CRUISE REPORT

CORIOLIS II 2019001

SCOTIAN SHELF

AZMP TRANSECTS +

April 7 – 25

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CRUISE NARRATIVE

Highlights

Area Designation:	NAFO Regions: 5Ze, 5Y, 4X, 4W, 4Vs, 4Vn, 3Pn Extent: 41^{o} 52'N - 47^{o} 35'N; 055^{o} 50'W - 070^{o} 16'W
Expedition Designation:	COR2019001 or 18OL19001 (ISDM format)
Chief Scientist:	Andrew Cogswell Ocean Ecosystem Science Division Ocean Monitoring and Observation Section Department of Fisheries and Oceans Bedford Institute of Oceanography PO Box 1006 Dartmouth, NS, Canada B2Y 4A2 Andrew.Cogswell@dfo-mpo.gc.ca
Ship:	Coriolis II (call sign - CGDN) oceanographic research vessel
Ports of Call:	Apr 7th, 2019 – Depart BIO, Dartmouth, NS Apr 9th , 2019 – 2 science staff disembark, Yarmouth, NS Apr 9th , 2019 – Depart Yarmouth, NS Apr 15th, 2019 – Arrival BIO, Dartmouth, NS (weather) Apr 17th, 2019 – Depart BIO, Dartmouth, NS Apr 25th, 2019 – Arrival BIO, Dartmouth, NS
Cruise Dates:	Apr 7th – 25th

Mission Summary

Overview

* All times listed in the summary below are in Atlantic Standard Time.

On March 7th, well prior to sailing, the Master of the Coriolis II contacted the Canadian Coast Guard (CCG), Regional Operations Command Centre (ROC) in St. John's N.L. to secure dock space at the Bedford Institute of Oceanography (BIO) starting in the morning of Friday April 5th. Just prior to sailing, the forecast for the 4th and 5th was predicting strong winds from the west, which would make it difficult for the Coriolis II to depart her home berth at the Cove in Dartmouth. For this reason, the Coriolis II received permission from the ROC on the Wednesday the 3rd of April to arrive later that day at BIO. One day prior, On April 2nd, science staff from the Ocean Engineering and Technology Section (OETS) began the installation of the transducer for the mooring acoustic release in the well aboard the Coriolis II. The DFO CTD Technician also installed the deck unit and operating system for the CTD on the same day.
Mobilization began on April 5th and 6th and the ship was ready for departure by 9 am on April 7th. After the safety orientation, two CTD test casts were conducted in the basin. While a pump on the secondary CTD system was being changed and the plumbing for both systems was being flushed, we conducted a ring net test tow. Basin testing concluded with a final CTD cast before beginning the nearly 20 hour steam to Grand Manan Basin to recover the M2064 acoustic mooring and deploy M2090 at the same location on April 8th (Appendix 4) (Figure 1). On the steam to the next station in Jordan Basin, the mooring team prepared the next acoustic mooring for deployment. On our arrival in the morning of April 9th, M2089 was deployed and we were underway towards Yarmouth to disembark the mooring team (Jay Barthelotte and Matt Lawson) in the mid-afternoon of April 9th.

The ship was underway again shortly after our arrival in Yarmouth. We arrived at YL_01 in the afternoon of April 9th to begin occupations of the Yarmouth Line as we moved South West towards Portsmouth. We transited into American waters after midnight on April 10th, and occupied stations consecutively to YL_06 before moving directly to YL_10. From previous experience, we knew that a day time arrival at YL_10 and YL_09 was prudent because both stations are located in waters with a high concentration of fishing gear. PL_01 was then occupied just after 2100 and was immediately followed by PL_02 before traversing north to complete the last 2 stations on the Yarmouth Line (YL_08 and YL_07) by 10 am on April 11th. After a short steam to PL_03, the remaining Portsmouth Line stations were occupied as we moved south east towards PL_09, completing this line at ~0800 on April 12th.

At ~1300 on April 12th, we began with the occupation of BBL_07, followed successively by BBL_06 and BBL_05, finishing at ~2230, before proceeding to the first North East Channel Station (NEC_01). Work at NEC_01 began at ~0100 on April 13th, and was followed by even station occupations as we moved across the channel from east to west, finishing at NEC_10 at ~1230 before occupying odd stations as we reversed course and travelled east. We finished at NEC_03 at ~1930 on April 13th before returning to the Browns Bank Line at BBL_04 at ~2130. The Browns Bank Line stations were occupied in reverse order as we approached the coast of N.S., finishing at BBL_01 at ~0700 on April 14th.

It was clear that a broad and intense low pressure system was very likely to impact the region in the morning of April 15th. During much of the 1st week of sailing, the vessel had been working at

very near borderline weather conditions. As had been only occasionally experienced by our science program in the spring of 2017 aboard the Coriolis II, over the first week of the spring 2019 mission we experience sustained 20-25 kt winds and the ship had proven especially prone to intense rolling and pitching when on station. This created unsafe working situations on deck, which are elaborated on in the "Additional Remarks/Comments" section below. As a result, a decision was made to proceed directly towards HL_05, with the understanding that we would work our way back towards shore occupying Halifax Line stations consecutively until we finished at HL_01 at ~12 pm on April 15th. The vessel then returned to BIO to wait out the storm.

Conditions had improved sufficiently by April 17th, and we began our departure towards HL_05.5 by 0900. The swell was significant upon reaching the mouth of the harbour and we steamed rather slowly on our transit, not arriving at HL_05.5 until ~0300 on April 18th. Due to the time lost to weather and trasiting, a decision was made to cancel the eXtended Halifax Line stations, from HL_08 onward. Instead, we completed the occupation of the core Halifax line at HL_07 at ~1330 on April 18th. We then travelled Northwest towards the Gully MPA, beginning operations at SG_28 at ~1030 on April 19th. We then occupied stations SG_28 and GULD_03, finishing at 1700 on April 19th before weather conditions began to deteriorate. Again, it was expected that conditions would not allow for a safe working environment aboard this platform for at least the next 24 hours. To reduce the discomfort for the staff, the Captain sought shelter in the lee of the North side of Sable Island to avoid intense and persistent Southwesterly winds while we waited out the storm. In the late afternoon of April 20th, the sea state had improved and we began the steam south to GULD_04, arriving on site at ~0120 on April 21st and completing the occupation by ~0440 before steaming to SG_23 to complete the final Gully station occupation by 0940.

After a nearly 5 hour steam, the deepest station on the Louisbourg Line (LL_09) was occupied starting at ~1420. After the completion of consecutive Argo float deployments, the Coriolis II began to steam towards LL_08 at ~1948, where we began operations at ~2220. After this, the remaining Louisbourg Line nominal stations were occupied in descending order, finishing at LL_01 on April 23rd at ~0005 before beginning our turn around Cape Breton, heading north for the first station of the Cabot Strait Line (CSL_01). Work began at CSL_01 on April 23rd at ~0710 and finished at CSL_06 later that same day at ~2100 before beginning our steam south towards STAB_06. Late in the evening of April 23rd the weather began to deteriorate during our steam, and by the time we arrived on site, conditions made work on the ship impossible. A decision was quickly made to immediately head southwest towards STAB_05, which according to weather charts, would move us away from a low impacting the eastern side of the Laurentian Channel. We lost significant time in this transit as the ship had to adjust the heading to the west to avoid unsafe conditions aboard the vessel because of severe rolling and pitching. Once weather conditions began to improve, the course was corrected towards STAB_05 and we arrived on site to begin operations at 0915 on April 24th, 12 hours after our departure from CSL_06.

The St. Anns Bank Line was then occupied, starting at STAB_05 on April 24th at ~0840 and moving west towards Cape Breton, finishing at STAB_01 at 1810. The Coriolis then steamed nearly 6 hours west along the coast towards the last known coordinates of a mooring operated by Doug Shillinger. When they had attempted to release the mooring earlier in the year, the acoustic release had been successful, but the buoy never made it to the surface upon. The ship was given ½ hour to scan the area for a surface buoy, but fog and the time of day made for poor search conditions. We were underway just before midnight, as we began the 11 hour steam towards

HL_02. The occupation of HL_02 began at ~11 am on April 25th and was completed ~2.5 hours later at 1320 before steaming back to Halifax for a mid-afternoon arrival. This was followed by demobilization on April 26th.

Figure 1 and Table 1 show the mission route and an operational breakdown of the mission. As well, a list of mission participants and a table describing the level of completion for pre-defined mission-objectives is provided below (Table 2 and 3)

Additional Remarks/Comments

Vessel Safety

Throughout the mission, the vessel regularly experienced sea state conditions close to the edge of its ability to accommodate safe scientific operations (20-25 kts and ~1.5 - 2 m waves). The Captain and crew were safety focused, but the vessel dynamics coupled with the launch and recovery set up for the CTD made it challenging to safely operate. Within a week of the conclusion of the spring AZMP mission, a summary of safety concerns was relayed to our regional management team during the monthly AZMP Steering Committee meeting.

Other Issues of Note

It was noticed at the beginning of the mission that the CTD cable was not spooled properly on the winch. This caused significant issues throughout the mission when the winch had to be stopped upon the ascent of the CTD to adjust the spooling gear and/or fill voids in the cable on the drum. Over the mission, this resulted in a measureable slowdown in operations. It is strongly suggested that REFORMAR address this issue prior to providing similar program support in the future.

The changeover between Net and CTD operations aboard the Coriolis is on the order of 3-5 minutes. This is over 10 times longer than a similar gear swap on the CCGS Hudson. This meant that even though the size of the vessel meant that it could quickly arrive on station and commence operations, this agility was more than offset by the loss of time recovering and deploying the net system using the telescoping crane and the complexity and awkwardness of the CTD launch and recovery system.

On April 19th while occupying the SG_28 station, the CTD winch blew a fuse and was no longer responding on descent at 30 m above bottom. Luckily the ship was drifting into deeper water while the issue was being resolved and we were able to complete the cast. Nonetheless, under just slightly different circumstances this situation could have resulted in interaction with the bottom and, in an area as topographically diverse as the Gully MPA, loss of the instrument. This area is known for, and protected partially as a result of, its benthic diversity, so a bottom interaction at the wrong location could result in significant impacts to habitat. Upon conclusion of the cast, the winch was placed on a different circuit to reduce the likelihood that this would happen again.

On April 23rd, just after 1300, there was a complete power outage affecting all systems (including uninterrupted power supplies - UPS) in the navigation room. No instruments were in the water when this happened and no data were lost. Nonetheless, 2-3 hours was required to diagnose the problem and bring all systems back on line. The UPS system should have mitigated the impact

of this power loss, but it had not functioned properly. In the future when travelling on charter vessels, AZMP may want to consider providing its own UPS to supply power to critical systems.

Finally, throughout much of the mission the CTD deck unit was throwing an alarm that did not appear to be impacting data quality in any way. There was no clear impact on the quality of the cast data. The problem was investigated during our time north of Sable Island when the DFO and Coriolis Technicians conducted an electrical re-termination and checked the resistance of sea cable and the slip rings. There was nothing obviously wrong with the cable, but the seemingly pressure induced issue persisted at depths below 60 m for much of the final ¼ of the mission.

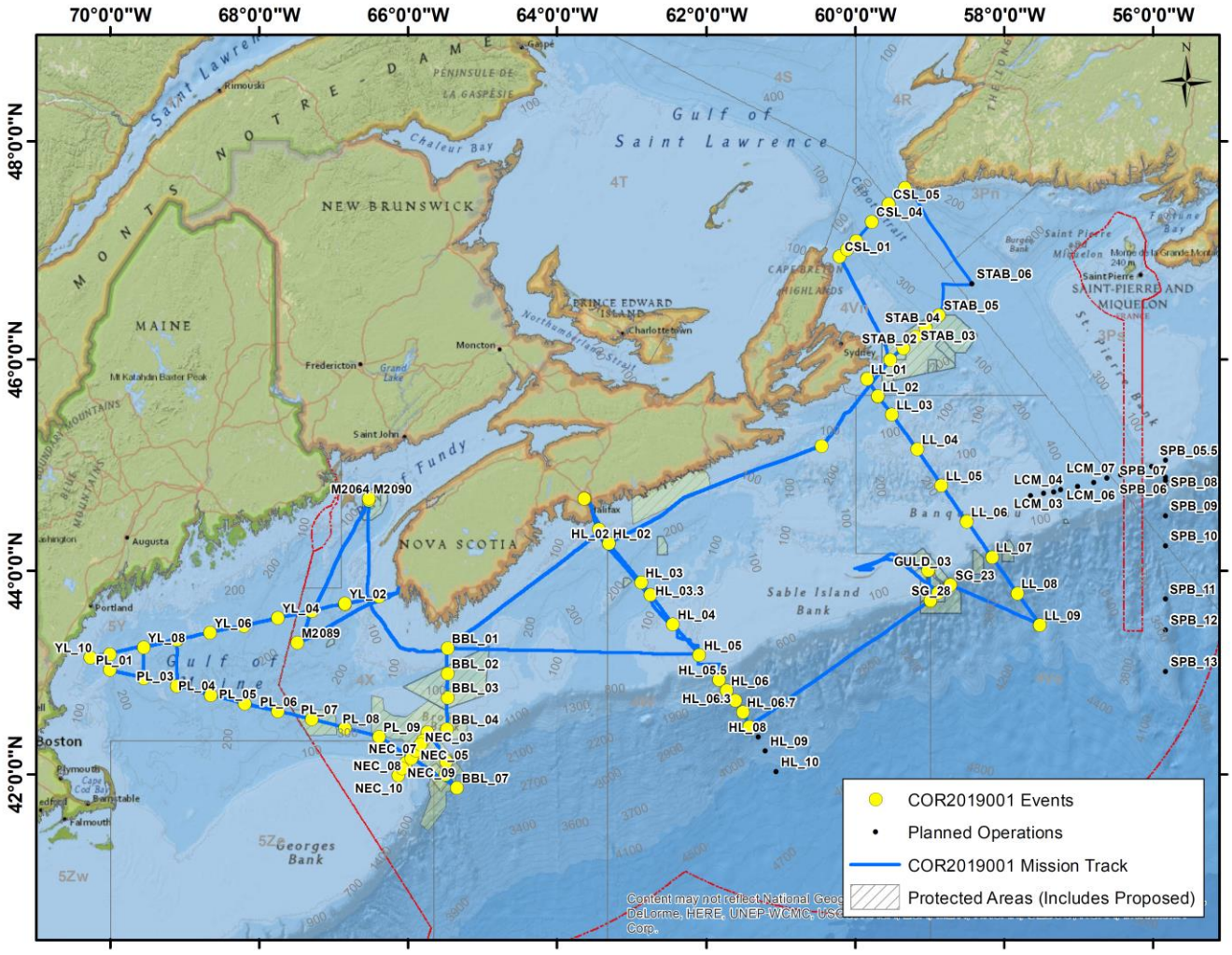


Figure 1. The locations for all 160 events during the COR2019001 AZMP fall survey. Some overlapping station labels may not be visible. Black dots represent stations that were planned but were not occupied because of time lost to weather.

Table 1. Operational time by gear type during COR2019001.

Gear	~Operation Duration (hrs)
CTD	~57
Vertical Net Tows	~23
Closing Nets	~0.5
Argo	~0.2
Mooring Deployment	~0.3
Mooring Recovery	~1.5
Mooring Search	~0.5
Release Test	~4
Secchi Disk	~0.05

Mission Participants

Table 2. List of science staff aboard the COR2019001 spring AZMP mission.

	Name	Affiliation	Duty	Shift
1	Barthelotte, Jay	DFO - OESD - OETS	Mooring Technician	Day
2	Cardoso, Diana	DFO - OESD	Data Manager	Day
3	Cogswell, Andrew**	DFO - OESD - OMOS	CTD/Elog	Day
4	Cormier, Terry	DFO - OESD - OETS	CTD Technician	Night
5	Emery, Pam	DFO - OESD - OES	Marine Mammal Observer/Whale Group	Day
6	Lawson, Matt	DFO - OESD – OETS	Mooring Technician	Day
7	Layton, Chantelle	DFO - OESD - OMOS	CTD/Elog	Night
8	MacIsaac, Kevin	DFO – OESD – OMOS	CTD/Nets/Biologist	Night
9	Perry, Tim	DFO - OESD – OMOS	Lab Technician and Night Shift Supervisor	Night
10	Rose, Sonja	Dal	Technician	Split
11	Spry, Jeff	DFO - OESD – OMOS	CTD/Nets/Biologist	Day
12	Thamer, Peter	DFO - OESD - OMOS	Lab Technician	Day
13	Waclawik, Magdalena	Dal	Technician	Split
14	Winkel, Jeannine	ECCC-CWS	Bird Observer	Day

DFO: Fisheries and Oceans Canada
OESD: Ocean Ecosystem Science Division
OMOS: Ocean Monitoring and Observation Section
OETS: Ocean Engineering and Technology Section
OES: Ocean Ecology Section
ECCC – CWS: Environment and Climate Change Canada, Canadian Wildlife Service
Dal: Dalhousie University
**Chief Scientist

Objectives

There were 15 defined objectives in the final version of the mission plan sent to the Coriolis II on March 28th, 2019. The 16th objective noted below in Table 3, was added just prior to sailing. Refer to Table 3 for a synopsis of the missions ability in meeting these objectives.

Mission Goals

Primary

1. Obtain spring observations of the hydrography and distribution of nutrients, phytoplankton and zooplankton at standard sampling stations along "**core**" Atlantic Zone Monitoring Program sections within the Maritimes Region (**Contact Mr. Andrew Cogswell** - http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html).

Additional

2. Carry out hydrographic, chemical and biological sampling at stations in the Gully in support of Gully MPA monitoring initiatives by Oceans and Coastal Management Division (**Contact Dr. Dave Hebert** - https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/gully/index-eng.html).
3. Nutrients and hydrography across the Northeast Channel and Gulf of Maine as part of NERACOOS Cooperative Agreement, (**Contact Dr. Dave Hebert** - http://www.neracoos.org/).
4. Deploy ARGO floats in support of the International Argo Float Program (**Contact Dr. Ingrid Peterson** - http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html).
5. Collect underway and CTD water samples at specified locations and depths to fulfil the regional component of an Aquatic Climate Change Adaptation Services Program (ACCASP) initiative investigating the delineation of ocean acidification and calcium carbonate saturation state of the Atlantic zone (**Contact Dr. Kumiko Azetsu-Scott** - http://www.dfo-mpo.gc.ca/science/oceanography-oceanographie/accasp-psaccma/index-eng.html).
6. Collect water samples for the Bertrand lab at Dalhousie University to evaluate whether and how organic and organometallic micronutrients influence primary productivity and phytoplankton community structure on the Scotian Shelf (**Contact Dr. Erin Bertrand** – https://www.dal.ca/faculty/science/biology/faculty-staff/our-faculty/erin-bertrand.html).
7. Collect water samples from strategic locations and depths to support a microbial community analysis via DNA, RNA and flow cytometry, as well as the isolation of novel diazotrophs (**Contact Dr. Julie Laroche** - http://www.dal.ca/faculty/science/biology/faculty-staff/our-faculty/julie-laroche.html).
8. Bird and mammal observations as part of EC-CWS sea-bird observation program and in fulfilment of Gully and St. Anns Bank MPA occupation requirements (**Contact Carina Gjerdrum –** carina.gjerdrum@canada.ca).
9. Carry out hydrographic, chemical and biological sampling at stations in the St. Anns Bank Marine Protected Area as a continued monitoring effort in support of Oceans and Coastal Management Division (**Contact Dr. Dave Hebert** - http://www.dfo-mpo.gc.ca/oceans/mpa-zpm/stanns-sainteanne/index-eng.html).
10. Conduct hydrographic, chemical and biological sampling across the mouth of the Laurentian Channel and St. Pierre Bank. These transects have been implemented to enhance our understanding of hydrographic phenomenon in support of current modelling efforts (**Contact Dr. Dave Brickman**).

11. Mammal observations as part of DFO Whale Group observation program and fulfilment of Gully and St. Anns Bank MPA occupation requirements (**Contact Dr. Hilary Moors-Murphy –** Hilary.Moors-Murphy@dfo-mpo.gc.ca).
12. Deploy 2 and recover 1 Autonomous Multichannel Acoustic Recorders (AMAR) in support of Oceans Protection Plan, National Conservation Plan and Species at Risk funded projects investigating ambient and anthropogenic noise, and the occurrence of North Atlantic right whales and other cetacean species on the Scotian Shelf (**Contact Dr. Hilary Moors-Murphy** - https://profils-profiles.science.gc.ca/en/profile/hilary-moors-murphy).
13. Collect EK60 acoustic data for Right Whale foraging project (**Contact Dr. Catherine Johnson).**
14. Two-layer stratified net sampling will be performed at the Halifax-2 station to improve estimates of *Calanus sp.* transition timing between active development in near-surface waters and diapause in deep water. Depth strata are 0 - 80 m and 80 m – bottom (**Contact Dr. Catherine Johnson).**
15. An RBR Concerto CTD will be run alongside the 911 to do a comparison of the RBR conductivity pressure correction for the new C cell (which they recently updated), towards understanding how it will behave when deployed on freely-drifting Argo floats, as well as their new thermal-mass corrections (**Contact Dr. Clark Richards)**.
16. Additional nutrient samples collected at HL_02 for inter-regional comparison (**Contact Mr. Peter Thamer -** added just prior to sailing).

Table 3. Status of objectives upon completion of the COR2019001 mission.

Objective	Status	Comments
1	Completed	
2	Completed	
3	Completed	
4	Partially Completed	XHL and SPB deployment stations were dropped because of time lost due to weather, so only 2/4 planned floats were deployed, and only at LL_09.
5	Partially Completed	Due to limited bench space in the lab the underway system was not installed so ocean acidification samples could only be taken from nominal CTD locations and depths specified prior to sailing. Due to time lost because of weather, not all of these stations could be occupied.
6	Completed	
7	Completed	
8	Completed	
9	Completed	STAB_06 is outside of the eastern boundary of the St. Anns Bank MPA, but it could not be occupied because of inclement weather.
10	Cancelled	Early mission weather delays meant that we had to cut the lower priority Laurentian Channel and St. Pierre Bank stations.
11	Completed	
12	Completed	
13	Completed	
14	Completed	
15	Completed	
16	Completed	

SUMMARY OF ACTIVITIES

CTD Summary

Narrative

A small group of science staff visited the Coriolis II on January 16th to discuss logistical issues in the lead up to the spring 2019 AZMP shelf survey. A decision was made prior to this visit that REFORMAR would ship their SBE32 frame and pylon to BIO along with 24 bottles. It was agreed that DFO would provide all cables, sensors, plumbing, frame weights and deck units for the mission. The equipment arrived at BIO on January 30th and our CTD technician from the Ocean Engineering and Technology Section (OETS), began assembling the CTD and rosette components prior to sailing. The decision for DFO to supply our own sensors comes from an observation we made concerning the drawings of the proposed CTD set up by REFORMAR sent to us on January 10th. It was clear that all of the sensors provided by REFORMAR were to be equipped with wet pluggable XSG bulkhead connectors and their associated cables. Reformar was not able to provide spare sensors or cables, as they were not specified in the RFP, so there was concern that if we did send DFO spares aboard the Coriolis II with the standard MCH bulkhead connectors, that we'd need to order more jumper cables from SeaBird to do so. Unfortunately, a change in cable supplier for SeaBird made this impossible in the time frame available, so a decision was made that DFO would outfit the CTD using our sensors, so we'd have access to spares if the need arose.

When we started mobilizing the ship on the 5th of April, it was clear that the mechanical termination completed by the Ship's Technician would have to be re-done because the nut at the end of the termination could not mate with the round bar at the top of the CTD rosette frame. The new termination was completed by OETS staff prior to sailing. As mentioned in the "Additional Remarks/Comments" section of the Mission Overview, it was noticed prior to sailing that the CTD cable was spooled with gaps on the drum. As it turns out, this was an issue throughout the mission because the spooling gear often had to be adjusted on ascent so the cable would not pile up in the center of the drum.

The bridge would orient the ship to minimize roll in an attempt to improve launch and recovery conditions for the CTD. Unfortunately, this meant that the ship would then pitch instead of roll, trading a safety concern for generally poor CTD profiles. The stern LARS meant that the pitching was amplified, making for very large loops in the pre-processed profile data, often resulting in perceived density inversions. The SeaBird "Loop Edit" Module would remove the worst offenders but it should be noted that on days with bad seas, this was a significant issue.

In the morning of April 7th, the CTD system was tested at HL_00 in Bedford Basin. A full depth cast was conducted and all bottles were fired at the bottom (Event 001). The secondary profile data was not what we expected, showing large differences with the primary system. On recovery, both systems were flushed with Triton, the bleeder valve was cleaned and another cast was conducted (Event 002). The problem persisted with the secondary system, so upon recovery the secondary pump was replaced and the problem was mitigated.

YL_01 was the first station to be occupied upon completion of the mooring work. It was clear during the cast that the secondary oxygen sensor was still an issue, with large oscillations. Upon

recovery, the oxygen cable and secondary sensor (S/N: 0042) was replaced (S/N: 3030) and a new configuration file was produced and used for the remainder of the mission (COR2019001_B.xmlcon – Appendix 1)

There were a total of 77 CTD casts during the mission (Figure 2 and Table 4). Two of these were aborted casts: events 011 (YL_02) and 118 (LL_07). During event 011, the primary system was showing bad data upon deployment, because the plumbing had come undone. During event 118, the cap had been left on the pH sensor.

Throughout much of the mission, the deck unit was throwing a "Communication Error". During these errors, data quality was not impacted and the "Acquisition Logs" showed an "on/off error" with the pumps, but it was clear that this was not affecting the data output. There were also no dropped scans and the NMEA data looked fine throughout the mission. As can be observed in Table 4, these errors were a regular occurrence and despite efforts to diagnose the problems (e.g., cable replacements, electrical termination, checking the resistance of the sea-cable and slip rings, etc…), it was never properly diagnosed or rectified.

The sensors on the package functioned well for the entirety of the mission and only minor problems were observed. For example, during event 100 at HL_06.7, bottle number 2 (Sample ID 473585) was compromised because the vent cap was left off the top. Other than the persistent general error described in the previous paragraph, the spooling of the winch and the large loops in the profile data, the system worked as expected.

Finally, upon conclusion of the mission when examining the .HDR and .ODF files, there was a 24 hour offset between the NMEA UTC time for the CTD computer and NMEA UTC time for the CTD computer for 9 profiles (Events: 34, 64, 92, 98, 104, 123, 137, 147 and 160 – refer to Table 4). R Script was written to identify the casts for which this occurred and "fix" the NMEA time in the .HDR, and .HEX files (Appendix 5). As well, there was a mission wide discrepancy between the NMEA UTC time (GPS time) and the System UTC time (computer time). During the CTDDAP processing, the System UTC parameter that is present in the .HDR, .HEX and for every bottle fire in the .BL file, comes from the CTD computer time, which is normally synced with the NMEA UTC. On this mission the 2 times were not synced, so R script was written to adjust the System UTC by replacing all instances of it in the .HEX and .HDR files with the NMEA UTC time. As well, all times in the .BL file were adjusted by adding 3 hours, 59 minutes and 44 seconds. These raw files were then used to reprocess the data and produce new .ODF and QAT files that are now stored on ODIS serves (Data Management Section).

Conditions

Preliminary section plots and anomalies (where available) of temperature (°C), salinity (P.S.U.) and sigma-t (kg/m^3) in order of occupation (Yarmouth, Portsmouth, Northeast Channel, Browns Bank, Halifax, Louisbourg, Cabot Strait, and St. Anns Bank) can be viewed in Appendix 3. Please note that the Halifax line was occupied from HL_05 to HL_01 on April 14th and 15th and after a nearly 2 days weather delay we completed the deeper part of the line from HL_05.5 to HL_07 on April 18th and 19th.

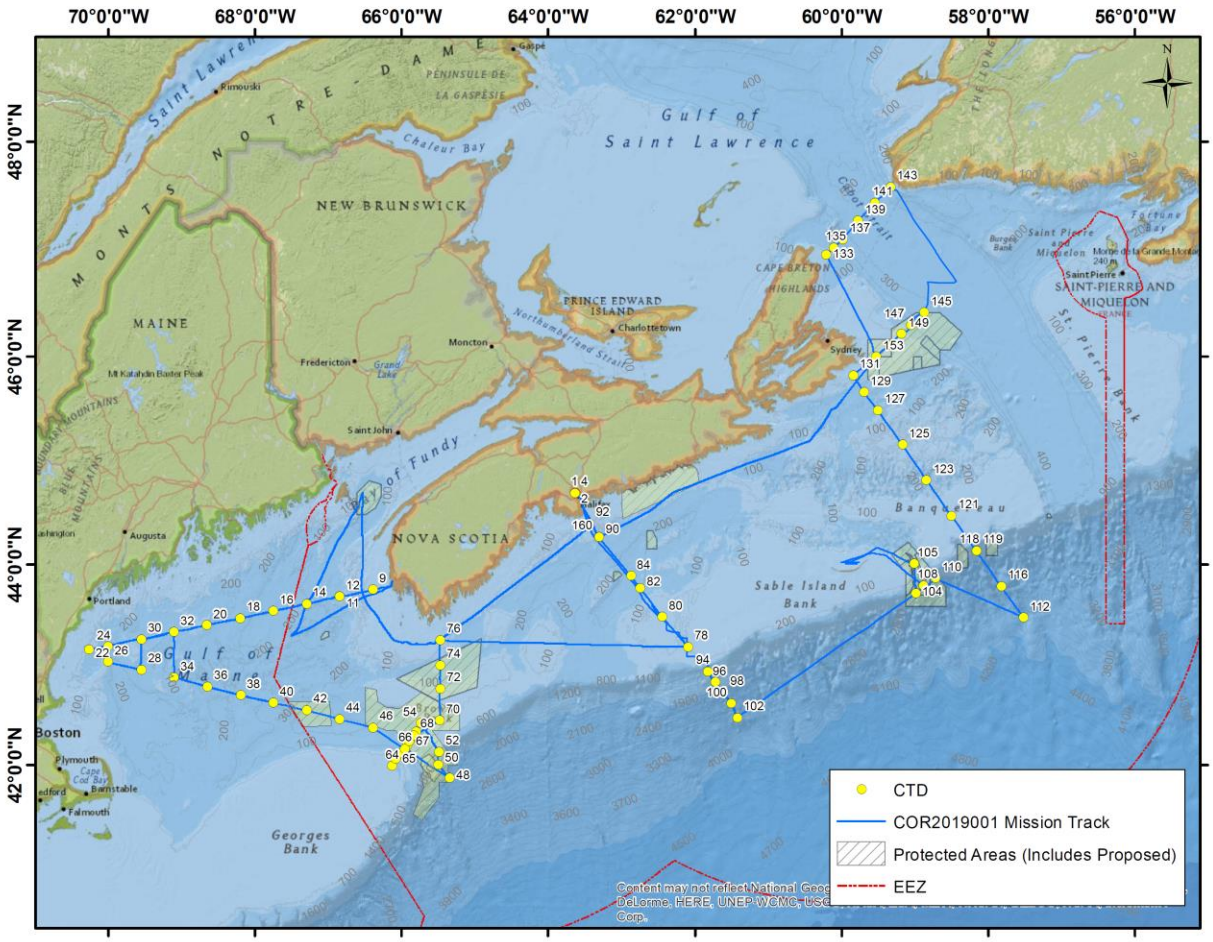


Figure 2. Locations for the 77 CTD casts during COR2019001 AZMP fall survey. Each cast is labelled with the consecutive mission event.

