.629
Reference Mean	-4180.684
Data Z-Range	[-4304.657, -4025.247]
Reference Z-Range	[-4284.480, -4043.819]

Results

Multibeam bathymetry, backscatter, and water column data were acquired along approximately 2624.8 nautical line miles (4861.1 km) with useable swath widths up to 10 km across, generally 2 to 4 times water depths between 30 and 5500 m (Fig 11).

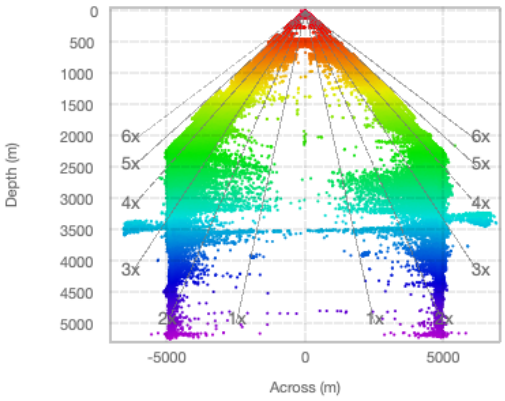


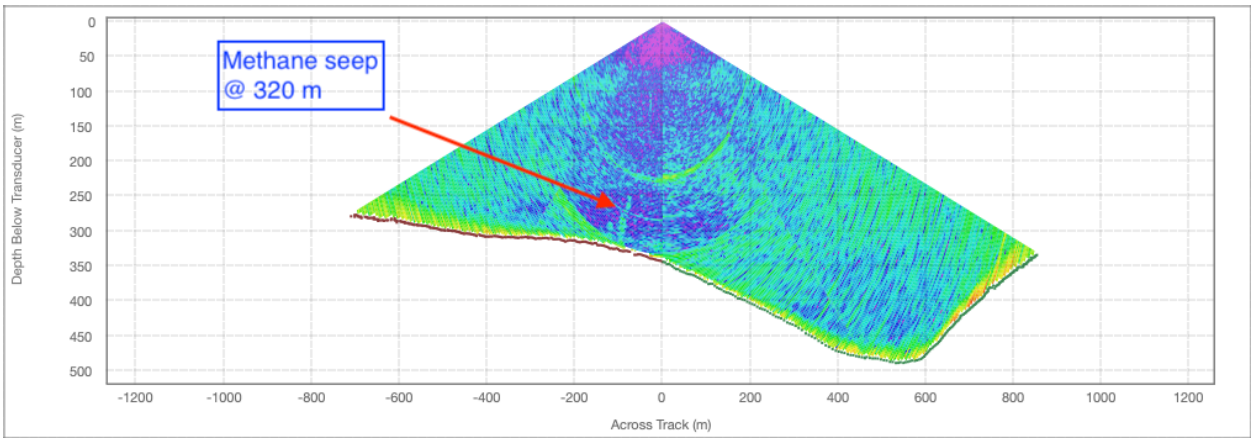
Figure 11. Extinction plot showing the EM122 swath coverage in various water depths.

Edited swath bathymetry data were used to create a 50 meter grid cell size Qimera dynamic surface. This surface was exported to 32-bit GeoTIFF grid formats for display (Figure 5). Backscatter data were exported from FMGT as an 8-bit GeoTIFF image with a 25 m/pixel resolution. The edited swath data were exported from Qimera as generic sensor formatted (GSF) files to facilitate further editing (if desired) in other software packages, and for upload into the Lamont MGDS repository.

The multibeam data acquired during MGL2306 are of excellent quality and imaged a variety of geologic features of interest while surveying the Atlantic US margin in the area of the Cape Fear Slide Complex (Appendix B). During several storms the multibeam data quality degraded significantly due to bubble washdown. This may have been alleviated by decreasing the swath angles to 45 degrees port/starboard and putting the multibeam into "very deep" mode which would have enabled an FM pulse for all transmit sectors.

The backscatter and water column data collected are of excellent quality as well. Processing the backscatter data using the QPS FMGT software was streamlined and handled the EM122 data quite efficiently without having to modify settings from line to line. A 1.5 dB offset for the EM122 mode change from deep to medium was observed and entered in the software to minimize the backscatter change noted at that boundary. Backscatter data helped to illuminate subtle changes in seabed geology and morphology and was a useful data set for picking gravity and piston core locations.

Two methane seeps were identified in the water column data within the survey area at previously observed seep locations (Fig 12).



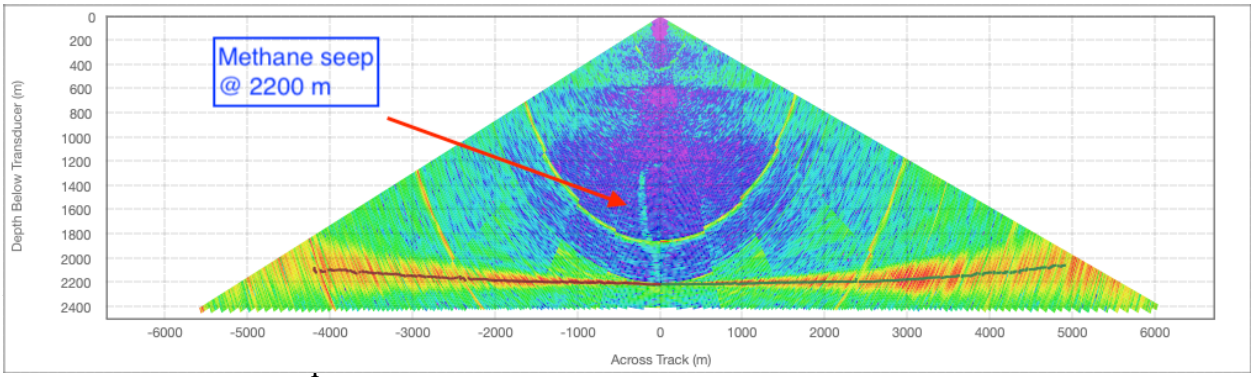


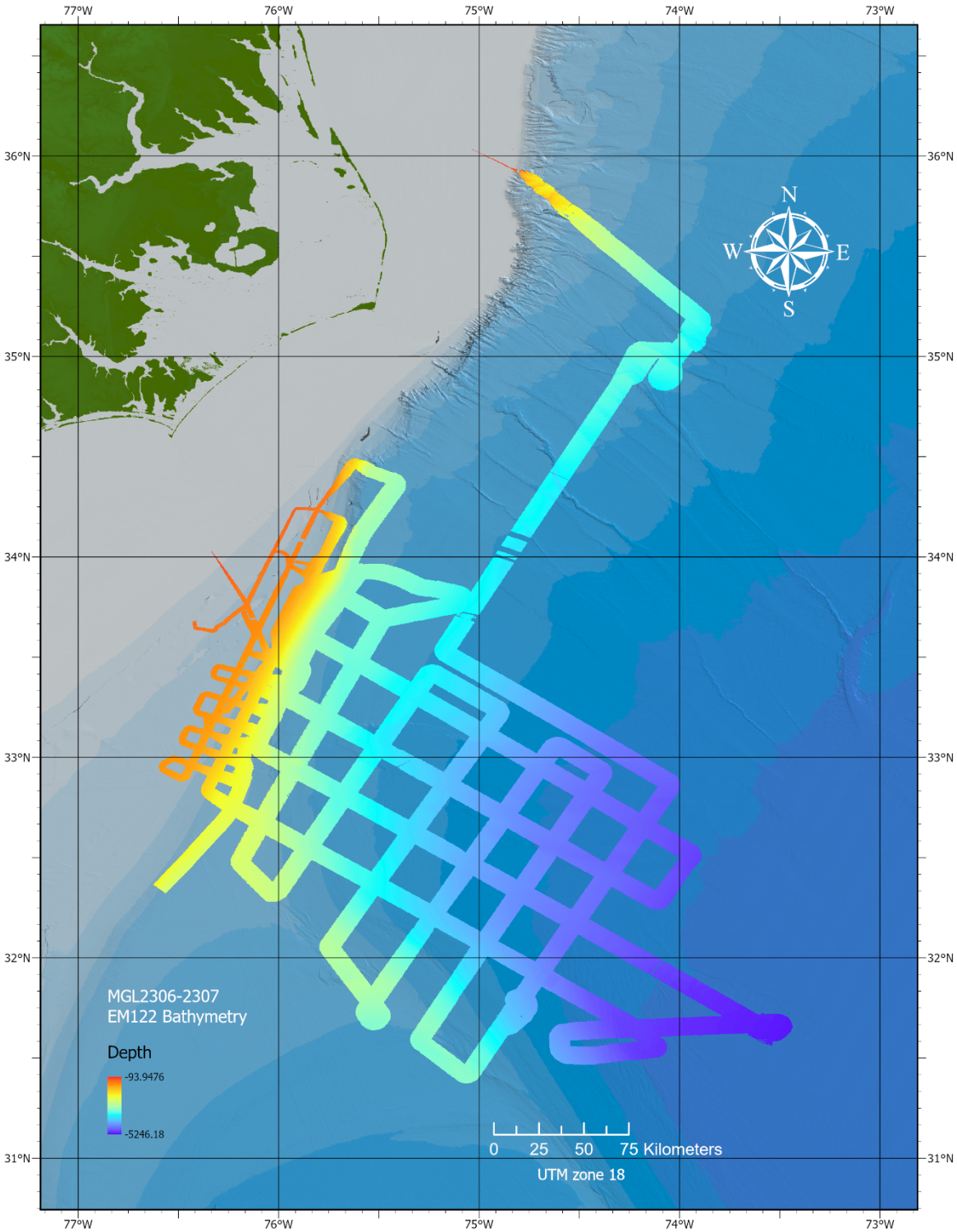
Figure 12. Qimera water column dock images showing the presence of two methane seeps within the collected water column backscatter data.

Supplementary material:

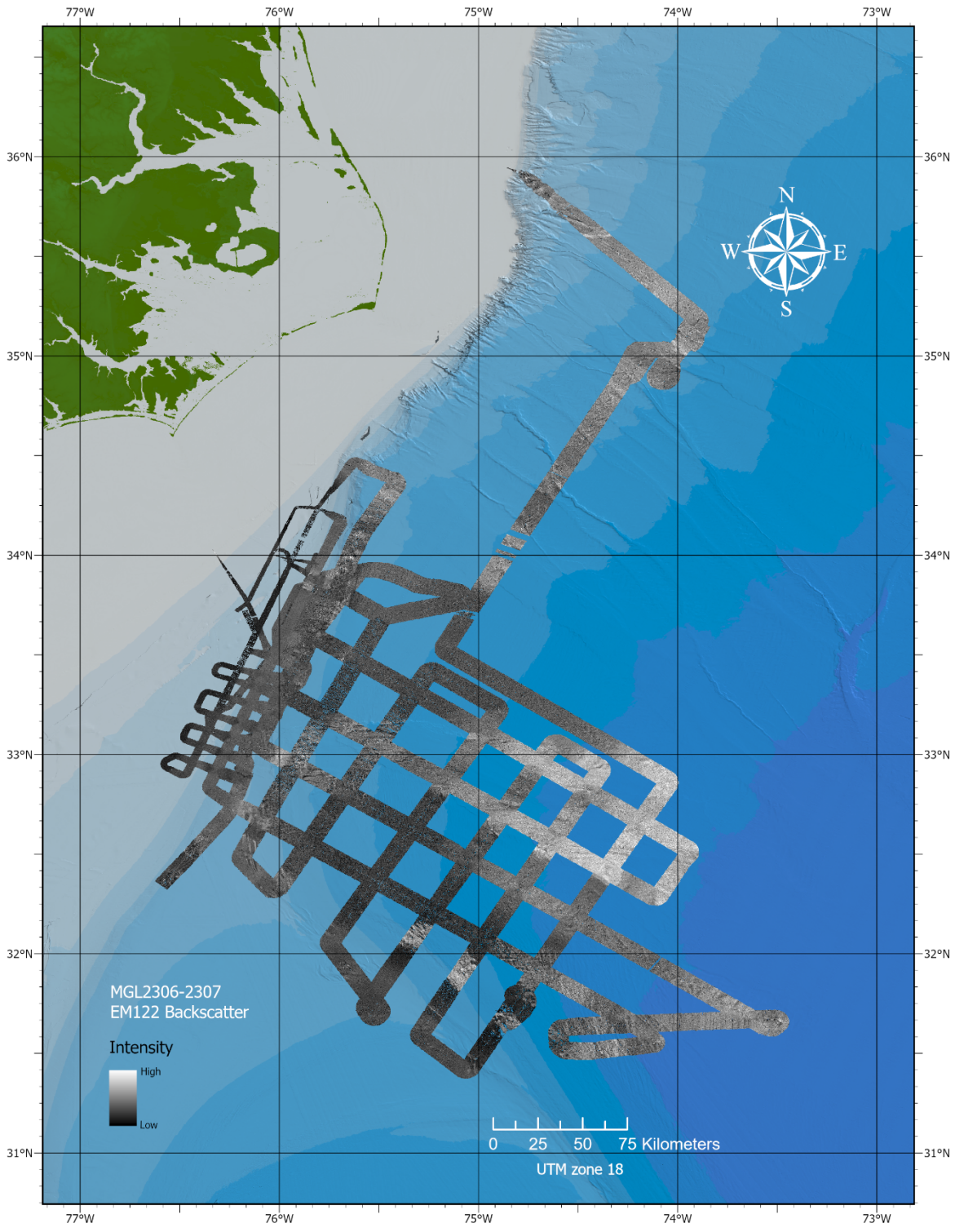
A. Location Maps.
B. Perspective views and figures.
C. MGL2306 line attributes table.
D. MGL2307 line attributes table.

Supp. Mat. A: Location Maps

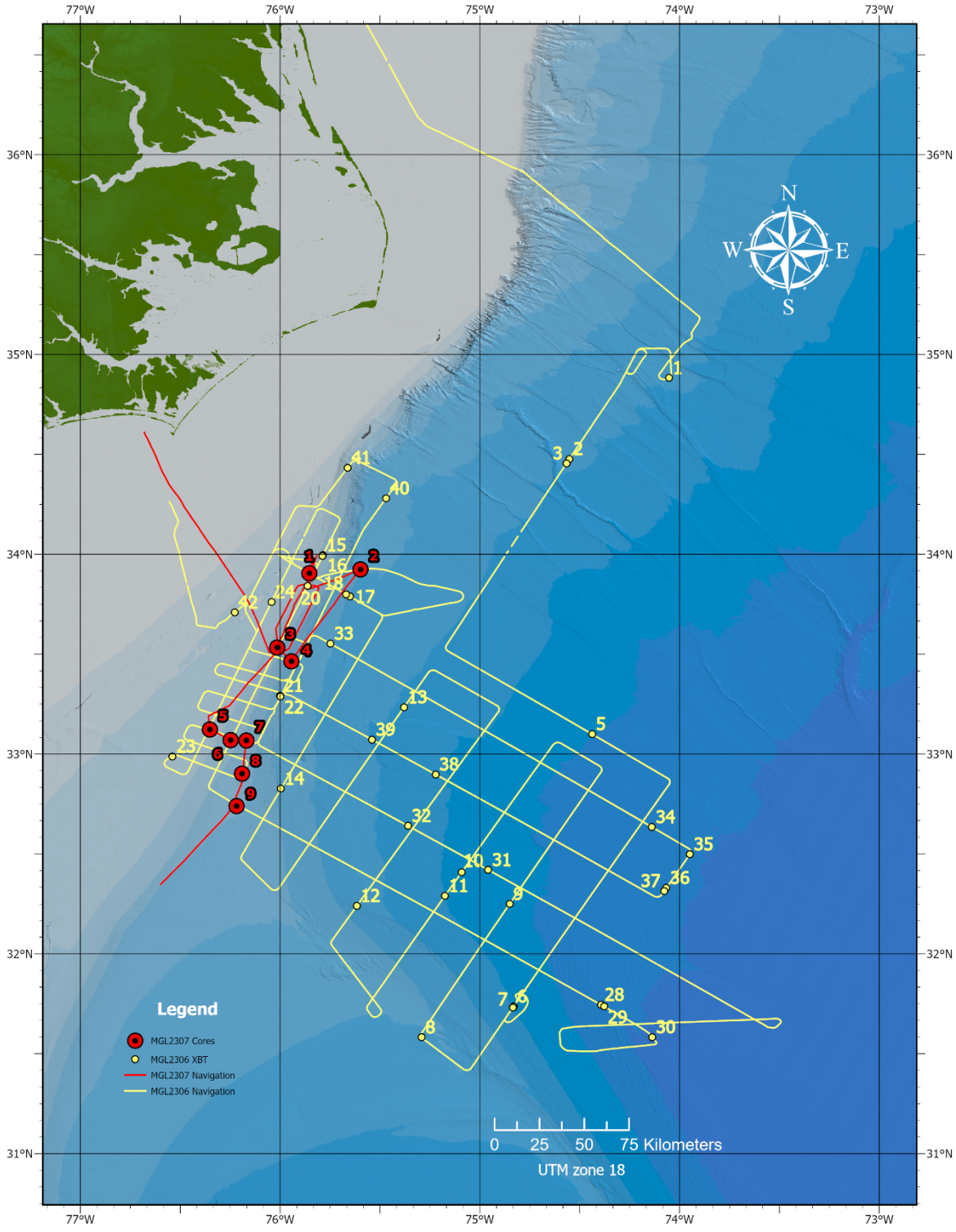
MGL2306 and MGL2307 EM122 Bathymetry coverage map



MGL2306 and MGL2307 EM122 Backscatter coverage map

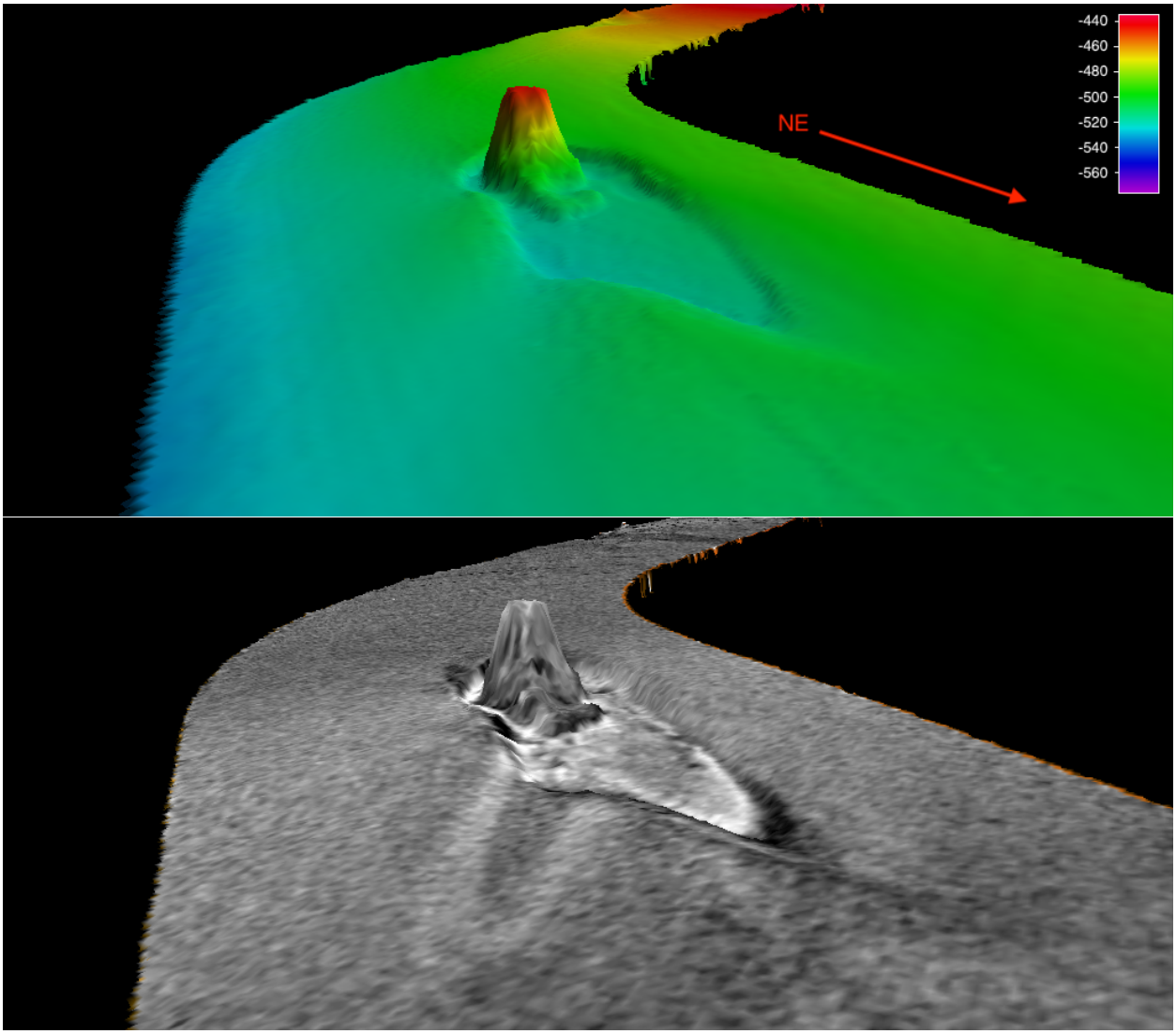


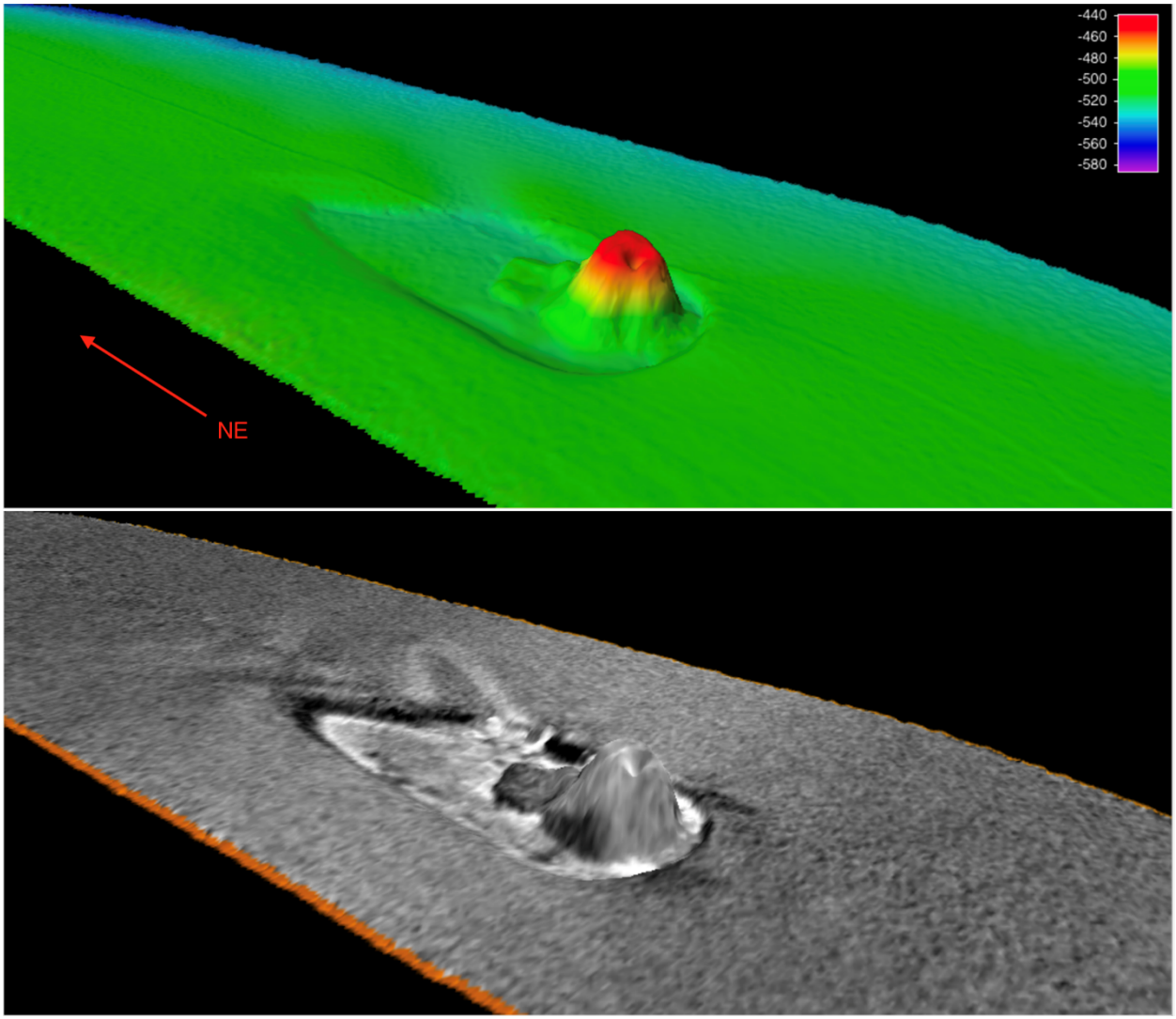
MGL2306 and MGL2307 EM122 Navigation, Coring, and XBT locations



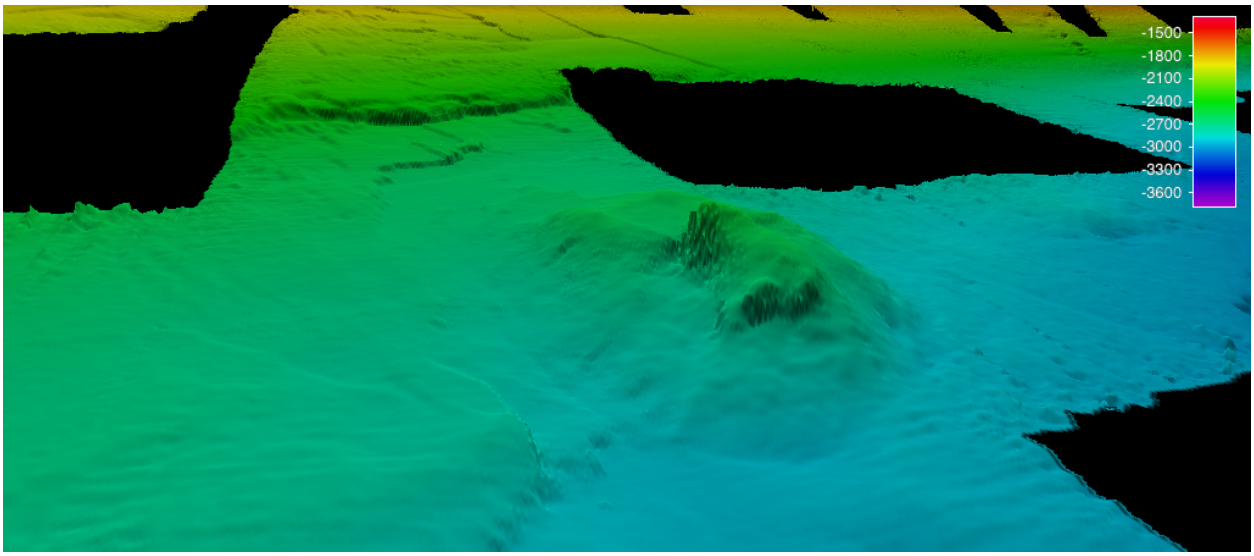
Supp. Mat. B

Perspective views of a 60 meter high anomolous mound located on the outer shelf in approximately 500 meters water depth. Of note is the large scour surrounding the mound pointing in the direction of the northeast flowing gulf stream current in this location. The top figure represents shaded relief color-coded bathymetry, and the bottom figure is the associated backscatter with light colors representing high backscatter returns.

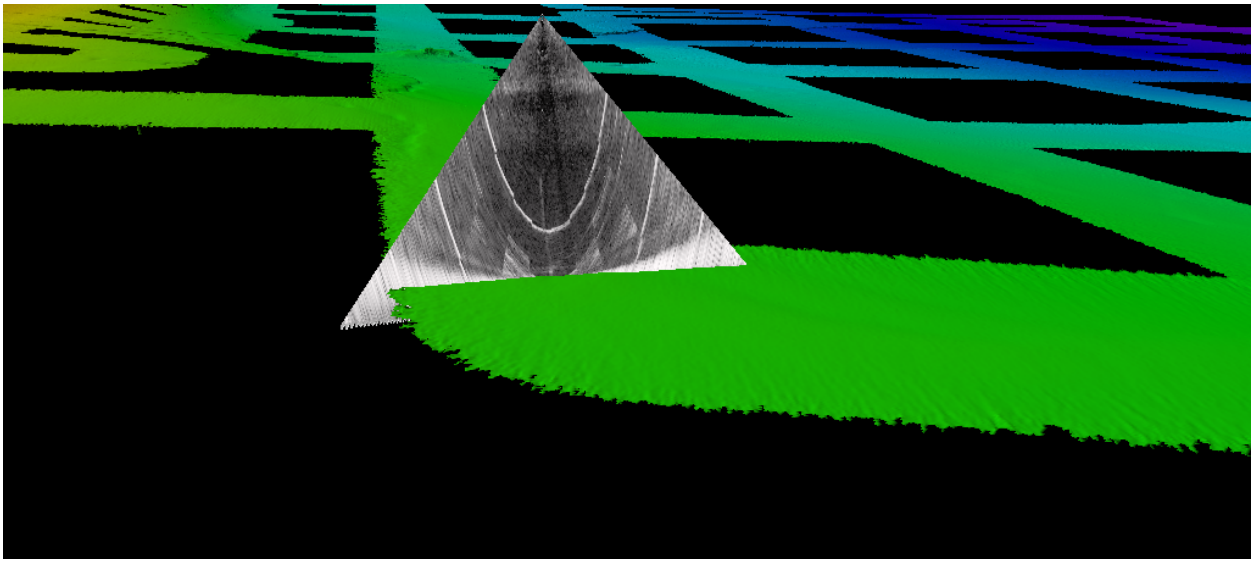



-440
-460
-480
-500
-520
-540
-560
-580
NE

Perspective view of one of the salt diapirs present in the Cape Fear and Blake Ridge slide complex areas. This diapir was imaged in the western portion of the survey area on the upper rise in approximately 2900 meters water depth, previously mapped during Okeanos Explorer expedition EX1205 Leg 1.



Perspective view of the seep seen in the Qimera water column data located in the southwestern portion of the survey area. This seep had been previously identified in past surveys of the area (below; Skarke et al., 2014).



Skarke, A., Ruppel, C., Kodis, M., Brothers, D., & Lobecker, E. (2014). Widespread methane leakage from the sea floor on the northern US Atlantic margin. *Nature Geoscience*, *7*(9), 657-661.

Supp. Mat. C

Listing of EM122 multibeam and water column line files showing start and end times as well as areal line extents for MGL2306.

Line Number	Start Date	Start Time	Start East	Start North	End Date	End Time	End East	End North
0	5/9/2023	21:32:39	436743.3	4069912	5/9/2023	22:31:30	449255.1	4056479
1	5/9/2023	22:31:30	449255.4	4056478	5/9/2023	23:31:30	457321.3	4038475
2	5/9/2023	23:31:30	457321.6	4038475	5/9/2023	23:37:55	458195.5	4036543
3	5/9/2023	23:45:39	459220.8	4034204	5/10/2023	0:45:33	467059.3	4016309
4	5/10/2023	0:45:34	467059.6	4016308	5/10/2023	1:45:33	476405.8	3999645
5	5/10/2023	1:45:34	476406.5	3999645	5/10/2023	1:51:33	477989.7	3998681
6	5/10/2023	1:51:33	477990.4	3998681	5/10/2023	2:51:33	494071	3989158
7	5/10/2023	2:51:33	494071.7	3989157	5/10/2023	3:00:19	496417	3987759
8	5/10/2023	3:00:19	496417.8	3987758	5/10/2023	4:00:19	512921.6	3978027
9	5/10/2023	4:00:19	512923.7	3978026	5/10/2023	4:14:23	516968.4	3975860
10	5/10/2023	4:17:43	517946.2	3975419	5/10/2023	5:17:21	531842.8	3962314
11	5/10/2023	5:17:28	531867.4	3962289	5/10/2023	5:49:21	539016.9	3955190
12	5/10/2023	5:49:51	539131.1	3955073	5/10/2023	6:49:23	551661.1	3942731
13	5/10/2023	6:49:32	551692.3	3942700	5/10/2023	7:49:27	563833.3	3930450
14	5/10/2023	7:49:36	563866.7	3930418	5/10/2023	8:49:27	576149.8	3918020
15	5/10/2023	8:49:37	576183	3917986	5/10/2023	9:49:27	586274.6	3907987
16	5/10/2023	9:49:37	586283.2	3907979	5/10/2023	10:49:26	588898.1	3905281
17	5/10/2023	10:49:36	588912.1	3905269	5/10/2023	11:49:27	593267.5	3901316
18	5/10/2023	11:49:37	593276.6	3901308	5/10/2023	12:06:07	594408.1	3900225
19	5/10/2023	12:06:17	594420.9	3900213	5/10/2023	13:06:09	599040.9	3895588
20	5/10/2023	13:06:19	599054.8	3895574	5/10/2023	14:05:58	599128.4	3890335
21	5/10/2023	14:06:10	599118.9	3890320	5/10/2023	15:06:06	596693.6	3885817
22	5/10/2023	15:06:19	596684.7	3885804	5/10/2023	16:05:58	596413.2	3882253
23	5/10/2023	16:06:11	596402.8	3882244	5/10/2023	17:06:04	593514	3880058
24	5/10/2023	17:06:14	593506.2	3880051	5/10/2023	18:06:04	590355.9	3875742
25	5/10/2023	18:06:15	590349.3	3875732	5/10/2023	19:06:00	587269.4	3871043
26	5/10/2023	19:06:10	587260.4	3871028	5/10/2023	20:06:02	584344.9	3866250
27	5/10/2023	20:06:12	584338.3	3866238	5/10/2023	21:06:00	581937.2	3861722
28	5/10/2023	21:06:11	581936.8	3861708	5/10/2023	22:06:03	587283.1	3861503
29	5/10/2023	22:06:13	587292.8	3861528	5/10/2023	23:06:04	587276.1	3869811
30	5/10/2023	23:06:14	587276.6	3869834	5/11/2023	0:06:04	585524.7	3876552
31	5/11/2023	0:06:14	585512	3876559	5/11/2023	1:06:07	581838.5	3876711
32	5/11/2023	1:06:17	581828.9	3876710	5/11/2023	2:06:02	578423.3	3876717
33	5/11/2023	2:06:12	578413.7	3876717	5/11/2023	3:06:04	574607.2	3876721
34	5/11/2023	3:06:14	574597	3876721	5/11/2023	3:33:12	572681.9	3876282
35	5/11/2023	3:38:41	572196.5	3875851	5/11/2023	3:48:34	571726.3	3875034
36	5/11/2023	3:48:44	571722.2	3875025	5/11/2023	4:21:55	570870.9	3873006
38	5/11/2023	4:22:06	570866.3	3872995	5/11/2023	5:21:57	569369.2	3869445
39	5/11/2023	5:22:07	569362.8	3869429	5/11/2023	5:36:09	568864.8	3868233

