Mission Report for the Maritimes Region Atlantic Zone Monitoring Program 2024 Fall Survey (DY18402)

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MISSION REPORT FOR THE MARITIMES REGION ATLANTIC ZONE MONITORING PROGRAM 2024 FALL SURVEY (DY18402)

by

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CONTENTS

ABSTRACT

Beazley, L., Lawson, M., Colbourne, N., Gordon, C., Upson, P., Gjerdrum, C., Warman, K., Cardoso, D. 2025. Mission Report for the Maritimes Region Atlantic Zone Monitoring Program 2024 Fall Survey (DY18402). Can. Tech. Rep. Hydrogr. Ocean Sci. 402: vii + 109 p. https://doi.org/10.60825/yz8j-n555

As part of a collaborative agreement between Fisheries and Oceans Canada (DFO), Natural Resources Canada, and the National Oceanography Centre in the UK, an oceanographic research mission was conducted on the RRS *Discovery* from October 4 to 22, 2024 off the coast of Nova Scotia and in the Gulf of Maine. This multidisciplinary mission was in support of 3 DFO programs and objectives: delivery of the Maritimes Region Atlantic Zone Monitoring Program 2024 fall survey, DFO's Cetacean Research and Monitoring Program, and a DFO-led project to evaluate the vertical structure of *Calanus* zooplankton for evaluation of the foraging habitat of the North Atlantic right whale. A total of 22 science staff participated in the mission from across federal departments and local and international research institutions. In total, 199 deployments of various oceanographic sampling equipment were conducted across a network of fixed monitoring stations, including CTD-Rosette deployments for the collection of vertical profiles of e.g., temperature and salinity, and water samples from pre-determined depths, vertical ring net tows and multinet deployments for zooplankton sample collection, deployments of a Video Plankton Recorder system, and Argo float deployments in support of the International Argo program. In collaboration with the Woods Hole Oceanographic Institution, an Imaging Flow Cytobot was used to collect high-resolution images of phytoplankton from surface waters sampled while underway, and an infrared camera system and associated machine-learning software was used to record and identify detections of cetaceans. This report provides an overview of the mission's objectives, achievements, impacts, gear operations and operational issues. Summaries of the marine mammal and seabird observations collected during the mission are presented, as are the results of preliminary exercises to calculate new calibration coefficients for the dissolved oxygen and conductivity CTD sensors.

RÉSUMÉ

Beazley, L., Lawson, M., Colbourne, N., Gordon, C., Upson, P., Gjerdrum, C., Warman, K., Cardoso, D. 2025. Mission Report for the Maritimes Region Atlantic Zone Monitoring Program 2024 Fall Survey (DY18402). Can. Tech. Rep. Hydrogr. Ocean Sci. 402: vii + 109 p. https://doi.org/10.60825/yz8j-n555

Dans le cadre d'un accord de collaboration entre Pêches et Océans Canada (MPO), Ressources naturelles Canada et le National Oceanography Centre du Royaume-Uni, une mission de recherche océanographique a été menée sur le RRS Discovery du 4 au 22 octobre 2024 dans l'ensemble du plateau néo-écossais et du golfe du Maine. Cette mission multidisciplinaire appuyait trois programmes et objectifs du MPO : la réalisation du relevé d'automne 2024 du Programme de monitorage de la zone Atlantique de la région des Maritimes, des objectifs du Programme de recherche et de surveillance des cétacés du MPO, et d'un projet dirigé par le MPO visant à évaluer la structure verticale du zooplancton Calanus aux fins de l'évaluation de l'habitat d'alimentation de la baleine noire de l'Atlantique Nord. Au total, 22 membres du personnel scientifique de divers ministères fédéraux et d'établissements de recherche locaux et internationaux ont participé à la mission. Au total, 199 déploiements de divers équipements d'échantillonnage océanographique ont été effectués dans un réseau de stations de monitorage, y compris des déploiements d'instruments de mesure de CTP/de rosettes pour la collecte de profils verticaux de température et de salinité et d'échantillons d'eau dans des profondeurs prédéterminées, des traits de filet verticaux et des déploiements de filets multiples pour la collecte d'échantillons de zooplancton, des déploiements d'un enregistreur vidéo de plancton et des déploiements de flotteurs Argo à l'appui du programme international Argo. En collaboration avec la Woods Hole Oceanographic Institution, on a utilisé le système Imaging Flow Cytobot pour recueillir des images à haute résolution du phytoplancton dans les eaux de surface échantillonnées pendant le trajet, ainsi qu'un système de caméra infrarouge et un logiciel d'apprentissage automatique connexe pour enregistrer et identifier les détections de cétacés. Ce rapport fournit une vue d'ensemble des objectifs, des réalisations, des répercussions, de l'utilisation des engins et des enjeux opérationnels de la mission. Il contient également un résumé des observations d'oiseaux de mer et de mammifères marins consignées au cours de la mission, ainsi que les résultats des exercices préliminaires visant à calculer de nouveaux coefficients d'étalonnage pour les capteurs d'oxygène dissous et de conductivité (CTP).

1 Mission Overview

1.1 Background

As part of a collaborative agreement between Fisheries and Oceans Canada (DFO), Natural Resources of Canada (NRCan), and the National Oceanography Centre (NOC) based in Southampton, UK, the Royal Research Ship (RRS) *Discovery* was used to deliver a joint geological and oceanographic mission during the fall 2024 in support of NRCan and DFO programs and initiatives. The survey, identified as DY184 (where 'DY' represents the *Discovery*), was divided into three legs. The first leg, DY18401, was a geological survey on the Scotian Shelf led by NRCan from August 31 - October 1, 2024. Leg 2 (DY18402, October 4 - 22, 2024) was a multidisciplinary mission in support of DFO's Atlantic Zone Monitoring Program (AZMP) and cetacean research and monitoring initiatives in the Maritimes Region, and a DFO-led whale foraging habitat assessment project. Finally, Leg 3 (DY18403, October 28 - November 25, 2024) was in support of the Newfoundland and Labrador Region's fall AZMP survey. Each of the three legs of the mission were conducted as separate surveys, each with different chief scientists and scientific teams.

The AZMP was initiated in 1998 with the aim to detect, track, and predict changes in the state and productivity of waters across the northwest Atlantic. The AZMP's sampling strategy in the Maritimes Region is based on high-frequency (weekly, biweekly, monthly) data collection, hydrographic data collection on the winter and summer Ecosystem Trawl Surveys, and dedicated oceanographic surveys conducted each spring and fall. During the DY18402 mission, data and sample collection was planned across a network of fixed monitoring stations spanning from the Gulf of Maine and the Northeast Channel in the west, and across the Scotian Shelf to the Cabot Strait in the east, and included CTD-Rosette deployments for the collection of vertical profile data and water samples for nutrient, salinity, dissolved oxygen, chlorophyll *a* determination, ocean acidification and phytoplankton monitoring, and vertical ring net tows for the collection of data on zooplankton abundance and biomass. In addition to the AZMP's core activities, a request was made to recover an ocean glider in distress near the end of the AZMP's Halifax Line, which would be achieved during the DY18402 mission.

The second primary objective of the mission was to recover and deploy a number of passive acoustic monitoring moorings in support of cetacean research and monitoring efforts in the Maritimes Region. Marine mammal observations were also actively collected from the bridge by up to three marine mammal observers while under transit. In collaboration with the Woods Hole Oceanographic Institution (WHOI), passive observations of marine mammals were collected using an infrared camera system mounted on the vessel's meteorological tower, representing the first time vessel-based thermal imaging technology was used by DFO during one of its monitoring surveys.

Finally, the third primary objective of the mission was to identify potential foraging habitat for North Atlantic right whale (NARW) on the Scotian Shelf by quantifying variation in abundance and fine-scale vertical distribution of *Calanus* spp. copepods (zooplankton). Vertical profiles of *Calanus* spp. abundance were obtained using a video plankton recorder (VPR) supplemented with depth stratified zooplankton samples collected using a multinet sampler. NARW prey concentrations and their vertical distribution on the eastern Scotian Shelf has been identified by the DFO Maritimes Species at Risk Program as an information gap for developing advice on mitigating risks to NARW

injury and mortality.

In addition to the survey's three primary objectives, data and samples were also collected in support of a number of ancillary research programs and initiatives led by both DFO and its external partners, including eDNA sample collection in support of marine conservation efforts, and university projects aimed at evaluating nitrate isotopes on the Scotian Shelf, and aspects of the phytoplankton community (e.g., microbial component) not monitored by DFO (see the Mission Achievements section below for more details).

This report provides an overview of the mission objectives, achievements and impacts, and a summary of operations and data collected.

1.2 Mission Synopsis

Due to the unavailability of berth space at the Bedford Institute of Oceanography (BIO) in Dartmouth, Nova Scotia, mobilization of the DY18402 mission was scheduled to occur at Pier 9 in Halifax starting on the afternoon of Tuesday October 1, 2024, after conclusion and demobilization of the NRCan leg DY18401. However, a pilot was not available to escort the vessel through the Halifax Harbour until 11:30 ADT, which shifted the docking of the vessel ahead to 13:00 ADT and subsequently the mobilization of DY18402 to the following day, Wednesday October 2. At this time, the chief scientist of DY18402 (Lindsay Beazley, AZMP Operational Lead, Maritimes Region) was made aware of the need to investigate an issue with one of the vessel's ancillary engines while the vessel was in port, which would potentially impact the original planned departure of Thursday October 3. Nonetheless, mobilization activities for DY18402 began on Wednesday October 2 in anticipation of maintaining the original departure date of October 3.

On Wednesday October 2, the Halifax Port Authority requested a brief pause in mobilization activities at 12:00 ADT while they reviewed the port program for the vessel. Activities were permitted to resume at 15:00 ADT, resulting in a loss of 4 hours. This resulted in only a minor impact to mobilization activities, and all laboratory equipment was loaded by the end of the day. At this time, the chief scientist was informed that departure would not be possible on Thursday October 3 due to the original engine survey and other outstanding vessel activities. The final science equipment for the mission, which included two mooring containers, was loaded on the following morning (Thursday October 3) and the laboratory spaces were set up in anticipation of departure on Friday, October 4.

Departure of the RRS *Discovery* occurred at 11:00 ADT on Friday October 4. After transiting through the Halifax Harbour, the vessel headed towards the location of the first station, the AZMP's 'Nova Scotia Current Mooring' (NSCM), where the existing mooring was recovered and a new mooring deployed. The vessel then proceeded towards the approximate location of the AZMP ocean glider, reaching its position on Saturday October 5 at 10:45 UTC. The glider was pre-programmed to surface prior to arrival of the vessel. Upon approach of the vessel, the glider's flashing light was sighted at the surface while the vessel was approximately 3 nm away. The vessel's fast rescue craft was then deployed with DFO glider technician and mooring specialist Matthew Lawson on board, who would facilitate the towing of the glider to the vessel where it could then be recovered using the vessel's P-frame. Upon its recovery, the physical condition of the glider was assessed and it was found to be missing two starboard wings. Significant damage was also sustained to its nose

and frame. Upon further investigation and evaluation of images of the damage, it was determined that the glider was subjected to an attack by a white shark (*Carcharodon carcharias*; pers. comm. Warren Joyce, shark specialist, DFO Maritimes Region). The glider was stowed on board for the duration of the mission and returned to BIO where it underwent further assessment.

Upon recovery of the glider, the *Discovery* proceeded towards the AZMP's Browns Bank Line, where AZMP stations BBL_05 through BBL_07 were sampled prior to recovering a passive acoustic monitoring (PAM) mooring (station FCM, 'Fundian Channel-Mid') south of station BBL_07. Upon conclusion of the mooring operation there, the vessel returned to the Browns Bank Line and stations BBL_04 through BBL_01 were successfully sampled. The vessel then headed towards the next mooring site located near Grand Manan Island at the mouth of Bay of Fundy. While on route, the chief scientist directed the vessel to stop at the AZMP's Yarmouth Line (YL) and sample as many stations as possible before breaking off to finish its transit towards Grand Manan. This would ensure that the vessel arrived in the Grand Manan area during daylight hours, when mooring operations would be permitted. Stations YL_01 through YL_04 were sampled before breaking off the Yarmouth Line, and the vessel headed north towards the Grand Manan Basin (GMB) mooring, arriving at 12:15 UTC on Tuesday October 8. The transit towards this location involved traversing across a traffic separation scheme, which added additional time to the transit. Upon arrival and successful recovery and redeployment of the mooring at this station, the vessel returned to the Yarmouth Line to complete stations YL_05 through YL_10, and headed southeast towards the start of the AZMP's Portsmouth Line (PL). Stations PL_01 through PL_09 were successfully occupied, followed by all 10 AZMP stations located across the Northeast Channel (NEC). This marked the completion of the science activities on the western Scotian Shelf and Gulf of Maine.

The next work area was located in Roseway Basin. Here, a PAM mooring designed to track changes in NARW distribution was recovered from station ROBP ('Roseway Basin PAM') and a new mooring was deployed. Six stations were targeted for the deployment of the VPR and multinet systems to collect data on the vertical distribution of *Calanus* copepods. Given the recent sighting of a NARW and calf in the area, vessel speed was reduced to 8 knots or below while transiting through the Roseway Basin NARW critical habitat zone. Although weather conditions significantly worsened while in Roseway Basin, all six VPR/multinet stations were successfully sampled, and the vessel proceeded towards the first station on the AZMP's Halifax Line, station HL_01.

Weather conditions continued to worsen as the vessel arrived on station HL_01 at ~05:30 UTC October 13. While a CTD-Rosette deployment was successfully completed there, ring net operations were not possible due to high wind speeds. The vessel moved on to the next station, high-frequency AZMP station HL_02, and conditions were re-evaluated and deemed suitable for deployment of the CTD-Rosette system. Following this, ring net operations were attempted starting with a smaller (76 µm mesh) net system, followed by the standard AZMP (202 µm mesh) ring net. Both ring net operations were successful at HL_02 despite sustained winds of 30 kts and ~2.5 m waves, and the vessel proceeded to station HL_03. Planned operations at station HL_03.3 further down the Halifax Line included the standard AZMP data collection (CTD/Rosette and 202 µm ring net sample), as well as deployment of the multinet and VPR systems. While the multinet operation was successful, conditions were deemed too rough for deployment of the VPR. Operations on the remaining stations of the Halifax Line stations were conducted successfully.

Following the Halifax Line, the next work location was The Gully Marine Protected Area (MPA). CTD-Rosette and ring net deployments were conducted at stations GUL_01 and GUL_02 prior

to recovering a nearby PAM mooring at station MGL ('Mid-Gully'). Station GULD_03, which is a relict Gully AZMP station designed to sample areas of high zooplankton concentrations, was not occupied due to time constraints. After successful occupation of the final stations in The Gully MPA (GUL_03 and GUL_04), the vessel headed towards the end of the AZMP's Louisbourg Line. A single PAM mooring at station ECD ('Eastern Canyons Deep') was deployed south of Louisbourg Line station LL_09 in support of a collaborative project between DFO and NRCan, the data of which would be used by DFO and NRCan, respectively, to assess off-shelf cetacean acoustic occurrences and evaluate benthic processes in the Eastern Canyons Conservation Area. As this mooring was deployed in deeper water where there was the potential for drift during its descent to the seabed, a triangulation exercise was done using the echosounder of the vessel to obtain a precise location of the mooring once it reached the seabed. Upon completion of this exercise, the vessel was directed to transit towards station LL_09 on the Louisbourg Line. While on route, an Argo float was hand-deployed from the stern of the vessel.

The weather conditions significantly worsened during the transit to station LL_09. While the CTD-Rosette deployment was successful at this station, the ring net mesh was torn during recovery, invalidating the sample. As the conditions prevented its redeployment, the sample was kept but not considered representative. The local conditions at the next station, LL_08, were assessed. Sustained winds ranged from 40 to 43 knots with a Beaufort Scale of 8-9, which prevented deployment of both the CTD-Rosette and ring net systems. From here, the vessel departed the Louisbourg Line and transited northeast towards a PAM mooring station located along the western edge of the Laurentian Channel (station MLC, 'Mid-Laurentian Channel'). The vessel arrived on Thursday October 17 and the mooring was recovered at 14:38 UTC. At this time, the weather conditions had significantly improved and the vessel was directed back to the Louisbourg Line to station LL_07. The remaining stations on the Louisbourg Line were occupied successfully prior to departing for the next work location in the Cabot Strait.

Operations in the Cabot Strait included the recovery and re-deployment of 6 PAM moorings situated in an array across Cabot Strait, and the occupation of the AZMP's six stations that form the Cabot Strait Line (CSL). These operations were planned over the course of two days to ensure that mooring operations occurred during daylight hours. On the first day, moorings were turned over at four of the six locations before nightfall, and AZMP stations CSL_01 through CSL_06 were sampled overnight on October 19/20. The remaining two moorings were turned over during daytime on October 20, marking the completion of operations in the Cabot Strait area.

Prior to arriving in the St. Anns Bank MPA, the final work location of the mission, the chief scientist assessed the schedule and found that additional time was available to allow for the collection of samples and data in support of other DFO projects and initiatives. In addition to successful AZMP CTD-Rosette and ring net operations at the 6 AZMP stations of the St. Anns Bank Line, additional ring net samples were collected at AZMP stations STAB_01 through STAB_05 in support of a DFO stable isotope analysis project aimed at monitoring fish functional diversity in DFO's conservation areas in the Maritimes Region. Additionally, the VPR and multinet systems were deployed at station STAB_03 and STAB_04 to collect zooplankton samples and data.

The original disembarkation location of the DY18402 mission was scheduled to occur at the Government Wharf in Sydney, Nova Scotia. However, the port authority in Sydney indicated that berth space was not available for the vessel during the week of October 22. As the mission progressed, the NOC agent worked to identify an alternative disembarkation location, and secured

a berth in Mulgrave, NS. This shift from Sydney to Mulgrave would result in the loss of ~5.5 hours to the program.

Upon the completion of operations on St. Anns Bank, the RRS *Discovery* began its transit towards Mulgrave. While on route, two additional VPR and multinet stations ('A2' and 'A3') were opportunistically occupied. These stations were identified as key for assessing changes in the vertical distribution of *Calanus* copepods on the eastern Scotian Shelf. Upon completion of science operations, the vessel proceeded towards the pilot station off Canso, NS. Once the pilot boarded, the vessel transited through the Strait of Canso, arriving in Mulgrave at 08:30 ADT on October 22, 2024. Once the vessel was secured, demobilization activities began using the vessel's crane. A forklift hired by NOC provided support moving scientific equipment to a U-Haul rented by DFO to transport gear and samples back to BIO. Upon loading the U-Haul, science staff boarded a mini passenger bus and returned to BIO to offload samples and equipment, marking the conclusion of the 2024 fall DY18402 mission.

2 Participants

A total of 22 scientific staff participated in the DY18402 mission (see Table 1), including 16 DFO personnel, 2 scientists from the Woods Hole Oceanographic Institution (WHOI), 1 seabird observer from Environment and Climate Change Canada's Canadian Wildlife Service (ECCC-CWS), and 3 Dalhousie University students representing the laboratories of Drs. Carolyn Buchwald, Julie LaRoche, and Erin Bertrand. The chief scientist was Lindsay Beazley (OESD-OMOS), with Tim Perry (OESD-OMOS) as night shift captain. Most science staff were split into day (0600-1800) and night (1800-0600) watches.

Mooring technicians Matthew Lawson, Mike Vining, and Katie Warman from the Ocean Engineering and Technology Section (OETS) participated in the mission and led the recovery and deployment of the moorings and also assisted with CTD operations and laboratory processing during the day shift. Three marine mammal observers (Mike Adams, Natalie Colbourne, and Kate Christie) from BIO's Ocean Ecology Section (OES) also participated in the mission to collect observations of marine mammals during transits between stations, and also satisfied DFO's requirement to conduct marine mammal watches while stationary in DFO critical habitat zones and MPAs.

A total of 23 ship's crew sailed on the mission plus 6 National Marine Facilities (NMF) technicians. The lead NMF technician was Dougal Mountifield, who along with Jade Garner led the CTD-Rosette operations, while one technician (Mark Maltby) was dedicated to overseeing all ship-board scientific equipment (e.g., multibeam, VMADCP). The shore-side project manager for the DY18402 mission was Matthew Tiahlo, who handled all planning and coordination up to the arrival of the vessel in Halifax.

Table 1. List of science staff that participated in the 2024 fall AZMP mission (DY18402). Affiliation is Department-Section for Fisheries and Oceans Canada participants. OMOS = Ocean Monitoring and Observation Section; OETS = Ocean Engineering and Technology Section; OES = Ocean Ecology Section; ODIS = Ocean Data and Information Section.

	Name	Affiliation	Duty	Shift
1	Tim Perry	DFO-OMOS	Night shift captain/Lab filtration	Night
2	Peter Thamer	DFO-OMOS	Lab filtration	Day
3	Rebecca Milne	DFO-OMOS	Ring net/VPR/Multinet operator	Day
4	Kevin Sorochan	DFO-OMOS	Ring net/VPR/Multinet operator	Night
5	Lindsay Beazley	DFO-OMOS	Chief scientist	Day
6	Benoit Casault	DFO-OMOS	CTD acquisition computer	Day
7	Patrick Upson	DFO-ODIS	CTD acquisition computer/data manager	Night
8	Melanie Hardy	DFO-OMOS	Lab filtration	Night
9	Maija McGraw	DFO-OMOS	Lab filtration	Day
10	Matthew Lawson	DFO-OETS	Moorings/Water sampler	Day
11	Mike Vining	DFO-OETS	Moorings/Water sampler	Day
12	Katherine Warman	DFO-OETS	Moorings/Water sampler	Day

Table 1. *(continued)*

	Name	Affiliation	Duty	Shift
13	Michael Adams	DFO-OES	Marine mammal observer/moorings	Day
14	Natalie Colbourne	DFO-OES	Marine mammal observer	07:00-19:00
15	Kate Christie	DFO-OES	Marine mammal observer	07:00-19:00
16	Elizabeth Taylor Crockford	WHOI	IFCB/water sampling	07:00-19:00
17	Hayden Kinkade	WHOI	IFCB/water sampling	19:00-07:00
18	Stephanie Duffy	Dalhousie (LaRoche)	Water sampling/filtration	24:00-12:00
19	Zach Whitworth	Dalhousie (Buchwald)	Water sampling/filtration	12:00-24:00
21	Anna Gleason	Dalhousie (Bertrand)	Water sampling/filtration	12:00-24:00
22	Jon Joy	ECCC-CWS	Seabird observer	07:00-19:00

3 Mission Achievements

A total of 21 objectives were identified during the planning stages of the DY18402 mission, with another objective added just prior to sailing (see Table 2). The 3 primary objectives included delivery of the Maritimes Region AZMP 2024 fall survey, mooring operations in support of DFO cetacean research and monitoring, and data and sample collection in support of a NARW foraging habitat assessment project. In addition to the primary objectives, the mission would also support 9 secondary AZMP/DFO objectives, and 9 objectives in support of external (to DFO) partners and collaborators. Upon conclusion of the mission, all objectives were completed or partially completed with the exception of the AZMP secondary objective to sample the Laurentian Channel Mouth section, which was cancelled as a result of the time lost due to vessel issues prior to departure. An additional, unplanned objective to recover a DFO ocean glider in distress near station HL_07 at the end of the Halifax Line was added to the mission plan several days prior to departure. The glider, which incurred damage from an attack by a white shark, was successfully recovered and brought back to BIO for assessment by the DFO glider program.

Of the AZMP's 33 core stations, all were sampled in full with the exception of station LL_08, which was cancelled due to inclement weather. Additionally, ring net operations were not possible on station HL_01 due to inclement weather, and the net sample collected on station LL_09 did not follow the AZMP's standard collection protocol due to a tear in the net that was experienced upon its recovery.

All 13 mooring recoveries and 10 deployments were successfully completed on the DY18402 mission. One mooring deployed in the Cabot Strait suddenly released and resurfaced. As the vessel was still on location at the time of its release, the mooring was recovered and redeployed with a new train wheel anchor. The details of this occurrence can be found in section 4.5 Mooring Operations below.

The VPR and multinet operations and sample collection are detailed in Section 4.6 below. VPR and multinet operations were planned at 6 stations in Roseway Basin, and at AZMP stations BBL_02 and HL_03.3, with operations at station HL_03.3 being lowest priority. Upon conclusion of the mission, all VPR and multinet deployments were completed at the 6 stations in Roseway Basin and at BBL_02. Due to inclement weather conditions, only the multinet was deployed at station HL_03.3. Additional multinet and VPR deployments occurred at two lower-priority stations (A2 and A3) located south of Mulgrave, NS, where the vessel would disembark.

The DY18402 mission also supported a number of internal (DFO) and external partnerships and collaborations. A wildlife observer (Jon Joy) collected observations of seabirds in support of the Canadian Wildlife Service (CWS) of ECCC's Eastern Canada Seabirds at Sea (ECSAS) monitoring program established in 2005 (Gjerdrum et al. 2012). An Autonomous Recording Unit (ARU) was installed on the mast of the ship that used microphones to record ultrasonic signals emitted by bats while echolocating. This initiative was in support an ECCC-CWS project to better understand the offshore distribution and migration patterns of bats as part of a risk assessment for offshore wind development.

As part of a collaborative agreement between DFO and the Woods Hole Center for Oceans and Human Health (WHCOHH), an Imaging FlowCytobot (IFCB) was installed and operational for the duration of the mission. This system collected high-resolution images of phytoplankton from surface

waters sampled while in transit. Additionally, an Environmental Sample Processor (ESP) was installed and plumbed into the science seawater, and was used to evaluate the presence of domoic acid produced by phytoplankton of the genus *Pseudo-nitzschia*, representing the first time this system was used on an oceanographic survey. See section 5 In situ Phytoplankton Monitoring for more details.

As part of a collaboration between DFO's North Atlantic Right Whale Research Unit (led by Dr. Angelia Vanderlaan) and Dr. Daniel Zitterbart (WHOI), an infrared camera was mounted to the meteorological tower situated on the bow of the vessel, and recorded detections of marine mammals in front of the vessel. This system is particularly useful for night time applications when observations by marine mammal observers are not possible. Detections and tentative identifications were monitored and validated remotely by WHOI and DFO staff using an associated web application. This represented the first time an infrared camera and associated machine-learning identification software were used on a DFO survey to support the detection and identification of cetaceans.

Finally, data and samples were collected by three Dalhousie University students and/or assistants in support of student projects led by the Dalhousie University laboratories of Drs. Carly Buchwald, Julie LaRoche, and Erin Bertrand. The focus of this research was on nitrate stable isotope signatures and variability in the nutrient supply of the Scotian Shelf (Buchwald); understanding phytoplankton growth, phytoplankton-bacterial interactions, and the role of cobalamin and other B-vitamins in phytoplankton community composition and productivity (Bertrand); and on the characterization of the microbial communities of the Scotian Shelf through the collection of eDNA and flow cytometry samples (LaRoche). This research is considered complementary to the monitoring conducted by the AZMP, and aids in the understanding of the biogeochemical processes of the Scotian Shelf.

3.1 Program Impacts

A series of events delayed both the mobilization and departure of the RRS *Discovery* on the DY18402 mission and resulted in lost program time and objectives. On September 25, NOC project manager communicated to the chief scientist that the RRS *Discovery* would need to set time aside once the vessel arrived in port to evaluate mechanical issues that arose during Leg 1, and advised that mobilization and potentially departure of the DY18402 mission would be delayed. Consequently, mobilization of DY18402 was rescheduled from Tuesday October 1 to Wednesday October 2. On Monday September 30, the captain communicated to the chief scientist that due to increased harbour traffic, a pilot could not be arranged until 11:30 on Tuesday October 1, delaying arrival of the vessel and further impacting demobilization/mobilization and other vessel activities planned while in port.

Shortly after mobilization began on Wednesday October 2, the Halifax Port Authority requested that the vessel halt all crane activities until a full review of the port and science program could be completed. Mobilization was finally permitted to restart at 3:30 ADT, resulting in a loss of approximately 4 hours to the program's mobilization period. Despite this, all science gear was loaded and secured on the vessel by noon on Thursday October 3. However, as final assessments of the vessel's mechanical issues were still ongoing, departure of the DY18402 mission was not possible on its planned departure date of October 3, and was tentatively rescheduled to 11:00 on Friday October 4. This resulted in a loss of 27 hours to the program. Consequently, the Laurentian Channel Mouth AZMP section was dropped from the mission to compensate for this lost time.

On the morning of Friday October 4, the chief scientist and NMF technicians assessed the status of the CTD/Rosette system and its readiness for planned deployments on the Halifax Line that day, and determined that use of the CTD-Rosette would not be possible until the morning of Saturday October 5 at the earliest. Consequently, the mission itinerary was reworked to start with the recovery and redeployment of the Nova Scotia Current Mooring, followed by the recovery of the AZMP ocean glider that was in distress, before heading to the Browns Bank Line. This would provide enough time to ready the CTD-Rosette before its rescheduled deployment time of Sunday October 6 on the Browns Bank Line. This shift in mission itinerary and recovery of the ocean glider added increased transit time to the program.

The CTD winch experienced scrolling issues that resulted in a loss of approximately 1 hour. Issues were also incurred to the active heave control package (see section 4.1 below), which resulted in a minimal loss of 30 minutes to the program.

Table 2. Primary and secondary objectives of the fall AZMP mission (DY18402), and their status upon conclusion of the mission.

Objective	Status	Comment
Primary		
Obtain fall observations on physical, chemical, and lower trophic-level biological oceanographic conditions at fixed sampling stations along core Atlantic Zone Monitoring Program sections within the Maritimes Region (Contact: Lindsay Beazley - http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html).	Completed	All core stations were sampled with the exception of LL_08, and a ring net sample was not collected at station HL_01 due to inclement weather.
Recover 13 and deploy 10 passive acoustic moorings in support of the Species at Risk (SAR), Marine Protected Areas (MPA), Marine Conservation Targets (MCT), and 3 Whales science programs (Contact: Hilary Moors-Murphy - Hilary.Moors-Murphy@dfo-mpo.gc.ca, Angelia Vanderlaan - Angelia.Vanderlaan@dfo-mpo.gc.ca, Jinshan Xu - Jinshan.Xu@dfo-mpo.gc.ca)	Completed	
Identify foraging habitat for North Atlantic Right Whales by quantifying variation and fine-scale vertical distribution of Calanus spp. copepods through the deployment of a Video Plankton Recorder and Multinet systems (Contact: Catherine Johnson - Catherine.Johnson@dfo-mpo.gc.ca)	Completed	Two additional stations (A2 and A3) were sampled using the VPR and multinet systems.
Secondary		
Deploy ARGO floats in support of the International Argo Float Program (Contact: Blair Greenan - http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html)	Completed	
Collect physical, chemical, and lower trophic-level biological measurements in the Northeast Channel and Gulf of Maine as part of NERACOOS Cooperative Agreement (Contact: Emmanuel Devred; Catherine Johnson - http://www.neracoos.org/)	Completed	
Carry out hydrographic, chemical and biological sampling at stations in The Gully as a continued monitoring effort in support of DFO's Marine Planning and Conservation group (Contact: Lindsay Beazley - https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/gully/index-eng.html)	Completed	

Table 2. *(continued)*

Objective	Status	Comment
Secondary cont.		
Carry out hydrographic, chemical and biological sampling at stations in the St. Anns Bank MPA as a continued monitoring effort in support of DFO's Marine Planning and Conservation group (Contact: Lindsay Beazley - https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/stanns-sainteanne/index-eng.html)	Completed	
Conduct hydrographic, chemical and biological sampling across the mouth of the Laurentian Channel. This transect has been implemented to enhance our understanding of hydrographic phenomenon in support of current modelling efforts (Contact: Dr. Dave Brickman - David.Brickman@dfo-mpo.gc.ca).	Not completed	Sample collection on the LCM line was cancelled as a result of the lost time prior to departure.
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)	Completed	
Collect opportunistic marine mammal observations between stations in support of DFO's cetacean research and monitoring programs (Contact: Hilary Moors-Murphy - Hilary.Moors-Murphy@dfo-mpo.gc.ca)	Completed	
Collect Niskin water samples in marine conservation areas for eDNA filtration in support of eDNA monitoring conducted by the Marine Conservation and MPA Monitoring group (Contact: Ryan Stanley - Ryan.Stanley@dfo-mpo.gc.ca)	Completed	
Collect zooplankton samples within The Gully and St. Anns Bank MPAs in support of stable isotope analysis project to monitor the functional diversity within the MPAs (Contact: Harri Pettitt-Wade - Harri.Pettitt-Wade@dfo-mpo.gc.ca)	Partially completed	Due to time constraints, samples were collected from the St. Anns Bank MPA only.

Table 2. *(continued)*

Objective	Status	Comment
External to DFO		
Bird and marine mammal observations as part of ECCC-CWS Eastern Canada Seabirds at Sea observation program (Contact: Carina Gjerdrum - carina.gjerdrum@canada.ca)	Completed	
Record observations of bats using an Autonomous Recording Unit in support of a Canadian Wildlife Service project to better understand the distribution and movements of bats in offshore Nova Scotia in relation to offshore wind turbine risk (Contact: Paul Knaga - Paul.Knaga@ec.gc.ca)	Completed	
Collect high-resolution imagery of phytoplankton while underway using an Imaging FlowCytobot (IFCB), and water samples for phytoplankton omics and Pseudo-nitzschia DNA in collaboration with the Woods Hole Oceanographic Institution (Contact: Dennis McGillicuddy - dmcgillicuddy@whoi.edu; Emmanuel Devred - Emmanuel.Devred@dfo-mpo.gc.ca)	Completed	
Collect data on the presence and quantity of biological toxins (specifically domoic acid) produced by harmful algal bloom species while underway using an Environmental Sampler Processor in collaboration with the Woods Hole Oceanographic Institution (Contact: Dennis McGillicuddy - dmcgillicuddy@whoi.edu; Mike Brosnahan - mbrosnahan@whoi.edu; Emmanuel Devred - Emmanuel.Devred@dfo-mpo.gc.ca)	Completed	
Collect thermal-based observations of cetaceans using an infrared camera and association identification systems in collaboration with the Woods Hole Oceanographic Institution (Contacts: Dan Zitterbart - dpz@whoi.edu; Angelia Vanderlaan - Angelia.Vanderlaan@dfo-mpo.gc.ca)	Completed	
Collect water samples for the Bertrand lab at Dalhousie University to evaluate microbial protein and metabolite samples from the Scotian Shelf to better understand phytoplankton growth, phytoplankton bacterial interactions, and the role of cobalamin and other B-vitamins in phytoplankton community composition and productivity (Contact: Erin Bertrand - https://www.dal.ca/faculty/science/biology/faculty-staff/our-faculty/erin-bertrand.html)	Completed	

Table 2. *(continued)*

Objective	Status	Comment
External to DFO cont.		
Collect water samples for the LaRoche lab at Dalhousie University from strategic locations and depths to support a microbial community analysis (metabarcoding, metagenomics, flow cytometry analysis) (Contact: Julie Laroche - http://www.dal.ca/faculty/science/biology/faculty-staff/our-faculty/julie-laroche.html)	Completed	
Collect water samples for the Buchwald lab at Dalhousie University from strategic locations and depths to measure nitrate isotopes (d15N and d18O) to interpret changes in nutrient uptake and supply on the Scotian Shelf (Contact: Carolyn Buchwald - cbuchwald@dal.ca - https://www.dal.ca/faculty/science/oceanography/people/faculty/carly-buchwald.html)	Completed	
Collect CTD profile data in deep water using an RBR Concerto CTD system mounted to the CTD/Rosette frame in support of a study to evaluate and compare turbidity sensor data (Contact: Mathieu Dever - mdever@whoi.edu)	Completed	
Requested prior to sailing		
Recover a DFO ocean glider in distress at the end of the Halifax Line (Contact: Clark Richards - Clark.Richards@dfo-mpo.gc.ca)	Completed	

4 Summary of Operations

Figure 1 and Table 3 provide an overview of operations conducted on the DY18402 mission. A summary of the ELOG comments on various issues encountered during operations is provided in the 'Comments' field. A total of 199 gear operations (events) were conducted at 94 unique stations. Of the 199 gear deployments, 1 CTD-Rosette deployment and 2 ring net operations were aborted, both of which are detailed below. All planned stations were occupied with the exception of station GULD_03 located in The Gully MPA (time constraints) and station LL_08 on the Louisbourg Line (inclement weather). High-frequency station HL_02 on the Halifax Line was occupied once during the mission. Argo floats were released at HL_07 and southwest of station LL_09 at mooring station ECD ('Eastern Canyons Deep').