Table 4. CTD casts during the COR2019001 AZMP spring survey. The coordinates provided are in decimal degrees and reflect the ship's position at the time of deployment as recorded using the ELOG meta-data logger.

#	Event	Station	Date	Slat (DD)	Slon (DD)	Sounding (m)	pH	Water Collected	Aborted	Comments
1	1	HL_00	07/04/2019	44.694	-63.64	70	pH			All bottles fired at bottom for test and both systems need to be flushed.
2	2	HL_00	07/04/2019	44.6957	-63.6447	72	pH			All bottles fired at bottom for test. Both primary and secondary sensors flushed with Triton between casts. Secondary bank of sensors continues to be a problem. Could very likely be the pump. We are going to change the pump on the secondary and re-test.
3	4	HL_00	07/04/2019	44.6959	-63.6446	71	pH			With new pump on secondary. No bottles fired. Both temperature salinity and oxygen in good agreement on downcast. Generally good agreement between T and S on upcast. Oxygen still slightly off.
4	9	YL_01	09/04/2019	43.7509	-66.3999	76	pH	X		The secondary oxygen sensor is still an issue large oscillations upon deployment this should be investigated upon recovery. Other secondary sensors are oscillating as well but not at the same rate
5	11	YL_02	09/04/2019	43.6799	-66.8514	122	pH	X	X	Primary system needs to be flushed with triton. Upon inspection the primary plumbing had come undone.
6	12	YL_02	09/04/2019	43.6805	-66.8498	129	pH	X		
7	14	YL_03	10/04/2019	43.6102	-67.3034	210	pH	X		
8	16	YL_04	10/04/2019	43.5384	-67.7531	247	pH	X		
9	18	YL_05	10/04/2019	43.4677	-68.2123	183	pH	X		

#	Event	Station	Date	Slat (DD)	Slon (DD)	Sounding (m)	pH	Water Collected	Aborted	Comments
10	20	YL_06	10/04/2019	43.3985	-68.663	144	pH	X		
11	22	YL_10	10/04/2019	43.1544	-70.2716	123	pH	X		
12	24	YL_09	10/04/2019	43.186	-70.0092	91	pH	X		
13	26	PL_01	11/04/2019	43.0333	-70.008	140	pH	X		Start time latitude and longitude taken from playback of hex file.
14	28	PL_02	11/04/2019	42.9552	-69.5578	173	pH	X		Communication error on the way up suspect it might be the Seapoint it will be checked before next station.
15	30	YL_08	11/04/2019	43.2581	-69.5564	158	pH	X		In between stations the jumper for the Seapoint was changed
16	32	YL_07	11/04/2019	43.3281	-69.106	152	pH	X		Salinity and temperature differences on up cast quite large. Flush both primary and secondary on recovery.
17	34	PL_03	11/04/2019	42.8768	-69.1071	180	pH	X		Communication alarm at 60 m but CTD continued to function as did all sensors.
18	36	PL_04	11/04/2019	42.7891	-68.6558	198	pH	X		
19	38	PL_05	11/04/2019	42.7024	-68.2049	184	pH	X		
20	40	PL_06	12/04/2019	42.6258	-67.7533	201	pH	X		Manual recording of event number, sounding and time position.
21	42	PL_07	12/04/2019	42.5525	-67.3017	301	pH	X		Manual recording of event number, sounding and time position.
22	44	PL_08	12/04/2019	42.4619	-66.8529	330	pH	X		Manual recording of event number, sounding and time position.
23	46	PL_09	12/04/2019	42.3766	-66.4017	267	pH	X		
24	48	BBL_07	12/04/2019	41.8662	-65.3501	1888		X		Alarm briefly sounded ~100 m off bottom when winch speed dropped to zero from 60 m/min when transitioning to 30 m/min. Changed remote display to pressure from salt water depth on up cast at 1500 m. The cable had to be spooled out a little at ~370 m

#	Event	Station	Date	Slat (DD)	Slon (DD)	Sounding (m)	pH	Water Collected	Aborted	Comments
										to remove a large hump in the spool.
25	50	BBL_06	12/04/2019	42.0009	-65.5105	1080	pH	X		
26	52	BBL_05	13/04/2019	42.1333	-65.4998	190	pH	X		Upon reaching the bottom the pressure readings jumped up 10m and the altimiter readings gave 20m above the bottom instead of 10m suspect it could be software. TC suggested turning the computer on and off during our weather day.
27	54	NEC_01	13/04/2019	42.4195	-65.745	101	pH	X		Bottle 2 fell off its mount. we almost lost her, water samples were able to be taken from it.
28	56	NEC_02	13/04/2019	42.3375	-65.8095	205	pH	X		Had to stop to re-spool the wire on the way up to 75m
29	58	NEC_04	13/04/2019	42.2723	-65.8699	231	pH	X		
30	60	NEC_06	13/04/2019	42.2004	-65.9365	227	pH	X		
31	62	NEC_08	13/04/2019	42.1172	-66.0373	208	pH	X		
32	64	NEC_10	13/04/2019	41.9879	-66.1409	92	pH	X		
33	65	NEC_09	13/04/2019	42.0617	-66.0837	96	pH	X		
34	66	NEC_07	13/04/2019	42.1631	-65.9693	226	pH	X		
35	67	NEC_05	13/04/2019	42.2335	-65.9052	239	pH	X		pH bottle left on during the cast.
36	68	NEC_03	13/04/2019	42.2995	-65.8398	218	pH	X		
37	70	BBL_04	14/04/2019	42.4498	-65.4842	101	pH	X		
38	72	BBL_03	14/04/2019	42.7642	-65.4811	105	pH	X		
39	74	BBL_02	14/04/2019	43.0005	-65.4812	119	pH	X		
40	76	BBL_01	14/04/2019	43.2507	-65.4799	63	pH	X		
41	78	HL_05	14/04/2019	43.1833	-62.101	101	pH	X		
42	80	HL_04	15/04/2019	43.48	-62.4516	87	pH	X		
43	82	HL_03.3	15/04/2019	43.7643	-62.7527	208	pH	X		
44	84	HL_03	15/04/2019	43.885	-62.8843	267	pH	X		
45	90	HL_02	15/04/2019	44.2662	-63.3164	153	pH	X		Extra nutrients collected for regional comparison study
46	92	HL_01	15/04/2019	44.4009	-63.4486	88	pH	X		
47	94	HL_05.5	18/04/2019	42.9396	-61.8341	460	pH	X		

#	Event	Station	Date	Slat (DD)	Slon (DD)	Sounding (m)	pH	Water Collected	Aborted	Comments
48	96	HL_06	18/04/2019	42.8319	-61.7341	1116	pH	X		Adjusting spooling gear periodically at beginning of ascent. Declutch at 10 m starting this cast to avoid prop wash.
49	98	HL_06.3	18/04/2019	42.7313	-61.6157	1723		X		
50	100	HL_06.7	18/04/2019	42.6164	-61.5169	2327		X		Bottle number 2 473585 - the bottle was compromised because the vent cap was left off the top. Will replace with a new vent cap before the next cast.
51	102	HL_07	18/04/2019	42.4752	-61.4334	2760		X		Had to stop to adjust cable coming in multiple times probably added 10-15 min to this station. Deck unit chirped on the way up around 160m while they were adjusting the cable. Communication/receiving error repeatedly when at 150m waiting to fire bottle.
52	104	SG_28	19/04/2019	43.7134	-58.9995	754	pH	X		Drifting south through coordinates for station due to wind/current. Started north of planned location. deck unit throwing computer interface recieving errors and word display going to 0001 upon descent to 100 m. Periodic but does not seem to affect data received. More frequent at 200 m. Winch stopped working 30 m above bottom and breaker would not start the winch. Started back up about 5 minutes later. he pH profile is very different on the up cast. When Terry is up, we should consider changing this. The deck unit is in error at 250 but the data collection

#	Event	Station	Date	Slat (DD)	Slon (DD)	Sounding (m)	pH	Water Collected	Aborted	Comments
										is still good. Alarm sounding all the way until the surface. 4 cables west of station upon conclusion of cast but up and down cast matched well. Alarm turned off at 20 m.
53	105	GULD_03	19/04/2019	44.0032	-59.0193	430	pH	X		Reversed operations due to increasing winds and seas. CTD first, then nets. Deck unit throwing errors on descent past 20 m. When winch slowed on ascent at 100m off bottom - alarm did not shut off. Data still good. Alarm persists on return to the surface.
54	108	GULD_04	21/04/2019	43.7902	-58.9005	2036		X		Deck unit threw an error alternated between communication and 001 starting around 80m on the way down fairly persistently stopped around 230m briefly then consistently at 330m all the way to the bottom. Pump failure. Data still coming in and primary and secondary agreed so continued with profile. TC plans to change out pumps and examine cables. T/S/Oxy still matched on upcast. Some slight devotions from the downcast around 1000m but mainly in oxygen could be due to the fact that we drifted so far off station. Alarm stopped sounding at 20m. Forgot to radio bridge when we were at 20m. TC changed both primary and secondary pump and the cable.
55	110	SG_23	21/04/2019	43.8596	-58.7312	1223	pH	X		

#	Event	Station	Date	Slat (DD)	Slon (DD)	Sounding (m)	pH	Water Collected	Aborted	Comments
56	112	LL_09	21/04/2019	43.4734	-57.5276	3712		X		Deck unit continuing to throw an alarm upon descent. Sporadic from surface to 500 m. The Altimeter was reading a bottom on descent starting at 600 m. Work done on drum at edges to fill gaps at 50 m off bottom upon ascent. Deck unit threw error at 500m on upcast 0001 error. Stopped at 50m.
57	116	LL_08	22/04/2019	43.7841	-57.8332	2893		X		Alarm sounded from 40m to 190m deck unit showed 0001 error. Chirping around 200m on the way up then stayed on until 80m 0001 on word display
58	118	LL_07	22/04/2019	44.1327	-58.1744	770	pH	X	X	Forgot to take pH cap off.
59	119	LL_07	22/04/2019	44.1319	-58.175	769	pH	X		Stopping the drum on ascent to fix the cable. Alarm on ascent starting at 500 m. Alarm stopped at 80 m on ascent. Upon recovery the pH cable was replaced.
60	121	LL_06	22/04/2019	44.475	-58.5082	66	pH	X		Additional nuts for regional comparison study. Alarm sounding on descent.
61	123	LL_05	22/04/2019	44.8169	-58.8497	239	pH	X		The bottom cap of bottle 12 is closing and filling with water at the surface. The rubber band should be shortened.
62	125	LL_04	22/04/2019	45.1586	-59.1757	104	pH	X		
63	127	LL_03	22/04/2019	45.4904	-59.5155	148	pH	X		
64	129	LL_02	23/04/2019	45.6604	-59.7034	142	pH	X		
65	131	LL_01	23/04/2019	45.8255	-59.8511	95	pH	X		
66	133	CSL_01	23/04/2019	46.959	-60.2161	80	pH	X		
67	135	CSL_02	23/04/2019	47.0226	-60.1162	185	pH	X		Alarm sounded on ascent but deltas are good and no bad data.
68	137	CSL_03	23/04/2019	47.1003	-59.9911	334	pH	X		Just prior to the cast all power was

#	Event	Station	Date	Slat (DD)	Slon (DD)	Sounding (m)	pH	Water Collected	Aborted	Comments
										lost in the lab and none of the equipment on UPS maintained power. It took about 1/2 hour to get everything back on and establish NAV link for Elog through the Regulus computer. Alarm started at 60 m on ascent and did not shut off until recovery.
69	139	CSL_04	23/04/2019	47.2712	-59.7831	482	pH	X		
70	141	CSL_05	23/04/2019	47.4357	-59.5564	478	pH	X		Alarm sounding on descent sounding at ~130 m. Alarm stopped sounding at 40 m on the upcast.
71	143	CSL_06	23/04/2019	47.5833	-59.3423	271	pH	X		Alarm 0001 on downcast at 30m stopped at 110m then back on at 140m to the bottom. Alarm stopped at 80m on upcast some chirping from 20m to the surface. Data still looked good.
72	145	STAB_05	24/04/2019	46.4167	-58.8827	373	pH	X		Alarm started sounding at 40 m on descent. Not affecting data quality. Alarm off at 40 m on ascent.
73	147	STAB_04	24/04/2019	46.2995	-59.0637	162	pH	X		Alarm sounded at 30 m on descent.
74	149	STAB_03	24/04/2019	46.2158	-59.1949	94	pH	X		Alarm sounded at 30 m on descent.
75	151	STAB_02	24/04/2019	46.1076	-59.3646	67	pH	X		
76	153	STAB_01	24/04/2019	46.0018	-59.534	63	pH	X		
77	160	HL_02	25/04/2019	44.2665	-63.3168	157	pH	X		Alarm below ~60 m on ascent and descent.

Oxygen

The oxygen data collected by the CTD sensors and Winkler titration method will be used to create new calibration coefficients before the final run of the CTD processing. It will be necessary to extract these corrected oxygen values when they are produced so they can be accurately reflected in our data archives.

The adjusted Soc values are calculated by a 2 step process. First, a "threshold field" is produced that subtracts the mean difference between the sensor and the average Winkler value for all samples, from the individual sample difference between the sensor and Winkler:

Equation 1: (SBE O2 – Winkler O2) - mean(SBE O2 – Winkler O2)

The next step calculates a new slope term by using the following equation:

Equation 2: NewSoc = mean(previousSoc*([Winkler O2]/[SBE O2]))

As noted in the Narrative section, the secondary oxygen sensor #0042 was replaced with #3030 after event 9 (YL_01). All coefficient calculations conducted below use data from events 011 to 160.

The first step is to compare the differences between the primary (#0133, calibrated Nov 22nd, 2018) and the secondary (#3030, calibrated Nov 27th, 2018) sensors and remove any outliers beyond the 1.5 IQR before proceeding (Figure 3). Of the 9 outliers, 7 of them come from a single cast during event 009 at YL_01. It was obvious that the secondary sensor needed to be changed as described in the previous paragraph.

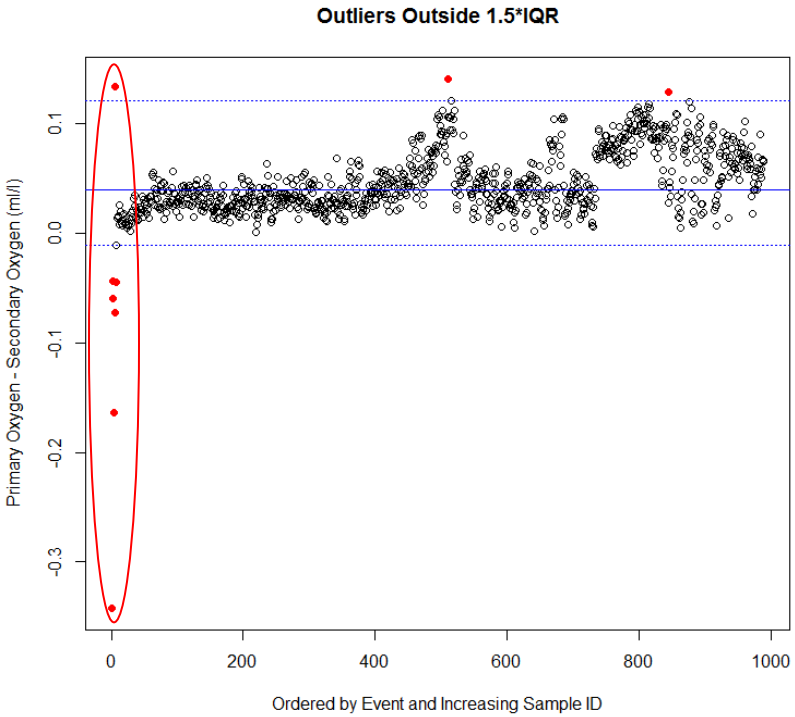


Figure 3. The comparrison between the primary and secondary oxygen values throughout the mission (Mean = -0.040, IQR min = -0.011, IQR max = 0.120). YL_01 (event 009) data are circled in red.

After event 009 (YL_01) the primary and secondary sensors remain consistantly different from each other until just prior to event 092 at HL_01, after which point the difference goes back to normal. A slight jump is also observed at event 119 (LL_07) and increases until a maximum during event 135 (CSL_02), then declining gradually until the end of the mission. These differences after YL_01 are small enough that the mission does not necessarily need to be parsed to calculate a time adjusted Soc coefficient for post-processing. In fact, the average difference between the primary and secondary sensor throughout the mission was ~0.04 ml/l.

The next step was to compare the Winkler replicates throughout the mission. In total, 10 of the 44 (23%) rows where Winkler replicates were taken during the first half of the mission were removed prior to proceeding (Figure 4).

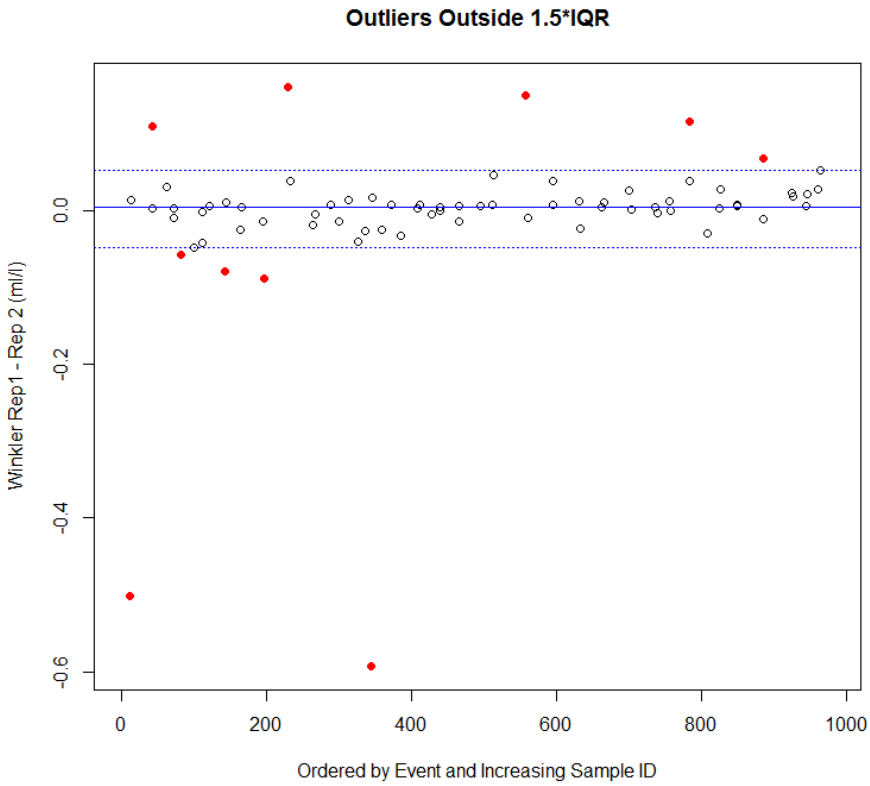


Figure 4. Comparrison of winkler replicates (Mean = -0.005, IQR min = -0.049, IQR max = 0.053). Red dots are outliers beyond the 1.5 IQR.

Equation 1 was then used on both the primary and secondary sensors to identify threshold outliers for removal (1.5 IQR) prior to the calculation of revised Soc values.

The revised Soc values were then calculated and the ratio between the new and old values (Table 5) were used to correct the primary and secondary sensors.

Table 5. Previous and new Soc values for the primary and secondary oxygen sensors.

	Old Soc	**New Soc**	**Ratio**
Primary #0133	4.1725e-1	4.3580e-1	1.0445
Secondary #3030	4.8965e-1	5.1459e-1	1.0509

Figure 5 shows the uncorrected and corrected primary and secondary sensor data. These data were corrected using the ratios from Table 5, and the corrected sensor data now rougly demonstrates a 1:1 relationship with the Winkler data. Figure 6 shows the relative difference between the 2 sensors before and after correction. Before correction, there was a mean difference between sensors of 0.047 ml/l, but after correction this was reduced to 0.004 ml/l.

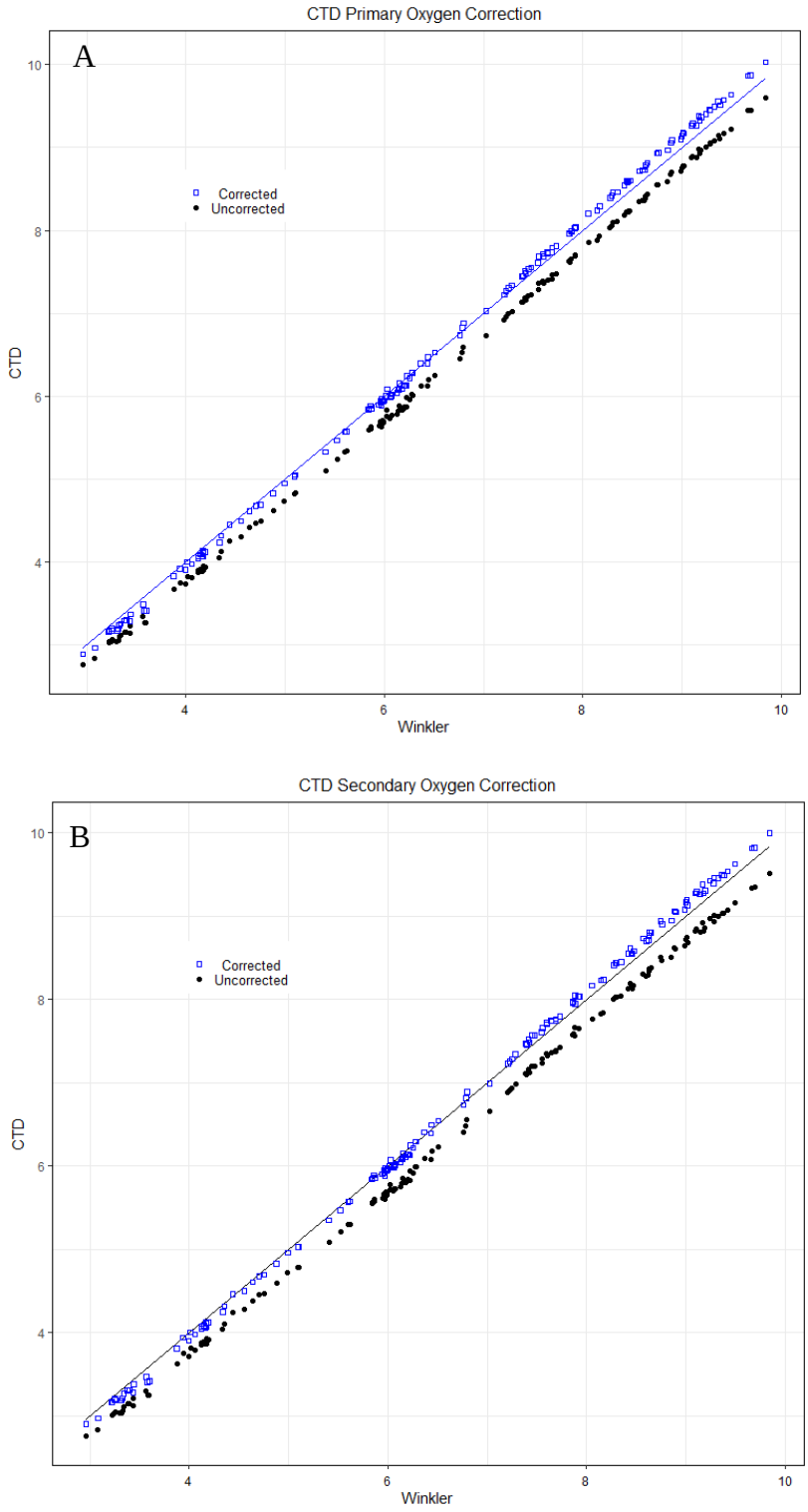


Figure 5. The Soc corrected **A)** Primary oxygen sensor #0133, and **B)** Secondary oxygen sensor #3030. Black dots – uncorrected outlier free sensor values, and Blue squares – Soc corrected sensor values.

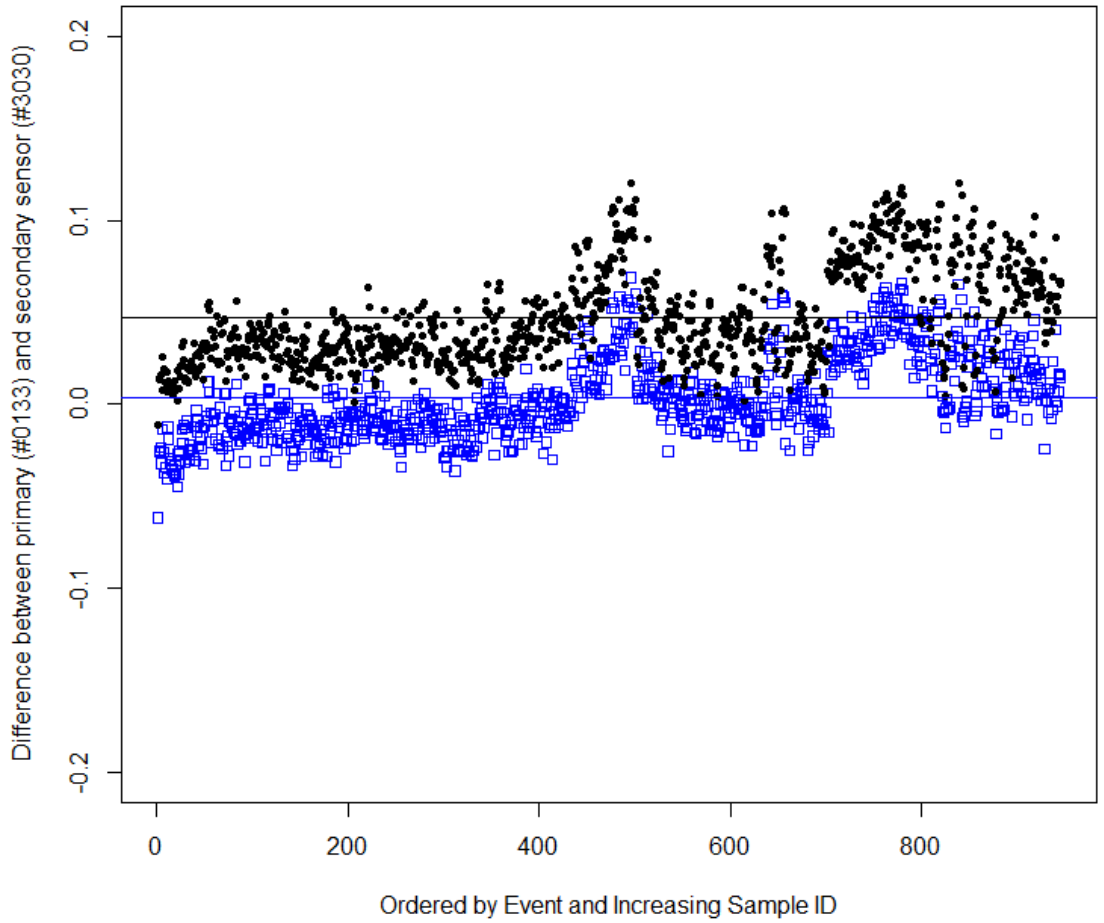


Figure 6. The difference between primary (#0133) and secondary (#3030) oxygen senors throughout the mission, before (black – mean=0.047 ml/l) and after (blue – mean=0.004 ml/l) calibration.

Salinity

(With portions extracted from HUD2014017 Cruise Report)

Conductivity Calibration

The salinometer outputs the conductivity as a ratio with the standard; therefore, some conversions are done to get the conductivity of the bottle. The standard has a given K15 value:

K15 = conductivity of standard seawater at 15°C and 1 atm/conductivity of KCl solution (32.4356g/kg) at 15°C and 1 atm.

Where K15 = 0.99984 for this particular standard and the conductivity of KCl standard = 4.29140 S/m and can be found in the seawater Matlab package (gsw_C3515 function). Knowing K15 and the conductivity of the KCl solution, the conductivity of the standard seawater can be determined. Then, by multiplying by the conductivity ratio from the salinometer, the conductivity of the sample can be determined.

It should be noted that these samples were analyzed with a bath temperature of 24°C rather than the 15°C that the standard conductivity was defined. The salinometer program accounted for this temperature difference so that the output sample conductivity ratios with the standard are at 15°C.

Now we have the conductivity of the sample at 15°C and at the pressure of the bath in the salinometer; however, this needs to be converted to conductivity at the temperature and pressure of the CTD. This can be done using some functions from the same Matlab package.

First calculate the salinity of the bottle using the conductivity and pressure from the salinometer and a temperature of 15°C.

Salinity_bottle = gsw_SP_from_C(Conductivity_salinometer[mS/cm],T[C],P_bath)

Then re-calculate the conductivity from this salinity value using temperature and pressure from the CTD.

Conductivity_bottle = gsw_C_from_SP(Salinity_bottle,T_CTD,P_CTD) %[mS/cm]

This now gives conductivity values that can be compared to the CTD values. To correct the CTD conductivity a linear regression is done on this equation:

Bottle_conductivity = b1 + b2*CTD_conductivity

to find an intercept, b1, and slope, b2, that will make the CTD conductivity better match the bottle conductivity.

First, a comparison of the primary (#4361, Calibrated November 21, 2018) and secondary (#3561, Calibrated November 9, 2018) sensor data (P.S.U.) was performed to highlight and remove any outliers beyond 1.5 * the inter-quartile range of the data (Figure 7). This revealed 57 outliers (out of 989) that were removed from the analysis. Next, the difference between the primary sensor and salinometer values was compared in a similar manner to identify outliers that should be removed from analysis (Figure 8) (n=23). The same process was completed for the secondary sensor and n=9 outliers were identified and removed before proceeding (Figure 9). After outliers were removed, it was determined that the primary and secondary salinometers were on average -0.0053 and 0.0018 P.S.U different from their corresponding salinometer values throughout the mission (Figure 10).

At this point the swCSTp function, which uses the Gibbs-Sea Water (gsw_C_from_SP) formulation, from the R OCE package, was used to convert the salinity of the bottle sample to conductivity (mS/cm). These data were filtered and used to fit a linear regression for both the primary and secondary CTD sensor conductivity cells. The intercept (b1) and slope (b2) values for both primary and secondary sensor regressions were extracted from the linear regression summary. These terms were used directly to calibrate the primary and secondary sensor salinity values for CTD output files prior to data archiving (Table 6).

Figure 11 shows the relationship between the primary and secondary sensor before correction (black circles), and after correction using the revised b1 and b2 coefficients (blue squares).