41	5/11/2023	5:36:19	568858.9	3868218	5/11/2023	6:20:50	567241.6	3864363
43	5/11/2023	6:21:00	567235.5	3864347	5/11/2023	6:39:11	568051.1	3862612
45	5/11/2023	6:39:21	568072.3	3862603	5/11/2023	7:00:20	570664.7	3863523
47	5/11/2023	7:00:31	570675.9	3863542	5/11/2023	7:20:27	571903.1	3865844
49	5/11/2023	7:20:37	571913.8	3865864	5/11/2023	8:19:31	575751.8	3872820
51	5/11/2023	8:19:41	575762.1	3872840	5/11/2023	8:34:17	575963.5	3874613
53	5/11/2023	8:34:27	575955.1	3874630	5/11/2023	9:02:09	573834.2	3876198
55	5/11/2023	9:02:19	573818.6	3876194	5/11/2023	9:58:42	570316.3	3871676
57	5/11/2023	9:58:52	570308.9	3871659	5/11/2023	10:54:49	567901.4	3865936
59	5/11/2023	10:54:59	567891.9	3865916	5/11/2023	11:04:00	567442.1	3864836
61	5/11/2023	11:04:10	567433.8	3864816	5/11/2023	12:04:02	564351.7	3857477
63	5/11/2023	12:04:12	564342.9	3857456	5/11/2023	13:00:04	560670.3	3850579
65	5/11/2023	13:00:14	560658.1	3850559	5/11/2023	14:00:08	556426.5	3842839
66	5/11/2023	14:00:18	556413.9	3842817	5/11/2023	14:07:46	555863.1	3841815
68	5/11/2023	14:07:56	555850.7	3841792	5/11/2023	15:03:28	551722.1	3834265
69	5/11/2023	15:03:38	551709.1	3834242	5/11/2023	15:59:21	547627.1	3826798
71	5/11/2023	15:59:31	547614.9	3826775	5/11/2023	16:59:16	543265.1	3818845
73	5/11/2023	16:59:27	543252.7	3818821	5/11/2023	17:59:09	539018.5	3811108
74	5/11/2023	17:59:19	539006.6	3811086	5/11/2023	18:01:16	538872.2	3810840
76	5/11/2023	18:01:26	538860.4	3810818	5/11/2023	18:30:00	536827.3	3807111
77	5/11/2023	18:32:19	536663.2	3806809	5/11/2023	18:59:26	534732.2	3803293
79	5/11/2023	18:59:36	534720.1	3803271	5/11/2023	19:59:24	530461.8	3795508
80	5/11/2023	19:59:34	530449.4	3795487	5/11/2023	19:59:45	530436.7	3795464
82	5/11/2023	19:59:55	530424.1	3795441	5/11/2023	20:59:52	526159	3787661
83	5/11/2023	21:00:02	526146.4	3787638	5/11/2023	21:59:19	521922.9	3779941
84	5/11/2023	21:59:30	521910.7	3779919	5/11/2023	22:39:46	519052.5	3774712
85	5/11/2023	22:59:39	517608.3	3772080	5/11/2023	22:59:50	517595.2	3772056
86	5/11/2023	23:00:00	517582.5	3772033	5/11/2023	23:39:40	514657	3766695
87	5/12/2023	0:00:09	513145.6	3763942	5/12/2023	0:12:53	512209.6	3762238
88	5/12/2023	0:23:40	511417.2	3760796	5/12/2023	1:23:06	507038.6	3752810
89	5/12/2023	1:23:17	507025.7	3752787	5/12/2023	2:23:06	502602.6	3744728
90	5/12/2023	2:23:16	502589.3	3744705	5/12/2023	3:23:06	498188.9	3736681
91	5/12/2023	3:23:16	498176.4	3736659	5/12/2023	4:23:12	494289.3	3729574
92	5/12/2023	4:23:22	494279.4	3729556	5/12/2023	4:31:14	493785.6	3728651
94	5/12/2023	4:31:34	493763.4	3728611	5/12/2023	5:31:05	490141.6	3722008
95	5/12/2023	5:31:15	490131.6	3721990	5/12/2023	6:31:05	486578.7	3715513
96	5/12/2023	6:31:15	486568	3715493	5/12/2023	7:31:06	485384.4	3708286
97	5/12/2023	7:31:16	485406.3	3708271	5/12/2023	8:30:58	492963	3703103
98	5/12/2023	8:31:08	492984.4	3703089	5/12/2023	9:31:03	499895.6	3698370
99	5/12/2023	9:31:14	499916.6	3698355	5/12/2023	10:31:01	507321.4	3693298
100	5/12/2023	10:31:11	507343.6	3693282	5/12/2023	11:30:56	514843.4	3688160
101	5/12/2023	11:31:07	514865.9	3688144	5/12/2023	12:31:01	522367.2	3683021
102	5/12/2023	12:31:12	522388.6	3683006	5/12/2023	13:31:06	529869.1	3677899
103	5/12/2023	13:31:17	529891.7	3677884	5/12/2023	14:31:01	537296.7	3672828
104	5/12/2023	14:31:11	537319.7	3672812	5/12/2023	15:31:06	544741.4	3667741
105	5/12/2023	15:31:17	544764.1	3667725	5/12/2023	16:01:15	548498	3665179

107	5/12/2023	16:01:26	548521.5	3665163	5/12/2023	17:00:13	555994.6	3660057
109	5/12/2023	17:00:24	556017.7	3660042	5/12/2023	18:00:09	563576	3654882
110	5/12/2023	18:00:20	563599.4	3654866	5/12/2023	19:00:04	571074.4	3649761
111	5/12/2023	19:00:15	571097.4	3649746	5/12/2023	20:00:06	578573.5	3644641
112	5/12/2023	20:00:18	578597.8	3644624	5/12/2023	21:00:08	586203.8	3639431
113	5/12/2023	21:00:19	586227.5	3639414	5/12/2023	22:00:12	587050.8	3632040
114	5/12/2023	22:00:24	587035.5	3632015	5/12/2023	23:00:09	582356.4	3624053
115	5/12/2023	23:00:20	582342	3624029	5/13/2023	0:00:08	577704.1	3616143
116	5/13/2023	0:00:19	577689.7	3616119	5/13/2023	1:00:07	573175.7	3608443
117	5/13/2023	1:00:18	573161.4	3608419	5/13/2023	2:00:04	568622.6	3600699
118	5/13/2023	2:00:16	568608.4	3600674	5/13/2023	3:00:11	564224.5	3593216
119	5/13/2023	3:00:22	564215.1	3593200	5/13/2023	4:00:06	561237.4	3588143
120	5/13/2023	4:00:17	561228.8	3588128	5/13/2023	5:00:14	557525.8	3581831
121	5/13/2023	5:00:25	557511.3	3581806	5/13/2023	6:00:10	554526.4	3576732
122	5/13/2023	6:00:21	554518.2	3576717	5/13/2023	7:00:12	551524.3	3571626
123	5/13/2023	7:00:24	551509.3	3571601	5/13/2023	8:00:10	546983.4	3563906
124	5/13/2023	8:00:21	546969.6	3563882	5/13/2023	9:00:08	542602.4	3556460
125	5/13/2023	9:00:19	542589.1	3556437	5/13/2023	10:00:07	540010.2	3552052
126	5/13/2023	10:00:18	540002.9	3552039	5/13/2023	11:00:07	537569.1	3547899
127	5/13/2023	11:00:19	537561.3	3547886	5/13/2023	12:00:08	535091.6	3543688
128	5/13/2023	12:00:19	535084.4	3543676	5/13/2023	13:00:11	531347.7	3537326
129	5/13/2023	13:00:22	531334.3	3537304	5/13/2023	14:00:06	527117.4	3530129
130	5/13/2023	14:00:17	527103.8	3530107	5/13/2023	15:00:05	522979.9	3523098
131	5/13/2023	15:00:16	522967.1	3523076	5/13/2023	16:00:15	518933.7	3516221
132	5/13/2023	16:00:26	518921.9	3516201	5/13/2023	17:00:08	514968.7	3509472
133	5/13/2023	17:00:19	514956.6	3509451	5/13/2023	18:00:09	512324.3	3504983
134	5/13/2023	18:00:19	512318.4	3504974	5/13/2023	19:00:08	515994.9	3503985
135	5/13/2023	19:00:17	516014	3504004	5/13/2023	20:00:09	522262.9	3511713
136	5/13/2023	20:00:20	522273.6	3511736	5/13/2023	21:00:12	518041.8	3518327
137	5/13/2023	21:00:23	518021.5	3518321	5/13/2023	22:00:10	516737.4	3512505
138	5/13/2023	22:00:21	516727.8	3512485	5/13/2023	23:00:08	513733.7	3507364
139	5/13/2023	23:00:19	513725.5	3507350	5/14/2023	0:00:15	510580.6	3502015
140	5/14/2023	0:00:25	510569.3	3501996	5/14/2023	1:00:14	506652.3	3495341
141	5/14/2023	1:00:24	506641.2	3495322	5/14/2023	1:59:35	502724.7	3488659
142	5/14/2023	1:59:45	502713.5	3488639	5/14/2023	2:59:39	498656.7	3481746
143	5/14/2023	2:59:49	498645.3	3481727	5/14/2023	3:59:35	494140.5	3475927
144	5/14/2023	3:59:45	494121.7	3475924	5/14/2023	4:59:37	487728.5	3480403
145	5/14/2023	4:59:47	487709.4	3480420	5/14/2023	5:59:35	480926.4	3486393
146	5/14/2023	5:59:45	480908.3	3486409	5/14/2023	6:59:44	474783.9	3491795
147	5/14/2023	6:59:54	474766.9	3491810	5/14/2023	7:59:37	473783.8	3498874
148	5/14/2023	7:59:47	473797.7	3498897	5/14/2023	8:59:37	478432.7	3506875
149	5/14/2023	8:59:47	478445.6	3506897	5/14/2023	9:59:38	483095.1	3514885
150	5/14/2023	9:59:48	483108.1	3514908	5/14/2023	10:59:37	487730.5	3522851
151	5/14/2023	10:59:48	487743.5	3522873	5/14/2023	11:59:43	492379.9	3530842
152	5/14/2023	11:59:53	492393.6	3530865	5/14/2023	12:59:34	497016.4	3538807
153	5/14/2023	12:59:45	497030.4	3538830	5/14/2023	13:59:34	501660.2	3546792

154	5/14/2023	13:59:45	501674.3	3546816	5/14/2023	14:59:38	506300.4	3554764
155	5/14/2023	15:00:00	506328.3	3554812	5/14/2023	15:59:38	510584.1	3562129
156	5/14/2023	15:59:49	510596.4	3562150	5/14/2023	16:59:41	514937.5	3569607
157	5/14/2023	16:59:52	514951.2	3569631	5/14/2023	17:59:36	519565.4	3577561
158	5/14/2023	17:59:47	519579.1	3577585	5/14/2023	18:59:43	524258.1	3585628
159	5/14/2023	18:59:53	524272.2	3585652	5/14/2023	19:59:35	528852.6	3593522
160	5/14/2023	19:59:46	528865.6	3593546	5/14/2023	20:59:35	533496.7	3601508
161	5/14/2023	20:59:46	533510.2	3601531	5/14/2023	21:59:35	538156.5	3609515
162	5/14/2023	21:59:46	538169.4	3609538	5/14/2023	22:59:43	542785.7	3617476
163	5/14/2023	22:59:53	542798.9	3617499	5/14/2023	23:59:35	547389.8	3625384
164	5/14/2023	23:59:45	547403	3625407	5/15/2023	0:59:42	551760.4	3632900
165	5/15/2023	0:59:52	551771.6	3632919	5/15/2023	1:59:45	555093.4	3638629
166	5/15/2023	1:59:55	555100.1	3638640	5/15/2023	2:59:41	557101.6	3642685
167	5/15/2023	2:59:51	557102	3642698	5/15/2023	3:59:41	553641.3	3646467
168	5/15/2023	3:59:51	553626.8	3646477	5/15/2023	4:59:42	548711.6	3649867
169	5/15/2023	4:59:53	548697.8	3649877	5/15/2023	5:59:41	544138.3	3653018
170	5/15/2023	5:59:52	544123.9	3653028	5/15/2023	6:59:36	539585.5	3656153
171	5/15/2023	6:59:47	539572.2	3656163	5/15/2023	7:59:34	533839.7	3655772
172	5/15/2023	7:59:45	533828.8	3655754	5/15/2023	8:59:43	529387.7	3648407
173	5/15/2023	8:59:54	529373.6	3648384	5/15/2023	9:59:42	524711.3	3640676
174	5/15/2023	9:59:54	524696.6	3640651	5/15/2023	10:59:41	519890.9	3632699
175	5/15/2023	10:59:52	519876.1	3632675	5/15/2023	11:59:44	515184.5	3624910
176	5/15/2023	11:59:55	515169.5	3624886	5/15/2023	12:59:40	510399.4	3616996
177	5/15/2023	12:59:51	510384.4	3616972	5/15/2023	13:59:41	505657.1	3609154
178	5/15/2023	13:59:52	505642.2	3609130	5/15/2023	14:59:34	500884.8	3601265
179	5/15/2023	14:59:45	500870.5	3601241	5/15/2023	15:59:40	496383.2	3593817
180	5/15/2023	15:59:51	496370.5	3593795	5/15/2023	16:59:42	492097.4	3586727
181	5/15/2023	16:59:53	492084.2	3586706	5/15/2023	17:59:45	487976.8	3579910
182	5/15/2023	17:59:56	487964.4	3579890	5/15/2023	18:59:42	484168.9	3573612
183	5/15/2023	18:59:52	484157.8	3573594	5/15/2023	19:59:44	480543.8	3567618
184	5/15/2023	19:59:55	480533.5	3567601	5/15/2023	20:59:43	477152.1	3562005
185	5/15/2023	20:59:54	477142.6	3561989	5/15/2023	21:59:36	474030.7	3556851
186	5/15/2023	21:59:46	474022.2	3556836	5/15/2023	22:59:35	470632.9	3551220
187	5/15/2023	22:59:46	470622.7	3551204	5/15/2023	23:59:39	467124.1	3545416
188	5/15/2023	23:59:49	467113.9	3545399	5/16/2023	0:59:39	463367.6	3539205
189	5/16/2023	0:59:49	463357	3539187	5/16/2023	1:59:44	459492.4	3532790
190	5/16/2023	1:59:54	459481.5	3532773	5/16/2023	2:59:43	455476.1	3526151
191	5/16/2023	2:59:53	455465.5	3526133	5/16/2023	3:59:41	451383.2	3519382
192	5/16/2023	3:59:51	451371.7	3519364	5/16/2023	4:59:39	447207.1	3512496
193	5/16/2023	4:59:49	447195.9	3512477	5/16/2023	5:59:43	450100	3505486
194	5/16/2023	5:59:53	450127.7	3505484	5/16/2023	6:59:45	451965	3511391
195	5/16/2023	6:59:55	451957.5	3511402	5/16/2023	7:59:46	448394.5	3516963
196	5/16/2023	7:59:56	448382.5	3516980	5/16/2023	8:59:42	444268.6	3523347
197	5/16/2023	8:59:52	444257.7	3523364	5/16/2023	9:59:40	440215.9	3529626
198	5/16/2023	9:59:49	440205.2	3529643	5/16/2023	10:59:38	436111.9	3535972
199	5/16/2023	10:59:47	436099.9	3535990	5/16/2023	11:59:39	431841	3542580

200	5/16/2023	11:59:48	431829.1	3542598	5/16/2023	12:59:44	430830.2	3549199
201	5/16/2023	12:59:54	430839.2	3549213	5/16/2023	13:59:40	434719	3555473
202	5/16/2023	13:59:49	434730.4	3555492	5/16/2023	14:59:47	438815.8	3562082
203	5/16/2023	14:59:57	438828.2	3562102	5/16/2023	15:59:40	443078.2	3568959
204	5/16/2023	15:59:50	443090.3	3568978	5/16/2023	16:59:47	447211.6	3575625
205	5/16/2023	16:59:57	447223.3	3575644	5/16/2023	17:59:40	451479	3582507
206	5/16/2023	17:59:50	451491.6	3582527	5/16/2023	18:59:37	455930.4	3589686
207	5/16/2023	18:59:47	455943.5	3589706	5/16/2023	19:59:36	460568.9	3597169
208	5/16/2023	19:59:47	460582.6	3597191	5/16/2023	20:59:47	465335.9	3604857
209	5/16/2023	20:59:57	465350.1	3604880	5/16/2023	21:59:44	470234.6	3612759
210	5/16/2023	21:59:55	470249.1	3612782	5/16/2023	22:59:41	475095.3	3620598
211	5/16/2023	22:59:52	475110	3620621	5/16/2023	23:59:38	480011	3628523
212	5/16/2023	23:59:48	480025.8	3628546	5/17/2023	0:59:45	484968.4	3636518
213	5/17/2023	0:59:56	484982.9	3636542	5/17/2023	1:59:43	489889	3644454
214	5/17/2023	1:59:54	489903.7	3644477	5/17/2023	2:59:43	494663.3	3652155
215	5/17/2023	2:59:54	494677.8	3652178	5/17/2023	3:59:39	499550.3	3660039
216	5/17/2023	3:59:50	499565.2	3660063	5/17/2023	4:59:47	504361.2	3667792
217	5/17/2023	4:59:58	504375.6	3667815	5/17/2023	5:59:36	509009.6	3675528
218	5/17/2023	5:59:47	509014.7	3675551	5/17/2023	6:59:37	504366.8	3680631
219	5/17/2023	6:59:48	504347.5	3680644	5/17/2023	7:59:37	497835.1	3685051
220	5/17/2023	7:59:48	497815.6	3685064	5/17/2023	8:59:45	491235.3	3689533
221	5/17/2023	8:59:55	491216.8	3689545	5/17/2023	9:59:43	485125	3693670
222	5/17/2023	9:59:54	485106.3	3693681	5/17/2023	10:59:45	478590.4	3697790
223	5/17/2023	10:59:55	478570.1	3697792	5/17/2023	11:59:45	473835.7	3692794
224	5/17/2023	11:59:55	473822.2	3692773	5/17/2023	12:59:39	469755.1	3685927
225	5/17/2023	12:59:50	469742.7	3685907	5/17/2023	13:59:39	465634.2	3678966
226	5/17/2023	13:59:50	465620.5	3678945	5/17/2023	14:59:40	461762.8	3672440
227	5/17/2023	14:59:50	461755.4	3672429	5/17/2023	15:59:40	459137.5	3668043
228	5/17/2023	15:59:50	459128.3	3668028	5/17/2023	16:59:47	456136.4	3662974
229	5/17/2023	16:59:57	456127.1	3662957	5/17/2023	17:59:46	452098.4	3656164
230	5/17/2023	17:59:57	452085.8	3656143	5/17/2023	18:59:47	448026.4	3649300
231	5/17/2023	18:59:57	448015.9	3649282	5/17/2023	19:59:40	443980.5	3642483
232	5/17/2023	19:59:50	443970.7	3642466	5/17/2023	20:59:40	439963.6	3635712
233	5/17/2023	20:59:51	439952.6	3635691	5/17/2023	21:59:48	435717.1	3628556
234	5/17/2023	21:59:58	435704.7	3628535	5/17/2023	22:59:44	431336.2	3621172
235	5/17/2023	22:59:54	431324.4	3621152	5/17/2023	23:59:39	426894.8	3613681
236	5/17/2023	23:59:50	426882	3613659	5/18/2023	0:59:47	422293.3	3605938
237	5/18/2023	0:59:57	422279.2	3605915	5/18/2023	1:59:46	417459.7	3597772
238	5/18/2023	1:59:56	417445.5	3597749	5/18/2023	2:59:44	412680	3589721
239	5/18/2023	2:59:54	412667.4	3589699	5/18/2023	3:59:43	408072.9	3581954
240	5/18/2023	3:59:52	408060.7	3581934	5/18/2023	4:59:44	402262.2	3576483
241	5/18/2023	4:59:54	402244.7	3576491	5/18/2023	5:59:49	396915.8	3582461
242	5/18/2023	5:59:59	396901.4	3582479	5/18/2023	6:59:49	390932.5	3589597
243	5/18/2023	6:59:58	390918.2	3589614	5/18/2023	7:59:48	388723.3	3596956
244	5/18/2023	7:59:57	388733.5	3596976	5/18/2023	8:59:46	392789.5	3604955
245	5/18/2023	8:59:55	392799.7	3604976	5/18/2023	9:59:44	396961.2	3613144

246	5/18/2023	9:59:53	396972.2	3613164	5/18/2023	10:59:42	401123.2	3621325
247	5/18/2023	10:59:51	401134.7	3621346	5/18/2023	11:59:41	405163.5	3629243
248	5/18/2023	11:59:50	405176.6	3629265	5/18/2023	12:59:42	408813.1	3636435
249	5/18/2023	12:59:52	408824.7	3636455	5/18/2023	13:59:45	412750.7	3644155
250	5/18/2023	13:59:55	412759.7	3644175	5/18/2023	14:59:44	416758.1	3652036
251	5/18/2023	14:59:54	416765.4	3652052	5/18/2023	15:59:39	420561.5	3659530
252	5/18/2023	15:59:49	420573	3659551	5/18/2023	16:59:45	424444.3	3667143
253	5/18/2023	16:59:55	424455.1	3667166	5/18/2023	17:59:36	428375.6	3674868
254	5/18/2023	17:59:56	428392.4	3674908	5/18/2023	18:59:46	432355.8	3682663
255	5/18/2023	18:59:56	432368.3	3682686	5/18/2023	19:59:48	436282.6	3690398
256	5/18/2023	19:59:58	436292.7	3690422	5/18/2023	20:59:48	440264.1	3698200
257	5/18/2023	20:59:58	440271.3	3698220	5/18/2023	21:59:43	444195	3705934
258	5/18/2023	21:59:53	444206.6	3705956	5/18/2023	22:59:47	448048.7	3713483
259	5/18/2023	22:59:57	448059.9	3713505	5/18/2023	23:59:41	451918.8	3721094
260	5/18/2023	23:59:52	451931.5	3721116	5/19/2023	0:59:44	454218.8	3728774
261	5/19/2023	0:59:54	454202.9	3728795	5/19/2023	1:59:48	446931.2	3733963
262	5/19/2023	1:59:58	446910.8	3733977	5/19/2023	2:59:42	439529.3	3739113
263	5/19/2023	2:59:52	439509.3	3739128	5/19/2023	3:59:49	432211.2	3744202
264	5/19/2023	3:59:58	432192.8	3744215	5/19/2023	4:59:52	425262.2	3749032
265	5/19/2023	4:59:57	425250.3	3749039	5/19/2023	5:59:53	418687	3753603
266	5/19/2023	5:59:57	418681.6	3753607	5/19/2023	6:59:57	413301.3	3759453
267	5/19/2023	6:59:59	413302.1	3759461	5/19/2023	7:59:57	417824.8	3770167
268	5/19/2023	7:59:59	417830	3770174	5/19/2023	8:03:21	418059.4	3770753
269	5/19/2023	8:13:44	418799.7	3772530	5/19/2023	9:13:29	423144.8	3782826
270	5/19/2023	9:13:32	423147.5	3782833	5/19/2023	10:13:28	429655.4	3786339
271	5/19/2023	10:13:31	429660.1	3786336	5/19/2023	11:13:25	435111.8	3782552
272	5/19/2023	11:13:32	435116.9	3782542	5/19/2023	12:13:18	434617.3	3778926
273	5/19/2023	12:13:26	434614.6	3778918	5/19/2023	13:13:25	432953	3774990
274	5/19/2023	13:13:31	432950.8	3774983	5/19/2023	14:13:27	431216.1	3770866
275	5/19/2023	14:13:34	431212.1	3770861	5/19/2023	15:13:24	429762.8	3767427
276	5/19/2023	15:13:30	429761.8	3767421	5/19/2023	16:13:28	428233.1	3763805
277	5/19/2023	16:13:34	428230.2	3763799	5/19/2023	17:13:23	426654.8	3760055
278	5/19/2023	17:13:29	426652	3760050	5/19/2023	18:13:24	425126.7	3756436
279	5/19/2023	18:13:29	425123.8	3756431	5/19/2023	19:13:26	423559.8	3752722
280	5/19/2023	19:13:31	423556.9	3752716	5/19/2023	20:13:25	423542.5	3749461
281	5/19/2023	20:13:30	423552.3	3749459	5/19/2023	21:13:21	432242	3751724
282	5/19/2023	21:13:29	432259.7	3751727	5/19/2023	22:13:19	439282	3752835
283	5/19/2023	22:13:29	439296.6	3752838	5/19/2023	23:13:18	444243.4	3753858
284	5/19/2023	23:13:28	444257	3753860	5/20/2023	0:13:16	449290.5	3754339
285	5/20/2023	0:13:26	449305.8	3754339	5/20/2023	1:13:20	454183.2	3753941
286	5/20/2023	1:13:30	454195.6	3753938	5/20/2023	2:13:20	459596.3	3752328
287	5/20/2023	2:13:30	459612.6	3752321	5/20/2023	3:13:19	465417.3	3749681
288	5/20/2023	3:13:29	465438.2	3749669	5/20/2023	4:13:22	472082.7	3745881
289	5/20/2023	4:13:32	472098	3745875	5/20/2023	5:13:18	477578.2	3744697
290	5/20/2023	5:13:28	477593.5	3744695	5/20/2023	6:13:18	484810.9	3743161
291	5/20/2023	6:13:28	484834.7	3743154	5/20/2023	7:13:18	492193	3739731

292	5/20/2023	7:13:28	492199.6	3739711	5/20/2023	8:13:20	487349.3	3735245
293	5/20/2023	8:13:30	487327.2	3735241	5/20/2023	9:13:16	480131.8	3733636
294	5/20/2023	9:13:26	480109.7	3733631	5/20/2023	10:13:17	473130.3	3732049
295	5/20/2023	10:13:27	473111.9	3732045	5/20/2023	11:13:17	467167.8	3730698
296	5/20/2023	11:13:27	467149.7	3730693	5/20/2023	12:13:20	460257.3	3729122
297	5/20/2023	12:13:30	460236.9	3729116	5/20/2023	13:13:17	453138.5	3729642
298	5/20/2023	13:13:27	453119.9	3729656	5/20/2023	14:13:22	446635.1	3734174
299	5/20/2023	14:13:32	446617.9	3734186	5/20/2023	15:13:24	440628.3	3738353
300	5/20/2023	15:13:34	440611.7	3738365	5/20/2023	16:13:18	435181.6	3742146
301	5/20/2023	16:13:28	435167.6	3742156	5/20/2023	17:13:20	430115.9	3745677
302	5/20/2023	17:13:28	430104.1	3745685	5/20/2023	18:13:26	425339.9	3748998
303	5/20/2023	18:13:32	425331.3	3749003	5/20/2023	19:13:29	421054.3	3752026
304	5/20/2023	19:13:33	421050.6	3752029	5/20/2023	20:13:31	417694	3754364
305	5/20/2023	20:13:34	417691.8	3754365	5/20/2023	21:13:31	415510	3755831
306	5/20/2023	21:13:33	415508.5	3755833	5/20/2023	22:13:32	413228.4	3757518
307	5/20/2023	22:13:34	413227.4	3757519	5/20/2023	23:13:32	411567.9	3758590
308	5/20/2023	23:13:35	411566.7	3758591	5/21/2023	0:13:33	410032.5	3759725
309	5/21/2023	0:13:35	410031.7	3759726	5/21/2023	1:13:26	408609.2	3760938
310	5/21/2023	1:13:28	408608.1	3760939	5/21/2023	2:13:26	407460	3762232
311	5/21/2023	2:13:28	407460.3	3762232	5/21/2023	3:13:25	406978.8	3762166
312	5/21/2023	3:13:27	406978.3	3762166	5/21/2023	4:13:24	409270.6	3761314
313	5/21/2023	4:13:26	409273.4	3761314	5/21/2023	5:13:25	414879.5	3759926
314	5/21/2023	5:13:27	414884.2	3759925	5/21/2023	6:13:24	422126.7	3758281
315	5/21/2023	6:13:27	422133.8	3758279	5/21/2023	7:13:20	424702.1	3755566
316	5/21/2023	7:13:26	424700.4	3755563	5/21/2023	8:13:23	423792.3	3753423
317	5/21/2023	8:13:28	423790.8	3753420	5/21/2023	9:13:18	422870.8	3751248
318	5/21/2023	9:13:23	422869.6	3751245	5/21/2023	10:13:21	421874.9	3748903
319	5/21/2023	10:13:26	421873.7	3748899	5/21/2023	11:13:22	420828.4	3746433
320	5/21/2023	11:13:27	420826.5	3746430	5/21/2023	12:13:19	419833.3	3744089
321	5/21/2023	12:13:25	419832.4	3744085	5/21/2023	13:13:19	418833.3	3741733
322	5/21/2023	13:13:24	418832	3741729	5/21/2023	14:13:21	417690.3	3739038
323	5/21/2023	14:13:26	417688.2	3739033	5/21/2023	15:13:22	416421.5	3736046
324	5/21/2023	15:13:28	416419.5	3736041	5/21/2023	16:13:18	415181.9	3733127
325	5/21/2023	16:13:23	415179.8	3733122	5/21/2023	17:13:22	413840.9	3729962
326	5/21/2023	17:13:28	413838.6	3729957	5/21/2023	18:13:20	412314.9	3726368
327	5/21/2023	18:13:26	412312.5	3726361	5/21/2023	19:13:20	410547.9	3722198
328	5/21/2023	19:13:26	410544.9	3722190	5/21/2023	20:13:20	408611.2	3717634
329	5/21/2023	20:13:26	408607.6	3717626	5/21/2023	21:13:22	406379.4	3712371
330	5/21/2023	21:13:28	406375.1	3712360	5/21/2023	22:13:21	404649.7	3707012
331	5/21/2023	22:13:27	404652.1	3707003	5/21/2023	23:13:16	411483.6	3703431
332	5/21/2023	23:13:25	411505.6	3703423	5/22/2023	0:13:16	417406	3699067
333	5/22/2023	0:13:26	417402.5	3699050	5/22/2023	1:13:15	415362.4	3693974
334	5/22/2023	1:13:24	415357.6	3693962	5/22/2023	2:13:19	411318.2	3691805
335	5/22/2023	2:13:28	411300.2	3691811	5/22/2023	3:13:22	403950.7	3694275
336	5/22/2023	3:13:29	403935.5	3694282	5/22/2023	4:13:21	396443.5	3696793
337	5/22/2023	4:13:26	396433.8	3696796	5/22/2023	5:13:26	389312.6	3699181

338	5/22/2023	5:13:29	389306.7	3699183	5/22/2023	6:13:26	382388.9	3701503
339	5/22/2023	6:13:29	382383.3	3701505	5/22/2023	7:13:25	377713.7	3700896
340	5/22/2023	7:13:28	377712.6	3700894	5/22/2023	8:13:25	376981.3	3697310
341	5/22/2023	8:13:28	376982	3697307	5/22/2023	9:13:24	381355.5	3694895
342	5/22/2023	9:13:27	381360.6	3694893	5/22/2023	10:13:25	388321.6	3692414
343	5/22/2023	10:13:29	388329.2	3692412	5/22/2023	11:13:24	395825.3	3689749
344	5/22/2023	11:13:29	395836.5	3689746	5/22/2023	12:13:18	403131.9	3687153
345	5/22/2023	12:13:25	403147.5	3687148	5/22/2023	13:13:18	407027.9	3683406
346	5/22/2023	13:13:28	407025.6	3683395	5/22/2023	14:13:12	405308.9	3679500
347	5/22/2023	14:13:21	405304.6	3679490	5/22/2023	15:13:15	401280.9	3676997
348	5/22/2023	15:13:23	401264.4	3677002	5/22/2023	16:13:19	394681.8	3679407
349	5/22/2023	16:13:25	394669.6	3679413	5/22/2023	17:13:23	387944	3681880
350	5/22/2023	17:13:27	387936	3681883	5/22/2023	18:13:24	381948.9	3684078
351	5/22/2023	18:13:28	381943.3	3684081	5/22/2023	19:13:25	375049.2	3686611
352	5/22/2023	19:13:28	375044.1	3686613	5/22/2023	20:13:25	370677.3	3684106
353	5/22/2023	20:13:28	370675.2	3684101	5/22/2023	21:13:25	368627.6	3678390
354	5/22/2023	21:13:28	368628.3	3678385	5/22/2023	22:13:25	375058.5	3674582
355	5/22/2023	22:13:29	375065.2	3674580	5/22/2023	23:13:23	383173.6	3671493
356	5/22/2023	23:13:27	383183.6	3671489	5/23/2023	0:13:24	391582.4	3668297
357	5/23/2023	0:13:30	391598.2	3668291	5/23/2023	1:13:14	398447.8	3664364
358	5/23/2023	1:13:23	398450.4	3664349	5/23/2023	2:13:19	396263.6	3658639
359	5/23/2023	2:13:28	396253.9	3658629	5/23/2023	3:13:23	390494.3	3659227
360	5/23/2023	3:13:30	390482.9	3659230	5/23/2023	4:13:24	383621.4	3661765
361	5/23/2023	4:13:30	383610.2	3661770	5/23/2023	5:13:25	376384.4	3664441
362	5/23/2023	5:13:29	376376.6	3664443	5/23/2023	6:13:24	370141.4	3666745
363	5/23/2023	6:13:28	370135.8	3666747	5/23/2023	7:13:26	364292.9	3667732
364	5/23/2023	7:13:29	364289.6	3667729	5/23/2023	8:13:27	361794.6	3662511
365	5/23/2023	8:13:30	361794	3662505	5/23/2023	9:13:25	367901.7	3657974
366	5/23/2023	9:13:28	367908.9	3657971	5/23/2023	10:13:24	375936.6	3654595
367	5/23/2023	10:13:28	375946.8	3654591	5/23/2023	11:13:20	384181.3	3651126
368	5/23/2023	11:13:27	384195.3	3651119	5/23/2023	12:13:19	391043.9	3646884
369	5/23/2023	12:13:27	391045.3	3646871	5/23/2023	13:13:17	388939.3	3641368
370	5/23/2023	13:13:24	388934.2	3641357	5/23/2023	14:13:23	383508.2	3640001
371	5/23/2023	14:13:30	383495.5	3640008	5/23/2023	15:13:21	376753.9	3643137
372	5/23/2023	15:13:27	376742.3	3643143	5/23/2023	16:13:27	369210	3646641
373	5/23/2023	16:13:31	369201.3	3646645	5/23/2023	17:13:26	361984.2	3649997
374	5/23/2023	17:13:29	361977.8	3650001	5/23/2023	18:13:25	356141.4	3650986
375	5/23/2023	18:13:28	356137.6	3650983	5/23/2023	19:13:28	352587.1	3648222
376	5/23/2023	19:13:31	352585.4	3648218	5/23/2023	20:13:25	355868.7	3643661
377	5/23/2023	20:13:29	355875.2	3643657	5/23/2023	21:13:26	363609.2	3643108
378	5/23/2023	21:13:30	363614.1	3643118	5/23/2023	22:13:26	367658.2	3652578
379	5/23/2023	22:13:30	367662.2	3652588	5/23/2023	23:13:28	371437.6	3661307
380	5/23/2023	23:13:31	371441.7	3661316	5/24/2023	0:13:25	375101.1	3669833
381	5/24/2023	0:13:29	375105.1	3669841	5/24/2023	1:13:27	378695.5	3678218
382	5/24/2023	1:13:31	378699.6	3678227	5/24/2023	2:13:28	382274.1	3686539
383	5/24/2023	2:13:31	382277.3	3686546	5/24/2023	3:13:25	385898.7	3694981