4.0.1 Itinerary and Scenario Planning

Successful execution of the mission plan and achievement of most of the mission's objectives was greatly facilitated by use of the provisional 'cruisePlanning' R package (Layton (2024)). This package generates a full mission itinerary based on the station coordinates and operational time, and the transit distance and speed between them, and was developed as a tool to help chief scientists evaluate different mission scenarios that result in maximum use of the allocated vessel time. Mission scenarios were routinely updated and re-generated throughout the mission and were used to make decisions on the order of stations and their activities. A conservative transit speed of 9 knots was used for between-station transits.

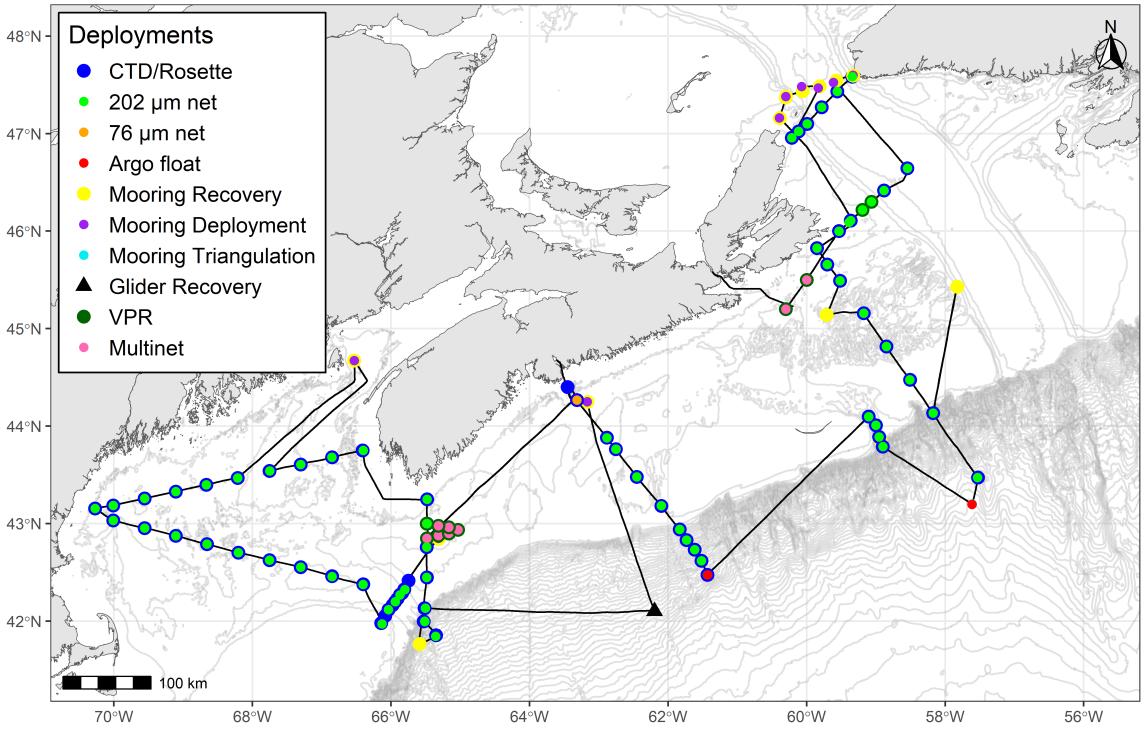

Figure 1. Location of stations sampled and gear deployments made during the 2024 fall AZMP mission (DY18402). Note that multiple operations at single stations may not be fully reflected in the map due to overlapping labels.

Table 3. Operations conducted at each station during the 2024 fall AZMP mission (DY18402), ordered sequentially by Event number. Event coordinates (in decimal degrees - DD) reflect the ship's position at the time of deployment, as recorded using the ELOG meta-data logger. Comments are associated with the 'action' on which they were entered for each event: Aborted (failed event), Deployed (gear in water), Bottom (gear at the bottom), and Recovered (gear out of water). Note that multiple comments/actions can be present for a single event.

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
1	NSCM	Mooring Recovery	44.2504	-63.1646	2024-10-04	170	00:15:47	
2	NSCM	Mooring Deployment	44.2499	-63.1674	2024-10-04	170	00:01:43	
3	GLIDER	Glider Recovery	42.1026	-62.1961	2024-10-05	3062	00:00:00	
4	BBL_05	CTD/Rosette	42.1336	-65.5163	2024-10-06	179	00:44:15	Deployed: Bottom Bottle misfired There was no TIC, PCO2
5	BBL_05	202 µm net	42.1335	-65.5026	2024-10-06	173	00:12:24	Recovered: Crossbow came off wire but was held by safety clip
6	BBL_06	CTD/Rosette	41.9981	-65.5281	2024-10-06	1072	01:23:48	Deployed: Firing extra bottle at 150m (see deck sheet for issue description) Bottom: Forgot to submit bottom event... We might have hit the bottom
7	BBL_06	202 µm net	41.9997	-65.5114	2024-10-06	1085	00:12:14	Aborted: Net under ship
8	BBL_06	202 µm net	41.9949	-65.5114	2024-10-06	1086	00:54:10	
9	BBL_07	CTD/Rosette	41.8561	-65.3504	2024-10-06	1744	03:20:32	Recovered: CTD cable crossed on drum. Paused at 482 db to assess. Went from 494 to 503 cable out and re-pressurized rosette. Will keep data. Total delay was 45 minutes.

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
10	BBL_07	202 µm net	41.8450	-65.3560	2024-10-06	1900	00:55:12	
11	FCM	Mooring Triangulation	41.7677	-65.5723	2024-10-06	1526	00:25:54	Other: Mooring triangulation was a success
12	FCM	Mooring Recovery	41.7648	-65.5856	2024-10-06	1542	00:50:10	
13	BBL_04	CTD/Rosette	42.4476	-65.4833	2024-10-06	102	00:33:13	
14	BBL_04	202 µm net	42.4493	-65.4835	2024-10-06	101	00:07:12	
15	BBL_03	CTD/Rosette	42.7597	-65.4838	2024-10-06	100	00:32:31	
16	BBL_03	202 µm net	42.7597	-65.4838	2024-10-07	100	00:07:45	
17	BBL_02	CTD/Rosette	42.9998	-65.4799	2024-10-07	116	00:26:09	Bottom: Forgot to submit bottom, ajdusted time to first bottle fired
18	BBL_02	202 µm net	42.9998	-65.4799	2024-10-07	116	00:05:07	Aborted: wire under ship
19	BBL_02	202 µm net	42.9998	-65.4802	2024-10-07	117	00:09:38	
20	BBL_02	VPR	42.9999	-65.4841	2024-10-07	119	00:42:11	
21	BBL_02	Multinet	43.0003	-65.4842	2024-10-07	121	00:15:30	Recovered: winch speed on ascent 30m/min instead of target speed (50m/min)
22	BBL_01	CTD/Rosette	43.2501	-65.4801	2024-10-07	67	00:20:51	
23	BBL_01	202 µm net	43.2502	-65.4801	2024-10-07	62	00:04:33	
24	YL_01	CTD/Rosette	43.7512	-66.4097	2024-10-07	78	00:25:30	Recovered: Strong current causing vessel to drift 2 miles during the cast.
25	YL_01	202 µm net	43.7514	-66.3993	2024-10-07	73	00:06:01	Recovered: bottom action hit late
26	YL_02	CTD/Rosette	43.6801	-66.8517	2024-10-07	132	00:29:20	
27	YL_02	202 µm net	43.6801	-66.8524	2024-10-07	130	00:09:57	
28	YL_03	CTD/Rosette	43.6071	-67.3029	2024-10-07	197	00:32:37	
29	YL_03	202 µm net	43.6072	-67.3030	2024-10-07	197	00:12:43	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
30	YL_04	CTD/Rosette	43.5397	-67.7529	2024-10-08	239	00:44:07	Deployed: Found out after the cast bottle #1 did not close. Bottom oxygen, salinity and nutrients were taken from next bottle. Recovered: Closing extra surface bottles to balance the CTD. The bottles will be removed from the .bl file before processing.
31	YL_04	202 µm net	43.5398	-67.7519	2024-10-08	242	00:17:45	Recovered: during deployment - descent stalled while net under ship at ~20 m. After ~ 1 minute continued downward
32	GMB	Mooring Recovery	44.6712	-66.5327	2024-10-08	202	00:23:08	Release: Sounder turned off. Manually filled in sounding from first action. On Deck: Sounder turned off. Manually filled in sounding from first action.
33	GMB	Mooring Deployment	44.6727	-66.5306	2024-10-08	179	00:06:04	
34	YL_05	CTD/Rosette	43.4689	-68.2120	2024-10-09	181	00:43:40	
35	YL_05	202 µm net	43.4691	-68.2121	2024-10-09	179	00:14:00	
36	YL_06	CTD/Rosette	43.3983	-68.6644	2024-10-09	146	00:24:06	
37	YL_06	202 µm net	43.3983	-68.6665	2024-10-09	145	00:10:33	
38	YL_07	CTD/Rosette	43.3281	-69.1061	2024-10-09	151	00:28:02	
39	YL_07	202 µm net	43.3283	-69.1068	2024-10-09	154	00:10:29	
40	YL_08	CTD/Rosette	43.2578	-69.5575	2024-10-09	156	00:36:04	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
41	YL_08	202 µm net	43.2577	-69.5575	2024-10-09	156	00:09:22	
42	YL_09	CTD/Rosette	43.1861	-70.0097	2024-10-09	88	00:32:01	
43	YL_09	202 µm net	43.1861	-70.0097	2024-10-09	87	00:06:28	
44	YL_10	CTD/Rosette	43.1560	-70.2719	2024-10-09	121	00:29:56	
45	YL_10	202 µm net	43.1560	-70.2718	2024-10-09	121	00:08:46	
46	PL_01	CTD/Rosette	43.0334	-70.0082	2024-10-09	137	00:33:06	Deployed: CTD deployed to 10 m before deckbox as turned ON.
47	PL_01	202 µm net	43.0334	-70.0082	2024-10-09	138	00:09:39	
48	PL_02	CTD/Rosette	42.9547	-69.5572	2024-10-09	169	00:24:39	
49	PL_02	202 µm net	42.9549	-69.5570	2024-10-09	168	00:09:34	
50	PL_03	CTD/Rosette	42.8757	-69.1065	2024-10-10	183	00:38:06	Recovered: Bottle #1 didn't close. Taking gasses from next bottle ID 512101
51	PL_03	202 µm net	42.8757	-69.1066	2024-10-10	182	00:11:27	
52	PL_04	CTD/Rosette	42.7893	-68.6556	2024-10-10	200	00:30:02	Recovered: Bottle #1 didn't close. Taking gasses from next bottle ID 512123
53	PL_04	202 µm net	42.7893	-68.6555	2024-10-10	200	00:11:19	
54	PL_05	CTD/Rosette	42.7025	-68.2042	2024-10-10	185	00:29:05	
55	PL_05	202 µm net	42.7021	-68.2043	2024-10-10	186	00:12:51	Recovered: 2 sample bottles
56	PL_06	CTD/Rosette	42.6254	-67.7532	2024-10-10	200	00:40:55	Bottom: Time of Bottom is off by a few minutes.
57	PL_06	202 µm net	42.6254	-67.7533	2024-10-10	200	00:12:16	
58	PL_07	CTD/Rosette	42.5525	-67.3022	2024-10-10	300	00:58:47	
59	PL_07	202 µm net	42.5525	-67.3022	2024-10-10	309	00:16:18	
60	PL_08	CTD/Rosette	42.4620	-66.8512	2024-10-10	328	00:49:30	
61	PL_08	202 µm net	42.4563	-66.8512	2024-10-10	329	00:29:50	
62	PL_09	CTD/Rosette	42.3772	-66.4014	2024-10-10	270	00:49:08	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
63	PL_09	202 µm net	42.3770	-66.4023	2024-10-10	270	00:16:12	
64	NEC_10	CTD/Rosette	41.9802	-66.1415	2024-10-11	92	00:28:29	
65	NEC_10	202 µm net	41.9719	-66.1285	2024-10-11	92	00:08:21	Recovered: Start flowmeter reading lost and assumed as end reading from last deployment
66	NEC_09	CTD/Rosette	42.0540	-66.0833	2024-10-11	96	00:26:11	
67	NEC_08	CTD/Rosette	42.1179	-66.0372	2024-10-11	192	00:33:55	
68	NEC_08	202 µm net	42.1178	-66.0375	2024-10-11	184	00:12:59	
69	NEC_07	CTD/Rosette	42.1630	-65.9784	2024-10-11	224	00:39:17	
70	NEC_06	CTD/Rosette	42.1997	-65.9398	2024-10-11	227	00:38:51	
71	NEC_06	202 µm net	42.1998	-65.9385	2024-10-11	228	00:13:45	
72	NEC_05	CTD/Rosette	42.2295	-65.9075	2024-10-11	236	00:38:27	
73	NEC_04	CTD/Rosette	42.2702	-65.8698	2024-10-11	230	00:51:44	Recovered: Paused twice on downcast at 170 m and 190 m to assess heave operation.
74	NEC_04	202 µm net	42.2696	-65.8699	2024-10-11	230	00:12:47	
75	NEC_03	CTD/Rosette	42.2894	-65.8393	2024-10-11	229	00:54:52	Bottom: Missed ELOG Bottom submit. Bottom action has wrong timestamp.
76	NEC_02	CTD/Rosette	42.3264	-65.8084	2024-10-11	204	01:05:17	Deployed: Paused at 170 m to assess active heave settings. Active heave disabled at 170 m for emainder of downcast and for upcast. Bottom: Missed ELOG Bottom submit. Bottom action has wrong timestamp.

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
77	NEC_02	202 µm net	42.3233	-65.8005	2024-10-11	207	00:19:39	Recovered: Flowmeter number unreliable; left on net in wind during repositioning
78	NEC_01	CTD/Rosette	42.4165	-65.7474	2024-10-11	100	00:31:37	
79	ROBP	Mooring Recovery	42.8454	-65.3101	2024-10-11	143	00:56:01	On Deck: Manually filled in sounding. Had to be turned off for mooring comms.
80	ROBP	Mooring Deployment	42.8496	-65.3141	2024-10-11	144	00:02:28	
81	RB_E	VPR	42.8782	-65.3141	2024-10-11	151	00:43:56	Recovered: VPR was jolted at surface which caused it to shut off
82	RB_E	Multinet	42.8773	-65.3142	2024-10-12	152	00:18:39	
83	RB_D	VPR	42.8998	-65.1650	2024-10-12	161	00:43:26	
84	RB_D	Multinet	42.8999	-65.1649	2024-10-12	160	00:19:26	
85	RB_C	VPR	42.9362	-65.0328	2024-10-12	111	00:42:44	
86	RB_C	Multinet	42.9362	-65.0328	2024-10-12	111	00:11:19	
87	RB_B	VPR	42.9630	-65.1648	2024-10-12	169	00:45:40	
88	RB_B	Multinet	42.9630	-65.1647	2024-10-12	169	00:16:46	
89	RB_A	VPR	42.9782	-65.3142	2024-10-12	171	00:43:32	
90	RB_A	Multinet	42.9782	-65.3141	2024-10-12	160	00:16:30	
91	RB_01	VPR	42.8497	-65.4814	2024-10-12	133	00:43:14	Deployed: depth 133 m.
92	RB_01	Multinet	42.8490	-65.4815	2024-10-12	132	00:16:10	
93	HL_01	CTD/Rosette	44.4002	-63.4500	2024-10-13	109	00:21:08	
94	HL_02	CTD/Rosette	44.2670	-63.3157	2024-10-13	132	00:30:11	
95	HL_02	76 µm net	44.2668	-63.3157	2024-10-13	149	00:09:41	
96	HL_02	202 µm net	44.2665	-63.3159	2024-10-13	150	00:09:55	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
97	HL_03	CTD/Rosette	43.8830	-62.8832	2024-10-13	269	00:58:32	Bottom: Paused at 200 m to assess active heave operation. Downcast depth to 259 m wire out but brought back to 257 m for bottom bottle due to altimeter reading 100 m unexpectedly. Recovered: Fired extra bottles for weight balancing during recovery.
98	HL_03	202 µm net	43.8801	-62.8848	2024-10-13	268	00:16:14	Deployed: discard flow meter - dipped and relaunched
99	HL_03.3	CTD/Rosette	43.7635	-62.7529	2024-10-13	209	00:45:48	Bottom: Missed ELOG Bottom submit. Bottom action has wrong timestamp. Recovered: Extra bottles fired for weight balancing during recovery.
100	HL_03.3	202 µm net	43.7635	-62.7530	2024-10-13	209	00:13:20	Deployed: net spent time in waves at surface affecting flowmeter
101	HL_03.3	Multinet	43.7636	-62.7520	2024-10-13	209	00:17:49	
102	HL_04	CTD/Rosette	43.4790	-62.4507	2024-10-13	86	00:30:15	Recovered: Surface bottle deeper than target depth due to rough surface conditions.
103	HL_04	202 µm net	43.4790	-62.4507	2024-10-13	86	00:06:09	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
104	HL_05	CTD/Rosette	43.1826	-62.0981	2024-10-13	101	00:32:34	
105	HL_05	202 µm net	43.1827	-62.0981	2024-10-14	101	00:09:20	
106	HL_05.5	CTD/Rosette	42.9400	-61.8325	2024-10-14	374	00:53:09	
107	HL_05.5	202 µm net	42.9400	-61.8324	2024-10-14	454	00:24:43	
108	HL_06	CTD/Rosette	42.8313	-61.7335	2024-10-14	1063	01:30:27	Deployed: Accidentally closed the 2 20m bottles at 30m. Closed bottle 512594 out of sequence at 20m. Re-ordered filter log so everyone still got water.
109	HL_06	202 µm net	42.8310	-61.7339	2024-10-14	1108	00:54:30	Recovered: extreme bird activity - Herons and warblers
110	HL_06.3	CTD/Rosette	42.7330	-61.6164	2024-10-14	1654	02:26:04	Recovered: Paused at 1635 m on upcast to deactivate active heave. Went back down to 1658 m. Multiple stops and slow winch speed intervals on upcast due to wire crossing on drum. Winch speed operation back to normal after bottle #5.
111	HL_06.3	202 µm net	42.7330	-61.6164	2024-10-14	1683	00:55:33	
112	HL_06.7	CTD/Rosette	42.6187	-61.5169	2024-10-14	2312	02:40:10	Bottom: Manually added sounding
113	HL_06.7	202 µm net	42.6187	-61.5169	2024-10-14	2309	00:53:07	Bottom: Manually added sounding from GPS logs Recovered: Manually added sounding from GPS logs

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
114	HL_07	CTD/Rosette	42.4752	-61.4333	2024-10-14	2769	00:05:58	Aborted: Sensor cap left on.
115	HL_07	CTD/Rosette	42.4752	-61.4333	2024-10-14	2767	02:22:42	Bottom: Manually added sounding from GPS logs Recovered: Manually added sounding from GPS logs
116	HL_07	202 µm net	42.4752	-61.4333	2024-10-14	2845	00:55:35	Bottom: Manually added sounding from GPS logs
117	HL_07	Argo float	42.4754	-61.4291	2024-10-14	2769	00:14:59	Other: Manually added sounding from GPS logs Other: Manually added sounding from GPS logs
118	GUL_01	CTD/Rosette	44.0978	-59.1059	2024-10-15	480	01:07:46	
119	GUL_01	202 µm net	44.0973	-59.1058	2024-10-15	699	00:40:03	Aborted: net lifted from water to reset - new flowmeter start not taken Recovered: net paused for 1 min on return to surface at 30m
120	GUL_02	CTD/Rosette	44.0099	-59.0001	2024-10-15	1091	01:32:13	
121	GUL_02	202 µm net	44.0098	-59.0002	2024-10-15	1141	00:55:15	
122	MGL	Mooring Recovery	43.8467	-58.9302	2024-10-15	1511	02:03:11	Release: Sounder was off. Using sounding from deployment event. On Deck: Sounder was off. Using sounding from deployment event.

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
123	GUL_03	CTD/Rosette	43.8883	-58.9535	2024-10-16	1650	00:00:00	Recovered: Sounding inaccurate. Actual wire out was 1762m was 5.2 meters off bottom according to altimeter
124	GUL_03	202 µm net	43.8884	-58.9538	2024-10-16	1684	00:58:23	Recovered: Giant hole in net after catching crossbow clip
125	GUL_04	CTD/Rosette	43.7900	-58.9000	2024-10-16	1853	01:50:04	
126	GUL_04	202 µm net	43.7900	-58.9000	2024-10-16	2023	00:53:41	
127	ECD	Mooring Deployment	43.2008	-57.6114	2024-10-16	4103	00:23:23	Other: Long mooring, 100 m
128	ECD	Mooring Triangulation	43.2007	-57.6117	2024-10-16	3961	01:44:47	Attempted Comms: Mooring triangulation Other: Manually added sounding from GPS logs for last valid sounding - PU
129	ECD	Argo float	43.1966	-57.6132	2024-10-16	3957	00:08:49	Other: Manually added sounding from GPS logs for last valid sounding - PU Other: Manually added sounding from GPS logs for last valid sounding - PU Deployed: Manually added sounding from GPS logs for last valid sounding - PU

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
130	LL_09	CTD/Rosette	43.4734	-57.5266	2024-10-16	3719	03:11:30	Deployed: Active heave activated at 110 m WO on downcast. Bottom: Active heave deactivated at 3324 m WO on upcast. Bottle #8 fired at 150 m (instead of 250 m target). Recovered: Waves too high to get any closer than 6.8 m at surface for final bottle stop.
131	LL_09	202 µm net	43.4736	-57.5316	2024-10-16	3724	01:13:39	Recovered: Net burst due to swell
133	MLC	Mooring Recovery	45.4303	-57.8274	2024-10-17	177	00:35:20	On Deck: Manually added sounding from last ship sounding
134	LL_07	CTD/Rosette	44.1331	-58.1749	2024-10-18	746	01:09:39	
135	LL_07	202 µm net	44.1331	-58.1749	2024-10-18	744	00:41:18	Recovered: Bad flowmeter reading - mesh fibers stuck in flowmeter prop - fixed by Dougal
136	LL_06	CTD/Rosette	44.4748	-58.5086	2024-10-18	63	00:15:31	
137	LL_06	202 µm net	44.4748	-58.5089	2024-10-18	65	00:06:36	Recovered: 30 degree wire angle as net approached surface
138	LL_05	CTD/Rosette	44.8164	-58.8500	2024-10-18	238	00:36:50	
139	LL_05	202 µm net	44.8164	-58.8499	2024-10-18	245	00:14:20	
140	LL_04	CTD/Rosette	45.1580	-59.1751	2024-10-18	104	00:35:22	
141	LL_04	202 µm net	45.1581	-59.1751	2024-10-18	104	00:06:43	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
142	MBK	Mooring Recovery	45.1405	-59.7127	2024-10-18	105	00:00:27	Attempted Comms: Used sounding from last ship sounding Release: used sounding from last ship sounding
143	LL_03	CTD/Rosette	45.4916	-59.5169	2024-10-18	145	00:41:24	Recovered: Modified .bl file manually to account for bottles fired out of sequence. Must use .SN file when reprocessing.
144	LL_03	202 µm net	45.4917	-59.5170	2024-10-18	139	00:08:45	
145	LL_02	CTD/Rosette	45.6579	-59.7022	2024-10-18	140	00:24:41	
146	LL_02	202 µm net	45.6578	-59.7035	2024-10-18	138	00:09:52	Recovered: 30 degree wire angle as net approached surface
147	LL_01	CTD/Rosette	45.8249	-59.8500	2024-10-19	93	00:00:00	
148	LL_01	202 µm net	45.8249	-59.8500	2024-10-19	93	00:07:19	
149	CBN	Mooring Recovery	47.1586	-60.3864	2024-10-19	178	00:31:13	
150	CBN	Mooring Deployment	47.1618	-60.3935	2024-10-19	183	00:03:38	
151	CSW	Mooring Recovery	47.3701	-60.3003	2024-10-19	126	00:30:05	
152	CSW	Mooring Deployment	47.3788	-60.2995	2024-10-19	118	00:09:15	Aborted: mooring did not sink. recovering
153	CSW	Mooring Recovery	47.3807	-60.2975	2024-10-19	120	00:00:00	On Deck: recovery after failed deployment
154	CSW	Mooring Deployment	47.3789	-60.2994	2024-10-19	119	00:01:13	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
155	CS1	Mooring Recovery	47.4346	-60.0581	2024-10-19	457	00:23:21	Attempted Comms: Used sounding from last available sounding Release: Used sounding from last available sounding On Deck: Used sounding from last available sounding
156	CS1	Mooring Deployment	47.4828	-60.0724	2024-10-19	473	00:03:32	
157	CS2	Mooring Recovery	47.4842	-59.8094	2024-10-19	508	00:28:28	Release: Used sounding from last action On Deck: Used sounding from last action
158	CS2	Mooring Deployment	47.4681	-59.8324	2024-10-19	505	00:03:00	
159	CSL_01	CTD/Rosette	46.9584	-60.2161	2024-10-19	80	00:28:27	
160	CSL_01	202 µm net	46.9584	-60.2159	2024-10-20	80	00:04:06	
161	CSL_02	CTD/Rosette	47.0230	-60.1163	2024-10-20	186	00:39:10	
162	CSL_02	202 µm net	47.0231	-60.1163	2024-10-20	186	00:11:18	Recovered: Two sample jars used
163	CSL_03	CTD/Rosette	47.0998	-59.9915	2024-10-20	334	00:41:26	
164	CSL_03	202 µm net	47.0999	-59.9915	2024-10-20	334	00:18:06	
165	CSL_04	CTD/Rosette	47.2714	-59.7832	2024-10-20	470	00:45:40	
166	CSL_04	202 µm net	47.2714	-59.7832	2024-10-20	470	00:25:43	
167	CSL_05	CTD/Rosette	47.4333	-59.5579	2024-10-20	478	00:53:33	
168	CSL_05	202 µm net	47.4332	-59.5580	2024-10-20	492	00:26:09	Bottom: sounder acting weird - bridge says 470m water sounder said 520m
169	CSL_06	CTD/Rosette	47.5834	-59.3415	2024-10-20	264	00:51:20	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
170	CSL_06	202 µm net	47.5832	-59.3415	2024-10-20	264	00:15:14	
171	CSE	Mooring Recovery	47.5934	-59.3292	2024-10-20	216	00:28:18	
172	CSE	Mooring Deployment	47.5995	-59.3289	2024-10-20	199	00:03:55	
173	CS3	Mooring Recovery	47.5439	-59.5689	2024-10-20	472	00:24:44	
174	CS3	Mooring Deployment	47.5253	-59.6124	2024-10-20	472	00:04:04	Start Deployment: used sounding from closest $SDDBS reading Other: used sounding from closest $SDDBS reading
175	STAB_06	CTD/Rosette	46.6450	-58.5460	2024-10-20	417	00:50:09	
176	STAB_06	202 µm net	46.6450	-58.5455	2024-10-21	419	00:11:16	
177	STAB_05	CTD/Rosette	46.4168	-58.8834	2024-10-21	373	00:44:15	
178	STAB_05	202 µm net	46.4167	-58.8833	2024-10-21	374	00:23:41	Deployed: Bottom depth ~10 m shallower than sounding
179	STAB_05	202 µm net	46.4167	-58.8833	2024-10-21	361	00:19:22	Deployed: Stable isotope sample Bottom: Stable isotope sample Recovered: Stable isotope sample
180	STAB_04	CTD/Rosette	46.3000	-59.0645	2024-10-21	159	00:31:02	
181	STAB_04	202 µm net	46.3000	-59.0645	2024-10-21	159	00:12:13	
182	STAB_04	202 µm net	46.2999	-59.0645	2024-10-21	159	00:08:46	Recovered: Stable isotope sample
183	STAB_04	VPR	46.3000	-59.0645	2024-10-21	159	00:55:20	Recovered: Sounding 159 m throughout, fault on recovery
184	STAB_04	Multinet	46.2999	-59.0644	2024-10-21	159	00:15:37	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
185	STAB_03	CTD/Rosette	46.2166	-59.1950	2024-10-21	91	00:30:16	Bottom: Bottom action submitted later than actual bottom stop.
186	STAB_03	202 µm net	46.2165	-59.1948	2024-10-21	92	00:08:00	
187	STAB_03	202 µm net	46.2165	-59.1946	2024-10-21	92	00:05:06	Bottom: isotopes
188	STAB_03	VPR	46.2165	-59.1946	2024-10-21	92	00:41:29	
189	STAB_03	Multinet	46.2165	-59.1946	2024-10-21	92	00:06:41	
190	STAB_02	CTD/Rosette	46.1083	-59.3642	2024-10-21	66	00:29:59	
191	STAB_02	202 µm net	46.1082	-59.3642	2024-10-21	66	00:02:59	
192	STAB_02	202 µm net	46.0911	-59.3879	2024-10-21	64	00:20:27	Deployed: for isotopes Recovered: recovered hit late
193	STAB_01	CTD/Rosette	45.9998	-59.5329	2024-10-21	61	00:25:29	
194	STAB_01	202 µm net	45.9997	-59.5330	2024-10-21	61	00:07:32	
195	STAB_01	202 µm net	45.9997	-59.5330	2024-10-21	61	00:04:32	Bottom: for isotopes
196	A2	VPR	45.4998	-60.0001	2024-10-21	159	00:42:39	
197	A2	Multinet	45.4998	-60.0001	2024-10-21	159	00:08:58	Bottom: multibeam gives 155m
198	A3	VPR	45.2000	-60.3000	2024-10-21	69	00:00:00	
199	A3	Multinet	45.1999	-60.3000	2024-10-22	70	00:06:29	

4.1 CTD-Rosette Operations

4.1.1 CTD-Rosette Deployments

A 24, 20-L bottle CTD-Rosette system was provided and operated by the National Oceanography Centre (NOC) for the DY18402 mission. Table 4 shows a list of the installed sensors along with their model numbers, date of last calibration, and owner. The CTD included dual pressure, temperature, conductivity, and dissolved oxygen sensors, and single PAR, transmissometer, and altimeter sensors. A pH sensor was supplied by the DFO NL Region for use, and chlorophyll and CDOM Seapoint fluorometers were supplied by DFO Maritimes to ensure consistency with data collection on previous missions.

On the RRS *Discovery*, normal CTD deployment and recovery operations include landing the CTD-Rosette system on deck using the P-frame, disconnecting the conducting cable from the system, and connecting a gantry boom to move the CTD-Rosette into the sampling hangar. However, as the process of moving the CTD-Rosette into the hangar added ~5 to 7 minutes of operation time to each cast, the CTD-Rosette was left on deck for sampling after most casts, weather permitting.

The SBE Seasave acquisition software was operated from the Main Laboratory of the vessel, while the winch operators were situated in a winch cab overlooking the starboard deck. Communications between the CTD computer operator and the winch operators were done via radio. Data acquisition was conducted on two NOC-supplied acquisition computers that were both connected to the same SBE 11 deck unit. Having two acquisition computers provided redundancy in the event one computer malfunctioned.

The order of operations at each AZMP station was CTD-Rosette deployment first, followed by the ring net tow. General CTD-Rosette standard operating procedures were followed during the mission, which included lowering the CTD-Rosette to 10 m for a 3-minute 'soak' period to trigger the pumps to turn on and allow the sensors to acclimate. After the soak period, the CTD was raised to the surface, and then sent on its downcast. For casts greater than 100 m depth, active heave control was engaged by the winch operators once the CTD reached ~100 m depth. This involved a brief pause in descent between 100 and 110 m depth. Standard operating procedures on the RRS *Discovery* involved lowering the CTD-Rosette to within 100 m depth from the seabed to allow the altimeter to detect the bottom. Then, the system was lowered in a controlled manner to within 5 m from the seabed, often stopping at 30 and 15 m from the seabed and re-assessing the depth of the CTD package. During periods of inclement weather or high swell, the CTD package was lowered to within 7 to 10 m from the seabed.

The 2 NMF CTD technicians conducted regular post-deployment maintenance on the CTD-Rosette (sensor flushes with Milli-Q when required) and armed the bottles throughout the trip. Regular tests of the CTD cable's electrical specifications were conducted throughout the mission using a voltage multimeter.

An RBR Concerto CTD plus two attached turbidity sensors were mounted in a vertical position on the exterior of the rosette frame in support of an exercise to compare the outputs from the turbidity sensors in deep water (see the Mission Achievements section for more details). This system was completely autonomous, and was turned on and off by the NMF CTD technicians before and after each cast.

A total of 72 CTD-Rosette casts were conducted during the DY18402 mission, only one of which was aborted (and redeployed shortly thereafter). The CTD-Rosette worked very well throughout the mission. Niskin bottle 1 misfired on two occasions, and the lanyards were reconfigured and tightened on all the bottles thereafter. The output from all sensors were evaluated periodically throughout the mission (see Appendix A, B, and C). While drift from factory values was detected in both the primary and secondary dissolved oxygen and conductivity sensors, the relationship with time/event appeared to be linear and relatively minor. Consequently, the sensors were not changed and remained on the CTD package throughout the mission.

On station BBL_07, the first deep station sampled during the mission, the CTD winch experienced scrolling issues and an overlapping wrap on the winch drum. The overlapping wrap was noticed while the CTD was deployed to ~480 m depth, and the CTD-Rosette package was paused for approximately 45 minutes and then lowered to spool out additional cable to remove the overlap. Issues with the active heave compensation system were also experienced throughout the mission. The issue was first noticed after the winch appeared to pay out cable more than necessary while the CTD package was near the bottom. After continued monitoring, it was noted that active heave appeared to be overcompensating for the movement of the vessel, resulting in poorer heave compensation compared to when active heave was turned off. To remedy this situation, the engineers on board replaced the motion reference unit (MRU) sensor, which is designed to measure the pitch, roll, and other metrics of the vessel. Once replaced, the active heave compensation worked without issue.