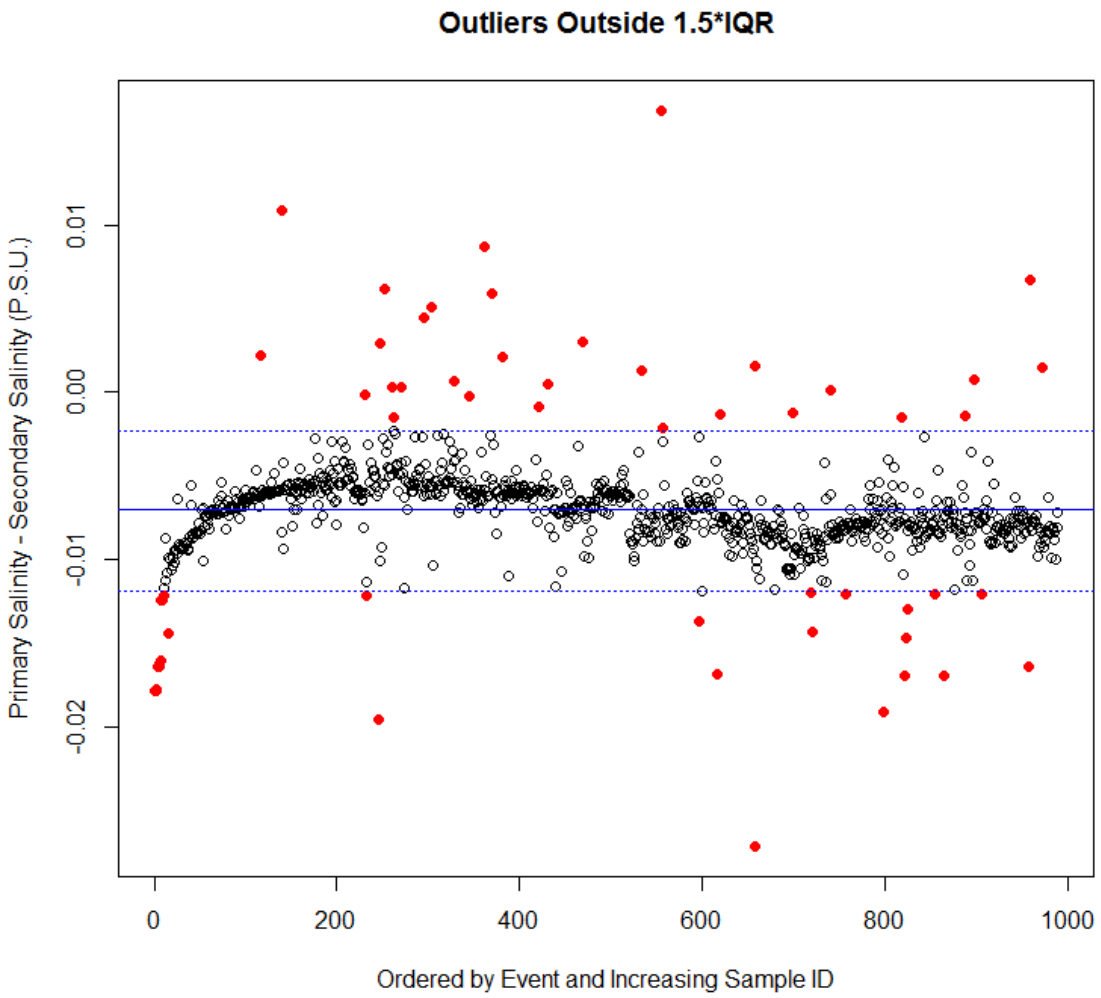


Figure 7. The outlier sensor values (red dots) were removed prior to further analysis (n=57). The average difference between the primary (#4361) and the secondary (#3561) before calibration was ~-0.0070 P.S.U. throughout the mission.

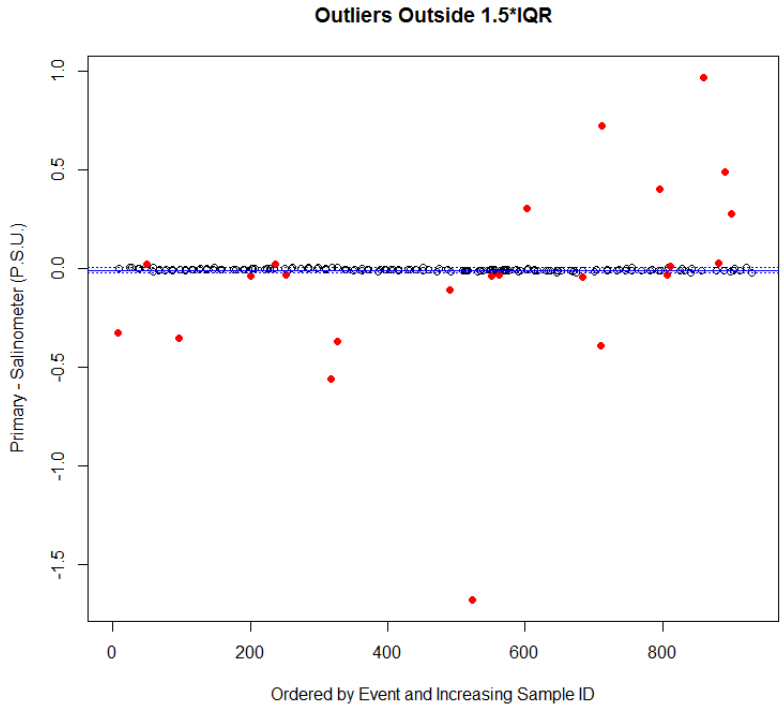


Figure 8. The outlier differences between the primary sensor and the salinometer values (red dots) are removed prior to further analysis (n=23).

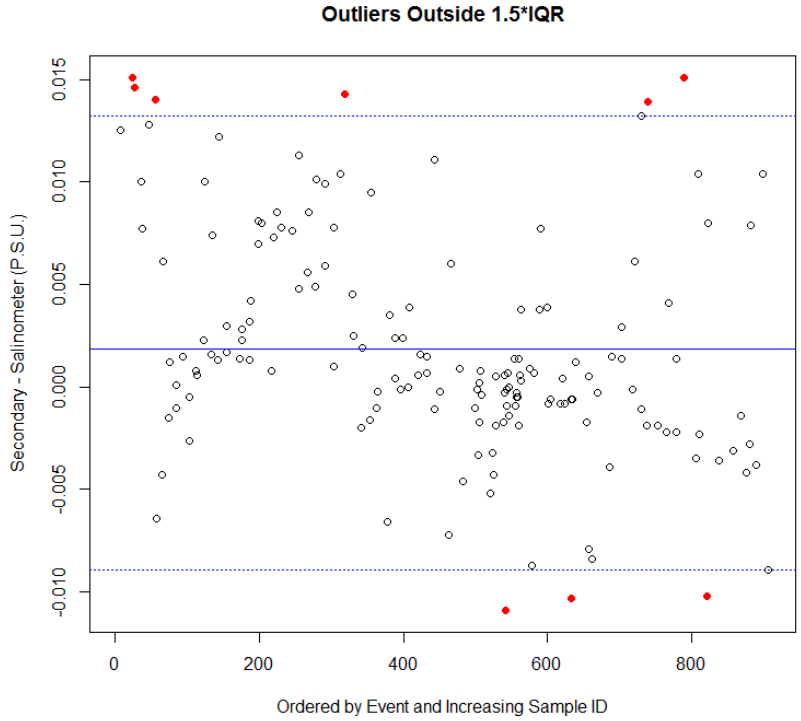


Figure 9. The outlier differences between the secondary sensor and the salinometer values (red dots) were also removed (n=9).

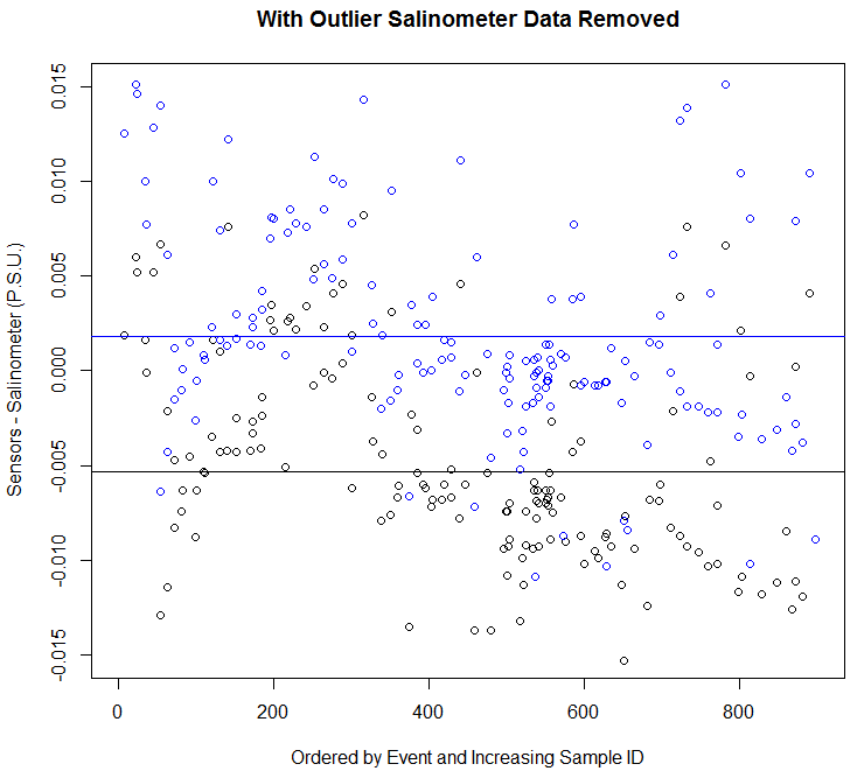


Figure 10. Note that after the outliers have been removed, the differences between the primary (#4361) and secondary (#3561) sensors and corresponding salinometer values are -0.0053 (black line) and 0.0018 (blue line) respectively.

Table 6. The revised intercept (b1) and slope (b2) terms calculated for the primary and secondary conductivity sensors.

Conductivity Sensor	b1	b2
Primary (#4361)	9.2476e-03	0.999853
Secondary (#3561)	7.2754e-03	0.999722

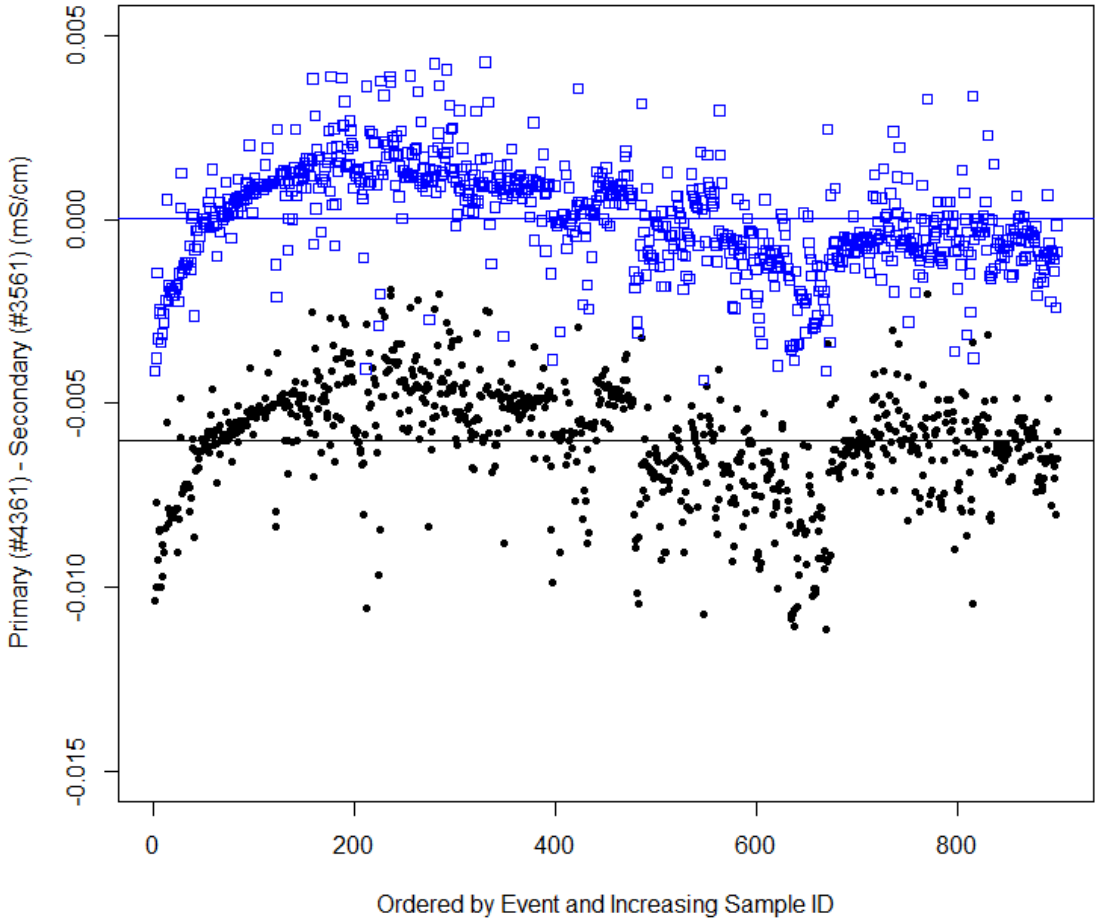


Figure 11. Black dots – the difference between the uncorrected primary and secondary sensors (mean = -6.0127e-3 mS/cm). Blue squares – the difference between the corrected primary and secondary sensors (mean= 2.5934e-05 mS/cm).

Chlorophyll a

Throughout the mission, Chl a was measured in-situ via a SeaPoint fluorometer (SN: 6210) attached to the CTD (Appendix 1b). Duplicate samples (n=593) were regularly taken for Chl a analysis with a Turner Fluorometer. Comparisons of the replicates showed that while the mean difference between replicates was -0.0093 µg/L, there were a total of 79/593 replicates that were considered outliers (Figure 12). Outliers were selected via the 1.5 * interquartile range (1.5 IQR) method discussed in the previous oxygen and salinity sections of this report. These outliers were removed before making the comparison between the SeaPoint and Turner values.

Similar outlier identification methodology was employed to remove data that showed larger than expected differences between the SeaPoint sensor and the Turner Fluorometer data (Figure 13). First, both the SeaPoint data and the Turner data were standardized by dividing both data sets by the SeaPoint data value. This made each SeaPoint data value for a bottle fire equal to 1, and the corresponding mean replicate Turner fluorometer

value a percentage of the SeaPoint value. A value of 1.15 means that the Turner Fluorometer value was 15% greater than its corresponding SeaPoint value and a value of 0.85 means that the Turner value was 15% less than the SeaPoint value. This was done, because calculating the straight difference between values was influenced greatly by their magnitude. The difference between 0.01 and 0.1 and the difference between 6.31 and 6.4 are both 0.09, but the relative difference is ~90% and ~1.4 % respectively. Figure 13 shows the outliers calculated in this way. Out of 537 comparisons between the CTD sensor and the mean of the Turner Fluorometer replicates, 25 outliers were identified and removed before proceeding. The blue line shows that on average, SeaPoint sensor concentration values are ~43.7 % less than corresponding Turner fluorometer values.

Figure 14 shows the log/log relationship between the SeaPoint Fluorometer values and the Mean Turner ChlA values with the outliers from Figure 13 highlighted in red. The black line corresponds to the 1:1 line. When the outliers are removed and a linear regression is applied to the log10/log10 linear relationship between the CTD sensor and the mean replicates (Figure 15), the relationship is strong and significant (R-squared: 0.8822, p<2.2e-16). Unlike salinity and oxygen, this comparison between sensor and Turner chlorophyll concentration values was not used to calibrate the instrument, but rather to demonstrate the relationship between the two.

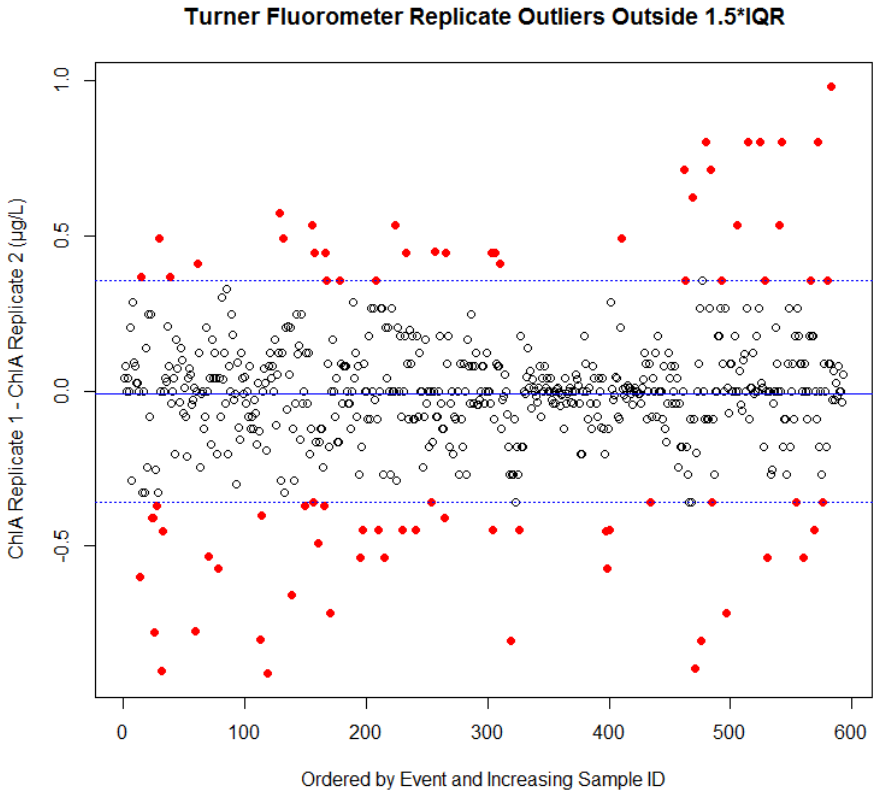


Figure 12. The outlier Turner replicates removed prior to determining the relationship between the Turner Fluorometer and SeaPoint sensor values (n=79).

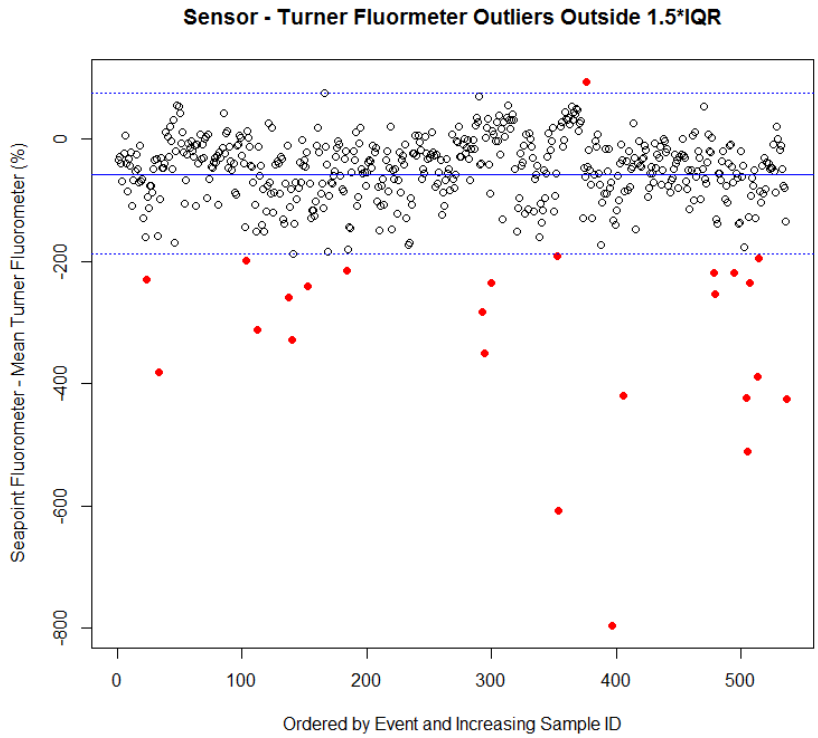


Figure 13. The outliers identified from calculating the % difference between Turner Fluorometer values and the SeaPoint sensor values (n=25).

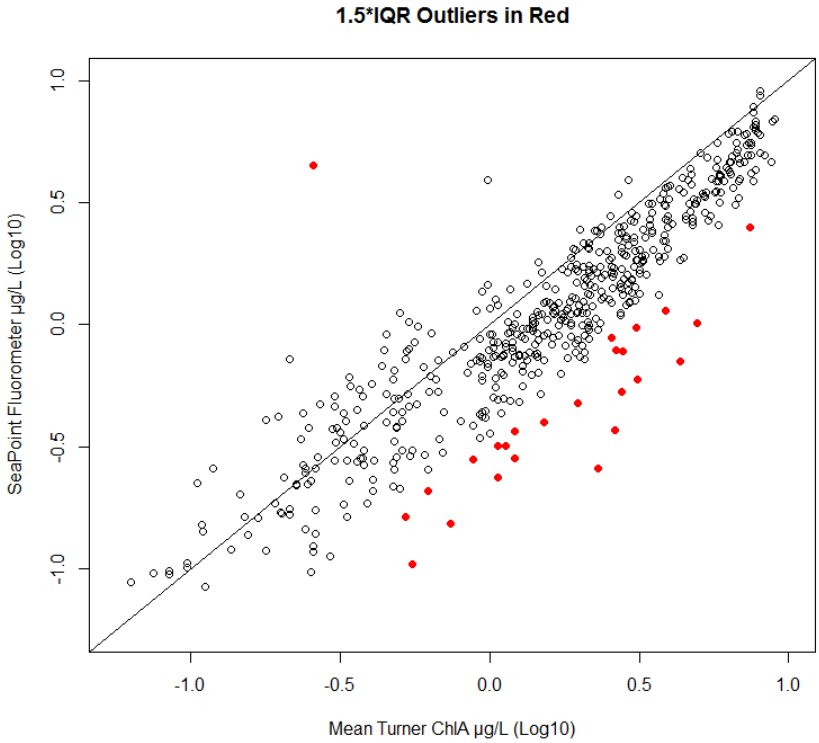


Figure 14. The log10 scale plot of SeaPoint Fluorometer values and the corresponding mean replicate Turner Fluorometer values. Note the highlighted 1.5 * IQR outliers from Figure 13 in red.

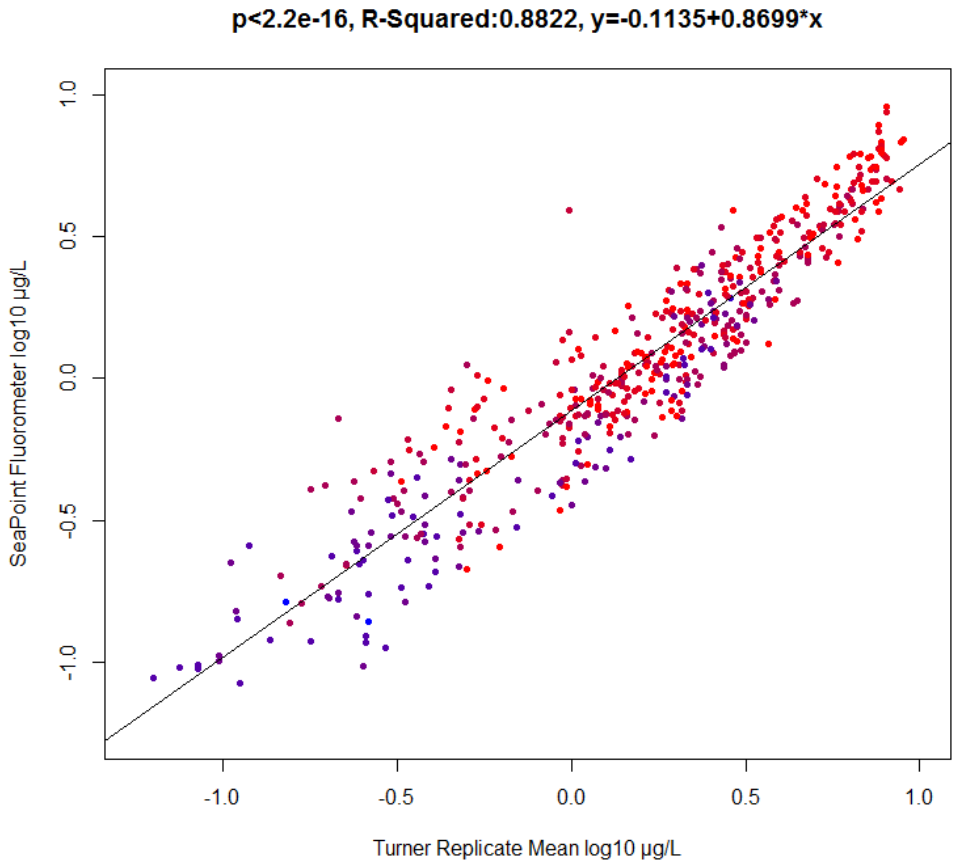


Figure 15. The log10 plot of SeaPoint Fluorometer values and the corresponding mean replicate Turner Fluorometer values colour coded by depth, where red and dark red are shallow (closer to the surface) and purple and blue are deep (closer to 100 m).

Water Samples for Chemical Analyses

Station specific rosette bottle firing depths and water collections for chemical analysis can be found by referring to the CTD deck sheet binder and/or water chemistry sampling sheets that are provided to the Ocean Data Information Section (ODIS). Table 4 highlights CTD casts where water collections were made.

Biological Program

Narrative

The "core" biological program conducted as part of COR2019001, with some modifications, was a continuation of studies began in pre-AZMP years to describe the large-scale (spatial and temporal) variability in plankton biomass, productivity and biogenic carbon inventories on the Scotian Shelf.

The program currently consists of essentially 3 elements:

1. mesozooplankton community structure, population growth and biomass, and
2. dissolved organic carbon measurements;
3. Pigment analysis and flow cytometry for assessment of phyto-, micro- and nano-plankton communities.

Table 4 and the digital water chemistry sampling sheets archived on ODIS servers for the mission, provides a review of the stations where water samples were taken from rosette bottles for element 2 above. The mesoplankton sampling program is described below in more detail. This is followed by a summary of "non-core" or ancillary biological sampling that includes a description of water sampling efforts in support of projects investigating how organic and organometallic micronutrients influence primary productivity and phytoplankton community structure on the Scotian Shelf (Erin Bertrand – Dalhousie University), and an assessment microbial communities and their associated processes (Julie LaRoche – Dalhousie University). The Biological Program section is concluded with a summary of pelagic seabird observations provided by Carina Gjerdrum of the Canadian Wildlife Service, and marine mammal observations provided by Pam Emery of DFO, Team Whale.

The ultimate aim of "core" studies is twofold:

1. to provide a description of the inventories of biogenic carbon, their turnover rates and variability in space and time as part of Ocean Ecosystem Science Division's (OESD) continuing climate studies, and
2. to provide a description of plankton life-cycles and productivity on the Scotian Shelf and its influence or contribution to ecosystems in support of OESD's ecosystem-related research.

Mesozooplankton Sampling

Remarks/Comments

In order to estimate the mesozooplankton community abundance and biomass, a conical ring net of 202 µm mesh size with an aperture of 75 cm in diameter (filtering ratio 1:5) equipped with a KC Denmark flow-meter was towed vertically from the bottom to the surface at most stations (or from a maximum depth of 1000m – AZMP standard). In total, there were 72 vertical ring net tows during the mission (Table 7, Figure 16). Of these, 2 were 76 µm mesh tows (30 cm diameter and 1:5 filtering ratio) at HL_02 (Events 86 and 156), and 35 were 202 µm mesh tows at core stations along core AZMP sections (HL, BBL, CSL and LL) (Table 7 - objective 1). The 76 µm net tows at HL_02 serve the same purpose of quantifying the community but targets a smaller fraction of the mesozooplankton community (i.e. smaller developmental stages, eggs and nauplii). Regardless of the mesh size, contents of the cod end were preserved in 4% buffered formaldehyde. Finally, the stratified "Closing" net was deployed 3 times at HL_02, during events 88, 157 and 158; each time taking 2 stratified samples: bottom to 80 m and 80 m to surface (Table 7 – objective 13 and Figure 16).

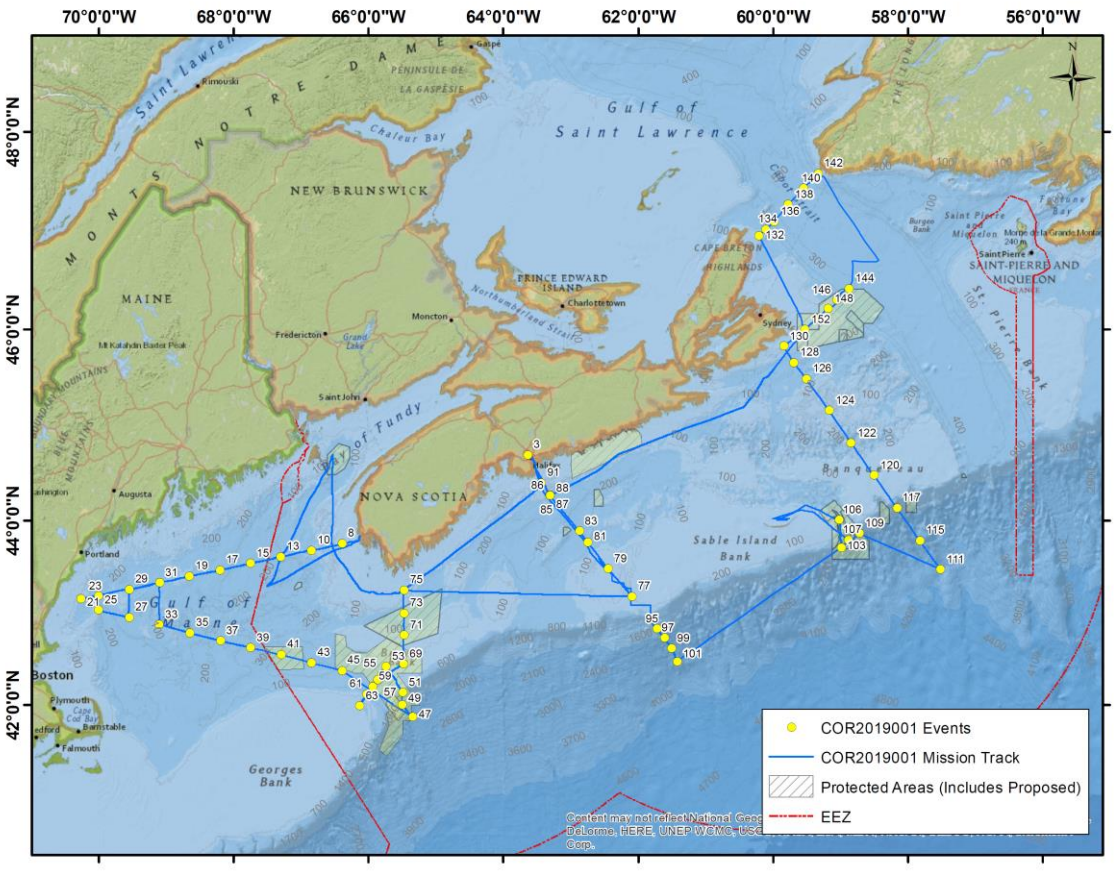


Figure 16. Locations for vertical ring net and closing net tows. Each tow is labelled with the consecutive mission event.