384	5/24/2023	3:13:29	385901.8	3694989	5/24/2023	4:13:25	389657.9	3703727
385	5/24/2023	4:13:29	389659.8	3703735	5/24/2023	5:13:28	393652.7	3713089
386	5/24/2023	5:13:31	393655.9	3713097	5/24/2023	6:13:26	395215	3722378
387	5/24/2023	6:13:29	395211.8	3722385	5/24/2023	7:13:29	391355.4	3731875
388	5/24/2023	7:13:32	391354.7	3731885	5/24/2023	8:13:30	395544.5	3743232
389	5/24/2023	8:13:32	395547.7	3743239	5/24/2023	9:13:30	400113.7	3753780
390	5/24/2023	9:13:32	400116.9	3753786	5/24/2023	10:13:30	404636.8	3764118
391	5/24/2023	10:13:31	404639.1	3764122	5/24/2023	11:13:29	411913.7	3761316
392	5/24/2023	11:13:31	411913	3761312	5/24/2023	12:13:29	411364.6	3754843
393	5/24/2023	12:13:31	411361.7	3754838	5/24/2023	13:13:27	408983.9	3749238
394	5/24/2023	13:13:30	408981.4	3749233	5/24/2023	14:13:29	406511.2	3743413
395	5/24/2023	14:13:31	406509.7	3743409	5/24/2023	15:13:29	404001.2	3737491
396	5/24/2023	15:13:32	403998.7	3737487	5/24/2023	16:13:27	401483.8	3731559
397	5/24/2023	16:13:30	401482	3731555	5/24/2023	17:13:28	399024.3	3725755
398	5/24/2023	17:13:31	399023	3725750	5/24/2023	18:13:28	396715.9	3720312
399	5/24/2023	18:13:31	396714.4	3720307	5/24/2023	19:13:30	394560.3	3715235
400	5/24/2023	19:13:32	394559.1	3715231	5/24/2023	20:13:29	393805.3	3709956
401	5/24/2023	20:13:32	393810.4	3709952	5/24/2023	21:13:23	402179.4	3706651
402	5/24/2023	21:13:28	402190	3706646	5/24/2023	22:13:20	411166.3	3703531
403	5/24/2023	22:13:29	411188.1	3703523	5/24/2023	23:13:21	417828.5	3708018
404	5/24/2023	23:13:31	417839	3708044	5/25/2023	0:13:22	414553.8	3715364
405	5/25/2023	0:13:30	414536.4	3715373	5/25/2023	1:13:23	407883.7	3715181
406	5/25/2023	1:13:30	407877.3	3715170	5/25/2023	2:13:22	405058	3709260
407	5/25/2023	2:13:29	405052.1	3709248	5/25/2023	3:13:26	402490	3703261
408	5/25/2023	3:13:33	402486.1	3703250	5/25/2023	4:13:23	399889.8	3697228
409	5/25/2023	4:13:29	399885.9	3697218	5/25/2023	5:13:26	397276.2	3691163
410	5/25/2023	5:13:32	397271.1	3691152	5/25/2023	6:13:21	394564.1	3684871
411	5/25/2023	6:13:27	394558.6	3684859	5/25/2023	7:13:22	391755.9	3678357
412	5/25/2023	7:13:29	391750.5	3678345	5/25/2023	8:13:25	388753.2	3671397
413	5/25/2023	8:13:31	388748	3671385	5/25/2023	9:13:25	385587.5	3664050
414	5/25/2023	9:13:31	385582.4	3664039	5/25/2023	10:13:27	382745.3	3657463
415	5/25/2023	10:13:33	382740.9	3657453	5/25/2023	11:13:24	380095.6	3651306
416	5/25/2023	11:13:30	380090.8	3651296	5/25/2023	12:13:22	377395.4	3645042
417	5/25/2023	12:13:28	377390.7	3645032	5/25/2023	13:13:26	374633.1	3638635
418	5/25/2023	13:13:32	374629.3	3638626	5/25/2023	14:13:21	373013.2	3634596
419	5/25/2023	14:13:28	373012.4	3634588	5/25/2023	15:13:25	377005.1	3630097
420	5/25/2023	15:13:31	377016.2	3630089	5/25/2023	16:13:24	384299.7	3624847
421	5/25/2023	16:13:32	384315	3624837	5/25/2023	17:13:18	391718.8	3620022
422	5/25/2023	17:13:27	391736.7	3620009	5/25/2023	18:13:21	399367	3615047
423	5/25/2023	18:13:30	399386.6	3615034	5/25/2023	19:13:21	407035.4	3610064
424	5/25/2023	19:13:31	407055.6	3610051	5/25/2023	20:13:17	414811.2	3605007
425	5/25/2023	20:13:27	414832.9	3604993	5/25/2023	21:13:24	422593.7	3599954
426	5/25/2023	21:13:34	422615.2	3599940	5/25/2023	22:13:21	430437.3	3594857
427	5/25/2023	22:13:31	430461.2	3594843	5/25/2023	23:13:14	438381.7	3589695
428	5/25/2023	23:13:24	438404	3589681	5/26/2023	0:13:18	446474.2	3584435
429	5/26/2023	0:13:28	446497.3	3584420	5/26/2023	1:13:21	454614	3579139

430	5/26/2023	1:13:32	454636.6	3579125	5/26/2023	2:13:20	462704.9	3573886
431	5/26/2023	2:13:30	462735.4	3573867	5/26/2023	3:13:16	471314.6	3568286
432	5/26/2023	3:13:27	471342.2	3568270	5/26/2023	4:13:18	480461.9	3562343
433	5/26/2023	4:13:29	480490.2	3562324	5/26/2023	5:13:17	489396.1	3556536
434	5/26/2023	5:13:28	489422.7	3556521	5/26/2023	6:13:18	497264.4	3551424
435	5/26/2023	6:13:29	497287.4	3551409	5/26/2023	7:13:16	504984.1	3546410
436	5/26/2023	7:13:27	505007.7	3546396	5/26/2023	8:13:19	512577.4	3541475
437	5/26/2023	8:13:29	512602.1	3541461	5/26/2023	9:13:19	520282.2	3536469
438	5/26/2023	9:13:29	520305.2	3536454	5/26/2023	10:13:15	528032.1	3531433
439	5/26/2023	10:13:26	528056	3531419	5/26/2023	11:13:21	535853.1	3526356
440	5/26/2023	11:13:32	535877.8	3526340	5/26/2023	12:13:21	543417.1	3521440
441	5/26/2023	12:13:32	543440.7	3521423	5/26/2023	13:13:20	551186.9	3516388
442	5/26/2023	13:13:32	551211.6	3516372	5/26/2023	14:13:17	558848.3	3511407
443	5/26/2023	14:13:28	558872.9	3511392	5/26/2023	15:13:18	566585.3	3506378
444	5/26/2023	15:13:30	566609.9	3506362	5/26/2023	16:13:12	574370.3	3501317
445	5/26/2023	16:13:24	574395.4	3501300	5/26/2023	17:13:22	579753.6	3497207
446	5/26/2023	17:13:34	579767.7	3497195	5/26/2023	18:13:20	581680	3494886
447	5/26/2023	18:13:32	581684.8	3494879	5/26/2023	18:31:22	582186.6	3494203
448	5/26/2023	18:31:33	582191.9	3494195	5/26/2023	19:31:26	583854.9	3490987
449	5/26/2023	19:31:37	583842.3	3490964	5/26/2023	20:31:25	575459.6	3489456
450	5/26/2023	20:31:36	575433.9	3489454	5/26/2023	21:31:19	566992.6	3488463
451	5/26/2023	21:31:30	566965.3	3488460	5/26/2023	22:31:21	559340.7	3487398
452	5/26/2023	22:31:33	559314	3487394	5/26/2023	23:31:21	553368.3	3486543
453	5/26/2023	23:31:32	553342.4	3486542	5/27/2023	0:31:23	544683.5	3486687
454	5/27/2023	0:31:34	544661.9	3486688	5/27/2023	1:31:26	538377.4	3490150
455	5/27/2023	1:31:37	538371	3490175	5/27/2023	2:31:28	538550.3	3498117
456	5/27/2023	2:31:39	538562.3	3498137	5/27/2023	3:31:25	546007.2	3500104
457	5/27/2023	3:31:36	546034.1	3500106	5/27/2023	4:31:21	554418.7	3500635
458	5/27/2023	4:31:32	554446.6	3500635	5/27/2023	5:31:23	562873.2	3501083
459	5/27/2023	5:31:35	562899.9	3501083	5/27/2023	6:31:28	571184.4	3501526
460	5/27/2023	6:31:39	571211.1	3501527	5/27/2023	7:31:27	579679	3502011
461	5/27/2023	7:31:39	579705.2	3502013	5/27/2023	8:31:31	588277.6	3502480
462	5/27/2023	8:31:42	588305.1	3502482	5/27/2023	9:31:23	596989.1	3502955
463	5/27/2023	9:31:34	597016.5	3502955	5/27/2023	10:31:29	605909	3503433
464	5/27/2023	10:31:41	605938.2	3503435	5/27/2023	11:31:27	614860.8	3503918
465	5/27/2023	11:31:39	614889.3	3503919	5/27/2023	12:31:27	624147.5	3504425
466	5/27/2023	12:31:39	624177	3504426	5/27/2023	13:31:21	633311.9	3504953
467	5/27/2023	13:31:33	633342.3	3504953	5/27/2023	14:31:21	641287.3	3505412
468	5/27/2023	14:31:33	641309.8	3505408	5/27/2023	15:31:21	640462.9	3500589
469	5/27/2023	15:31:32	640443.1	3500577	5/27/2023	15:45:36	638742.1	3500300
470	5/27/2023	15:45:51	638713.3	3500307	5/27/2023	16:45:36	631694.8	3504002
471	5/27/2023	16:45:51	631667.4	3504021	5/27/2023	16:55:59	630540.8	3504721
472	5/27/2023	16:56:13	630517.5	3504737	5/27/2023	17:55:56	623888.4	3509052
473	5/27/2023	17:56:08	623866.9	3509066	5/27/2023	18:55:58	617308.5	3513324
474	5/27/2023	18:56:10	617286.3	3513338	5/27/2023	19:55:59	610751.4	3517589
475	5/27/2023	19:56:11	610730	3517603	5/27/2023	20:55:57	604320.2	3521771

476	5/27/2023	20:56:08	604298.5	3521784	5/27/2023	21:56:00	597737.1	3526050
477	5/27/2023	21:56:12	597714.9	3526065	5/27/2023	22:55:55	591062.9	3530384
478	5/27/2023	22:56:07	591039.7	3530396	5/27/2023	23:56:00	584347	3534749
479	5/27/2023	23:56:12	584324.9	3534763	5/27/2023	23:56:59	584235.6	3534822
480	5/28/2023	0:02:25	583608.3	3535229	5/28/2023	1:01:34	576878.4	3539602
481	5/28/2023	1:01:46	576856.1	3539616	5/28/2023	2:01:26	570062.3	3544035
482	5/28/2023	2:01:38	570040	3544050	5/28/2023	3:01:35	562864.1	3548715
483	5/28/2023	3:01:47	562840.5	3548731	5/28/2023	4:01:36	555553.8	3553469
484	5/28/2023	4:01:48	555530.3	3553483	5/28/2023	5:01:32	548772	3557870
485	5/28/2023	5:01:43	548751.4	3557883	5/28/2023	6:01:30	542529.7	3561924
486	5/28/2023	6:01:42	542510.3	3561938	5/28/2023	7:01:26	536559.5	3565808
487	5/28/2023	7:01:38	536541.5	3565820	5/28/2023	8:01:33	531059.6	3569382
488	5/28/2023	8:01:44	531041.4	3569392	5/28/2023	9:01:35	525729.7	3572842
489	5/28/2023	9:01:46	525712.1	3572853	5/28/2023	10:01:32	520349.3	3576343
490	5/28/2023	10:01:43	520331.9	3576353	5/28/2023	11:01:37	514909.2	3579878
491	5/28/2023	11:01:48	514890.8	3579888	5/28/2023	12:01:35	509371.8	3583471
492	5/28/2023	12:01:47	509355	3583483	5/28/2023	13:01:30	503834.4	3587071
493	5/28/2023	13:01:41	503818	3587082	5/28/2023	14:01:37	498457.3	3590568
494	5/28/2023	14:01:48	498442.2	3590578	5/28/2023	15:01:30	493303.5	3593918
495	5/28/2023	15:01:41	493289.2	3593927	5/28/2023	16:01:34	487774.1	3597513
496	5/28/2023	16:01:45	487755.2	3597526	5/28/2023	17:01:35	481047.5	3601883
497	5/28/2023	17:01:46	481025.7	3601897	5/28/2023	18:01:34	473629.5	3606708
498	5/28/2023	18:01:45	473608.6	3606723	5/28/2023	19:01:35	466210.8	3611525
499	5/28/2023	19:01:45	466188	3611539	5/28/2023	20:01:36	458906.9	3616263
500	5/28/2023	20:01:46	458886.1	3616276	5/28/2023	21:01:38	451879.1	3620835
501	5/28/2023	21:01:48	451859.5	3620848	5/28/2023	22:01:34	445091.2	3625248
502	5/28/2023	22:01:44	445073.1	3625260	5/28/2023	23:01:39	438997.1	3629204
503	5/28/2023	23:01:49	438982	3629214	5/29/2023	0:01:29	434389.9	3632205
504	5/29/2023	0:01:39	434376.7	3632212	5/29/2023	1:01:36	430017	3635042
505	5/29/2023	1:01:46	430004.1	3635051	5/29/2023	2:01:38	425224.8	3638153
506	5/29/2023	2:01:48	425209.5	3638162	5/29/2023	3:01:30	419721.7	3641733
507	5/29/2023	3:01:40	419706.3	3641745	5/29/2023	4:01:33	413680.7	3645658
508	5/29/2023	4:01:42	413665.3	3645670	5/29/2023	5:01:37	407366.5	3649766
509	5/29/2023	5:01:46	407349	3649777	5/29/2023	6:01:39	400661.8	3654124
510	5/29/2023	6:01:48	400645.7	3654135	5/29/2023	7:01:40	397226	3660381
511	5/29/2023	7:01:49	397234.9	3660401	5/29/2023	8:01:33	400848.9	3668835
512	5/29/2023	8:01:42	400858.1	3668856	5/29/2023	9:01:32	404111.8	3676048
513	5/29/2023	9:01:41	404113.6	3676066	5/29/2023	10:01:31	407437.2	3684216
514	5/29/2023	10:01:40	407447.1	3684240	5/29/2023	11:01:35	411150.3	3692885
515	5/29/2023	11:01:45	411159.8	3692907	5/29/2023	12:01:33	414882.9	3701595
516	5/29/2023	12:01:43	414892.6	3701618	5/29/2023	13:01:35	418631.4	3710349
517	5/29/2023	13:01:45	418641.7	3710373	5/29/2023	14:01:38	423788	3717168
518	5/29/2023	14:01:48	423811.3	3717162	5/29/2023	15:01:34	431037.8	3712465
519	5/29/2023	15:01:44	431058.7	3712451	5/29/2023	16:01:32	438657	3707303
520	5/29/2023	16:01:42	438678.1	3707290	5/29/2023	17:01:38	446204	3702206
521	5/29/2023	17:01:48	446223.3	3702193	5/29/2023	18:01:35	452852.2	3697701

522	5/29/2023	18:01:45	452871.1	3697689	5/29/2023	19:01:38	459483.2	3693214
523	5/29/2023	19:01:48	459503.1	3693200	5/29/2023	20:01:30	466564.2	3688425
524	5/29/2023	20:01:40	466584.3	3688411	5/29/2023	21:01:37	473785	3683538
525	5/29/2023	21:01:47	473805.9	3683523	5/29/2023	22:01:37	481171.2	3678541
526	5/29/2023	22:01:48	481192.7	3678525	5/29/2023	23:01:30	488643.5	3673488
527	5/29/2023	23:01:41	488665	3673473	5/30/2023	0:01:35	495912.3	3668568
528	5/30/2023	0:01:45	495932.6	3668554	5/30/2023	1:01:37	502799.1	3663911
529	5/30/2023	1:01:47	502818.8	3663898	5/30/2023	2:01:30	509526.7	3659356
530	5/30/2023	2:01:41	509547.3	3659343	5/30/2023	3:01:29	516528.7	3654623
531	5/30/2023	3:01:40	516550.1	3654609	5/30/2023	4:01:35	523954.3	3649599
532	5/30/2023	4:01:46	523976.7	3649583	5/30/2023	5:01:35	531385.4	3644571
533	5/30/2023	5:01:46	531408.8	3644555	5/30/2023	6:01:35	538698	3639623
534	5/30/2023	6:01:46	538719.8	3639608	5/30/2023	7:01:38	545755.1	3634845
535	5/30/2023	7:01:49	545777.5	3634829	5/30/2023	8:01:33	552909.7	3630006
536	5/30/2023	8:01:44	552932.8	3629990	5/30/2023	9:01:31	560140.4	3625117
537	5/30/2023	9:01:43	560161.9	3625103	5/30/2023	10:01:33	567063.5	3620431
538	5/30/2023	10:01:45	567085.2	3620416	5/30/2023	11:01:28	573388	3616149
539	5/30/2023	11:01:40	573407.7	3616137	5/30/2023	12:01:36	579558.6	3611977
540	5/30/2023	12:01:47	579579.1	3611962	5/30/2023	13:01:35	586196.5	3607486
541	5/30/2023	13:01:46	586217.9	3607471	5/30/2023	14:01:36	593376.8	3602627
542	5/30/2023	14:01:48	593402.1	3602610	5/30/2023	15:01:30	599043.3	3596597
543	5/30/2023	15:01:42	599035.3	3596574	5/30/2023	16:01:38	596083.8	3591413
544	5/30/2023	16:01:50	596075.5	3591398	5/30/2023	17:01:36	593264.4	3586581
545	5/30/2023	17:01:48	593254.8	3586565	5/30/2023	18:01:34	589505.1	3580128
546	5/30/2023	18:01:45	589491.9	3580105	5/30/2023	19:01:30	585273.5	3573041
547	5/30/2023	19:01:41	585258	3573027	5/30/2023	20:01:32	580193.9	3574017
548	5/30/2023	20:01:43	580178	3574028	5/30/2023	21:01:29	576599.7	3576368
549	5/30/2023	21:01:41	576589.9	3576374	5/30/2023	22:01:30	572251.1	3579215
550	5/30/2023	22:01:41	572236.6	3579224	5/30/2023	23:01:30	567551.9	3582288
551	5/30/2023	23:01:41	567536.7	3582298	5/31/2023	0:01:35	562480.6	3585605
552	5/31/2023	0:01:47	562464	3585616	5/31/2023	1:01:40	557493.8	3588867
553	5/31/2023	1:01:51	557478.9	3588877	5/31/2023	2:01:34	552693.9	3592005
554	5/31/2023	2:01:45	552678.3	3592015	5/31/2023	3:01:40	547175.1	3595617
555	5/31/2023	3:01:51	547156.9	3595629	5/31/2023	4:01:29	540822.2	3599770
556	5/31/2023	4:01:40	540801.4	3599784	5/31/2023	5:01:37	534007.3	3604231
557	5/31/2023	5:01:48	533986.3	3604245	5/31/2023	6:01:35	527151.4	3608713
558	5/31/2023	6:01:46	527129.9	3608727	5/31/2023	7:01:35	519970.7	3613413
559	5/31/2023	7:01:46	519947.9	3613427	5/31/2023	8:01:31	512747.6	3618133
560	5/31/2023	8:01:42	512725	3618148	5/31/2023	9:01:38	505189.2	3623081
561	5/31/2023	9:01:49	505165.9	3623096	5/31/2023	10:01:32	497443.9	3628147
562	5/31/2023	10:01:43	497420.8	3628163	5/31/2023	11:01:36	489857.3	3633112
563	5/31/2023	11:01:47	489834.6	3633127	5/31/2023	12:01:38	482072.9	3638199
564	5/31/2023	12:01:49	482050	3638214	5/31/2023	13:01:33	474633.7	3643061
565	5/31/2023	13:01:44	474613.3	3643076	5/31/2023	14:01:38	467183.9	3647925
566	5/31/2023	14:01:48	467167.7	3647936	5/31/2023	15:01:33	461933.4	3651375
567	5/31/2023	15:01:43	461917.7	3651385	5/31/2023	16:01:39	457104.9	3654535

568	5/31/2023	16:01:49	457092.2	3654543	5/31/2023	17:01:39	452221.6	3657723
569	5/31/2023	17:01:49	452206.9	3657734	5/31/2023	18:01:32	446551.3	3661438
570	5/31/2023	18:01:42	446534.2	3661449	5/31/2023	19:01:42	440128.5	3665637
571	5/31/2023	19:01:52	440109	3665648	5/31/2023	20:01:42	433096.2	3670236
572	5/31/2023	20:01:52	433076.5	3670250	5/31/2023	21:01:34	425663.5	3675105
573	5/31/2023	21:01:44	425641.9	3675119	5/31/2023	22:01:40	418153.8	3680016
574	5/31/2023	22:01:49	418134.3	3680031	5/31/2023	23:01:34	410820.5	3684425
575	5/31/2023	23:01:44	410801.9	3684431	6/1/2023	0:01:41	410432.9	3690938
576	6/1/2023	0:01:51	410440.9	3690960	6/1/2023	1:01:42	413987.8	3699334
577	6/1/2023	1:01:52	413996.4	3699356	6/1/2023	2:01:42	417491.2	3707577
578	6/1/2023	2:01:51	417498.6	3707598	6/1/2023	3:01:40	421018.4	3715882
579	6/1/2023	3:01:50	421029.1	3715907	6/1/2023	4:01:41	424522.9	3724216
580	6/1/2023	4:01:51	424532.4	3724241	6/1/2023	5:01:35	427945.3	3732358
581	6/1/2023	5:01:45	427955.2	3732382	6/1/2023	6:01:42	431377.9	3740522
582	6/1/2023	6:01:52	431386.1	3740545	6/1/2023	7:01:40	434796.2	3748657
583	6/1/2023	7:01:49	434805.7	3748677	6/1/2023	8:01:35	438220.7	3756814
584	6/1/2023	8:01:44	438232.2	3756840	6/1/2023	9:01:34	441831.6	3765400
585	6/1/2023	9:01:44	441841.6	3765424	6/1/2023	10:01:41	445436.9	3773988
586	6/1/2023	10:01:50	445447.2	3774012	6/1/2023	11:01:40	450048.9	3782202
587	6/1/2023	11:01:50	450061.8	3782224	6/1/2023	12:01:42	455098.9	3790500
588	6/1/2023	12:01:52	455113.4	3790522	6/1/2023	13:01:42	460380.2	3799215
589	6/1/2023	13:01:52	460394.2	3799240	6/1/2023	14:01:41	458936.1	3805076
590	6/1/2023	14:01:51	458923.8	3805083	6/1/2023	15:01:40	455239.4	3807316
591	6/1/2023	15:01:49	455230.8	3807321	6/1/2023	16:01:42	452067.6	3809211
592	6/1/2023	16:01:51	452057.5	3809217	6/1/2023	17:01:42	448563.7	3811298
593	6/1/2023	17:01:51	448556	3811303	6/1/2023	18:01:43	445136	3813343
594	6/1/2023	18:01:51	445127.1	3813349	6/1/2023	19:01:41	441240.3	3813475
595	6/1/2023	19:01:47	441235.1	3813469	6/1/2023	19:54:33	438955.5	3809998
596	6/1/2023	19:54:38	438951.9	3809992	6/1/2023	20:54:30	435992.5	3805317
597	6/1/2023	20:54:35	435988.1	3805311	6/1/2023	21:54:35	433252.4	3800994
598	6/1/2023	21:54:39	433248.6	3800989	6/1/2023	22:54:36	430237	3796235
599	6/1/2023	22:54:38	430235.5	3796233	6/1/2023	23:54:36	427644.1	3792141
600	6/1/2023	23:54:38	427642.5	3792139	6/2/2023	0:54:36	424966	3788959
601	6/2/2023	0:54:38	424964.2	3788958	6/2/2023	1:54:38	420630.6	3789148
602	6/2/2023	1:54:39	420628.5	3789149	6/2/2023	2:54:38	415873.1	3789076
603	6/2/2023	2:54:39	415871.6	3789076	6/2/2023	3:54:38	413964.4	3785783
604	6/2/2023	3:54:40	413964.1	3785781	6/2/2023	4:54:38	412534	3782488
605	6/2/2023	4:54:40	412533.5	3782487	6/2/2023	5:54:37	410941.4	3778818
606	6/2/2023	5:54:39	410940.9	3778817	6/2/2023	6:54:37	409237.2	3774883
607	6/2/2023	6:54:39	409236.3	3774881	6/2/2023	7:54:38	407391.6	3770632
608	6/2/2023	7:54:40	407390.6	3770630	6/2/2023	8:54:38	405462.4	3766181
609	6/2/2023	8:54:40	405461.7	3766178	6/2/2023	9:54:38	403516.6	3761695
610	6/2/2023	9:54:40	403515.4	3761693	6/2/2023	10:54:37	401378.8	3756770
611	6/2/2023	10:54:39	401377.5	3756767	6/2/2023	11:54:38	398849.2	3750935
612	6/2/2023	11:54:40	398847.7	3750932	6/2/2023	12:54:37	396094.9	3744577
613	6/2/2023	12:54:40	396093.3	3744573	6/2/2023	13:54:38	393226.9	3737948

614	6/2/2023	13:54:40	393225.4	3737944	6/2/2023	14:54:38	390130.1	3734173
615	6/2/2023	14:54:40	390127.9	3734171	6/2/2023	15:54:38	387286.2	3731622
616	6/2/2023	15:54:40	387284.9	3731620	6/2/2023	16:54:39	385948.4	3730271
617	6/2/2023	16:54:41	385948.1	3730271	6/2/2023	17:54:37	385112.2	3729656
618	6/2/2023	17:54:40	385110.6	3729654	6/2/2023	18:54:38	382232.3	3726532
619	6/2/2023	18:54:40	382230.4	3726530	6/2/2023	19:54:38	380229	3725216
620	6/2/2023	19:54:40	380227.2	3725214	6/2/2023	20:54:37	379173.1	3724688
621	6/2/2023	20:54:39	379172.7	3724688	6/2/2023	21:54:38	378572.8	3724099
622	6/2/2023	21:54:40	378572.5	3724098	6/2/2023	22:54:37	378000.4	3722868
623	6/2/2023	22:54:39	377999.7	3722867	6/2/2023	23:54:39	374869.3	3722428
624	6/2/2023	23:54:41	374864.7	3722429	6/3/2023	0:54:39	368349.5	3727612
625	6/3/2023	0:54:41	368349.1	3727617	6/3/2023	1:54:40	366138.9	3737672
626	6/3/2023	1:54:41	366138.2	3737675	6/3/2023	2:42:22	364523.7	3745702
627	6/3/2023	2:52:04	364204.1	3747361	6/3/2023	3:00:02	363926.3	3748724
628	6/3/2023	3:01:09	363888.1	3748911	6/3/2023	4:00:07	361901.8	3758954
629	6/3/2023	4:00:07	361901.5	3758955	6/3/2023	5:00:07	359868.5	3769125
630	6/3/2023	5:00:08	359868.4	3769126	6/3/2023	6:00:07	360135.6	3779183
631	6/3/2023	6:00:08	360135.7	3779183	6/3/2023	7:00:07	358234.2	3789293
632	6/3/2023	7:00:08	358234	3789294	6/3/2023	7:18:18	356828.6	3792271

Supp. Mat. D

Listing of EM122 multibeam and water column line files showing start and end times as well as areal line extents for MGL2307.

Line Number	Start Date	Start Time	Start East	Start North	End Date	End Time	End East	End North
0	6/4/2023	12:25:25	346023.7	3831175.52	6/4/2023	12:41:55	347787	3826392
1	6/4/2023	12:41:55	347787.2	3826391.28	6/4/2023	13:13:54	351178.7	3817340
2	6/4/2023	13:13:54	351179	3817338.91	6/4/2023	14:13:54	357870.9	3800245
3	6/4/2023	14:13:54	357871.1	3800244.13	6/4/2023	15:13:54	366519.4	3784267
4	6/4/2023	15:13:54	366519.8	3784266.91	6/4/2023	16:13:54	375621.5	3767794
5	6/4/2023	16:13:54	375621.9	3767793.1	6/4/2023	17:13:52	383567	3753715
6	6/4/2023	17:13:54	383567.9	3753709.17	6/4/2023	18:13:51	390681.2	3740668
7	6/4/2023	18:13:53	390685.3	3740662.36	6/4/2023	19:09:58	395469.4	3728904
8	6/4/2023	19:13:57	395774.2	3728071.19	6/4/2023	20:13:51	399966.7	3714892
9	6/4/2023	20:13:54	399967.6	3714878.18	6/4/2023	21:13:48	405492.7	3710528
10	6/4/2023	21:13:53	405500	3710532.26	6/4/2023	22:13:49	406222.5	3711429
11	6/4/2023	22:13:54	406222.8	3711434.33	6/4/2023	23:13:47	407386.6	3715283
12	6/4/2023	23:13:52	407389.5	3715289.33	6/5/2023	0:13:46	408740.5	3718599
13	6/5/2023	0:13:51	408743.3	3718604.31	6/5/2023	1:13:46	409688.9	3722299
14	6/5/2023	1:13:50	409690.4	3722304.27	6/5/2023	2:13:47	411241.2	3726035
15	6/5/2023	2:13:52	411242.8	3726040.22	6/5/2023	3:13:47	412605.3	3729937
16	6/5/2023	3:13:52	412608.8	3729943.95	6/5/2023	4:13:50	413804.3	3733946
17	6/5/2023	4:13:54	413805.4	3733952.39	6/5/2023	5:13:49	415931.6	3738654
18	6/5/2023	5:13:53	415934.9	3738660.11	6/5/2023	6:13:47	418340.7	3743554
19	6/5/2023	6:13:51	418344	3743561.14	6/5/2023	7:13:48	420893.6	3748943
20	6/5/2023	7:13:52	420894.9	3748949.03	6/5/2023	8:13:50	422437.4	3753991
21	6/5/2023	8:13:54	422439	3753995.85	6/5/2023	9:13:51	423769.3	3758782
22	6/5/2023	9:13:55	423770.2	3758788.33	6/5/2023	10:13:50	424101	3760299
23	6/5/2023	10:13:54	424099.1	3760294.57	6/5/2023	11:01:29	422122.4	3756756
24	6/5/2023	11:01:32	422119.9	3756751.74	6/5/2023	12:01:27	420089	3752307
25	6/5/2023	12:01:31	420092.5	3752306.29	6/5/2023	13:01:26	422451.7	3751617
26	6/5/2023	13:01:31	422450.8	3751617.63	6/5/2023	14:01:26	422638.2	3753301
27	6/5/2023	14:01:30	422640.7	3753301.59	6/5/2023	15:01:25	422363.8	3753331
28	6/5/2023	15:01:30	422361.7	3753328.12	6/5/2023	16:01:25	421322.6	3751949
29	6/5/2023	16:01:29	421322.3	3751948.21	6/5/2023	17:01:26	421295.9	3751944
30	6/5/2023	17:01:30	421295.9	3751943.66	6/5/2023	18:01:25	421299.7	3751943
31	6/5/2023	18:01:29	421299.1	3751942.59	6/5/2023	19:01:28	421298.5	3751942
32	6/5/2023	19:01:32	421298.3	3751941.55	6/5/2023	20:01:24	422933.8	3743986
33	6/5/2023	20:01:29	422961.4	3743997.73	6/5/2023	21:01:14	442294.2	3752835
34	6/5/2023	21:01:24	442343.9	3752862.28	6/5/2023	22:01:20	444808	3753923
35	6/5/2023	22:01:30	444808.1	3753923.21	6/5/2023	23:01:18	444456	3754218
36	6/5/2023	23:01:27	444456	3754218.63	6/6/2023	0:01:23	444455.9	3754219
37	6/6/2023	0:01:33	444456.2	3754219.05	6/6/2023	1:01:16	444455.4	3754219
38	6/6/2023	1:01:26	444455.2	3754219.4	6/6/2023	2:01:15	437917.9	3743815
39	6/6/2023	2:01:25	437896.3	3743782.16	6/6/2023	3:01:14	430287	3731432

40	6/6/2023	3:01:24	430264.9	3731397.63	6/6/2023	4:01:17	421936.8	3718875
41	6/6/2023	4:01:27	421912.6	3718841.06	6/6/2023	5:01:16	413708.4	3705643
42	6/6/2023	5:01:26	413693.6	3705619.77	6/6/2023	6:01:17	411519	3703494
43	6/6/2023	6:01:26	411530.9	3703511.92	6/6/2023	7:01:16	412374	3703148
44	6/6/2023	7:01:26	412374.1	3703147.29	6/6/2023	8:01:20	412374.2	3703147
45	6/6/2023	8:01:30	412374.4	3703147.28	6/6/2023	9:01:22	407672	3709353
46	6/6/2023	9:01:28	407651.9	3709380.05	6/6/2023	10:01:24	405848.6	3710809
47	6/6/2023	10:01:29	405848.7	3710808.73	6/6/2023	11:01:27	405848.3	3710809
48	6/6/2023	11:01:32	405848.2	3710808.68	6/6/2023	12:01:26	405848.3	3710810
49	6/6/2023	12:01:31	405848.4	3710810.18	6/6/2023	13:01:24	405848.8	3710810
50	6/6/2023	13:01:29	405848.7	3710809.93	6/6/2023	14:01:24	405848.3	3710809
51	6/6/2023	14:01:29	405848	3710808.69	6/6/2023	15:01:24	405847.7	3710810
52	6/6/2023	15:01:29	405847.7	3710810.5	6/6/2023	16:01:29	405909.4	3710466
53	6/6/2023	16:01:34	405910.2	3710456.19	6/6/2023	17:01:19	413878.7	3716295
54	6/6/2023	17:01:27	413894.6	3716331.66	6/6/2023	18:01:17	420765.5	3732460
55	6/6/2023	18:01:26	420782.3	3732500.3	6/6/2023	19:01:27	422432.2	3745253
56	6/6/2023	19:01:32	422415	3745256.83	6/6/2023	20:01:30	413004.3	3739089
57	6/6/2023	20:01:33	412998.7	3739077.11	6/6/2023	21:01:29	408990.6	3729862
58	6/6/2023	21:01:33	408986.9	3729852.37	6/6/2023	22:01:30	405677.7	3717202
59	6/6/2023	22:01:34	405679.5	3717184.32	6/6/2023	23:01:25	405847.4	3710805
60	6/6/2023	23:01:30	405847.2	3710804.83	6/7/2023	0:01:28	405866.5	3710842
61	6/7/2023	0:01:33	405866.1	3710842.09	6/7/2023	1:01:27	405958.2	3711037
62	6/7/2023	1:01:32	405958.3	3711036.96	6/7/2023	2:01:27	405961.1	3711038
63	6/7/2023	2:01:32	405961.1	3711038.48	6/7/2023	3:01:26	405959.5	3711037
64	6/7/2023	3:01:31	405959.7	3711037.06	6/7/2023	4:01:28	405958.3	3711035
65	6/7/2023	4:01:33	405958.1	3711035.24	6/7/2023	5:01:28	405958.6	3711039
66	6/7/2023	5:01:33	405958.9	3711038.95	6/7/2023	6:01:25	405955.8	3711039
67	6/7/2023	6:01:30	405956	3711039.06	6/7/2023	7:01:26	406192.9	3710896
68	6/7/2023	7:01:31	406192.4	3710893.56	6/7/2023	8:01:26	407019.1	3710983
69	6/7/2023	8:01:31	407020.5	3710983.5	6/7/2023	9:01:28	407049.5	3710766
70	6/7/2023	9:01:33	407048.6	3710764.71	6/7/2023	10:01:29	403860.5	3706319
71	6/7/2023	10:01:34	403848.4	3706302.06	6/7/2023	11:01:30	395279.4	3695264
72	6/7/2023	11:01:34	395268.2	3695251.19	6/7/2023	12:01:30	386712.8	3683704
73	6/7/2023	12:01:34	386703.8	3683692.21	6/7/2023	13:01:32	376429.8	3674972
74	6/7/2023	13:01:35	376419.8	3674966.39	6/7/2023	14:01:31	374805.6	3666667
75	6/7/2023	14:01:34	374814.4	3666674.57	6/7/2023	15:01:30	373998.9	3665822
76	6/7/2023	15:01:33	373995.3	3665817.94	6/7/2023	16:01:30	373899.1	3665721
77	6/7/2023	16:01:33	373898.9	3665721.47	6/7/2023	17:01:29	373903.3	3665722
78	6/7/2023	17:01:32	373903	3665721.8	6/7/2023	18:01:29	373899.8	3665720
79	6/7/2023	18:01:33	373900.1	3665720.37	6/7/2023	19:01:30	373901.8	3665718
80	6/7/2023	19:01:33	373901.9	3665717.78	6/7/2023	20:01:29	373900.2	3665717
81	6/7/2023	20:01:32	373900.3	3665716.82	6/7/2023	21:01:29	374561.3	3665566
82	6/7/2023	21:01:33	374563.7	3665566.3	6/7/2023	22:01:31	374408.3	3665472
83	6/7/2023	22:01:35	374408.3	3665471.7	6/7/2023	23:01:31	375157.5	3665108
84	6/7/2023	23:01:34	375157.5	3665108.18	6/8/2023	0:01:31	375444.9	3665067
85	6/8/2023	0:01:35	375449.8	3665064.25	6/8/2023	1:01:32	375899.6	3664744
86	6/8/2023	1:01:35	375899.5	3664743.99	6/8/2023	2:01:31	383640	3659809

87	6/8/2023	2:01:36	383645	3659811.51	6/8/2023	3:01:27	383546	3659694
88	6/8/2023	3:01:33	383545.6	3659694.19	6/8/2023	4:01:29	383547	3659694
89	6/8/2023	4:01:34	383546.7	3659693.59	6/8/2023	5:01:30	383541.6	3659693
90	6/8/2023	5:01:36	383541.8	3659692.53	6/8/2023	6:01:28	383546.3	3659694
91	6/8/2023	6:01:33	383546.3	3659694.24	6/8/2023	7:01:28	384300.3	3661755
92	6/8/2023	7:01:33	384321.8	3661753.01	6/8/2023	8:01:24	392580.4	3660097
93	6/8/2023	8:01:31	392569.1	3660094.56	6/8/2023	9:01:25	390832.6	3659097
94	6/8/2023	9:01:31	390833	3659097.46	6/8/2023	10:01:25	390835.9	3659099
95	6/8/2023	10:01:31	390836	3659099.34	6/8/2023	11:01:29	390830.5	3659099
96	6/8/2023	11:01:36	390830.7	3659098.66	6/8/2023	12:01:25	390832.4	3659099
97	6/8/2023	12:01:32	390832.9	3659099.08	6/8/2023	13:01:25	389318.5	3645236
98	6/8/2023	13:01:32	389315	3645198.12	6/8/2023	14:01:29	389409	3641479
99	6/8/2023	14:01:36	389398.6	3641475.63	6/8/2023	15:01:29	388797.7	3641062
100	6/8/2023	15:01:36	388797.6	3641062.13	6/8/2023	16:01:26	388796.8	3641062
101	6/8/2023	16:01:33	388796.9	3641061.69	6/8/2023	17:01:26	388799.7	3641056
102	6/8/2023	17:01:33	388799.8	3641056.16	6/8/2023	18:01:25	388799.3	3641055
103	6/8/2023	18:01:32	388799.3	3641055.34	6/8/2023	19:01:27	388800.3	3641056
104	6/8/2023	19:01:34	388800.4	3641055.31	6/8/2023	20:01:28	389557.7	3640040
105	6/8/2023	20:01:35	389557.6	3640035.6	6/8/2023	21:01:26	389588.8	3640008
106	6/8/2023	21:01:33	389588.7	3640007.89	6/8/2023	22:01:22	389587.9	3640007
107	6/8/2023	22:01:30	389587.8	3640006.78	6/8/2023	23:01:24	389588.4	3640009
108	6/8/2023	23:01:32	389588.2	3640008.62	6/9/2023	0:01:27	389589.4	3640008
109	6/9/2023	0:01:35	389589.5	3640007.91	6/9/2023	1:01:24	389588.3	3640008
110	6/9/2023	1:01:31	389588.1	3640007.89	6/9/2023	2:01:29	389588.3	3640009
111	6/9/2023	2:01:36	389588.4	3640008.74	6/9/2023	3:01:29	389588.1	3640008
112	6/9/2023	3:01:36	389588.1	3640008.21	6/9/2023	4:01:28	389587.9	3640008
113	6/9/2023	4:01:36	389588.1	3640007.8	6/9/2023	5:01:24	388572.3	3636258
114	6/9/2023	5:01:31	388562.7	3636223.23	6/9/2023	6:01:26	382433.5	3620135
115	6/9/2023	6:01:33	382415.1	3620103.94	6/9/2023	7:01:28	371820	3606616
116	6/9/2023	7:01:36	371796.2	3606586.71	6/9/2023	8:01:21	360934.3	3593103
117	6/9/2023	8:01:29	360908.8	3593074.93	6/9/2023	9:01:27	349558.6	3580042

8. Crew and Shipboard Scientific Party

Ship Crew
Breck Crum, Captain
David Wolforf, Chief Mate
Joseph (Joe) Hoffer, 2nd Mate
Joselyn White, 3rd Mate
Jay Butler, Chief Engineer
Mike Slonaker, 1 A/Engineer
Tristian Boro, 3rd A/Engineer
Vincent Rodriguez, 2nd A/Engineer
Jared Gursslin, Mate
Rodolfo Florendo, Oiler
Maurice Dawson, Oiler
Joseph (Joe) Walsh, Oiler /AB
Bill Robison, AB
Robert Hammond, AB
Felix Sandoval, AB
George Cereno, Bosun
Ricardo Rios, Cook
Hervin McLean Fuller, OS/Cook
Tanaycious (T.) Gibson, OS
Marcialleo Rillera de Guzman, OS-Utility

Shipboard Technical Staff, Leg 1
Cody Bahlau, Chief Science Officer, Acquisition
Koray Ergun, Contract Navigator
James Alan De Long, Contract Source Observer
Gilles Guerin, Marine Science Technician - Obs
Riley Lopez, Marine Science Technician - Obs
Josh Kasinger, Chief Source Mechanic
Brian Agee, Senior Source Mech.
Malcom Moddy, Contract Source Mech.
Ray Hatton, Contract Source Mech.