A full CTD report was written by the CTD technicians and provided to DFO upon conclusion of the DY18402 mission. This report can be accessed from the Ocean Data and Information Section (ODIS) 'BIO Data Services' server by sending a request to DFO.BIODataServices-BIOServicesdeDonnees.MPO@dfo-mpo.gc.ca. See the Data Management section below for further details on how to access the data collected on this mission.

4.1.2 CTD Data Post-Processing

Once a CTD cast was completed, the raw CTD files were manually copied from the primary acquisition computer to the ship's science network where they could be accessed from any networked computer on the vessel. From here, they were copied onto BIO's post-processing computer, where the CTD Data Acquisition and Processing System (CTDDAP, beta version 6), an in-house wrapper application to facilitate downloading and processing of CTD data from various SBE instruments, was used to post-process the .hex files from each cast. This allowed for the creation of ODF (Ocean Data Format) files, BIO's in-house CTD file format, and other files necessary for archival and the upload of data to DFO's national repository for discrete bottle and plankton data, BioChem. The NMF technicians did not process the CTD files separately, and archived only the raw CTD data.

Table 4. List of sensors included on the CTD system used during the 2024 fall AZMP mission on board the RRS *Discovery* (DY18402). Model number and date of last calibration is shown.

Sensor	Model	Sensor Units	QAT Output Variable Name	Serial No.	Calibration Date	Owner
Primary CTD deck unit	SBE 11plus					NOC
CTD underwater unit	SBE 9plus					NOC
Stainless steel 24-way CTD frame	Custom					NOC
Primary temperature	SBE 3P	ITS-90 temperature, Celcius	t090C	5785	2024-04-19	NOC
Primary conductivity	SBE 4C	Conductivity, S/m	c0S/m	3272	2023-12-07	NOC
Digiquartz pressure sensor	Paroscientific	dbar	prDM	758	2022-09-23	NOC
Primary dissolved oxygen	SBE 43	Dissolved oxygen, ml/l	sbeox0	1624	2024-05-03	NOC
Secondary temperature	SBE 3P	ITS-90 temperature, Celcius	t191C	5835	2024-06-05	NOC
Secondary conductivity	SBE 4C	Conductivity, S/m	c1S/m	3529	2023-12-14	NOC
Secondary dissolved oxygen	SBE 43	Dissolved oxygen, ml/l	sbeox1	2831	2024-06-14	NOC
pH	SBE 18		ph	1244	2024-03-11	DFO NL
Chlorophyll fluorometer	Seapoint Ultraviolet Fluorometer SUVF	micro g/L	flSP	3668	2024-02-01	DFO MAR
CDOM fluorometer	Seapoint Fluorometer SCF	micro g/L	flSPuv0	6229	2024-02-01	DFO MAR
PAR/Log	Satlantic	micromoles photons/m2/s	par	1054	2021-01-06	DFO NL

Table 4. *(continued)*

Sensor	Model	Sensor Units	QAT Output Variable Name	Serial No.	Calibration Date	Owner
Transmissometer	WET Labs C-Star	Beam attenuation (1/m), Beam transmission (%)	CStarAt0	1797TR	2022-04-18	NOC
Altimeter	Valeport VA500	metres	altM	81629		NOC

4.1.3 Water Sampling

Water samples were collected from each station and either processed while on board or preserved/frozen for processing on shore. The number of water samples collected from each station depended on depth and other station characteristics. Standard AZMP depths (surface, 10, 20, 30, 40, 50, 60, 80, 100 m, and bottom) are consistently sampled at stations 100 m or less, while deeper bottles are typically collected at 500 m intervals (e.g., 1500, 2000 m). Water samples were processed according to standard AZMP protocols: nutrients, chlorophyll *a*, dissolved oxygen, and salinity: Mitchell et al. (2002); total inorganic carbon, total alkalinity, pCO_2, pH, and methane: Dickson et al. (2007); particulate organic carbon and nitrogen: https://www.nodc.noaa.gov/archive/arc0022/0001155/1.1/data/1-data/docs/common/proto-18.htm; coloured-dissolved organic matter (CDOM): Mannino et al. (2019); high-performance liquid chromatography (HPLC): Head and Harris (1992); phytoplankton absorption: Hoepffner and Sathyendranath (1992); Hoepffner and Sathyendranath (1993); and flow cytometry: Li and Dickie (2001). During occupation of AZMP high-frequency station HL_02 on the Halifax Line, integrated phytoplankton samples were collected by collating 50 mL of water from each of the 10 bottle depths sampled, and preserving the sample using 2% Lugol's preservative (Mitchell et al. 2002).

Sample management included the assignment of unique 6-digit 'sticky IDs' to each Niskin bottle and sample vial. These IDs allow for unique identification of samples across the entire Maritimes Region AZMP time series. The ID range used for samples collected from the CTD-Rosette on this mission was 511771 to 513115.

Table 5 shows the total number of samples collected for each parameter measured and evaluated by the AZMP from CTD-Rosette deployments at each station/event. Bottle samples collected for salinity determination were analyzed at sea using a shipboard Guildline Autosal 8410A Salinometer. Dissolved oxygen and chlorophyll samples were analyzed at sea using a Winkler titration system and Turner Designs fluorometer, respectively. Samples collected for all other parameters were either stored at room temperature, refrigerated, or frozen for subsequent analysis ashore.

In order to meet the water requirement of all programs and projects, the CTD-Rosette system was outfitted with 24, 20-L bottles during the mission instead of 10 or 12 L bottles normally used during Maritimes Region AZMP surveys. As the use of 20-L bottles significantly increases the weight of the CTD-Rosette package, there was a request made by the NMF CTD technicians to close all 24 bottles on the rosette during stations where the CTD would be moved to the hangar using the gantry boom, to ensure the weight of the rosette was evenly distributed. Closing additional bottles was done on a limited number of stations, and the extra bottle fires were removed from the raw .BL file prior to post-processing to maintain the correct sample ID sequence.

4.1.4 Evaluation of Sensor Data against Corresponding Bottle Measurements

Plots were routinely generated using R scripts that were designed to evaluate the relationship between the primary and secondary sensors, and between the sensor data and bottle measurements. The purpose of this was to 1) evaluate any discrepancies between the dual sensors, and 2) evaluate which of the dual sensors more closely reflected the corresponding bottle measurements, a task which helps guide the final sensor calibration process. Appendix A provides

a visual depiction of the relationship between the dissolved oxygen and conductivity sensor data and their corresponding bottle measurements. Although bottle chlorophyll measurements are not used to calibrate the sensor data, they were routinely compared against the chlorophyll fluorometer sensor data throughout the mission to evaluate the reliability of the sensor, and to ensure that all bottle sample IDs for parameters measured at sea were accounted for.

For the majority of the casts conducted during the mission there was excellent congruence between both the primary and secondary dissolved oxygen and conductivity sensors, and between the sensor and bottle data. Although data from the primary and secondary oxygen sensors were comparable, the secondary sensor was closer to the corresponding Winkler titration values than the primary.

For the purpose of this report, preliminary calibrations of the dissolved oxygen and conductivity primary and secondary sensors were conducted to help guide the final calibration process. The results of these exercises can be found in Appendices B and C. Final data calibration will be conducted by BIO ODIS staff Yongcun Hu and Jeff Jackson prior to archival of the final ODF CTD files on ODIS servers. While Turner chlorophyll values are not currently used to correct the chlorophyll sensor data, the relationship between the two is evaluated in Appendix D.

Table 5. Summary of water samples collected for each parameter sampled on the 2024 fall AZMP mission (DY18402). Numbers represent the total number of samples per station, where O_2 = dissolved oxygen, pCO_2 = partial pressure of carbon dioxide, TIC/TA = total inorganic carbon and total alkalinity, NUTS = nutrients, SAL = salinity, CHL = chlorophyll, POC = particulate organic carbon, HPLC = high performance liquid chromatography, ABS = phytoplankton absorption, CDOM = coloured dissolved organic matter, and CYTO = flow cytometry.

Station	Event	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/PON	HPLC	ABS	CDOM	CYTO
BBL_05	4	3	6	6	22	2	18	2	2	2	2	18
BBL_06	6	4	9	9	30	3	18	2	1	1	1	20
BBL_07	9	5	11	11	32	4	18	2	2	2	2	24
BBL_04	13	3	0	0	18	2	18	2	1	1	1	18
BBL_03	15	3	5	5	18	2	18	2	2	2	2	18
BBL_02	17	3	0	0	18	2	18	2	1	1	1	18
BBL_01	22	3	4	4	14	2	14	2	2	2	2	14
YL_01	24	3	5	5	16	2	16	2	1	1	1	16
YL_02	26	3	0	0	20	2	18	2	1	1	1	18
YL_03	28	3	7	7	22	2	18	2	1	1	1	18
YL_04	30	3	0	0	22	2	18	2	1	1	1	18
YL_05	34	3	7	7	22	2	18	2	1	1	1	18
YL_06	36	3	0	0	20	2	18	2	1	1	1	18
YL_07	38	3	6	6	20	2	18	2	1	1	1	18
YL_08	40	3	6	6	20	2	18	2	1	1	1	18
YL_09	42	3	0	0	16	2	16	2	1	1	1	16
YL_10	44	3	5	5	18	2	18	2	1	1	1	18
PL_01	46	3	5	5	20	2	18	2	1	1	1	18
PL_02	48	3	0	0	20	2	18	2	1	1	1	18
PL_03	50	3	6	6	20	2	18	2	1	1	1	18
PL_04	52	3	0	0	20	2	18	2	1	1	1	18
PL_05	54	3	6	6	20	2	18	2	1	1	1	18
PL_06	56	3	0	0	22	2	18	2	1	1	1	18
PL_07	58	4	8	8	24	3	18	2	1	1	1	18
PL_08	60	4	0	0	24	3	18	2	1	1	1	18
PL_09	62	4	7	7	24	3	18	2	1	1	1	18
NEC_10	64	3	0	0	18	2	18	2	1	1	1	18

Table 5. *(continued)*

Station	Event	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/PON	HPLC	ABS	CDOM	CYTO
NEC_09	66	3	5	5	18	2	0	0	0	0	0	0
NEC_08	67	3	0	0	26	2	18	2	1	1	1	18
NEC_07	69	3	7	7	26	2	0	0	0	0	0	0
NEC_06	70	3	0	0	26	2	18	2	1	1	1	18
NEC_05	72	3	6	6	26	2	0	0	0	0	0	0
NEC_04	73	3	0	0	26	2	18	2	1	1	1	18
NEC_03	75	3	6	6	26	2	0	0	0	0	0	0
NEC_02	76	3	6	6	26	2	0	0	0	0	0	0
NEC_01	78	3	0	0	18	2	18	2	1	1	1	18
HL_01	93	3	5	5	16	2	16	2	1	1	1	16
HL_02	94	3	6	6	20	2	18	2	2	2	2	18
HL_03	97	3	7	7	22	2	18	2	1	1	1	18
HL_03.3	99	3	0	0	20	2	18	2	2	2	2	18
HL_04	102	3	5	5	16	2	16	2	1	1	1	16
HL_05	104	3	5	5	18	2	18	2	2	2	2	18
HL_05.5	106	4	7	7	22	3	18	2	1	1	1	18
HL_06	108	9	11	11	30	8	18	2	2	2	2	20
HL_06.3	110	6	0	0	32	5	18	2	1	1	1	20
HL_06.7	112	12	0	0	34	11	18	2	1	1	1	22
HL_07	115	12	13	13	34	11	18	2	2	2	2	20
GUL_01	118	4	1	1	24	3	18	2	1	1	1	20
GUL_02	120	4	1	1	26	3	18	2	1	1	1	18
GUL_03	123	4	2	2	28	3	18	2	1	1	1	20
GUL_04	125	4	6	6	28	3	19	2	1	1	1	20
LL_09	130	5	12	12	34	3	18	2	2	2	2	20
LL_07	134	4	7	7	26	3	18	2	2	2	2	18
LL_06	136	3	0	0	14	2	14	2	1	1	1	14
LL_05	138	3	7	7	20	2	20	2	2	2	2	20
LL_04	140	3	7	7	18	2	16	2	1	1	1	17
LL_03	143	3	7	7	20	2	18	2	2	2	2	18
LL_02	145	3	7	7	20	2	18	2	1	1	1	18

Table 5. *(continued)*

Station	Event	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/PON	HPLC	ABS	CDOM	CYTO
LL_01	147	3	6	6	18	2	18	2	2	2	2	18
CSL_01	159	3	6	6	16	2	16	2	2	2	2	16
CSL_02	161	3	8	8	22	2	18	2	1	1	1	18
CSL_03	163	4	10	10	26	3	18	2	2	2	2	18
CSL_04	165	4	11	11	28	3	18	2	1	1	1	18
CSL_05	167	4	11	11	28	3	18	2	2	2	2	18
CSL_06	169	3	9	9	24	2	18	2	1	1	1	18
STAB_06	175	3	0	0	26	2	18	2	1	1	1	20
STAB_05	177	3	3	3	26	2	18	2	1	1	1	20
STAB_04	180	3	0	0	20	2	18	2	1	1	1	18
STAB_03	185	3	2	2	16	2	16	2	1	1	1	16
STAB_02	190	3	0	0	14	2	14	2	1	1	1	14
STAB_01	193	3	2	2	12	2	12	2	1	1	1	12

4.2 Vertical Ring Net Tows

As part of the standard AZMP protocol to estimate mesozooplankton community abundance and biomass, a conical ring net of 202 µm mesh size with an aperture of 75 cm in diameter (filtering ratio of 1:5) was towed vertically from near-bottom to the surface (or from a maximum depth of 1000 m) at each station. Ring net operations were conducted using an NOC-supplied general purpose LeBus winch mounted on the starboard aft deck. This winch was fitted with a galvanized steel hydrowire with a thickness of 8 mm. The starboard aft pedestal crane was used for ring net deployments. The NOC crew assisted with deployments and recoveries, including affixing the crossbow and wire clamps onto the hydrowire.

Samples were preserved in the Deck Lab on board the vessel, which was closest to the aft deck where ring net operations were conducted. The contents of the cod end were preserved in 4% buffered formaldehyde (10% formalin). Ring nets were equipped with a KC Denmark flow meter, which was used to record the start and end flow for each cast. Net operations at station HL_02 consisted of the standard (202 µm) net deployment, and a 76 µm net deployment preserved in formalin. Closing net operations were not conducted at high-frequency station HL_02 as the winch wire was too thick to allow for the fastening of messengers that are used to close the net.

A total of 73 ring net operations were conducted at 65 unique stations during the mission (see Table 3), including the 76 µm net deployment at station HL_02. Ring net samples were not collected at stations HL_01 and LL_08 due to inclement weather, and ring net tows were aborted and redeployed at stations BBL_06, BBL_02, NEC_02, and GUL_01 due to poor wire angle. During the redeployment at station GUL_01 (Event 119), the net was paused for approximately 1 minute at 30 m depth on its ascent, after the wire and net veered under the vessel. Due to time constraints, the net was not redeployed and the sample was kept. Significant tears were discovered in the nets during ring net deployments at stations GUL_03 and LL_09. In both cases the sample was kept as redeployment was not possible due to time constraints, but the sample may not be quantitative.

Additional ring net samples were collected at stations STAB_01 through STAB_05 in support of a DFO stable isotope analysis project to evaluate the functional diversity within the St. Anns Bank MPA (see the 3 Mission Achievements section above for more details). These samples were preserved in the -80○ freezer.

4.3 Argo Floats

During the DY18402, DFO and NOC collaboratively deployed 2 Argo floats from the RRS *Discovery* in support of the international Argo program (Wong 2020). Both floats were PROVOR biogeochemical (BGC) models, which record temperature, conductivity, dissolved oxygen, chlorophyll fluorescence, and backscatter. The first float was deployed at station HL_07 after completion of the CTD and ring net operations. The second float, which was initially planned for deployment at station LL_09, was deployed further south in approximately 3960 m of water, at the location of the mooring deployment at station ECD. The decision to deploy the float at this location instead of at AZMP station LL_09 was to take advantage of deeper water and good weather, which was forecasted to deteriorate later that day.

Both floats were deployed by hand by two crew using a slip rope that was tied off on the ship's infrastructure for leverage. One hour prior to deployment, the floats were pre-tested to confirm establishment of the GPS and iridium communications for each float. The floats will remain active for approximately 5 years, collecting vertical profiles from the surface to 2000 m every 10 days.

Table 6. Metadata associated with the deployment of two Argo floats during the fall AZMP DY18402 survey. The WMO and serial numbers (S/N) of each float are provided, along with the time of magnet removal and deployment (UTC), and associated date, event, station, and latitude and longitude (in decimal degrees) of deployment.

S/N	WMO	Date	Event	Stn.	Magnet Removal (UTC)	Deploy. (UTC)	Lat. (DD)	Lon. (DD)
P41305-23CA001	4902674	10/14/2024	117	HL_07	22:07:01	22:21:38	42.4759	-61.4261
P41305-23CA005	4902678	10/16/2024	129	ECD	15:11:13	15:19:21	43.2057	-57.6132

The first profile recorded by each float is shown in Figure 2. For salinity, oxygen, and chlorophyll, analogous water samples from nearby stations (HL_07 and LL_09) were compared. The floats performed their first ascent two days following deployment, highlighting the temporal and potentially spatial separation from nearby water samples, depending on the drift of the float during that time. For the float deployed at mooring station ECD, the nearest CTD-Rosette station in both time and space was Louisbourg Line station LL_09, which was ~15 nautical miles away at the time of deployment.

At both stations, the float and bottle sample data were very well aligned. Float oxygen data were adjusted by a gain factor calculated by comparing the Argo surface data to the nearest available surface data in the World Ocean Atlas. For float 4902674 deployed at HL_07, float measurements were slightly higher than bottle samples at depth, a feature that may be resolved with the collection of more profiles, or by using in-air measurements taken by the float while at the surface, which are preferred over in-water samples for correction.

Chlorophyll measurements were very well aligned when compared to station HL_07, showing good agreement in magnitude and location of the deep chlorophyll maximum in the mixed layer. Comparison of float and chlorophyll measurements from LL_09 and the float deployed at ECD were not as well aligned, but this could be a result of the spatial and temporal difference between measurements.

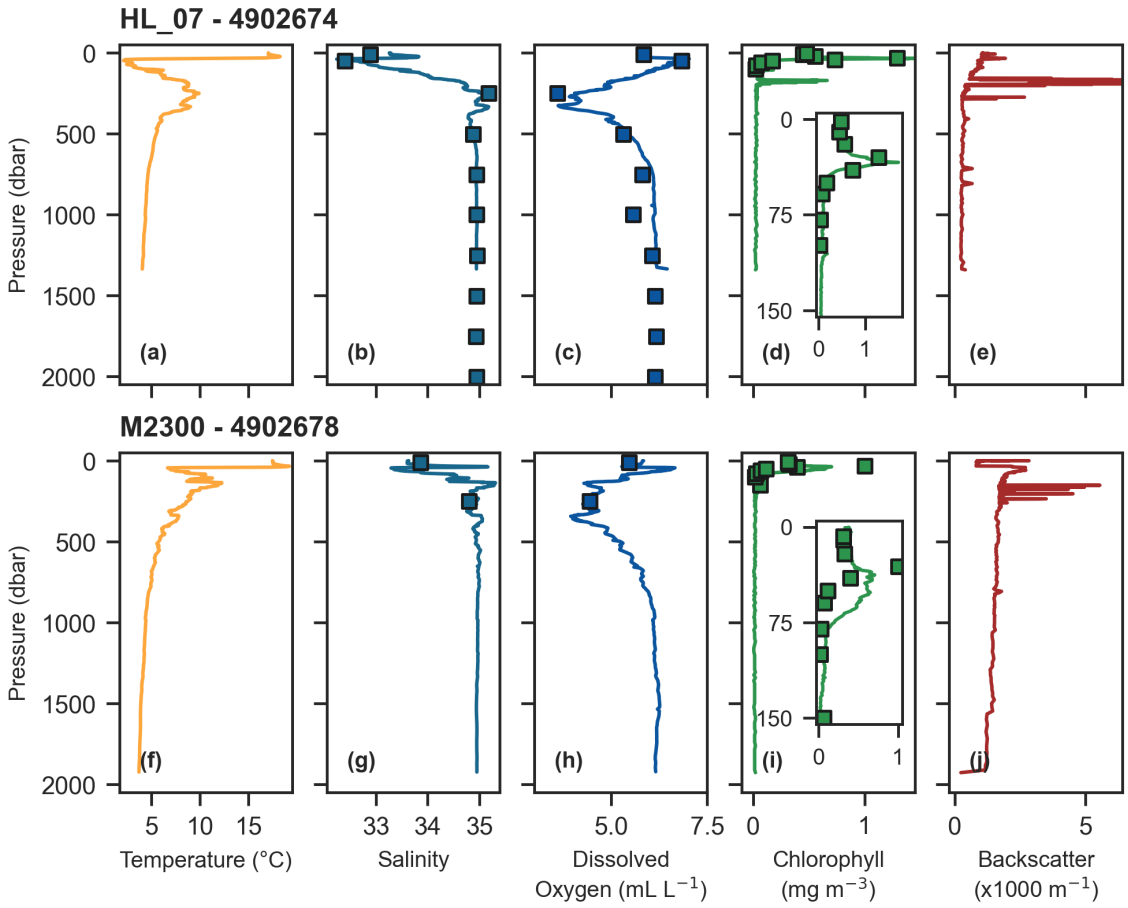

Figure 2. Initial profile for Argo floats 4902674 and 4902678 deployed at stations HL_07 and mooring station ECD (labelled by mooring ID 2300), respectively. Solid coloured lines show float data, and square points show water sample data for salinity (autosal), oxygen (Winkler titrations), and chlorophyll (fluorometry) from stations HL_07 and LL_09 respectively. Insets on the chlorophyll plots (d, i) show the surface layer.

4.4 Underway Systems

4.4.1 TSG and associated sensors

The RRS *Discovery* is equipped with its own flow-through system as part of its meteorological ('MET') package (see Beazley et al. (2024) for description of sensors included in the package). This system was used to collect continuous measurements of surface temperature, salinity, chlorophyll and beam transmission data during the DY18402 mission. Recently, a General Oceanics Model 8060 pCO_2 measuring system was installed in the Meteorological Laboratory (see Figure 3) on the vessel and was used to collect observations of surface carbon dioxide along the mission track. This system is calibrated using several gas standards at different concentrations, and also includes an Aanderaa optode dissolved oxygen sensor that records measurements of dissolved oxygen concentration at the same interval as the pCO_2 measurements (i.e., at 3-minute intervals).

A second flow-through system owned and maintained by BIO's Ocean Engineering and Technology Section (OETS) was installed in the General Purpose Laboratory on the *Discovery*, and was operational throughout the mission. This allowed for measurements of additional parameters (e.g., pH, CDOM) not measured by the flow-through system on the *Discovery*. While this system normally comes with its own pCO_2 sensor, the pCO_2 tank was not installed in lieu of the independent pCO_2 system on board.

Shortly after the mission began, daily observations of the underway system's optode dissolved oxygen sensor measurements suggested that the sensor was malfunctioning. The calphase values were mostly unchanging, but would occasionally spike from 10 to 30. The optode calphase values were converted to concentration in ml/L and plotted, confirming that the sensor was not functioning properly (see Figure 4). As a spare optode was not available, this sensor remained installed for the duration of the mission. However, it is recommended that the dissolved oxygen data from the vessel's General Oceanics Model 8060 pCO_2 measuring system be used instead for analytical purposes.

4.4.2 Daily underway system sampling

Daily sampling of dissolved oxygen, chlorophyll, salinity, CDOM, and TIC/TA samples were collected from the outflow of the BIO flow-through system throughout the mission (see Table 7). Samples were collected daily with the exception of on October 15, when sampling was not possible due to time constraints. As the vessel's pCO_2 system uses a series of gas standards for calibration, pCO_2 samples were not separately collected. Upon conclusion of the mission, the underway system was left set up for use by the Newfoundland and Labrador Region AZMP, and daily samples were collected. The sample ID range for daily underway samples collected during the mission was 511753 to 511769.

4.4.3 Data management

The Advanced Serial Data Logger software installed on the underway computer system records the TSG, flow rate, NMEA data, and pCO_2 (when installed) RS-232 serial data directly into text (.csv) files produced daily. The frequency of measurements within each file type varies, with NMEA recordings occurring every second, TSG measurements every 5 seconds, and flow data approximately every second. A script was developed using R statistical software to collate the TSG and flow rate data with the corresponding positional data in the NMEA file. Measurements were interpolated in hourly bins and plotted to visualize spatial patterns and help validate the sensor outputs (see Figures 4 and 5 below).

The chlorophyll and salinity samples collected from the outflow water from the underway system and were plotted against the corresponding underway sensors throughout the mission using R scripts (see Figure 6) as a means to validate the sensor outputs. There was relatively good congruence between sensor salinity and bottle salinity measurements for most comparisons (mean difference of 0.081 ± 0.520). An exception occurred on October 13 when the daily bottle salinity measurement was nearly two units of salinity lower than the corresponding sensor measurement (29.795 vs. 31.821). Turner chlorophyll *a* replicates were consistently lower than the corresponding sensor values throughout the mission. Given the erroneous values from the dissolved oxygen optode sensor, no comparisons were made between the oxygen bottle measurements and optode sensor values.

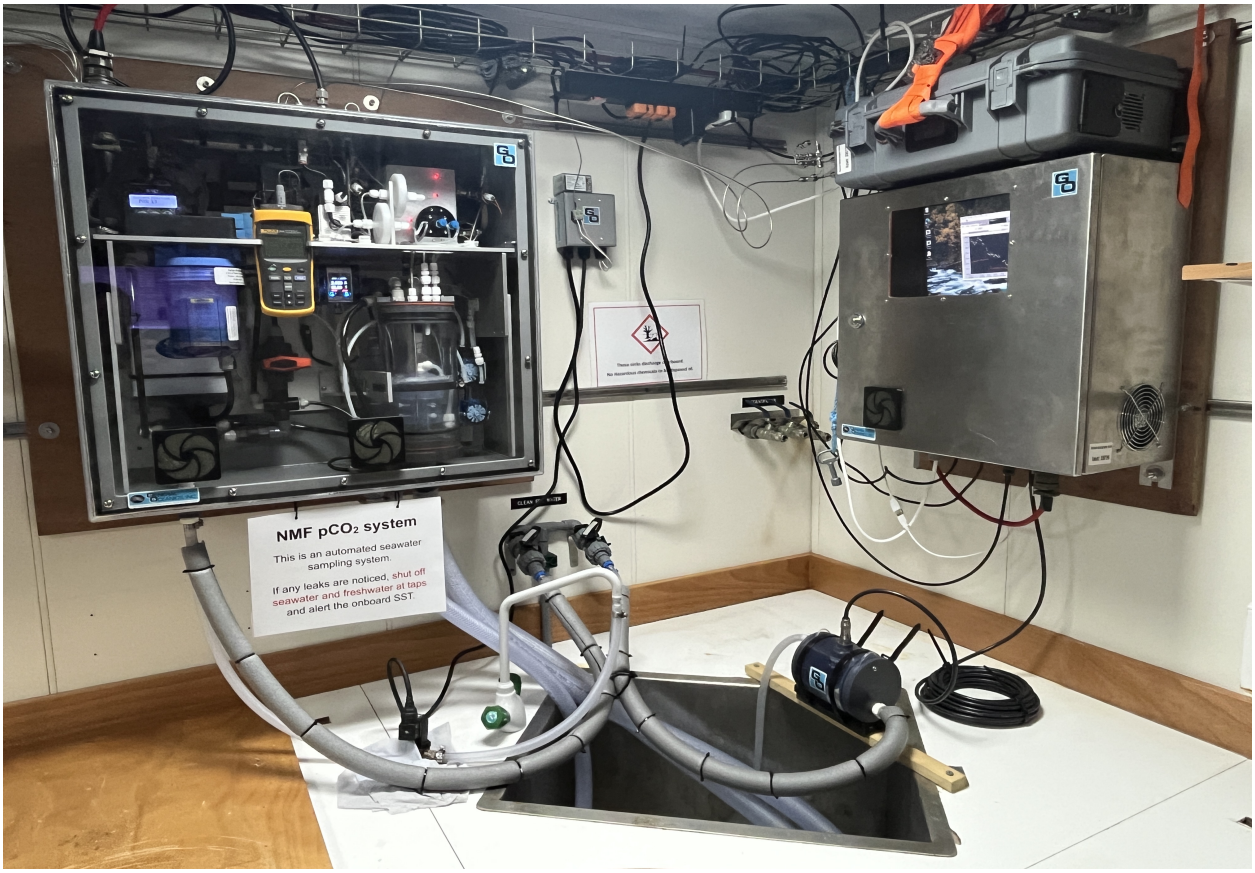

Figure 3. National Marine Facilities (NMF) General Oceanics Model 8060 pCO_2 system installed in the Meteorological Laboratory on the RRS *Discovery*.

Table 7. Metadata associated with the collection of water samples from the underway system during the 2024 fall AZMP mission (DY18402). Date, time (UTC), latitude and longitude (in decimal degrees) of the ship's position were recorded in ELOG at the time of sample entry, while temperature (℃), salinity, and pH were recorded from the thermosalinograph. 'X' and 'XX' indicate single and duplicate sampling, respectively.

								Bottle Samples				
Date	**Time (UTC)**	**Lat. (DD)**	**Lon. (DD)**	**Temp**	**Sal**	**Sample ID**	**TSG Flow Rate (L/min)**	**O2**	**Chl**	**Sal**	**TIC/ TA**	**CDOM**
10/4/2024	20:14	43.9702	-63.0743	17.45	31.27	511753	20.9	X	XX	X	X	X
10/5/2024	15:02	42.0834	-63.1647	19.01	32.68	511754	21.2	X	XX	X	X	X
10/6/2024	16:00	41.8384	-65.5859	17.64	32.14	511755	22.3	X	XX	X	X	X
10/7/2024	16:45	43.7347	-66.5124	16.22	31.03	511756	18.1	X	XX	X	X	X
10/8/2024	15:10	44.3958	-66.6402	14.44	31.27	511757	18.5	X	XX	X	X	X
10/9/2024	16:52	43.1002	-70.1569	14.85	31.97	511758	17.5	X	XX	X	X	X
10/10/2024	15:16	42.4983	-67.0246	16.44	31.71	511759	18.0	X	XX	X	X	X
10/11/2024	17:27	42.4842	-65.6945	16.45	31.18	511760	18.8	X	XX	X	X	X
10/12/2024	15:22	43.0782	-65.1434	16.58	30.85	511761	17.3	X	XX	X	X	X
10/13/2024	17:33	43.7152	-62.7068	15.79	31.70	511762	17.1	X	XX	X	X	X
10/14/2024	17:31	42.5954	-61.5049	17.55	32.95	511763	17.4	X	XX	X	X	X
10/16/2024	15:24	43.2046	-57.6067	17.52	33.20	511764	17.3	X	XX	X	X	X
10/17/2024	15:57	45.3600	-57.8487	12.97	30.82	511765	17.6	X	XX	X	X	X
10/18/2024	14:50	45.1688	-59.4347	14.18	29.81	511766	17.0	X	XX	X	X	X
10/19/2024	15:45	47.3825	-60.2888	11.88	30.96	511767	17.0	X	XX	X	X	X
10/20/2024	16:25	47.4847	-59.5704	10.59	31.36	511768	16.9	X	XX	X	X	X
10/21/2024	16:18	45.9678	-59.5631	11.44	29.80	511769	17.0	X	XX	X	X	X

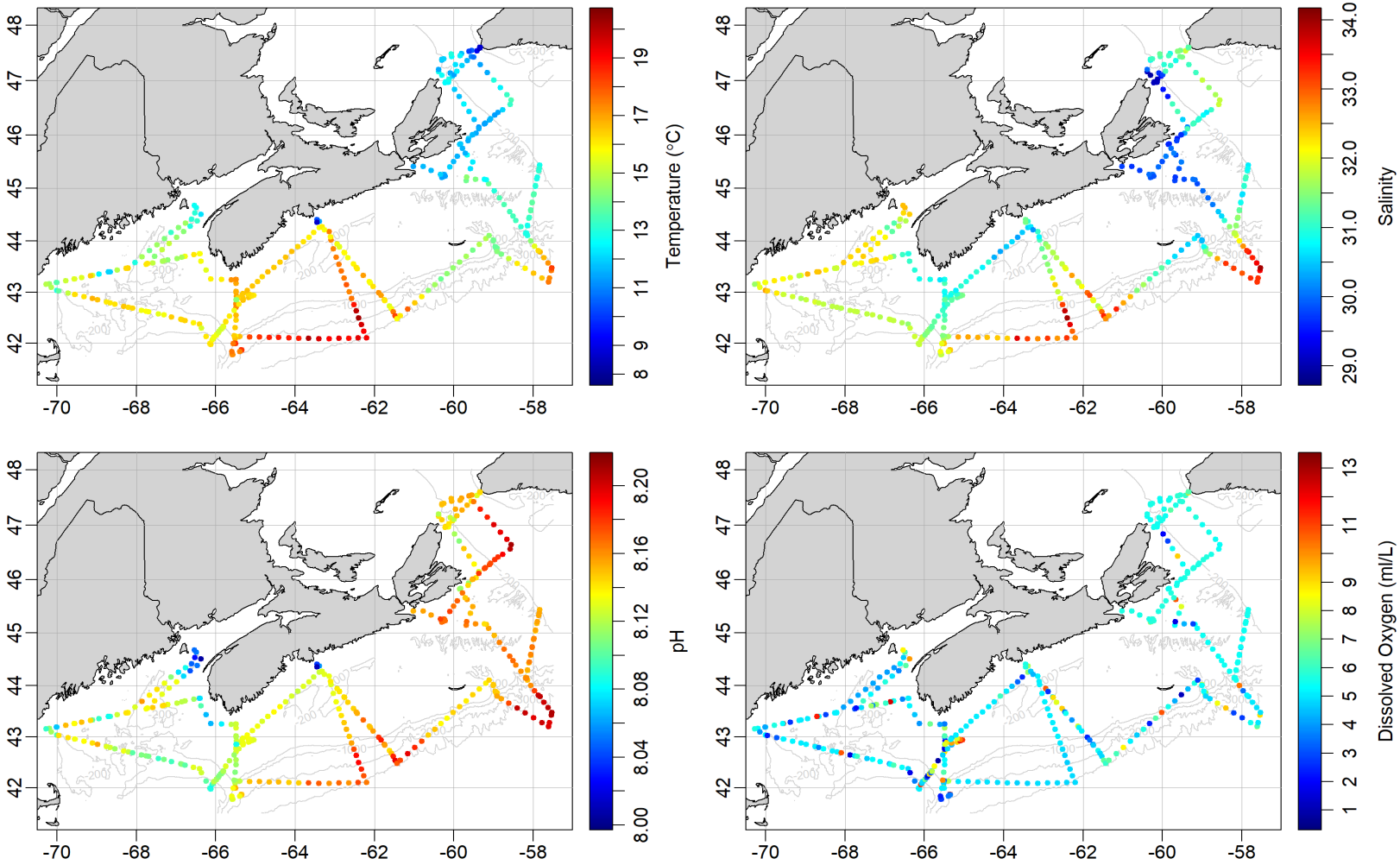

Figure 4. Surface temperature (°C; top left), salinity (top right), pH (lower left), and dissolved oxygen concentration (ml/L; lower right) measured along the cruise track during the 2024 fall AZMP mission (DY18402). Data are measured at variable intervals and presented as hourly interpolations.