Table 7. Zooplankton collection activities during the COR2019001 AZMP spring survey. The coordinates provided are in decimal degrees and reflect the ship's position at the time of deployment as recorded using the ELOG meta-data logger. Bolded rows represent aborted net tows.

#	Event	Date	Station	Operation	Mesh Size (µm)	Slat (DD)	SLong (DD)	Objective	Comment
1	3	07/04/2019 10:04	HL_00	Ring Net	202um	44.6959	-63.6442	Test	
2	8	09/04/2019 15:34	YL_01	Ring Net	202um	43.7522	-66.3989	3	
3	10	09/04/2019 18:45	YL_02	Ring Net	202um	43.6791	-66.8530	3	
4	13	09/04/2019 22:10	YL_03	Ring Net	202um	43.6095	-67.3046	3	
5	15	10/04/2019 2:32	YL_04	Ring Net	202um	43.5404	-67.7526	3	
6	17	10/04/2019 6:25	YL_05	Ring Net	202um	43.4686	-68.2117	3	
7	19	10/04/2019 9:34	YL_06	Ring Net	202um	43.3988	-68.6646	3	
8	21	10/04/2019 16:45	YL_10	Ring Net	202um	43.1547	-70.2722	3	
9	23	10/04/2019 19:17	YL_09	Ring Net	202um	43.1856	-70.0094	3	
10	25	10/04/2019 21:07	PL_01	Ring Net	202um	43.0329	-70.0070	3	
11	27	11/04/2019 0:36	PL_02	Ring Net	202um	42.9549	-69.5564	3	
12	29	11/04/2019 4:10	YL_08	Ring Net	202um	43.2585	-69.5560	3	
13	31	11/04/2019 12:23	YL_07	Ring Net	202um	43.3280	-69.1039	3	
14	33	11/04/2019 15:42	PL_03	Ring Net	202um	42.8758	-69.1070	3	
15	35	11/04/2019 19:00	PL_04	Ring Net	202um	42.7888	-68.6555	3	
16	37	11/04/2019 22:07	PL_05	Ring Net	202um	42.7025	-68.2036	3	
17	39	12/04/2019 0:12	PL_06	Ring Net	202um	42.6241	-67.7519	3	
18	41	12/04/2019 2:14	PL_07	Ring Net	202um	42.5521	-67.3023	3	
19	43	12/04/2019 3:39	PL_08	Ring Net	202um	42.4620	-66.8526	3	
20	45	12/04/2019 7:09	PL_09	Ring Net	202um	42.3779	-66.3981	3	
21	47	12/04/2019 12:56	BBL_07	Ring Net	202um	41.8664	-65.3501	1	
22	49	12/04/2019 17:24	BBL_06	Ring Net	202um	42.0013	-65.5102	1	
23	51	12/04/2019 21:35	BBL_05	Ring Net	202um	42.1341	-65.5005	1	
24	53	13/04/2019 0:46	NEC_01	Ring Net	202um	42.4182	-65.7436	3	
25	55	13/04/2019 2:21	NEC_02	Ring Net	202um	42.3376	-65.8087	3	
26	57	13/04/2019 4:29	NEC_04	Ring Net	202um	42.2726	-65.8707	3	
27	59	13/04/2019 6:49	NEC_06	Ring Net	202um	42.2000	-65.9386	3	

#	Event	Date	Station	Operation	Mesh Size (µm)	Slat (DD)	SLong (DD)	Objective	Comment
28	61	13/04/2019 9:27	NEC_08	Ring Net	202um	42.1169	-66.0369	3	
29	63	13/04/2019 11:44	NEC_10	Ring Net	202um	41.9879	-66.1423	3	
30	69	13/04/2019 21:34	BBL_04	Ring Net	202um	42.4477	-65.4832	1	
31	71	14/04/2019 1:04	BBL_03	Ring Net	202um	42.7608	-65.4813	1	
32	73	14/04/2019 3:46	BBL_02	Ring Net	202um	43.0006	-65.4794	1	
33	75	14/04/2019 6:38	BBL_01	Ring Net	202um	43.2509	-65.4795	1	
34	77	14/04/2019 19:48	HL_05	Ring Net	202um	43.1827	-62.0990	1	
35	79	14/04/2019 22:36	HL_04	Ring Net	202um	43.4790	-62.4509	1	
36	81	15/04/2019 1:29	HL_03.3	Ring Net	202um	43.7636	-62.7523	1	
37	83	15/04/2019 3:41	HL_03	Ring Net	202um	43.8840	-62.8840	1	
38	85	15/04/2019 7:40	HL_02	Ring Net	202um	44.2660	-63.3168	1	
39	86	15/04/2019 7:53	HL_02	Ring Net	76um	44.2634	-63.3181	1	
40	87	15/04/2019 8:14	HL_02	Closing Net		44.2672	-63.3174	1	Surface to 80
41	88	15/04/2019 8:33	HL_02	Closing Net		44.2659	-63.3158	1	80 to bottom
42	91	15/04/2019 11:05	HL_01	Ring Net	202um	44.4004	-63.4484	1	
43	93	18/04/2019 3:34	HL_05.5	Ring Net	202um	42.9368	-61.8325	1	
44	95	18/04/2019 7:12	HL_06	Ring Net	202um	42.8306	-61.7350	1	
45	97	18/04/2019 11:17	HL_06.3	Ring Net	202um	42.7322	-61.6157	1	
46	99	18/04/2019 15:07	HL_06.7	Ring Net	202um	42.6182	-61.5179	1	
47	101	18/04/2019 19:39	HL_07	Ring Net	202um	42.4760	-61.4329	1	
48	103	19/04/2019 10:27	SG_28	Ring Net	202um	43.7095	-58.9998	2	
49	106	19/04/2019 16:34	GULD_03	Ring Net	202um	44.0021	-59.0257	2	
50	107	21/04/2019 1:23	GULD_04	Ring Net	202um	43.7910	-58.9004	2	
51	109	21/04/2019 7:10	SG_23	Ring Net	202um	43.8608	-58.7317	2	
52	111	21/04/2019 14:23	LL_09	Ring Net	202um	43.4734	-57.5264	1	
53	115	21/04/2019 21:49	LL_08	Ring Net	202um	43.7837	-57.8317	1	
54	117	22/04/2019 4:27	LL_07	Ring Net	202um	44.1333	-58.1754	1	
55	120	22/04/2019 9:28	LL_06	Ring Net	202um	44.4755	-58.5083	1	
56	122	22/04/2019 12:23	LL_05	Ring Net	202um	44.8174	-58.8496	1	
57	124	22/04/2019 15:46	LL_04	Ring Net	202um	45.1583	-59.1748	1	
58	126	22/04/2019 19:00	LL_03	Ring Net	202um	45.4920	-59.5157	1	

#	Event	Date	Station	Operation	Mesh Size (µm)	Slat (DD)	SLong (DD)	Objective	Comment
59	128	22/04/2019 21:16	LL_02	Ring Net	202um	45.6591	-59.7022	1	
60	130	22/04/2019 23:20	LL_01	Ring Net	202um	45.8256	-59.8502	1	
61	132	23/04/2019 7:07	CSL_01	Ring Net	202um	46.9586	-60.2158	1	
62	134	23/04/2019 8:42	CSL_02	Ring Net	202um	47.0229	-60.1152	1	
63	136	23/04/2019 10:36	CSL_03	Ring Net	202um	47.0993	-59.9912	1	
64	138	23/04/2019 13:53	CSL_04	Ring Net	202um	47.2718	-59.7838	1	
65	140	23/04/2019 16:48	CSL_05	Ring Net	202um	47.4343	-59.5572	1	
66	142	23/04/2019 19:45	CSL_06	Ring Net	202um	47.5829	-59.3427	1	
67	144	24/04/2019 8:40	STAB_05	Ring Net	202um	46.4175	-58.8829	9	
68	146	24/04/2019 11:33	STAB_04	Ring Net	202um	46.2996	-59.0625	9	
69	148	24/04/2019 13:49	STAB_03	Ring Net	202um	46.2163	-59.1944	9	
70	150	24/04/2019 15:47	STAB_02	Ring Net	202um	46.1080	-59.3656	9	
71	152	24/04/2019 17:38	STAB_01	Ring Net	202um	46.0013	-59.5332	9	
72	155	25/04/2019 10:55	HL_02	Ring Net	202um	44.2663	-63.3162	1	
73	156	25/04/2019 11:13	HL_02	Ring Net	76um	44.2663	-63.3168	1	
74	157	25/04/2019 11:32	HL_02	Closing Net		44.2661	-63.3164	1	Surface to 80
75	158	25/04/2019 11:49	HL_02	Closing Net		44.2665	-63.3167	1	80 to bottom

Secchi Disk

The Secchi disk was deployed at HL_02 during events 89 and 159, and the depth of last visibility in metres was recorded as a measure of water transparency (Table 8).

Table 8. Secchi disk deployment details.

Event	Date	Station	Slat (DD)	SLong (DD)
89	15/04/2019	HL_02	44.2666	-63.3167
159	25/04/2019	HL_02	44.2661	-63.3165

Microbial Protein and Organic Micronutrient Sampling

Principle Investigator: Dr. Erin Bertrand (Dalhousie University, Department of Biology)
Sampling by: Magda Waclawik and Sonja Rose (Dalhousie University)

Objective

The objective was to collect rosette samples for protein and vitamin analyses in order to determine whether and how organic and organometallic micronutrients influence primary productivity and phytoplankton community structure on the Scotian Shelf. Sampling locations were coordinated with the LaRoche lab since our datatypes are synergistically informative.

Microbial Protein Sampling

Purpose

Proteins are key to microbial activity: the type and amount of proteins present determines, in large part, the contributions microbes make to the ecosystems they occupy. Proteins can also be used as indices for nutritional status: elevated expression of specific proteins can be diagnostic for different nutritional states, such as nitrogen starvation, iron starvation, or vitamin starvation. Protein sequences also contain taxonomic information and can be used to assess contributions of different organisms to specific functions.

Samples were collected for targeted, mass spectrometry- based proteomic analyses of microbial communities in order to characterize the role of organic micronutrients in structuring phytoplankton communities on the Scotian Shelf. Primary objectives include measuring phytoplankton nutritional status indicator proteins (nitrogen, vitamin B_{12}, vitamin B_1 starvation) and vitamin- production biomarker proteins. Development and application of peptides for primary producer community composition analyses is a secondary focus.

Sampling Methods

10L samples: A total of 87 size-fractionated microbial protein samples (10L of water each) were taken from the CTD rosette at depths ranging from the surface to 300 m (Table 9) along AZMP transects located in Canadian waters. Water was filtered sequentially through 3 and 0.2 µm polycarbonate filters via peristaltic pumping. Filters were then frozen immediately at -80°C.

Vitamin Sampling

Purpose

To determine the particulate and dissolved concentrations of organic and organometallic micronutrients on the Scotian Shelf. Organic and organometallic micronutrients are required by many phytoplankton groups and only produced by a select few microbes, setting up a series of interactive dependencies between microbial groups. The importance of these dependencies are not well known, as they have not yet been studied on the Scotian Shelf. Measuring the concentrations of these micronutrients in the particulate and dissolved phases is one step towards understanding the role of microbial interactions in driving primary productivity and phytoplankton community structure.

Sampling Methods

A total of 87 particulate and 1 dissolved vitamin samples (1L each) were taken from the CTD rosette at depths ranging from the surface to 300m depth along lines of the AZMP in Canadian waters (Table 9). Samples were protected from light and gently vacuum filtered through 0.2 µm nylon filters. Filters were frozen at -80°C and dissolved samples were frozen in amber HDPE bottles at -20°C.

Table 9. Protein and vitamin samples – Bertrand lab – AZMP Spring 2019 – COR2019001.

Station	Event #	Depth (m)	ID#	Protein 0.2um	Protein 3um	Particulate Vitamin	Dissolved Vitamin
YL_03	14	1	473037	1	1	1	
		20	473033	1	1	1	
		40	473029	1	1	1	
		80	473023	1	1	1	
PL_07	42	1	473189	1	1	1	
		20	473185	1	1	1	
		80	473179	1	1	1	
		250	473173	1	1	1	
BBL_07	48	1	473237	1	1	1	
		20	473233	1	1	1	
		80	473227	1	1	1	
		250	473221	1	1	1	
BBL_05	52	1	473271	1	1	1	
		20	473267	1	1	1	

		40	473263	1	1	1	
		80	473259	1	1	1	
BBL_03	72	1	473415	1	1	1	
		20	473411	1	1	1	
		40	473407	1	1	1	
		80	473403	1	1	1	
BBL_01	76	1	473435	1	1	1	
		40	473429	1	1	1	
HL_04	80	1	473461	1	1	1	1
		20	473457	1	1	1	
		40	473451	1	1	1	
		80	473449	1	1	1	
HL_02	90	1	473503	1	1	1	
		20	473495	1	1	1	
		40	473491	1	1	1	
		80	473487	1	1	1	
HL_01	92	1	473519	1	1	1	
		20	473515	1	1	1	
		40	473511	1	1	1	
		80	473507	1	1	1	
HL_05.5	94	1	473543	1	1	1	
		20	473539	1	1	1	
		50	473535	1	1	1	
		80	473529	1	1	1	
HL_06	96	1	473567	1	1	1	
		20	473563	1	1	1	
		50	473557	1	1	1	
		80	473553	1	1	1	
HL_07	102	1	473625	1	1	1	
		20	473621	1	1	1	
		50	473617	1	1	1	
GULD_04	108	1	473671	1	1	1	
		20	473667	1	1	1	
		40	473664	1	1	1	
		60	473661	1	1	1	
LL_09	112	1	473709	1	1	1	
		20	473705	1	1	1	
		80	473697	1	1	1	
		250	473693	1	1	1	
LL_07	118	1	473745	1	1	1	
		20	473741	1	1	1	

		80	473735	1	1	1
		250	473729	1	1	1
LL_04	125	1	473779	1	1	1
		20	473775	1	1	1
		40	473771	1	1	1
		80	473767	1	1	1
LL_01	131	1	473817	1	1	1
		20	473813	1	1	1
		40	473809	1	1	1
		60	473805	1	1	1
CSL_01	133	1	473833	1	1	1
		20	473829	1	1	1
		40	473825	1	1	1
		60	473821	1	1	1
CSL_04	139	1	473879	1	1	1
		20	473875	1	1	1
		60	473869	1	1	1
		300	473861	1	1	1
CSL_06	143	1	473913	1	1	1
		20	473909	1	1	1
		60	473903	1	1	1
		200	473897	1	1	1
STAB_05	145	1	473933	1	1	1
		20	473929	1	1	1
		80	473923	1	1	1
		300	473917	1	1	1
STAB_01	153	1	473971	1	1	1
		40	473965	1	1	1
HL_02R	160	1	473989	1	1	1
		20	473985	1	1	1
		40	473981	1	1	1
		80	473975	1	1	1

Microbial Community Analysis

Principle Investigator: Dr. Julie LaRoche (Dalhousie University)
Sampling by: Magda Waclawik and Sonja Rose (Dalhousie University)

Microbial communities and their associated processes are the foundation of marine life. Of particular interest to our group is the marine nitrogen cycle, comprising complex microbially-driven reactions whereby atmospheric nitrogen is fixed into a biologically-available form and cycled through the ecosystem. Though nitrogen is an essential element for life, the availability of fixed nitrogen can be a limiting factor for primary production and thus diazotrophs – organisms capable of biological nitrogen fixation – can be key to the productivity of an ecosystem.

Samples were collected for genomic and fluorescence-based analyses of the microbial communities on the Scotian shelf. Community composition will be assessed via 16S tag sequencing, and the naturally-fluorescent population will be characterized via flow cytometry. The latter method can also be used to quantify the bacterial community via nucleic acid stain SYBR green. Community function will be assessed via metagenomic sequencing, and qPCR assays for selected functional genes. Further samples were taken for manipulation in the lab, including targeted metagenomics and single cell isolation via fluorescence-associated cell sorting (FACS), and enrichment culturing of putative diazotrophs.

Sampling Methods

Genomics:
Samples were taken for genomics at 22 select stations along the AZMP transects located in Canadian waters. At most stations (18), duplicate 4L water samples were collected from the CTD rosette at each of 4 depths ranging from the surface to 1000m (Table 10). Several stations deviated from this pattern (Table 10): At select stations, more (8) or less (2) depths were sampled, and HL2 was sampled twice, for a total of 192 samples. Each water sample was sequentially filtered through 3 and 0.2μm polycarbonate filters by peristaltic pump until the water was depleted or the filters clogged. Filters were immediately frozen at -80°C.

Flow Cytometry:
At each station and depth where genomic samples were collected, duplicate 2mL water samples were fixed with 2% paraformaldehyde (PFA) for 10 minutes at room temperature, then frozen at -80°C for later enumeration of bacteria and characterization of the naturally fluorescent microbial community via the Accuri C6 flow cytometer.

At select stations (Table 10), 45mL of water were mixed with 5mL of gly-TE buffer and frozen at -80°C for later cell sorting on the BD Influx FACS instrument.

Enrichment Cultures:

At select stations (Table 10) where FACS samples were collected, 500mL water samples were also collected for enrichment cultures. These samples were spiked with phosphate (200nM) and iron (2nM) and secured to the window of the lab to approximate natural light/dark cycles and ambient temperature until return to the lab.

Table 10. Microbial community samples – LaRoche lab – AZMP Spring 2019 – COR2019001

Station	Event #	Depth (m)	Niskin #	DNA samples (size-fractionated)	Flow Cytometry Samples	FACS Sample + Culture
YL_03	14	1	473036	2	2	
		20	473032	2	2	
		40	473028	2	2	
		80	473024	2	2	
PL_07	42	1	473190	2	2	
		20	473184	2	2	
		80	473178	2	2	
		250	473174	2	2	
BBL_07	48	1	473238	2	2	
		20	473234	2	2	
		80	473226	2	2	
		250	473222	2	2	
BBL_05	52	1	473272	2	2	
		20	473268	2	2	
		40	473264	2	2	
		80	473258	2	2	
BBL_03	72	1	473416	2	2	
		20	473412	2	2	
		40	473408	2	2	
		80	473402	2	2	
BBL_01	76	1	473436	2	2	
		40	473430	2	2	
HL_04	80	1	473460	2	2	1
		20	473456	2	2	
		40	473452	2	2	
		80	473448	2	2	
HL_02	90	1	473504	2	2	
		20	473496	2	2	

		40	473492	2	2	
		80	473486	2	2	
HL_01	92	1	473520	2	2	
		20	473516	2	2	
		40	473512	2	2	
		80	473508	2	2	
HL_05.5	94	1	473542	2	2	1
		20	473538	2	2	1
		40	473534	2	2	
		80	473528	2	2	
		60	473531	2	2	
		100	473526	2	2	
		250	473524	2	2	
		Btm	473522	2	2	
HL_06	96	1	473566	2	2	1
		20	473562	2	2	
		50	473558	2	2	
		80	473554	2	2	
		250	473549	2	2	
		500	473548	2	2	
		750	473547	2	2	
		1000	473545	2	2	
HL_07	102	1	473626	2	2	1
		20	473622	2	2	1
		50	473616	2	2	
		80	473614	2	2	1
GULD_04	108	1	473672	2	2	
		20	473668	2	2	
		60	473660	2	2	
		250	473656	2	2	
LL_09	112	1	473708	2	2	1
		20	473704	2	2	
		80	473698	2	2	
		250	473694	2	2	
LL_07	118	1	473746	2	2	
		20	473742	2	2	
		80	473734	2	2	
		250	473730	2	2	
LL_04	125	1	473780	2	2	1
		20	473776	2	2	

		40	473772	2	2	
		80	473766	2	2	
LL_01	131	1	473816	2	2	1
		20	473812	2	2	
		40	473808	2	2	
		60	473804	2	2	
CSL_01	133	1	473832	2	2	
		20	473828	2	2	
		40	473824	2	2	
		60	473820	2	2	
CSL_04	139	1	473878	2	2	
		20	473874	2	2	
		60	473868	2	2	
		300	473860	2	2	
CSL_06	143	1	473912	2	2	
		20	473908	2	2	
		60	473902	2	2	
		200	473896	2	2	
STAB_05	145	1	473934	2	2	
		20	473930	2	2	
		80	473922	2	2	
		300	473916	2	2	
STAB_01	153	1	473970	2	2	
		40	473964	2	2	
HL_02	160	1	473988	2	2	
		20	473984	2	2	
		40	473980	2	2	
		80	473976	2	2	

Pelagic Seabird and Marine Mammal Observations

Seabird Survey Report
7-25 April 2019
Canadian Wildlife Service, Environment and Climate Change Canada
Prepared by: Carina Gjerdrum carina.gjerdrum@ec.gc.ca
Observer(s): Jeannine Winkel

Background

The east coast of Canada supports millions of breeding marine birds as well as migrants from the southern hemisphere and northeastern Atlantic. In 2005, the Canadian Wildlife Service (CWS) of Environment Canada initiated the Eastern Canada Seabirds at Sea (ECSAS) program with the goal of identifying and minimizing the impacts of human activities on birds in the marine environment. Since that time, a scientifically rigorous protocol for collecting data at sea and a sophisticated geodatabase have been developed, relationships with industry and DFO to support offshore seabird observers have been established, and over 100,000 km of ocean track have been surveyed by CWS-trained observers. These data are now being used to identify and address threats to birds in their marine environment. In addition, data are collected on marine mammals, sea turtles, sharks, and other marine organisms when they are encountered.

Methods

Seabird surveys were conducted from the port side of the bridge of the Coriolis II during the Scotian Shelf AZMP from 7-25 April 2019. Surveys were conducted while the ship was moving at speeds greater than 4 knots, looking forward and scanning a 90° arc to one side of the ship. All birds observed on the water within a 300m-wide transect were recorded, and we used the snapshot approach for flying birds (intermittent sampling based on the speed of the ship) to avoid overestimating abundance of birds flying in and out of transect. Distance sampling methods were incorporated to address the variation in bird detectability. Marine mammal and other marine wildlife observations were also recorded, although surveys were not specifically designed to detect marine mammals. Details of the methods used can be found in the CWS standardized protocol for pelagic seabird surveys from moving platforms[1].

[1]Gjerdrum, C., D.A. Fifield, and S.I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series. No. 515. Atlantic Region. vi + 36 pp.

Results

Seabird Sightings

We surveyed 1883 km of ocean from 7-25 April 2019. A total of 1638 birds were observed in transect (2021 birds in total) from 14 families (Table 11). Bird densities averaged 3.4 birds/km^2 (ranging from 0 – 231.9 birds/km^2). The highest densities of birds (> 50 birds/km^2) were observed in the mouth of the Bay of Fundy, northern Gulf of Maine, Fundian Channel, the Gully, and near the ports of Yarmouth and Halifax (Figure 17).

The most abundant family observed were those from Laridae (40% of the observations), most of which were Herring and Great Black-backed Gulls (Table 11); they were seen throughout the survey area. Alcids made up 23% of the sightings, 8% of which were Common Murre (Table 11). Northern Gannet and waterfowl both made up 15% of the sightings. The vast majority of the species observed in high numbers are breeders in the area.

Marine Mammal Sightings

Just 14 marine mammals were recorded during the surveys (Table 12), including long-finned pilot whale, humpback whale, and common dolphin (Figure 18).

Gully MPA

Surveys were conducted within the Gully MPA on 17 and 21 April. A total of 35 birds were observed, and 10 marine mammals (Table 13).

St. Anns Bank MPA

Surveys were conducted within the St. Anns Bank MPA on 24 April. Just 15 birds and no marine mammals were observed during the transits (Table 14).

Table 11. List of bird species observed during surveys on the Scotian Shelf AZMP, from 7-25 April, 2019.

Family	English	Latin	Number observed in transect	Total number observed
Gaviidae	Common Loon	*Gavia immer*	15	19
Procellariidae	Northern Fulmar	*Fulmarus glacialis*	56	58
	Sooty Shearwater	*Ardenna griseus*	24	27
	Manx Shearwater	*Puffinus puffinus*	1	1
Hydrobatidae	Leach's Storm-Petrel	*Oceanodroma leucorhoa*	4	5
	Wilson's Storm Petrel	*Oceanites oceanicus*	2	2
	Unidentified Storm-Petrels	Hydrobatidae	3	3
Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*	2	2
Sulidae	Northern Gannet	*Morus bassanus*	246	321
Anatidae	Canada Goose	*Branta canadensis*	22	22
	Common Eider	*Somateria mollissima*	82	185
	Surf Scoter	*Melanitta perspicillata*	75	78
	Black Scoter	*Melanitta nigra*	40	40
	Unidentified Scoters	*Melanitta*	0	6
	Long-tailed Duck	*Clangula hyemalis*	27	27
	Unidentified Ducks	All duck genera	4	4
Scolopacidae	Red-necked Phalarope	*Phalaropus lobatus*	1	1
Laridae	Pomarine Jaeger	*Stercorarius pomarinus*	1	1
	Black-legged Kittiwake	*Rissa tridactyla*	3	5
	Herring Gull	*Larus argentatus*	489	502
	Great Black-backed Gull	*Larus marinus*	105	119
	Glaucous Gull	*Larus hyperboreus*	3	3
	Ring-billed Gull	*Larus delawarensis*	39	39
	Iceland Gull	*Larus glaucoides*	10	11
Alcidae	Common Murre	*Uria aalge*	132	133
	Thick-billed Murre	*Uria lomvia*	17	36
	Unidentified Murres	*Uria*	50	80
	Razorbill	*Alca torda*	16	16
	Atlantic Puffin	*Fratercula arctica*	9	10
	Black Guillemot	*Cepphus grylle*	1	1
	Dovekie	*Alle alle*	101	113
	Unidentified Auks	Alcidae	51	132
Falconidae	Merlin	*Falco columbarius*	1	2
Corvidae	American Crow	*Corvus brachyrhynchos*	3	3
Parulidae	Common Yellowthroat	*Geothlypis trichas*	0	1
Emberizidae	Savannah Sparrow	*Passerculus sandwichensis*	1	2
	Fox Sparrow	*Passerella iliaca*	0	1
	Dark-eyed Junco	*Junco hyemalis*	0	1
Icteridae	Brown-headed Cowbird	*Molothrus ater*	0	2
	Unidentified Passerines	Passeriformes	2	7
TOTAL			1638	2021

Table 12. List of marine mammals, fish and invertebrates observed during surveys on the Scotian Shelf AZMP, from 7-25 April, 2019.

English	Latin	Total number observed
Long-finned Pilot Whale	*Globicephala melas*	5
Humpback Whale	*Megaptera novaeangliae*	1
Order: Whales and Dolphins	Cetacea	1
Common Dolphin	*Delphinus delphis*	1
Family: Dolphins	Delphinidae	3
Family: Seals (True seals)	Phocidae	3
Total		**14**

Table 13. List of species observed in the Gully Marine Protected Area during surveys on the Scotian Shelf AZMP on 19 and 21 April, 2019.

English	Total number observed
Herring Gull	32
Great Black-backed Gull	3
Long-finned Pilot Whale	5
Unidentified Dolphin	3
Unidentified Seal	2
Total	**45**

Table 14. List of species observed in the St. Anns Bank Marine Protected Area during surveys on the Scotian Shelf AZMP, on 24 April, 2019.

English	Total number observed
Herring Gull	10
Great Black-backed Gull	5
Total	**15**

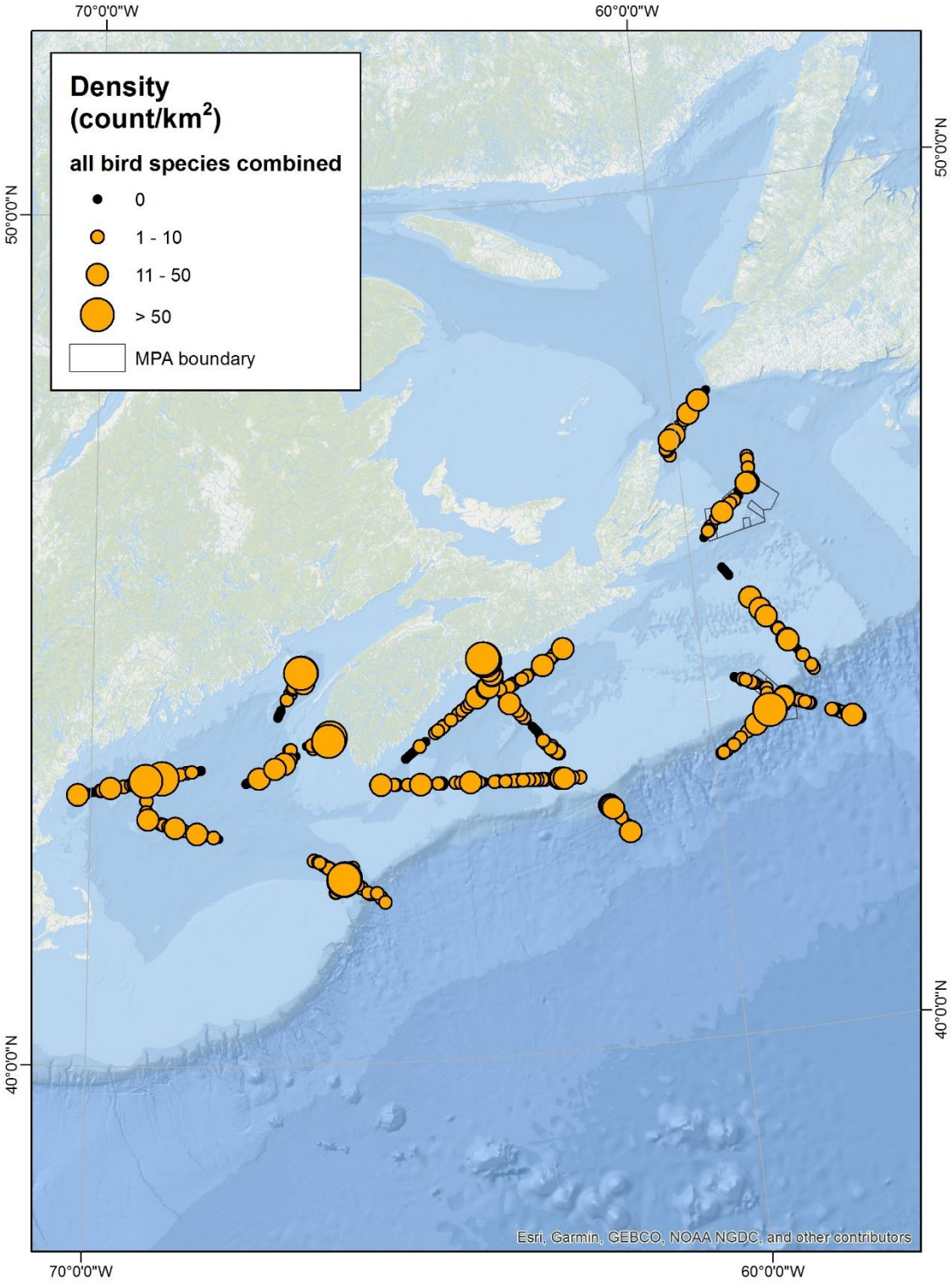


Figure 17. Density of birds observed during the seabird survey on the Scotian Shelf AZMP, from 7-25 April 2019.