PSOs (Protected Species Observers)
Cassandra Frey, PSO
Kristal Mohammed, PSO
Jo-Ann Sookar, PSO
Shelby Tobin, PSO
Ana Durazo, PSO

Scientific Party, Leg 1
Anne Bécel, Chief Scientist
Hugh Daigle, co-Chief Scientist

Jo C Grall, co-Chief Scientist
Nathan Miller, co-PI and Reveal wizard
Wayne Baldwin, MCS processing
David Foster, MCS and Chirp data processing
Bill Danforth, Multibeam bathymetry processing
James Gibson, postdoctoral research scientist
Ali Mohammed, PhD student
Mason Farnsworth, PhD student
Tanner Acquisto, PhD student
Louis Marin Bodiguel Dupuis, Master Student
Emma LeGall Master Student

Scientific Watch Schedule

MCS Leg 1

- **Shipboard Technical Staff**
  Midnight to Noon (12am-12pm)
  Koray Ergun (Navigation), Gilles Guérin (Acquisition) and Brian Agee (Sound Source/Handling)

  Noon to Midnight (12pm-12am)
  Cody Bahlau (Navigation), Riley Lopez (Acquisition) and Josh Kasinger (Sound Source/Handling)

- **Science Party**
  Anne Bécel (16:00-24:00)
  Hugh Daigle (8:00-16:00)
  Jo Gral (0:00-8:00)
  Nathan Miller (14:00-22:00)
  Wayne Baldwin (14:00-22:00)
  David Foster (06:00-14:00)
  Bill Danforth (06:00-14:00)
  James Gibson (12:00-19:00)
  Ali Mohamed (16:00-00:00)
  Mason Farnsworth (08:00-16:00)
  Tanner Acquisto (14:00-22:00)
  Louis Marin Dupuis Bodiguel (00:00-08:00)
  Emma LeGall (02:00-10:00)

MGL2306-LEG1

Hour	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jo																								
Hugh																								
Anne																								
Nathan																								
Dave																								
Bill																								
Wayne																								
James																								
Tanner																								
Emma																								
Louis-Marin																								
Ali																								
Mason																								

Scientific Party Contact Information – MGL2306

Anne Bécel
Lamont Doherty Earth Observatory, Columbia University
annebcl@ldeo.columbia.edu

Hugh Daigle
The University of Texas at Austin
daigle@austin.utexas.edu

C Jo Grall
University of La Rochelle and Lamont Doherty Earth Observatory, Columbia University
celine.grall@univ-lr.fr

Nathan Miller
USGS Woods Hole
ncmiller@usgs.gov

Wayne Baldwin
USGS Woods Hole
wbaldwin@usgs.gov

Dave Foster
USGS Woods Hole
bdanforth@usgs.gov

Bill Danforth
USGS Woods Hole
bdanforth@usgs.gov

James Gibson,
Lamont Doherty Earth Observatory, Columbia University

jgibson@ldeo.columbia.edu

Ali Mohamed
The University of Texas at Austin
ali.mohamed@austin.utexas.edu

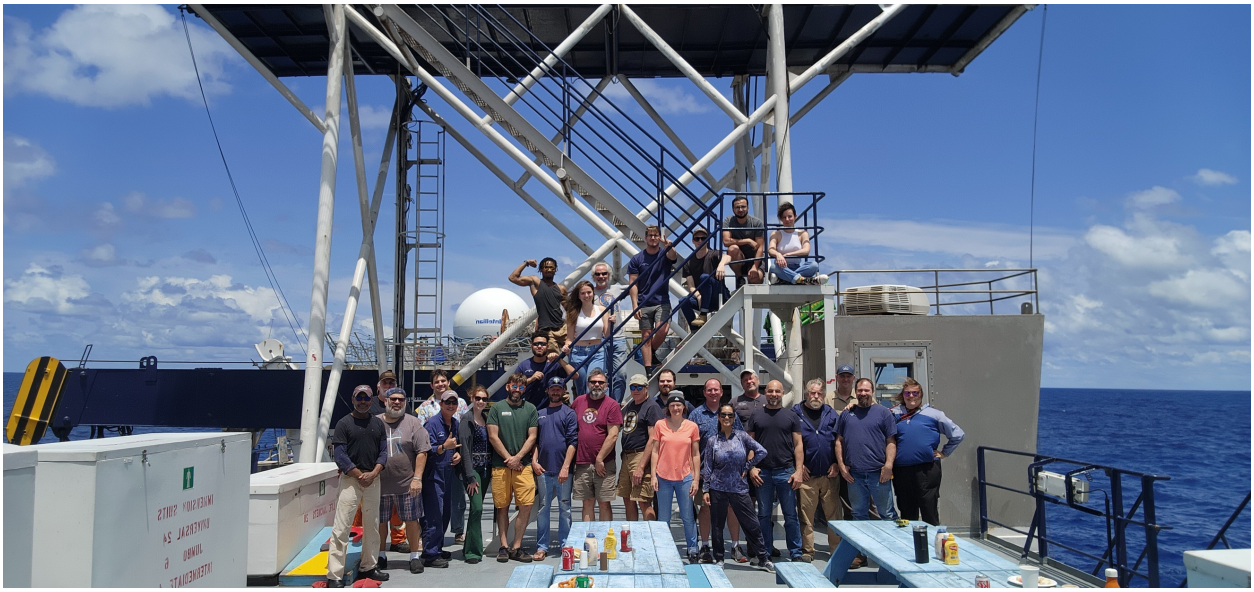
Tanner Acquisto
Lamont Doherty Earth Observatory, Columbia University
acquisto@ldeo.columbia.edu

Mason Farnsworth
The University of Texas at Austin
mason.farnsworth@utexas.edu

Louis Marin Bodiguel Dupuis
University of La Rochelle
lepokeultime@gmail.com

Emma LeGall
University of La Rochelle
emmalg1505@gmail.com

Group photo – Leg 1



Appendix A: Specifications on MCS equipment and acquisition parameters

Content of the Appendix ……. A1
A.1. MCS acquisition parameters …….…….. A2
A.2. Streamer and guns configurations (primary profiles)…….. A3-A14
A.3. Start/End dates and times of each MCS profile ……..... A15
A.5. Hydrophone calibration certificates …… A16-A30

A.1. MCS acquisition parameters

Sequence	line name	Shot spacing (m)	Number of active channels	sample rate	record length	source sub-array used	source depth	streamer depth	TB1	comment
001	MGL2306001P01	25	552	1	9.5	2 Arrays used	6	6		First Line of the Cruise
002	MGL2306002P02	25	552	1	9.5	2 Arrays used	6	6		
003	MGL2306003P03	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
004	MGL2306004P03a	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
005	MGL2306005P04	25	552	1	9.5	2 Arrays used	6	6		
006	MGL2306006P05	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
007	MGL2306007P06	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
008	MGL2306008P07	25	552	1	9.5	2 Arrays used	6	6		
009	MGL2306009P08	25	552	1	9.5	2 Arrays used	6	6		
010	MGL2306010P09	25	552	1	9.5	2 Arrays used	6	6		
011	MGL2306011P10	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
012	MGL2306012P11	25	552	1	9.5	2 Arrays used	6	6		
013	MGL2306013P12	25	552	1	9.5	2 Arrays used	6	6		
014	MGL2306014P13	25	552	1	9.5	2 Arrays used	6	10		
015	MGL2306015P14	25	552	1	9.5	2 Arrays used	6	10	No TB	Source repairs during line, only 1 array operational at times
016	MGL2306016P15	25	552	1	9.5	1 Array used	6	10	No TB	Source repairs during line, only 1 array operational at times
017	MGL2306017P16	25	552	1	9.5	1 Array used	6	10	No TB	Source repairs during line, only 1 array operational at times
018	MGL2306018P17	25	552	1	9.5	1 Array used	6	10	No TB	
019	MGL2306019P17a	25	552	1	9.5	1 Array used	6	10	No TB	Source repairs during line, only 1 array operational at times
020	MGL2306020P14R	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
021	MGL2306021P14S	8	552	1	9.5	2 Arrays used	6	6		Shot point spacing was changed to 8 meters
022	MGL2306022P17b	25	552	1	9.5	2 Arrays used	6	6		
023	MGL2306023P20	25	552	1	9.5	2 Arrays used	6	6		
024	MGL2306024P21	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
025	MGL2306025P22	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
026	MGL2306026P23	25	552	1	9.5	2 Arrays used	6	6		
027	MGL2306027P24	25	552	1	9.5	2 Arrays used	6	6		
028	MGL2306028P25	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
029	MGL2306029P26	25	552	1	9.5	2 Arrays used	6	6		
030	MGL2306030P27	25	552	1	9.5	2 Arrays used	6	6		
031	MGL2306031P28	25	552	1	9.5	2 Arrays used	6	6		
032	MGL2306032P29	25	552	1	9.5	2 Arrays used	6	6		
033	MGL2306033P30	25	552	1	9.5	2 Arrays used	6	6		
034	MGL2306034P31	25	552	1	9.5	2 Arrays used	6	6		
035	MGL2306035P32	25	552	1	9.5	2 Arrays used	6	6		
036	MGL2306036P33	25	552	1	9.5	2 Arrays used	6	6		
037	MGL2306037P34	25	552	1	9.5	2 Arrays used	6	6		
038	MGL2306038P35	25	552	1	9.5	2 Arrays used	6	6		
039	MGL2306039P36	25	552	1	9.5	2 Arrays used	6	6		
040	MGL2306040P37	25	552	1	9.5	2 Arrays used	6	6		
041	MGL2306041P20a	50	552	1	9.5	2 Arrays used	6	6		
042	MGL2306042P19	50	552	1	9.5	2 Arrays used	6	6		
043	MGL2306043P14b	50	552	1	9.5	2 Arrays used	6	6-8-10-9		
044	MGL2306044P37a	25	552	1	9.5	2 Arrays used	6	8		
045	MGL2306045P20b	25	552	1	9.5	2 Arrays used	6	8 (bad)		
046	MGL2306046P18	25	552	1	9.5	2 Arrays used	6	15		
047	MGL2306047P39	25	552	1	9.5	2 Arrays used	6	10		Source repairs during line, only 1 array operational at times
048	MGL2306048P40	25	552	1	9.5	2 Arrays used	6	10 and 6		Source repairs during line, only 1 array operational at times
049	MGL2306049P41	25	552	1	9.5	2 Arrays used	6	6		
050	MGL2306050P42	25	552	1	9.5	2 Arrays used	6	6		
051	MGL2306051P43	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
052	MGL2306052P44	25	552	1	9.5	2 Arrays used	6	6		
053	MGL2306053P45	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
054	MGL2306054P46	25	552	1	9.5	2 Arrays used	6	6		Source repairs during line, only 1 array operational at times
055	MGL2306055P47	25	552	1	9.5	2 Arrays used	6	6		
056	MGL2306056P48	25	552	1	9.5	2 Arrays used	6	6		
057	MGL2306057P49	25	552	1	9.5	2 Arrays used	6	6		
058	MGL2306058P50	25	552	1	9.5	2 Arrays used	6	6		
059	MGL2306059P51	25	552	1	9.5	2 Arrays used	6	6		

Company: L-DEO - Lamont - Doherty Earth Observatory
Vessel: Marcus G. Langseth
Client: LDEO, UT Austin, USGS

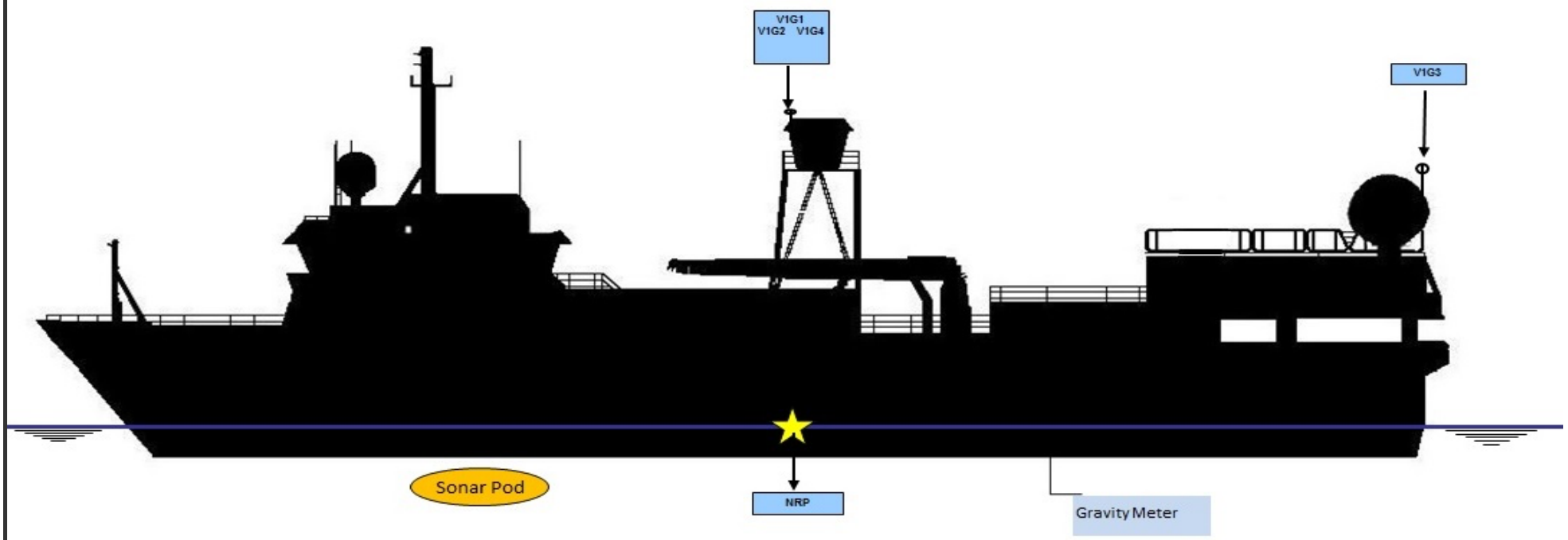
Project: MGL2306
Area: Cape Fear
Scope: Modern & Past Mass Transport Deposits
Start Date: 9-May-23

Vessel Sensor Offsets
Towing Offsets
Towing Configuration

Gun Array Offsets
Streamer Front End
Streamer Tail End
Streamer Complete
Hydrophone Offsets
Tailbuoy Offsets
Timing



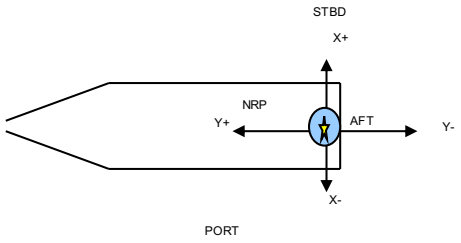
R/V Marcus G. Langseth - Vessel Sensor Offsets



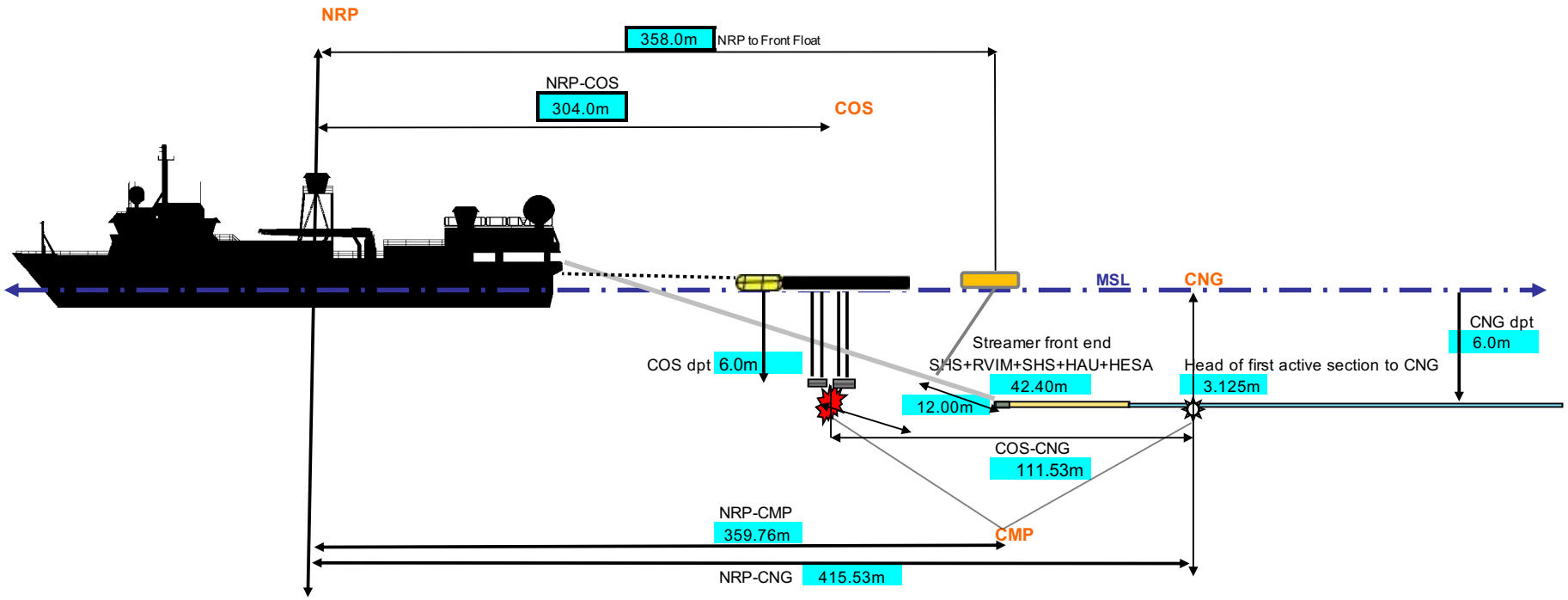
Negative values are above water line

All measurements in meters

			STBD/PORT (X)	FORE/AFT (Y)	UP/DOWN (Z)
NRP	NAVIGATION REFERENCE POINT		0.00	0.00	0.00
V1G1	SeaPath 330	Orca	0.00	0.00	-16.90
V1G2	C-Nav3050 MMO Tower	Orca	0.00	0.00	-16.90
V1G3	C-Nav3050 Stern	Orca	-1.95	-31.83	-14.50
V1G4	Pos MV	Orca	2.39	12.75	-16.90
	PosMV Output position is IMU mounted in stbd drylab				
V1R1	PosNet		-1.30	-0.02	-16.90
Sonar Pod	EM122 Knudsen ADCP		0.00	20.20	7.49
	EM122 Center Beam offset (in Spectra)		0.00	13.4	7.49
MRU	Seapath MRU		2.39	12.75	-4.30
BGM	Bell Gravity Meter		0.00	-13.10	1.10



R/V Marcus G. Langseth - Towing Offsets



NRP	Nav Reference Point
COS	Centre of Source
CNG	Centre of Near Group Trace # 1 Of S1
CMP	Common Mid-Point
MSL	Mean Sea Level
NRP-Stern	29.2m
NRP-COS	304.0m

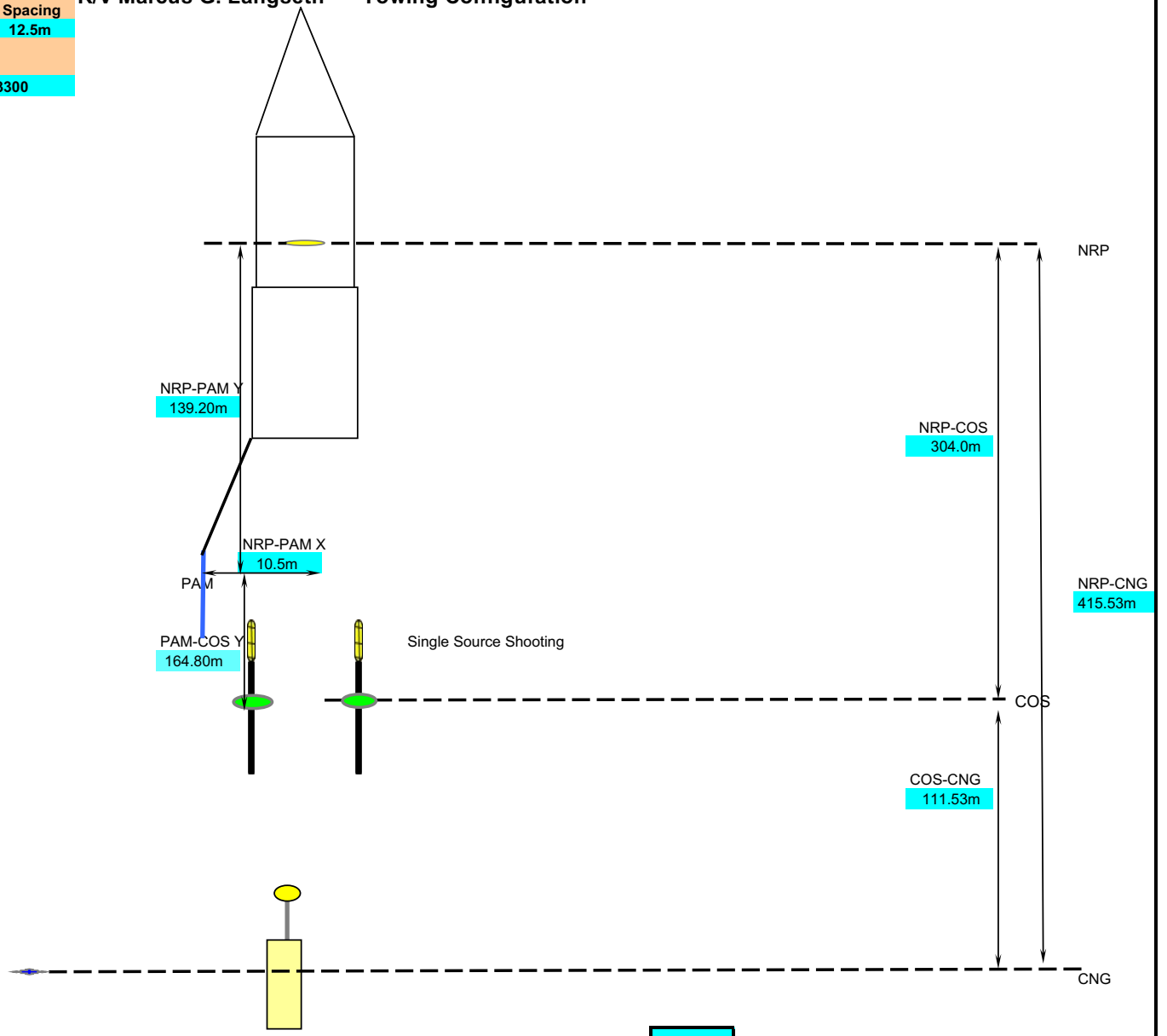
All measurements in meters

Cell contents referenced from Config_offsets tab

R/V Marcus G. Langseth - Towing Configuration

	# Streamers	Length	Channels	Spacing
SEAL	1	6000	552	12.5m

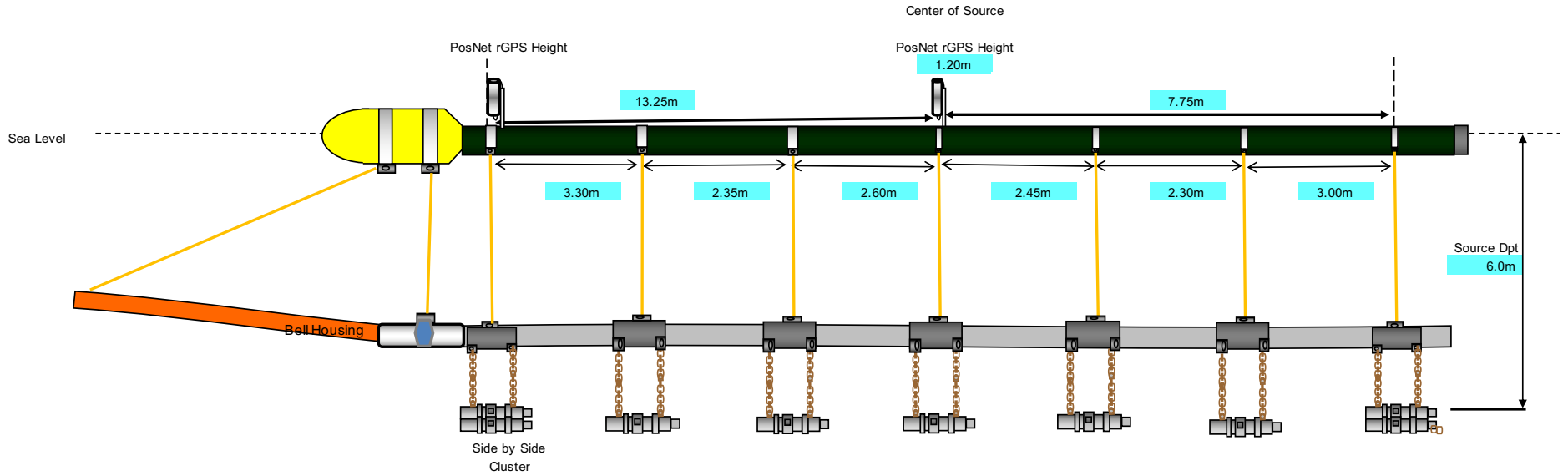
# Gun Strings Used	2	Vol (in^3)	3300



NOT to Scale

Cell contents referenced from Config_offsets tab

R/V Marcus G. Langseth - Gun Array Offsets



Gun volumes by number		
Gun	Volume	Status
Gun 1	360 cu. in.	Primary
Gun 2	360 cu. in.	Primary
Gun 3	40 cu. in.	Primary & Mitigation
Gun 4	180 cu. in.	Primary
Gun 5	90 cu. in.	Primary
Gun 6	120 cu. in.	Primary
Gun 7	60 cu. in.	Primary
Gun 8	220 cu. in.	Primary
Gun 9	220 cu. in.	Primary

Array total volume (without spares) is 3300 cu. in.

Total volume/string (without spare) 1650 cu. in.

Guns (1 & 2) & (8 & 9) in a horizontal cluster.

Gun clusters have 0.75m between guns and hang 0.95m from center of hanger

Horizontal Clusters are 1m from gun port to gun port

Single guns hang from hanger 1.15m

All gun volumes, numbering, locations, and offsets were inspected and verified by Chief Source Mechanic.