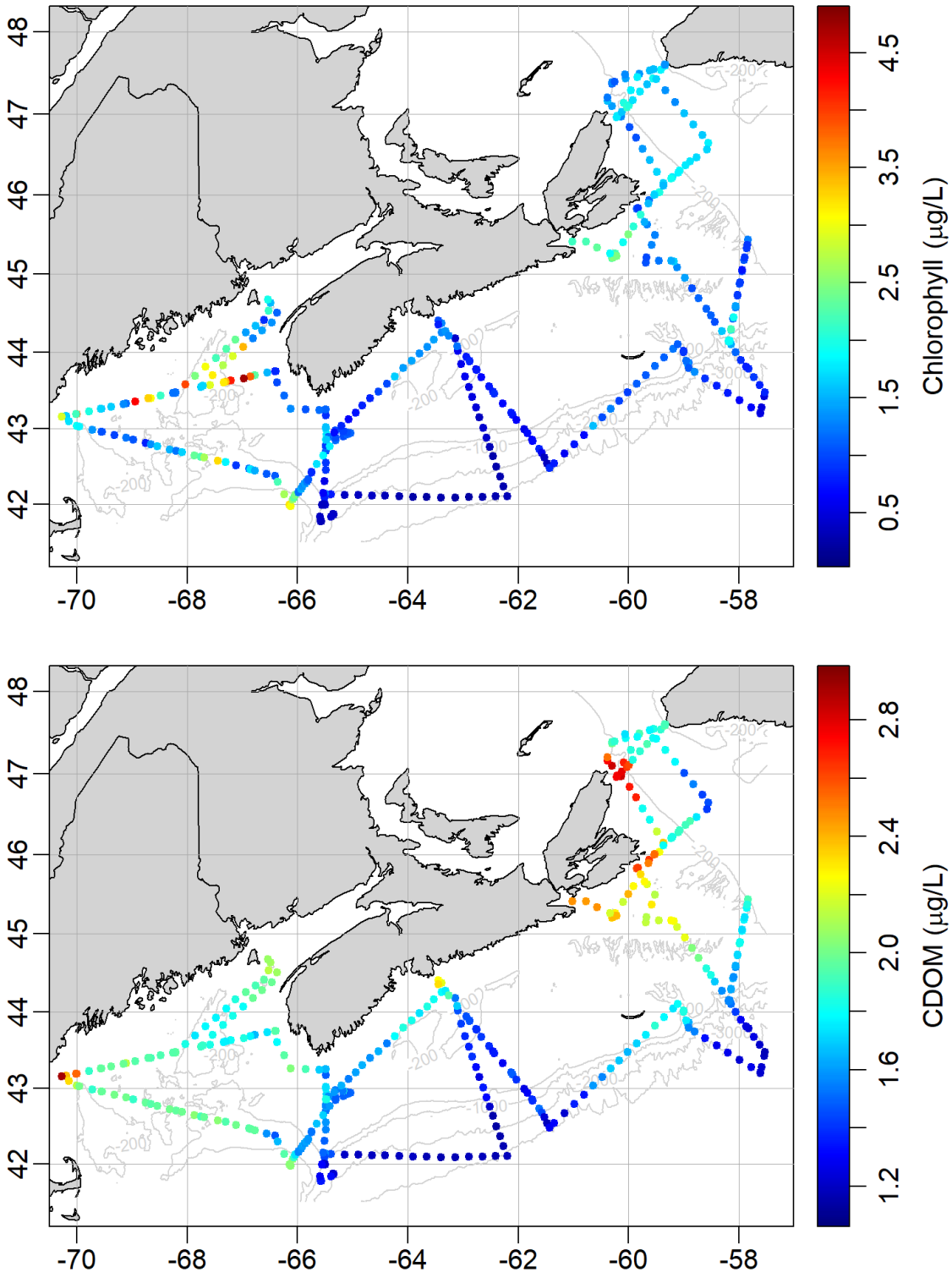

Figure 5. Chlorophyll fluorescence (μg/L; middle), and CDOM (μg/L; bottom) measured along the cruise track during the 2024 fall AZMP mission (DY18402). Data are measured at variable intervals and presented as hourly interpolations.

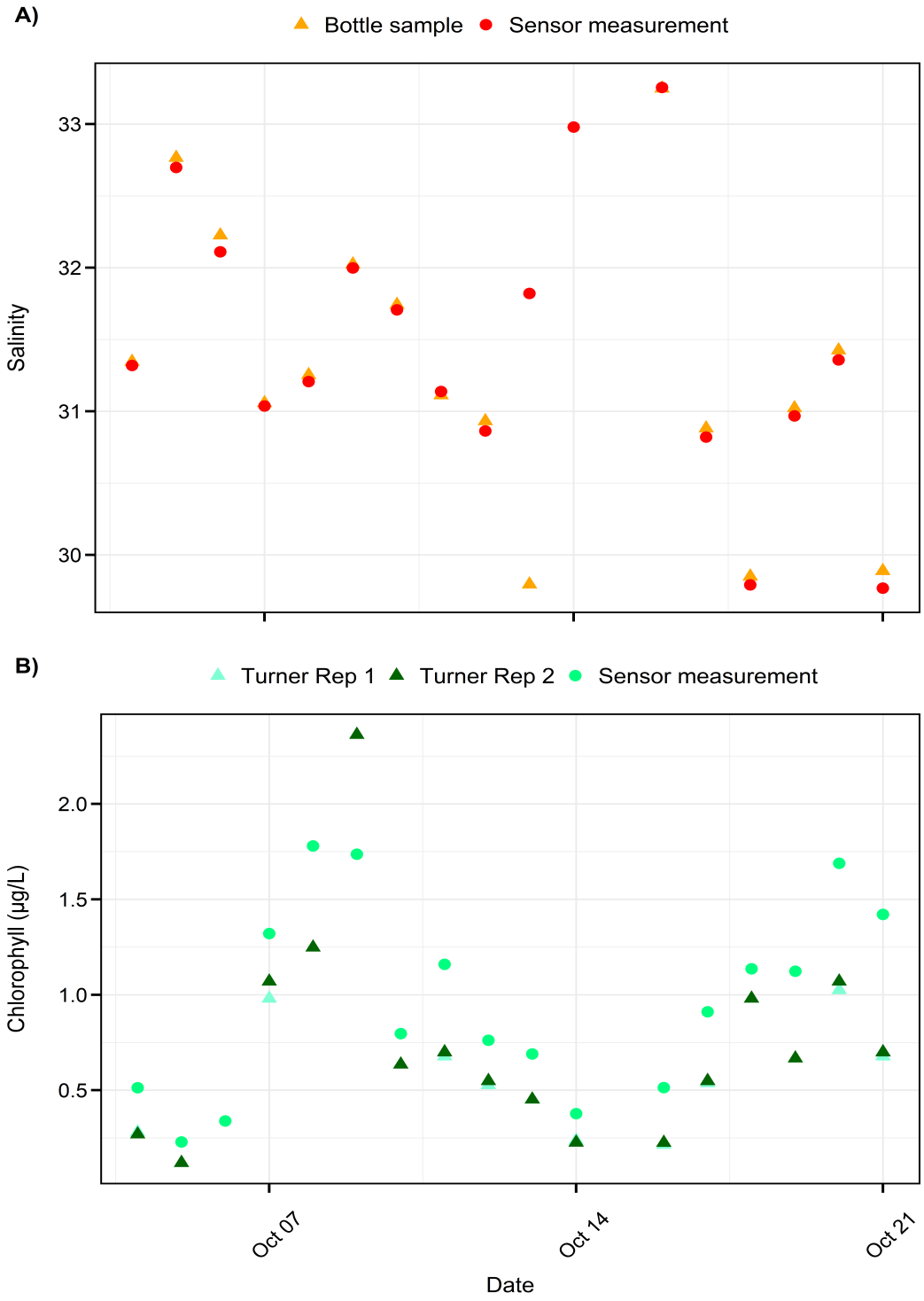

Figure 6. Comparison between bottle samples and sensor measurements of A) salinity and B) chlorophyll collected using the underway system installed on the RRS *Discovery* during the 2024 fall AZMP survey.

4.5 Mooring Operations

4.5.1 Background

A total of 23 mooring operations were performed on the RRS *Discovery*, including 13 recoveries and 10 deployments. The size and length of each mooring varied, ranging from as short as 3 m to as long as 112 m. When daily activities included mooring operations, a toolbox talk was conducted with the Captain, officers, deck crew, chief scientist, and mooring technicians to go over the mooring diagrams and discuss strategies for deployments and recoveries.

4.5.2 Deployments

Mooring deployments were all performed from the stern of the vessel. When working at the stern of the vessel with the safety rails down, a fall restraint harness tethered to the vessel was worn by the mooring technician, but was not required when the railings were installed. Nine of the 10 mooring deployments were done in a single lift, with only 1 mooring deployment requiring multiple lifts due to its length. The 9 single-lift moorings were deployed using a Sea-Catch® quick release, the secondary starboard winch, a block, and the A-frame. The single mooring that required multiple lifts also required the use of the main mooring winch.

Six of 10 moorings were ultradeep Autonomous Multichannel Acoustic Recorders (AMARs) that had the same design and were deployed with a single lift. These moorings were 9 meters in length but were able to be 'folded' in half to minimize overhead lifting height. Two moorings similar in design had 750 m-rated 36" Deepwater Buoyancy syntactic foam spheres. One mooring consisted of a double B3 SUBS frame and a single acoustic release. These moorings were all lifted and deployed over the safety railings in a single pick.

The largest mooring of the mission was deployed at station ECD in the Eastern Canyons Conservation Area, and had a total length of 112 m with a 100-m wire section. This operation was complicated and required a total of three lifts to deploy. Weather on this day was also not favorable, with swells reaching 3 m. The first pick was done with the main mooring winch and a block, which lifted the top flotation package and ADCP from the deck while the port articulating knuckle crane moved the block off the stern of the vessel. Once the 100 m mooring wire was fully payed out it was connected to the bottom flotation packages where the second pick would occur. A securing rope was attached to an eye-bolt on the deck to prevent the mooring being dragged off the stern. The ultradeep AMAR BUB, which was connected to the mooring cable, was lifted from the deck using a Sea-Catch® quick release and over the stern using the secondary starboard winch, block, and A-Frame. The anchor, which was initially secured to an eye-bolt on the deck to prevent it being dragged off the stern, was lifted using the same method noted above. Despite the heavy sea state, deployment went smoothly and exactly as planned during the morning toolbox talk. This mooring deployment required the safety rails to be down and therefore a fall restraint harness was worn by the mooring technician.

4.5.3 Recoveries

Recovery operations typically prove to be more challenging than deployments, largely due to the maneuverability limitations of the vessel when positioning alongside the mooring. If great care is not taken, damage to the mooring or vessel can occur. Weather is also a contributing factor to the difficulty of the recovery. Of the 13 mooring recoveries, only one required the vessel to make a second attempt to recover due to adverse weather conditions. The other 12 moorings were successfully recovered on the first attempt.

Mooring recovery operations were all performed mid-ship on the starboard deck of the vessel. An extendable carbon fiber pole (loaned to DFO by NRCan) with a large heavy duty Sea-Catch® snap hook (WLL of 3.52 tons) was used to hook on to the moorings once the vessel was alongside. The snap hook was attached to a 16 foot long, one inch lifting strap which would then be attached to the winch. A 50 m lead line from the main aft mooring winch was brought through the A-frame and around the starboard side of the vessel to the mid-ship recovery area. This lead line was fed through a block on the port articulating knuckle crane that had the ability to move in various positions to ensure optimal wire angle from the block.

Mooring design, particularly their overall length was a determining factor in where the moorings were landed on deck. The shorter ultradeep AMAR's composed of four pairs of BUB's and a dual acoustic release were recovered in a single lift using a winch on the CTD P-Frame at the mid-ship location on the starboard deck. These moorings were all less than 8 m in length at the surface and were shorter when brought on board after being hooked in the middle and 'folded' in half when lifted out of the water.

Moorings with 20 m or more of wire between top and bottom packages required two lifts to recover, an activity which took place at the stern of the vessel. The winch, block, and crane was used to bring the first package on deck where the mooring wire was stopped off with a wire stopper. The wire was disconnected from the top package and re-connected to the winch line. Once tension was taken by the main mooring winch the wire stopper was released the crane and block lifted the second section up and on to the deck.

4.5.4 Challenges

The mooring recovery operation at station MGL ('Mid-Gully', Event 122) in The Gully MPA was the most challenging recovery of the mission. The bathymetry of The Gully proved to be problematic for acoustics when attempting to communicate with the mooring's dual acoustic releases. The vessel moved to several different positions around the mooring, all of which did not improve acoustics and communication. After 55 minutes, communications were finally established, and a release command was sent to initiate recovery before fading daylight. Heavy seas of 2.5 m to 3 m swells caused the vessel and the mooring to have a lot of motion on the surface, which also made recovery challenging. Once the Stablemoor buoy was out of the water, its large size and weight of 1170 lb (531 kg) swung forcefully in the high waves and vessel motion and required multiple tag lines to safely land it in its cradle. Landing this mooring in its cradle also proved difficult in the increased sea and wind state and took several attempts before it was successfully landed. This mooring used 44 m of faired Kevlar rope which prevented the use of the wire stopper and required a loop to be

tied in the Kevlar line to secure it before disconnecting from the Stablemoor. Holding the line to tie a loop with three C2 SUBS and a dual acoustic release dragging in the water also added to the challenges of this recovery.

The mooring deployed at station CSW ('Cabot Strait West', Event 152) experienced a critical instrumentation failure after deployment which resulted in a unexpected release of the mooring anchor. The R2K acoustic release experienced water ingress, which caused electrical shorting on the end-cap's motor board. This caused the release cam motor to begin spinning endlessly and disengage the locking mechanism, releasing the mooring assembly. This happened almost immediately after deployment, and consequently it is likely the mooring did not reach the seabed at 120 m depth before rising to the surface. After the flotation was noticed on the surface, the mooring was then recovered and serviced before re-deploying. During the recovery, the hydrophone mounting pole broke after the mooring was knocked along the side of the vessel and needed to be replaced. Normally, this design of mooring would be recovered with the P-frame at the mid-ship location. However, given a new train wheel/anchor was required for re-deployment, which was stored at the stern of the vessel, recovery was conducted at the stern. As spare acoustic releases were not available, a battery from a recently recovered R2K with 71% battery life was used as the replacement. These R2K acoustic releases have a 4 year deployment capability, which allows for deployment for a second year without servicing or battery replacement. A spare anchor was used for the re-deployment.

Station ECD ('Eastern Canyons Deep'; Event 127) was a new mooring station selected as part of a collaboration between DFO's Cetacean Research and Monitoring group and NRCan in support of monitoring cetacean presence at a deep location (~4100 m) in the Eastern Canyons Conservation Area. Once the mooring was released, its descent was tracked with constant ranging pings at 10 second intervals to get an estimate of its rate of descent. It was calculated to descent at a rate of approximately 70 m/minute which resulted in a 58 minute descent time. As the mooring's descent was tracked, the vessel held position using DP. The noise and cavitation bubbles from the azimuth thrusters while holding DP interfered with the response pings from the acoustic release, and long pauses occurred between successful ranges. Even with the drop keel lowered, the response frequency did not improve. Confirmation of the mooring on bottom was never completed after attempting for 79 minutes, and the vessel was directed to leave the area.

It is common practice to conduct an acoustic positioning survey on moorings deployed in depths greater than 1000 m to get a more accurate position of the mooring once it reaches the seabed. To complete an acoustic positioning survey of a mooring, the vessel typically travels at a speed of 3 knots around the release location in a circle, while taking constant slant ranges. These slant ranges and the GPS feed are combined by the Benthos deck unit to generate an accurate on-bottom position. Normally, only a half-circle around a mooring is required for the deck unit to generate a survey position with low error. However, the survey position at station ECD took more than a full circle around the mooring release position and resulted in seemingly erroneous coordinates. The calculated mooring position was over 2 nautical miles from its release location and the calculated depth was 247 m, compared to true depth of ~ 4104 m. Due to the amount of time it took to complete this survey and the communication issues experienced, a second survey was not attempted. Upon recovery of this mooring in 2025, it is recommended to re-attempt a position survey at this mooring station.

All moorings deployed during the DY18402 mission were prone to spinning upon lifting for

deployment. This often caused the quick release line to become wrapped around the mooring as much as four or five times. The cause of this was possibly increase cable torsion due to the de-spooling of the winch wire. For most deployments, it was necessary to position the mooring close to the stern on deck and throw the quick release line around the mooring to unwrap it while it was suspended. In the future, a mechanical swivel could be used between the winch wire and quick release to minimize spinning.

4.6 Video Plankton Recorder and Multinet Operations in Support of Whale Foraging Habitat Assessments

Data and samples characterizing the vertical distribution of *Calanus* spp. copepod abundance and environmental conditions (temperature, salinity, depth, fluorescence) were collected at pre-selected stations (see Table 8) in Roseway Basin, on the AZMP's Halifax and St. Anns Bank lines, and south of Cape Breton, NS, during the DY18402 mission. This work was in support of research on North Atlantic right whale (NARW) foraging habitat under DFO's Whales Initiative and Species at Risk programs, with the overall goal of identifying potential foraging habitat for NARW by quantifying variation in abundance and fine-scale vertical distribution of *Calanus* spp. copepods. Observations will be incorporated into statistical and numerical models of *Calanus* 3-D spatial distribution and dynamics.

Vertical profiles of *Calanus* spp. abundance in Roseway Basin were collected using a video plankton recorder (VPR). The VPR is an underwater video microscope system that takes images of plankton and particulate matter as small as 50 µm and up to a few centimeters in size. The VPR was deployed vertically in 'yo-yo' mode, which involved repeatedly lowering the system to within 10 m from bottom and raising it to 3 m below surface repeatedly for approximately 40 minutes. A winch speed of 30 m/min was used for both descent and ascent. Deployments were conducted using the Lebus deck winch and starboard-side pedestal crane on the RRS *Discovery*. Deployments were overseen by zooplankton specialists Kevin Sorochan and Rebecca Milne (both of DFO Maritimes Region).

The VPR data were supplemented with depth-stratified zooplankton samples collected using a Hydro-Bios MultiNet Type Midi multinet sampler system. The multinet system is a medium-sized sampler consisting of 5 nets with a 202 µm mesh size and a net opening of 0.25 m^2. The nets were closed at different depth intervals while the system is being towed from the near-bottom to surface. The system was deployed in 'live' mode using the CTD conducting cable and P-frame system at a speed of 0.5 m/s on the descent, and 0.8 m/s on the ascent. The depth intervals chosen for most stations were near-bottom to 100 m, 100 - 50 m, and 50 m to surface. Samples were preserved in 10% formalin upon recovery, and will be analyzed in the laboratory at a later date.

Both VPR and multinet were deployed at stations in the Roseway Basin critical habitat. However, only the multinet was deployed in Emerald Basin (station HL_03.3) due to poor weather conditions.

Table 8. Summary of video plankton recorder (VPR) and multinet deployments in Roseway Basin (station suffix RB), on the Browns Bank Line (BBL), Halifax Line (HL), St. Anns Bank (STAB), and at two additional stations (A2, A3) made during the DY18402 mission. VPR deployments do not have an associated Sample ID and the system was deployed to within 10 m from the seabed.

Station	Event	Date	Instrument	Start Lat. (DD)	Start Lon. (DD)	Sample ID	Depth Strata
BBL_02	20	2024-10-07	VPR	42.99994	-65.48412		
BBL_02	21	2024-10-07	MULTINET	43.00030	-65.48421	511889	112 - 50 m
BBL_02	21	2024-10-07	MULTINET	43.00030	-65.48421	511890	47 - 0 m
RB_E	81	2024-10-11	VPR	42.87819	-65.31411		
RB_E	82	2024-10-12	MULTINET	42.87732	-65.31417	512421	144 - 100 m
RB_E	82	2024-10-12	MULTINET	42.87732	-65.31417	512422	100 - 50 m
RB_E	82	2024-10-12	MULTINET	42.87732	-65.31417	512423	50 - 0 m
RB_D	83	2024-10-12	VPR	42.89982	-65.16504		
RB_D	84	2024-10-12	MULTINET	42.89987	-65.16488	512424	153 - 100 m
RB_D	84	2024-10-12	MULTINET	42.89987	-65.16488	512425	100 - 50 m
RB_D	84	2024-10-12	MULTINET	42.89987	-65.16488	512426	50 - 0 m
RB_C	85	2024-10-12	VPR	42.93618	-65.03283		
RB_C	86	2024-10-12	MULTINET	42.93619	-65.03281	512427	100 - 50 m
RB_C	86	2024-10-12	MULTINET	42.93619	-65.03281	512428	50 - 0 m
RB_B	87	2024-10-12	VPR	42.96299	-65.16476		
RB_B	88	2024-10-12	MULTINET	42.96305	-65.16471	512429	158 - 100 m
RB_B	88	2024-10-12	MULTINET	42.96305	-65.16471	512430	100 - 50 m
RB_B	88	2024-10-12	MULTINET	42.96305	-65.16471	512431	50 - 0 m
RB_A	89	2024-10-12	VPR	42.97818	-65.31416		
RB_A	90	2024-10-12	MULTINET	42.97818	-65.31407	512432	150 - 100 m
RB_A	90	2024-10-12	MULTINET	42.97818	-65.31407	512433	100 - 50 m
RB_A	90	2024-10-12	MULTINET	42.97818	-65.31407	512434	50 - 0 m
RB_01	91	2024-10-12	VPR	42.84975	-65.48142		
RB_01	92	2024-10-12	MULTINET	42.84903	-65.48149	512435	122 - 100 m
RB_01	92	2024-10-12	MULTINET	42.84903	-65.48149	512436	100 - 50 m
RB_01	92	2024-10-12	MULTINET	42.84903	-65.48149	512437	50 - 0 m
HL_03.3	101	2024-10-13	MULTINET	43.76355	-62.75200	512506	200 - 150 m
HL_03.3	101	2024-10-13	MULTINET	43.76355	-62.75200	512507	150 - 100 m
HL_03.3	101	2024-10-13	MULTINET	43.76355	-62.75200	512508	100 - 50 m

Table 8. *(continued)*

Station	Event	Date	Instrument	Start Lat. (DD)	Start Lon. (DD)	Sample ID	Depth Strata
HL_03.3	101	2024-10-13	MULTINET	43.76355	-62.75200	512509	50 - 25 m
HL_03.3	101	2024-10-13	MULTINET	43.76355	-62.75200	512510	25 - 0 m
STAB_04	183	2024-10-21	VPR	46.30000	-59.06447		
STAB_04	184	2024-10-21	MULTINET	46.29993	-59.06440	513067	144 - 100 m
STAB_04	184	2024-10-21	MULTINET	46.29993	-59.06440	513068	100 - 50 m
STAB_04	184	2024-10-21	MULTINET	46.29993	-59.06440	513069	50 - 0 m
STAB_03	188	2024-10-21	VPR	46.21650	-59.19464		
STAB_03	189	2024-10-21	MULTINET	46.21650	-59.19463	513087	86 - 50 m
STAB_03	189	2024-10-21	MULTINET	46.21650	-59.19463	513088	50 - 0 m
A2	196	2024-10-21	VPR	45.49985	-60.00011		
A2	197	2024-10-21	MULTINET	45.49981	-60.00013	513118	144 - 100 m
A2	197	2024-10-21	MULTINET	45.49981	-60.00013	513119	100 - 50 m
A2	197	2024-10-21	MULTINET	45.49981	-60.00013	513120	50 - 0 m
A3	198	2024-10-21	VPR	45.19998	-60.30003		
A3	199	2024-10-22	MULTINET	45.19986	-60.29997	513121	64 - 43 m
A3	199	2024-10-22	MULTINET	45.19986	-60.29997	513122	43 - 0 m

5 *In situ* Phytoplankton Monitoring

5.1 Imaging FlowCytobot

As part of a collaborative agreement with the Woods Hole Center for Oceans and Human Health (WHCOHH), an Imaging FlowCytobot (IFCB) was installed in the General Purpose (GP) Laboratory (Figure 7) and was operational for the duration of the DY18402 mission. This represents the third Maritimes Region AZMP mission in which this system was used to monitor phytoplankton communities across the Scotian Shelf and in the Gulf of Maine. The IFCB is designed to draw small seawater samples from its environment (or in this case, from the ship's science seawater system) every 23 minutes using a syringe pump, which then pushes a thin stream of the sampled water across a microscope objective. Cells and other particles are detected by an in-line laser immediately upstream of the objective. Detections trigger a precisely-timed flash lamp that illuminates the cell/particle just as it passes in front of the microscope objective. Images of cells are captured by a charged-coupled device (CCD) camera and stored in data files that are associated with each seawater sample. Raw data includes gray-scale images of each particle and associated measurements of laser scatter and fluorescence. This system requires a minimum flow rate of 2 L/min, and the total volume sampled is 25 mL per hour. The collected images are accessible via an in-house IFCB dashboard.

5.2 Environmental Sample Processor

An Environmental Sample Processor (ESP) owned by the WHOI was also installed in the GP Laboratory (Figure 7), and was used to collect and analyze *in situ* water samples for the presence of biotoxins and the phytoplankton species that produce them. The use of the ESP was considered a complimentary approach to the IFCB to detect the presence of domoic acid produced by *Pseudo-nitzschia* species. Preliminary results from the ESP showed that domoic acid was not detected in significant concentrations from any surface waters sampled during the DY18402 mission.

5.3 Microplankton Monitoring using FlowCAM

A Fluid Imaging Technologies 8000 series FlowCAM system was used on a trial basis during the DY18402 mission to evaluate its utility in monitoring microplankton communities *in situ* during AZMP surveys. This marked the first time this system was used on a Maritimes Region AZMP survey. The system was used to collect imagery of microplankton ranging in size from > 5 to < 80 μm from both discrete Niskin bottle samples and water samples collected from the outflow of the IFCB. The purpose of this was to compare whether the species being detected in both systems were comparable.

Prior to analysis using the FlowCAM, the water samples were concentrated by filtering approximately 1 L of water through 5 μm mesh, until less than 100 mL remained. The remaining water was then filtered through an 80 μm mesh to remove particles above this size. The associated VisualSpreadsheet v.6 was used to analyze and view the samples during ~ 6 minute runs. A 10X objective was used.

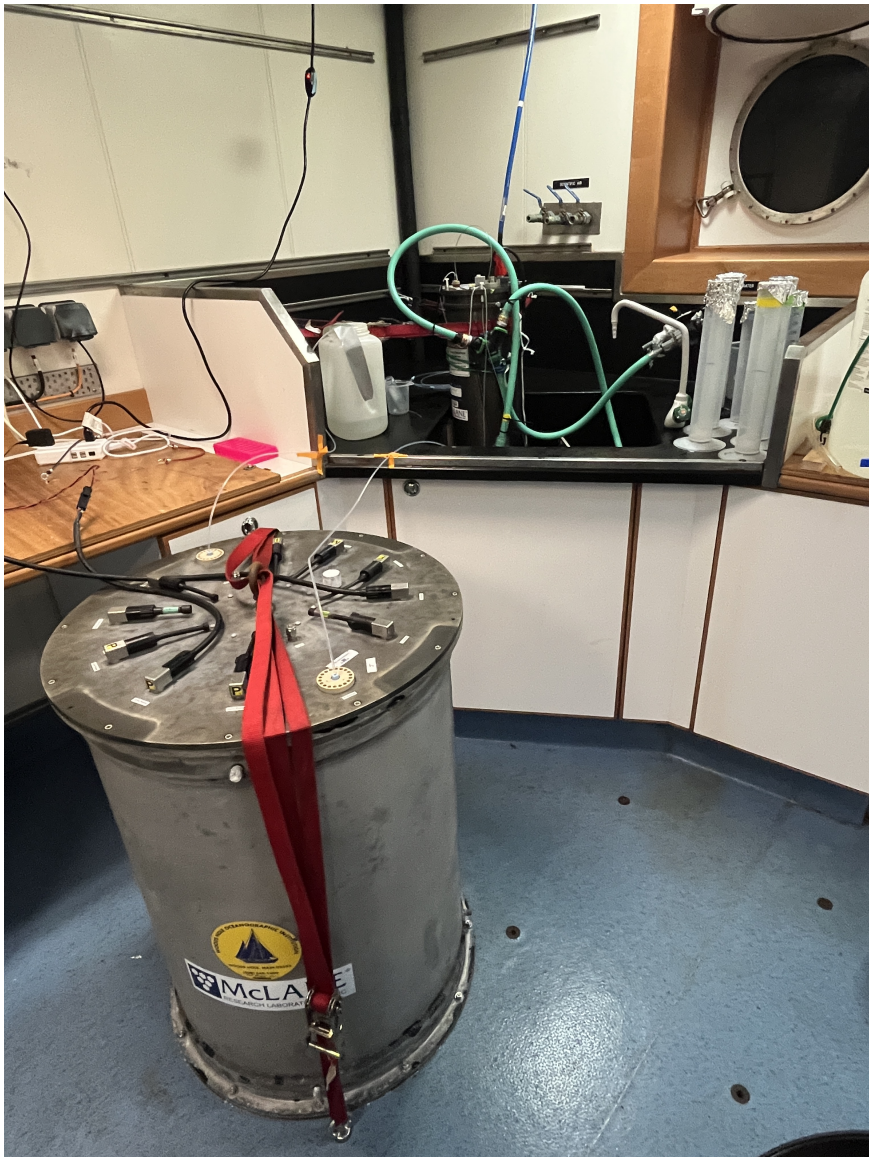

Figure 7. Imaging FlowCytobot (upper centre) and Environmental Sample Processor (lower left) installed in the General Purpose Laboratory on board the RRS *Discovery*. These systems were used to evaluate the presence and abundance of harmful algal bloom-forming phytoplankton species and their biotoxins from surface waters sampled during the DY18402 mission.

6 Marine Mammal Observations

Visual surveys were conducted throughout the DY18402 mission by a team of marine mammal observers (MMOs) stationed on the bridge. Two different types of visual survey effort were used depending on vessel speed, activity, and weather conditions. Full survey effort was used during transits occurring in daylight hours when vessel speed was greater than 5 knots, Beaufort Sea State less than 6, and visibility greater than 1 km. This effort consisted of 2-3 MMOs on duty, with one MMO stationed on port and one on starboard. When a third MMO was on duty, they were designated as the data recorder and also aided in scanning from either side of the bridge. MMOs scanned from 0 degrees (relative to ship's heading) to 90 degrees on their respective sides of the vessel, using naked eye and handheld binoculars. Effort was reduced to "limited/opportunistic" effort whenever environmental conditions deteriorated beyond the conditions listed above, or when the vessel speed was less than 3 knots, including during all CTD and mooring station operations. This type of effort consisted of 1-2 MMOs on duty, one stationed on the port side of the bridge, and one on the starboard side of the bridge, each recording their own data. In the event where only one MMO was on duty, they were stationed on starboard side and scanned from 0 to 90 degrees. During both types of survey effort, off-duty science staff and ship's crew often assisted voluntarily, and all sightings were recorded, regardless of whether they were initially seen by the on-duty MMOs or others.

Marine mammal sightings data were recorded on both a laptop computer and a Windows tablet using a custom-written MATLAB-based data entry program developed by H. Whitehead of Dalhousie University, and customized by J. Stanistreet and W. Beslin prior to the mission. Information collected for each sighting included the following: 1) Date and time, in UTC; 2) latitude and longitude of the vessel, obtained from a USB GPS unit connected to the laptop or a Bluetooth GPS connected to the tablet; 3) estimated bearing to sighting relative to the ship's current heading; 4) approximate distance to sighting, estimated using range sticks when a clear horizon was visible; 5) species identification and species ID certainty (definite, probable, or possible); 6) minimum, maximum, and best estimate of group size; 7) number of calves or juveniles present; 8) animal behaviour, if known; 9) camera frame numbers corresponding to any photographs taken; 10) additional comments about the sighting; and 11) the name of the MMO who initially saw the animal. Information on survey effort was recorded anytime the survey effort changed, either due to change in MMOs on duty or a change in vessel activity. Environmental conditions were recorded every 30 minutes and whenever there was a notable change in environmental conditions.

Surveys were conducted throughout daylight hours on 18 days (October 4 - 21) during the DY18402 mission. In total, there were 106 hours of full survey effort which occurred while transiting between CTD and mooring stations, and 65.5 hours of limited/opportunistic effort which occurred during CTD and mooring station operations and poor weather conditions. Weather was variable throughout the trip, and sea state was a limiting factor on several days, where a Beaufort sea state of greater than 5 limited sighting probability.

There were 135 unique sightings of cetaceans, turtles, sharks, and other fish recorded during the cruise (Table 9, figures 8 through 11). Ten different cetacean species were identified, along with many sightings of unidentified whales and dolphins. Humpback whales were the most commonly encountered baleen whale species, with 21 confirmed sightings. Among odontocetes, common dolphins and pilot whales were the most commonly encountered species. Non-cetacean sightings

included ocean sunfish, leatherback turtle, and unidentified sharks, fish, and turtles. There were several sightings of species at risk, including northern bottlenose whales (2 confirmed sightings), fin whales (5 confirmed sightings), and leatherback turtle (1 confirmed sighting). No NARW were sighted. Additionally, there were 32 records of marine debris collected throughout the cruise, which included plastic (sheet, bag, containers, ball), free-floating fishing gear, containers (i.e. rain barrel, milk carton), a balloon, and one unidentifiable piece of debris (Figure 12).

All survey data including effort, environmental conditions, sightings, and photographs will be archived and maintained by Team Whale. Information on marine mammal sightings will additionally be entered in the Whale Sightings Database maintained by DFO Maritimes.

Table 9. Summary of cetacean, turtle, and fish sightings. The number of distinct sightings at each species ID certainty level is provided (note that the number of individuals in each sighting is not shown here).