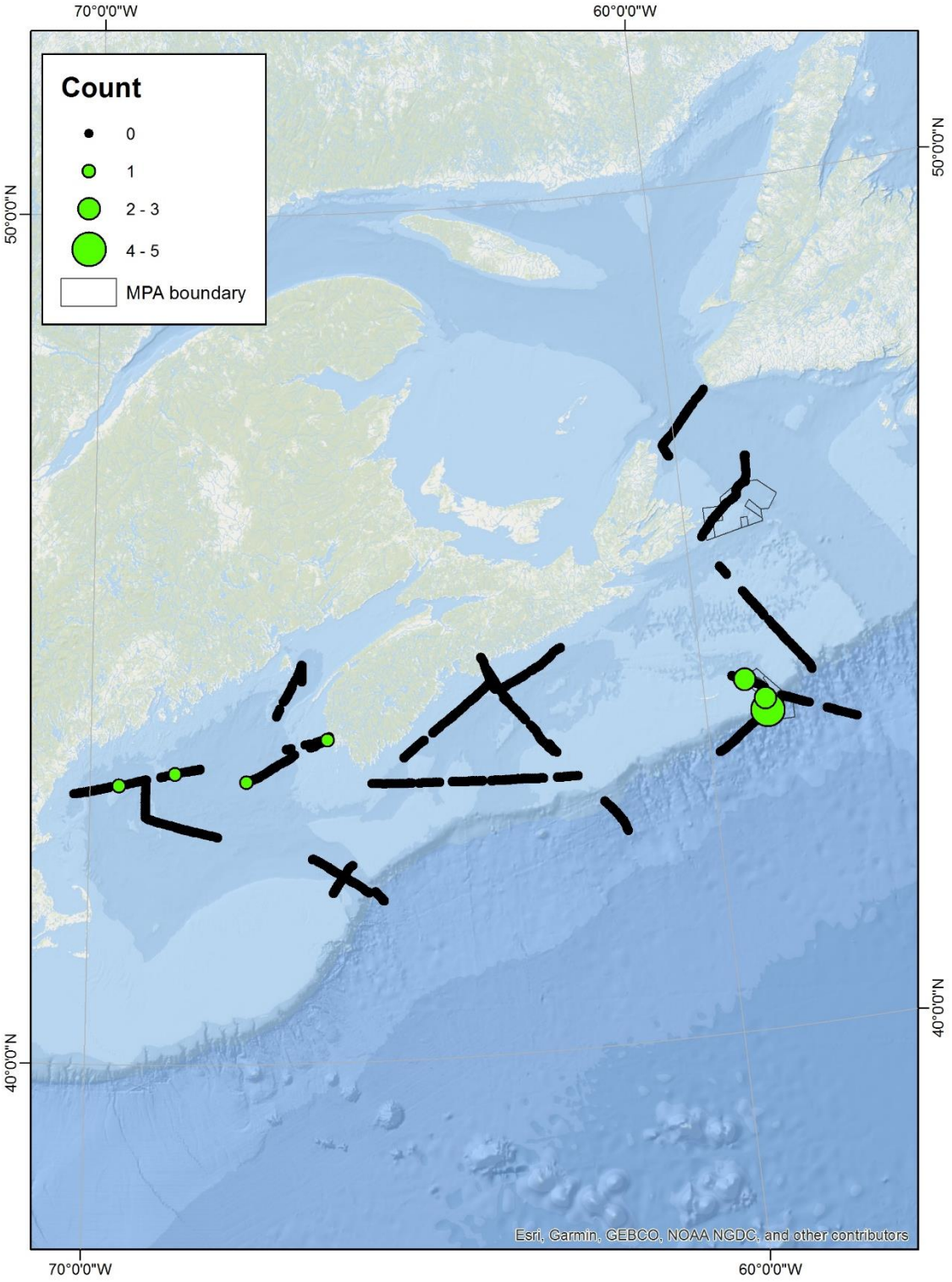


Figure 18. Counts of marine mammals observed during the seabird survey on the Scotian Shelf AZMP, from 7-25 April 2019.

Marine Mammal and Pelagic Fish Observations

Marine Mammal Report for the 2019 AZMP Spring Survey
April 07 – 25 2019
Prepared by: Pamela Emery
Ocean and Ecosystem Sciences Division
Maritimes Region Fisheries and Ocean Canada

Background

Collecting data on marine mammal sightings during DFO research cruises can offer a valuable source of information that can be used to help assess marine mammal presence and distribution within an area. Often research cruises go to areas that otherwise have little observer coverage, as is the case with the Scotian shelf in general, and offshore areas such as along the shelf edge. Sometimes unusual sightings are recorded during research cruises which can add to the small data sets of rare species. In particular, research cruises going to Marine Protected Areas (MPAs) provide a platform to help monitor top-level predators of these important ecosystems by collecting data on marine mammals observed within the area.

Methods

During the 2019 spring AZMP marine mammal observations took place on the port side of the bridge onboard the Coriolis II. Observations took place during daylight hours from April 07 until April 25, 2019. Effort is recorded when the vessel is moving ("in transit"), sightings that may occur outside of this (i.e. on station) are considered "opportunistic" or "off" effort, with exception being given to Marine protected areas (MPA) in which an observer is on-effort for the duration of the MPA sampling period. Periods of on effort observation are often limited to fair weather conditions. Generally, ideal conditions require a Beaufort state of 4 or less and 1-2 nm of visibility. Any marine mammal observation recorded will include the conditions at the time of the sighting such as wind, Beaufort sea state, and visibility. The intention is to record all observations (encounters) of marine mammals in particular, but also of other large pelagic species of interest including sea turtles, ocean sunfish, and sharks.

Results

Over the course of the 2019 spring AZMP research cruise 83.67 hours were spent "on effort" collecting marine mammal sightings data. During periods of on-effort, recorded winds ranged from 2- 38 kts, with an average wind speed of 17.5 kts. Recorded on-effort sea states ranged from 1-5 with an average of 2.6. Marine mammal observations are ideal when winds are less than 20 kts and sea states are less than 4.

In total there were 58 individuals observed representing nine species of marine mammals and large pelagic fish (Table 15: Figure 19-20). Long-finned pilot whales represented the highest number of marine mammals observed (Table 15). There were two species of baleen whales, Humpback and Minke, that were observed and identified to the species level. Seven baleen whales were observed in the distance and the observer as unable to positively ID these to the species level. There were also two sightings of unknown whales

and seven unknown dolphins. Northern bottlenose whales, long-finned pilot whales, dolphins, and grey seals were observed while on station in the Gully MPA.

Gully MPA

Visual surveys were conducted within the Gully MPA on April 19 and 21, 2019. 27 individuals, representing four species of marine mammals were observed: Long-finned pilot whales (n=20), unknown dolphin (n=1), Northern bottlenose whales (n=2) and grey seals (n=4) (Table 16; figure 21) .

St. Ann's Bank MPA

Visual surveys were conducted within the St. Ann's Bank MPA on April 24, 2019. During this survey 6 individual unknown baleen whales were observed (Table 17; Figure 22). Identification of whale species was not possible as the individuals were greater than 1000m from the vessel, and only the blow of the individuals was observed.

Table 15. List of marine mammals and pelagic fish observed on the Scotian Shelf 2019 spring AZMP survey, from April 07-25, 2019.

Common name	Scientific name	On effort observations	Off effort observations	Total Number Observed
Grey seal	*Halichoerus grypus*	5	0	5
Humpback whale	*Megaptera novaeangliae*	2	0	2
Minke whale	*Balaenoptera acutorostrata*	1	0	1
Northern Bottlenose Whales	*Hyperoodon ampullatus*	2	0	2
Long-finned Pilot Whale	*Globicephala melas*	20	11	31
Unknown Baleen Whale		7	0	7
Unknown Dolphin		7	0	7
Unknown turtle		0	1	1
Unknown whale		1	1	2

Table 16. List of marine mammals and pelagic fish observed in the Gully Marine Protected Area during the Scotian Shelf 2019 spring AZMP survey, from April 07-25, 2019.

Common name	Scientific name	ON effort observations	Off effort observations	Total number observed
Pilot Whale	*Globicephala melas*	14	0	14
Northern Bottlenose Whales	*Hyperoodon ampullatus*	2	0	2
Grey seal	*Halichoerus grypus*	3	0	3
Unknown Dolphin		3	0	3

Table 17. List of marine mammals and pelagic fish observed in the St. Ann's Bank Marine Protected Area during the 2019 spring AZMP survey, from April 07-25, 2019.

Common name	Scientific name	ON effort observations	Off effort observations	Total number observed
Unknown baleen whale		6	0	6

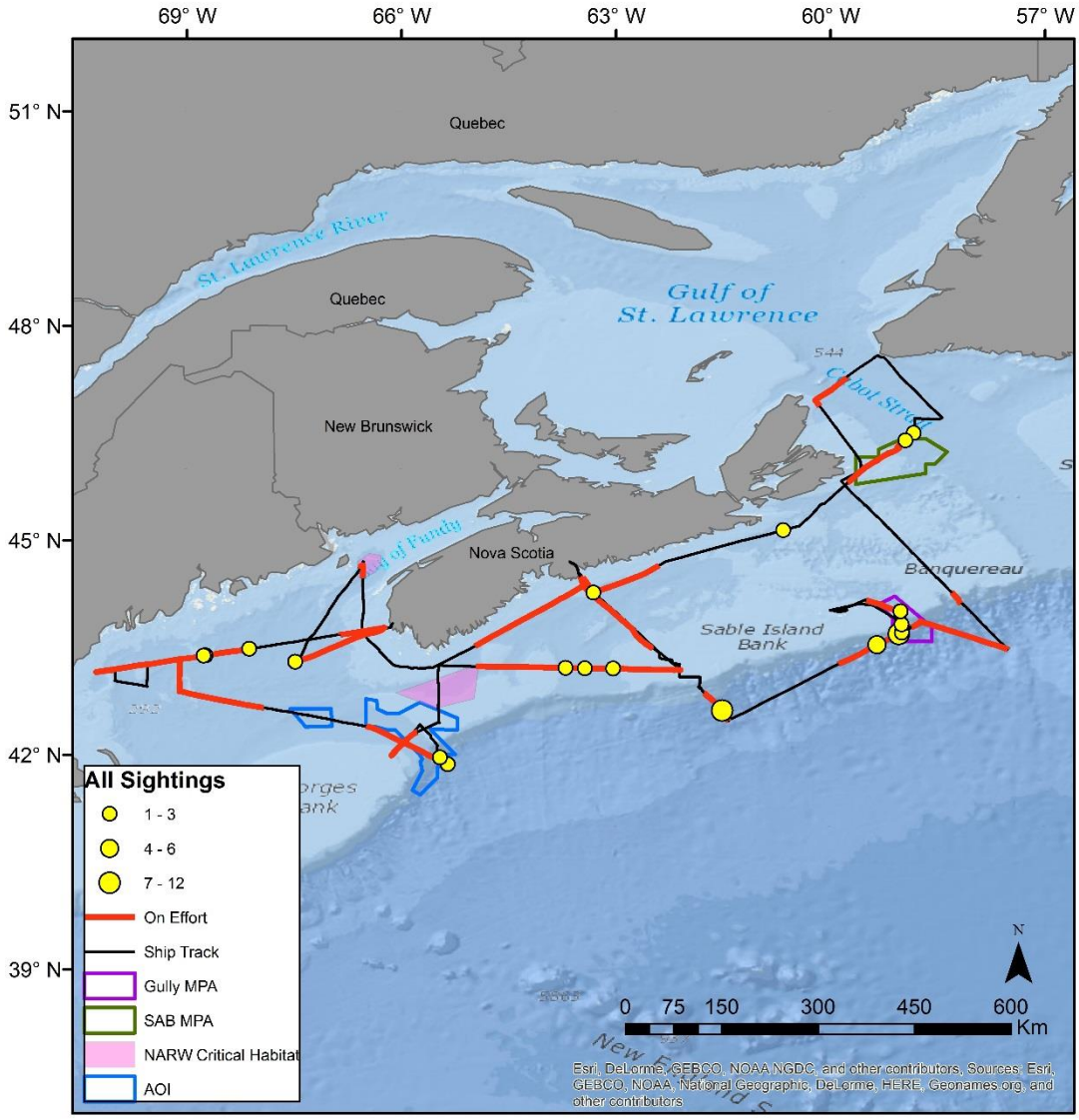


Figure 19. Overview of the number of observations of marine mammal and large pelagic fish, sightings during the Scotian Shelf 2019 spring AZMP survey. Periods of time when the marine mammal observer was on effort (actively looking for marine mammals) is highlighted in red along the ship tracks (black).

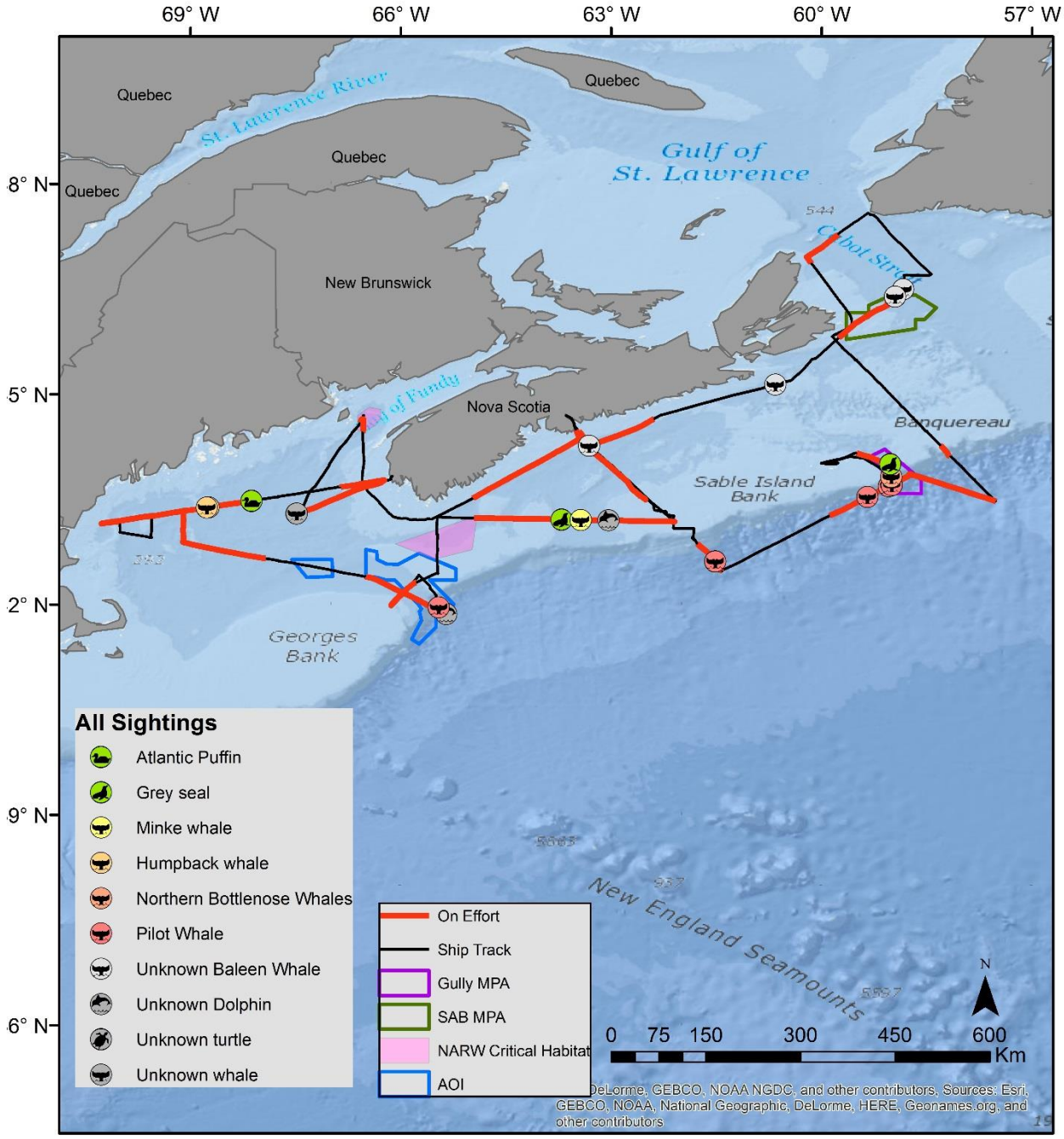


Figure 20. Overview of the species observed during the Scotian Shelf 2019 spring AZMP survey. Periods of time when the marine mammal observer was on effort (actively looking for marine mammals) is highlighted in red along the ship tracks (black).

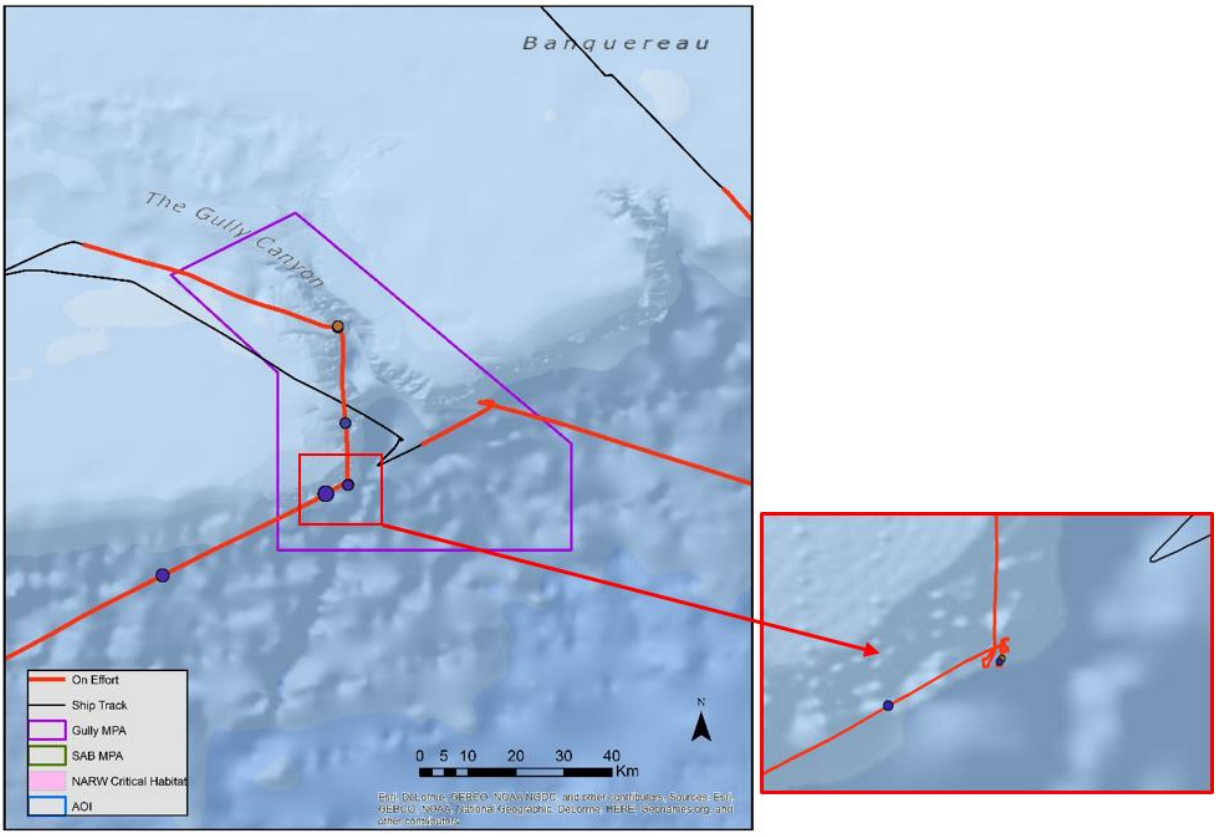


Figure 21. Marine mammal sightings in the Gully Marine Protected Area during the Scotian Shelf 2019 spring AZMP survey. Sightings in the Gully MPA represent the following: Long-finned pilot whales (purple; n=20), unknown dolphin (tan; n=1), Northern bottlenose whales (blue; n=2) and grey seals (brown; n=4)

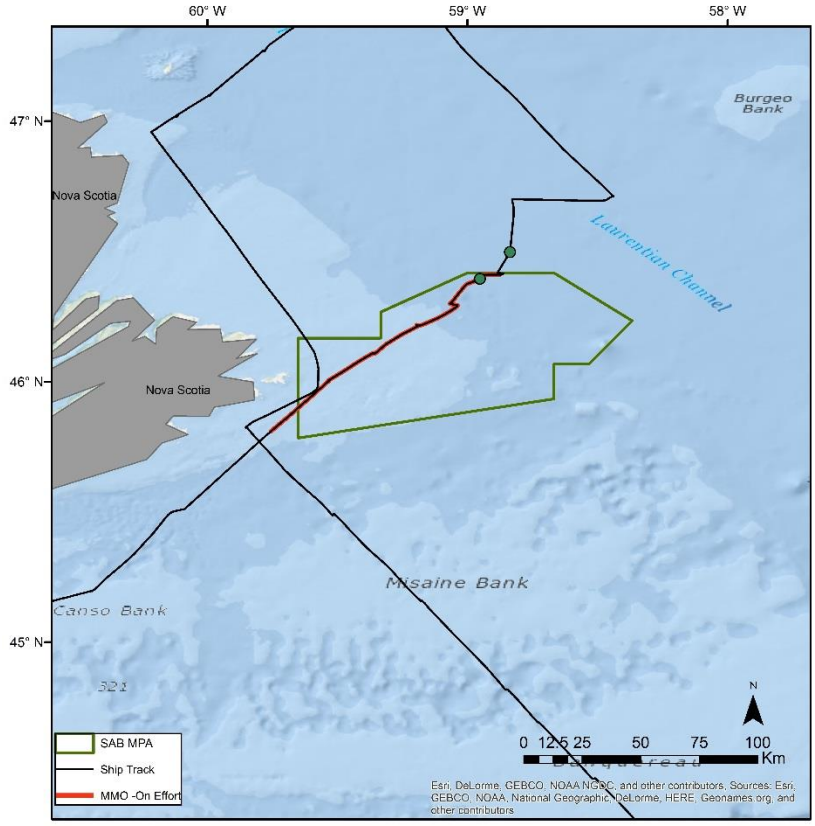


Figure 22. Marine mammal sightings in the St. Anns Bank Marine Protected Area during the Scotian Shelf 2019 spring AZMP survey. All observations were unknown baleen whales.

Argo

Narrative

Over the mission we were able to successfully deploy 2 of the 4 planned ARGO floats at LL_09 on April 21st (Figure 23 and Table 18). Both floats have returned their first good HK message prior to the conclusion of the mission on April 25th. The profiles for all floats deployed during the mission can be found here by typing in their WMO numbers:

http://www.argodatamgt.org/Access-to-data/Description-of-all-floats2

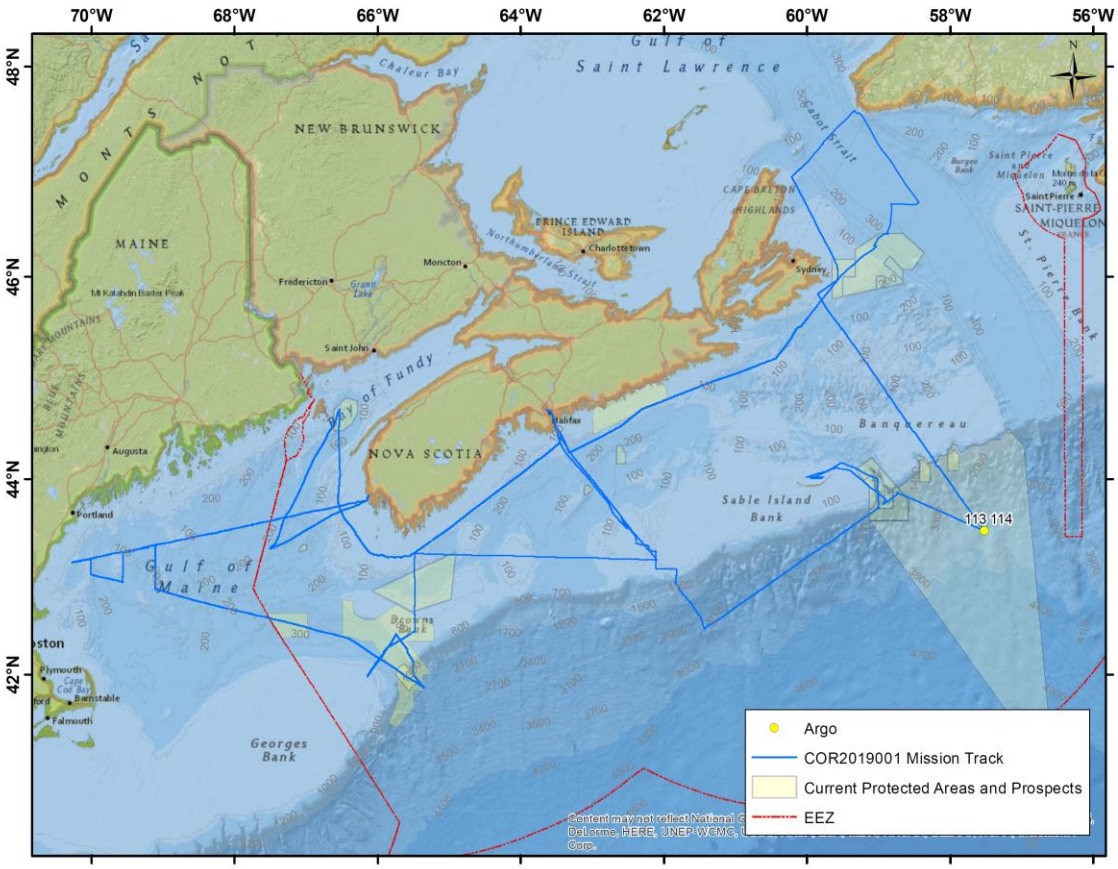


Figure 23. Argo float deployment locations during COR2019001. Refer to Table 18 for more details.

Table 18. Details for Argo float deployments during COR2019001. The coordinates provided below are in decimal degrees and represent the ship's position at the time of deployment.

Date	Event	Station	Float Type	Float Deployed (UTC)	IMEI#	WMO#	S/N	Lat(DD)	Long(DD)
4/21/2019	113	LL_09	NKE	22:41	300234067203290	4902470	AI2600-18CA014	43.4738	-57.5267
4/21/2019	114	LL_09	NKE	22:48	300234067205890	4902467	AI2600-18CA011	43.4750	-57.5264

Mooring Operations

Contributions by: Jay Barthelotte

Narrative

Along with the CTD, the bladder for the 16" well/moon pool was shipped by BIO on the 30th of January. This was used to allow the OETS team to design a flange adapter and mount for our acoustic release transducers that would be used during the first few days of the mission to release moorings from their anchor.

The diagrams of the moorings described below are provided in Appendix 4. The first mooring operation (event 005) was the recovery of the "clam shell", M2064, on April 8th in Grand Manan Basin at ~0930 UTC (Table 19 and Figure 24). We arrived at ~ slack tide to minimize the potential for drift during deployment and recovery of the moorings. Communication was established with the deck unit at 0904 UTC and the first portion of the mooring was on deck by 0918 and the second stage by 0944. The "clam" was jammed pack with mud and it was not clear if this had occurred during recovery or while it was on site. M2090 was deployed at nearly the same location (event 6). This mooring recent design that was deployed by attaching buoys and an acoustic release to a large concrete anchor with a syntactic foam insert. The buoy was deployed at 1127, reached bottom a few minutes later when an acoustic signal was sent to release the buoys. The buoys were on deck by 1142 and we were already prepping for the next mooring deployment (M2089) planned for the morning of the 9th in Jordan Basin.

On the 9th of April at 0740, the first stage of M2089 was in the water and was quickly followed by the second stage at 0741. The anchors were away at 0743 and by 0745 the mooring was in position and we began our steam to Yarmouth to exchange our mooring staff as described in the Mission Summary.

On April 24th, at nearly midnight, we searched for surface floats attached to a Doug Shillinger mooring on our steam back to HL_02. The search was only ½ hour, with the time of day, wind, wave and foggy conditions making it difficult to see anything. We were unsuccessful in locating this missing mooring.

Jay Barthelotte and Matt Lawson from Ocean Engineering and Technology Section, Ocean and Ecosystem Sciences Division, Science Branch were the Mooring Technicians for the mission. All planned operations were completed.

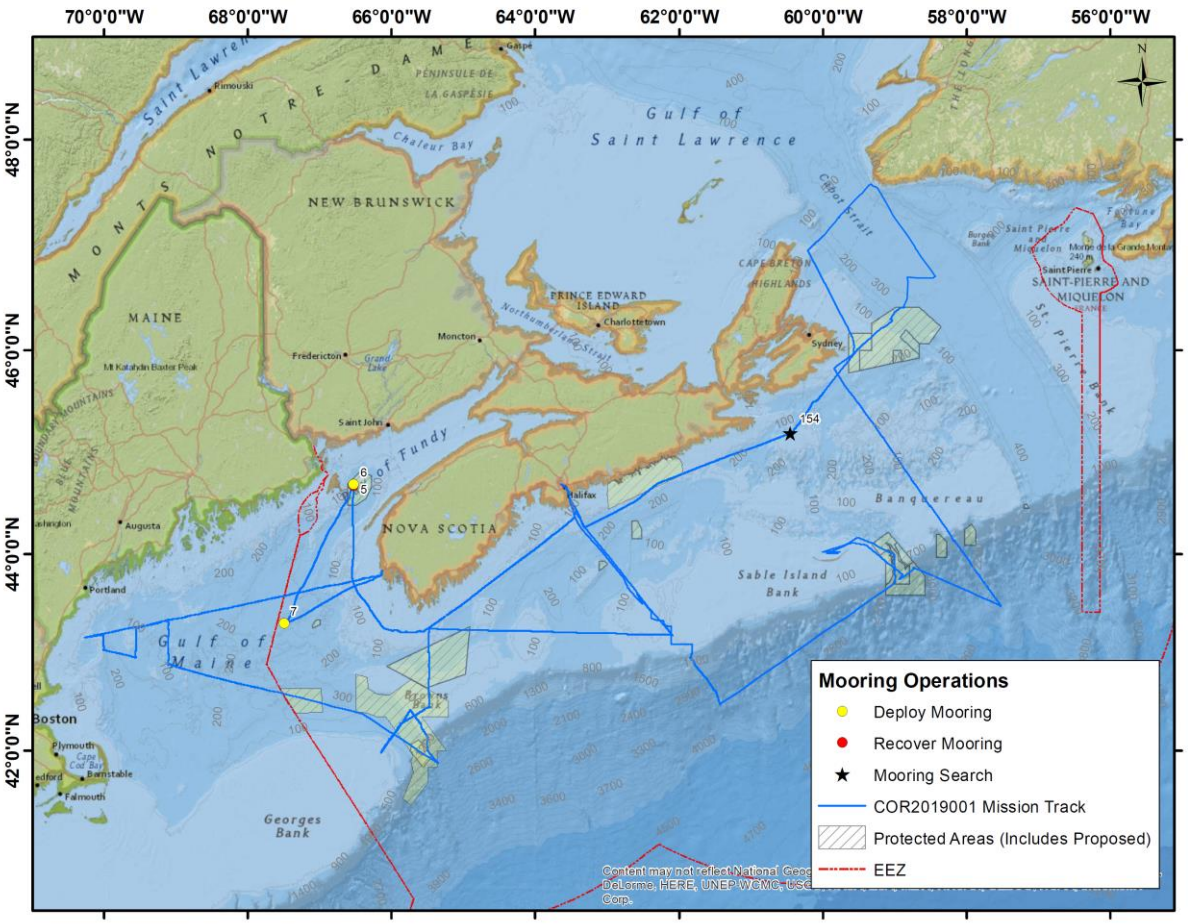


Figure 24. Positions of moorings operations during COR2019001.