All measurements in meters

NOTE: drawing not to scale

Cell contents referenced from Config_offsets tab

R/V Marcus G. Langseth - Gun Configuration

Center of Source

Gun Clusters

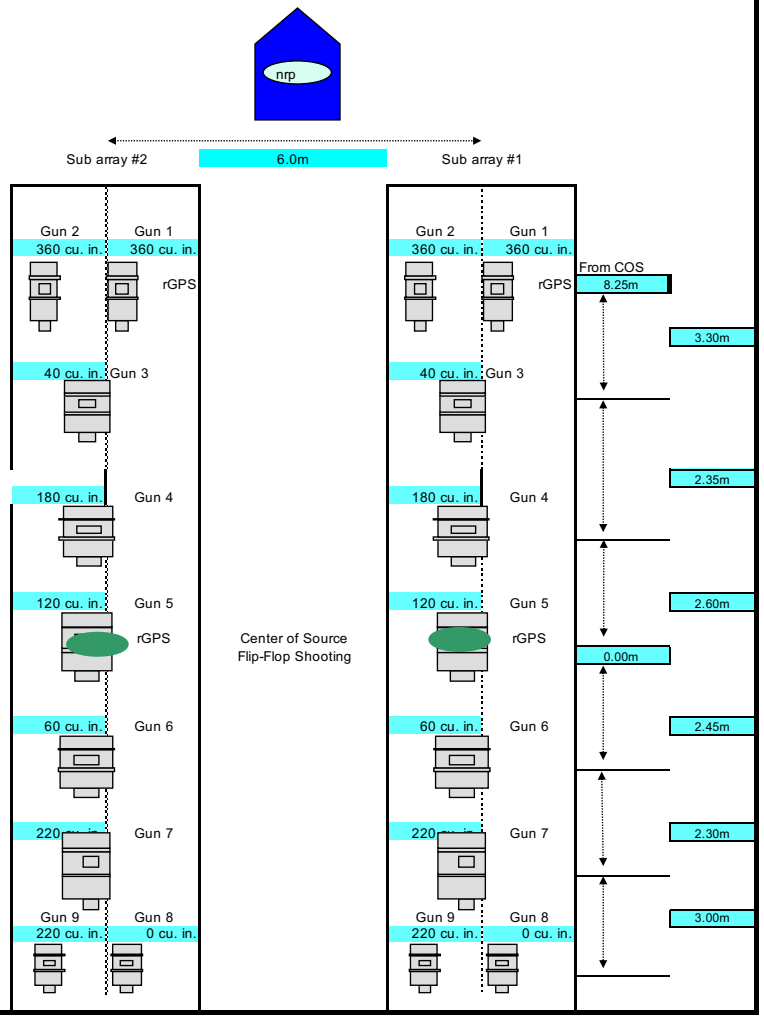
Guns 1 & 2 horizontal array

Guns 8 & 9 horizontal array

Gun Offsets relative to Center of String

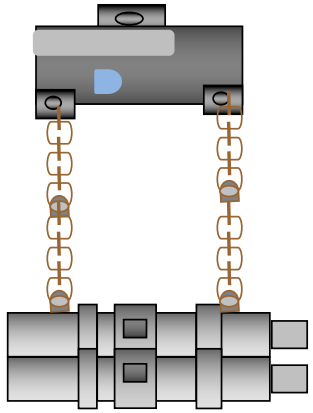
	X	Y
Gun 1	0.50m	8.23m
Gun 2	-0.50m	8.23m
Gun 3	0.00m	5.00m
Gun 4	0.00m	2.60m
Gun 5	0.00m	-2.46m
Gun 6	0.00m	-4.77m
Gun 7	0.50m	-7.77m
Gun 8	-0.50m	-7.77m
Gun 9	0.50m	8.23m

All measurements in meters

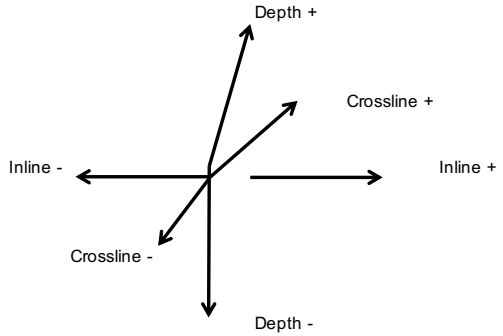


Distances in Meters

Gun Plate



Center of ports between guns 1 and 2 is the reference point



Hydrophone Offsets

Gun String 1				
Plate	Phone	Inline	Crossline	Depth
1	1	0.00	0.00	0.98
2	2	3.35	0.00	0.95
3	3	5.53	0.00	0.91
4	4	8.35	0.00	0.94
5	5	10.68	0.00	0.95
6	6	13.23	0.00	0.90
7	7	16.26	0.00	0.93

Gun String 2				
Plate	Phone	Inline	Crossline	Depth
1	1	0.00	0.00	0.94
2	2	3.25	0.00	0.93
3	3	5.63	0.00	0.96
4	4	8.37	0.00	0.96
5	5	10.71	0.00	0.92
6		13.21	0.00	0.92
7	7	16.14	0.00	0.97

Depth Transducer Offsets

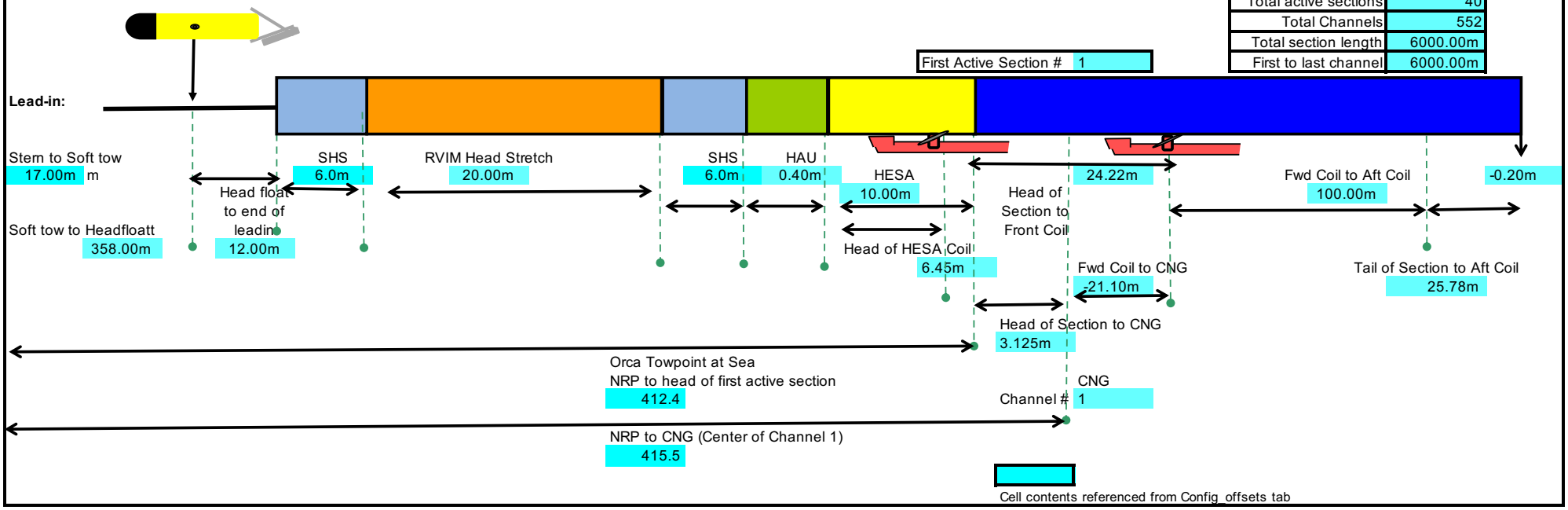
Gun String 1				
Plate	DT	Inline	Crossline	Depth
1	1	0.00	N/A	1.20
2		N/A	N/A	N/A
3	2	5.68	N/A	1.08
4		N/A	N/A	N/A
5		N/A	N/A	N/A
6		N/A	N/A	N/A
7	3	16.28	N/A	1.23

Gun String 2				
Plate	DT	Inline	Crossline	Depth
1	1	0.00	N/A	1.23
2		N/A	N/A	N/A
3		N/A	N/A	N/A
4	2	8.00	N/A	1.07
5		N/A	N/A	N/A
6		N/A	N/A	N/A
7	3	16.08	N/A	1.30

R/V Marcus G. Langseth - Streamer Front End

Total active sections	40
Total Channels	552
Total section length	6000.00m
First to last channel	6000.00m

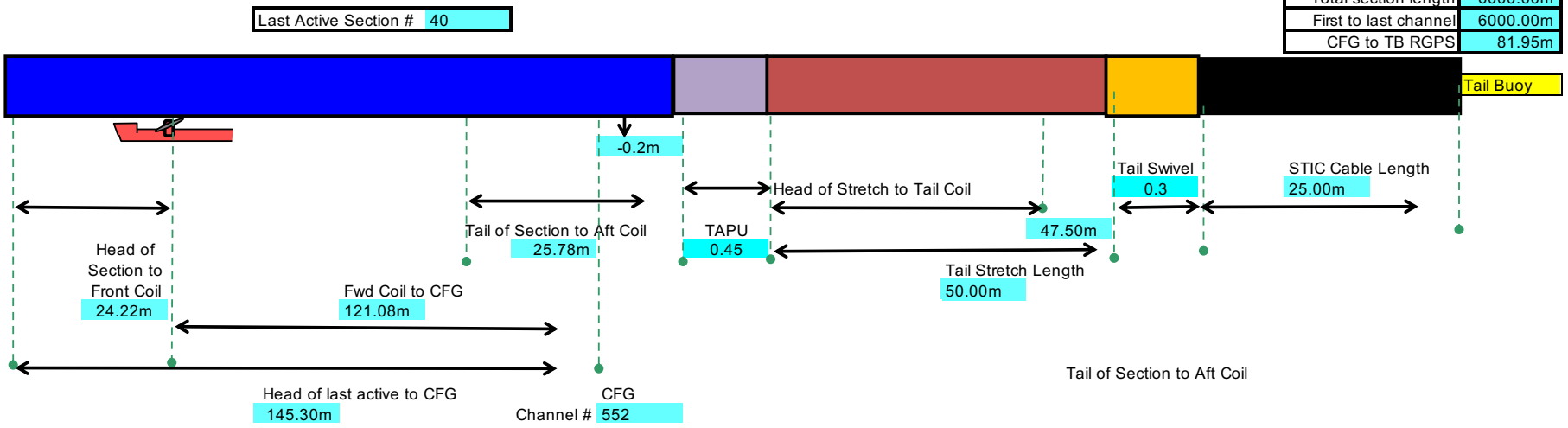
First Active Section # 1



Cell contents referenced from Config_offsets tab

R/V Marcus G. Langseth - Streamer Tail End

Total active sections	40
Total Channels	552
Total section length	6000.00m
First to last channel	6000.00m
CFG to TB RGPS	81.95m

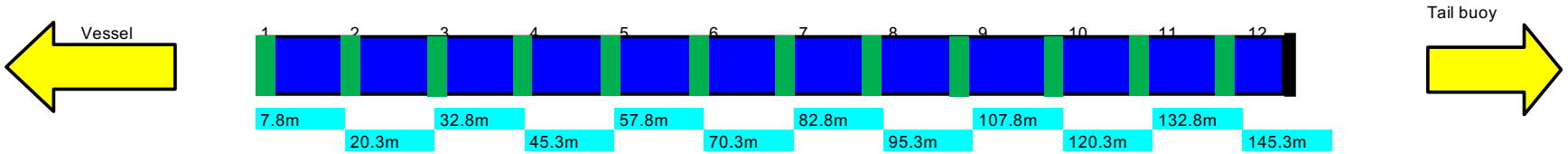


Cell contents referenced from Config_offsets tab

R/V Marcus G. Langseth - Hydrophone Offsets

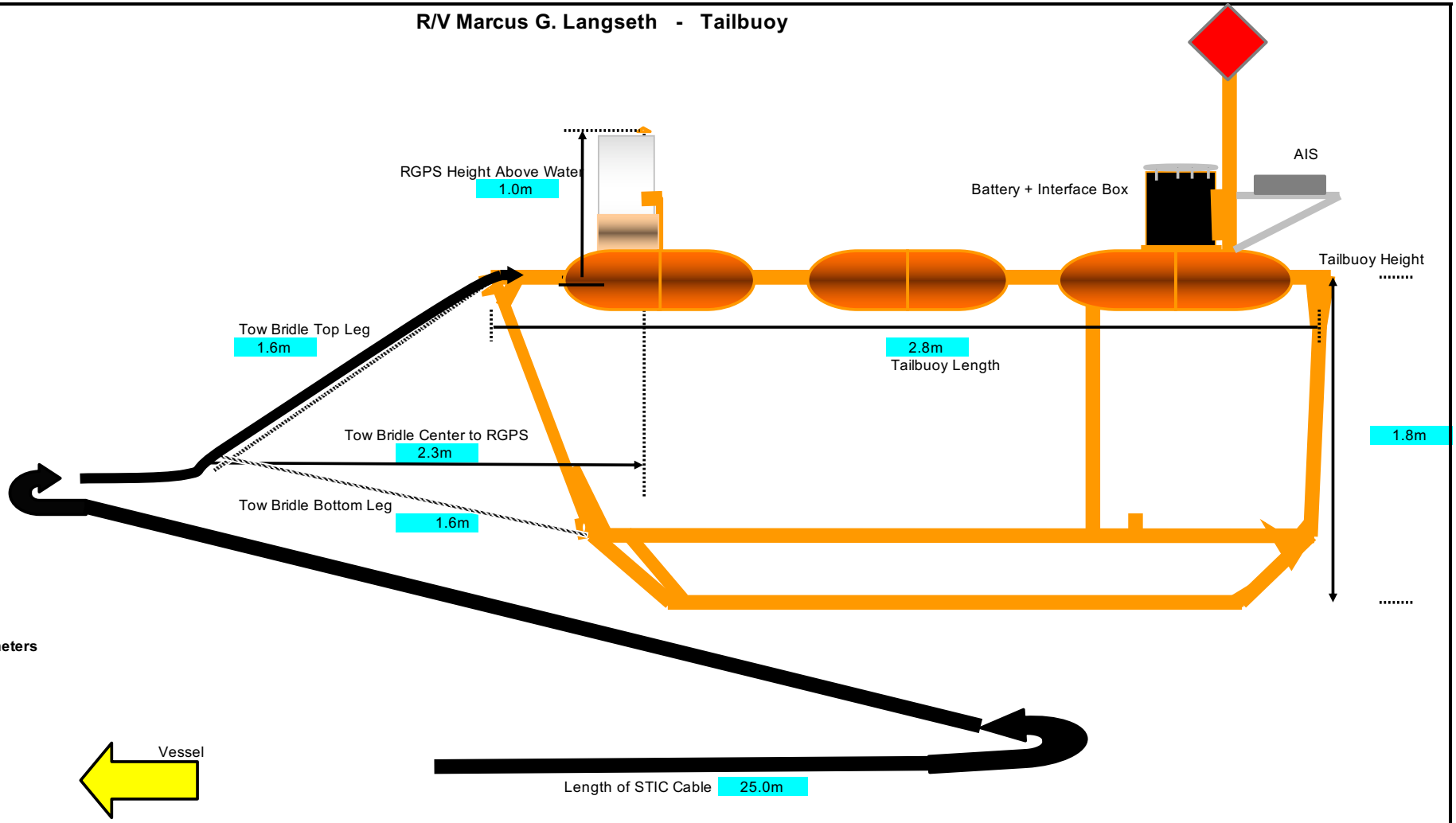
Sercel 150meter SSAS

Number of SSAS Sections	40
Channels per active section	12
Total channels	552



Cell contents referenced from Config_offsets tab

R/V Marcus G. Langseth - Tailbuoy



Cell contents referenced from Config_offsets tab

Job Specific	
NRP to COS Y	304
NRP to COS X	0
Source Depth	6
Streamer Depth	6
# streamer sections	40
# channels	552
CNG Channel #	1
CFG Channel #	552
#MCS Streamers	1
lead-in: stern to head float	358
MCS Streamer Sep.	0
Gun volume total	3300
Volume per string	1650
# of guns used	18
# Gun Strings	2
gun string separation	6
PAM Y from stern	110
PAM X - (outside of stern rail) PORT	3
Stern to MAG Y	110
Stern to MAG X - (outside of stern rail) STBD	3

Fixed Positions Streamer	
NRP to Stern	29.2
tow point at sea to end of lead-in	12
STU/module length	0.4
Coil to coil	100
head of section to coil	24.223
tail of section to coil	25.777
channel spacing	12.5
NRP to Port/STBD Rail	7.5
Head to First RX	3.125
Head to Last RX	145.3
Channels per section	12
Center of section to Acx transducer	-0.2
First Section Number	1
HAU/HAPU Length	0.4
SHS Length	6
RVIM length	20
HESA Length	10
Active Section Length (SSAS)	150
TES tail stretch length	50
STIC	25
TES Fwd Coil	2.5
TES Aft Coil	47.5
HESA Aft Coil	6.45

Tailbuoy offsets	
RGPS height above water	1
TB length	2.8
TB height	1.83
RGPS-ACX	0
Bridle-RGPS	2.25
Top Leg	1.55
Bottom Leg	1.6
STIC	25
ACX below water line	0

Derived Offsets (formula)	
NRP to CMP	359.7625
COS-CNG	111.525
CNG-CFG	-6887.5
NRP-Mag Y	139.2
NRP-Mag X	10.5
NRP to tail buoy RGPS	6560.141
Total Length of Streamer sections	6000
PAM-COS Y	164.8
PAM-COS X	10.5
NRP-PAM Y	139.2
NRP-PAM X	10.5
NRP-CNG	415.525
Soft to length, stern to bridle	17
Max RVIM 17.5m-25m	20
LAUM 0.3386 x 14 modules	4.7404
SSCU 0.474 x (2 modules)	0.948
TAPU 0.4526	0.4526

Derived Offsets (formula)	
Towing Offsets Tab	
NRP-COS	304
NRP-CNG	415.525
NRP-CMP	359.7625
COS-ONG	111.525
CNG Channel #	1
NRP-Stern	29.2
Distance from Head of first section to CNG	3.125
Source Depth	6
Streamer Depth	6
Front End Length	42.4
Head of first section to headfloat	12

Derived Offsets (formula)	
Towing Configuration TAB	
NRP-COS	304
NRP-CNG	415.525
COS-ONG	111.525
NRP-Pcable CNG	0
COS-Pcable CNG	4.7404
P-Cable Streamer Sep	0
NRP-PAM Y	139.2
NRP-PAM X	10.5
PAM-COS Y	164.8
PAM-COS X	10.5
# Gun Strings	2
gun volume	3300
Gun separation	6
# 2D Streamers	1
2D Streamer Ch Spacing	12.5
Number 2D Channels	552
2D Streamer Length	6000
2D Streamer Sep	0
NRP-MAG X	10.5
NRP-MAG Y	139.2

Derived Offsets	
Acoustic Overhead TAB	
G1T1	0
G2T1	0
G3T1	0
G4T1	0
S1T1	0
S1T2	0
S1T3	0
S1T4	0
S1T5	0
S1T6	0
S1T7	0
S2T1	0
S2T2	0
S2T3	0
S2T4	0
S2T5	0
S2T6	0
S2T7	0
S3T1	0
S3T2	0
S3T3	0
S3T4	0
S3T5	0
S3T6	0
S3T7	0
S4T1	0
S4T2	0
S4T3	0
S4T4	0
S4T5	0
S4T6	0
S4T7	0
Front to TB	6075
S1T1-S1T2	0
S1T3-S1T4	0
S1T4-S1T5	100.777

Derived Offsets (formula)	
Gun array offsets	
Bracket distance 1-2	5
Bracket distance 2-3	3.3
Bracket distance 3-4	2.35
Bracket distance 4-5	2.6
Bracket distance 5-6	2.45
Bracket distance 6-7	2.3
Bracket distance 7-8	3
SourceGPS-COS Y	0
COS - Acoustic Y	0
rGPS height above water	1.2
G1 Volume	360
G2 Volume	360
G3 Volume	40
G4 Volume	180
G5 Volume	90
G6 Volume	120
G7 Volume	60
G8 Volume	220
G9 Volume	220
G10 Volume	0
G-Depth 1	0.95
G-Depth 2	0.95
G-Depth 3	1.15
G-Depth 4	0.95
G-Depth 5	0.75
G-Depth 6	1.15
G-Depth 7	1.15
G-Depth 8	1.15
G-Depth 9	0.95
G-Depth 10	0
G10 to Acx Z	0
G10 to Acx X	0
Surface to Acx	6
Fwd bracket to COS	13.25
Aft bracket to COS	7.75

Derived Offsets	
Streamer Front End	
Stern-towpoint at sea	358
towpoint at sea to end of lead-in	12
SHS Length	6
rvim length	20
HAU/STU length	0.4
HESA Lgth	10
Fwd Coil to Aft Coil	100
Head to First RX	3.125
Fwd Coil to CNG	-21.098
Head to Fwd Coil	24.223
Tail to Aft Coil	25.777
CNG Channel #	1
Center of streamer to Acx transducer	-0.2
First Section #	1
# channels	552
section length	6000
# sections	40
channel spacing	12.5
First to last	6000
HESA Head to aft coil	6.45

Derived Offsets	
Streamer Tail End	
Head to Fwd Coil	24.223
Tail to Aft Coil	25.777
Head to CFG	145.3
Coil to Coil	100
TAPU Lngth	0.45
Tail Stretch Length	50
Tealvel Lngth	0.3
STIC Length	25
Last active	40
# channels	552
# sections	40
total section length	6000
First to last	6000
Stretch Coil	
Center of streamer to Acx transducer	-0.2
channel spacing	12.5
CFG #	552
Fwd coil to CFG	121.077
CFG to TIBRGPS	81.95
Stretch head to fwd coil	2.5
Stretch head to aft coil	47.5

Derived Offsets	
Streamer complete	
#Sections	40
# Channels	552
First to last	6000
Total section length	6000

Derived Offsets	
Hydrophone Offsets	
Channel 1	7.825
2	20.325
3	32.825
4	45.325
5	57.825
6	70.325
7	82.825
8	95.325
9	107.825
10	120.325
11	132.825
12	145.325
# channels	12
# Active's	40
Total Channels	552

Derived Offsets	
Tailbuoy offsets	
RGPS height above water	1
TB length	2.8
TB height	1.83
RGPS-ACX	0
Bridle-RGPS	2.25
Top Leg	1.55
Bottom Leg	1.6
STIC	25
ACX below water line	0

Guns						
Source GPS Aft - COS Y	0				G1 X	0.5
Source GPS Fwd - COS Y	5				G1 Y	8.23
Bracket distance 2-3	3.3				G2 X	-0.5
Bracket distance 3-4	2.35				G2 Y	8.23
Bracket distance 4-5	2.6				G3 X	0
Bracket distance 5-6	2.45				G3 Y	5
Bracket distance 6-7	2.3				G4 X	0
Bracket distance 7-8	3				G4 Y	2.6
COS - Acoustic Y	0				G5 X	0
rGPS height above water line	1.2				G5 Y	0
G1 Volume	360		G-Depth 1	0.95	G6 X	0
G2 Volume	360		G-Depth 2	0.95	G6 Y	-2.46
G3 Volume	40		G-Depth 3	1.15	G7 X	0
G4 Volume	180		G-Depth 4	0.95	G7 Y	-4.77
G5 Volume	90		G-Depth 5	0.75	G8 X	0.5
G6 Volume	120		G-Depth 6	1.15	G8 Y	-7.77
G7 Volume	60		G-Depth 7	1.15	G9 X	-0.5
G8 Volume	220		G-Depth 8	1.15	G9 Y	-7.77
G9 Volume	220		G-Depth 9	0.95	G10 X	0.5
					G10 Y	8.23
					G11 X	-0.5
					G11 Y	8.23
					G12 X	0
					G12 Y	5
					G13 X	0
					G13 Y	2.6
					G14 X	0
					G14 Y	0
					G15 X	0
					G15 Y	-2.46
					G16 X	0
					G16 Y	-4.77
					G17 X	0.5
					G17 Y	-7.77
					G18 X	-0.5
					G18 Y	-7.77

Acoustics referenced to CNG or COS	
G1T1	0
G2T1	0
G3T1	0
G4T1	0
S1T1	0
S1T2	0
S1T3	0
S1T4	0
S1T5	0
S1T6	0
S1T7	0
S2T1	0
S2T2	0
S2T3	0
S2T4	0
S2T5	0
S2T6	0
S2T7	0
S3T1	0
S3T2	0
S3T3	0
S3T4	0
S3T5	0
S3T6	0
S3T7	0
S4T1	0
S4T2	0
S4T3	0
S4T4	0
S4T5	0
S4T6	0
S4T7	0

Log sheet Completed By: Cbahlau
Log sheet Completion date: 2023-06-02

Ignore columns that are not applicable to your program
** If preferred, use decimal degrees with five or six decimal places*
** (NS (+/-) (E/W) (+/-)*

Line #	Seq #	Start of line: Date	Start of line: Time (UTC)	Start of line: Latitude* whole degrees	Start of line: Latitude* decimal minutes	Start of line: Longitude* whole degrees	Start of line: Longitude* decimal minutes	End of line: Date	End of line: Time (UTC)	End of line: Latitude* whole degrees	End of line: Latitude* decimal minutes	End of line: Longitude* whole degrees	End of line: Longitude* decimal minutes	Start: file#	Start: shot#	End: file#	End: shot#	3590 tape #s	Sample Rate ms	Sample Length seconds	# Channels
MGL2306001P01	001	2023-05-11	9:59	34	59.13833	-74	13.75817	2023-05-12	7:17	33	31.68483	-75	10.19150	1	107	7334	7440		1	9.5	552
MGL2306002P02	002	2023-05-12	7:26	33	31.08600	-75	09.79933	2023-05-12	21:24	32	52.02833	-74	02.96133	7335	8057	12396	13118		1	9.5	552
MGL2306003P03	003	2023-05-12	21:37	32	51.00567	-74	03.04600	2023-05-13	17:52	31	41.03383	-74	52.04017	12397	14074	18416	20093		1	9.5	552
MGL2306004P03a	004	2023-05-13	21:12	31	47.66450	-74	49.17850	2023-05-14	4:02	31	25.06483	-75	03.89667	18417	20579	20329	22491		1	9.5	552
MGL2306005P04	005	2023-05-14	4:08	31	25.11583	-75	04.35150	2023-05-14	7:35	31	35.53100	-75	17.65350	20330	23066	23066	24207		1	9.5	552
MGL2306006P05	006	2023-05-14	7:46	31	36.42133	-75	17.30517	2023-05-15	3:03	32	55.42400	-74	23.36467	21472	25087	28224	31839		1	9.5	552
MGL2306007P06	007	2023-05-15	3:18	32	56.04150	-74	23.60783	2023-05-15	7:33	33	03.45917	-74	36.79117	28225	32042	29213	33030		1	9.5	552
MGL2306008P07	008	2023-05-15	7:44	33	03.17317	-74	37.57750	2023-05-16	5:02	31	44.60350	-75	33.58033	29214	33560	36002	40348		1	9.5	552
MGL2306009P08	009	2023-05-16	6:43	31	43.51967	-75	29.89883	2023-05-16	12:35	32	03.31283	-75	44.68600	36003	41863	37595	43455		1	9.5	552
MGL2306010P09	010	2023-05-16	12:50	32	04.12750	-75	44.32383	2023-05-17	6:05	33	13.50583	-74	54.15433	37596	44067	43528	50080		1	9.5	552
MGL2306011P10	011	2023-05-17	6:19	33	14.37233	-74	54.60267	2023-05-17	11:03	33	25.16783	-75	34.04483	43529	50563	44976	52010		1	9.5	552
MGL2306012P11	012	2023-05-17	11:13	33	25.03583	-75	14.72667	2023-05-18	4:48	32	19.16033	-76	01.38633	44977	52538	50651	58212		1	9.5	552
MGL2306013P12	013	2023-05-18	4:58	32	19.20933	-76	02.16600	2023-05-18	7:40	32	28.85283	-76	11.71283	50652	58577	51538	59508		1	9.5	552
MGL2306014P13	014	2023-05-18	7:52	32	29.72933	-76	11.38950	2023-05-19	0:55	33	41.56050	-75	29.43467	51584	60076	57502	65994		1	9.5	552
MGL2306015P14	015	2023-05-19	1:03	33	42.07400	-75	29.88167	2023-05-19	6:54	33	57.76517	-75	56.36467	57503	67076	59507	69070		1	9.5	552
MGL2306016P15	016	2023-05-19	7:09	33	59.24300	-75	55.86667	2023-05-19	9:43	34	13.61050	-75	48.07000	59508	69632	60673	70797		1	9.5	552
MGL2306017P16	017	2023-05-19	9:57	34	13.45783	-75	46.79883	2023-05-19	11:17	34	10.81283	-75	42.18450	60674	71105	61019	71450		1	9.5	552
MGL2306018P17	018	2023-05-19			00.00000		00.00000	2023-05-19			00.00000		00.00000						1	9.5	552
MGL2306019P17a	019	2023-05-19	11:38	34	10.12000	-75	42.04950	2023-05-19	19:52	33	53.52033	-75	50.20517	61024	72044	62350	73370		1	9.5	552
MGL2306020P14R	020	2023-05-20	12:54	33	41.63150	-75	28.94967	2023-05-21	0:53	33	58.86667	-75	59.01867	62351	74000	64601	76250		1	9.5	552
MGL2306021P14S	021	2023-05-21	1:01	33	58.93750	-75	59.11567	2023-05-21	2:05	33	59.77133	-76	00.13700	64610	78567	64873	78830		1	9.5	552
MGL2306022P17b	022	2023-05-21	7:00	33	56.51983	-75	48.75867	2023-05-21	22:17	33	29.73050	-76	01.51733	64874	80130	67007	82263		1	9.5	552
MGL2306023P20	023	2023-05-21	22:24	33	29.39600	-76	01.28200	2023-05-22	0:01	33	26.40783	-76	53.37333	67008	83041	67543	83576		1	9.5	552
MGL2306024P21	024	2023-05-22	0:05	33	26.10267	-75	53.28633	2023-05-22	1:56	33	21.58067	-75	55.95883	67544	84045	67916	84417		1	9.5	552
MGL2306025P22	025	2023-05-22	2:05	33	21.55850	-75	56.55517	2023-05-22	6:47	33	27.02400	-76	18.19067	67917	85064	69318	86465		1	9.5	552
MGL2306026P23	026	2023-05-22	6:55	33	26.87867	-76	18.48067	2023-05-22	8:07	33	24.66783	-76	19.45400	69319	87029	69493	87203		1	9.5	552
MGL2306027P24	027	2023-05-22	8:21	33	24.26150	-76	19.22467	2023-05-22	12:49	33	18.06700	-76	00.05150	69494	87537	70768	88811		1	9.5	552
MGL2306028P25	028	2023-05-22	13:09	33	17.31267	-75	59.87483	2023-05-22	14:57	33	13.55400	-76	02.41550	70769	89065	71087	89383		1	9.5	552
MGL2306029P26	029	2023-05-22	15:13	33	13.65133	-76	03.59183	2023-05-22	19:34	33	18.81367	-76	21.96250	71088	90095	72291	91246		1	9.5	552
MGL2306030P27	030	2023-05-22	19:42	33	18.62050	-76	22.41383	2023-05-22	21:17	33	13.97117	-76	24.53500	72292	92030	72660	92398		1	9.5	552
MGL2306031P28	031	2023-05-22	21:25	33	13.57217	-76	24.27533	2023-05-23	1:09	33	07.05750	-76	05.39633	72661	93040	73929	94308		1	9.5	552
MGL2306032P29	032	2023-05-23	1:16	33	06.63167	-76	05.28450	2023-05-23	2:24	33	03.38500	-76	07.18750	73930	95048	74197	95256		1	9.5	552
MGL2306033P30	033	2023-05-23	2:33	33	03.28117	-76	07.73333	2023-05-23	7:07	33	08.53400	-76	27.00283	74198	96045	75458	97305		1	9.5	552
MGL2306034P31	034	2023-05-23	7:29	33	07.75367	-76	27.85500	2023-05-23	8:26	33	04.80283	-76	28.70267	75459	97587	75682	97810		1	9.5	552
MGL2306035P32	035	2023-05-23	8:34	33	04.49167	-76	28.26950	2023-05-23	12:08	33	57.60100	-76	10.03583	75683	98059	76923	99299		1	9.5	552
MGL2306036P33	036	2023-05-23	12:16	32	57.09883	-76	09.92600	2023-05-23	13:43	32	53.05983	-76	12.45933	76924	99551	77261	99888		1	9.5	552
MGL2306037P34	037	2023-05-23	13:52	32	52.99950	-76	13.19500	2023-05-23	17:53	32	59.62717	-76	31.39767	77262	100060	78498	101296		1	9.5	552
MGL2306038P35	038	2023-05-23	18:00	32	59.55800	-76	31.77167	2023-05-23	19:31	32	56.99383	-76	34.75583	78501	102018	78759	102278		1	9.5	552
MGL2306039P36	039	2023-05-23	19:40	32	56.57567	-76	34.59467	2023-05-23	20:57	32	53.96933	-76	28.65850	78760	103095	79177	103512		1	9.5	552
MGL2306040P37	040	2023-05-23	21:04	32	54.33000	-76	27.98717	2023-05-24	6:00	33	37.16117	-76	07.24100	79178	104066	82597	107485		1	9.5	552
MGL2306041P20a	041	2023-05-24	6:09	33	37.83283	-76	07.59467	2023-05-24	7:19	33	43.84033	-76	10.32517	82598	108012	82749	108163		1	9.5	552
MGL2306042P19	042	2023-05-24	7:34	33	45.50283	-76	09.73700	2023-05-24	10:12	34	00.65067	-76	02.06350	82750	109484	83358	110092		1	9.5	552
MGL2306043P14b	043	2023-05-24	10:23	34	01.44150	-76	00.95967	2023-05-24	11:45	33	57.34550	-75	56.97117	83359	110505	83546	110692		1	9.5	552
MGL2306044P37a	044	2023-05-24	11:55	33	56.76883	-75	57.10950	2023-05-24	20:10	33	31.59700	-76	08.75300	83547	111042	85542	113037		1	9.5	552
MGL2306045P20b	045	2023-05-24	20:18	33	31.19367	-76	08.29000	2023-05-24	22:35	33	27.66250	-75	55.18100	85543	114068	86396	114921		1	9.5	552
MGL2306046P18	046	2023-05-24	23:37	33	32.84600	-75	52.45417	2023-05-25	0:59	33	35.00933	-75	58.92683	86397	116001	86827	116431		1	9.5	552
MGL2306047P39	047	2023-05-25	1:15	33	34.22200	-75	59.62733	2023-05-25	14:31	32	49.76167	-76	21.23333	86828	118599	90379	122150		1	9.5	552
MGL2306048P40	048	2023-05-25	14:51	32	49.20750	-76	20.60033	2023-05-26	16:10	31	38.82367	-74	13.18200	90380	123079	99929	132628		1	9.5	552
MGL2306049P41	049	2023-05-27	2:43	31	37.59150	-74	34.98917	2023-05-27	13:53	31	40.42300	-73	33.44850	99930	133613	103827	137510		1	9.5	552
MGL2306050P42	050	2023-05-27	16:14	31	38.56733	-73	34.41283	2023-05-29	6:44	33	03.25917	-76	06.49800	103828	138761	115242	150175		1	9.5	552
MGL2306051P43	051	2023-05-29	6:53	33	04.03200	-76	06.36483	2023-05-29	13:51	33	35.43683	-75	50.21533	115243	151077	117772	153606		1	9.5	552
MGL2306052P44	052	2023-05-29	14:05	33	35.39650	-75	48.94500	2023-05-30	14:52	32	30.80267	-73	56.67350	117773	154094	126240	162560		1	9.5	552
MGL2306053P45	053	2023-05-30	15:01	32	30.14217	-73	56.73233	2023-05-30	19:50	32	17.10167	-74	06.44450	126241	163060	127381	164200		1	9.5	552
MGL2306054P46	054	2023-05-30	19:22	32	17.07683	-74	06.84583	2021-05-31	23:21	33	18.46150	-75	58.71733	127382	165042	135701	173370		1	9.5	552
MGL2306055P47	055	2023-05-31	23:30	33	19.13267	-75	58.77817	2021-06-01	13:25	34	21.83467	-75	25.05167	135702	175061	140791	180150		1	9.5	552
MGL2306056P48	056	2023-06-01	13:32	34	22.34300	-75	25.33367	2021-06-01	18:14	34	28.06700	-75	37.34333	140792	181050	141641	181848		1	9.5	552
MGL2306057P49	057	2023-06-01	18:42	34	28.00417	-75	37.72467	2021-06-02	0:09	34	14.35650	-75	48.83517	141642	181910	142859	183093		1	9.5	552
MGL2306058P50	058	2023-06-02	1:05	34	14.27017	-75	49.28667	2021-06-02	2:52	34	14.42733	-75	54.67267	142869	184035	143188	184363		1	9.5	552
MGL2306059P51	059	2023-06-02	3:01	34	14.18017	-75	55.08167	2023-06-02	14:00	33	46.25450	-75	09.34033	143189	185023	145433	187267		1	9.5	552

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35062/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35062
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 26.1 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.46 V/Bar	10.41 V/Bar	10.35 V/Bar	10.67 V/Bar	15.86 V/Bar	11.55 V/Bar	10.10 nF
-199.61 dBv	-199.65 dBv	-199.70 dBv	-199.44 dBv	-195.99 dBv	-198.88 dBv	

Active Calibration Data:
Captured: 3/2021 at 26.2 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.47 V/Bar	10.42 V/Bar	10.36 V/Bar	10.63 V/Bar	15.34 V/Bar	11.44 V/Bar	10.09 nF
-199.60 dBv	-199.64 dBv	-199.69 dBv	-199.47 dBv	-196.28 dBv	-198.94 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric 

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35063/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35063
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 26.5 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.76 V/Bar	10.66 V/Bar	10.54 V/Bar	10.82 V/Bar	15.83 V/Bar	11.72 V/Bar	10.29 nF
-199.36 dBv	-199.44 dBv	-199.54 dBv	-199.32 dBv	-196.01 dBv	-198.74 dBv	

Active Calibration Data:
Captured: 3/2021 at 26.5 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.77 V/Bar	10.67 V/Bar	10.56 V/Bar	10.80 V/Bar	15.63 V/Bar	11.69 V/Bar	10.29 nF
-199.36 dBv	-199.44 dBv	-199.53 dBv	-199.33 dBv	-196.12 dBv	-198.75 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35064/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35064
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 26.6 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.78 V/Bar	10.68 V/Bar	10.58 V/Bar	10.88 V/Bar	16.15 V/Bar	11.81 V/Bar	10.25 nF
-199.35 dBv	-199.43 dBv	-199.51 dBv	-199.27 dBv	-195.84 dBv	-198.68 dBv	

Active Calibration Data:
Captured: 3/2021 at 26.6 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.54 V/Bar	10.69 V/Bar	10.59 V/Bar	10.85 V/Bar	15.75 V/Bar	11.68 V/Bar	10.26 nF
-199.54 dBv	-199.42 dBv	-199.50 dBv	-199.29 dBv	-196.05 dBv	-198.76 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35065/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35065
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 26.8 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.44 V/Bar	10.35 V/Bar	10.29 V/Bar	10.59 V/Bar	15.77 V/Bar	11.49 V/Bar	10.63 nF
-199.63 dBv	-199.70 dBv	-199.75 dBv	-199.50 dBv	-196.04 dBv	-198.92 dBv	

Active Calibration Data:
Captured: 3/2021 at 26.8 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.45 V/Bar	10.35 V/Bar	10.28 V/Bar	10.56 V/Bar	15.42 V/Bar	11.41 V/Bar	10.65 nF
-199.62 dBv	-199.70 dBv	-199.76 dBv	-199.53 dBv	-196.24 dBv	-198.97 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35066/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35066
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 26.8 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.39 V/Bar	10.36 V/Bar	10.29 V/Bar	10.59 V/Bar	15.76 V/Bar	11.48 V/Bar	10.20 nF
-199.67 dBv	-199.69 dBv	-199.75 dBv	-199.50 dBv	-196.05 dBv	-198.93 dBv	

Active Calibration Data:
Captured: 3/2021 at 26.8 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.39 V/Bar	10.36 V/Bar	10.29 V/Bar	10.57 V/Bar	15.57 V/Bar	11.44 V/Bar	10.22 nF
-199.67 dBv	-199.69 dBv	-199.75 dBv	-199.52 dBv	-196.15 dBv	-198.96 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35067/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35067
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 26.0 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.23 V/Bar	11.13 V/Bar	11.03 V/Bar	11.34 V/Bar	16.83 V/Bar	12.31 V/Bar	10.25 nF
-198.99 dBv	-199.07 dBv	-199.15 dBv	-198.91 dBv	-195.48 dBv	-198.32 dBv	