		Number of Sightings		
Species	**Scientific Name**	**Definite**	**Probable**	**Possible**
Common dolphin	*Delphinus delphis*	18	0	0
Fin whale	*Balaenoptera physalis*	5	0	0
Fin/sei whale	*Balaenoptera physalis/B. borealis*	7	1	0
Humpback whale	*Megaptera novaeangliae*	21	3	0
Killer whale	*Orcinus orca*	1	0	0
Minke whale	*Balaenoptera acutorostrata*	1	0	0
Northern bottlenose whale	*Hyperoodon ampullatus*	2	0	0
Pilot whale	*Globicephala melas*	9	1	0
Risso's dolphin	*Grampus griseus*	1	0	0
Sperm whale	*Physeter macrocephalus*	1	0	0
Leatherback turtle	*Dermochelys coriacea*	1	0	0
Ocean sunfish	*Mola mola*	4	0	0
Unidentified beaked whale		1	0	0
Unidentified dolphin		4	0	0
Unidentified fish		1	0	0
Unidentified shark		2	0	0
Unidentified turtle		1	0	0
Unidentified whale		49	0	0
Total sightings =135				

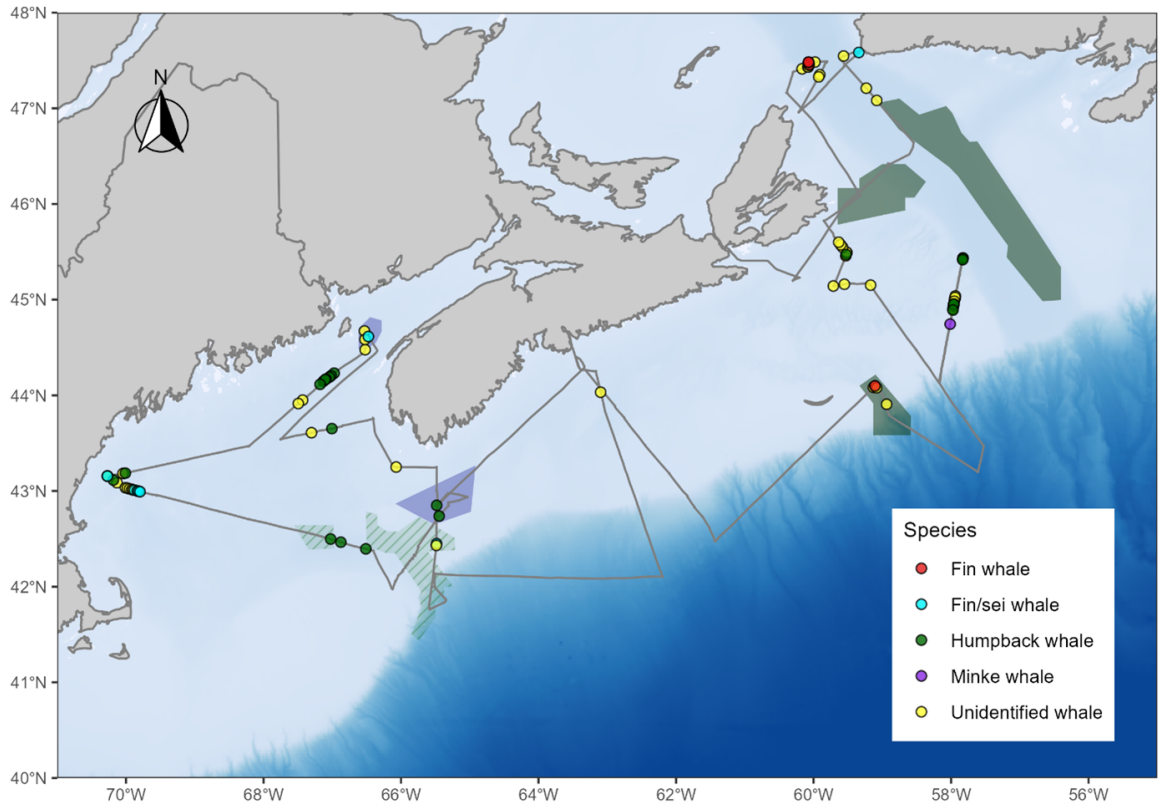

Figure 8. Ship track and locations of baleen whale sightings (including those with definite, probable, and possible species IDs and unidentified whales) made during the DY18402 mission.

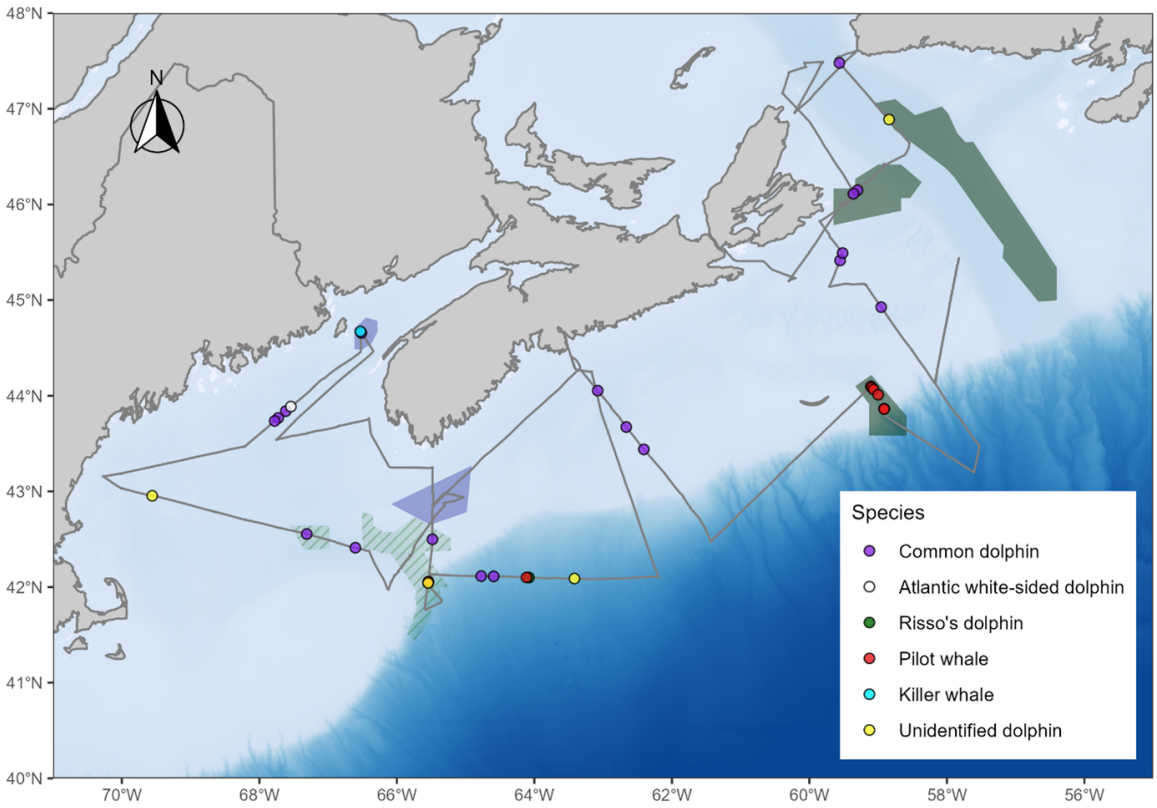

Figure 9. Ship track and locations of dolphin, pilot whale, and killer whale sightings (including those with definite, probable, and possible species IDs and unidentified dolphins) made during the DY18402 mission.

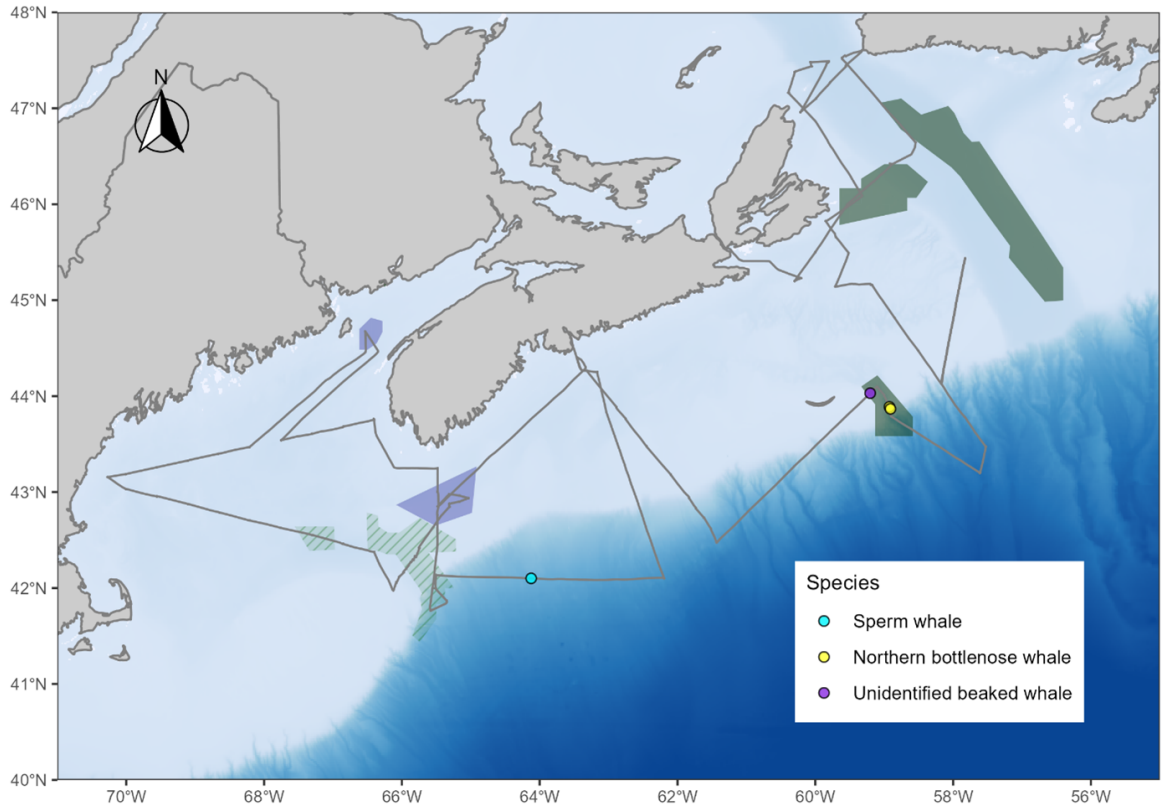

Figure 10. Ship track and locations of beaked and sperm whale sightings (including those with definite, probable, and possible species IDs and unidentified beaked whales) made during the DY18402 mission.

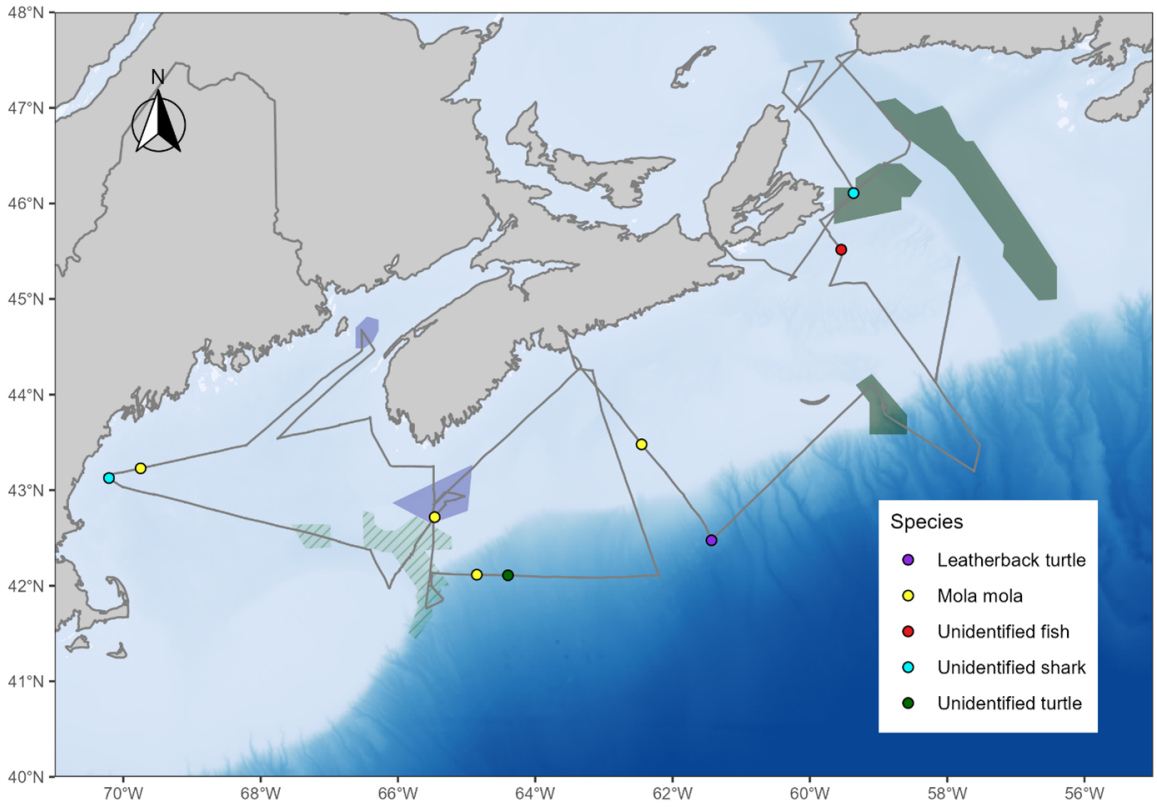

Figure 11. Ship track and locations of turtle, shark, and other fish sightings (including those with definite, probable, and possible species IDs and unidentified fish, sharks, and turtles) made during the DY18402 mission.

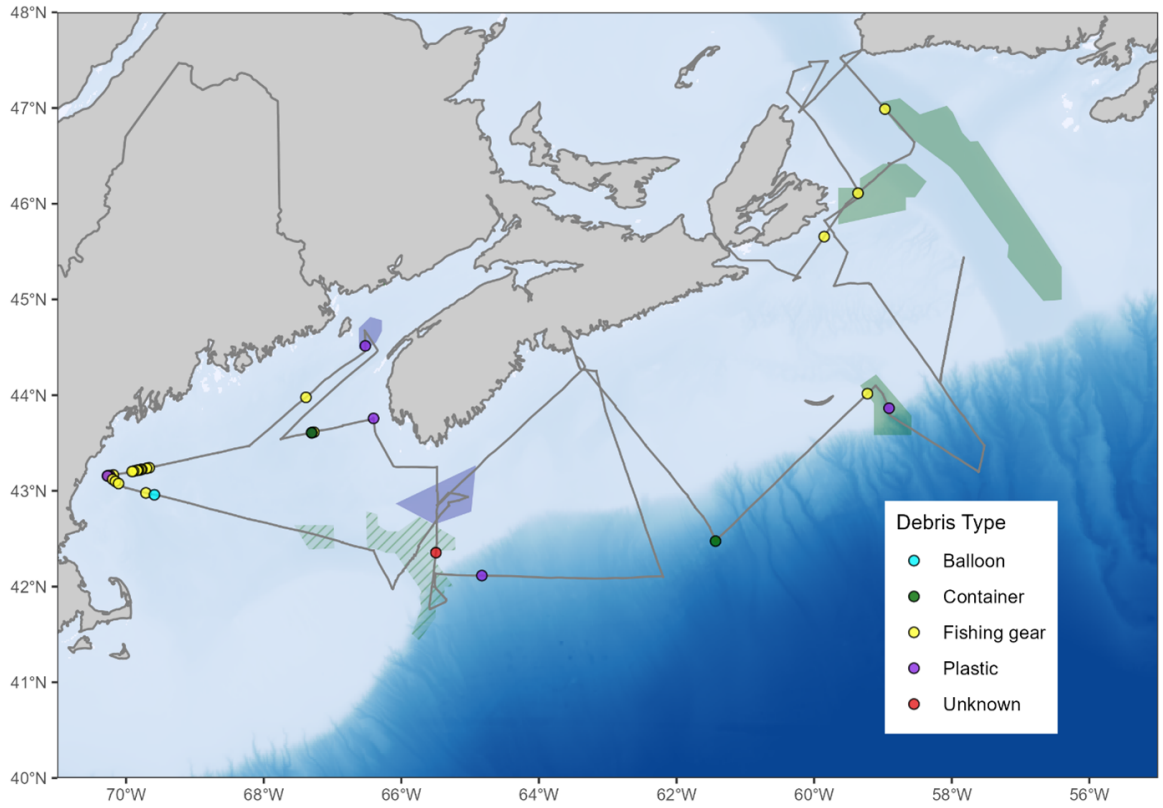

Figure 12. Ship track and locations of all marine debris sightings made during the DY18402 mission.

7 Seabird Observations

7.1 Background

The east coast of Canada supports millions of breeding marine birds as well as migrants from the southern hemisphere and the eastern North 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 various industries and DFO to support offshore seabird observers have been established, and over 300,000 km of ocean track have been surveyed by CWS-trained observers. These data are now being used to quantify seabird abundance and distribution at sea and identify and mitigate any threats. In addition, data are collected on marine mammals, sea turtles, sharks, and other marine organisms when they are encountered.

7.2 Methods

Seabird surveys were conducted from the port side of the bridge of the RRS *Discovery* during the DY18402 mission from 4 – 21 October 2024. 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 300 m-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 (Gjerdrum et al. (2012)).

7.3 Results

A total of 1610.9 km of ocean was surveyed over 18 days of the mission. A total of 1291 marine birds were observed in transect (1950 in total) from 8 families (Table 10).

Table 10. List of marine bird species observed during visual surveys conducted during the 2024 fall AZMP survey from October 4 to 21, 2024.

Family	Common Name	Latin	Total No.	No. Observed in Transect
Procellariidae	Northern Fulmar	*Fulmarus glacialis*	196	145

Table 10. *(continued)*

Family	Common Name	Latin	Total No.	No. Observed in Transect
	Great Shearwater	*Ardenna gravis*	359	272
	Sooty Shearwater	*Ardenna griseus*	4	3
	Cory's Shearwater	*Calonectris borealis*	5	3
	Unidentified shearwater	*Puffinus or Calonectris*	7	4
Hydrobatidae	Leach's Storm-Petrel	*Oceanodroma leucorhoa*	5	3
	Wilson's Storm-Petrel	*Oceanites oceanicus*	18	13
	Unidentified Storm-Petrel	*Hydrobatidae*	3	2
Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*	2	1
Sulidae	Northern Gannet	*Morus bassanus*	116	61
Anatidae	Surf Scoter	*Melanitta perspicillata*	1	1
	White-winged Scoter	*Melanitta fusca*	6	1
	Unidentified Scoter	*Melanitta*	28	0
	Unidentified Goose	*Anatidae*	70	0
	Unidentified Ducks	*All duck genera*	3	0
Scolopacidae	Red Phalarope	*Phalaropus fulicaria*	5	5
	Red-necked Phalarope	*Phalaropus lobatus*	28	28
	Unidentified phalarope	*Phalaropus*	516	318
Laridae	South Polar Skua	*Stercorarius maccormicki*	2	2
	Unidentified Skua	*Stercorarius*	5	3
	Pomarine Jaeger	*Stercorarius pomarinus*	3	1
	Parasitic Jaeger	*Stercorarius parasiticus*	6	4
	Unidentified Jaegers	*Stercorarius Jaegers*	13	7
	Black-legged Kittiwake	*Rissa tridactyla*	193	170
	Herring Gull	*Larus argentatus*	147	110
	Great Black-backed Gull	*Larus marinus*	53	34
	Ring-billed Gull	*Larus delawarensis*	4	2
	Unidentified Gull	*Larus*	14	12
	Unidentified Tern	*Sterna*	5	5
Alcidae	Common Murre	*Uria aalge*	3	2
	Unidentified Murres	*Uria*	2	0
	Razorbill	*Alca torda*	5	5
	Atlantic Puffin	*Fratercula arctica*	51	28
	Dovekie	*Alle alle*	68	42
	Unidentified Auks	*Alcidae*	4	4
Total			1950	1291

8 Data Management Summary

8.1 Data Collection and Archival

The suite of digital data collected during the DY18402 mission included CTD sensor data (raw and processed .ODF files), continuous recordings of surface T/S, pH, and CDOM and chlorophyll fluorescence by the underway system, CTD data collected during multinet deployments, data collected by ship's systems, including multibeam and vessel-mounted ADCP data, digital filter logs that denote all water samples collected and their associated sample ID, on-board analysis of water samples collected at standard depths for salts, oxygen and chlorophyll, and NMEA GIS data. Hard-copy paper logs included CTD 'deck' sheets, ring net, multinet, mooring logs, Argo float deployment logs, a chlorophyll laboratory logbook and log for samples collected from the underway system. All hard-copy logsheets were scanned upon conclusion of the mission.

The program Robocopy, a Windows DOS utility, was deployed by mission data manager Patrick Upson to copy directories and files to back up drives to provide redundancy of the collected data. The utility has functionality to copy only new and changed files from large directories of files and provide metrics on what files have changed and subsequently copied, or were skipped. Robocopy is useful for creating scripts to move data to and from network drives to avoid long copy times when new or changed files are mixed in with large numbers of unchanged files that do not need to be copied.

Upon return from the mission, all digital data collected on the mission and scanned logsheets were sent to the BIO Data Services for upload and archival into their protected server. For access to these data, please contact DFO.BIODataServices-BIOServicesdeDonnees.MPO@dfo-mpo.gc.ca.

8.2 ELOG

ELOG is a freely-available electronic logging application used to record event data for the mission. The recording of metadata in ELOG facilitates the upload of discrete and plankton data to the BioChem national repository. The ELOG server ran on a field laptop in the General Purpose (GP) Laboratory and was made accessible by IP address over the vessel's network. Several PCs and mobile devices were installed around the vessel and were used to access the server using HTTP. On the DY18402 mission, the ELOG configuration, deployment and backup was managed using Git, with the repository stored on GitHub. This not only allowed for the quick deployment of ELOG configuration files to any machine with ELOG and Git installed, but also allowed for changes to the configuration files and logbooks to be tracked (with or without an internet connection) and backed up to an off-site location, provided an internet connection was available. If no internet connection is available, local git tracking still works and can then be pushed up to GitHub when the connection does become available.

8.3 DFO At-sea Reporting Template (DART)

The in-house DFO At-sea Reporting Template DART was used to compile and reformat all discrete data collected and analyzed at sea (dissolved oxygen, chlorophyll, and salinity measurements) to facilitate upload to BioChem. This process involved loading the .log files and their associated event metadata into DART, the CTD bottle (.btl) files containing the 6-digit sample IDs, and the discrete bottle measurements. DART was also used to produce 'bottle reports', which contain the sensor values at the time each bottle was fired closed in the rosette, and links these values to the corresponding laboratory measurements. These reports help facilitate the quality control of both sensor and bottle measurements while at sea.

9 Operational Considerations and Issues of Note

This section contains a brief summary of the various operational considerations or issues encountered with science equipment and/or data and sample post-processing during the DY18402 mission. This information should help to guide both CTD and laboratory post-processing procedures, and future interpretation of the data collected on the mission.

9.1 CTD Operations

1. During CTD operations where the CTD-Rosette was brought into the hangar for sampling, extra bottles were fired to balance the rosette if the number of planned bottles was less than 12. Once fired, the additional sample IDs were removed from the .bl file produced by SeaSave. However, an unedited version of the raw CTD data was kept and is stored in a folder titled 'CTD RAW DATA' in the ODIS server.
2. During the mission, .SN files were generated for each CTD cast during post-processing using CTDDAP. This is the first time .SN files were generated on an AZMP mission. This process appends the 6-digit sample ID to each bottle fire, and helps facilitate the post-processing of data when bottles are fired out of sequence. This task should be added to the data management workflow of future AZMP missions.
3. On the CTD upcast of Event 006, bottles were fired out of sequence. Bottle 24 with ID 511814 at 150 m after Bottle 8. In this case, the .SN file was modified to add Bottle 24 between Bottles 8 and 9. Similarly, on Event 143, Bottles 7, 14, and 15 were fired at the wrong depths. To remedy this, Bottles 7 & 14 from the .bl file were removed, and the sample ID for Bottle 8 and Bottle 15 were changed to 512846 and 512847 in the .SN file, and prior to final post-processing.
4. After post-processing of the CTD cast data collected on the mission, the T-S diagrams showed an abnormal amount of noise. Upon further inspection and consultation, an error was discovered in the setting for the temperature variable in the AlignCTD module of CTDDAP. This error was corrected and the data reprocessed, which significantly improved the results. T-S diagrams should be included as part of the review of CTD data collected on future missions.

9.2 Ring Net Operations

1. The ring net tow conducted on station LL_09 is not considered to be representative after the net ripped upon recovery. Results from this sample should be interpreted with caution.

9.3 Mooring Operations

1. The mooring initially deployed at station CSW ('Cabot Strait West', Event 152) experienced a critical instrumentation failure after deployment which resulted in an un-commanded release

of the mooring assembly from its anchor. Upon review after recovery, the R2K acoustic release was found to have experienced water ingression, which caused electrical shorting on the end-cap's motor board, resulting in the release cam motor to spin endlessly and disengage the locking mechanism.

9.4 Underway System

1. The Aanderaa optode (dissolved oxygen sensor) installed in the underway system produced erroneous measurements throughout the mission. As no spare was available to replace this sensor, it was left installed in the underway system. However, the data should not be used for analytical purposes.

10 Acknowledgements

We would like to thank all science staff of the DY18402 mission for their dedication and hard work to make the mission a success. We also thank Commanding Officer Antonio Gatti, as well as the officers, crew, and National Marine Facilities technicians of the RRS *Discovery* for their dedication and support during the mission.

We thank Jay Barthelotte, Regional Vessel Coordinator, DFO Maritimes Region, for coordinating the logistics of the vessel's scheduling and arrival. We would like to thank Jason Green, Chris Beck, Mike Vining, and Jennifer Field (Ocean Engineering and Technology Section, DFO) for their assistance in the mobilization and demobilization of the science equipment used on the mission. We thank Alice Ortmann (DFO Ocean and Ecosystem Sciences Division, OESD) for providing use of the FlowCAM on the mission, as well as Dennis McGillicuddy and Mike Brosnahan (WHOI) for facilitating the installation of the IFCB and ESP systems.

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APPENDIX A Evaluation of Sensor Data against Bottle Measurements

This appendix contains plots of dissolved oxygen and salinity sensor data against their corresponding Winkler and salinometer measurements, respectively. These plots were generated almost daily throughout the mission and used as a tool to A) monitor the relationship between the oxygen and conductivity sensor data and their corresponding laboratory measurements as a means of validating the sensor outputs, and B) evaluate the laboratory measurements for visual outliers.

Plots were generated for each CTD cast using R scripts applied to the 'bottle reports' created using the DART application (see the Data Management section above for more details). The bottle reports contain only the sensor values associated with each bottle closure. Therefore, the plots in this appendix do not portray the full vertical resolution of the profile data. Note that replicate bottle samples are not collected for salinity, but are collected for dissolved oxygen at predetermined depths.

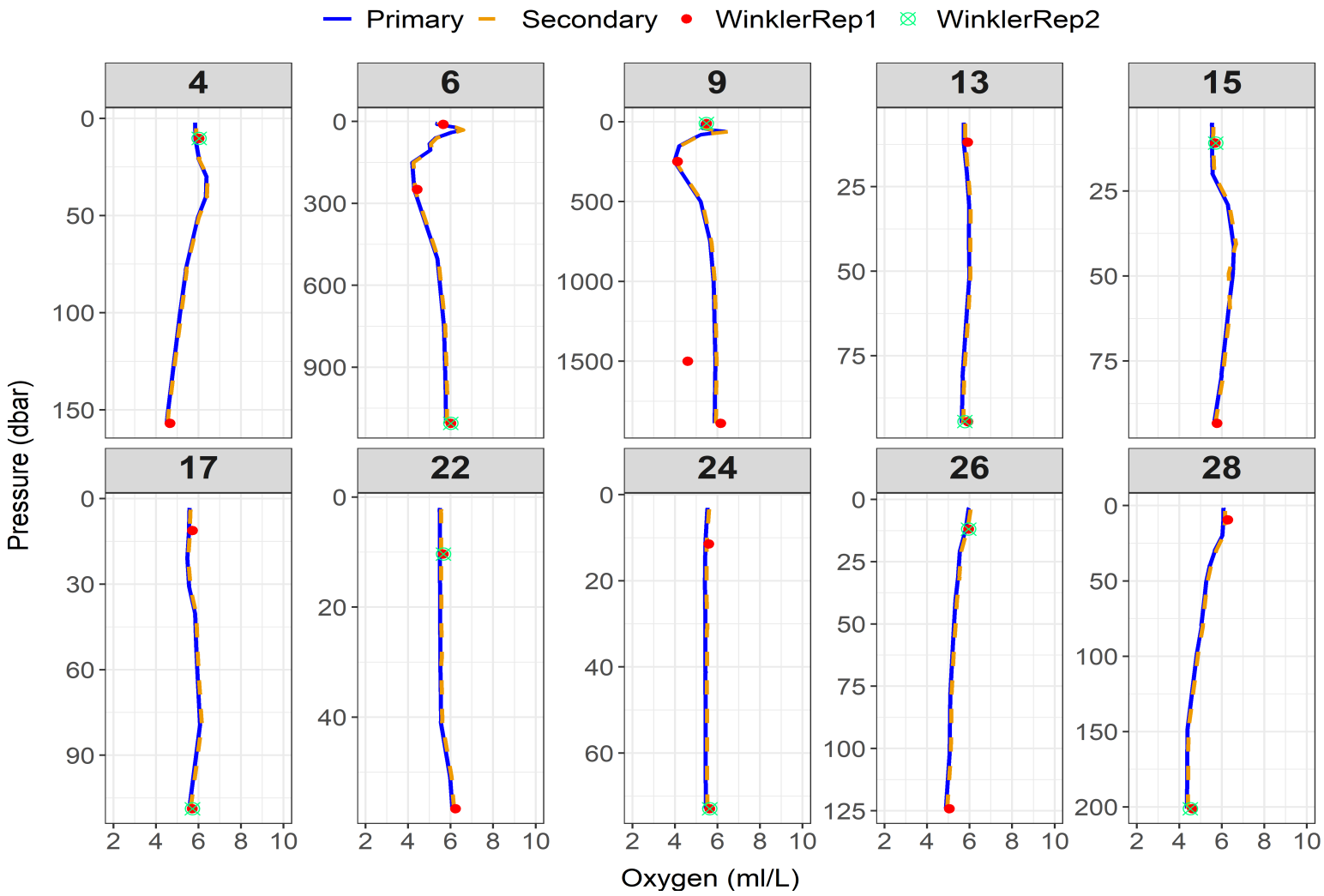

Figure A.1. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 4 to 28. Note the variable range in the y-axis.

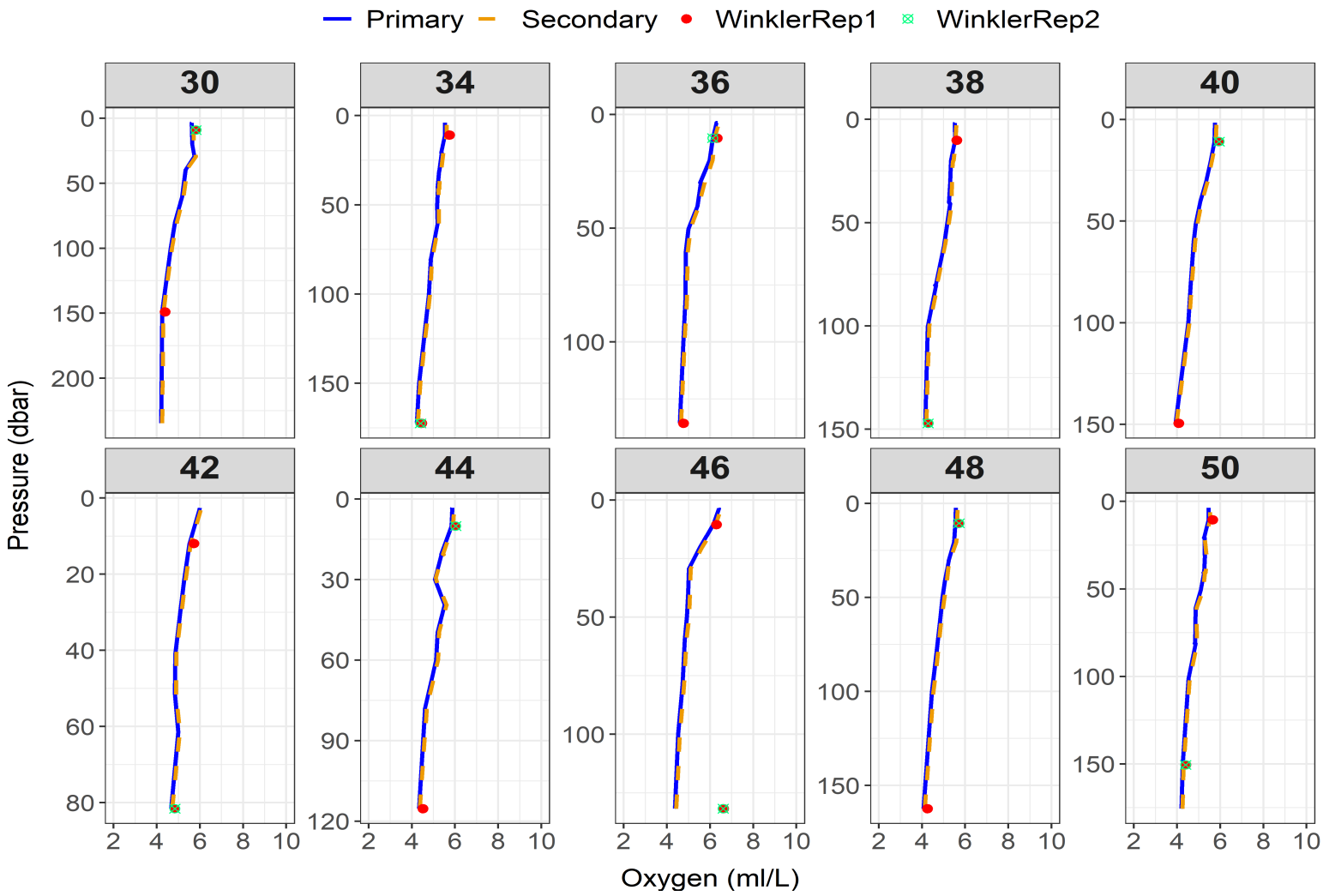

Figure A.2. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 30 to 50. Note the variable range in the y-axis.