Table 19. List of mooring operations during COR2019001. The coordinates provided below are in decimal degrees and represents the ship's position at the time of the operation.

Date	Event	Operation	Station	Slat (DD)	SLong (DD)	Action	Comments
08/04/2019	5	Recover Mooring	M2064	44.6772	-66.5336	Attempt Comms	Enable command sent.
08/04/2019	5	Recover Mooring	M2064	44.6934	-66.5336	Release	Communication was established with the deck unit. There is a gap between the comms attempt and the release because they had to move the CTD out of the way.
08/04/2019	5	Recover Mooring	M2064	44.6936	-66.5307	On Deck	on surface at 1205 GMT on port side. First stage on deck.
08/04/2019	5	Recover Mooring	M2064	44.6961	-66.5349	On Deck	Second stage on deck. The clam on M2064 was filled with mud on recovery. It was not clear if the mud was as a result of recovery or happened at deployment.
08/04/2019	6	Deploy Mooring	M2090	44.6913	-66.5295	In Water	This is the float with the large concrete frame and syntatic foam insert. The release command will be sent when it is on bottom.
08/04/2019	6	Deploy Mooring	M2090	44.6915	-66.5299	On Bottom	After this the release will be sent.
08/04/2019	6	Deploy Mooring	M2090	44.6916	-66.5299	Release Command	
08/04/2019	6	Deploy Mooring	M2090	44.691	-66.5299	On Deck	Floats on Deck and prepping for next mooring deployment at M2089.
09/04/2019	7	Deploy Mooring	M2089	43.2984	-67.5004	Start Deployment	hydrophone and releases turned on and plugs removed from microcat.
09/04/2019	7	Deploy Mooring	M2089	43.2988	-67.5003	In Water	First stage in water.
09/04/2019	7	Deploy Mooring	M2089	43.2991	-67.5003	In Water	Second Stage in water.
09/04/2019	7	Deploy Mooring	M2089	43.2998	-67.5002	Anchor Away	
09/04/2019	7	Deploy Mooring	M2089	43.3001	-67.4999	On Bottom	
24/04/2019	154	Mooring Search	SCHILLINGERMOORING	45.1928	-60.4584	Search	Searched from Shillinger mooring for ½ hour just before midnight.

Underway Sampling

Contributions by: Adam Hartling
Division: OESD

Positional data and Date/time (GPGGA and GPZDA) from the ship's GPS was logged throughout the mission alone with sounding data from the ships EK60 scientific echo sounder and Knudsen system. These data were logged at 1 Hz throughout the mission using NavNet, a data logging and distribution system designed by NRCAN. Prior to the ship's return to BIO, navigation data was converted into daily coordinate logs at 1 second intervals in both .csv and .shp formats.

Catherine Johnson had inquired on February 5th, 2019 (on behalf of Fred Paquet) whether the Coriolis II would allow us to use their Multi-Frequency Acoustic (EK) system throughout the mission. We'd asked Reformar if they could install the EK60 software instead of the EK80 software currently installed. They were able to complete this request at minimal cost and these data were recorded throughout the mission. As well, the Knudsen depth sounder data were recorded throughout the mission and like all other data collected during the mission were sent for storage on the Ocean Data and Information Section (ODIS) servers.

NOTE: The EK60 echo sounder is designed by Simrad. Details about the system can be found at www.simrad.com/ek60. The EK60 was setup with a three split beam transducer operating at 38 kHz, 120 kHz and 200 kHz. Sea floor bottom data was sent to the NavNet computer at 1 Hz in the standard SBBDT format.

ADCP

There were the 150 and 75 KHz transducers in the well of the vessel, and the 150 KHz was used predominantly in shallow water. The 75 KHz was turned on in deeper water but the Ship's Tech decided later in the mission that he run them simultaneously. We are currently unsure of the quality of these data and we won't know until they are assessed at a later date.

Data Management

Prepared by: Diana Cardoso
Division: Science Information Officer, Ocean and Ecosystem Sciences Division

Data Collection

The digital data collected consisted of; the sensor data from the CTD, ringnets, 150 and 75 kHz shipboard ADCP, EK60, Knudsen Depth Sounder, recovered moored instruments, and GIS. The water sample chemical analysis consisted of; chlorophyll, oxygen, salts, pH, nutrients, PCO2, TIC/TA, HPLC, POC/PON, FC, and ABS. The paper logs include; bridge, mooring, ring net, chlorophyll, O_2 and CTD. The recovered mooring number was M2064 and the two deployed moorings were M2089 and M2090. All digital data were backed up hourly or daily and at the end of the mission were sent to ODIS to archive with the exception of the acoustic data (ADCP, EK60, Knudsen Depth Sounder). The acoustic data is too big in size for the ODIS archive, it was given to Jinshan to back up on a NAS.

In addition to hard copy data collection methods, ELOG, an electronic logbook system for collecting event metadata including position and sounding, was again used. This electronic logbook was accessible via computers connected to the ship's *science network* with one terminal available at each major work area. Metadata related to each piece of equipment was collected in the electronic log including position/time deployed, on bottom and recovered. Additional logbooks were employed to act as an itinerary, and daily operational log to record comments and observations. All digital logbooks were backed up hourly, and at the end of the mission were sent to ODIS to archive.

For the first time on an AZMP mission a digital filter log was used in the form of several excel spread sheets, one per station. This replaced the paper filter log book. An example of the digital log is below in the comments section.

Nav-Net, an on board ship's data collection system, was used to collect GPS data, sounder data, gyro data, and wind and motion data.

Data Input Template

Reports were generated from shipboard input data in the AZMP Template Database to compare with corresponding CTD sensor data and conduct preliminary analyses included in this report. The input data included; CTD QAT files, ELOG files, salts, chlorophyll and oxygen data.

GIS

Daily navigation and operations were maintained in a geographic information system (QGIS). Final line and point shapefiles were generated from these data for the cruise report.

Hardware

A Regulus/Aldebaran computers (supplied by NRCAN) were placed in the computer lab, to provide positioning and station name information to operations and ELOG. ELOG was run from a Windows 10 laptop in the computer lab and other PCs used this laptop IP to connect to ELOG in a web browser. A laptop was used in the nutrients lab to provide a digital filter sheet replacing the paper log.

Comments

Since this was my first time acting as Data Manager for an AZMP mission on the Coriolis II I created two documents detailing ELOG and Nav-Net start-up steps. I also updated my previous document detailing my tasks and methods, all was given to ODIS to archive. Below is a list of main comments:

1) Digital Filter Log: Comments from first time users:
    a. Need to add a space for the technician name
    b. Need to create a summary of station name, Sample IDs and volumes for HPLC, POC and ABS at the end of the trip.
    c. Add the volumes as numeric values and place the units in the header

DATE: 10Apr19
EVENT:022
STATION: YL_10
#BOTTLES: 9
BTM_DEPTH: ~120

SAMPLE_ID	DEPTH	CHL	NUTS	WINKLER	TIC.TA	pCO2	SAL	POC	POC_VOLUME	HPLC	HPLC_VOLUME	ABS	ABS_VOLUME	LAROCHE	BERTRAND	COMMENTS
473070	BTM	AA	AA	A	K	K	A									
473071	80	AA	AA													
473072	60	AA	AA													
473073	50	AA	AA		K	K										
473074	40	AA	AA													
473075	30	AA	AA		K	K										
473076	20	AA	AA													
473077	10	AA	AA		K	K										
473078	1	AA	AA	AA	K	K	A	AA	1L	E	1L	E	1L			

2) Chlorophyll data is the one of the last manual data entries, I started to create an app in python to change to digital data entry.
3) Would like to add whale sightings data to the map
4) Added the stations Dal samples to the map

5) The “Navigation Processing” could not create a cruise track to CSV only offset to CSV
6) The newest download version of ELOG would not work since it does not support the in-house applications GetEvent_v2.exe & GetGpsDTLL_v2.exe.
7) Nav Net was not running on the network like on the Hudson and positions and depth data was not on the network, therefore the Regulus computer was set up to provide this data on the network and to log the data.

APPENDICES

Appendix 1. CTD Configuration Files

Appendix 1a. COR2019001.xmlcon (Events 001 - 009)

Instrument configuration file:
Z:\CurrentlyDeployed\Shipboard_Environment\CRUISE_SETUPS\COR2019001\CTD_Acquisition\2019001COR\ctd_con\COR2019001.xmlcon

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : Yes
Scan time added : No

1) Frequency 0, Temperature

Serial number : 4807
Calibrated on : 07-Nov-18
A : 3.68121233e-003
B : 6.00136403e-004
C : 1.53925508e-005
D : 1.75091769e-006
F0 : 2910.562
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 4361
Calibrated on : 21-Nov-18
G : -9.90360003e+000
H : 1.36221872e+000
I : -9.63485809e-004
J : 1.25328743e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008

Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 1214
Calibrated on : 21-Dec-18
C1 : -4.470905e+004
C2 : 3.840789e-001
C3 : 1.367850e-002
D1 : 3.661600e-002
D2 : 0.000000e+000
T1 : 3.015271e+001
T2 : -1.367200e-004
T3 : 3.926620e-006
T4 : 3.761680e-009
T5 : 0.000000e+000
Slope : 0.99998083
Offset : -0.35544
AD590M : 1.280000e-002
AD590B : -9.348400e+000

4) Frequency 3, Temperature, 2

Serial number : 5081
Calibrated on : 08-Nov-18
A : 3.68121200e-003
B : 6.01437749e-004
C : 1.57718883e-005
D : 2.16126748e-006
F0 : 3242.958
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 3561
Calibrated on : 09-Nov-2018
G : -1.03410464e+001
H : 1.24901601e+000
I : -1.75772408e-003
J : 1.88890676e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Altimeter

Serial number : 59017
Calibrated on : 01-Mar-2017
Scale factor : 15.000
Offset : 0.000

7) A/D voltage 1, PAR/Logarithmic, Satlantic

Serial number : 1069
Calibrated on : 24-Jun-2016
a0 : 1.01706100
a1 : 0.80964200
Im : 1.35890000
Multiplier : 1.00000000

8) A/D voltage 2, Oxygen, SBE 43

Serial number : 0133
Calibrated on : 22-Nov-18
Equation : Sea-Bird
Soc : 4.17250e-001
Offset : -6.42400e-001
A : -4.63750e-003
B : 1.59120e-004
C : -2.43420e-006
E : 3.60000e-002
Tau20 : 1.27000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

9) A/D voltage 3, Oxygen, SBE 43, 2

Serial number : 0042
Calibrated on : 07-Nov-18
Equation : Sea-Bird
Soc : 4.41530e-001
Offset : -5.00400e-001
A : -4.13670e-003
B : 2.05910e-004
C : -3.11380e-006
E : 3.60000e-002
Tau20 : 1.46000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002

H2 : 5.00000e+003
H3 : 1.45000e+003

10) A/D voltage 4, Fluorometer, Seapoint Ultraviolet

Serial number : 3668
Calibrated on : 1-Jan-2015
Range : 50.000000
Offset : 0.000000

11) A/D voltage 5, Fluorometer, Seapoint

Serial number : 6210
Calibrated on : 1-Jan-2015
Gain setting : 3 x, 0-50 µg/l
Offset : 0.000

12) A/D voltage 6, pH

Serial number : 1159
Calibrated on : 06-Nov-18
pH slope : 4.5658
pH offset : 2.5230

13) A/D voltage 7, OBS, WET Labs, ECO-BB

Serial number : 1490
Calibrated on : 9-Aug-2016
ScaleFactor : 0.002983
Dark output : 0.048000

14) SPAR voltage, Unavailable

15) SPAR voltage, SPAR/Surface Irradiance

Serial number : 1043
Calibrated on : 01-Dec-2015
Conversion factor : 1.00000000
Ratio multiplier : 1.00000000

Scan length : 40

Appendix 1b. COR2019001_B.xmlcon (Events 011 – 160)

Date: 04/09/2019

Instrument configuration file:
C:\CTD_ACQUISITION\2019001COR\ctd_con\COR2019001_B.xmlcon *

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : Yes
Scan time added : No

1) Frequency 0, Temperature

Serial number : 4807
Calibrated on : 07-Nov-18
A : 3.68121233e-003
B : 6.00136403e-004
C : 1.53925508e-005
D : 1.75091769e-006
F0 : 2910.562
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 4361
Calibrated on : 21-Nov-18
G : -9.90360003e+000
H : 1.36221872e+000
I : -9.63485809e-004
J : 1.25328743e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 1214
Calibrated on : 21-Dec-18
C1 : -4.470905e+004
C2 : 3.840789e-001
C3 : 1.367850e-002
D1 : 3.661600e-002
D2 : 0.000000e+000
T1 : 3.015271e+001
T2 : -1.367200e-004
T3 : 3.926620e-006
T4 : 3.761680e-009
T5 : 0.000000e+000
Slope : 0.99998083
Offset : -0.35544
AD590M : 1.280000e-002
AD590B : -9.348400e+000

4) Frequency 3, Temperature, 2

Serial number : 5081
Calibrated on : 08-Nov-18
A : 3.68121200e-003
B : 6.01437749e-004
C : 1.57718883e-005
D : 2.16126748e-006
F0 : 3242.958
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 3561
Calibrated on : 09-Nov-2018
G : -1.03410464e+001
H : 1.24901601e+000
I : -1.75772408e-003
J : 1.88890676e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Altimeter

Serial number : 59017
Calibrated on : 01-Mar-2017

Scale factor : 15.000
Offset : 0.000

7) A/D voltage 1, PAR/Logarithmic, Satlantic

Serial number : 1069
Calibrated on : 24-Jun-2016
a0 : 1.01706100
a1 : 0.80964200
Im : 1.35890000
Multiplier : 1.00000000

8) A/D voltage 2, Oxygen, SBE 43

Serial number : 0133
Calibrated on : 22-Nov-18
Equation : Sea-Bird
Soc : 4.17250e-001
Offset : -6.42400e-001
A : -4.63750e-003
B : 1.59120e-004
C : -2.43420e-006
E : 3.60000e-002
Tau20 : 1.27000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

9) A/D voltage 3, Oxygen, SBE 43, 2

Serial number : 3030
Calibrated on : 27-Nov-18
Equation : Sea-Bird
Soc : 4.89650e-001
Offset : -5.21400e-001
A : -3.94700e-003
B : 1.62150e-004
C : -2.43020e-006
E : 3.60000e-002
Tau20 : 1.24000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

10) A/D voltage 4, Fluorometer, Seapoint Ultraviolet

Serial number : 3668
Calibrated on : 1-Jan-2015
Range : 50.000000
Offset : 0.000000

11) A/D voltage 5, Fluorometer, Seapoint

Serial number : 6210
Calibrated on : 1-Jan-2015
Gain setting : 3 x, 0-50 µg/l
Offset : 0.000

12) A/D voltage 6, pH

Serial number : 1137
Calibrated on : 06-Nov-18
pH slope : 4.5630
pH offset : 2.5760

13) A/D voltage 7, OBS, WET Labs, ECO-BB

Serial number : 1490
Calibrated on : 9-Aug-2016
ScaleFactor : 0.002983
Dark output : 0.048000

14) SPAR voltage, Unavailable

15) SPAR voltage, SPAR/Surface Irradiance

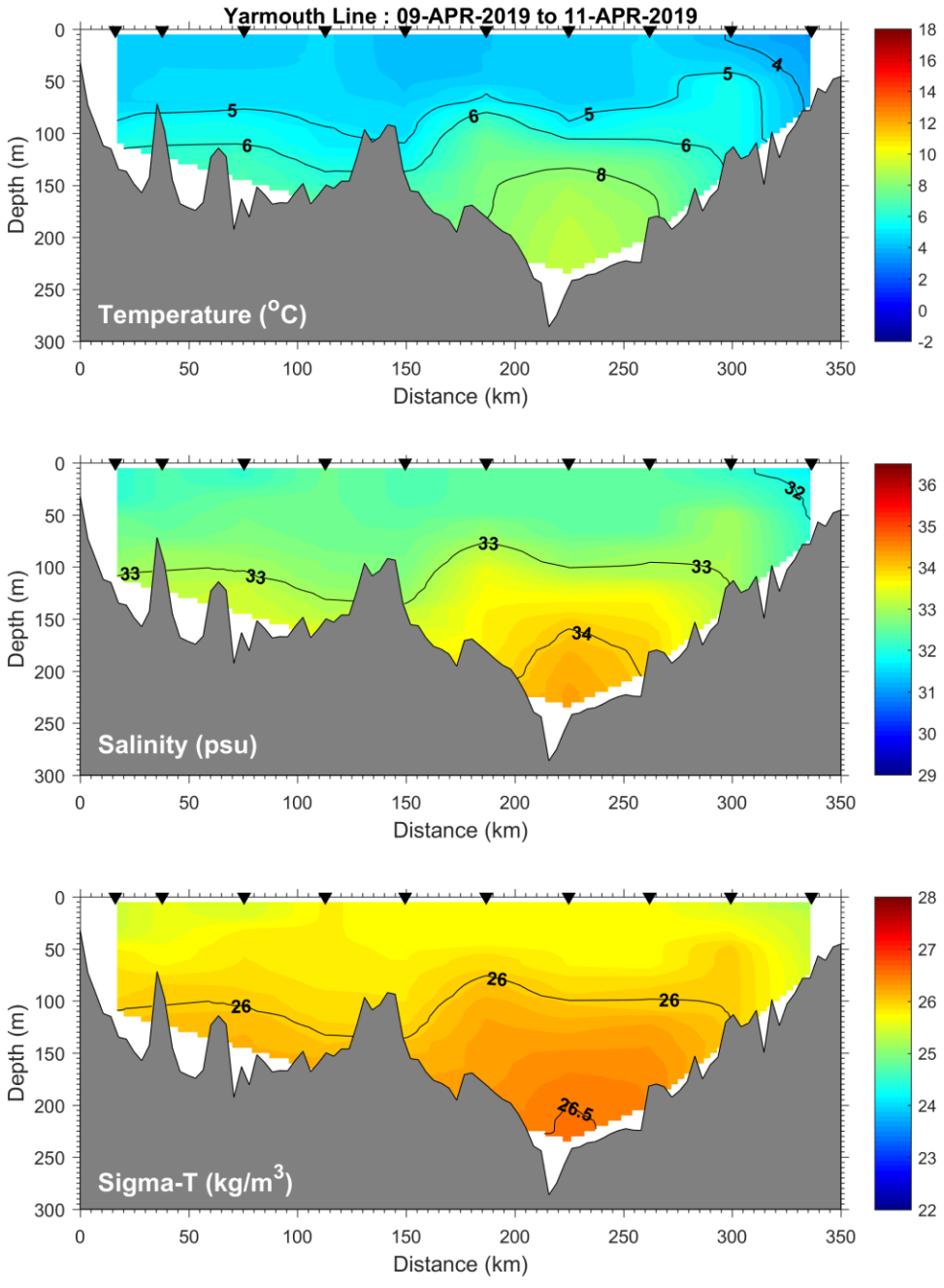
Serial number : 1043
Calibrated on : 01-Dec-2015
Conversion factor : 1.00000000
Ratio multiplier : 1.00000000

* - The configuration was changed after the file was opened.
Scan length : 40

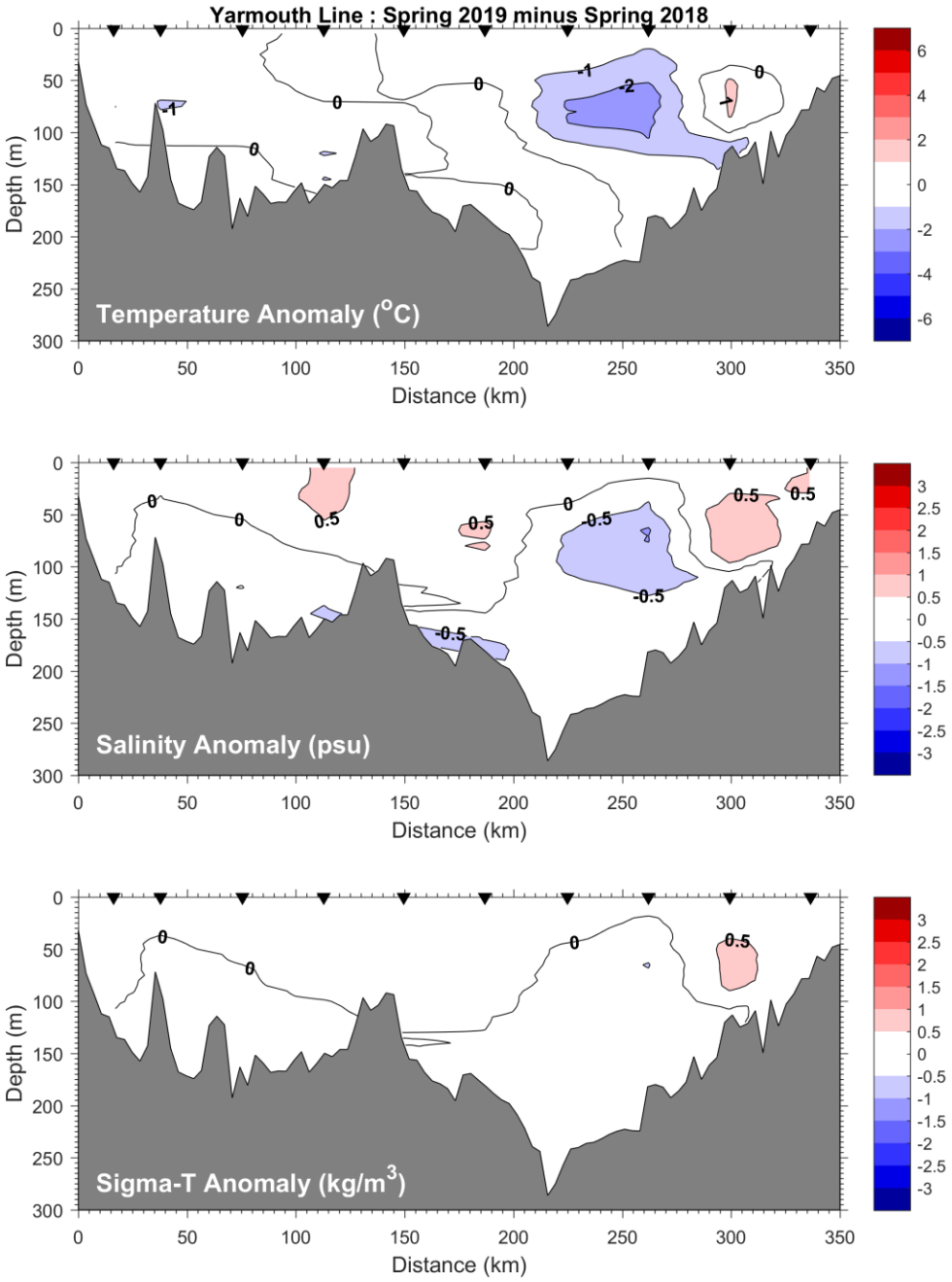
Appendix 3. Preliminary Section Plots and Anomalies (T/S/Sigma-T)

Yarmouth Line (east to west)

Section

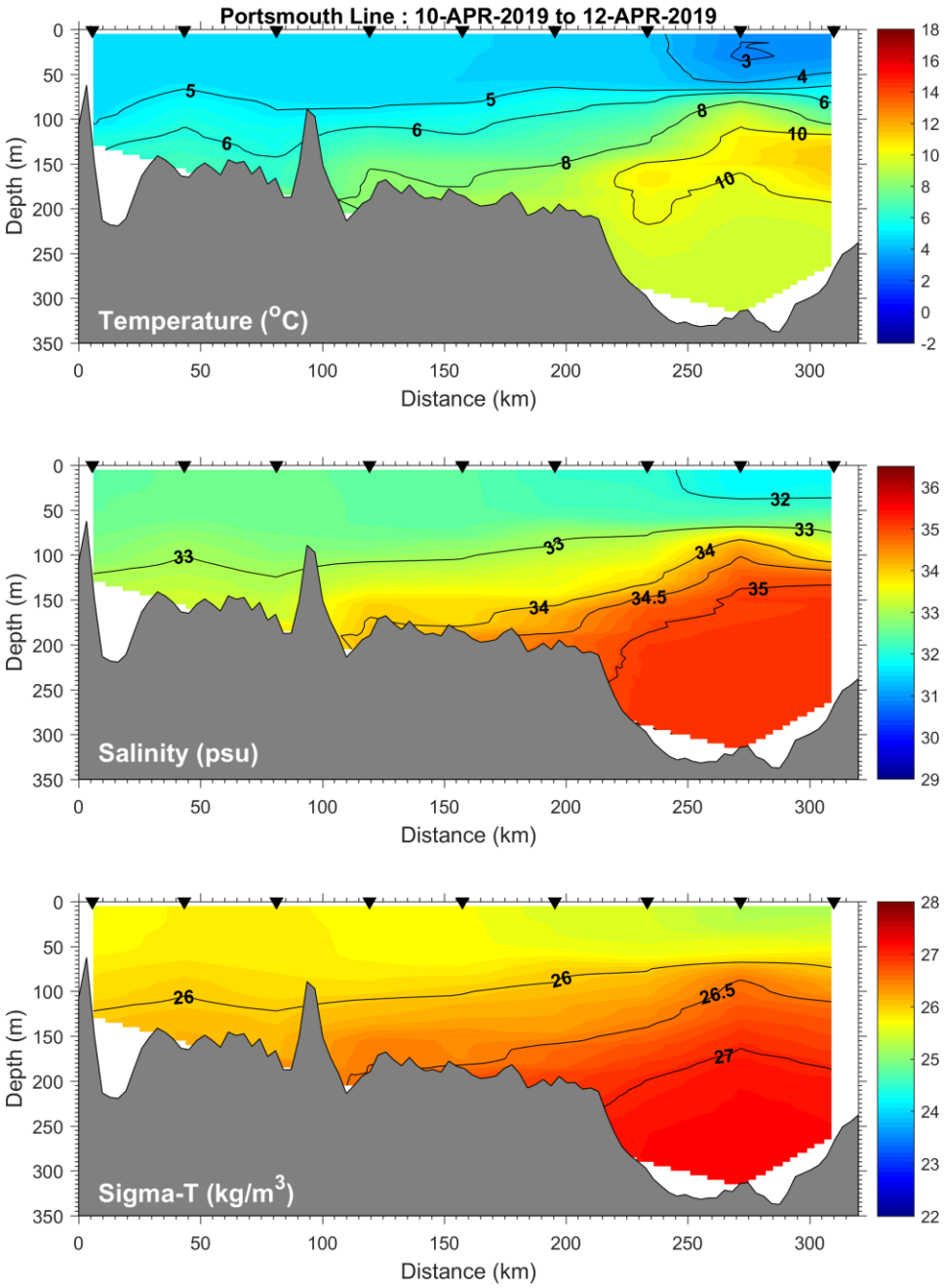


Anomaly

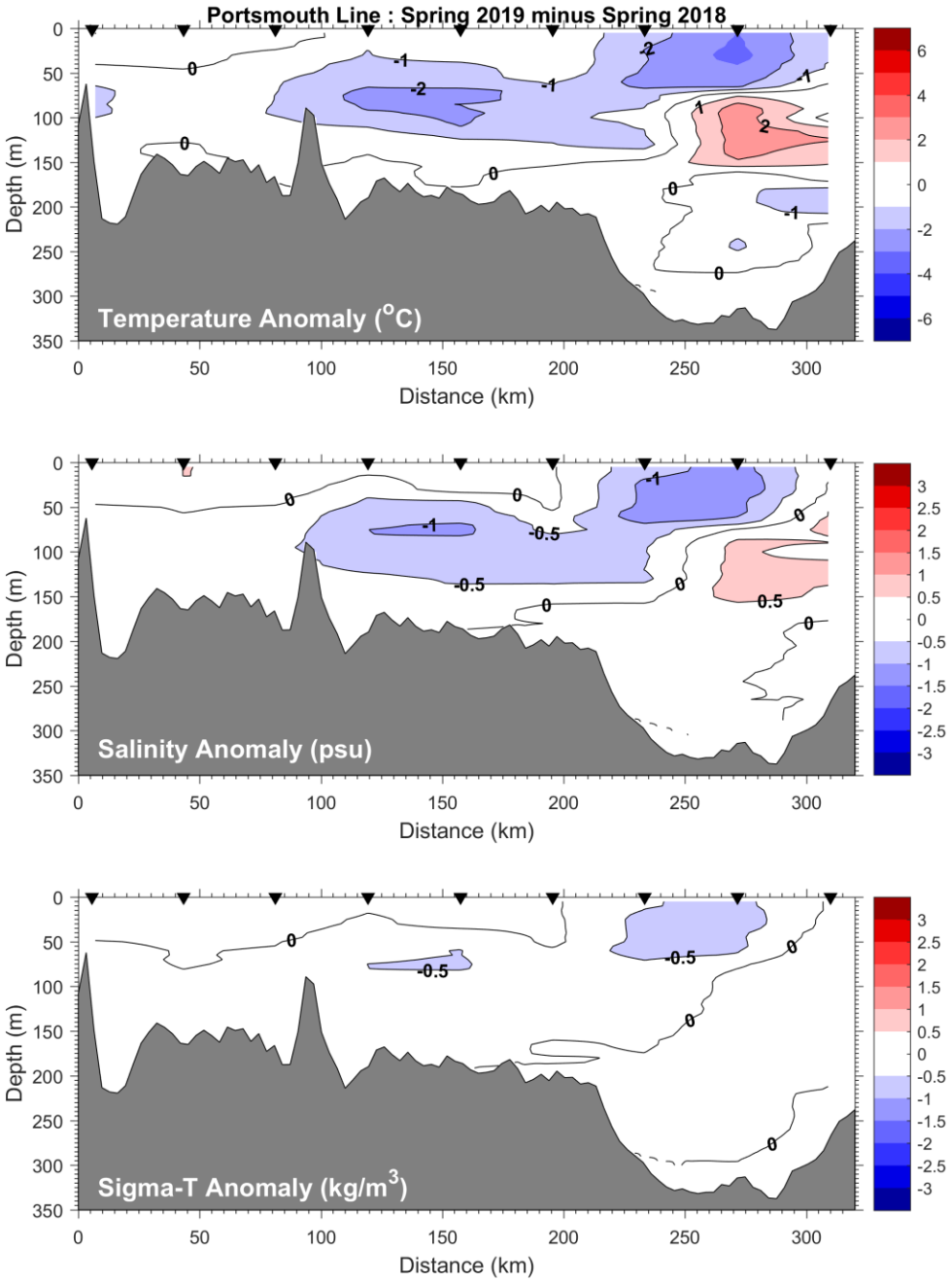

Yarmouth Line : Spring 2019 minus Spring 2018
Temperature Anomaly (°C)
Salinity Anomaly (psu)
Sigma-T Anomaly (kg/m3)
Depth (m)
Distance (km)