Active Calibration Data:
Captured: 3/2021 at 26.1 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.24 V/Bar	11.14 V/Bar	11.04 V/Bar	11.31 V/Bar	16.44 V/Bar	12.23 V/Bar	10.26 nF
-198.98 dBv	-199.06 dBv	-199.14 dBv	-198.93 dBv	-195.68 dBv	-198.36 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35068/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35068
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 25.6 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.01 V/Bar	10.96 V/Bar	10.90 V/Bar	11.24 V/Bar	16.75 V/Bar	12.17 V/Bar	10.00 nF
-199.16 dBv	-199.20 dBv	-199.25 dBv	-198.98 dBv	-195.52 dBv	-198.42 dBv	

Active Calibration Data:
Captured: 3/2021 at 25.7 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.01 V/Bar	10.96 V/Bar	10.90 V/Bar	11.22 V/Bar	16.41 V/Bar	12.10 V/Bar	10.02 nF
-199.16 dBv	-199.20 dBv	-199.25 dBv	-199.00 dBv	-195.70 dBv	-198.46 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35069/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

```
Hydrophone EEPROM Data:
Seamap Serial: 35069
Manufacture Year:      2021
Manufacture Month:     02
Model Code:    1

Original Calibration Data:
Captured: 3/2021 at 25.7 C
10Hz            26Hz            70Hz            215Hz           500Hz           Average         Capacitance
10.90 V/Bar     10.81 V/Bar     10.71 V/Bar     11.02 V/Bar     16.37 V/Bar     11.96 V/Bar     10.24 nF
-199.25 dBv     -199.32 dBv     -199.40 dBv     -199.16 dBv     -195.72 dBv     -198.57 dBv

Active Calibration Data:
Captured: 3/2021 at 25.7 C
10Hz            26Hz            70Hz            215Hz           500Hz           Average         Capacitance
10.90 V/Bar     10.82 V/Bar     10.71 V/Bar     10.97 V/Bar     15.86 V/Bar     11.85 V/Bar     10.25 nF
-199.25 dBv     -199.32 dBv     -199.40 dBv     -199.20 dBv     -195.99 dBv     -198.63 dBv

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...
```

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35070/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

```
Hydrophone EEPROM Data:
Seamap Serial: 35070
Manufacture Year:      2021
Manufacture Month:     02
Model Code:    1

Original Calibration Data:
Captured: 3/2021 at 25.8 C
10Hz            26Hz            70Hz            215Hz           500Hz           Average         Capacitance
10.08 V/Bar     10.00 V/Bar     9.92 V/Bar      10.20 V/Bar     15.15 V/Bar     11.07 V/Bar     10.19 nF
-199.93 dBv     -200.00 dBv     -200.07 dBv     -199.83 dBv     -196.39 dBv     -199.24 dBv

Active Calibration Data:
Captured: 3/2021 at 25.9 C
10Hz            26Hz            70Hz            215Hz           500Hz           Average         Capacitance
10.10 V/Bar     10.02 V/Bar     9.93 V/Bar      10.16 V/Bar     14.61 V/Bar     10.96 V/Bar     10.19 nF
-199.91 dBv     -199.98 dBv     -200.06 dBv     -199.86 dBv     -196.71 dBv     -199.31 dBv

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...
```

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35071/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35071
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 25.6 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.04 V/Bar	10.94 V/Bar	10.86 V/Bar	11.13 V/Bar	16.05 V/Bar	12.00 V/Bar	10.63 nF
-199.14 dBv	-199.22 dBv	-199.28 dBv	-199.07 dBv	-195.89 dBv	-198.52 dBv	

Active Calibration Data:
Captured: 3/2021 at 25.7 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.05 V/Bar	10.95 V/Bar	10.86 V/Bar	11.14 V/Bar	16.08 V/Bar	12.02 V/Bar	10.64 nF
-199.13 dBv	-199.21 dBv	-199.28 dBv	-199.06 dBv	-195.87 dBv	-198.51 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric 

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35072/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

```
Hydrophone EEPROM Data:
Seamap Serial: 35072
Manufacture Year:      2021
Manufacture Month:     02
Model Code:    1

Original Calibration Data:
Captured: 3/2021 at 25.9 C
10Hz            26Hz            70Hz            215Hz           500Hz           Average         Capacitance
10.43 V/Bar     10.37 V/Bar     10.31 V/Bar     10.64 V/Bar     15.82 V/Bar     11.51 V/Bar     10.17 nF
-199.63 dBv     -199.68 dBv     -199.73 dBv     -199.46 dBv     -196.02 dBv     -198.91 dBv

Active Calibration Data:
Captured: 3/2021 at 25.9 C
10Hz            26Hz            70Hz            215Hz           500Hz           Average         Capacitance
10.43 V/Bar     10.37 V/Bar     10.30 V/Bar     10.61 V/Bar     15.55 V/Bar     11.45 V/Bar     10.17 nF
-199.63 dBv     -199.68 dBv     -199.74 dBv     -199.49 dBv     -196.17 dBv     -198.94 dBv

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...
```

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35073/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35073
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 25.2 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.44 V/Bar	10.38 V/Bar	10.30 V/Bar	10.58 V/Bar	15.29 V/Bar	11.40 V/Bar	10.17 nF
-199.63 dBv	-199.68 dBv	-199.74 dBv	-199.51 dBv	-196.31 dBv	-198.97 dBv	

Active Calibration Data:
Captured: 3/2021 at 25.3 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
10.45 V/Bar	10.39 V/Bar	10.32 V/Bar	10.58 V/Bar	15.22 V/Bar	11.39 V/Bar	10.17 nF
-199.62 dBv	-199.67 dBv	-199.73 dBv	-199.51 dBv	-196.35 dBv	-198.97 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35074/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35074
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 25.0 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.40 V/Bar	11.31 V/Bar	11.23 V/Bar	11.59 V/Bar	17.21 V/Bar	12.55 V/Bar	10.47 nF
-198.86 dBv	-198.93 dBv	-198.99 dBv	-198.72 dBv	-195.28 dBv	-198.16 dBv	

Active Calibration Data:
Captured: 3/2021 at 25.1 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.42 V/Bar	11.33 V/Bar	11.24 V/Bar	11.56 V/Bar	16.69 V/Bar	12.45 V/Bar	10.47 nF
-198.85 dBv	-198.92 dBv	-198.98 dBv	-198.74 dBv	-195.55 dBv	-198.21 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric 

Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35075/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35075
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 24.9 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.16 V/Bar	11.03 V/Bar	10.88 V/Bar	11.17 V/Bar	16.54 V/Bar	12.16 V/Bar	10.24 nF
-199.05 dBv	-199.15 dBv	-199.27 dBv	-199.04 dBv	-195.63 dBv	-198.43 dBv	

Active Calibration Data:
Captured: 3/2021 at 25.0 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.19 V/Bar	11.05 V/Bar	10.91 V/Bar	11.14 V/Bar	16.02 V/Bar	12.06 V/Bar	10.25 nF
-199.02 dBv	-199.13 dBv	-199.24 dBv	-199.06 dBv	-195.91 dBv	-198.47 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric  Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Certificate of Calibration and Conformity

SEAMAP Private Limited
51 Changi North Crescent
Singapore 499626
Tel. +65 6545 1054
Fax +65 6545 0585
Email sales@seamap.com

Hydrophone Serial No. : 35076/0221
Work Order No. : WO-06018572
HVRU Serial No. : 29108 **Cal. Due Date: 14-01-2022**

Hydrophone EEPROM Data:
Seamap Serial: 35076
Manufacture Year: 2021
Manufacture Month: 02
Model Code: 1

Original Calibration Data:
Captured: 3/2021 at 25.0 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.60 V/Bar	11.51 V/Bar	11.40 V/Bar	11.74 V/Bar	17.44 V/Bar	12.74 V/Bar	10.39 nF
-198.71 dBv	-198.78 dBv	-198.86 dBv	-198.61 dBv	-195.17 dBv	-198.03 dBv	

Active Calibration Data:
Captured: 3/2021 at 25.2 C

10Hz	26Hz	70Hz	215Hz	500Hz	Average	Capacitance
11.63 V/Bar	11.52 V/Bar	11.42 V/Bar	11.71 V/Bar	16.92 V/Bar	12.64 V/Bar	10.38 nF
-198.69 dBv	-198.77 dBv	-198.85 dBv	-198.63 dBv	-195.43 dBv	-198.07 dBv	

H0:
No Data...

H1:
No Data...

H2:
No Data...

H3:
No Data...

H4:
No Data...

I hereby certify that the product has been manufactured, tested and calibrated in accordance with the relevant documented build information and procedures, and that the product meets the requirements as set out therein, and unless otherwise stated, conforms to the full requirements of the order.

Remarks:

Signed & Stamped: Eric  Date: 06-Mar-2021

For and on behalf of Seamap Private Limited

Appendix B – Acquisition and processing of potential fields data

Gravity

[Taken from MGL1806 cruise report] Gravity data were acquired with a Bell Aerospace BGM-3 air-sea gravimeter. The BGM-3 system consists of a forced feed-back accelerometer mounted on a gyro-stabilized platform (Fig. 1). The system on Langseth was first installed on R/V *Conrad* in February, 1984. The BGM-3 is a significant improvement over beam-type gravimeters and is thought to be capable of sub-mGal accuracy and resolution of wavelengths of 1-2 km, depending on sea state.

The output from the BGM-3 is a current proportional to the vertical accelerations which are typically in the range 0-200 Gal. This current is then filtered and converted to a digital pulse rate, which is then passed to the data handling system. By summing the output with a reference bias, currently set at 852521.58 mGal, the system is capable of responding to Earth's gravity field and a wide range of the heave, sway and pitch accelerations normally encountered at sea. These accelerations can reach hundreds of thousands of mGal.

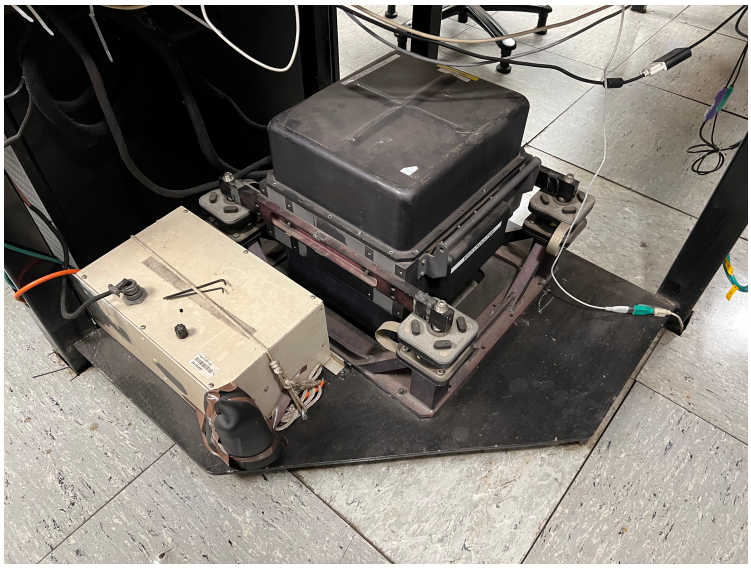


Figure F1. *The BGM-3 gravimeter installed in the main lab on R/V Langseth.*

The BGM-3 sensor on R/V *Langseth* has a current scale factor that converts the digital pulse rate to mGal of 5.096606269. In order to assess sensor drift, a gravity tie was carried out before the start of the cruise on 2023/05/04 using a Lacoste-Romberg at the NOAA AMC Wharf in Norfolk, VA.

Magnetics

[Taken from MGL1806 cruise report] Magnetic data were acquired with a Geometrics G-882 marine magnetometer towed ~110 m astern of R/V *Langseth*. The magnetometer consists of a Cesium-vapor sensor located inside a pressure vessel that is located at the back of the tow fish in a cylindrical body that forms a "T" with the long axis of the vessel. The magnetometer uses

an optically-pumped resonance system that functions as the frequency control element in an oscillator circuit. The oscillation varies with the strength of Earth's external ambient total magnetic field. The G-882 has a high sensitivity and is capable of 1 nT accuracy and a resolution of wavelengths of 1-2 km.

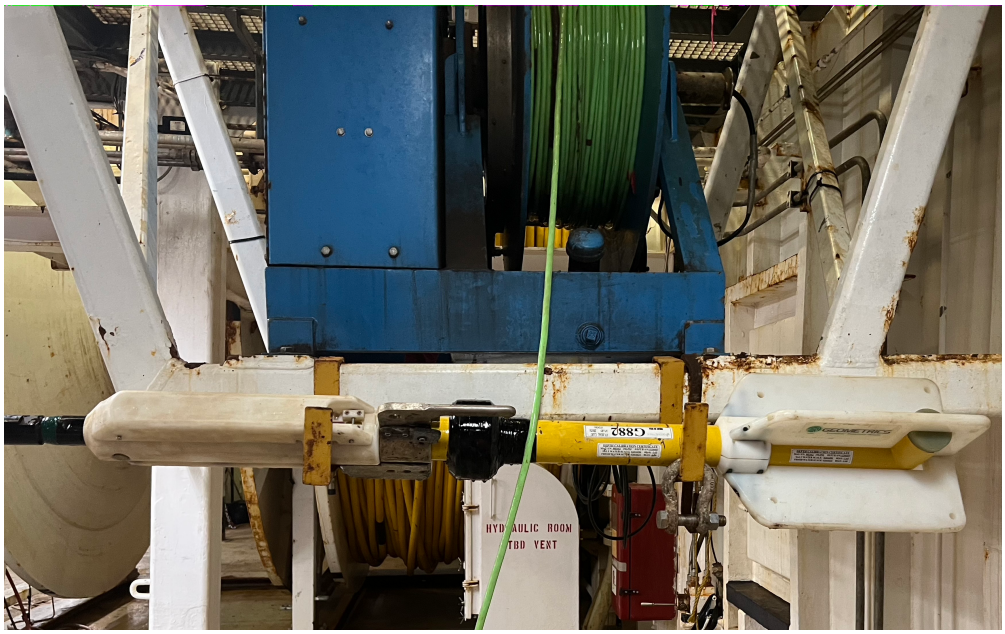


Figure F2. *The G-882 magnetometer as used on R/V Langseth.*

Magnetic field data were acquired throughout the cruise. However, in bad weather or in transit, the magnetometer was not deployed.

Corrections and Filtering

We used the *Langseth* 1-min .csv merged serial file to filter the potential field data and remove outliers in the bathymetry data. Gravity, magnetics, and bathymetry were checked to confirm when and if they were collected, and if not (due to weather or other issues) a "nan" was used instead.

For the gravity data, we applied the theoretical ellipsoid correction using the 1980 International Gravity Formula (IGF), the Eötvös correction, and filter the gravity data using a gaussian filter.

First, the international gravity formula (Eq. 1) and Eotvos effect (Eq. 2) were calculated for all latitudes in the survey area.

$$IG(\emptyset) = 978032.7\left(1 + 0.0053024\, sin^2(\emptyset) - 0.0000058\, sin^2(2\emptyset)\right) mGal \quad (1)$$

$$Et = 7.5038 \times sp \times sin(hd) \times cos(\emptyset) + 0.004154 \times sp \quad (2)$$

where $\emptyset$ is the latitude in decimal degrees, sp is the ship's speed in knots per second (Kts), and hd is the ship's heading in degrees. The corrected free-air gravity anomaly was then calculated using Eq. 3.

Free-air gravity anomaly = measured gravity – IG + Et (3)

Due to the high spatio-temporal resolution of the measured gravity, the resulting Free-air gravity anomaly shows extensive erratic behavior that should be smoothed out. A Gaussian

filter with a 120-minute width and a standard deviation of 8 was used to smooth the Free-air gravity anomaly values.
For the magnetic data, The total magnetic intensity was extracted for all points measured on the survey lines. The magnetic anomaly was then calculated through Eq. 4.
Magnetic anomaly = measured intensity – total intensity (4)

Based on data visualization, the selected filtering procedure is as follows

a. Median filter with 7 minutes width
b. gaussian filter with sigma=0.6 (roughly equal to 50 minutes width)

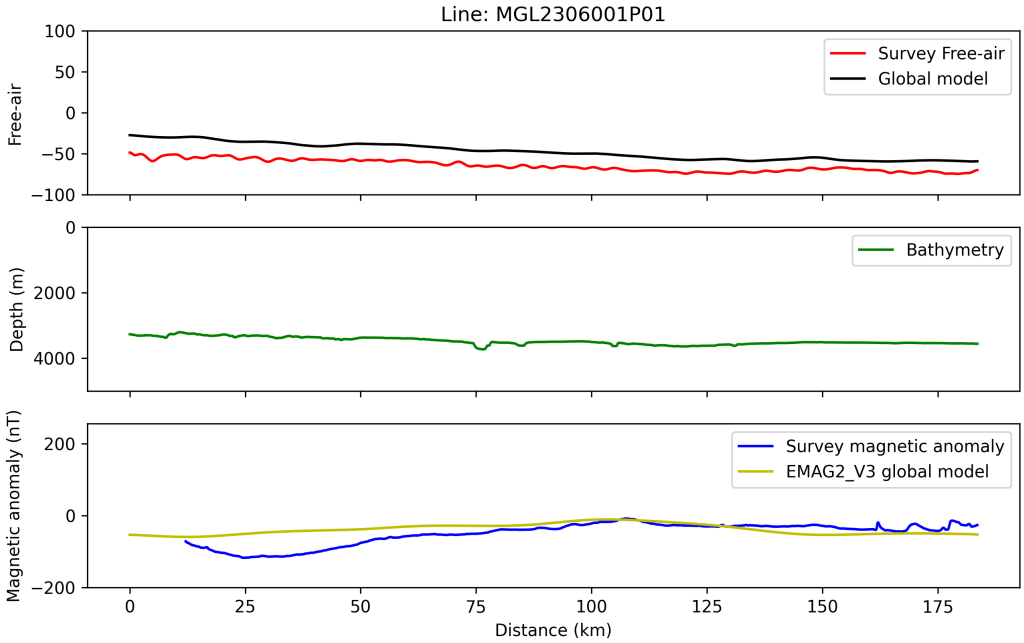
Based on data exploration, the measured bathymetry data includes NAN values and other non-NAN outliers. The NAN values can be easily sorted and detected while the erroneous depth values are detected visually and automatically through calculating the 90th percentile of the data as the maximum true value, giving that bathymetry data are given in positive values, while the correction is done on a region of interest (ROI). Hence, any value greater than this threshold in the ROI is considered as outlier. All the outliers are then replaced by using the average value of non-outlier values in the ROI. Therefore, the filtration workflow is as follows

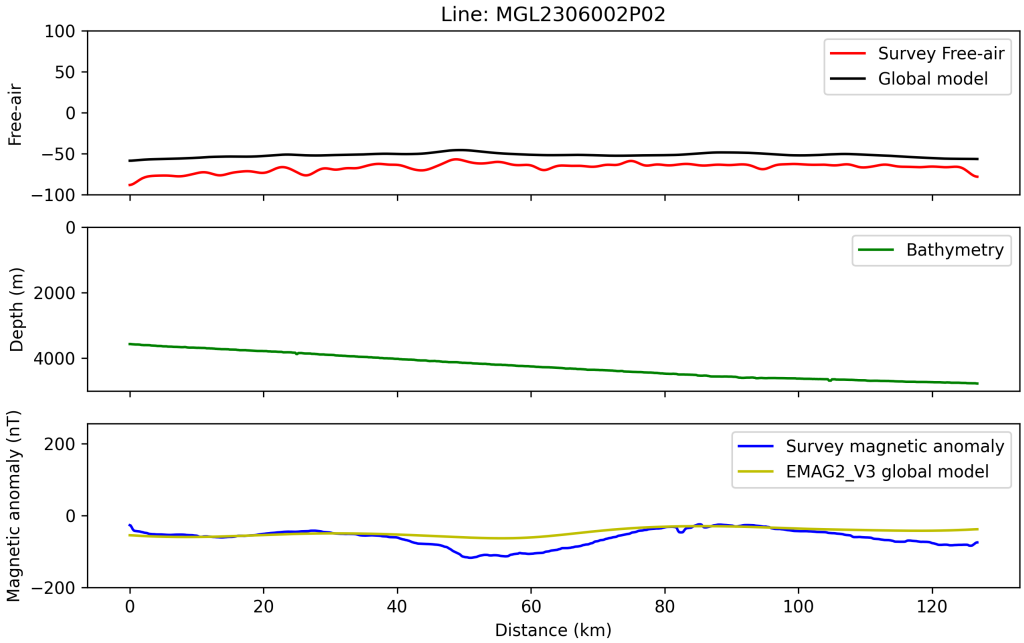
a. Detect NANs and replace them by average of neighboring 14 values. The average is then calculated for the non-NAN values of those neighbors. The window is based on our data visualization, as we have 10 consecutive NANs.
b. Run median filter with window size=4. This removes 1 or 2 consecutive outliers at maximum.
c. If other outliers exist, define an ROI, calculate the adequate threshold (here 90th percentile). Any value, in the ROI, greater than the threshold is replaced by the average of the ROI.

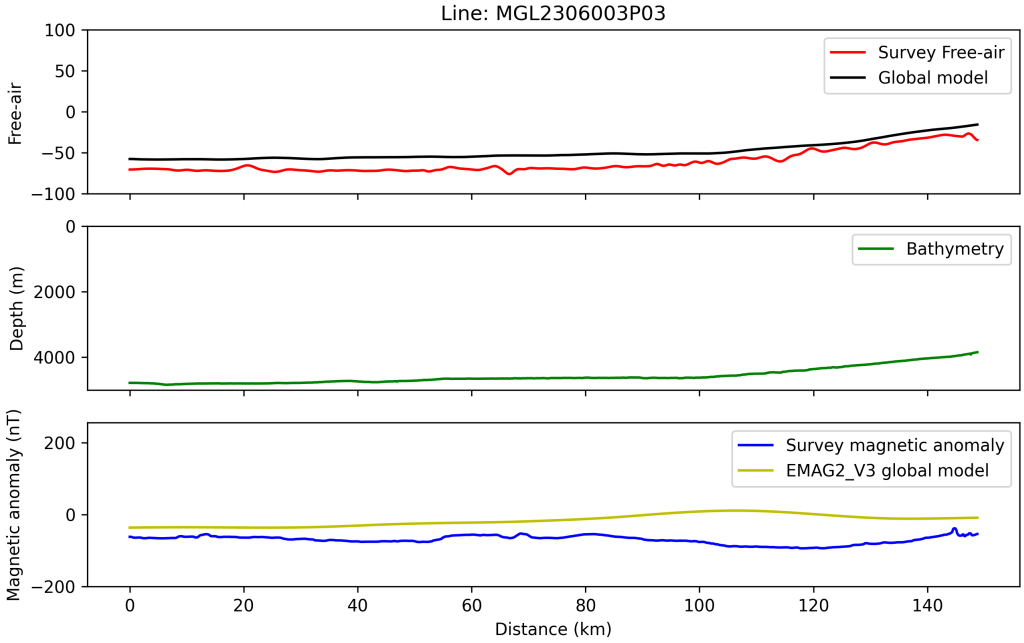
Profiles

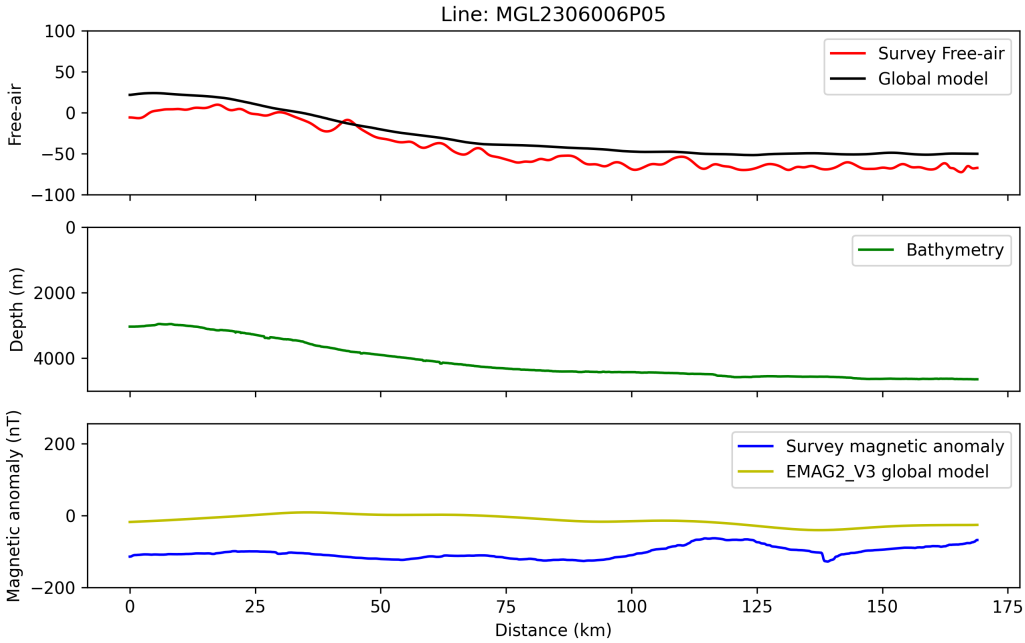
Figure F3 show profiles of the gravity and magnetic anomalies acquired during all the seismic lines. The profiles were constructed from the R/V *Langseth* merged 1-minute .csv file after applying corrections and filters as described above. The upper profile shows the free-air gravity anomaly, the middle profile shows the center beam of the multibeam echo sounder, and the lower profile shows the magnetic anomaly.

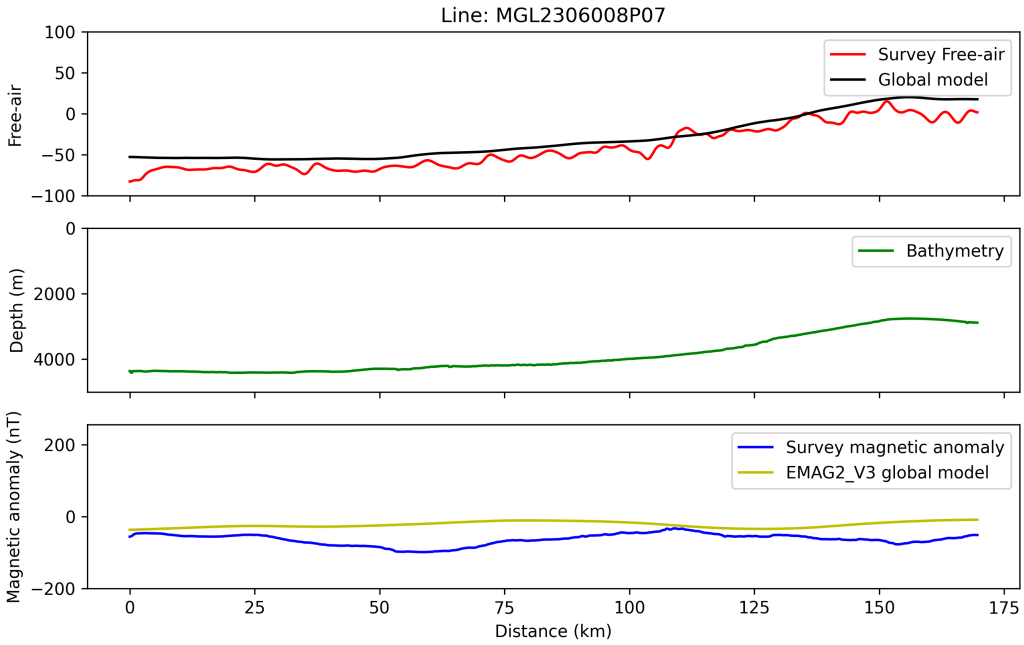
Free-air gravity anomaly and magnetic anomaly along each profile are compared with the global Earth Magnetic Anomaly Grid EMAG2V3 (Meyer et al., 2017) (Fig. 4) and the global marine gravity model from Sandwell et al., 2014 (Fig 4).

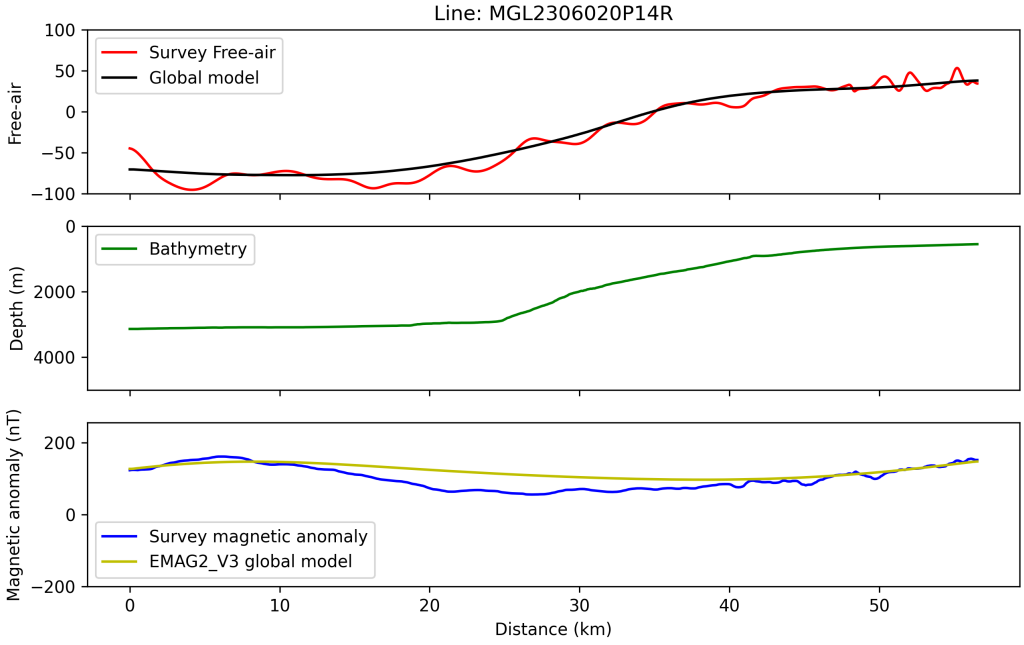

Line: MGL2306001P01
Free-air
Survey Free-air
Global model
Depth (m)
Bathymetry
Magnetic anomaly (nT)
Survey magnetic anomaly
EMAG2_V3 global model
Distance (km)


Line: MGL2306002P02
Free-air
Survey Free-air
Global model
Depth (m)
Bathymetry
Magnetic anomaly (nT)
Survey magnetic anomaly
EMAG2_V3 global model
Distance (km)


Line: MGL2306003P03
Free-air
Survey Free-air
Global model
Depth (m)
Bathymetry
Magnetic anomaly (nT)
Survey magnetic anomaly
EMAG2_V3 global model
Distance (km)


Line: MGL2306006P05
Free-air
Survey Free-air
Global model
Depth (m)
Bathymetry
Magnetic anomaly (nT)
Survey magnetic anomaly
EMAG2_V3 global model
Distance (km)


Line: MGL2306008P07
Free-air
Survey Free-air
Global model
Depth (m)
Bathymetry
Magnetic anomaly (nT)
Survey magnetic anomaly
EMAG2_V3 global model
Distance (km)


Line: MGL2306020P14R
Free-air
Survey Free-air
Global model
Depth (m)
Bathymetry
Magnetic anomaly (nT)
Survey magnetic anomaly
EMAG2_V3 global model
Distance (km)

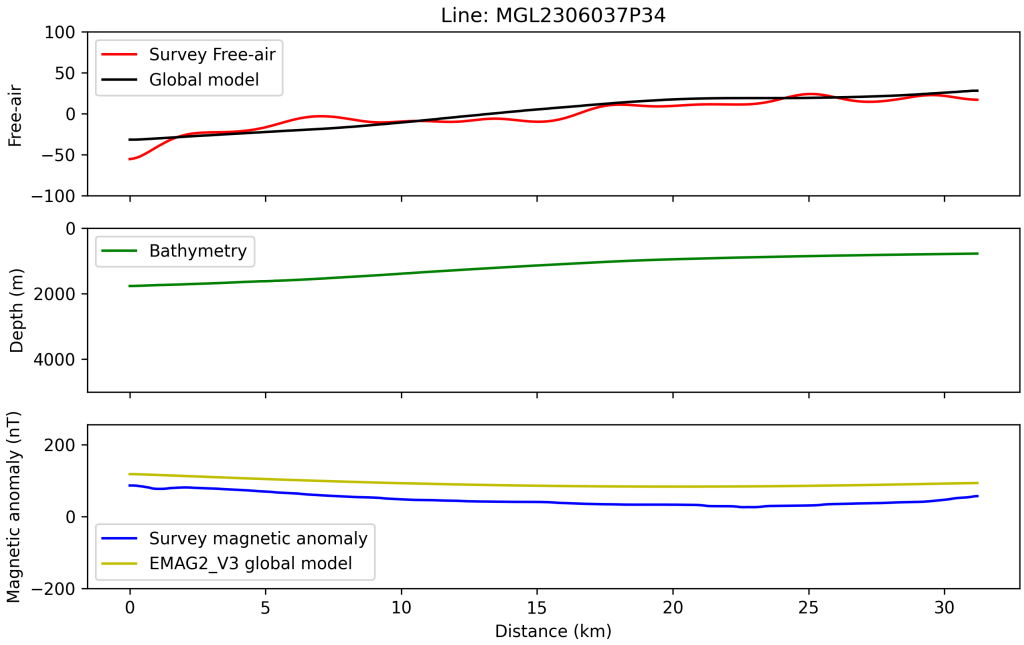
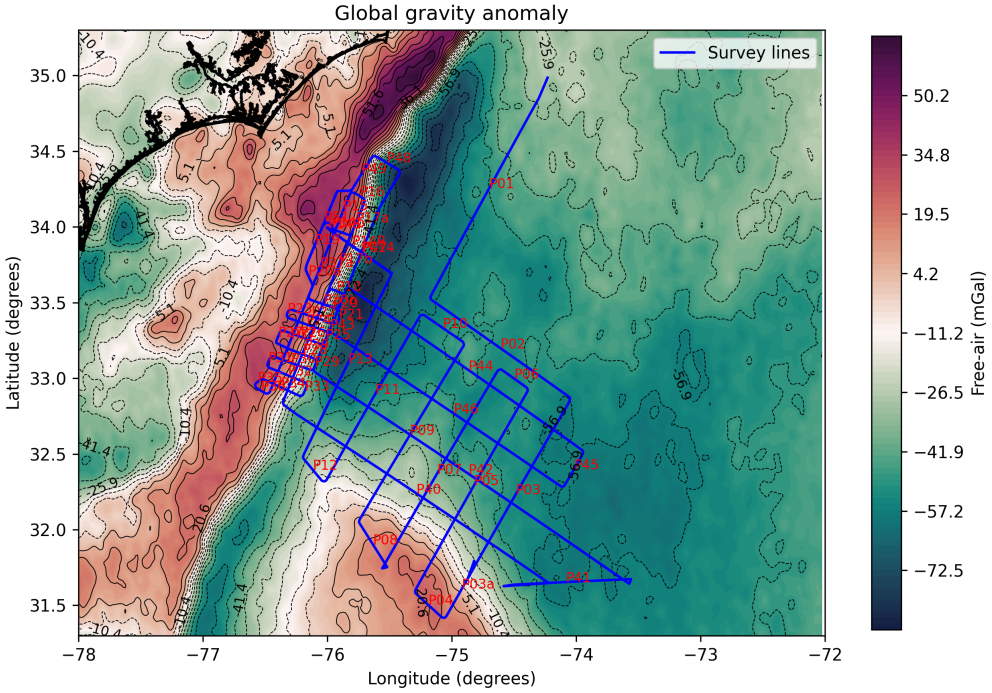


Figure F3. *Profiles of free-air gravity anomaly, magnetic anomaly, and bathymetry acquired during acquisition of seismic lines and compared to global models.*



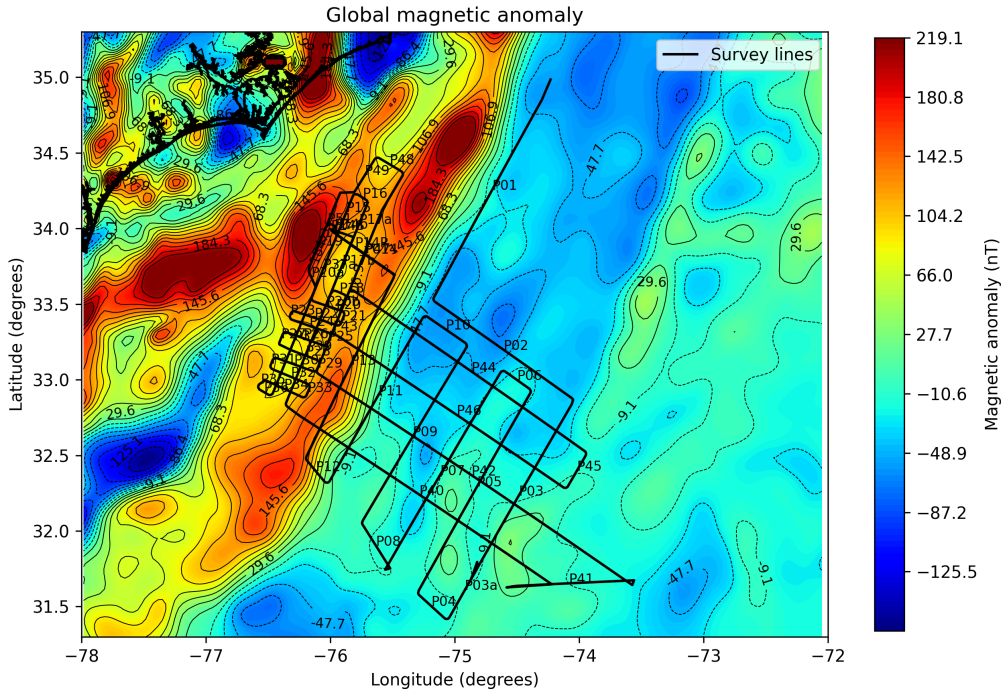


Figure F4. *Regional maps of both global gravity (top) and magnetic data (bottom).*

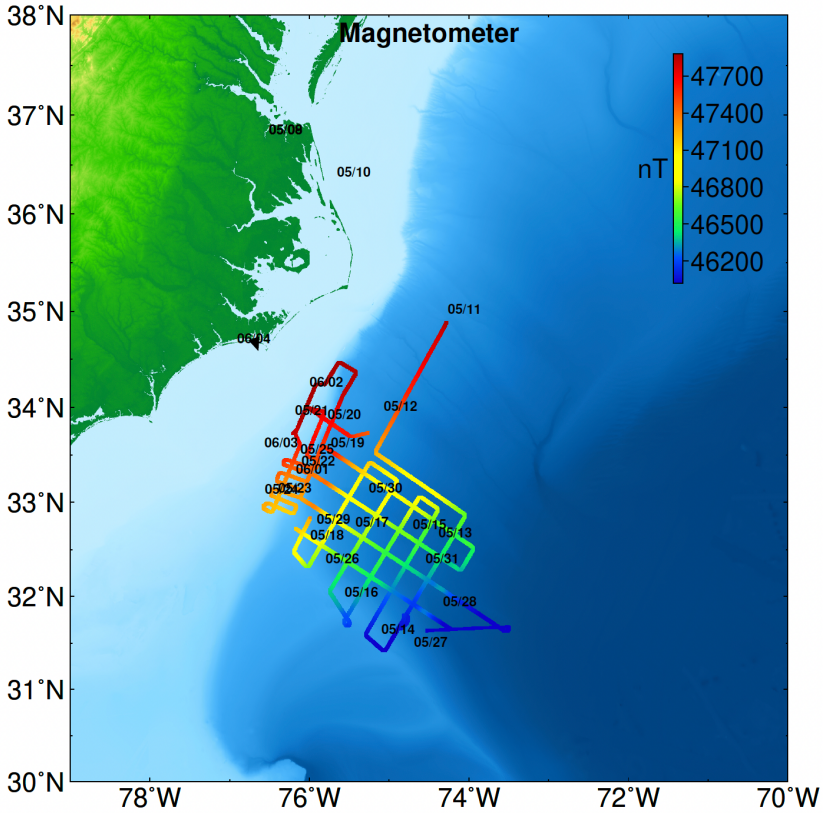


Figure F5. *Raw Magnetic data from the MGL2306 cruise gridded. This plot also highlights where magnetic data was acquired or not due to bad weather, etc.*

Meyer; Richard Saltus; and Arnaud Chulliat. 2017: EMAG2v3: Earth Magnetic Anomaly Grid (2-arc-minute resolution). Version 3. NOAA National Centers for Environmental Information. https://doi.org/10.7289/V5H70CVX.