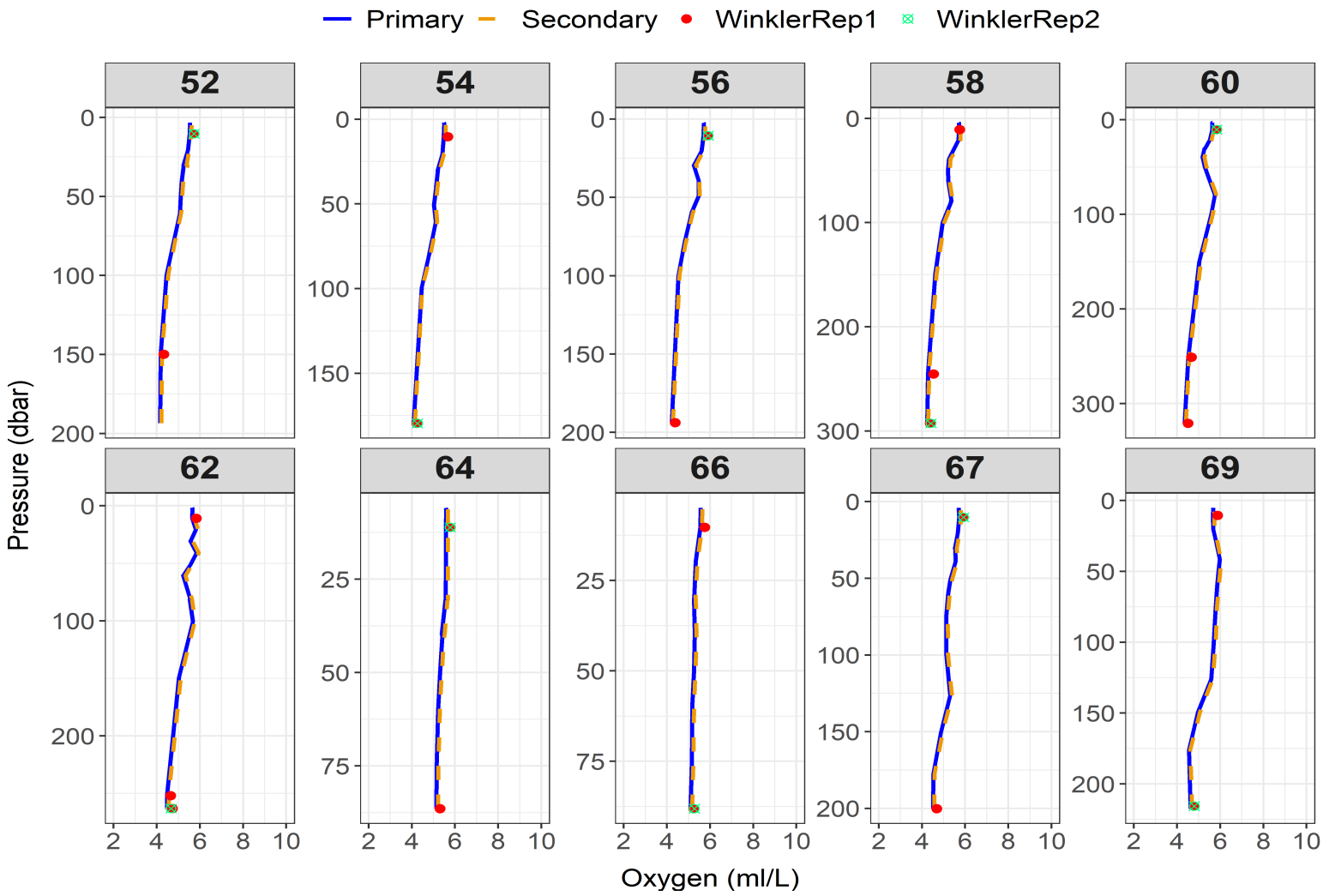

Figure A.3. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 52 to 69. Note the variable range in the y-axis.

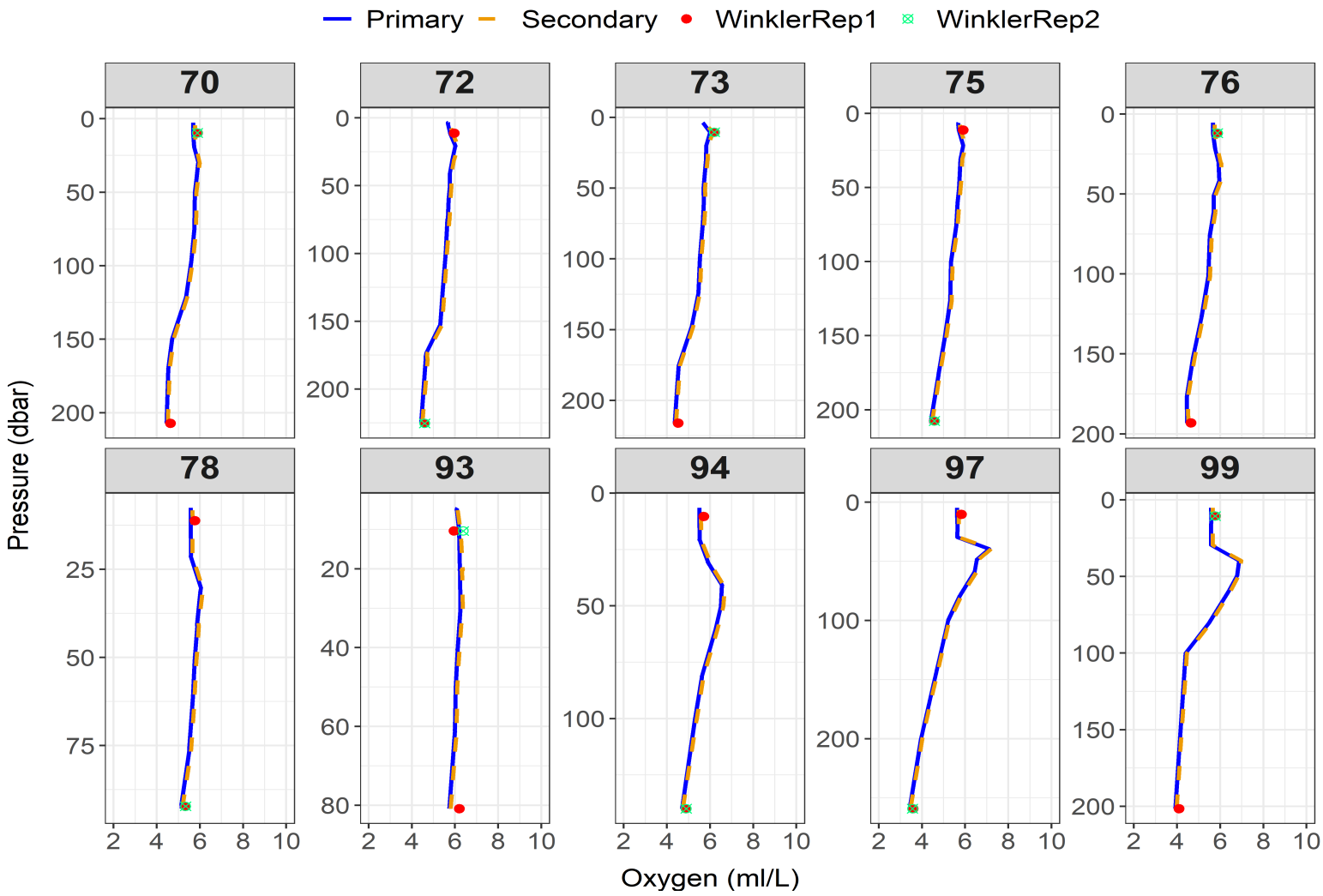

Figure A.4. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 70 to 99. Note the variable range in the y-axis.

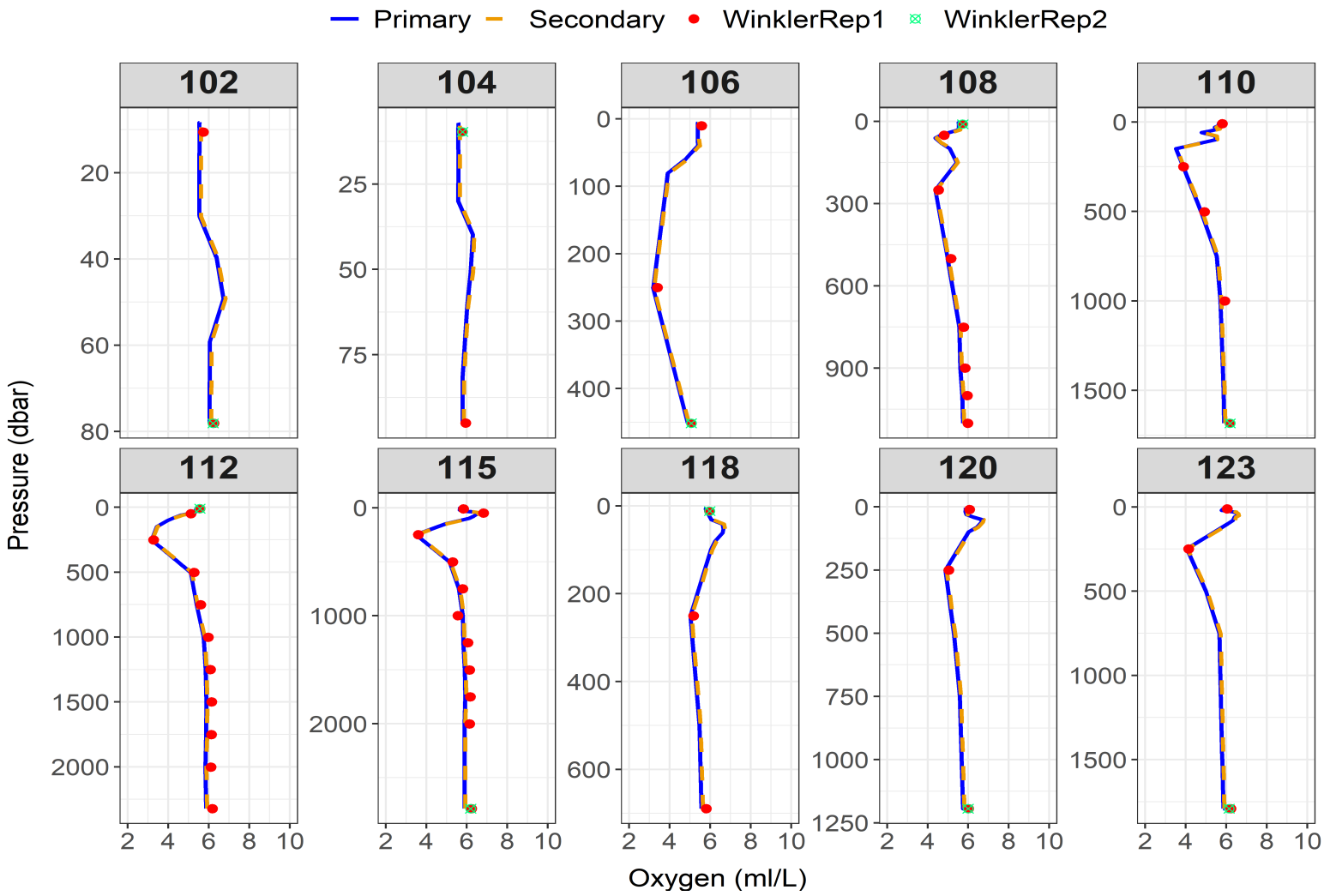

Figure A.5. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 102 to 123. Note the variable range in the y-axis.

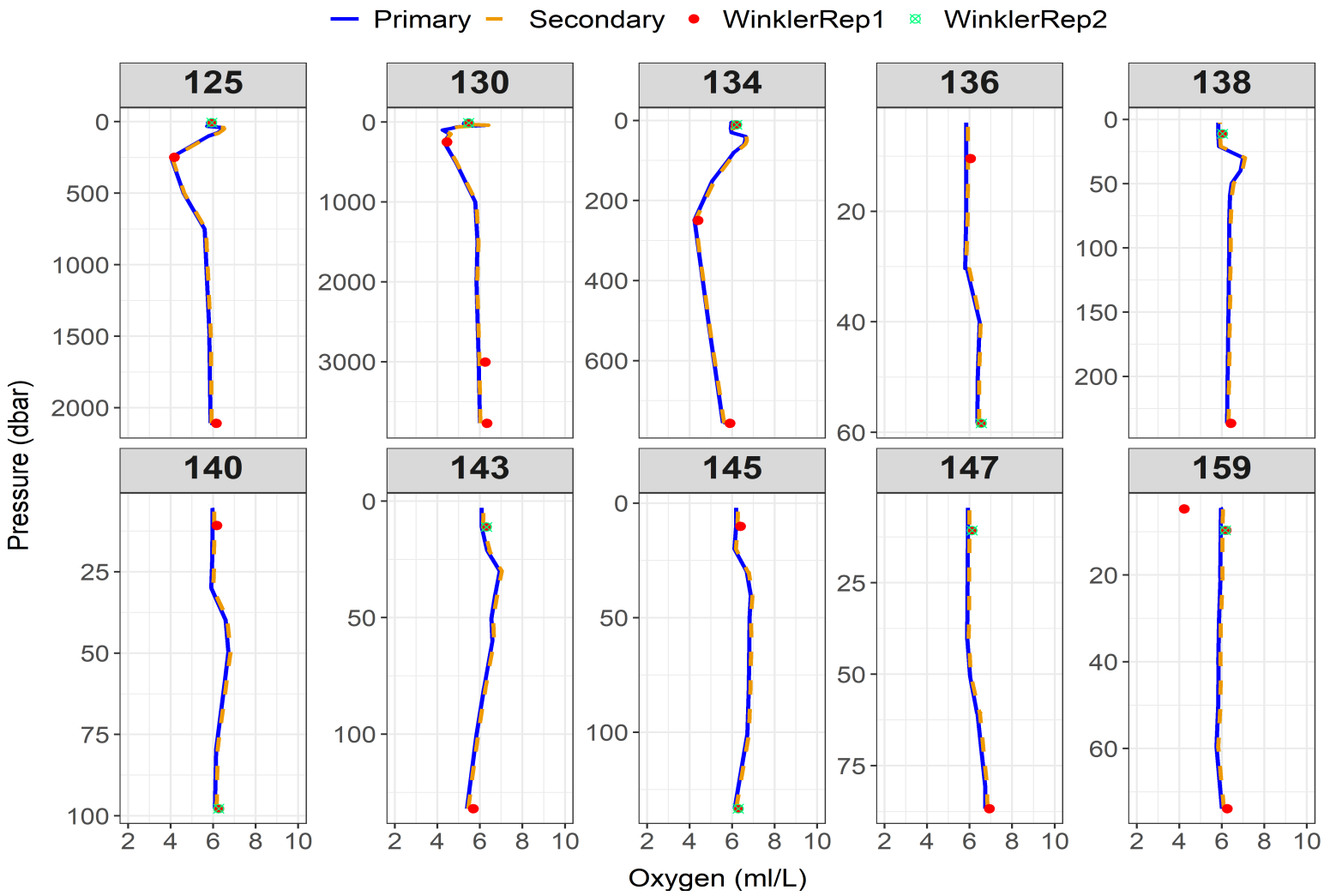

Figure A.6. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 125 to 159. Note the variable range in the y-axis.

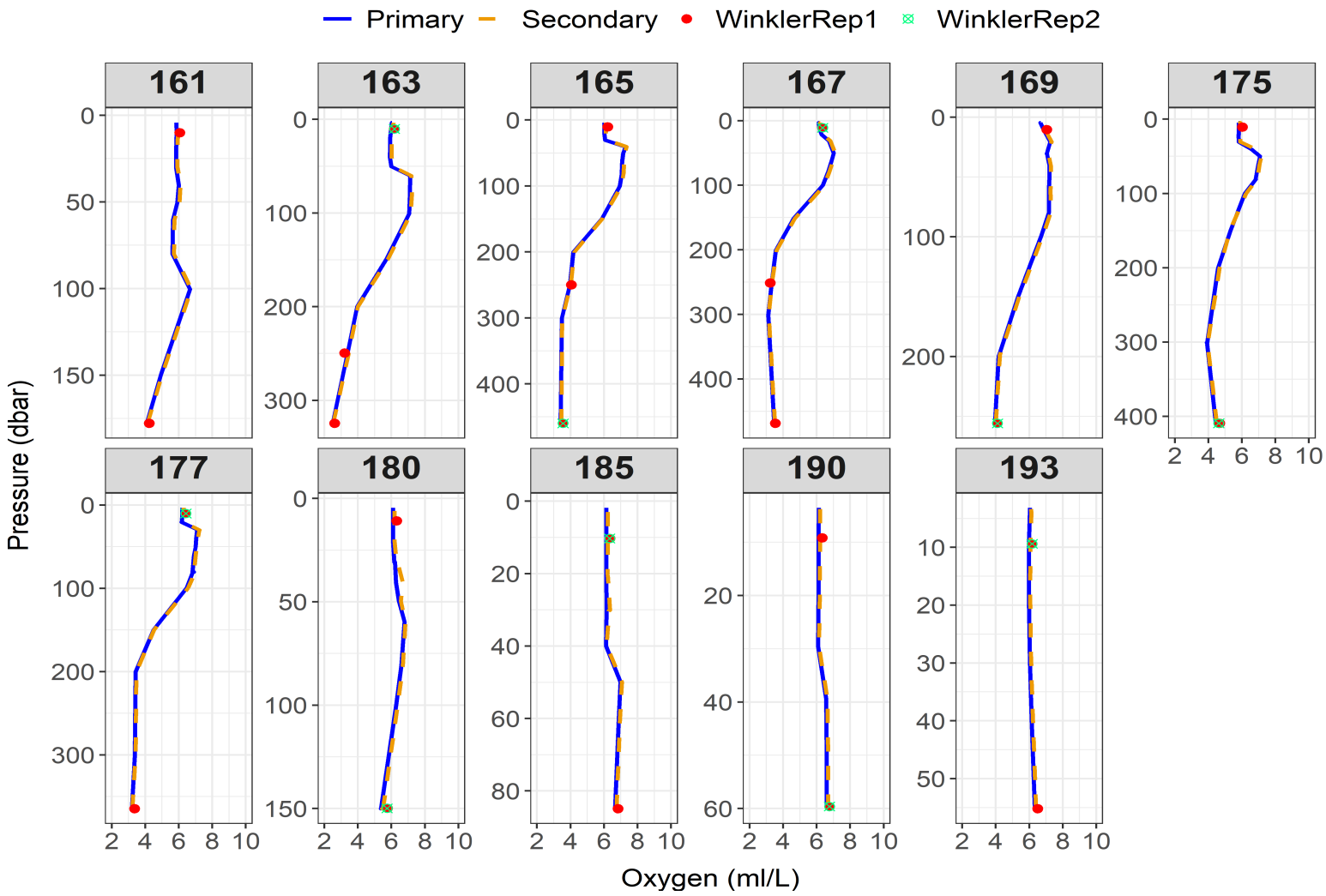

Figure A.7. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 161 to 193. Note the variable range in the y-axis.

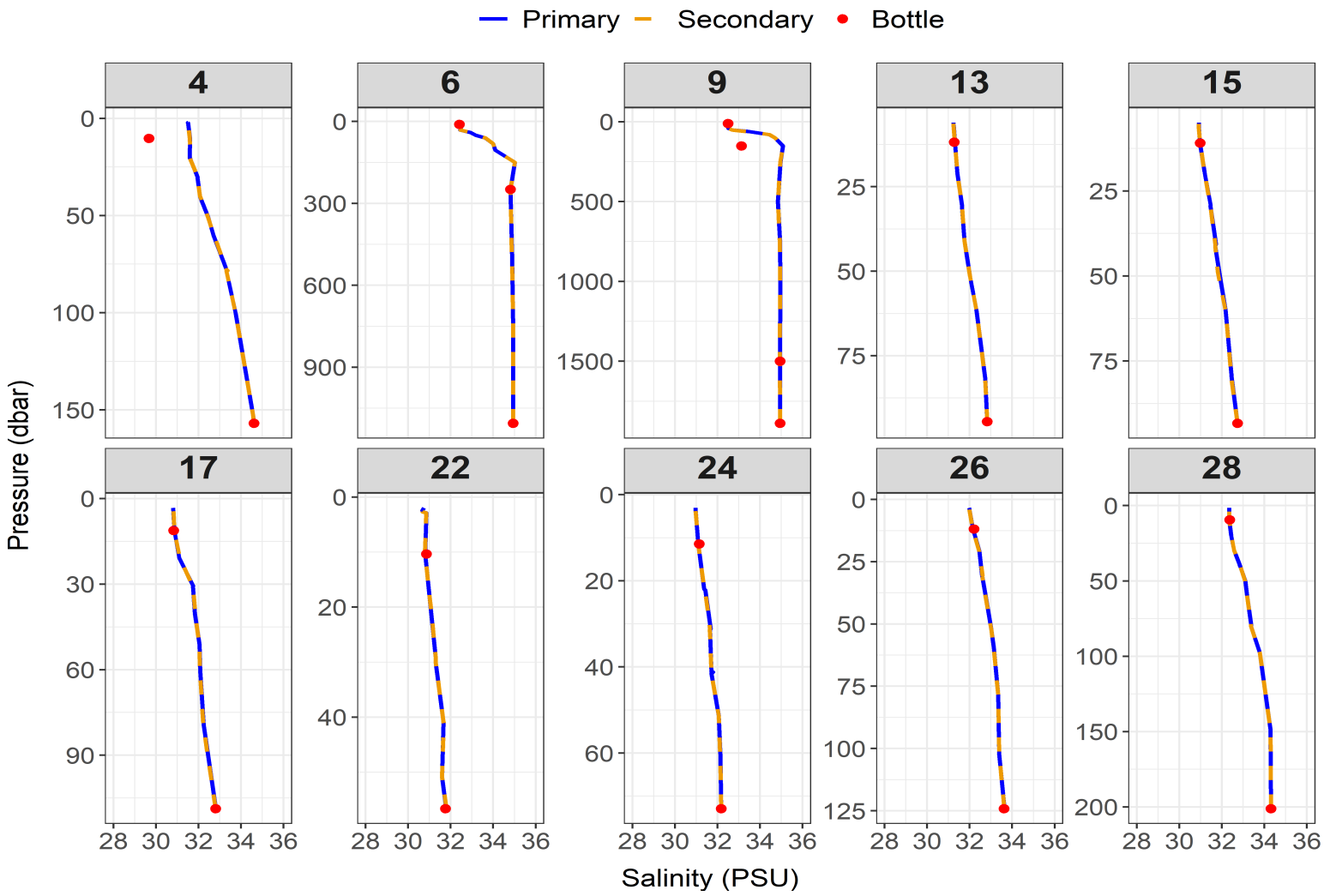

Figure A.8. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 4 to 28. Note the variable range in the y-axis.

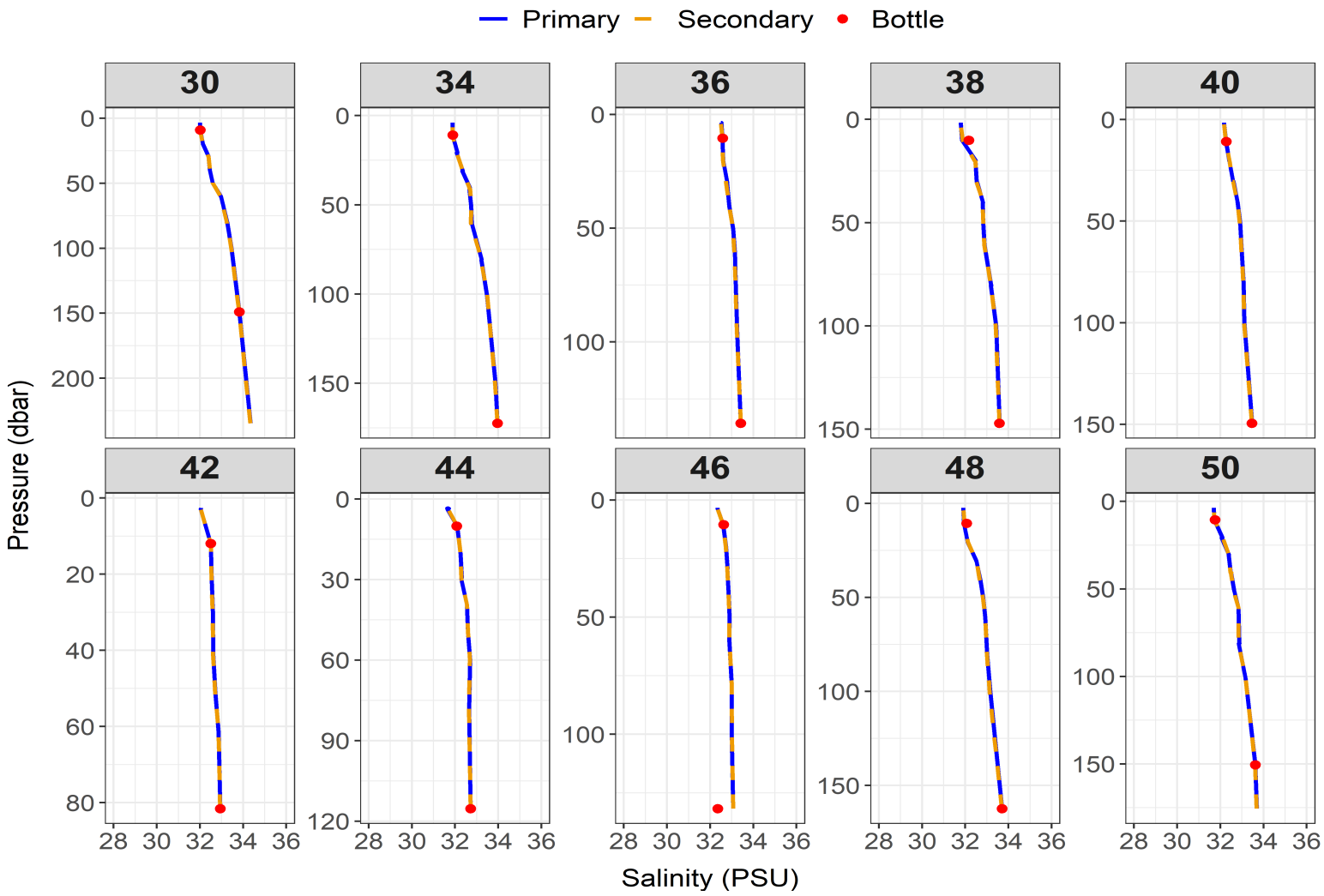

Figure A.9. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 30 to 50. Note the variable range in the y-axis.

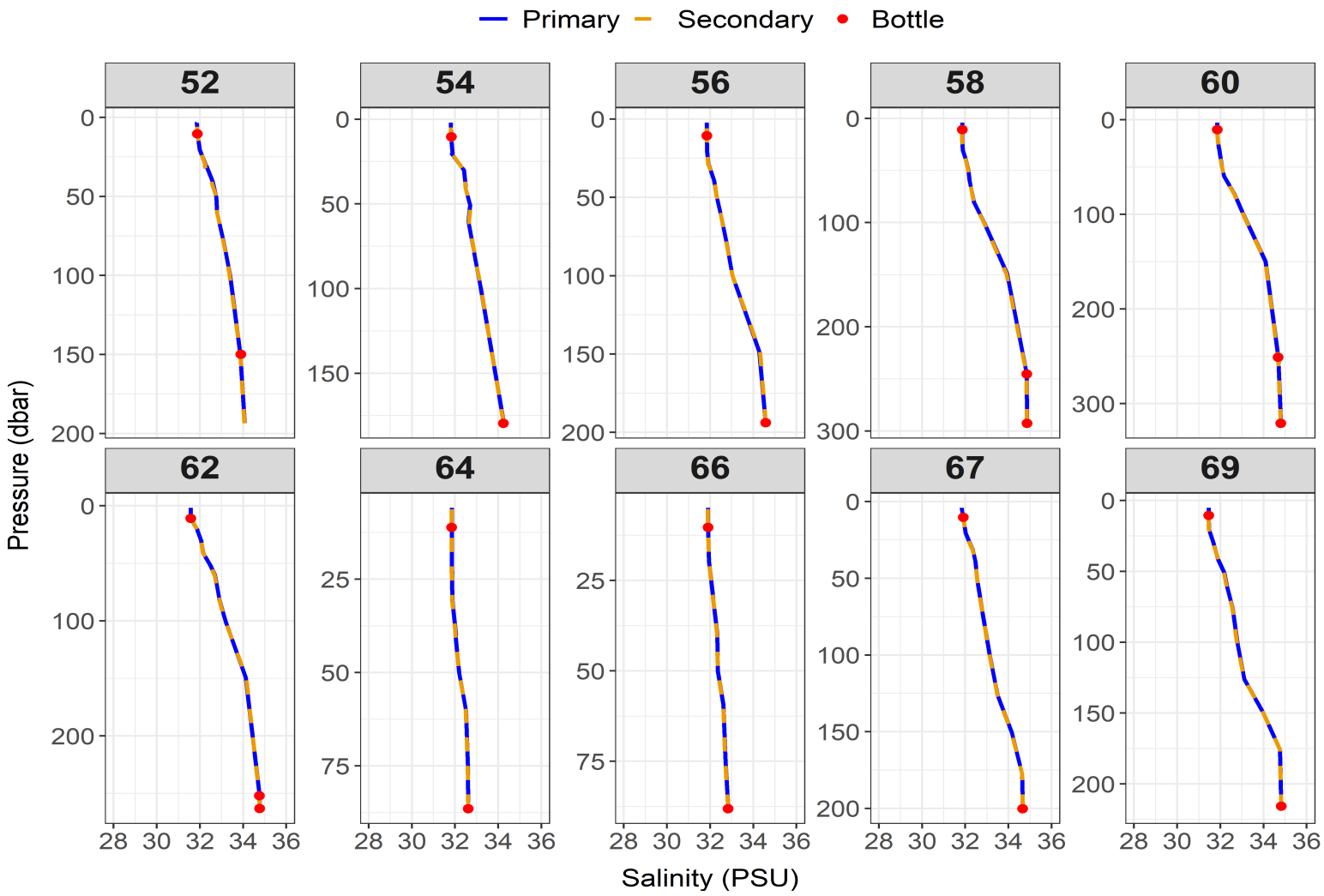

Figure A.10. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 52 to 69. Note the variable range in the y-axis.

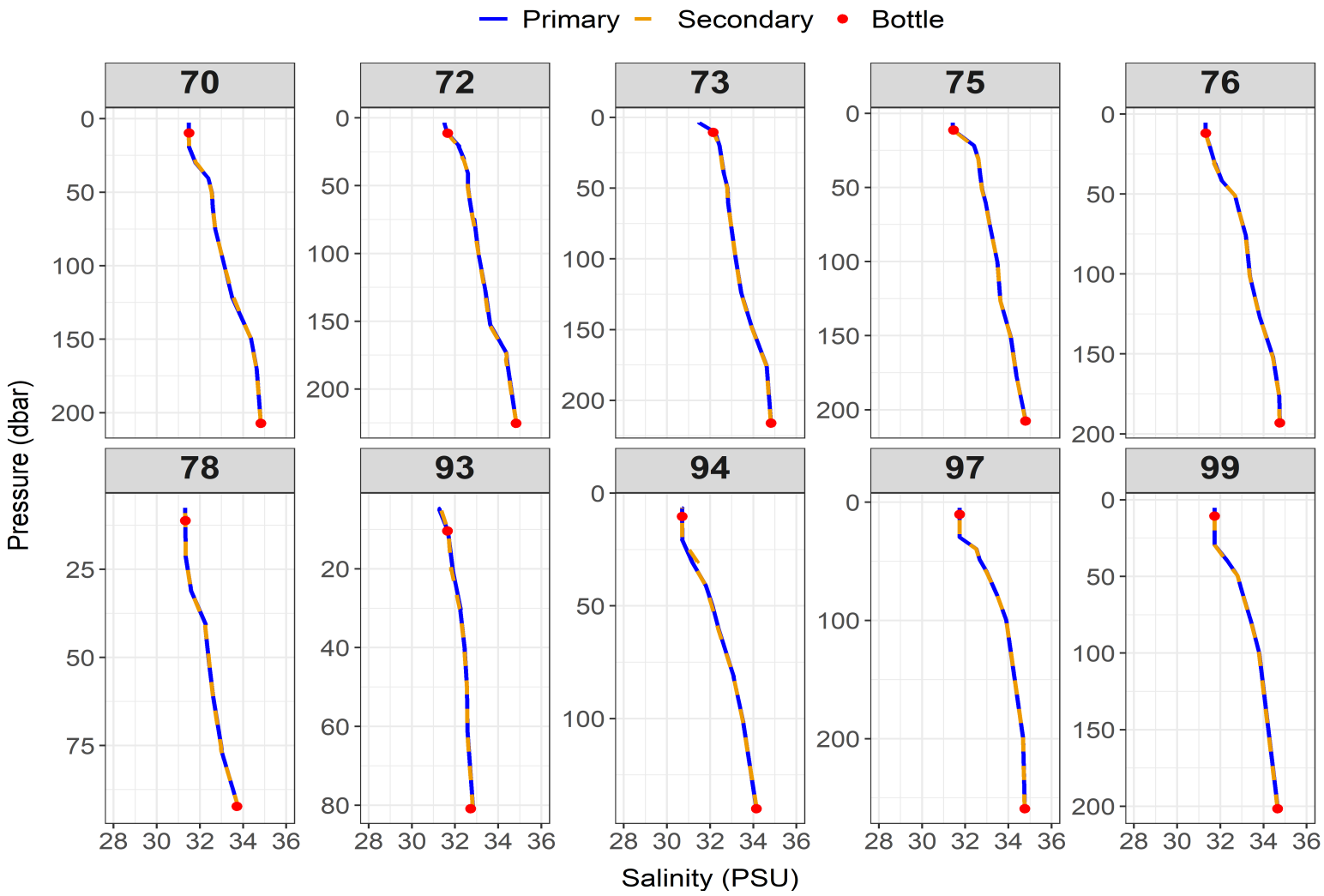

Figure A.11. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 70 to 99. Note the variable range in the y-axis.