Portsmouth Line (west to east)

Section

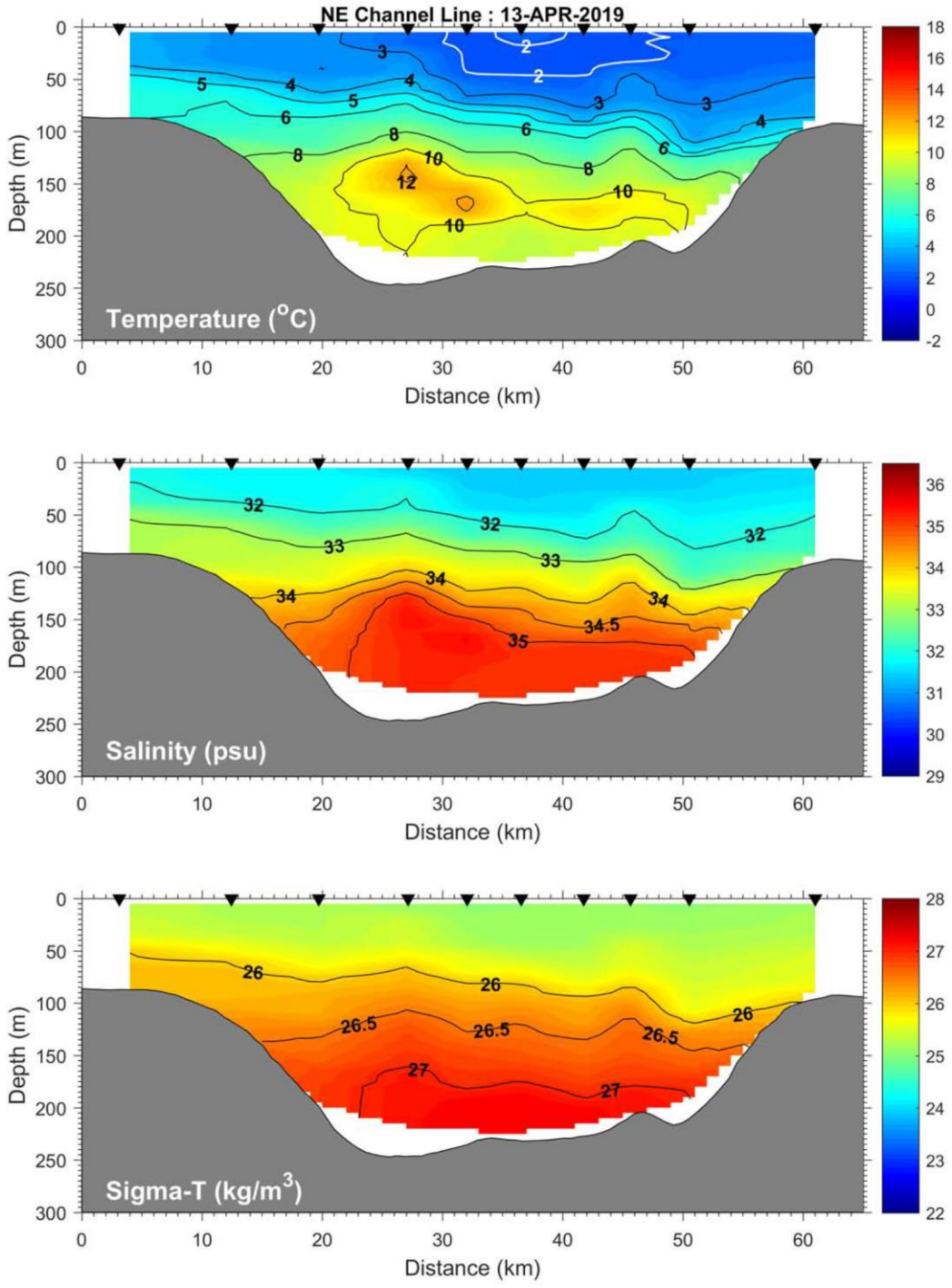


Anomaly

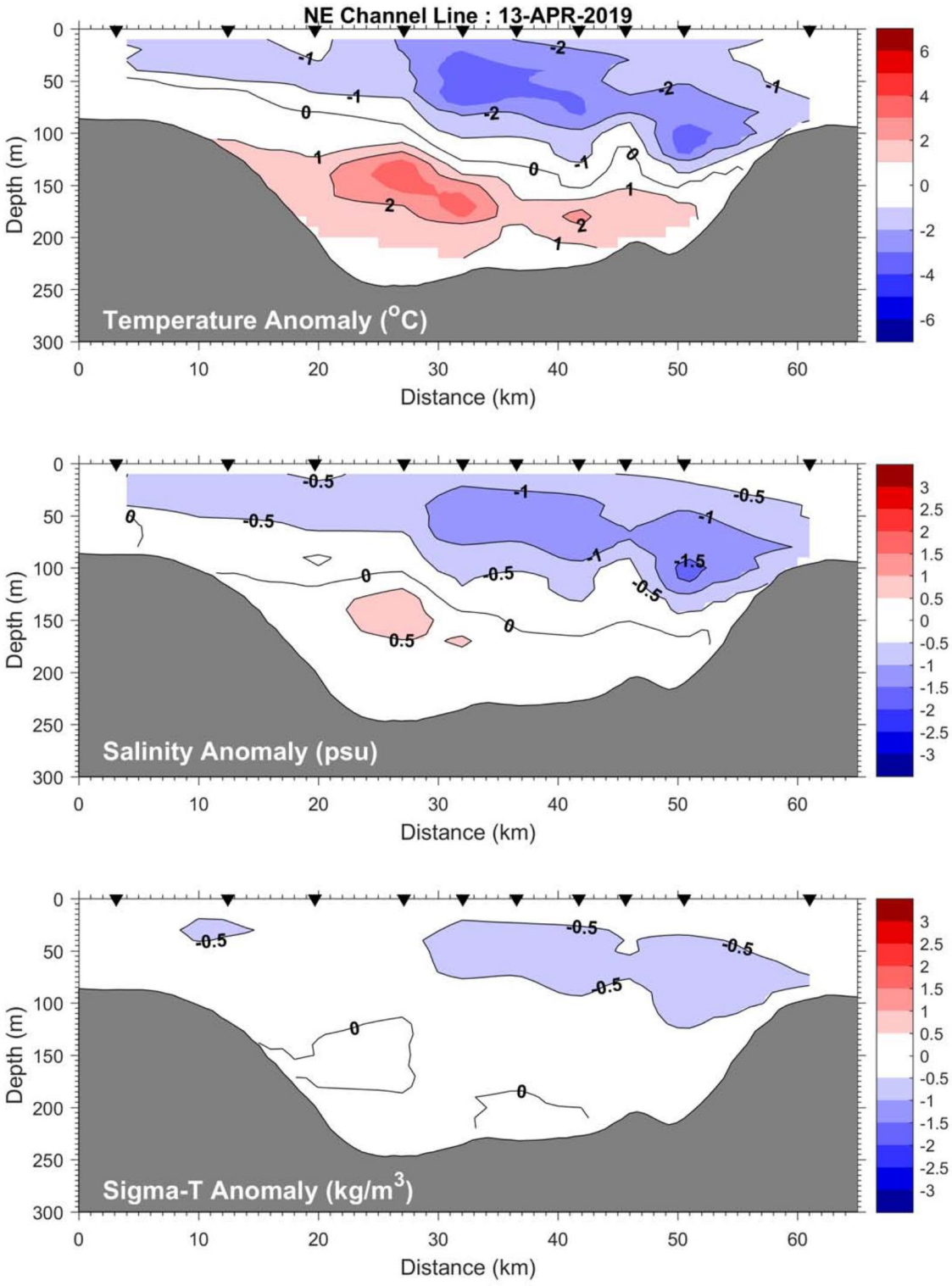

Portsmouth Line : Spring 2019 minus Spring 2018
Depth (m)
Distance (km)
Temperature Anomaly (°C)
Salinity Anomaly (psu)
Sigma-T Anomaly (kg/m3)

Northeast Channel Line (west to east)

Section

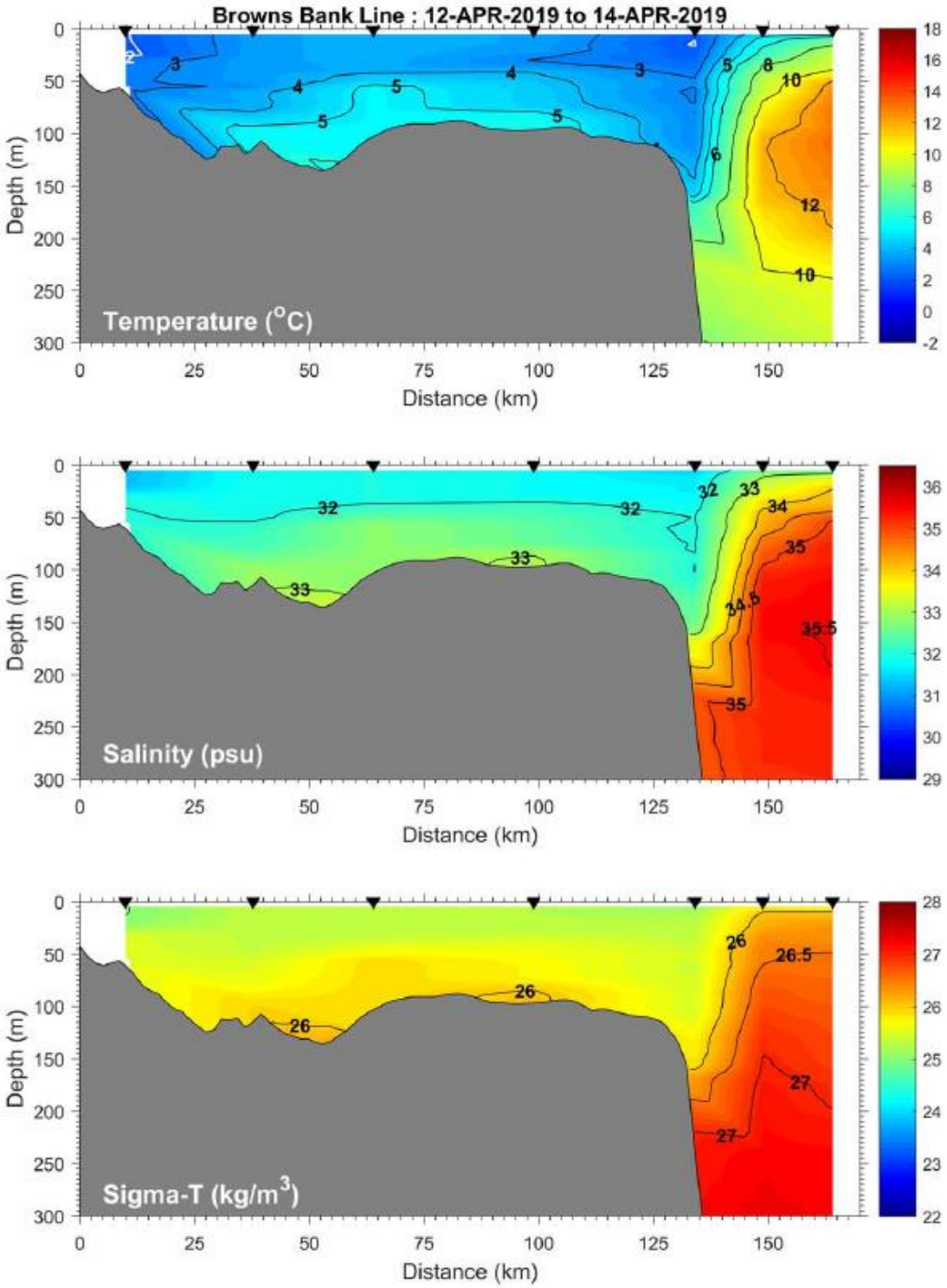


Anomaly

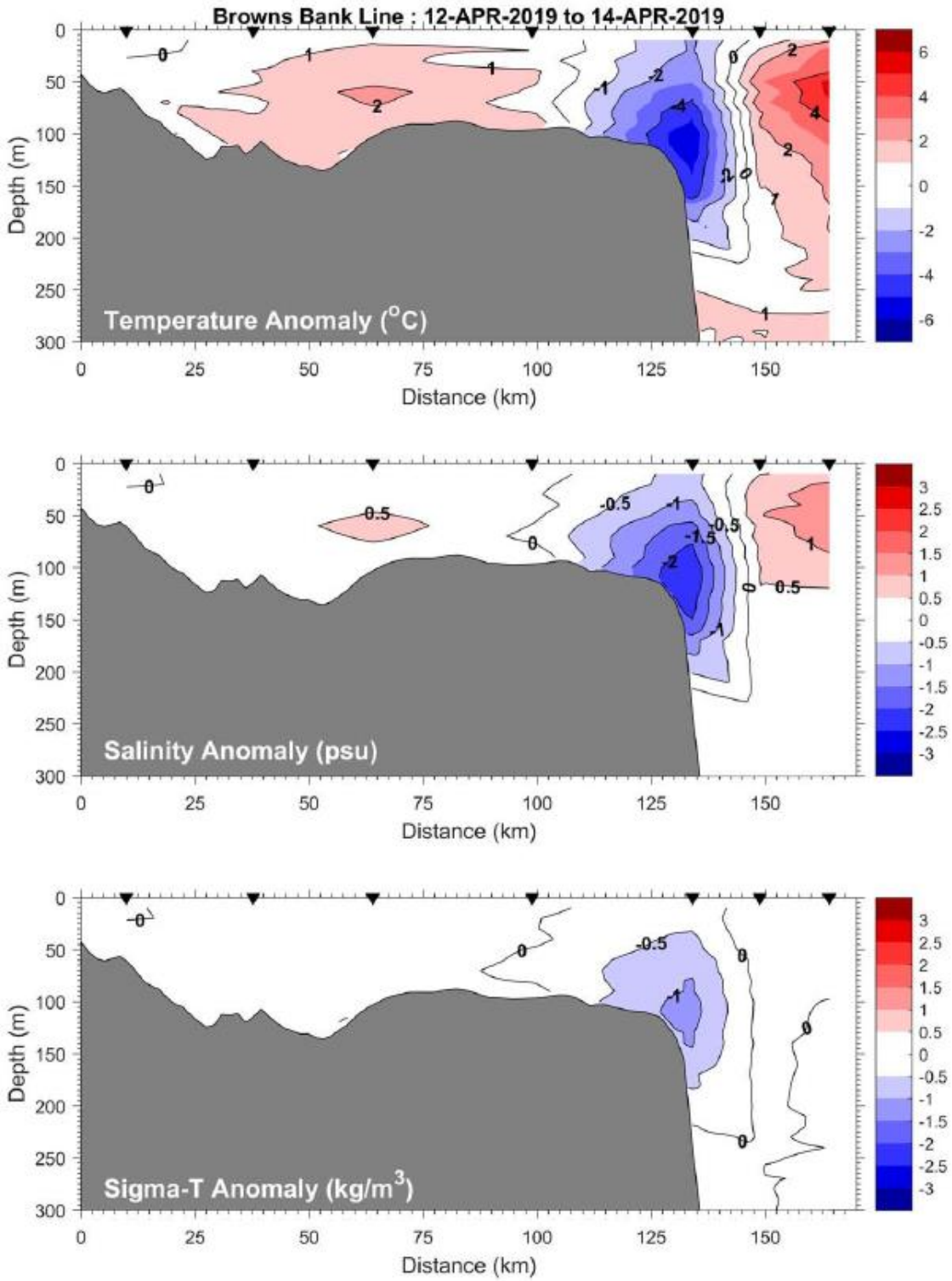

NE Channel Line : 13-APR-2019
Depth (m)
Distance (km)
Temperature Anomaly (°C)
Salinity Anomaly (psu)
Sigma-T Anomaly (kg/m3)

Browns Bank Line (north to south)

Section

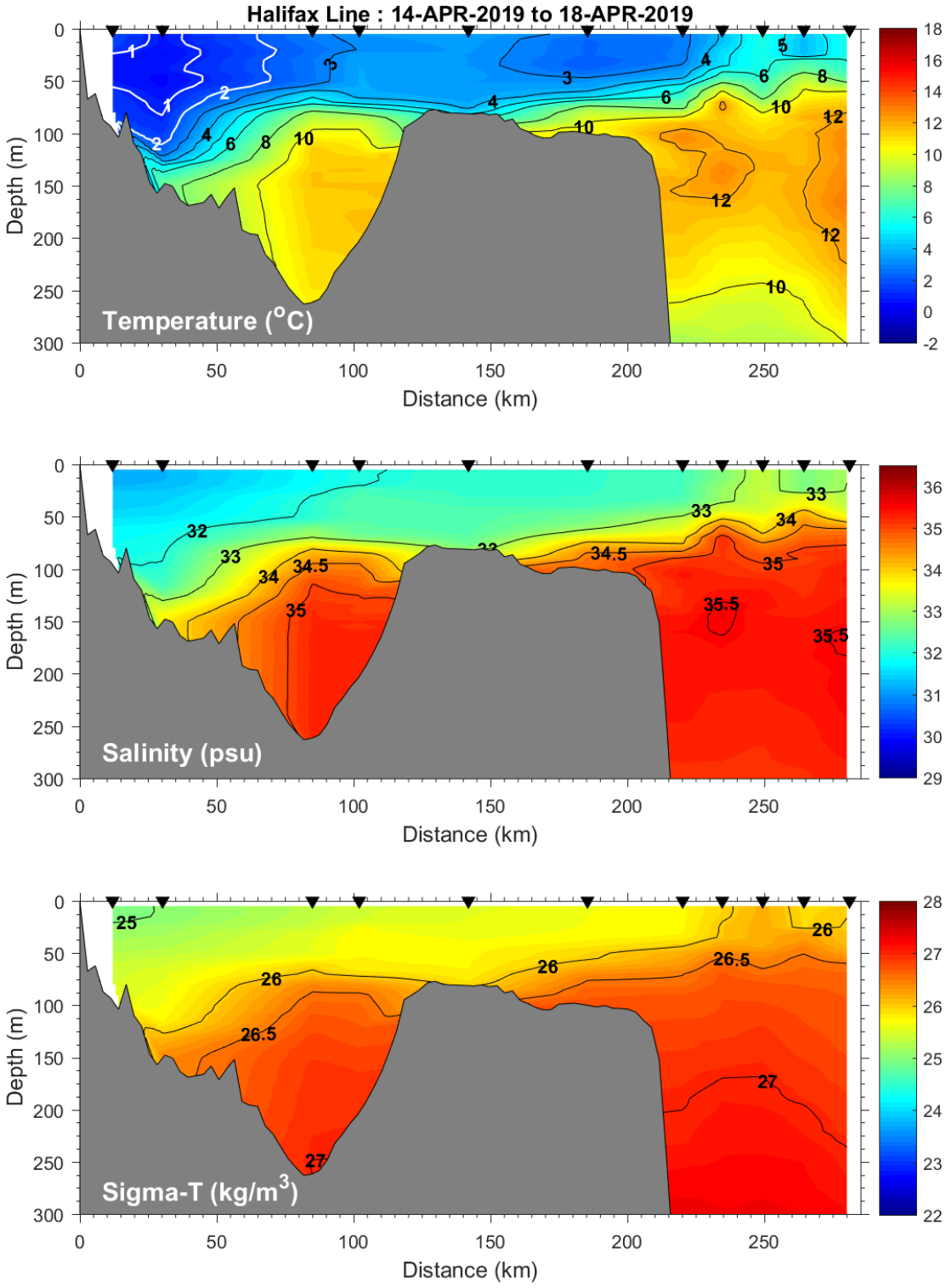


Anomaly

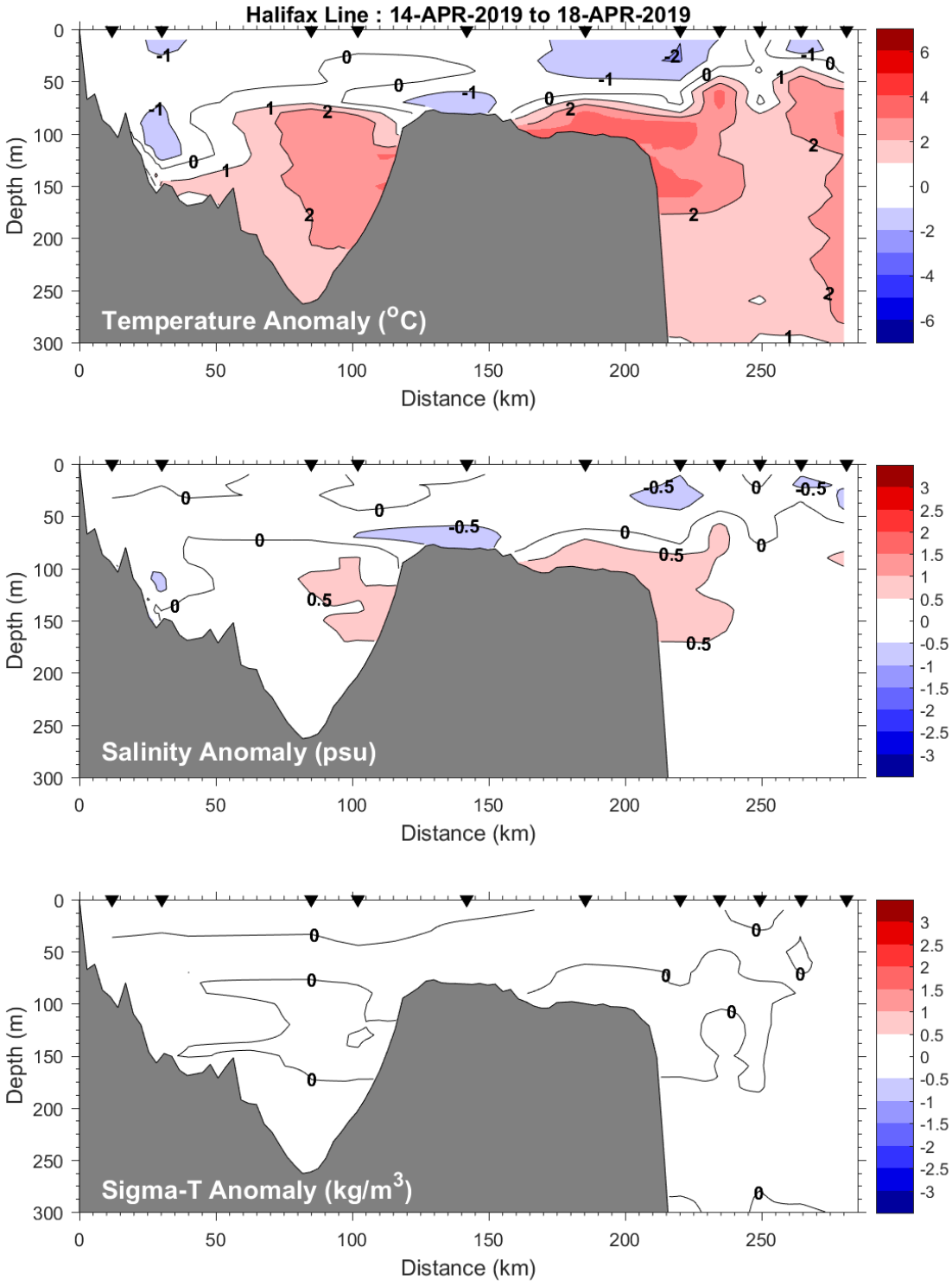

Browns Bank Line : 12-APR-2019 to 14-APR-2019
Temperature Anomaly (°C)
Salinity Anomaly (psu)
Sigma-T Anomaly (kg/m3)
Depth (m)
Distance (km)

Halifax Line (northeast to southwest)

Section

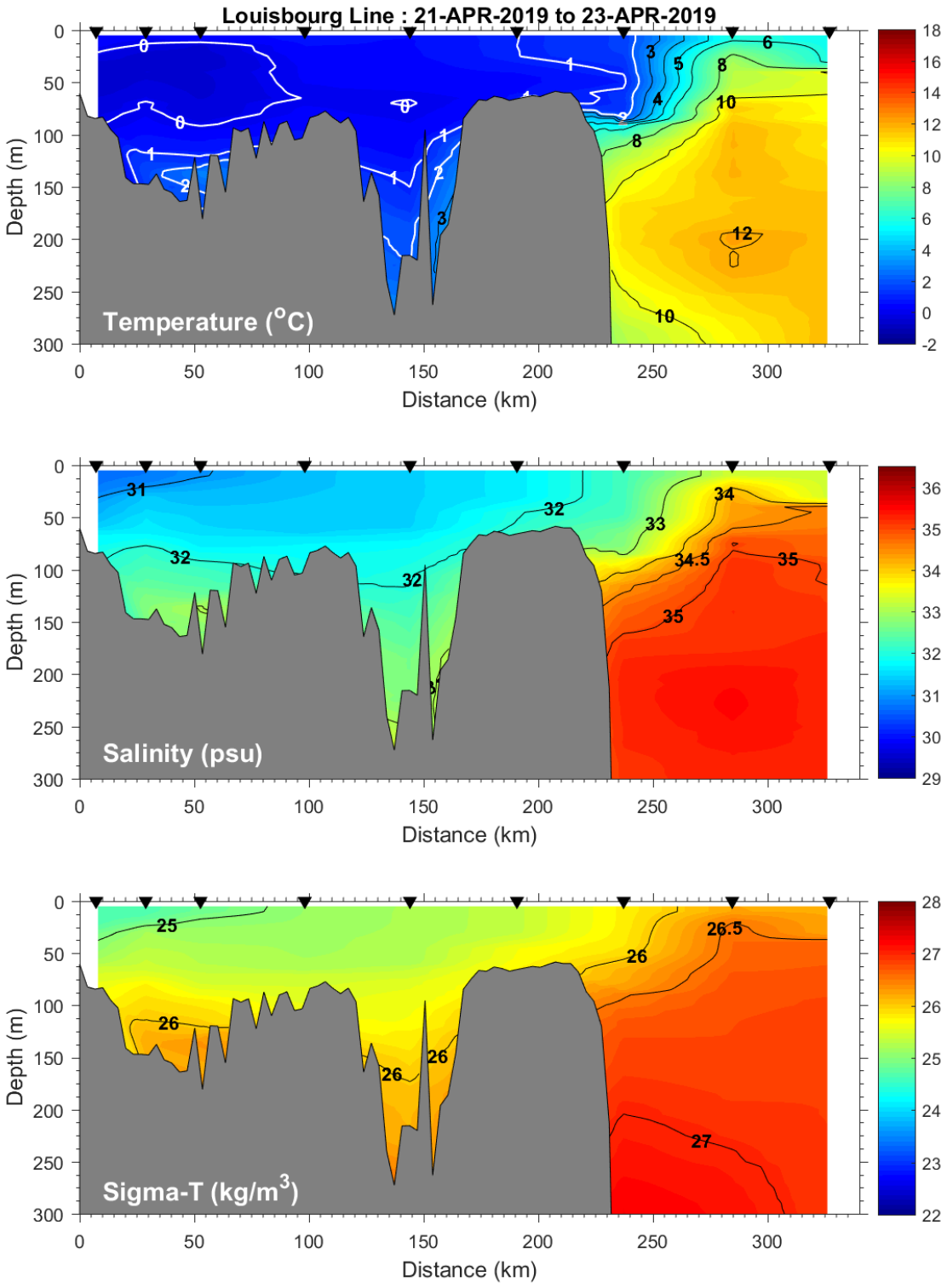


Anomaly

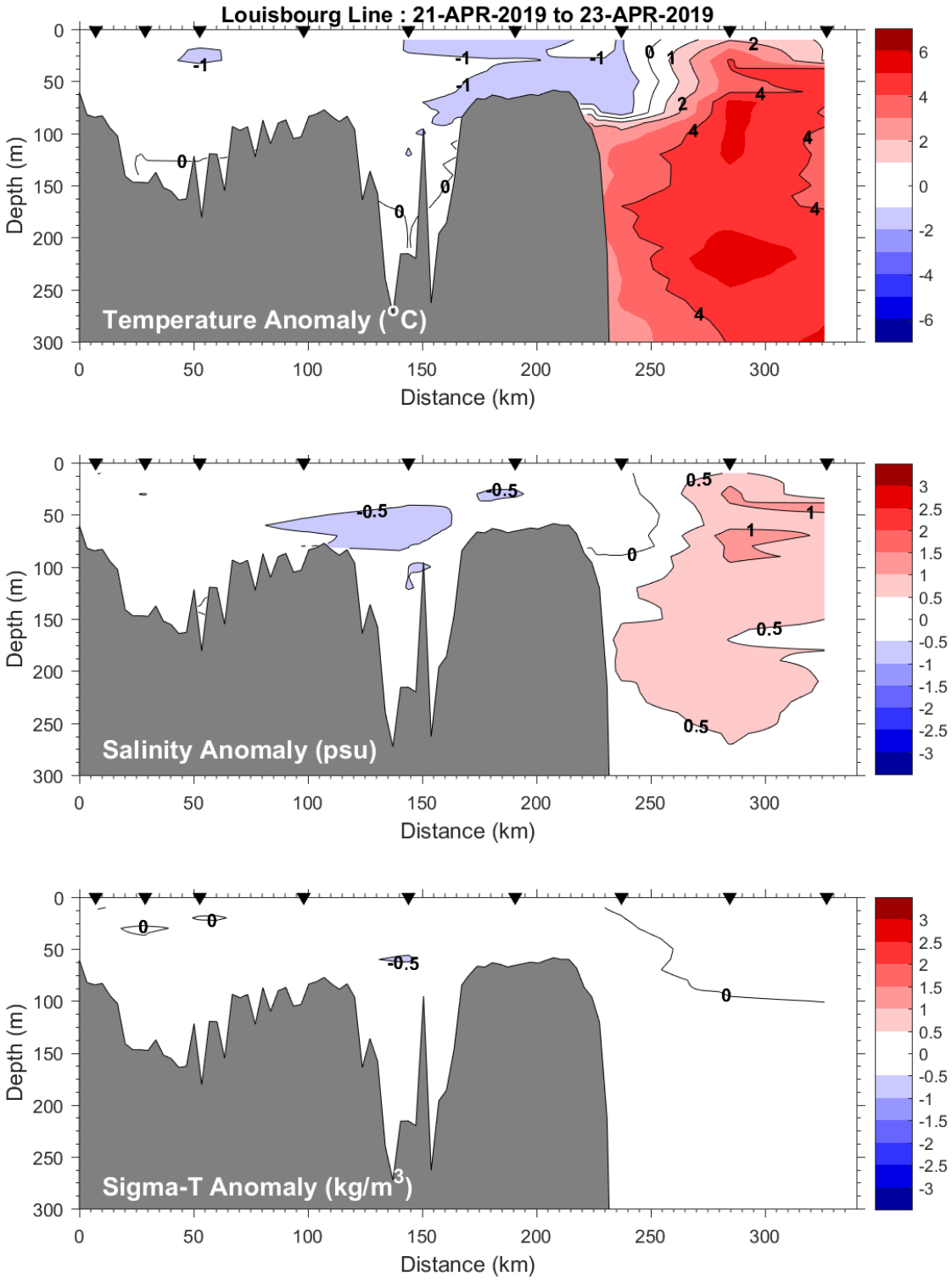

Halifax Line : 14-APR-2019 to 18-APR-2019
Temperature Anomaly (°C)
Salinity Anomaly (psu)
Sigma-T Anomaly (kg/m3)
Depth (m)
Distance (km)