Sandwell, D. T., R. D. Müller, W. H. F. Smith, E. Garcia, R. Francis, New global marine gravity model from CryoSat-2 and Jason-1 reveals buried tectonic structure, Science, Vol. 346, no. 6205, pp. 65-67, doi: 10.1126/science.1258213, 2014.

Appendix C – Acquisition of *Expandable bathythermographs (XBTs) data*

Expandable bathythermographs (XBTs) were deployed every day during MCS operations. The XBT provides water velocity information for the multi-beam bathymetry by measuring conductivity and temperature as a function of depth. T-5 and T-7 probes were used throughout the cruise. The T-5 is a lower resolution probe that reaches deeper water (1830m) whereas, the T-7 has a higher resolution and is used in shallower depths (760m).

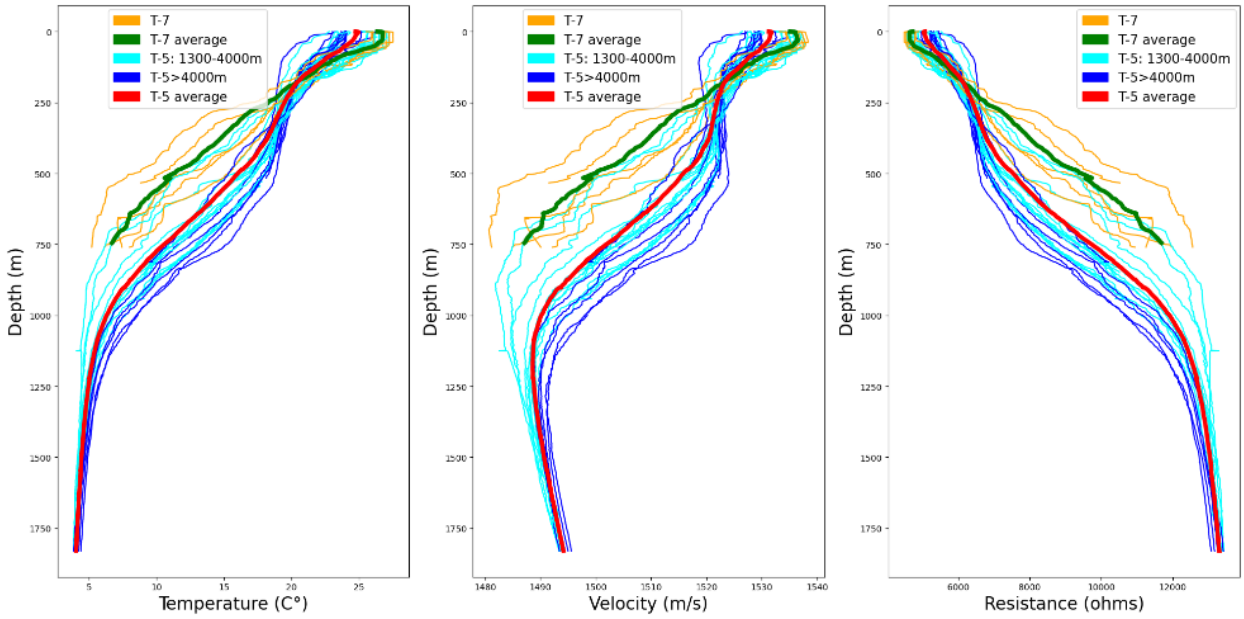


Figure 1: XBT profiles showing the T-7 profiles with their average profile as well as the T-5 profiles and their average profile. The T-5 probes are separated by probes launched at a seafloor depth 1300-4000m and greater than 4000m.

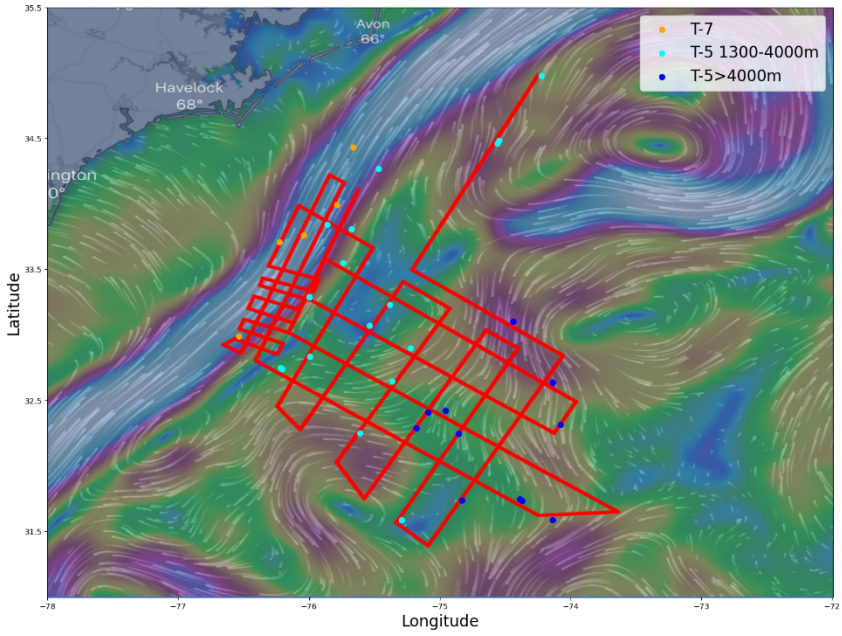


Figure 2: A map showing the survey area, XBT locations and ocean surface currents between latitudes 31 to 35.5 and longitudes -78 to -72. Ocean surface currents are provided by Windy.com on May 22, 2023. Each dot represents a survey location. The color of each dot corresponds with Figure 1 by showing at what depth/which probes were used for the acquisition.

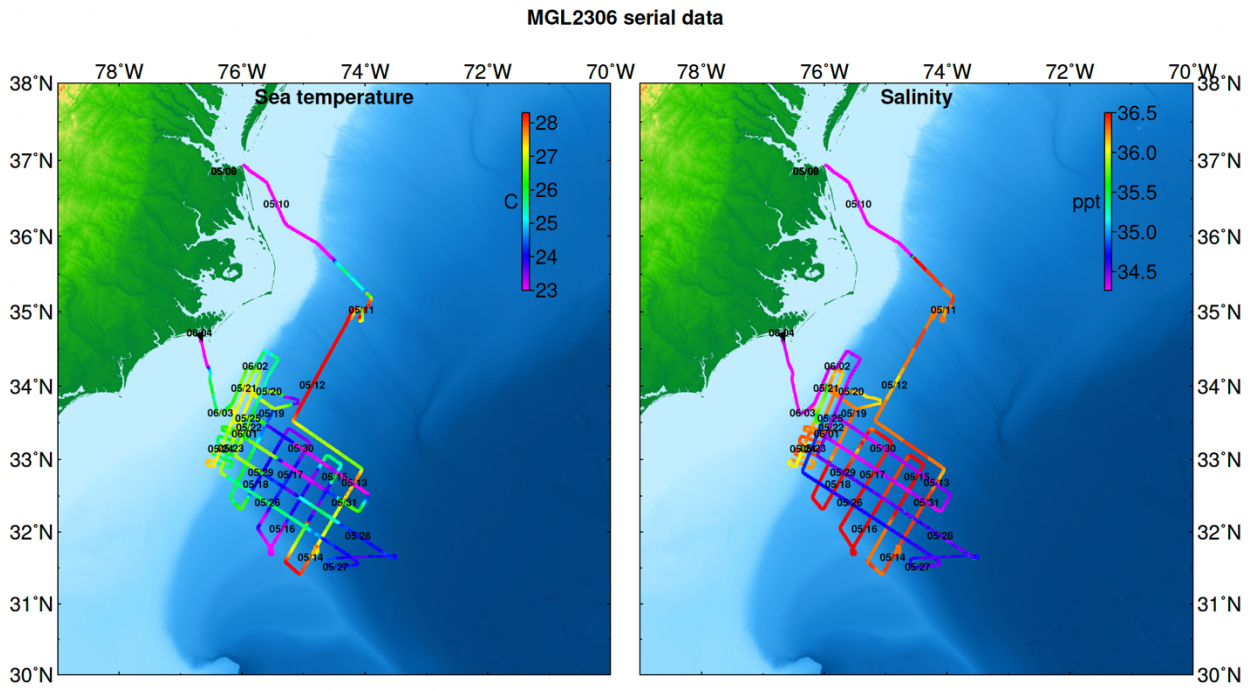


Fig. 3: Map showing sea temperature and salinity along all the profiles collected during MGL2306 cruise.

MGL2306- Expendable Logs

Date	Time UTC	Seq. #	Shot Num.	Lat deg	Lat min	Long deg	Long min	Probe Type	EM122 CBD (m) at splash point	Export Salinity Value (ppt)	SURFACE SV m/s	6.1m SV m/s	last Good Depth m	Water Temp (C)at LGD	Sound Velocity at LGD	Launch Location:	Deck OP	Lab Op	Imported to SIS	Comments
05/10/2023	21:57:00	1		34	53.11	-74	3.01	T-5	3375	36.31	1528.4	1528.27	1830.52	4.12	1494.42	streamer deck	James	bwd	yes	first drop of MGL 2306
05/11/2023	17:00:00	2		34	28.9	-74	32.9	T-5	3420	36.35	1527.8	1528.23				streamer deck			no	drop 2 – abort, probe cut at 900 meters
05/11/2023	17:40:00	3		34	27.6	-74	33.7	T-5	3450	36.34	1544.4	1535.29	1830	4.03	1493.98	streamer deck	James, mason	bwd	yes	drop 3
05/14/2023	7:27:44	8		31	34.93	-75	17.470	T-5	3010	36.351	1530.3	1530.4	1391.6	4.89	1490.22	streamer deck	Louis-Marin	Gilles	yes	drop 8- anomalous value beyond 1400m deep
05/14/2023	16:48:00	9		32	14.5	-74	51.4	T-5	4368	36.46	1533.1	1529.85	1830	4.27	1494.79	streamer deck	James-Emma	Danforth	yes	drop 9
05/15/2023	17:07:48	10		32	24.5	-75	5.4	T-5	4170	36.456	1533.3	1529.78	433.5	37.07	1522.91	streamer deck	James+Hugh	Howarth-Danfo	yes	drop 10- probe terminated. Bad launch
05/15/2023	19:09:32	11		32	17.09	-75	10.7	T-5	4000	36.465	1533.5	1529.48	1830	4.07	1494.16	streamer deck	James+Hugh	Howarth-Danfo	yes	drop 11
05/16/2023	15:44:43	12		32	14.8	-75	36.7	T-5	3161	36.609	1531.6	1527.43	1830	4.02	1493.81	streamer deck	Emma-James	Louis-Farnswor	yes	drop 12
05/17/2023	14:13:42	13		33	13.8	-75	22.9	T-5	3554	36.382	1532.9	1529.27	9411	9.08	1499.18	streamer deck	Emma-Danfor	Farnsworth	yes	drop 13 - Probe terminated. Bad launch
05/18/2023	12:25:59	14		32	49.9	-75	59.56	T-5	2383	36.6	1538.8	1534.79	1562.4	4.21	1490.3	streamer deck	louis-Jo	Farnsworth	yes	drop 14 - Probe terminated. Bad launch
05/19/2023	16:44:32	15		33	59.6	-75	47.1	T-7	1179	36.127	1540.2	1539.51	347	17.16	1516.44	streamer deck	James	Farnsworth	yes	drop 15 - Probe terminated. Bad launch
05/19/2024	16:51:22	16		33	59.4	-75	47.2	T-7	1164	36.224	1540.3	1536.71	760	6.24	1485.02	streamer deck	James	Farnsworth	yes	drop 16
05/20/2023		17		33		-75		T-5	3032	36.301						streamer deck	Ali	Farnsworth		drop 17 - abort ed drop. Wrong information entered
05/20/2024	15:41:20	18		33	48.27	-75	40.66	T-5	2982	36.282	1540.4	1537.27	1830	3.89	1492.23	streamer deck	Ali	Farnsworth	yes	drop 18
05/21/2025	11:52:51	20		33	50.49	-75	51.75	T-5	1311		1537.8	1537.8	1123	4.35	1483.74	streamer deck	Emma-Jo	Louis	yes	drop 20
05/22/2023	13:03:06	21		33	17.4	-75	59.8	T-5	2299	36.358	1538.4	1535.89	520.2	16.14	1516.2	streamer deck	Louis	Farnsworth	yes	drop 21- probe broke. Terminated at 520 m
05/22/2024	13:10:53	22		33	17.1	-75	59.9	T-5	2309	36.338	1538.2	1535.61	5241	13.76	1505.37	streamer deck	Louis	Farnsworth	yes	drop 22- probe broke. Terminated at 524 m
5/23/24	18:12:14	23		32	59.3	-76	32.3	T-7	855	36.24	1541.62	1537.92	760	8.21	1492.89		James	Farnsworth	yes	drop 23
5/24/24	15:28:11	24		33	45.63	-76	2.58	T-7	639	36.13	1538.2	1537.21	639	9.03	1494.01	streamer deck	Farnsworth	Louis	yes	drop 24 - probe reached seafloor
5/25/24	16:29:00	26		32	44.7	-76	13.08	T-5	1947	34.753	1537.2	1533.74	850	9.1	1497.7	streamer deck	Farnsworth	Danforth	yes	drop 25 - terminated probe broke
5/25/24	16:35:00	27		32	44.34	-76	12.25	T-5	1950	34.7	1537	1533.5	460	18	1520.8	streamer deck	Farnsworth	Danforth	no	drop 26 - terminated probe broke
5/26/23	14:02:18	28		31	44.54	-74	23.33	T-5	4868	34.705	1531.2	1529.76	373.3	19.21	1522.87	streamer deck	Emma	Farnsworth	no	drop 27 - Terminated Probe broke
5/26/23	14:13:55	29		31	43.95	-74	22.27	T-5	4879	34.644	1531.5	1529.7	515.6	18.15	1522.17	streamer deck	Emma	Farnsworth	yes	drop 28 - Terminated Probe broke
5/26/23	18:23:01	30		31	34.98	-74	8.2	T-5	5049	34.515	1531.6	1528.63	1830	4.12	1494.43	streamer deck	James	Danforth	yes	drop 29
5/28/23	13:00:02	31		32	26.2	-74	57.45	T-5	4280	34.56	1538.8	1532.45	807.2	9.67	1499	streamer deck	Mason	Danforth	yes	drop 31 - terminated probe. 800 m
5/28/23	19:03:00	32		32	36.36	-75	21.84	T-5	3762	34.5	1530.7	1528.14	220	19.6	1521.38	streamer deck	Mason	Danforth	No	drop 32 - terminated probe - 220 m
5/29/23	14:57:41	33		33	32.95	-75	44.32	T-5	2996	34.48	1539.5	1536.23	1830	3.88	1493.23	streamer deck	Mason,Louis	Danforth	Yes	drop 33 full depth. 1830m
5/30/23	12:13:33	34		32	38.07	-74	8.29	T-5	4830	34.424	1528.6	1520.88	463	16.84	1517.4	streamer deck	Mason, Emma	Luois	no	drop 34 - terminated probe broke
5/30/23	15:04:00	35		32	29.8	-73	56.9	T-5	4947	34.47	1532	1526.8	1830	10.7	1519.6	streamer deck	Mason	Danforth	yes	drop 35-not used, suspect temperature data @ 800m
5/30/23	18:24:23	36		32	16.9	-74	4	T-5	4919	34.39	1537.5	1534.05	500- 1007	11.767	15047	streamer deck	Mason	Danforth	no	drop 36 - not used, temperature data suspect again. Hitting streamer/gear
5/30/23	18:38:04	37		32	18.7	-74	4.7	T-5	4912	34.36	1537.9	1534.4	1830	3.9	1493.24	streamer deck	Mason	Danforth	yes	drop 37
5/31/23	12:23:32	38		32	53.87	-75	13.3	T-5	3908	34.39	1531	1526	1830	3.98	1493.52	streamer deck	Mason	Danforth	yes	drop 38
5/31/23	17:30:12	39		33	4.32	-75	32.36	T-5	3536	34.34	1539.8	1536.32	842	9.08	1497.28	streamer deck	Mason	Danforth	yes	drop 39 probe broke at 842 meters
6/1/23	12:21:00	40		34	16	-75	28.1	T-5	2826	34.32	1537.2	1533.6	1252	4.51	1486.3	streamer deck	Mason	Danforth	yes	drop 40 - probe broke @ 1252 m
6/1/23	19:49:38	41		34	25.73	-75	39.89	T-7	1163	34.39	1535.8	1534.28	760	5.21	1481.15	streamer deck	Mason	Danforth	yes	drop 41
6/2/23	16:33:00	42		33	42.5	-76	13.64	T-7	540	34.29	1538.1	1534.5	532	9.2	1491.34	streamer deck	Mason	Danforth	yes	drop 42

Table summarizing all the XBT launches

Appendix D: More Information on Data Format

This appendix provides information on the format of the following cruise data:

- AML Oceanographic
- POS/MV Position and Orientation System for Marine Vessels
- BGM-3 Gravimeter Data
- CNAV GPS receiver data
- CNAV 3050 GPS receiver data
- Furuno DS-50 Doppler Speedlog Data
- Furuno FE700 Navigational Echosounder data
- Geometrics G-882 Cesium Marine Magnetometer Data
- Kongsberg EM122 Multibeam – Center Beam Depth Data
- Kongsberg SEAPATH 200 Intertial Navigation System
- Lamont Data Systems - UDP Port datagrams
- LDEO PCO2 + CNav + TSG + WX01 + SBE38 Systems
- LDEO PCO2 System
- OBSIP Shotlog Format
- Seabird Electronics SBE-45 Thermosalinograph Station Data
- Simrad GC-80 Gyro Data
- Streamer Tension Unit Data
- Vaisala WXT-520 Meterological Station Data
- Vane Tension Load Cell Units Data

AML Oceanographic - Micro-X SV-Xchange Sensor Data

The AML SV-Xchange Sound Velocity probe outputs the directly measured time-of-flight of an acoustic ping from a single sensor The SV-Xchange sensor is output in the following serial sentence format:

FILE NAME: ***MGL-svuss01.y****d****

svuss01 2015:233:00:00:47.0489 1542.106
svuss01 yyyy:ddd:hh:mm:ss.ssss xxxx.xxx

Item	Definition	Units
xxxx.xx	Sound Velocity (Directly measured in meters per second)	m/s

NOTE:
1) Powering on the sensor outputs the Sensor information and Calibration Dates

Example:

```
Micro.X Sound Velocity Version 1.06 SN:010234
AML Oceanographic Ltd.
SV.Xchange Sensor SN:204749, Calibrated 06/30/15
```

POS/MV Position and Orientation System for Marine Vessels

POS/MV outputs data using the NMEA 0183 format at rates of up to fifty sentences per second. The following seven different sentence formats are available.

- 1. $INGGA-Global System Position Fix Data
- 2. $INHDT-Heading - True data
- 3. $INVTG-Course over ground and Ground speed data
- 4. $INGST-GPS pseudorange noise statistics
- 6. $PRDID-Attitude data
- 7. $INZDA-Time and date

$INGGA, hhmmss.sss, llll.lllll, a, yyyyy.yyyyy, b, t, nn, v.v, x.x, M,,,c.c,rrrr*hh

$INGGA-Global System Position Fix Data

Item	Definition	Value	Units
$INGGA	Header	$INGGA	
hhmmss.sss	UTC time of position	n/a	Hours/Minutes/Seconds.decimal. Two fixed digits of hours. Two fixed digits of minutes. Two fixed digits of seconds. Three digits for decimal fractions of a second.
llll.lllll	Latitude	-90 to +90	DegreeslMinutes.decimal. Two fixed digits of degrees Two fixed digits of minutes Five digits for decimal minutes.
a	N (north) or S (south)	N or S	
yyyyy.yyyyy	Longitude	-180 to +180	Degrees/Minutes.decimal. Three fixed digits of degrees. Two fixed digits of minutes. Five digits for decimal minutes.
b	E (east) or W (west)	E or W	
		0 = Fix not available or	

		invalid	
t	GPS Quality Indicator	1 = CIA standard GPS; fix valid. 2 = DGS mode; fix valid. 3 = PPP mode; fix valid. 4 = RTK fixed 5 = RTK float 6 = free inertial	
nn	Number of satellites used in fix	0 to 32	
v.v	Horizontal dilution of precision		
x.x	Altitude of the IMU above or below the mean sea level. A negative value indicates below sea level.	n/a	Metres
M	Units of measure = metres	M	
Null	Null		
Null	Null		
c.c	Age of differential corrections in records since last RTCM-104 message.	0 to 99.9	Seconds
rrr	DGPS reference station identity	0000 to 1023	
*hh	Checksum	00 - FF	
/CR/LF	Carriage return and line feed	/CR/LF	

Note that, in the case of the HDOP, IMU altitude and age of differential connections, POS/MV adds leading digits as required (i.e. if the value exceeds 9.9). Also, note that commas separate all items, including null fields. The information is valid at the location of the vessel frame.

$INHDT, x.x, T*hh

$INHDT-Heading - True data

Item	Definition	Value	Units
$INHDT	Header	$INHDT	
x.x	True vessel heading in the vessel frame	o to 359.99	degrees
*hh	Checksum	n/a	
/CR/LF	Carriage return and line feed	/CR/LF	

$INVTG, x.x, T,, M, n.n, N, k.k, K*hh

$INVTG-Course over ground and Ground speed data

Item	Definition	Value	Units
%INVTG	Header	$INVTG	
x.x	True vessel track in the vessel frame	0 to 359.99	degrees
T	True	T	
null	Not supported	null	
M		M	
n.n	Speed in the vessel frame	n/a	Knots
N	Knots	N	
k.k	Kilometres	K	
*hh	Checksum	n/a	
/CR/LF	Carriage return and line feed	/CR/LF	

Note that, in the case of the track and the speed fields, POS/MV adds the leading digits as required (i.e. if the value exceeds 9.9). ALso, note that commas separate all items in the including null fields.

$INGST, hhmmss,sss,,smjr.smjr,smnr.smnr, o.o, l.l, y.y, a.a *hh

$INGST-GPS pseudorange noise statistics

Item	Definition	Value	Units
$INGST	Header	$INGST	
hhmmss.sss	UTC time of position	n/a	Hours/Minutes/Seconds.decimal. 2 fixed digits of hours. 2 fixed digits of minutes. 2 fixed digits of seconds. Three digits for decimal fractions of a second.
null	Not supported	null	
smjr.smjr	Standard Deviation of semi-major axis of error ellipse	n/a	Metres
smnr.smnr	Standard deviation of semi-minor axis of error ellipse	n/a	Metres
o.o	Orientaion of semi-major axis ellipse	0 to 359.9	Degrees from true north

l.l	Standard deviation of latitude	n/a	Metres
y.y	Standard deviation of longitude	n/a	Metres
a.a	Standard deviation of Altitude	n/a	Metres
*hh	Checksum	n/a	
/CR/LF	Carriage return and line feed	/CR/LF	

Note that, in the case of all fields POS/MV adds leading digits as required (i.e. if the value exceeds 9.9). Also, note that commas separate all items, including null fields. The information is valid at the location of the vessel frame.

Note that commas separate all items

Two attitude data strings are available. The strings are identical except for the definition of roll and pitch angles. One string uses Tate-Bryant angles and the

other uses TSS angles. Use the POS/MV Controller program to set the required angle convention.

$PRDID, PPP.PP, RRR.RR, xxx.xx*hh

$PRDID-Attitude data

Item	Definition	Value	Units
$PRDID	Header	$PRDID	
PPP.PP	Pitch	-90.00 to +90.00	Degrees
RRR.RR	Roll	-90.00 to +90.00	Degrees
xxx.xx	Sensor heading	0 to 359.99	Degrees
*hh	Checksum	n/a	
/CR/LF	Carriage return and line feed	/CR/LF	

Note that commas separate all items

Two attitude data strings are available. The strings are identical except for the definition of roll and pitch angles. One string uses Tate-Bryant angles and the

other uses TSS angles. Use the POS/MV Controller program to set the required angle convention.

$INZDA, hhmmss.ss, DD, MM, YYYY,, *hh

$INZDA-Time and date

Item	Definition	Value	Units
$INZDA	Header	$INZDA	
			Hours/Minutes/Seconds.decimal.

hhmmss.sss	UTC time	n/a	2 fixed digits of hours 2 fixed digits of minutes 2 fixed digits of seconds Three digits for decimal fractions of a second
DD	Day of month	01 to 31	
MM	Month of year	01 to 12	
YYYY	Year		
Null	Null		
Null	Null		
*hh	Checksum	n/a	/CR/LF

BGM-3 Gravimeter Data

The BGM-3 Gravimeter outputs the gravitational force in the following serial sentence format:

FILE NAME: ***MGL-vc01.y****d****

vc01 2015:234:00:00:53.7862 04:024326 00
vc01 yyyy:ddd:hh:mm:ss.ssss xx:yyyyyy ff

Item	Definition	Units
xx	Output Frequency	Hz
yyyyyy	Raw Counts	n/a
ff	Sensor Status (00 – Null) See manual for other Error Codes.	n/A

CNAV GPS receiver data

CNAV outputs data in NMEA 0183 compatible format. Currently* the following sentence types are enabled:

- $GPVTG-GPS Velocity, Track made good and Ground speed data (computed by the CNAV GPS receiver).
- $GPGGA-Gobal Positioning System Fix data (computed by the CNAV GPS receiver).

*Note: there are other sentence types available from CNAV. Please consult the software manual for more options.

$GPVTG, xxx.x, T,, M, m.mm, N, n.nn, K*hh

$GPVTG Sentence Fields

Item	Definition	Units
xxx.x	Course over ground (COG)	Degrees from True North
T	Indicates course relative to True North	n/a
M	COG	Degrees from Magnetic North
m.mm	Speed over ground (SOG)	Nautical miles per hour (knots)
N	Indicates that the speed over ground is in knots	n/a
n.nn	SOG	km/h
K	Indicates that the SOG is in km/h	n/a /td>
*hh	Checksum (hexadecimal representation)	n/a

$GPGGA,hhmmss.ss, ddmm.mmmmm, a, ddmm.mmmmm, a, x, xx, x.x, xx.xx, M, xx.xx, M, x.x, xyy*hh

$GPGGA Sentence Fields

Item	Definition	Units
hhmms.ss	UTC time of position	Hours/Minutes/Seconds.decimal.
ddmm.mmmmm	Latitude	Degrees/Minutes.decimal.
a	Direction of Latitude N = North S = South	n/a
ddmm.mmmmm	Longitude	Degrees/Minutes.decimal
a	Direction of Longitude E = East	n/a

	W = West	
x	GPS Quality indicator 0 = fix not valid 1 = GPS Autonomous fix 2 = GcGPS Corrected Fix	n/a
xx	Number of GPS satellites used in solution fix	n/a
x.x	Horizontal Dilution of Precision (HDOP)	n/a
xx.xx	C-NAV GPS receiver antenna altitude reference to Mean Sea Level (MSL)	n/a
M	Altitude units--M indicates meters	n/a
xx.xx	WGS-84 Geoidal separation distance from MSL based on the NIMA/NASA EGM96 15-minute (Earth Gravity Model)	Meters
M	Geosoidal separation units--M indicates meters	n/a
x.x	Age of GcGPS corrections used in solution fix	n/a
xyy	C-NAV GPS receiver reference identification	x is downlink satellite communication beam in use yy is the GPS correction signal mode/type being used
*hh	Checksum (hexadecimal representation) followed by CRLF terminator pair	n/a

CNAV 3050 GPS receiver data

CNAV 3050 outputs data in NMEA 0183 compatible format. Currently* the following sentence types are enabled:

- $GPVTG-GPS Velocity, Track made good and Ground speed data (computed by the CNAV GPS receiver).
- $GPGGA-Gobal Positioning System Fix data (computed by the CNAV GPS receiver).

*Note: there are other sentence types available from CNAV. Please consult the software manual for more options.

$GPVTG, xxx.x, T,, M, m.mm, N, n.nn, K*hh

$GPVTG Sentence Fields

Item	Definition	Units
xxx.x	Course over ground (COG)	Degrees from True North
T	Indicates course relative to True North	n/a
M	COG	Degrees from Magnetic North
m.mm	Speed over ground (SOG)	Nautical miles per hour (knots)
N	Indicates that the speed over ground is in knots	n/a
n.nn	SOG	km/h
K	Indicates that the SOG is in km/h	n/a /td>
*hh	Checksum (hexadecimal representation)	n/a

$GPGGA,hhmmss.ss, ddmm.mmmmm, a, ddmm.mmmmm, a, x, xx, x.x, xx.xx, M, xx.xx, M, x.x, xyy*hh

$GPGGA Sentence Fields

Item	Definition	Units
hhmms.ss	UTC time of position	Hours/Minutes/Seconds.decimal.
ddmm.mmmmm	Latitude	Degrees/Minutes.decimal.
a	Direction of Latitude N = North S = South	n/a
ddmm.mmmmm	Longitude	Degrees/Minutes.decimal
a	Direction of Longitude E = East	n/a

	W = West	
x	GPS Quality indicator 0 = fix not valid 1 = GPS Autonomous fix 2 = GcGPS Corrected Fix	n/a
xx	Number of GPS satellites used in solution fix	n/a
x.x	Horizontal Dilution of Precision (HDOP)	n/a
xx.xx	C-NAV GPS receiver antenna altitude reference to Mean Sea Level (MSL)	n/a
M	Altitude units--M indicates meters	n/a
xx.xx	WGS-84 Geoidal separation distance from MSL based on the NIMA/NASA EGM96 15-minute (Earth Gravity Model)	Meters
M	Geosoidal separation units--M indicates meters	n/a
x.x	Age of GcGPS corrections used in solution fix	n/a
xyy	C-NAV GPS receiver reference identification	x is downlink satellite communication beam in use yy is the GPS correction signal mode/type being used
*hh	Checksum (hexadecimal representation) followed by CRLF terminator pair	n/a

Furuno DS-50 Doppler Speedlog Data

The FURUNO DS-50 is a highly advanced, precision Doppler Speed Log incorporating FURUNO's advanced computer technology. The DS-50 provides accurate display of speed over a wide range from dead slow to 40 kt. Speeds are detected relative to ground or water both fore/aft and athwart ship.