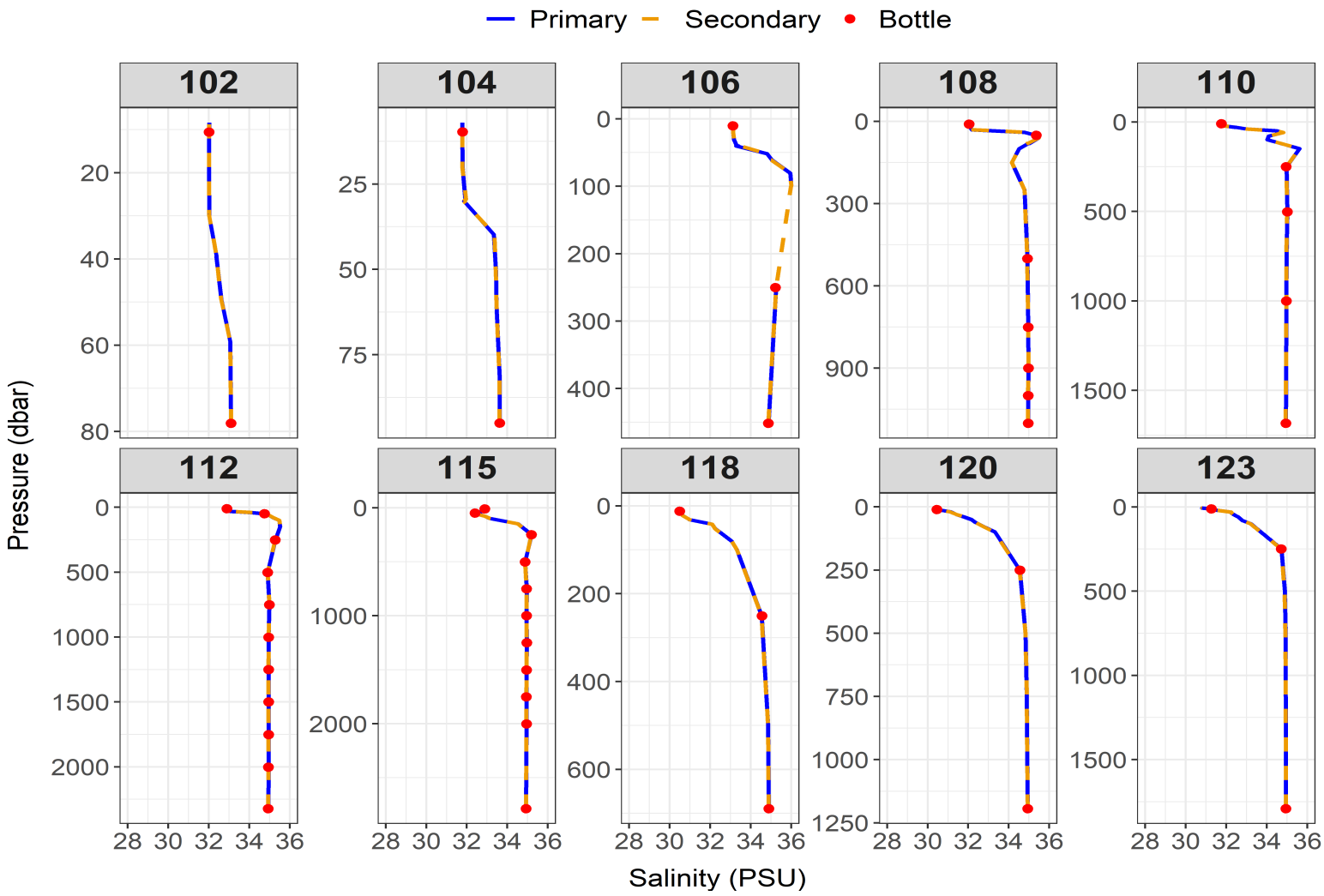

Figure A.12. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 102 to 123. Note the variable range in the y-axis.

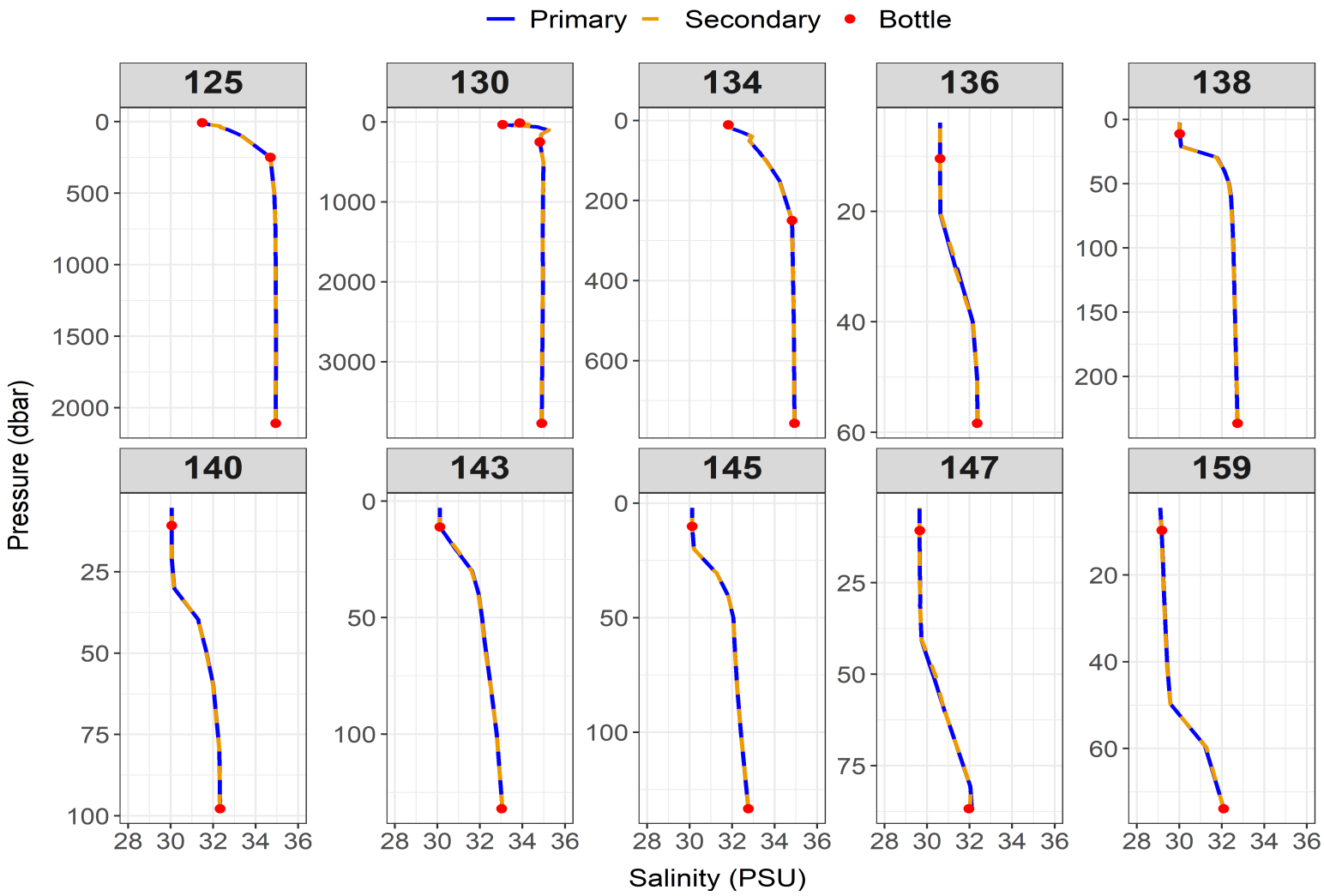

Figure A.13. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 125 to 159. Note the variable range in the y-axis.

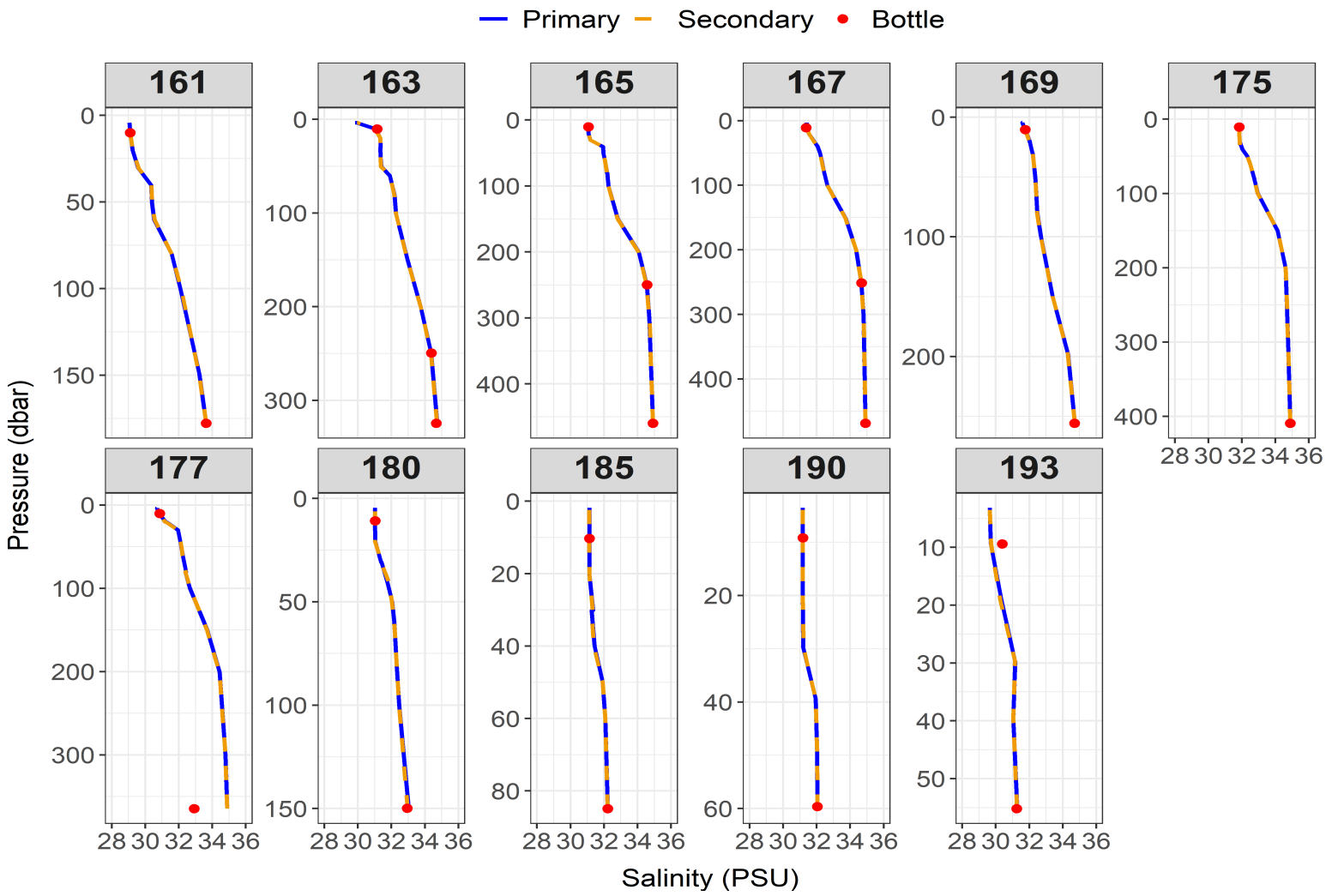

Figure A.14. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 161 to 193. Note the variable range in the y-axis.

APPENDIX B Calibration of Dissolved Oxygen Sensor Data

B.1 Background

A preliminary exercise was undertaken to calculate new dissolved oxygen calibration coefficients based on the relationship between the CTD oxygen sensor data and dissolved oxygen measurements from bottle samples using the Winkler titration method. The purpose of this exercise was to highlight potentially erroneous data, and to calculate preliminary calibration coefficients that could then be used to guide the final post-calibration process conducted by the BIO Data Services group. The calibration coefficients determined during final post-processing will be applied to the Ocean Data Format (ODF) files prior to their archival.

The process for calibrating SBE 43 dissolved oxygen sensor data is outlined in the 'SBE 43 Dissolved Oxygen Sensor Calibration and Data Corrections' Application Note No. 64-2 (Scientific 2024a) and is summarized here. Given that the loss of sensitivity resulting from sensor membrane fouling is typically observed as a linear change in sensor output compared to a set of reference samples (i.e., Winkler samples), the main term of interest for correcting sensor drift due to fouling is the *Soc* term in the SBE 43 sensor calibration equation (#1):

$$Oxygen\ (\frac{ml}{l}) = Soc * (V + Voffset) * \varphi \quad (1)$$

where,

- *Soc* is the linear slope scaling coefficient,
- *V* is the SBE 43 output voltage signal, measured in volts,
- *Voffset* is a fixed sensor voltage at zero oxygen, measured in volts,
- φ includes fixed terms that correct for the effects of temperature and pressure, and also includes oxygen solubility dependence on temperature and salinity. As these terms remain constant with fouling and sensor age, φ can be ignored here.

The AZMP performs both pre- and post-mission calibration of the dissolved oxygen sensor data collected on all its missions. For pre-mission calibration, the *Soc* value and other calibration coefficients provided by SeaBird Scientific upon factory calibration of the dissolved oxygen sensors (see Table 4 for calibration date) were entered into SeaBird's SeaSave acquisition software prior to the mission. Post-mission calibration of the data was performed by calculating a new *Soc* value (referred to as *NewSoc* in Equation #2), which is determined by calculating the average ratio between Winkler replicate values and the corresponding SBE 43 sensor O_2 across the entire mission dataset (or dataset associated with each new sensor), and multiplying this ratio by the previous *Soc* value found in the configuration (.con or .xmlcon) file and SBE sensor calibration sheet:

$$NewSoc = PreviousSoc * (\frac{Reference}{SBE\ 43\ sensor\ O_2}) \quad (2)$$

To correct previously collected and converted data (in ml/l), the ratio between the *NewSoc* and *PreviousSoc*, otherwise known as the slope correction ratio (Equation #3), is multiplied by the SBE 43 dissolved oxygen sensor data collected across the entire mission:

$$Corrected\ O_2 = SBE\ 43\ sensor\ O_2 * (\frac{NewSoc}{PreviousSoc}) \quad (3)$$

Real-time corrections of the dissolved oxygen sensor data could be conducted by replacing the *PreviousSoc* with the *NewSoc* in the configuration file. However, this is not conducted as part of the AZMP's standard protocols. Prior to the calculation of the *NewSoc* value, outliers in the dataset are evaluated and removed. These steps are outlined in detail below.

B.2 DY18402 dissolved oxygen data evaluation

Real-time validation of the primary oxygen sensor (SBE 43 SN 1624) was conducted during the mission in two ways: 1) using a calibrated secondary oxygen sensor (SBE 43 SN 2831) mounted on the CTD, and 2) visually inspecting the relationship between the sensor outputs against bottle samples measured via Winkler titration (see Appendix A). Periodically throughout the mission, the relationship between the sensor outputs and average Winkler values was evaluated, and a linear model was fitted to the data using R's ggplot2 package (see Figure B.1). While the linear trend lines for both sensors appeared to be somewhat consistent in their direction/slope, the presence of significant outliers between the sensor outputs and bottle data prevented full evaluation of these trends. These outliers were removed using the 1.5*IQR method (described in detail below), and the data were re-modelled (Figure B.2). In Figure B.2, negative trends between both sensor outputs and the bottle data were evident, indicating that the bottle measures were, on average, higher than the sensor outputs. The rate of change between the primary sensor and bottle data was over an order of magnitude higher than that of the secondary sensor (-1.18 x 10^{-4} for the primary sensor versus -4.38 x 10^{-5} for the secondary sensor), suggesting that the primary sensor was drifting relative to the secondary sensor.

The results of this exercise were reviewed with the NMF CTD technicians. As the nature of the relationship between the primary sensor and the bottle measurements was linear (and predictable), flushing the sensor with Triton X to remove biofouling was advised against, as it may result in a change in that relationship and a discontinuous dataset. Thus, the primary sensor was kept on the CTD package, and the rate of drift continued to be monitored throughout the mission. In the following exercise, new calibration coefficients were computed for both the primary and secondary dissolved oxygen sensors across the full range of events (001 through 193).

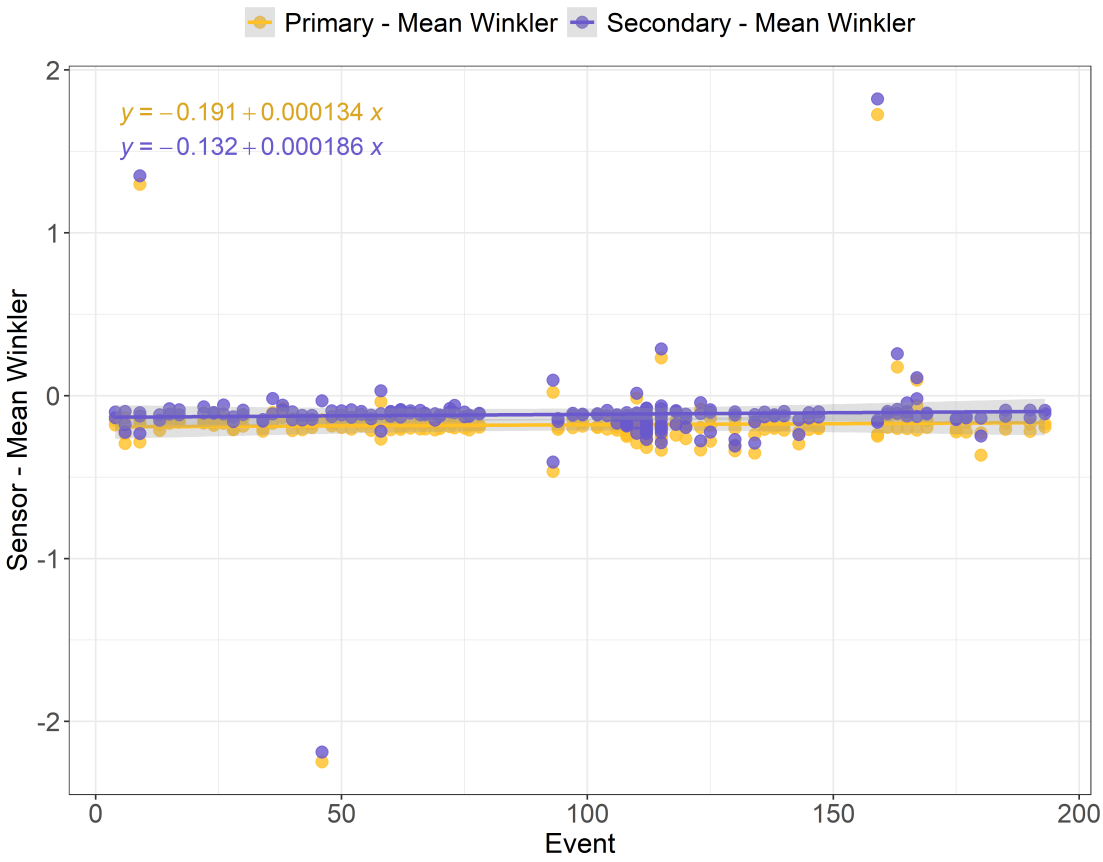

Figure B.1. Difference between the dissolved oxygen sensor and corresponding bottle measurements for both the primary (yellow) and secondary (purple) sensor data collected across Events 001 and 193. Equations of the linear models between the primary (yellow) and secondary (blue) sensor values and their associated Winkler values are also shown.

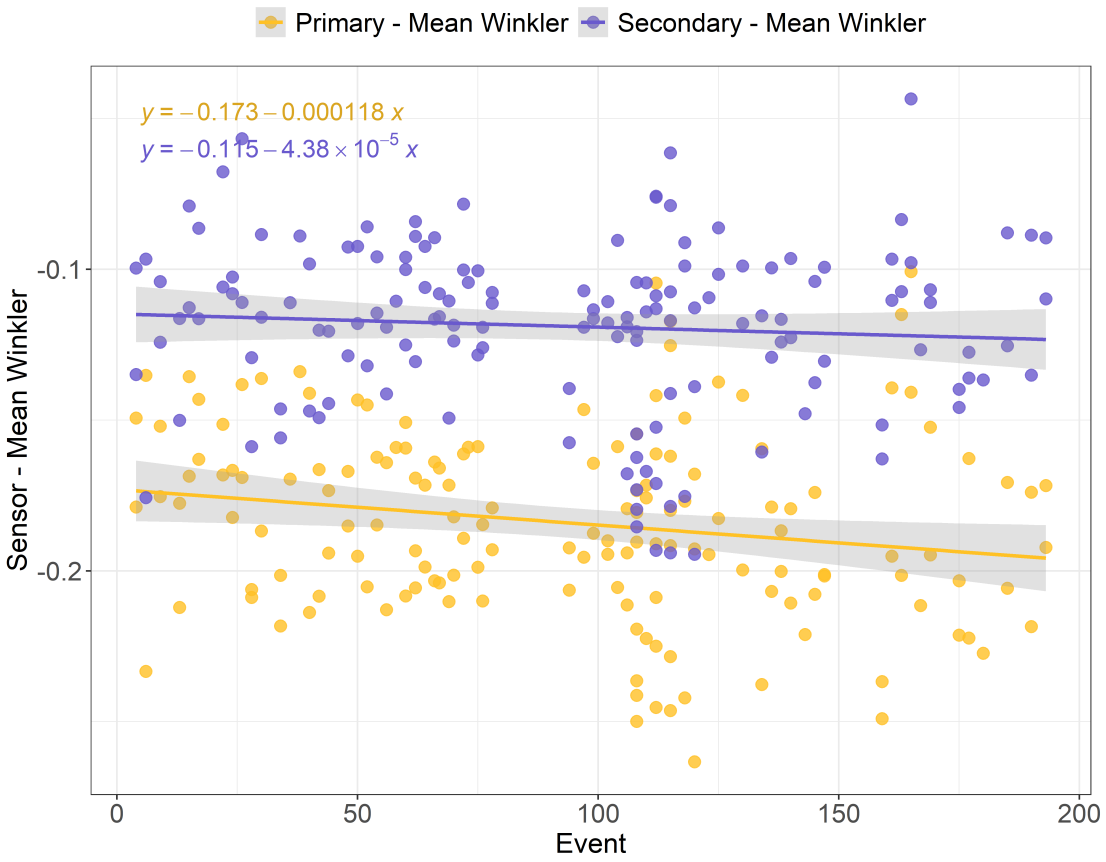

Figure B.2. Difference between the dissolved oxygen sensor and corresponding bottle measurements for both the primary (yellow) and secondary (purple) sensor data collected across Events 001 and 193, with outliers removed using the 1.5*IQR method. Equations of the linear models between the primary (yellow) and secondary (blue) sensor values and their associated Winkler values are also shown.

B.3 Outlier detection and removal - Winkler replicates

Data calibrations are only as good as the reference samples used to correct the data (Scientific 2024a). Therefore, outliers in the difference values between Winkler replicates, when collected, should be identified and removed prior to conducting post-mission calibration. Outliers in the Winkler replicate data were identified using the Interquartile Range (IQR) method. A data point was considered an outlier and removed from the calibration process if the difference between replicates, sensors, or sensors minus replicates was outside 1.5 times the interquartile range (1.5*IQR) calculated from box plot statistics.

Of the 70 data points where Winkler replicates were collected, 14 (20%) had difference values that fell outside 1.5*IQR and were considered outliers (Figure B.3). These 14 records were subsequently removed. The mean Winkler value was 5.4392 ± 0.8850 ml/l (mean ± SD) after outlier removal.

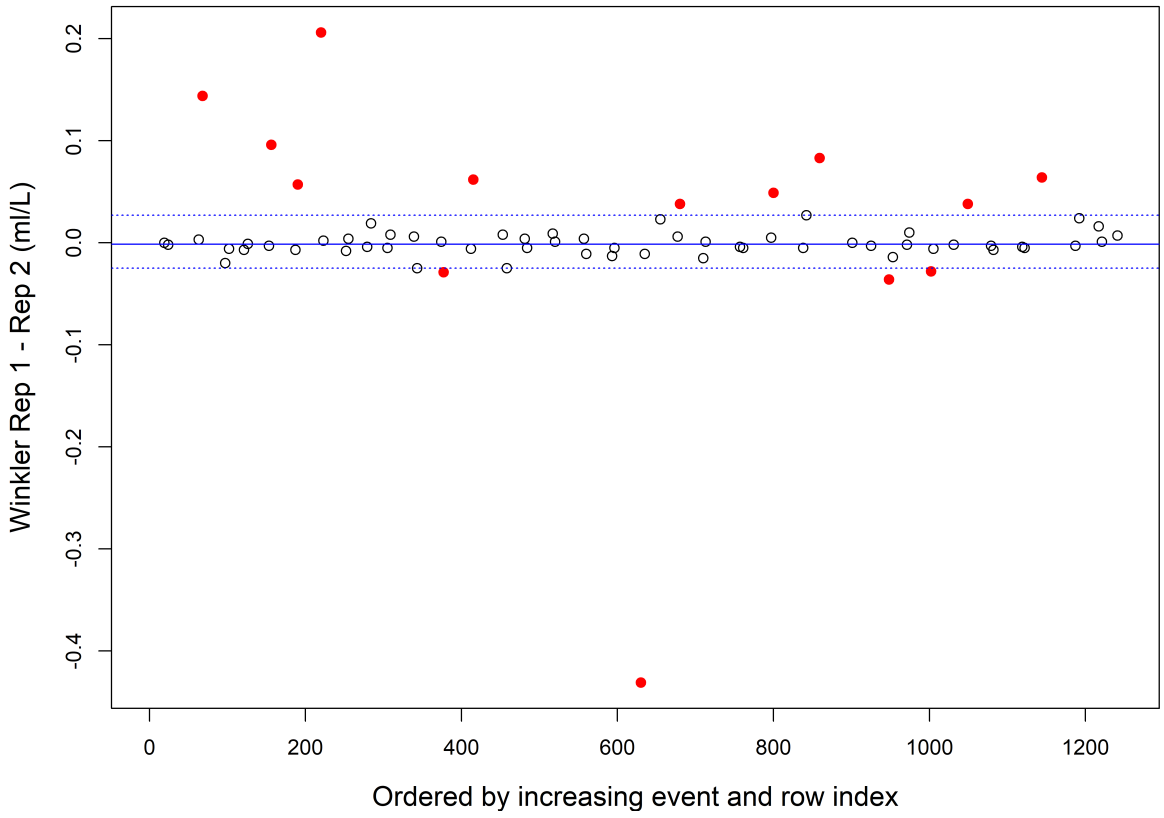

Figure B.3. Comparison of Winkler replicates measured during the 2024 fall AZMP mission (DY18402). Differences outside 1.5*IQR (horizontal dashed blue lines) are considered outliers (red dots) and were removed from the calibration process. Boxplot statistics are as follows: Median = -0.0015, IQR min = -0.0250, IQR max = 0.0270.

B.4 Primary oxygen sensor calibration

B.4.1 Outlier detection between sensor and Winkler values

Outliers between the sensor data and average Winkler data for both the primary and secondary sensors were also identified and removed. The purpose of this was to produce the *NewSoc* and slope correction ratios using only data that exhibited a small offset between the sensors and bottle measurements.

Outliers were identified by calculating a 'threshold field' (TF) using the following equation, where *SBE 43 O_2 sensor* is the CTD sensor oxygen, and *WINKLER O_2* is the average dissolved oxygen data from the bottle samples, measured by Winkler titrations:

$$TF = (SBE\ 43\ O_2 - \overline{WINKLER\ O_2}) - mean(SBE\ 43\ O_2 - \overline{WINKLER\ O_2}) \quad (4)$$

Values outside 1.5*IQR of the threshold field were considered outliers. Using this method, a total of 21 outliers were identified for the primary sensor (see Figure B.4), and were subsequently removed from further analysis.

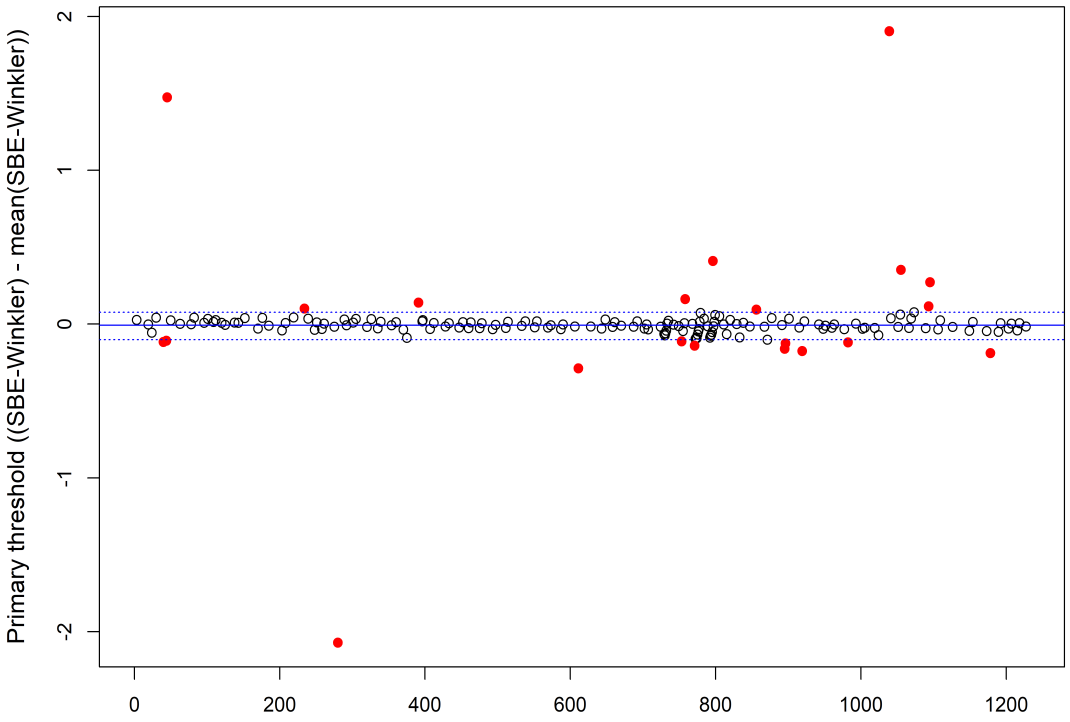

Figure B.4. Outliers (red dots) outside the 1.5*IQR (horizontal dashed blue line) of the threshold fields for the primary oxygen sensor. Boxplot statistics are as follows: Median = -0.0079, IQR min = -0.1019, IQR max = 0.07607.

B.4.2 NewSoc and slope correction ratio calculation

The *NewSoc* value for the primary sensor was then calculated using Equation #2 above. The sensor data were then corrected by multiplying them by the ratio between the *NewSoc* and the *PreviousSoc* (0.3839 and 0.5318 respectively, Table B.1), as in Equation #3 above. Figure B.5 shows the relationship between the corrected and uncorrected sensor data against the mean Winkler values. The corrected sensor data (in blue) roughly demonstrated a 1:1 relationship with the Winkler data. Before correction, the mean difference between the CTD sensor data and mean Winkler values was -0.1862 ± 0.0352 ml/L (mean ± SD). After correction, the mean difference was reduced to 0.0019 ± 0.0313 ml/L.

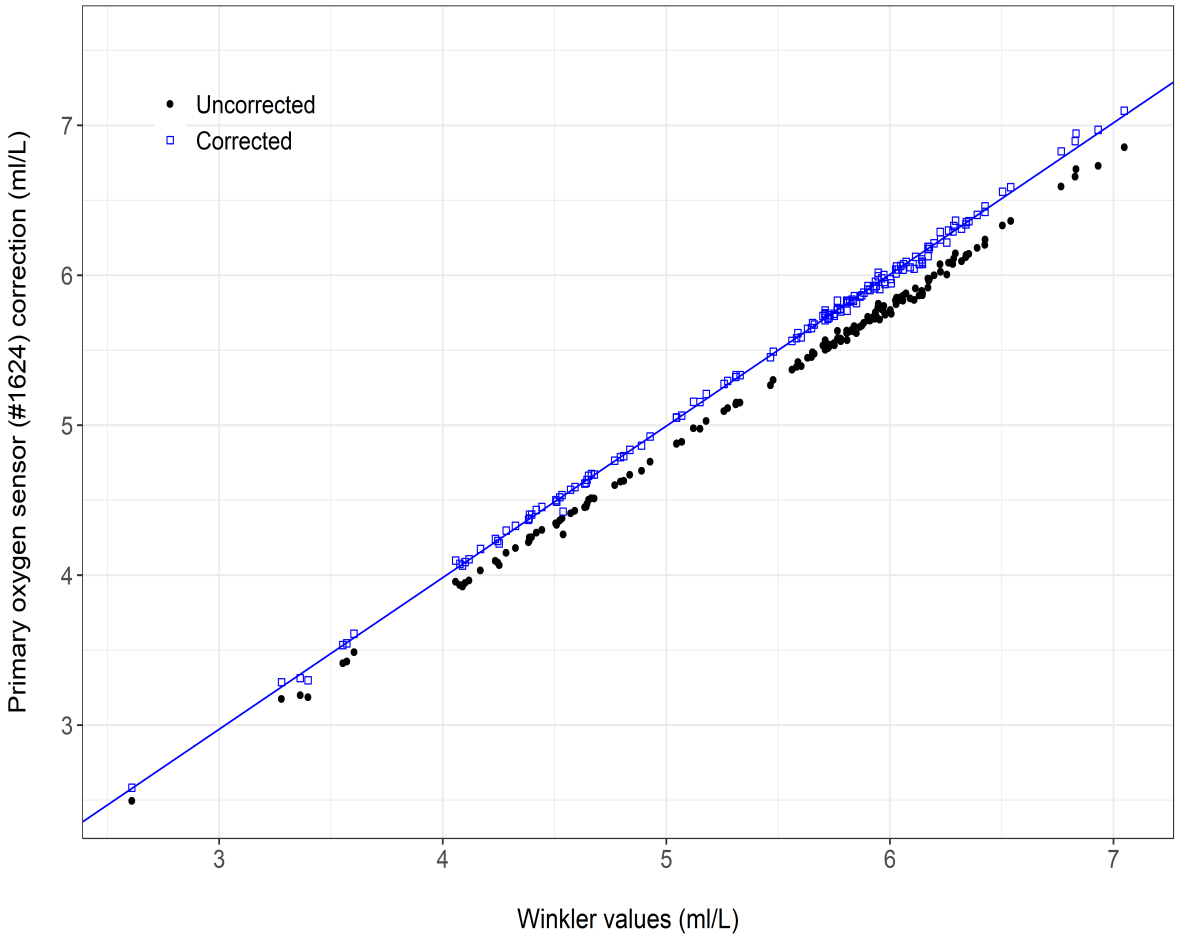

Figure B.5. Primary oxygen sensor data before (black dots) and after (blue squares) correction using the slope correction ratio. The blue line represents the 1:1 reference line of the corrected data.

B.5 Secondary oxygen sensor calibrations

B.5.1 Outlier detection between secondary sensor SN 2831 and Winkler values

Outliers in the difference between the secondary sensor (SN 2831) and mean Winkler values collected across Events 001 and 193, minus the mean difference between the secondary sensor values and mean Winkler values calculated across all data points (Equation #4) were assessed using the 1.5*IQR method. A total of 27 outliers were identified for the secondary sensor (see Figure B.6), and were subsequently removed from further analysis.

B.5.2 NewSoc and slope correction ratio calculation

The *NewSoc* value for secondary sensor SN 2831 is shown in Table B.1. Figure B.7 shows the relationship between the corrected and uncorrected sensor data against the mean Winkler values. The corrected sensor data (in blue) roughly demonstrated a 1:1 relationship with the Winkler data. Before correction, the mean difference between the CTD sensor data and mean Winkler values was -0.1159 ± 0.0292 ml/L (mean ± SD). After correction, the mean difference was reduced to 0.0023 ± 0.0312 ml/L, resulting in a significant improvement to the data.