Louisbourg Line (northeast to southwest)

Section

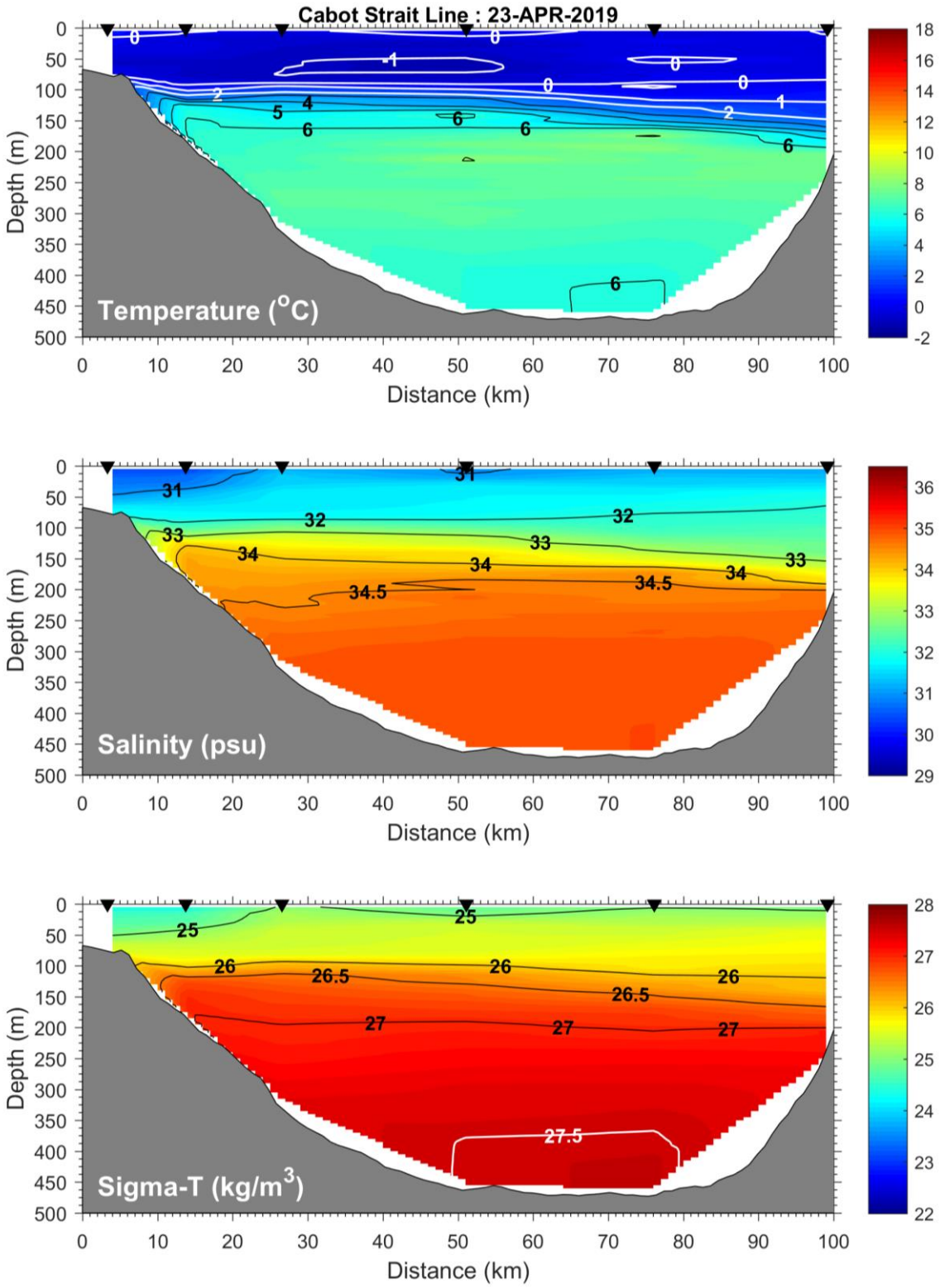


Anomaly

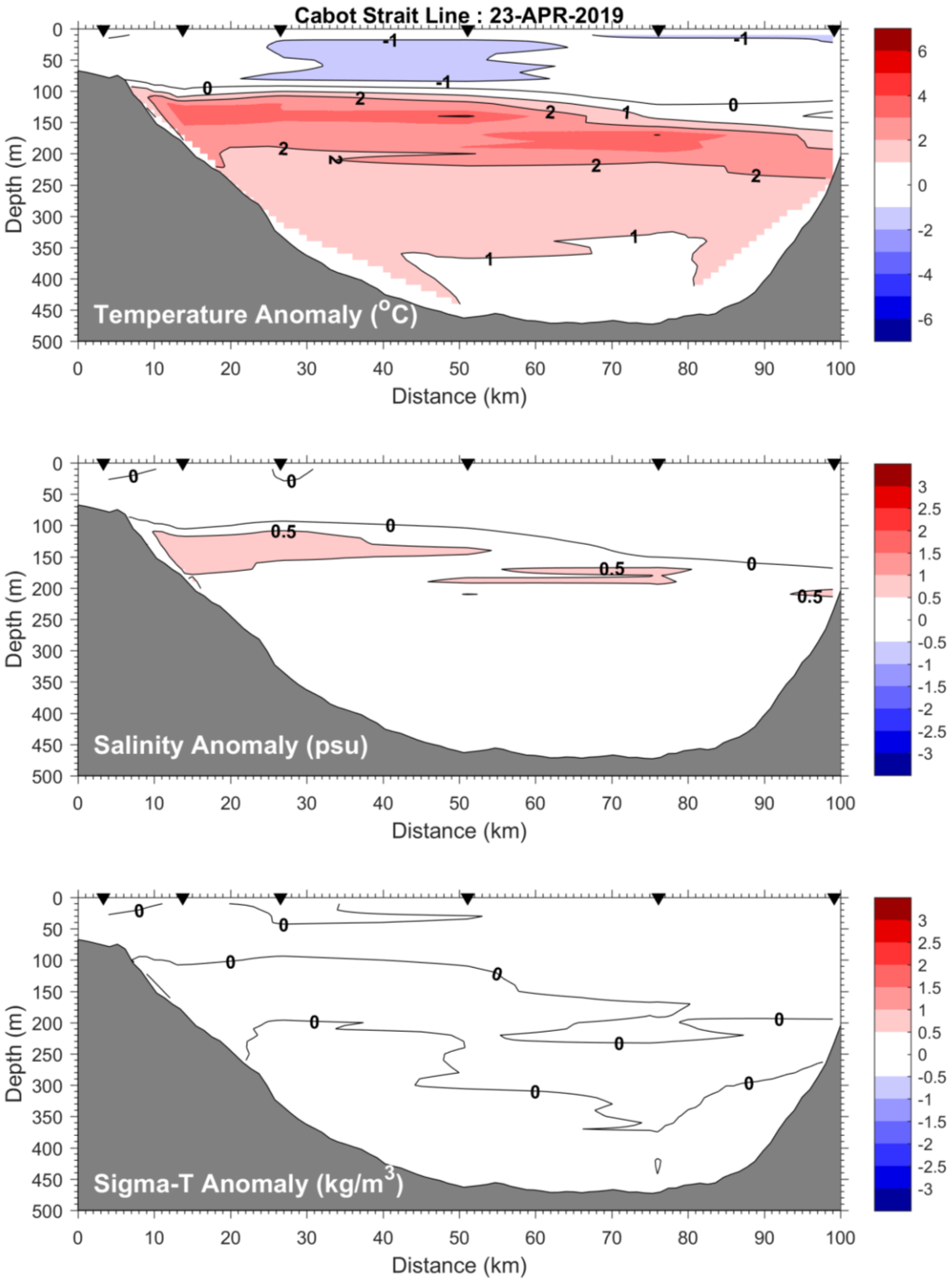

Louisbourg Line : 21-APR-2019 to 23-APR-2019
Temperature Anomaly (°C)
Salinity Anomaly (psu)
Sigma-T Anomaly (kg/m3)
Depth (m)
Distance (km)

Cabot Strait Line (west to east)

Section

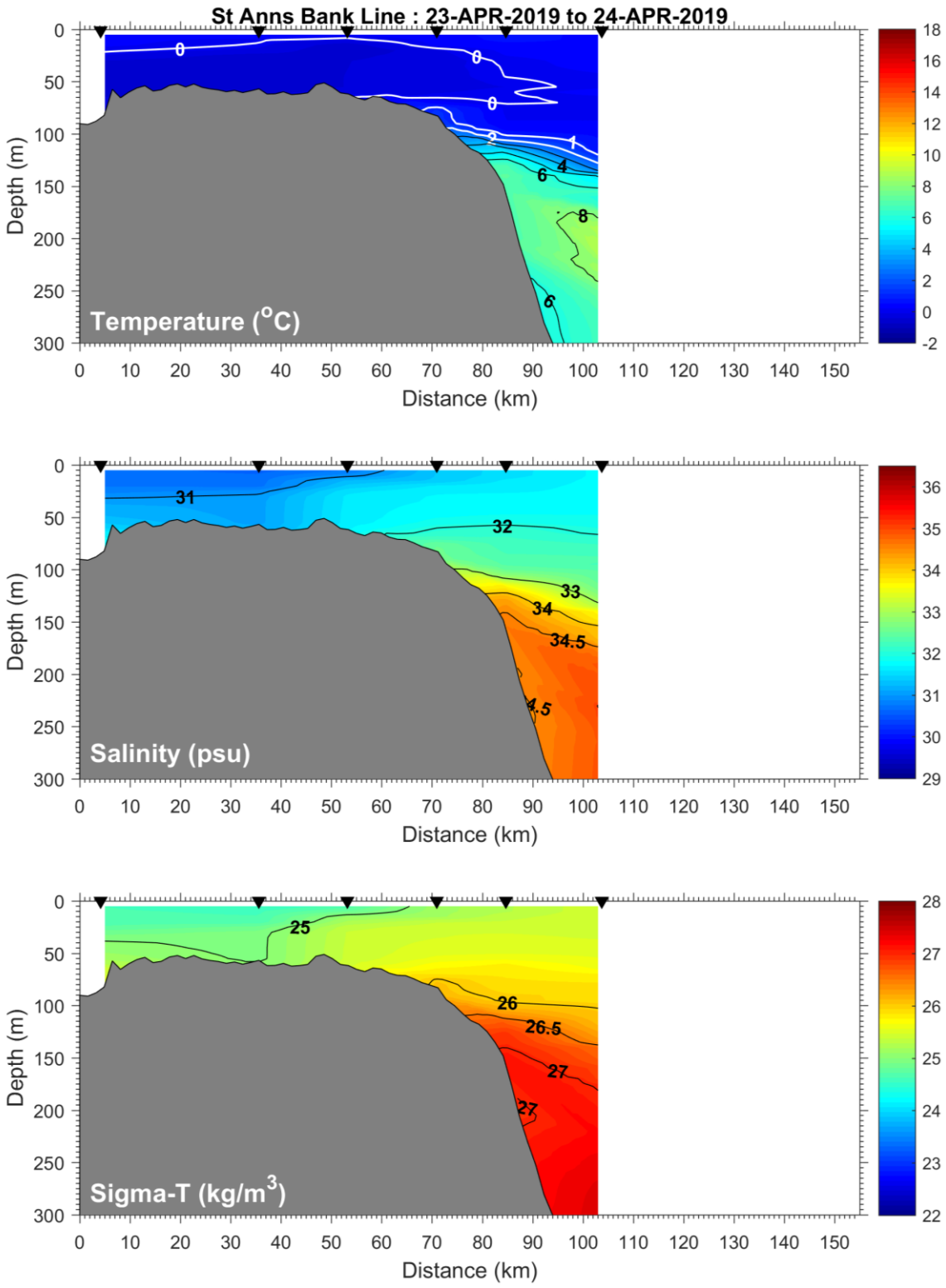


Anomaly


Cabot Strait Line : 23-APR-2019
Temperature Anomaly (°C)
Salinity Anomaly (psu)
Sigma-T Anomaly (kg/m3)
Depth (m)
Distance (km)

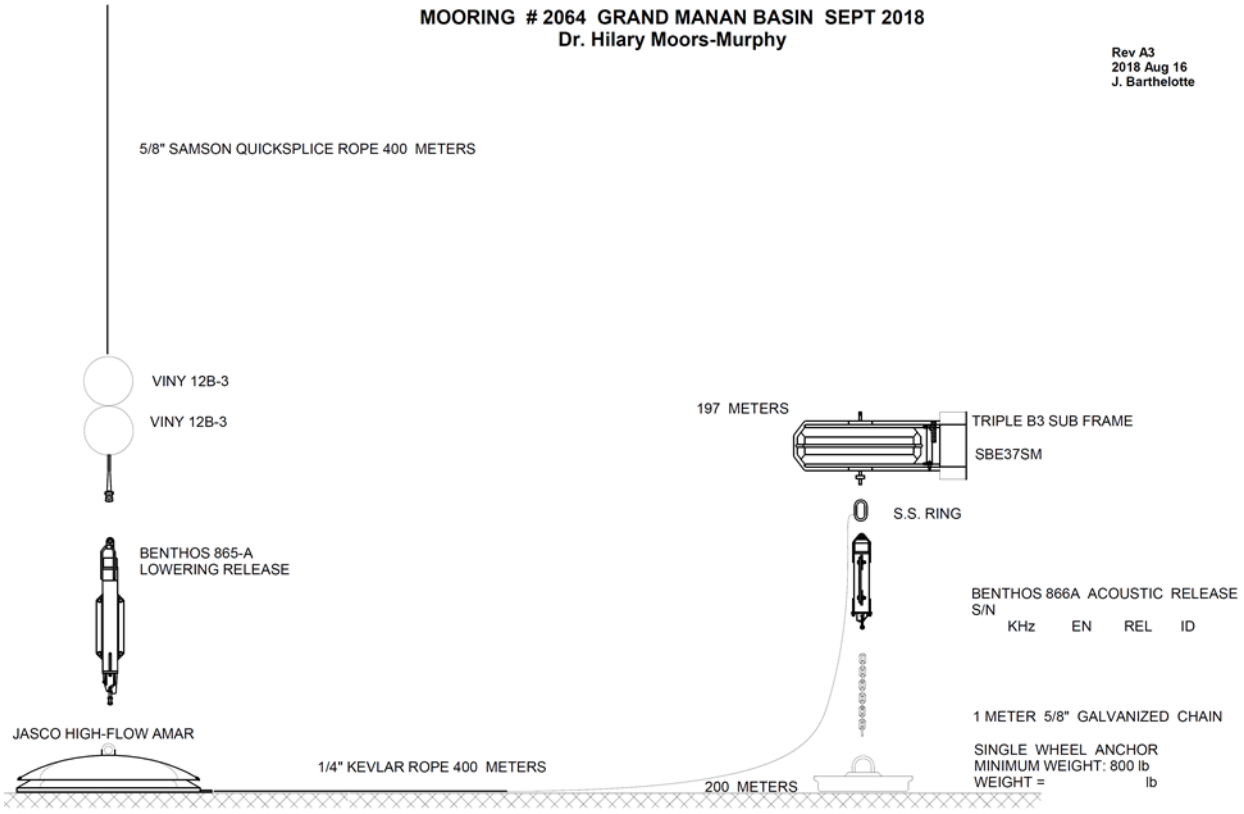
St. Anns Bank Line (west to east)

Section

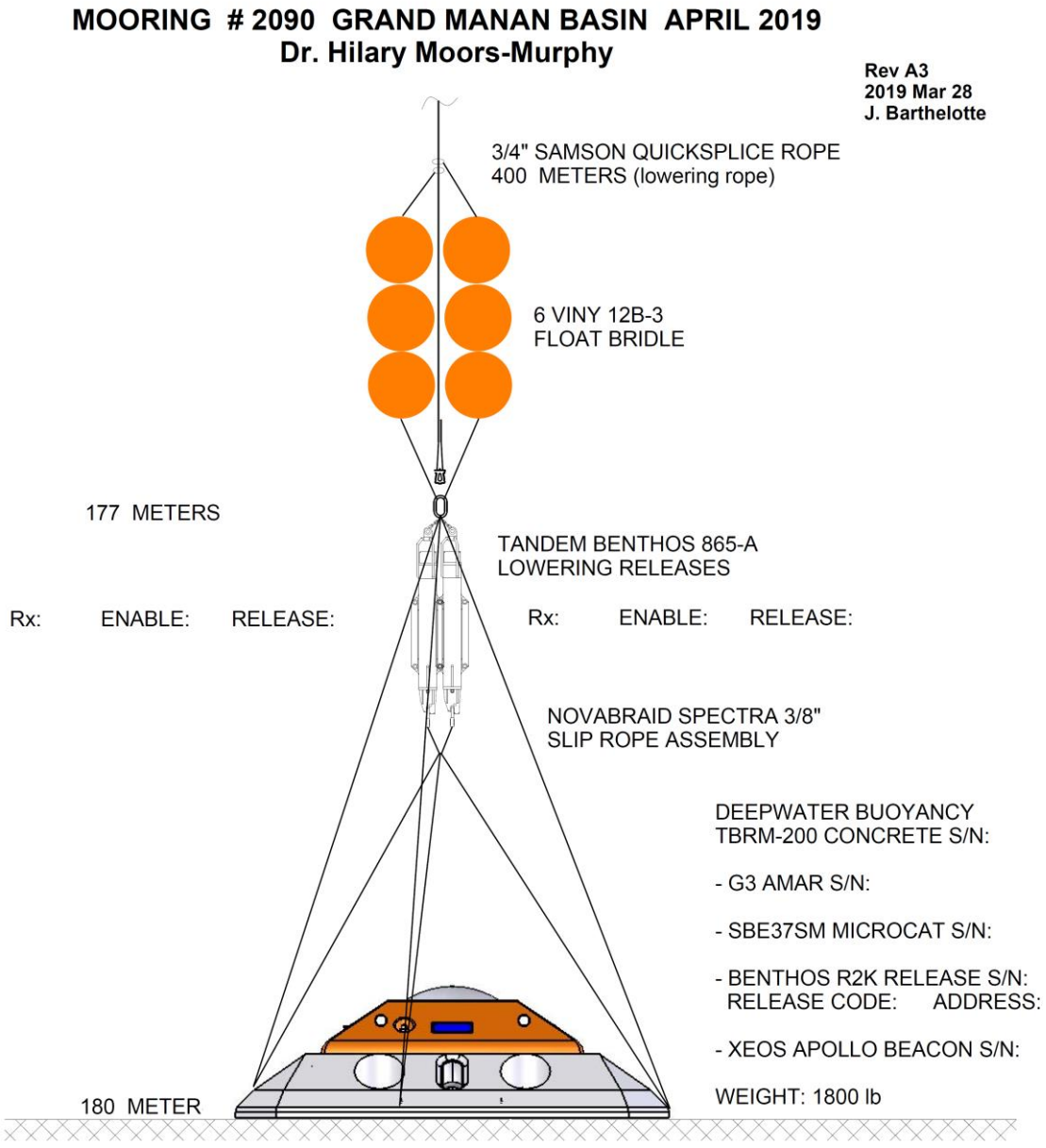


Appendix 4. Mooring Diagrams

Recoveries

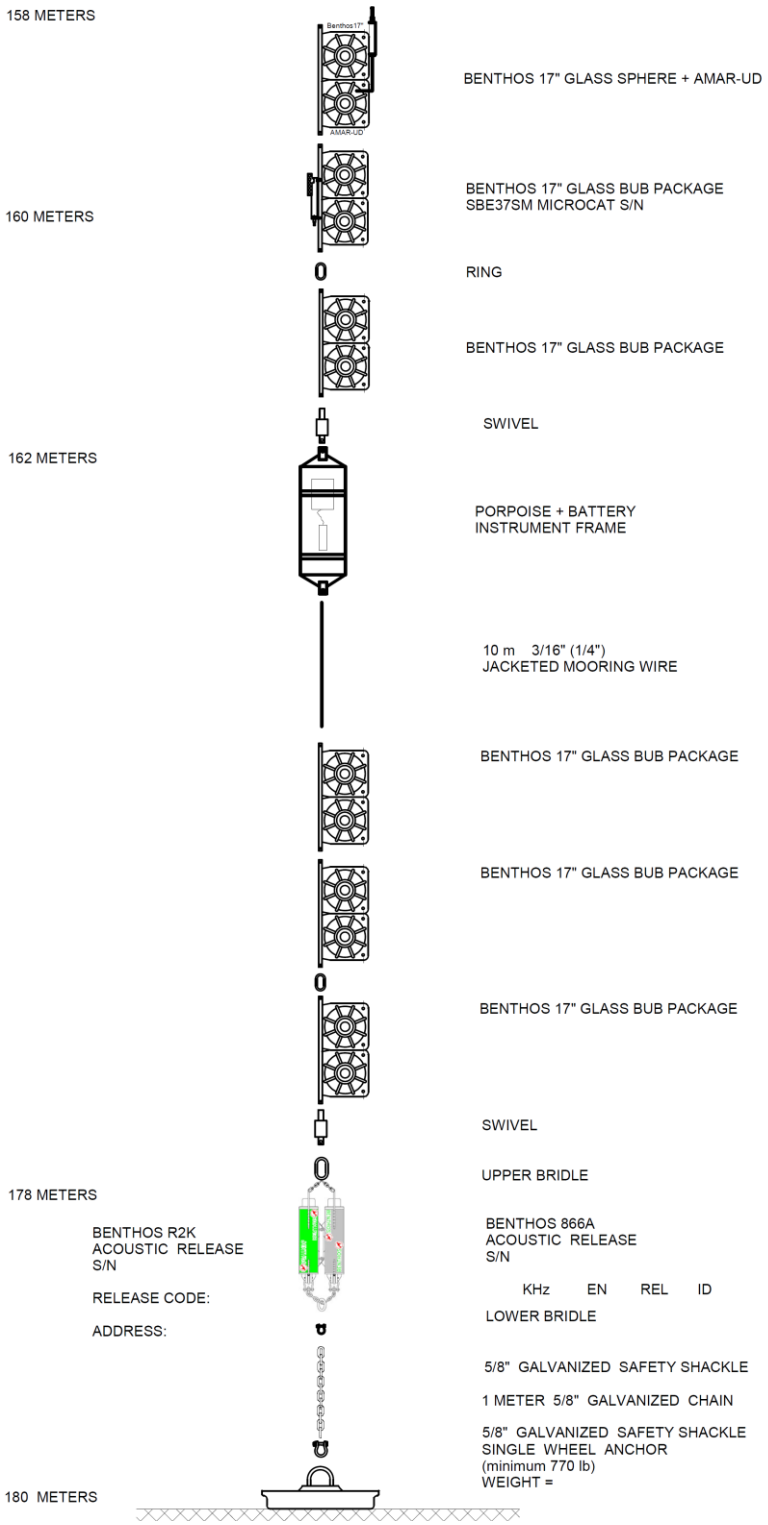


Deployments



MOORING # 2089 Cetacean Mooring - Jordan Basin April 2019
Dr. H. Moors-Murphy

Rev A1:
Model: 2089a1
2019 Feb 8
J. Barthelotte



Appendix 5. R Code to Correct Time Errors in Raw CTD Files

```
#RawFileTimeCorr_COR2019001.R

#  This code compiles the ODF files and compares their NMEA start times with the elog start times.  Anything greater than 5 minutes is  noted and will need to be revised to reflect a time change between nmea in the ODF and elog

source("C:\\Users\\CogswellA\\Documents\\AZMP\\Missions\\2019\\Spring2019\\R Code\\ODFcompile_COR2019001.R")

omes_sub #files with 24 hr conflict between NMEA and Elog UTC

setwd("C:\\Users\\CogswellA\\Documents\\AZMP\\Missions\\2019\\Spring2019\\atsea\\CTD_ACQUISITION\\2019001COR\\ctddata")

#extract .hdr, .bl and .hex file names
hdr <- grep(list.files(getwd()), pattern="*^.*001.*.hdr$",value=T)
bl <- grep(list.files(getwd()), pattern="*^.*001.*.bl$",value=T)
hex <- grep(list.files(getwd()), pattern="*^.*001.*.hex$",value=T)

omes_events <- as.vector(omes_sub$event)
omes_events2 <- omes_events

#this just changes the name to the proper 3 digit event nomenclature.
#These are the events that had a 24 hour discrepancy between the NMEA date and the PC date
for(n in 1:length(omes_events)){

  omes_events2[n] <- if (omes_events[n]<100) paste("0",omes_events[n],sep="") else omes_events[n]

}

#These are the .hdr names that required nmea correction
#this just loops through the .hdr and .hex files and increases the day of the NMEA time in the
#identified events by 24 hours
hdr_subnames <- paste("001A",omes_events2,".hdr",sep="") #.hdr files that need the NMEA day increased by 1

library(lubridate)
for (h in 1:length(hdr_subnames)){

  tmphdr <- readLines(hdr_subnames[h])
  tmpdate <- omes_sub$starttime[h]+days(1)
  tmpdate_new <- format(tmpdate,"%b %d %Y %H:%M:%S")
```

```
  nmeal <- which(substring(tmphdr,1,10) == "* NMEA UTC")
  tmphdr[nmeal] <- paste("* NMEA UTC (Time) = ",tmpdate_new, sep="")
  writeLines(tmphdr, hdr_subnames[h])

}

#These are the .hex names that required nmea correction
hex_subnames <- paste("001A",omes_events2,".hex",sep="") #.hdr files that need the
NMEA day increased by 1

for (x in 1:length(hex_subnames)){

  tmphex <- readLines(hex_subnames[x])
  tmpdate <- omes_sub$starttime[x]+days(1)
  tmpdate_new <- format(tmpdate,"%b %d %Y %H:%M:%S")
  nmeal <- which(substring(tmphex,1,10) == "* NMEA UTC")
  tmphex[nmeal] <- paste("* NMEA UTC (Time) = ",tmpdate_new, sep="")
  writeLines(tmphex, hex_subnames[x])

}



#Find and fix header times to match the nmea times in both .hex and .hdr files
#extracts the NMEA time and applies it to both instances of the System UTC (PC time)
for all files

for (i in 2:length(hdr)){

  tmphdr <- readLines(hdr[i])
  nmeal <- which(substring(tmphdr,1,10) == "* NMEA UTC")
  nmea <-substring(tmphdr[nmeal],21,40)
  sysupl <- which(substring(tmphdr,1,22) == "* System UpLoad Time =")
  tmphdr[sysupl] <- paste("* System UpLoad Time = ",nmea, sep="")

  sysutc <- which(substring(tmphdr,1,14) == "* System UTC =")
  tmphdr[sysutc] <- paste("* System UTC = ", nmea, sep="")
  writeLines(tmphdr, hdr[i])

}

# replace system UTC date and time with NMEA UTC
for (i in 2:length(hex)){

  tmphex <- readLines(hex[i])
  nmeal <- which(substring(tmphex,1,10) == "* NMEA UTC")
  nmea <-substring(tmphex[nmeal],21,40)
  sysupl <- which(substring(tmphex,1,22) == "* System UpLoad Time =")
```

```
  tmphex[sysupl] <- paste("* System UpLoad Time = ",nmea, sep="")
  sysutc <- which(substring(tmphex,1,14) == "* System UTC =")
  tmphex[sysutc] <- paste("* System UTC = ", nmea, sep="")
  writeLines(tmphex, hex[i])

}


#Fix the 03:59:46 issue with the .bl files.

library(stringr)
bl

for (b in 1:length(bl)){

  tmpbl_hdr <- readLines(bl[b])
  tmpbl_hdr1 <- tmpbl_hdr[1]
  tmpbl_hdr2 <- tmpbl_hdr[2]

  tmpbl_hdr2_t <- substring(tmpbl_hdr2,7,26) #orginal date time from row 2 of bl
  tmpbl_hdr2_jd <- as.Date(substring(tmpbl_hdr2_t,1,11), format='%b %d %Y') #extract
just date from row 2 of bl header
  tmpbl_hdr2_jt <-  format(substring(tmpbl_hdr2_t,13,20), format="%H:%M:%S")
#extract just time from row 2 of bl header
  tmpbl_hdr2_dt <- as.POSIXct(paste(tmpbl_hdr2_jd,tmpbl_hdr2_jt,sep="
"))+(3*60*60)+(59*60)+44 #new date time with time added
  ndt_hdr2 <- format(tmpbl_hdr2_dt, format="%b %d %Y %H:%M:%S") #new date time
for header 2
  tmpbl_hdr2 <- paste("RESET ", ndt_hdr2,sep="")


    if (length (tmpbl_hdr)>2) tmpbl <- read.delim(bl[b],sep=',', skip=2, header=F) #import
the bl scans
  if (length (tmpbl_hdr)>2) tmpbl$V3 <- as.character(tmpbl$V3) #change to character
from vector
  if (length (tmpbl_hdr)>2) justdate <- as.Date(substring(tmpbl$V3,2,12), format='%b %d
%Y')
  if (length (tmpbl_hdr)>2) justtime <-  format(substring(tmpbl$V3,14,21),
format="%H:%M:%S")
  if (length (tmpbl_hdr)>2) datetime <- as.POSIXct(paste(justdate,justtime,sep="
"))+(3*60*60)+(59*60)+44 # add 3 hours, 59 mins and 44 seconds to overall time
  if (length (tmpbl_hdr)>2) tmpbl$V3 <- as.factor(format(datetime, format="%b %d %Y
%H:%M:%S"))


  cat(tmpbl_hdr1,'\n',  file=bl[b])
  cat(tmpbl_hdr2,'\n', file=bl[b], append=T)
  #cat(tmpbl_hdr2,'\n', file=bl[b])
```

```
  tmp <- NULL
  if (length (tmpbl_hdr)>2) write.table(tmpbl, file=bl[b], col.names=F,
row.names=F,append=TRUE, sep=", ", quote=F) else write.table(tmp, file=bl[b],
col.names=F, row.names=F,append=TRUE, sep=", ", quote=F)


}
```