The speed logger data from the Furuno DS-50 is output in the following sentence formats:

FILE NAME: ***MGL-slog01.y****d****

*$VDVHW,90.0,T,95.0,M,11.07,N,20.50,K*47*
*$VDVHW,x.x,T,y.y,M,n.n,N,s.s,K*hh*

Item	Definition	Units
x.x	Vessel Heading	Degrees True
T	Units	n/a
y.y	Vessel Heading	Degree Magnetic
M	Units	n/a
n.n	Speed of vessel relative to water	Knots
N	Units	n/a
s.s	Speed of vessel relative to water	Km/hour
K	Units	n/a
*hh	Checksum	n/a

*$VDVLW,0005293.53,N,0005293.53,N*5F*
*$VDVLW,xxxxx.xx,N,yyyyy.yy,N*hh*

Item	Definition	Units
xxxxx.xx	Total cumulative distance of vessel travel	knots
N	Units	n/a
yyyyy.yy	Distance recorded since reset of DS-50 unit	knots
N	Units	n/a
*hh	Checksum	n/a

*$VDVBW,011.04,000.09,A,011.04,000.09,V*46*
*$VDVBW,xxx.xx,yyy.yy,A,zzz.zz,ttt.tt,V*hh*

Item	Definition	Units
xxx.xx	Longitudinal water speed	knots
yyy.yy	Transverse water speed	knots

A	**Status: water speed, A=data valid, V=data invalid**	**n/a**
zzz.zz	**Longitudinal ground speed**	**knots**
ttt.tt	**Transverse ground speed**	**knots**
V	**Status: ground speed, A=data valid, V=data invalid**	**n/a**
***hh**	**Checksum**	**n/a**

FE700 Navigational Echosounder data

The FE700 Navigational Echosounder outputs data in the following formats

- $PFEC - unspecified
- $SDDBT - Depth Below Transducer
- $SDDBS - Depth Below Surface

$PFEC ,aaaa,x,x*hF

PFEC sentence format

Item	Definition	Units
aaaa	unspecified	unspecified
x	unspecified	unspecified
x	unspecified	unspecified
*hF	unspecified	unspecified

$DBT,x.x,f,x.x,M,x.x,F*hh

SDDBT sentence format

Item	Definition	Units
x.x	Water depth	feet
f	f = feet	n/a
x.x	Water depth	meters
M	M = meters	n/a
x.x	Water depth	fathoms
F	F = fathoms	n/a
*hh	Checksum	n/a

$DBS,x.x,f,x.x,M,x.x,F*hh

SDDBS sentence format

Item	Definition	Units
x.x	Water depth	feet
f	f = feet	n/a
x.x	Water depth	meters
M	M = meters	n/a
x.x	Water depth	fathoms
F	F = fathoms	n/a
*hh	Checksum	n/a

Geometrics G-882 Cesium Marine Magnetometer Data

The G-822 Cesium Marine Magnetrometer converts the cesium Larmor signal (70 kHz to 350 kHz) into magnetic field strength in nano-Teslas (20,000 nT to 100,000 nT) by using a CM-221 counter module. The G-882 outputs magnetic field strength in the following serial sentence format:

FILE NAME: ***MGL-mag01.y****d****

mag01 2015:114:00:17:32.7965 $ 49034.313,0781,0876
mag01 yyyy:ddd:hh:mm:ss.ssss $ xxxxx.xxx,aaaa,bbbb

Item	Definition	Units
xxxxx.xxx	Magnetic Field Strength (nano Teslas)	nT
aaaa	A/D channel 0 (9999 full scale, 0 to +5 volts) *Not Used	n/a
bbbb	A/D channel 1 (9999 full scale, 0 to +5 volts) *Not Used	n/a

Kongsberg EM122 Multibeam – Center Beam Depth Data

The EM122 multibeam depth datagram from a single beam echo sounder are output for logging in the following NMEA 0183 DPT serial sentence format:

FILE NAME: ***MGL-bath02.y****d****

bath02 2015:233:00:14:27.1279 $KIDPT,4840.83,5.60,12000.0*73
bath02 yyyy:ddd:hh:mm:ss.ssss $KIDPT,xxxx.xx,z.zz,rrrrr.r*##

Item	*Definition*	*Units*
KIDPT	**Talker identifier and sentence formatter**	**n/a**
xxxx.xx	**Seafloor bottom depth from transducer face**	**Meters**
z.zz	**Offset of transducer from waterline of vessel calculated using heavy compensation from Kongsberg Seapath 200 MRU**	**Meters**
rrrrr.r	**Maximum range scale in uses by system**	**Meters**
***##**	**Checksum**	***hh**

SEAPATH 200 Intertial Navigation System

SEAPATH outputs data in NMEA format using the following sentence formats:

- 1. $INGGA-Global System Position Fix Data
- 2. $INHDT-Heading - True data
- 3. $INVTG-Course over ground and Ground speed data
- 4. $INZDA-Time and date

$INGGA, hhmmss.sss, llll.lllll, a, yyyyy.yyyyy, b, t, nn, v.v, x.x, M,,,c.c,rrrr*hh

$INGGA-Global System Position Fix Data

Item	Definition	Value	Units
$INGGA	Header	$INGGA	
hhmmss.sss	UTC time of position	n/a	Hours/Minutes/Seconds.decimal. Two fixed digits of hours. Two fixed digits of minutes. Two fixed digits of seconds. Three digits for decimal fractions of a second.
llll.lllll	Latitude	-90 to +90	DegreeslMinutes.decimal. Two fixed digits of degrees Two fixed digits of minutes Five digits for decimal minutes.
a	N (north) or S (south)	N or S	
yyyyy.yyyyy	Longitude	-180 to +180	Degrees/Minutes.decimal. Three fixed digits of degrees. Two fixed digits of minutes. Five digits for decimal minutes.
b	E (east) or W (west)	E or W	
t	GPS Quality Indicator	0 = Fix not available or invalid 1 = CIA standard GPS; fix valid. 2 = DGS mode; fix valid. 3 = PPP mode; fix valid. 4 = RTK fixed 5 = RTK float 6 = free inertial	
nn	Number of satellites used in fix	0 to 32	
v.v	Horizontal dilution of precision		
x.x	Altitude of the IMU above or below the mean sea level. A negative value indicates below sea level.	n/a	Metres
M	Units of measure = metres	M	

Null	Null		
Null	Null		
c.c	Age of differential corrections in records since last RTCM-104 message.	0 to 99.9	Seconds
rrr	DGPS reference station identity	0000 to 1023	
*hh	Checksum		
/CR/LF	Carriage return and line feed	/CR/LF	

$INHDT, x.x, T*hh

$INHDT-Heading - True data

Item	Definition	Value	Units
$INHDT	Header	$INHDT	
x.x	True vessel heading in the vessel frame	o to 359.99	degrees
*hh	Checksum	n/a	
/CR/LF	Carriage return and line feed	/CR/LF	

$INVTG, x.x, T,, M, n.n, N, k.k, K*hh

$INVTG-Course over ground and Ground speed data

Item	Definition	Value	Units
$INVTG	Header	$INVTG	
x.x	True vessel track in the vessel frame	0 to 359.99	degrees
T	True	T	
null	Not supported	null	
M		M	
n.n	Speed in the vessel frame	n/a	Knots
N	Knots	N	
k.k	Kilometres	K	
*hh	Checksum	n/a	
/CR/LF	Carriage return and line feed	/CR/LF	

$INZDA, hhmmss.ss, DD, MM, YYYY,, *hh

$INZDA-Time and date

Item	Definition	Value	Units
$INZDA	Header	$INZDA	

hhmmss.sss	UTC time	n/a	Hours/Minutes/Seconds.decimal. 2 fixed digits of hours 2 fixed digits of minutes 2 fixed digits of seconds Three digits for decimal fractions of a second
DD	Day of month	01 to 31	
MM	Month of year	01 to 12	
YYYY	Year		
Null	Null		
Null	Null		
*hh	Checksum	n/a	
/CR/LF	Carriage return and line feed	/CR/LF	

UDP Datagrams

In addition to the serial logs, each data stream is broadcast over the local ship's network via UDP.

```
UDP MESSAGES

33103 (C-Nav World DGPS +RTCM)
 cnav    2008:013:02:15:33.7076  $GPGGA,021533.00,2710.75894,N,09511.75255,W,2,7,1.3,10.86,M,-26.31,M,10,0108*5D
 cnav    2008:013:02:15:33.7276  $GPVTG,166.4,T,,M,3.74,N,6.93,K*69

33104 (Applanix POS/MV INS)
 posmv   2008:013:02:15:01.7342  $INGGA,021501.498,2710.78491,N,09511.75611,W,1,10,0.8,-1.51,M,,,,*11
 posmv   2008:013:02:15:01.7344  $INHDT,171.2,T*20
 posmv   2008:013:02:15:01.8504  $INVTG,168.1,T,,M,3.9,N,7.3,K*70
 posmv   2008:013:02:15:01.9667  $INGST,021501.498,,1.2,1.1,75.1,4.0,4.0,6.1*6C
 posmv   2008:013:02:15:02.0849  $PASHR,021501.498,171.25,T,0.38,-1.11,0.02,0.068,0.068,1.906,1,1*39
 posmv   2008:013:02:15:02.0850  $INZDA,021501.0000,13,01,2008,,*78

33106 (Simrad Seapath 200 INS)
 seapath 2008:013:02:14:15.7873  $INZDA,021415.73,13,01,2008,,*78
 seapath 2008:013:02:14:15.9036  $INGGA,021415.73,2710.833433,N,09511.767381,W,2,10,0.8,-28.43,M,,M,0.8,0291*79
 seapath 2008:013:02:14:15.9036  $INVTG,169.86,T,,M,4.0,N,,K,D*02
 seapath 2008:013:02:14:15.9037  $INHDT,170.23,T*12

33111 (Simrad GC-80 aka "Tokamak" gyrocompass)  NOTE: NOT Sperry MK027
 gy01    2008:013:02:16:10.7810  $HEHDT,170.1,T*28
 gy01    2008:013:02:16:10.7812  $HEROT,002.86,A*17
 gy01    2008:013:02:16:11.5544  $PTKM,HEALM,0000,0,G1*09

33121 (Furuno DS50 speedlog)
 slog01  2008:013:02:16:53.9002  $VDVHW,,T,,M,04.10,N,07.59,K*49
 slog01  2008:013:02:16:54.0185  $VDVBW,004.08,-00.47,A,004.08,-00.47,V*46
 slog01  2008:013:02:16:54.0186  $VDVLW,0000966.85,N,0000966.85,N*5F

33602 (Simrad EM120 centerbeam depth)
 bath02  2008:014:17:22:01.2949  $KGDPT,1143.40,0.0,12000.0*4e

33701 (RMYoung 26700)
 wx01    2008:013:02:18:26.9205    3.0   2.8   4.2   6.3  58  58   5   0.0   0.0   0.0   0.0 355 355   0  21.1  21.0  20.9  21.1  7  7  7 1015.0

33711 (RMY relative wind to the DP autopilot)
 mwv01   2008:013:02:19:00.9197  $INMWV,57.0,R,4.4,N,A*08

33611 (Bell BGM-3 gravimeter)
 vc01    2008:013:02:19:30.9852  01:024904 01
```

LDEO PCO2 + CNav + TSG + WX01 + SBE38 Systems

PCO2 merge is a combination of outputs of various serial data in the following sentence format:

yyyyjjj.jjj aaaa.aa bb.bb cccc.cc ddd.dd e.ee fff.f gggg.gg hh i k, llll.llllllm, nnnnn.nnnnnno, pp.pppp, q.qqqqq, rr.rrrr, ss.s, ttt, uu.u, vvvv, w.ww, xxx.x, yy.yyyy

PCO2 Data

Item	Definition	Value	Units
yyyyjjj.jjj	pco2 Computer Date/Time	n/a	Year/Julian Day.decimal Four fixed digits of year. Three fixed digits of julian day. Five fixed digits for decimal fractions of a julian day.
aaaa.aa	CO2 Raw Signal	n/a	mVolts
bb.bb	CO2 Analyzer Cell Temperature	n/a	Celcius
cccc.cc	PCO2 Barometer	n/a	mbar
ddd.dd	VCO2	n/a	ppm
e.ee	Equilibrator Water Temp	n/a	Celcius
fff.f	pCO2	n/a	uatm
gggg.gg	Flow Controller	n/a	mVolts
hh	Flow Meter	n/a	cc/min
i	Sample ID #	0 to 16	integer
k	Sample ID	Equil, Atmos, Nitrogen, CC18798, CA07163, CC15551, or CC63668	alphanumeric
llll.llllllm	CNav Latitude	0 to 90, N/S	degrees/minutes.decimal/direction
nnnnn.nnnnnno	CNav Longitude	0 to 180, E/W	degrees/minutes.decimal/direction
pp.pppp	TSG Internal Temperature	n/a	Celcius
q.qqqqq	TSG Conductivity	n/a	S/m
rr.rrrr	TSG Salinity	25 to 40	ppm
ss.s	WX01 Bird 1 Wind Speed 60 sec avg	n/a	knots
ttt	WX01 Bird 1 Wind Direction 60 sec avg	0 to 360	degrees
	WX01 Temperature		

uu.u	Instantaneous	n/a	Celcius
vvvv	WX01 Ship Barometer Instantaneous	n/a	mbar
w.ww	CNav Speed Over Ground / Speed Made Good	0 to 15	knots
xxx.x	CNav Course Made Good	0 to 360	degrees
yy.yyyy	SBE38 Temperature Probe	n/a	Celcius

LDEO PCO2 System

PCO2 outputs data in the following sentence format:

yyyyjjj.jjj aaaa.aa bb.bb cccc.cc ddd.dd e.ee fff.f gggg.gg hh i k

PCO2 Data

Item	Definition	Value	Units
yyyyjjj.jjj	pco2 Computer Date/Time	n/a	Year/Julian Day.decimal Four fixed digits of year. Three fixed digits of julian day. Five fixed digits for decimal fractions of a julian day.
aaaa.aa	CO2 Raw Signal	n/a	mVolts
bb.bb	CO2 Analyzer Cell Temperature	n/a	Celcius
cccc.cc	PCO2 Barometer	n/a	mbar
ddd.dd	VCO2	n/a	ppm
e.ee	Equilibrator Water Temp	n/a	Celcius
fff.f	pCO2	n/a	uatm
gggg.gg	Flow Controller	n/a	mVolts
hh	Flow Meter	n/a	cc/min
i	Sample ID #	0 to 16	integer
k	Sample ID	Equil, Atmos, Nitrogen, CC18798, CA07163, CC15551, or CC63668	alphanumeric

OBSIP Shotlog Format

Each OBSIP shotlog contains a header followed by shot records:

```
#obsipshotfile v1.0
#shotnumber date time sourceLat sourceLon shipLat shipLon waterDepth sciTag
0001280 2009-08-27 05:08:49.807873  48.495334 -129.201444  48.494097 -129.203017 2530.6 MGL0910_05
0001279 2009-08-27 05:12:33.961869  48.491860 -129.204474  48.490060 -129.205425 2526.4 MGL0910_05
0001278 2009-08-27 05:16:36.302883  48.488608 -129.206115  48.486807 -129.206944 2530.3 MGL0910_05
0001277 2009-08-27 05:19:51.053880  48.485157 -129.209212  48.483406 -129.209755 2526.1 MGL0910_05
0001276 2009-08-27 05:24:01.863875  48.480813 -129.212088  48.479293 -129.213152 2516.1 MGL0910_05
```

Shot records are in the following format:

```
0001276 2009-08-27 05:24:01.863875  48.480813 -129.212088  48.479293 -129.213152 2516.1 MGL0910_05
sssssss yyyy-mm-dd hh:mm:ss.ssssss  xx.xxxxxx  yyy.yyyyyy  vv.vvvvvv  www.wwwwww dddd.d lllllllllllllll
```

OBSIP record format

Item	Definition	Units
sssssss	shot number	n/a
yyyy-mm-dd	date	ISO8601 format
hh:mm:ss.ssssss	time	ISO8601 format
xx.xxxxxx	source lat	degrees, WGS84
yy.yyyyyy	source lon	degrees, WGS84
vv.vvvvvv	vessel lat	degrees, WGS84
ww.wwwwww	vessel lon	degrees, WGS84
dddd.d	depth	meters
lllllllllllllll	linename	n/a

Seabird Electronics SBE-45 Thermosalinograph Station Data

* Includes SBE-38 Remote Temperature Sensor Data

The Thermosalinograph data from the Seabird SBE-45 integrated temperature and conductivity unit is output in the following sentence formats that includes the Seabird SBE-38 Remote Temperature Sensor located at the Uncontaminated Seawater System intake in the bow of the RV Marcus G. Langseth.

FILE NAME: ***MGL-tsgraw.y****d****

tsgraw 2015:234:00:04:28.6392 t1= 27.7779, c1= 5.75784, s= 36.1196, sv=1541.693, t2= 27.6301
tsgraw yyyy:ddd:hh:mm:ss.ssss t1= tt.tttt, c1= cc.ccccc, s= ss.ssss, sv=vvvv.vvv, t2= tt.tttt

Item	Definition	Units
T1	Temperature from SBE 45 - TSG	°C, ITS-90
C1	Conductivity from SBE 45 - TSG	S/m
S	Salinity calculated from T1 and C1 by SBE 45	psu
SV	Calculated sound velocity based on S (or T1 and C1) from the SBE 45 and Temperature (T2) from the SBE 38. Using the Chen-Millero calculation.	Chen-Millero, m/sec
T2	Temperature from SBE 38 – Remote Temperature (USS)	°C, ITS-90

Gyroscope data

The gyroscope serial data is output in the following sentence formats:

- PTKM,HEALM -- Unspecified
- HEHDT -- Heading - True
- HEROT -- Rate Of Turn

$PCICM,HEALM,xxxx,x,xx*hh

ALM sentence format

Item	Definition	Units
xxxx	unspecified	n/a
x	unspecified	n/a
*hh	unspecified	n/a

$HEHDT,xxx.x,T*hh

HDT sentence format

Item	Definition	Units
xxx.x	Heading true	degrees
T	T = true	n/a
*hh	Checksum	n/a

$HEROT,-xxx.x,A*hh

HEROT sentence format

Item	Definition	Units
xxxx.x	Rate of turn	Degrees per minute, Note: "-" means bow turns to port
A	A = data valid	n/a
*hh	Checksum	n/a

Streamer Tension Unit Data

STU outputs data in the following sentence format:

aaa bbb cc dd ee f g hhhh iiii jjjj kkkk l m nnnn oooo pppp qqqq r s tttt uuuu vvvv wwww x y zzzz !!!! @@@@ ####

STU Data

Item	Definition	Value	Units
aaa	na	n/a	n/a
bbb	Julian Day	1 to 366	day
cc	Hour	0 to 24	integer
dd	Minutes	0 to 60	integer
ee	Seconds	0 to 60	integer
f	# 1 ID	1	integer
g	# 1 Channel #	0	integer
hhhh	# 1 Peak Tension	n/a	lbs
iiii	# 1 Average Tension	n/a	lbs
jjjj	# 1 Delta Tension	n/a	n/a
kkkk	# 1 Temperature	n/a	Celcius
l	# 2 ID	1	integer
m	# 2 Channel #	1	integer
nnnn	# 2 Peak Tension	n/a	lbs
oooo	# 2 Average Tension	n/a	lbs
pppp	# 2 Delta Tension	n/a	n/a
qqqq	# 2 Temperature	n/a	Celcius
r	# 3 ID	1	integer
s	# 3 Channel #	2	integer
tttt	# 3 Peak Tension	n/a	lbs
uuuu	# 3 Average Tension	n/a	lbs
vvvv	# 3 Delta Tension	n/a	n/a
wwww	# 3 Temperature	n/a	Celcius
x	# 4 ID	1	integer
y	# 4 Channel #	3	integer
zzzz	# 4 Peak Tension	n/a	lbs
!!!!	# 4 Average Tension	n/a	lbs

@@@@	# 4 Delta Tension	n/a	n/a
####	# 4 Temperature	n/a	Celcius

Vaisala WXT-520 Meteorological Station Data

The meteorological data from the Vaisala WXT-520 integrated weather station is output in the following sentence formats:

FILE NAME: ***MGL-vaisala.y****d****

*$WIMWV,105,R,3.8,N,A*32*
$WIMWV,x.x,R,y.y,N,A*32

Item	Definition	Units
x.x	Wind direction value: Wind direction is given in relation to the devices north-south axis.	Degrees
R	Wind direction unit (R = relative)	n/a
y.y	Wind speed value	Knots
N	Wind speed unit (knots	n/a
A	Data status: A = valid, V = Invalid	n/a

*$WIXDR,A,105,D,0,A,105,D,1,A,105,D,2,S,3.7,N,0,S,3.8,N,1,S,3.9,N,2,C,27.2,C,0,C,28.4,C,1,H,70.5,P,0,P,1013.5,H,0,V,0.00,M,0,Z,0,s,0,R,0.0,M,0,V,0.0,M,1,Z,0,s,1,R,0.0,M,1,R,1.7,M,2,R,0.0,M,3*6D*

$WIXDR,A,xxx,D,0,A,xxx,D,1,A,xxx,D,2,S,x.x,N,0,S,x.x,N,1,S,x.x,N,2,C,xx.x,C,0,C,xx.x,C,1,H,xx.x,P,0,P,xxxx.x,H,0,V,x.xx,M,0,Z,0,s,0,R,x.x,M,0,V,x.x,M,1,Z,0,s,1,R,x.x,M,1,R,x.x,M,2,R,x.x,M,3*6D

Item	Definition	Units
A	**Transducer id 0 type (Wind Direction)**	**n/a**
xxx	Transducer id 0 data (min wind direction)	Degrees
D	Transducer id 0 units (degrees, min wind direction)	n/a
0	Transducer id for min wind direction	n/a
A	Transducer id 1 type (wind direction)	n/a
xxx	Transducer id 1 data (average wind direction)	Degrees
D	Transducer id 1 units (degrees, average wind direction)	n/a
1	Transducer id for average wind direction	n/a
A	Transducer id 2 type (wind direction)	n/a
xxx	Transducer id 2 data (max wind direction)	Degrees
D	Transducer id 2 units (degrees, max wind direction)	n/a
2	Transducer id for max wind direction	n/a
S	**Transducer id 0 type (wind speed)**	**n/a**
x.x	Transducer id 0 data (min wind speed)	Knots
N	Transducer id 0 units (Knots, min wind speed)	n/a

0	Transducer id for min wind speed	n/a
S	Transducer id 1 type (wind speed)	n/a
x.x	Transducer id 1 data (average wind speed)	Knots
N	Transducer id 1 units (Knots, average wind speed)	n/a
1	Transducer id for average wind speed	n/a
S	Transducer id 2 type (wind speed)	n/a
x.x	Transducer id 2 data (max wind speed)	Knots
N	Transducer id 2 units (Knots, max wind)	n/a
2	Transducer id for max wind speed	n/a

C	**Transducer id 0 type (Temperature)**	**n/a**
xx.x	Transducer id 0 data (Temperature)	Celcius
C	Transducer id 0 units (C, Temperature)	n/a
0	Transducer id for Temperature	n/a
C	**Transducer id 1 type (temperature)**	**n/a**
xx.x	Transducer id 1 data (Tp internal temperature)	Celcius
C	Transducer id 1 units (C, Tp internal temperature)	n/a
1	Transducer id for Tp internal temperature	n/a
H	**Transducer id 0 type (Humidity)**	**n/a**
xx.x	Transducer id 0 data (Humidity)	% Reletive Humidity
P	**Transducer id 0 units (%, Humidity)**	**n/a**
0	Transducer id for Humidity	n/a
P	**Transducer id 0 type (Pressure)**	**n/a**
xxxx.x	Transducer id 0 data (Pressure)	hPA
H	Transducer id 0 units (hPa, Pressure)	n/a
0	Transducer id for Pressure	n/a

V	**Transducer id 0 type (Accumulated rainfall)**	**n/a**
x.xx	Transducer id 0 data (Accumulated rainfall)	millimeters
I	Transducer id 0 units (mm, Accumulated rainfall)	n/a
0	Transducer id for Accumulated rainfall	n/a
Z	**Transducer id 0 type (Rain duration)**	**n/a**
xx	Transducer id 0 data (Rain duration)	seconds
s	Transducer id 0 units (s, Rain duration)	n/a
0	Transducer id for Rain duration	n/a
R	**Transducer id 0 type (Rain intensity)**	**n/a**

x.x	Transducer id 0 data (Rain intensity)	mm/hr
M	Transducer id 0 units (mm/h, Rain intensity)	n/a
0	Transducer id for Rain intensity	n/a
V	**Transducer id 1 type (Hail accumulation)**	**n/a**
x.x	Transducer id 1 data (Hail accumulation)	hits/cm2
M	Transducer id 1 units (hits/cm2, Hail accumulation)	n/a
1	Transducer id for Hail accumulation	n/a
Z	**Transducer id 1 type (Hail duration)**	**n/a**
x	Transducer id 1 data (Hail duration)	seconds
s	Transducer id 1 units (s, Hail duration)	n/a
1	Transducer id for Hail duration	n/a
R	**Transducer id 1 type (Hail intensity)**	**n/a**
x.x	Transducer id 1 data (Hail intensity)	hits/cm2h
M	Transducer id 1 units (hits/cm2h, Hail intensity)	n/a
1	Transducer id for Hail intensity	n/a
R	**Transducer id 1 type (Rain peak intensity)**	**n/a**
x.x	Transducer id 1 data (Rain peak intensity)	mm/h
M	Transducer id 1 units (mm/h, Rain peak intensity)	n/a
2	Transducer id for Rain peak intensity	n/a
R	**Transducer id 1 type (Hail peak intensity)**	**n/a**
x.x	Transducer id 1 data (Hail peak intensity)	hits/cm2
M	Transducer id 1 units (hits/cm2, Hail peak intensity)	n/a

Vane Tension Load Cell Units Data

(Omega DP41-S High Performance Strain Gauge Indicators)

The Omega DP41-S Strain Gauges are directly linked to the Port and Starboard Seismic Streamer Barovane Tension Load Cells, the units are calibrated and output voltages to the Omega unit for conversion into Pounds (Lbs.) The Vane Tension Load data is output in the following serial format:

FILE NAME: ***MGL-vanep.y****d*** / MGL-vanes.y****d****

vanep 2015:171:23:59:59.9061 029096.
vanep yyyy:ddd:hh:mm:ss.ssss xxxxxxx.

Item	Definition	Units
xxxxxx	Strain force measured by load cell (pounds) to the nearest whole number	lbs

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to incidentally harass marine mammals, under the following conditions:

1. This incidental harassment authorization (IHA) is valid for one year from the date of issuance.

2. This IHA is valid only for geophysical survey activity in the Cape Fear submarine slide complex, off North Carolina in the Northwest Atlantic Ocean, as specified in L-DEO's IHA application.

3. General Conditions

   (a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO), and any other relevant designees of L-DEO operating under the authority of this IHA.

   (b) The species and/or stocks authorized for taking are listed in Table 1. Authorized take, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

   (c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

   (d) During use of the airgun array, if any marine mammal species that are not listed in Table 1 appear within or enter the Level B harassment zone (Table 3) the airgun array must be shut down.

   (e) L-DEO must ensure that relevant vessel personnel and the PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, marine mammal monitoring protocols, operational procedures, and IHA requirements are clearly understood.

   (f) L-DEO must notify the NMFS Southeast Regional Office (SERO) of the start and end date of seismic operations in the survey area via email (nmfs.ser.research.notification@noaa.gov).

4. Mitigation Requirements

The holder of this Authorization is required to implement the following mitigation measures:

a. No use of airguns is allowed from November 1 through April 30 for North Atlantic right whale migration. We request L-DEO submit daily observations to SERO (kara.shervanick@noaa.gov) during any non-airgun activities that are conducted between November 1 and April 30.

b. L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

c. At least one visual and two acoustic PSOs must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.

d. Visual Observation

i. During survey operations (e.g., any day on which use of the airgun array is planned to occur, and whenever the airgun array is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up of the airgun array.

ii. Visual monitoring of the shutdown and buffer zones must begin no less than 30 minutes prior to ramp-up, and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

iii. Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Estimated harassment zones are provided in Table 2 and 3 for reference.

iv. Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

v. During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the airgun array is not

operating for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable.

vi. Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

e. Acoustic Monitoring

i. The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the airgun array.

ii. When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

iii. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

iv. Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

1. Sea state is less than or equal to BSS 4;

2. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable shutdown zone in the previous two hours;

3. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

4. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

f. Shutdown zones and buffer zones

i. Except as provided in 4(f)(ii) and 4(f)(iii), the PSOs must establish and monitor a 500-m shutdown zone and additional 500-m buffer zone (total 1000 m). The 1000-m zone must serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iv) below, as appropriate. The shutdown zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the shutdown zone, out to a radius of 1000 meters from the edges of the airgun array (500–1000 m). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the shutdown zone) must be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the shutdown zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance).

ii. An extended 1500 m shutdown zone must be established for all beaked whales, dwarf and pygmy sperm whales, a large whale with a calf, and groups of six or more large whales. No buffer zone is required.

iii. The acoustic source must be shut down upon detection (visual or acoustic) of a North Atlantic right whale at any distance.

g. Pre-start clearance and Ramp-up

i. A ramp-up procedure must be followed at all times as part of the activation of the airgun array, except as described under 4(e)(iv).

ii. Ramp-up must not be initiated if any marine mammal is within the shutdown or buffer zone. If a marine mammal is observed within the shutdown zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes).

iii. Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes. The operator must provide information to the PSO documenting that appropriate procedures were followed.

iv. PSOs must monitor the shutdown and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation or acoustic detection of a marine mammal within the shutdown zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

v. Where operational planning cannot reasonably avoid such circumstances ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Acoustic source activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances.

vi. If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable shutdown zone. For any longer shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-start clearance watch is not required.

vii. Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

h. Shutdown requirements

i. Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the airgun array.

ii. The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

iii. When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the species described in 4(h)(iv)) appears within or enters the shutdown zone and/or (2) a marine mammal is detected acoustically and localized within the shutdown zone, the airgun array must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

iv. The shutdown requirement described in 4(h)(iii) shall be waived for small dolphins of the following genera: *Delphinus, Lagenodelphis, Stenella, Steno, and Tursiops.*

1. If a dolphin of these genera is visually and/or acoustically detected and localized within the shutdown zone, no shutdown is required unless the acoustic PSO or a visual PSO confirms the individual to be of a species other than those listed above, in which case a shutdown is required.

2. If there is uncertainty regarding identification, visual PSOs may use best professional judgement in making the decision to call for a shutdown.

v. Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable shutdown zone (*i.e.*, animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes) with no further observation of the marine mammal(s).

vi. Shutdown of the array is required upon observation of a species for which authorization has not been granted, or a species for which authorization has been granted but the authorized number of takes has been met, approaching or observed within any harassment zone.

i. Vessel strike avoidance

i. Vessel operators and crew must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammals. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal to taxonomic group (i.e., as a right whale, other large whale, or other marine mammal).

ii. All survey vessels, regardless of size, must observe a 10-kn speed restriction in specific areas designated by NMFS for the protection of North Atlantic right whales from vessel strikes. These include all Seasonal Management Areas (SMA) established under 50 CFR 224.105 (when in effect), any dynamic management areas (DMA) (when in effect), and Slow Zones. See *www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales* for specific detail regarding these areas.

iii. Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

iv. The vessel must maintain a minimum separation distance of 500 m from North Atlantic right whales. If a whale is observed but cannot be confirmed as a species other than a right whale, the vessel operator must assume that it is a right whale and take appropriate action.

v. The vessel must maintain a minimum separation distance of 100 m from sperm whales and all other baleen whales.

vi. The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).

vii. When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

viii. These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

5. Monitoring Requirements

Monitoring must be conducted in accordance with the following requirements:

a. The operator must provide PSOs with bigeye reticle binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

b. The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

i. PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

ii. Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).

iii. Global Positioning Unit (GPS) (plus backup).

iv. Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

v. Compass (plus backup)

vi. Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

vii. Any other tools necessary to adequately perform necessary PSO tasks.

c. Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

i. PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

ii. NMFS must review and approve PSO resumes.

iii. NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

iv. One visual PSO with experience as shown in 4(c) shall be designated as the lead for the PSO team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

v. PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

vi. PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

vii. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

d. Data Collection

i. PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

ii. At a minimum, the following information must be recorded:

1. Vessel name and call sign;

2. PSO names and affiliations;

3. Date and participants of PSO briefings (as discussed in General Requirement);

4. Dates of departure and return to port with port name;

5. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

6. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

7. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

8. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

9. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and

10. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

iii. Upon visual observation of any marine mammals, the following information must be recorded:

1. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

2. PSO who sighted the animal;

3. Time of sighting;

4. Vessel location at time of sighting;

5. Water depth;

6. Direction of vessel's travel (compass direction);

7. Direction of animal's travel relative to the vessel;

8. Pace of the animal;

9. Estimated distance to the animal and its heading relative to vessel at initial sighting;

10. Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

11. Estimated number of animals (high/low/best);

12. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

13. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

14. Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

15. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

16. Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and

17. Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

iv. If a marine mammal is detected while using the PAM system, the following information must be recorded:

1. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

2. Date and time when first and last heard;

3. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

4. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. The draft report must include the following:

(i) Summary of all activities conducted and sightings of marine mammals near the activities;

(ii) Summary of all data required to be collected (see condition 5(d));

(iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iv) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

(v) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(vi) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and

(vii) Raw observational data.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS Southeast Regional Stranding Coordinator (305-361-4586) as soon as feasible. The report must include the following information:

1. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

2. Species identification (if known) or description of the animal(s) involved;

3. Condition of the animal(s) (including carcass condition if the animal is dead);

4. Observed behaviors of the animal(s), if alive;

5. If available, photographs or video footage of the animal(s); and

6. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to the Southeast Regional Stranding Coordinator as soon as feasible. The report must include the following information:

1. Time, date, and location (latitude/longitude) of the incident;

2. Species identification (if known) or description of the animal(s) involved;

3. Vessel's speed during and leading up to the incident;

4. Vessel's course/heading and what operations were being conducted (if applicable);

5. Status of all sound sources in use;

6. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

7. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

8. Estimated size and length of animal that was struck;

9. Description of the behavior of the marine mammal immediately preceding and following the strike;

10. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

11. Estimated fate of the animal (e.g., dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

12. To the extent practicable, photographs or video footage of the animal(s).

(c) Reporting Species of Concern

(i) If a North Atlantic right whale is observed at any time by PSOs or personnel on any project vessels, during surveys or during vessel transit, L-DEO must immediately report sighting information to the NMFS North Atlantic Right Whale Sighting Advisory System: 877-WHALE-HELP (877-942-5343). North Atlantic right whale sightings in any location must

also be reported to the U.S. Coast Guard via channel 16 and through the WhaleAlert app (http://www.whalealert.org/).

7. Actions to minimize additional harm to live-stranded (or milling) marine mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

   (a) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise L-DEO that the shutdown around the animals' location is no longer needed.

   (b) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L-DEO that all live animals involved have left the area (either of their own volition or following an intervention).

   (c) If further observations of the marine mammals indicate the potential for restranding, additional coordination with L-DEO will be required to determine what measures are necessary to minimize that likelihood (e.g., extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

   (d) Additional information requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted, and an investigation into the stranding is being pursued, NMFS will submit a written request to L-DEO indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

      (i) Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

      (ii) If available, description of the behavior of any marine mammal(s) observed preceding (i.e., within 48 hours and 50 km) and immediately after the discovery of the stranding.

   In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing,

regarding the nature and location of survey operations prior to the time period above.

8. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, or (2) the prescribed measures are likely not or are not effecting the least practicable adverse impact on the affected species or stocks and their habitat.

9. Renewals

On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities are planned or (2) the specified activities would not be completed by the time this IHA expires and a Renewal would allow for completion of the activities, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (the Renewal IHA expiration date cannot extend beyond one year from expiration of this IHA).

(b) The request for renewal must include the following:

(i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed for this IHA, are a subset of the activities, or include changes so minor that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).

(ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings made in support of this IHA remain valid.

Kimberly Damon-Randall, Date

Director, Office of Protected Resources,

National Marine Fisheries Service.

Table 1. Authorized take numbers, by species

Species	Authorized Take	
	Level B	Level A
Humpback whale	2	0
Fin whale	4	0
Sei whale	8	0
Minke whale	10	0
Blue whale	1	0
Sperm whale	406	0
Kogia spp.	678	31
Cuvier's beaked whale	396	0
Mesoplodont Beaked whales	420	0
Pilot whales	385	0
Rough-toothed dolphin	82	0
Bottlenose dolphin	1,477	0
Atlantic white-sided dolphin	14	0
Pantropical spotted dolphin	114	0
Atlantic spotted dolphin	1,237	0
Spinner dolphin	41	0
Clymene dolphin	79	0
Striped dolphin	45	0
Fraser’s dolphin	163	0
Risso’s dolphin	189	0
Common dolphin	56	0
Melon-headed whale	83	0
Pygmy killer whale	6	0
False killer whale	6	0
Killer whale	4	0
Harbor porpoise	3	0

Table 2. Modeled Radial Distances (m) to Isopleths Corresponding to Level A Harassment Thresholds.

Airgun Configuration	Threshold	Level A harassment zone (m)		
		LF Cetaceans	MF Cetaceans	HF Cetaceans
18 airgun array (3300 in^3)	SELcum	101.9	0	0.5
	Peak	23.3	11.2	116.9

Table 3. Modeled Radial Distances (m) to Isopleths Corresponding to Level B Harassment Threshold.

Airgun Configuration	Water Depth (m)	Level B harassment zone (m)
18 airgun array (3300 in^3)	>1000m	2,886
	100-1000m	4,329