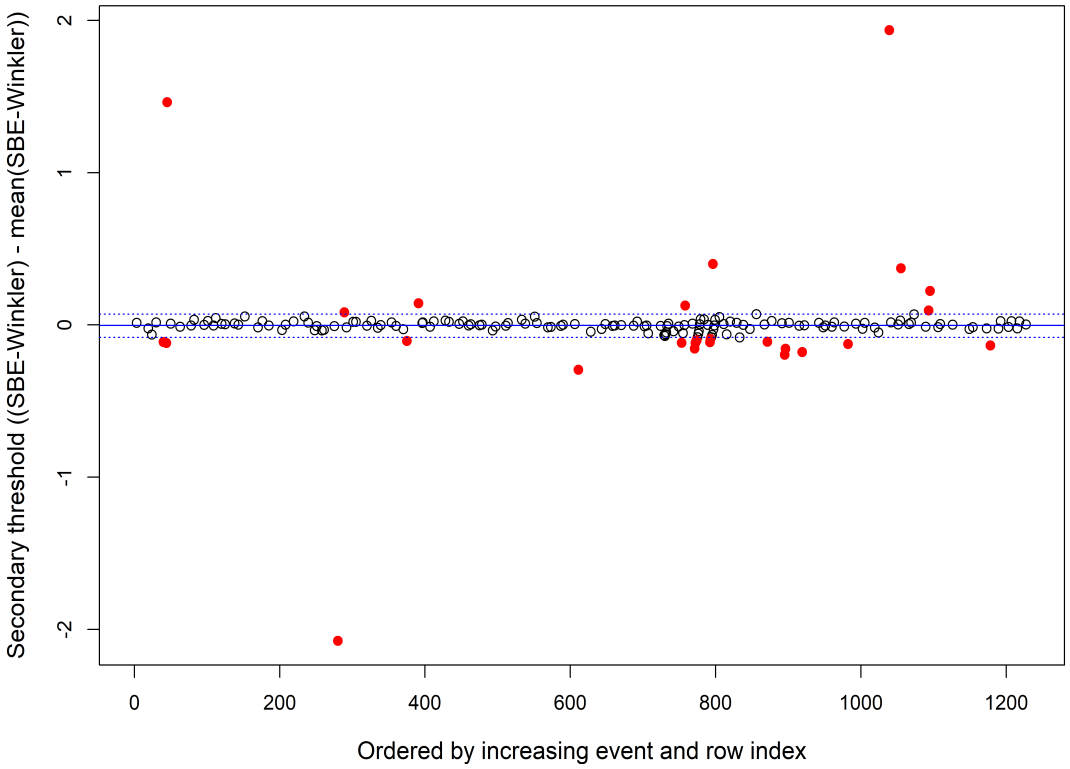

Figure B.6. Outliers (red dots) outside the 1.5*IQR (horizontal dashed blue line) of the threshold fields for the secondary oxygen sensor (SN 2831) used between Events 001 and 193. Boxplot statistics are as follows: Median = -0.0029, IQR min = -0.0815, IQR max = 0.0705.

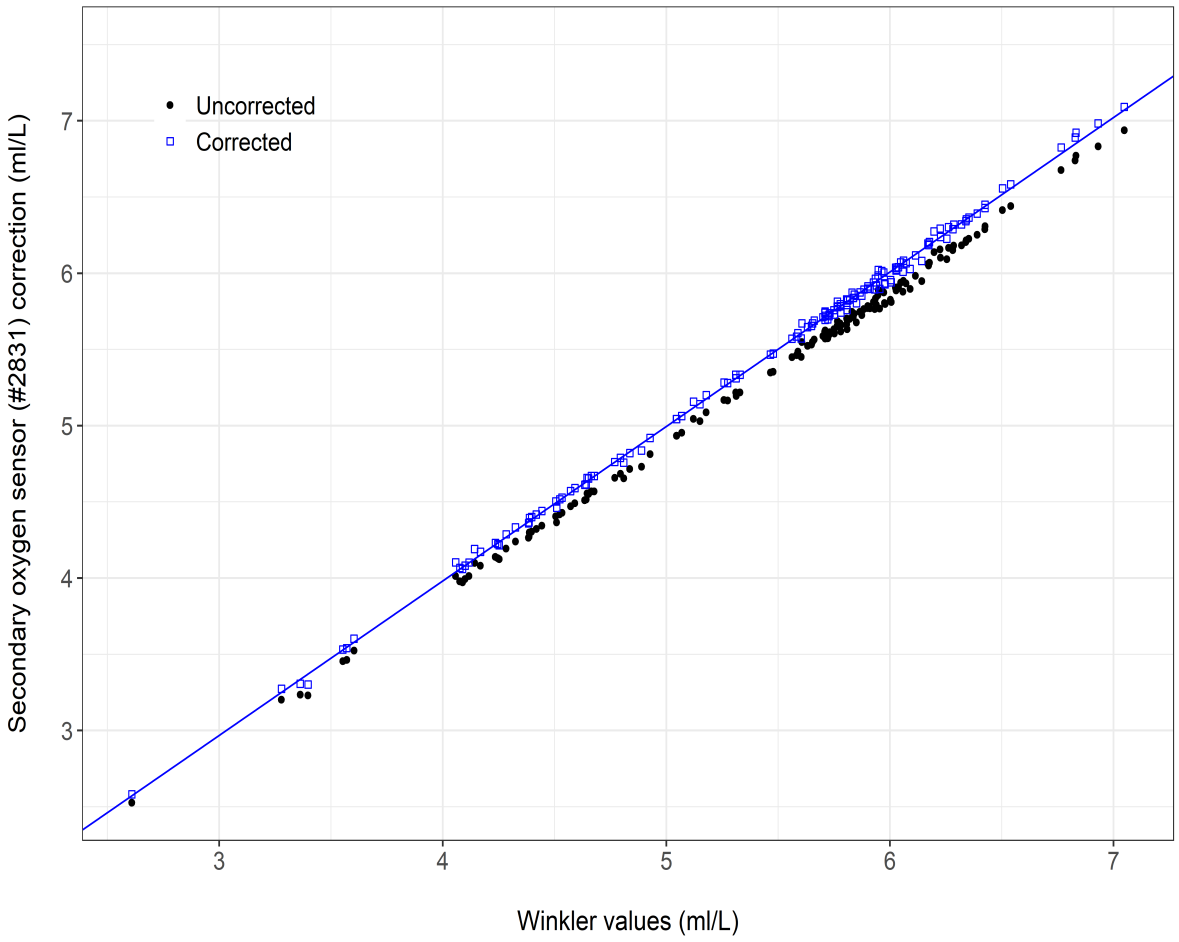

Figure B.7. Secondary oxygen sensor (SN 2831) from Events 001 to 193 before (black dots) and after (blue squares) correction using the slope correction ratio. The blue line represents the 1:1 reference line of the corrected data.

Table B.1. PreviousSoc, NewSoc, and the ratio between the two for the primary and secondary oxygen sensors used during the 2024 fall AZMP mission (DY18402).

Sensor	PreviousSoc	NewSoc	Ratio
Primary SBE 43 O2 sensor (1624)	0.3839	0.3976	1.0357
Secondary SBE 43 O2 sensor (2831)	0.5318	0.5436	1.0223

APPENDIX C Calibration of Conductivity Sensor Data

C.1 Background

The process for the calibration of SBE sensor conductivity data is outlined in SeaBird's 'Computing Temperature & Conductivity Slope & Offset Correction Coefficients from Lab Calibration and Salinity Bottle Samples' Application Note No. 31 (Scientific 2024b). The conductivity sensor *slope* and *offset* terms allow for the correction of sensor drift that may occur between factory calibrations. Both terms are extracted from a linear regression between measurements of true conductivity (i.e., as measured from bottle samples) and sensor conductivity, and are applied to the correct sensor output following Equation 1 below:

$$Corrected\ Conductivity = SBE\ sensor\ conductivity * slope + offset \quad (1)$$

Bottle samples collected on the DY18402 mission for the purpose of salinity determination were analyzed at sea using a Guildline 'Autosal' laboratory salinometer provided by the National Oceanography Centre. This system was situated in its own temperature-controlled Salinometer Laboratory on board the vessel. The autosal measures the salinity of a sample in terms of the ratio of its electrical conductivity at a temperature of 15°C and pressure of 1 atmosphere to that of an IAPSO Standard Seawater reference sample, which was calibrated to a solution of potassium chloride (KCl) with a practical salinity of 35, temperature of 15°C, and pressure of 0 dbar. The actual conductivity of the IAPSO Standard Seawater is computed by the autosal software based on the standard's K15 value (provided by the manufacturer) and the conductivity of the KCl solution (42.914 mS/cm). Once the conductivity ratio of the bottle sample is determined, bottle salinity is then calculated from the conductivity ratio following the PSS-78 algorithm for the calculation of Practical Salinity (IOC, 2010). As the Salinometer Lab on board the RRS *Discovery* was temperature-controlled and set closer to 20 - 21°C, the salinity bottle samples were analyzed using a bath temperature set to 21°C. The salinometer accounts for this temperature difference so that the output sample conductivity ratios are at 15°C.

To compare sensor conductivity values against bottle measurements, bottle salinity values from the autosal must be converted to absolute bottle conductivity at the temperature and pressure of the CTD package when the bottles were closed. This conversion is computed using the 'gsw_C_from_SP' function in the R package 'gsw', which uses the Gibbs Seawater formulation to calculate absolute electrical conductivity from Practical Salinity, temperature, and pressure. Note that as the units from the gsw_C_from_SP() function are mS/cm, the output of this function must be divided by 10 to ensure consistent units with the SBE conductivity sensor outputs (Siemens per meter, S/m).

Linear models are then fitted between bottle conductivity and sensor conductivity (in S/m), and the intercept (offset) and slope values are extracted from the linear regression summaries. The new slope and offset are then applied (the slope multiplied and the offset added) to the sensor data following Equation 1. The primary (Serial No. 3272, calibrated on December 7, 2023) and secondary (Serial No. 3529, calibrated December 14, 2023) conductivity sensors remained on the CTD-Rosette package for the entire duration of the mission (Table 4). As the sensors were not changed, slope and offset values were calculated across the full range of CTD events (001 to 193).

C.2 Evaluation of outliers in DY18402 conductivity sensor data

Prior to the calculation of the new slope and offset values, outliers were evaluated between A) the primary and secondary conductivity sensor data, and B) between sensor conductivity and bottle conductivity. For the evaluation between the primary and secondary sensor data, a total of 333 of 1245 data points fell outside the 1.5*IQR and were removed from the calibration process (Figure C.1), leaving a total of 912 data points for further assessment.

C.3 Calculation of bottle conductivity from bottle salinity and evaluation of outliers between sensor and bottle data

Next, the difference between the primary conductivity sensor and bottle conductivity was evaluated. When bottle conductivity was compared against the primary sensor data, a total of 38 outliers were identified (Figure C.2) and subsequently removed from the dataset. For the secondary sensor and bottle data, 37 outliers were identified (Figure C.2) and removed. After all outliers were removed, the difference between the conductivity sensor values and bottle conductivity data were, on average, 7.7381 x 10^{-5} ± 0.0003 S/m (mean ± SD) and -0.0004 ± 0.0003 S/m for the primary and secondary sensors, respectively.

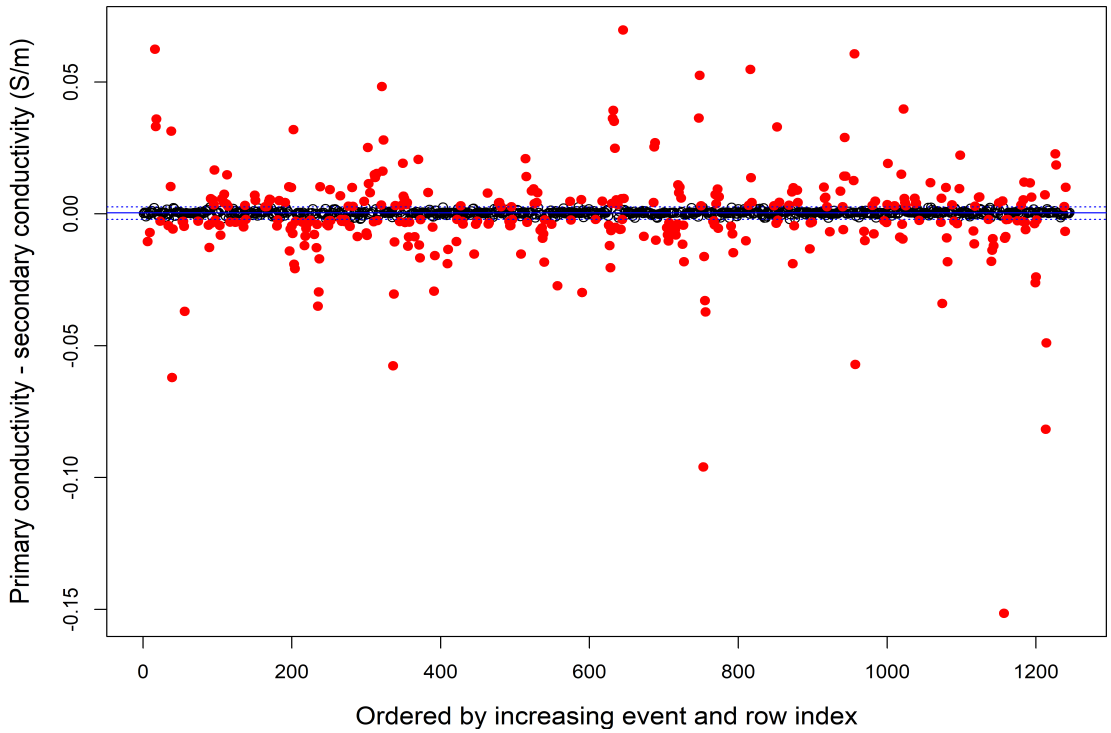

Figure C.1. Comparison between salinity values derived from the primary and secondary conductivity sensor data collected during the 2024 fall AZMP mission (DY18402). Differences outside 1.5*IQR (horizontal dashed blue lines) are considered outliers (red dots) and were removed from the calibration process. Boxplot statistics are as follows: Median = 0.0004, IQR min = -0.0021, IQR max = 0.0027.

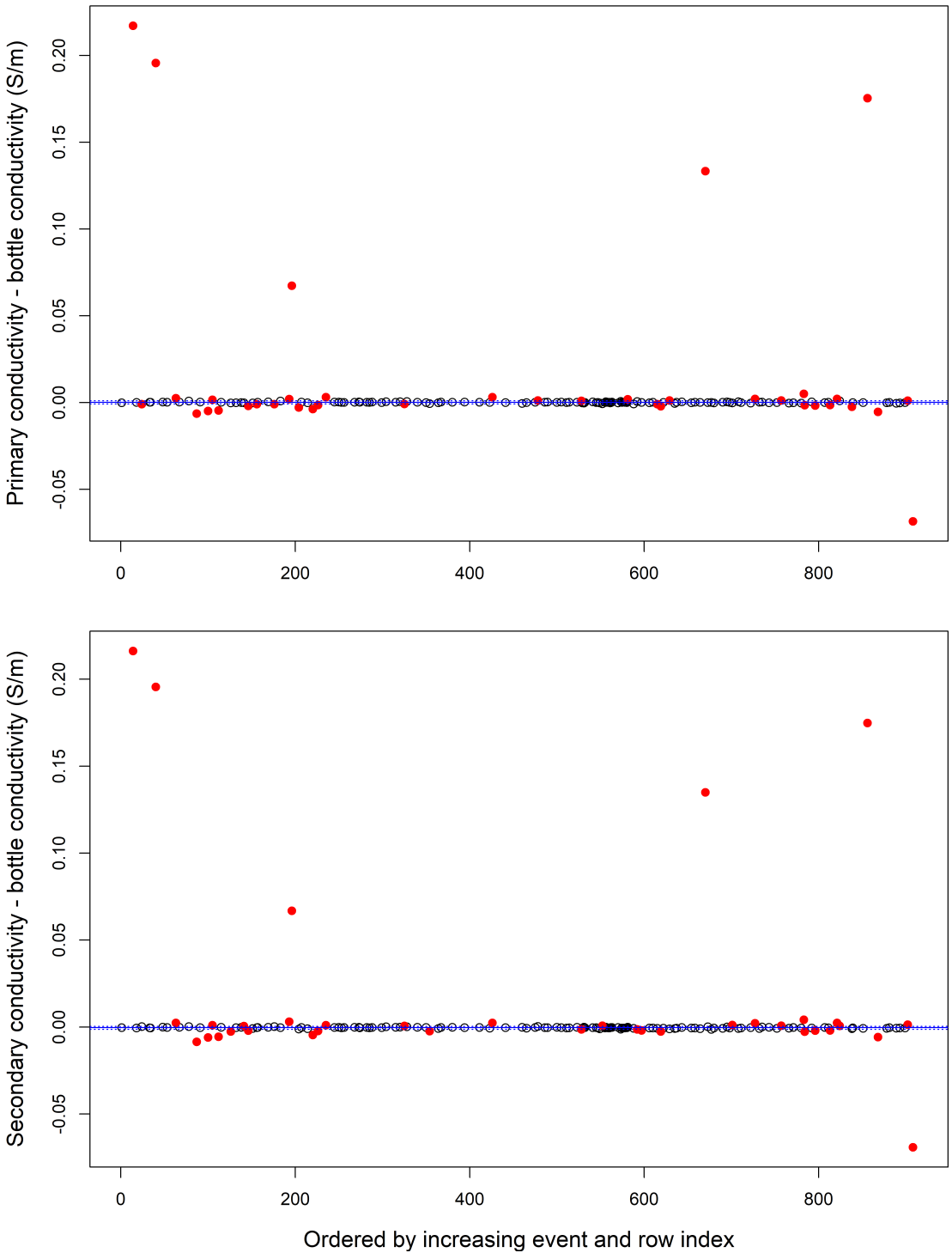

Figure C.2. Comparison between primary (top) and secondary (bottom) conductivity sensor data and bottle conductivity (S/m) collected during the DY18402 mission. Differences outside 1.5*IQR (horizontal dashed blue lines) are considered outliers (red dots) and were removed from the calibration process. Boxplot statistics are as follows: A) Median = -0.0001, IQR min = -0.0008, IQR max = 0.0009; B) Median = -0.0004, IQR min = -0.0013, IQR max = 0.0004.

C.4 Calculation of new slope and offset terms for conductivity data correction

Linear models were then fitted to the bottle conductivity and sensor conductivity data. The intercept (offset) and slope values were extracted from the linear regression summaries for both models (see Table C.1). These were then applied to the raw conductivity sensor data (dataset with sensor outliers removed; 912 data points) following Equation 1 above.

Figure C.3 shows the relationship between the primary and secondary conductivity sensor data before (black circles) and after (blue squares) correction using the calculated slope and offset values from Table C.1. The mean difference between the uncorrected and corrected primary and secondary conductivity sensor data and their corresponding bottle conductivity values is shown in Table C.2, while Figure C.4 shows the relationship between the corrected and uncorrected sensor data against their corresponding bottle conductivity values (in S/m). These results show that while correction of the primary conductivity sensor resulted in a minor improvement to sensor values (marked by the lower mean difference between the sensor outputs and bottle values, after correction), correction of the secondary conductivity sensor resulted in a larger mean difference between the sensor outputs and bottle values, suggesting that only the primary sensor should be corrected.

Table C.1. Revised offset and slope terms calculated for the primary and secondary conductivity sensors used during the 2024 fall AZMP mission (DY18402).

Sensor	Offset	Slope
Primary SBE 4 Conductivity Sensor (3272)	-0.0006	1.0002
Secondary SBE 4 Conductivity Sensor (3529)	0.0009	0.9999

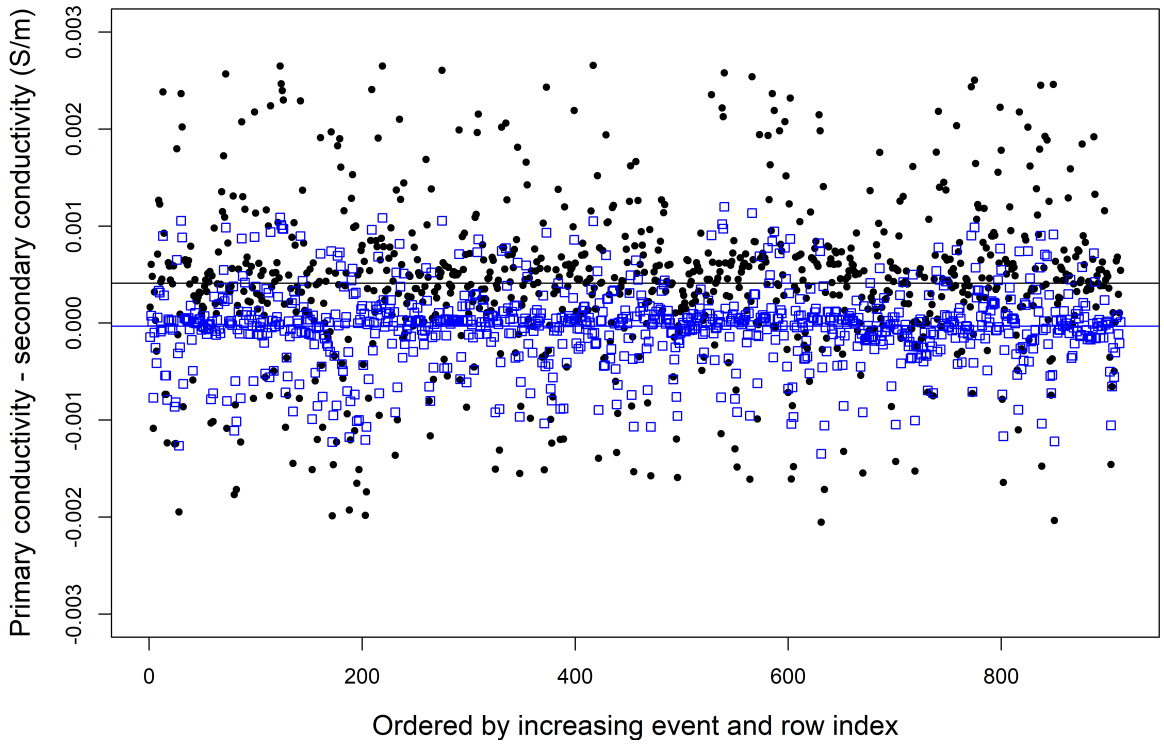

Figure C.3. Primary (top) and secondary (bottom) conductivity sensor data before (black dots) and after (blue squares) correction using the determined slopes and offsets. The blue line represents the 1:1 reference line of the corrected data.

Table C.2. Mean difference between uncorrected and corrected sensor conductivity versus their corresponding bottle conductivity values for the 2024 fall AZMP mission (DY18402).

Sensor	Mean Difference - Uncorrected	Mean Difference - Corrected
Primary Conductivity Sensor (3272)	0.00446	0.00438
Secondary Conductivity Sensor (3529)	0.00401	0.00441

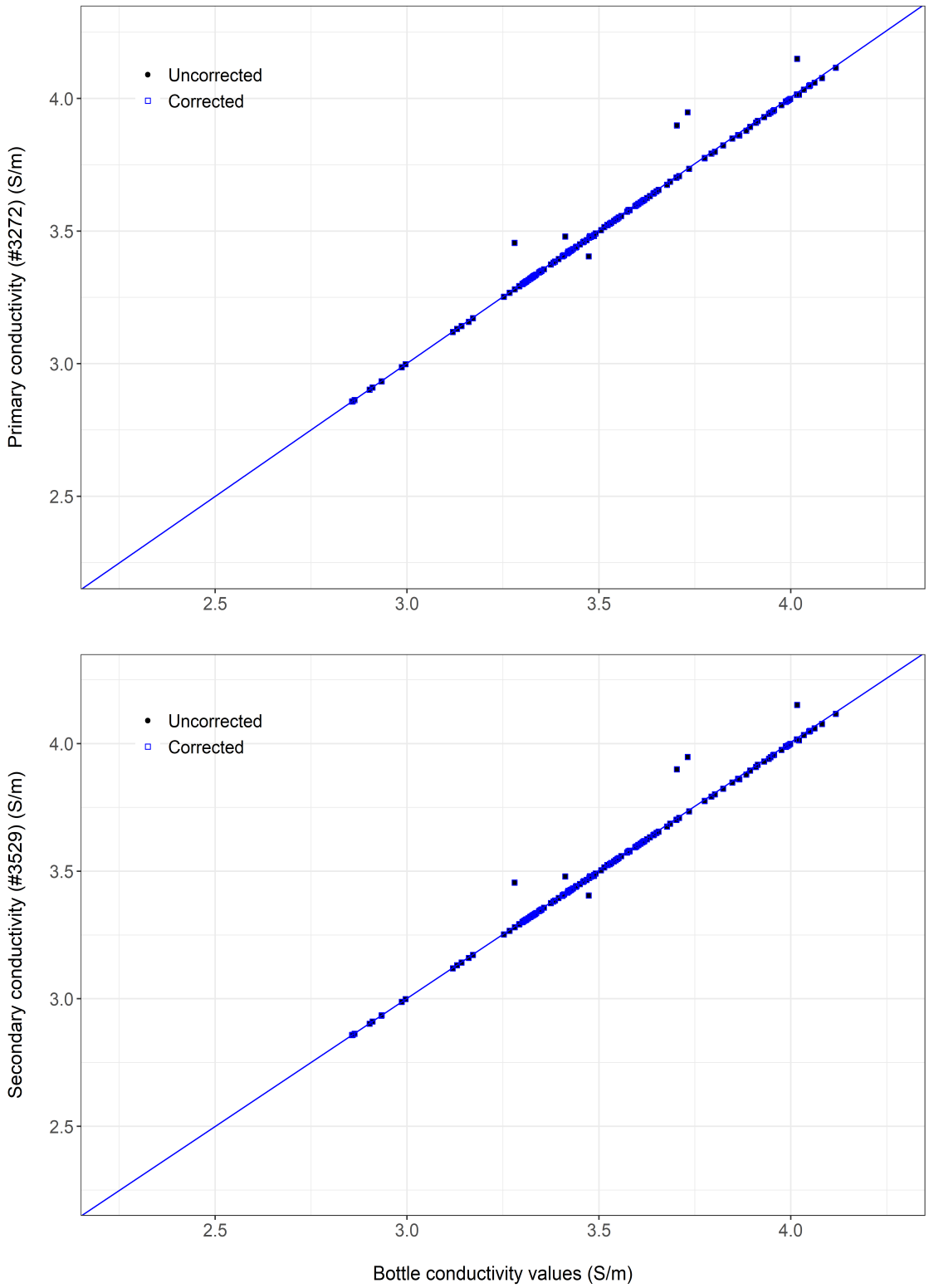

Figure C.4. Primary (top) and secondary (bottom) conductivity sensor data before (black dots) and after (blue squares) correction using the determined slopes and offsets. The blue line represents the 1:1 reference line of the corrected data.

APPENDIX D Evaluation of the Relationship between Sensor Chlorophyll *a* and Turner Fluorometer Chlorophyll *a*

D.1 Background

Seapoint chlorophyll and CDOM (UV) fluorometers supplied by DFO were used during DY18402 mission. Both the chlorophyll (SN 3668) and CDOM (SN 6229) sensors functioned well and remained on the CTD package for the duration of the mission. For the purpose of this exercise, chlorophyll *a* data from the *in situ* chlorophyll fluorometer was evaluated against the corresponding Turner chlorophyll *a* measurements in order to determine how consistent the data were with the bottle measurements, and *vice versa*. At present, the results of this exercise are not currently being used to revise the calibration coefficients for the sensors, although a method is currently being developed for this purpose.

A total of 579 replicate water samples (1158 measurements) were collected for chlorophyll *a* determination during the DY18402 mission. Replicate samples were averaged prior to evaluating the corresponding CTD fluorometer data. Using the 1.5*IQR method for outlier detection outlined in appendices B and C above, 95 of 579 measurements were identified as outliers (Figure D.1). The average difference between replicates was -0.0012 $\pm$ 0.0097 μg/L (mean $\pm$ SD) after removal. Similar outlier detection methods were used to remove outliers between the chlorophyll sensor and Turner fluorometer data. First, both the chlorophyll sensor and Turner measurements were standardized by dividing both datasets by the chlorophyll sensor data value at each sample depth. This converts the sensor data for each bottle fire to 1, and the corresponding mean replicate Turner value to a percentage of the sensor value. A value of 1.15 means that the Turner fluorometer value was 15% greater than its corresponding sensor value. This approach was taken because calculating the straight difference between values is greatly influenced by the magnitude of the values. In other words, the difference between 0.01 and 0.1 and the difference between 6.31 and 6.40 are both 0.09, but the relative difference is ~90% and 1.4%, respectively.

D.2 Seapoint SCF Fluorometer SN 3668

A total of 17 outliers between the chlorophyll sensor (Seapoint SCF SN 3668) outputs and mean Turner fluorometer bottle measurements were identified using the method described above and subsequently removed (Figure D.2). Figure D.3 shows the log relationship between the chlorophyll sensor values and the mean Turner chlorophyll measurements, with the 17 outliers from Figure D.2 shown in red. The blue line corresponds to the line of best fit from a linear regression between the log chlorophyll sensor data and Turner chlorophyll data, while the orange dashed line represents the 1:1 reference line. When the outliers were removed and a linear regression was fit between the two datasets (Figure D.3), the relationship between the two was positive and statistically significant (p value = 2 x 10^{-16} . The R^2 value was high (0.8961), suggesting an excellent fit between the fluorometer sensor outputs and Turner chlorophyll measurements.

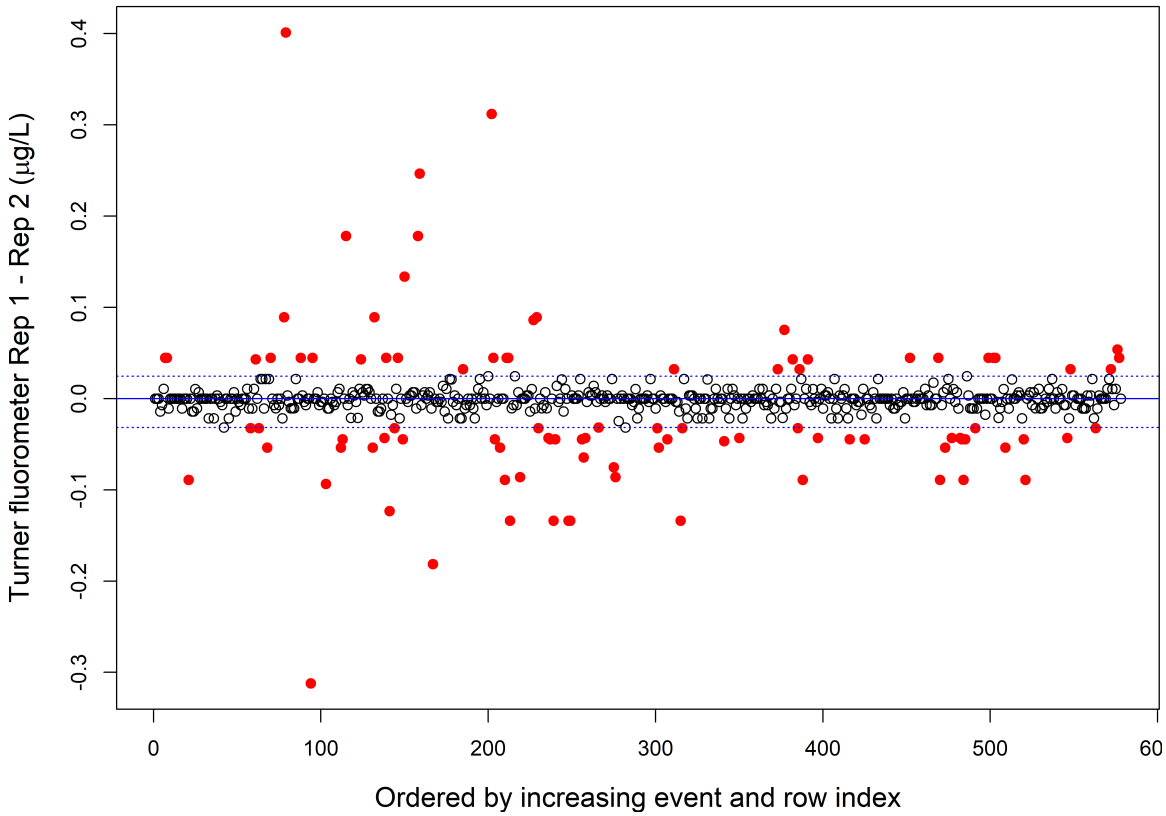

Figure D.1. Comparison of Turner fluorometer replicates. Differences above or below the IQR min/max are considered outliers (red dots) and were removed from the evaluation process. Boxplot statistics are as follows: Median = 0.0000, IQR min = -0.0317, IQR max = 0.0246.

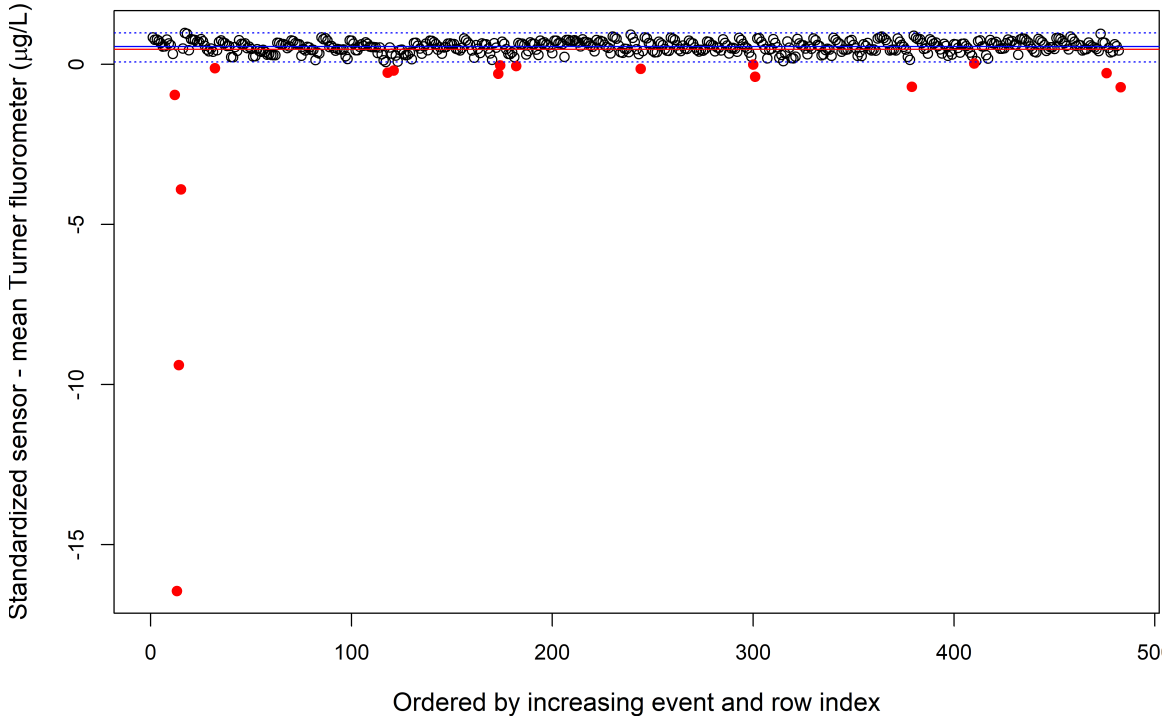

Figure D.2. Outliers identified from calculating the percent (%) difference between standardized chlorophyll sensor values and Turner fluorometer values (mean Turner fluorometer values divided by the chlorophyll sensor values). Boxplot statistics are as follows: Median = 0.5524, IQR min = 0.0754, IQR max = 0.9829. The solid red line indicates the mean (0.4654).

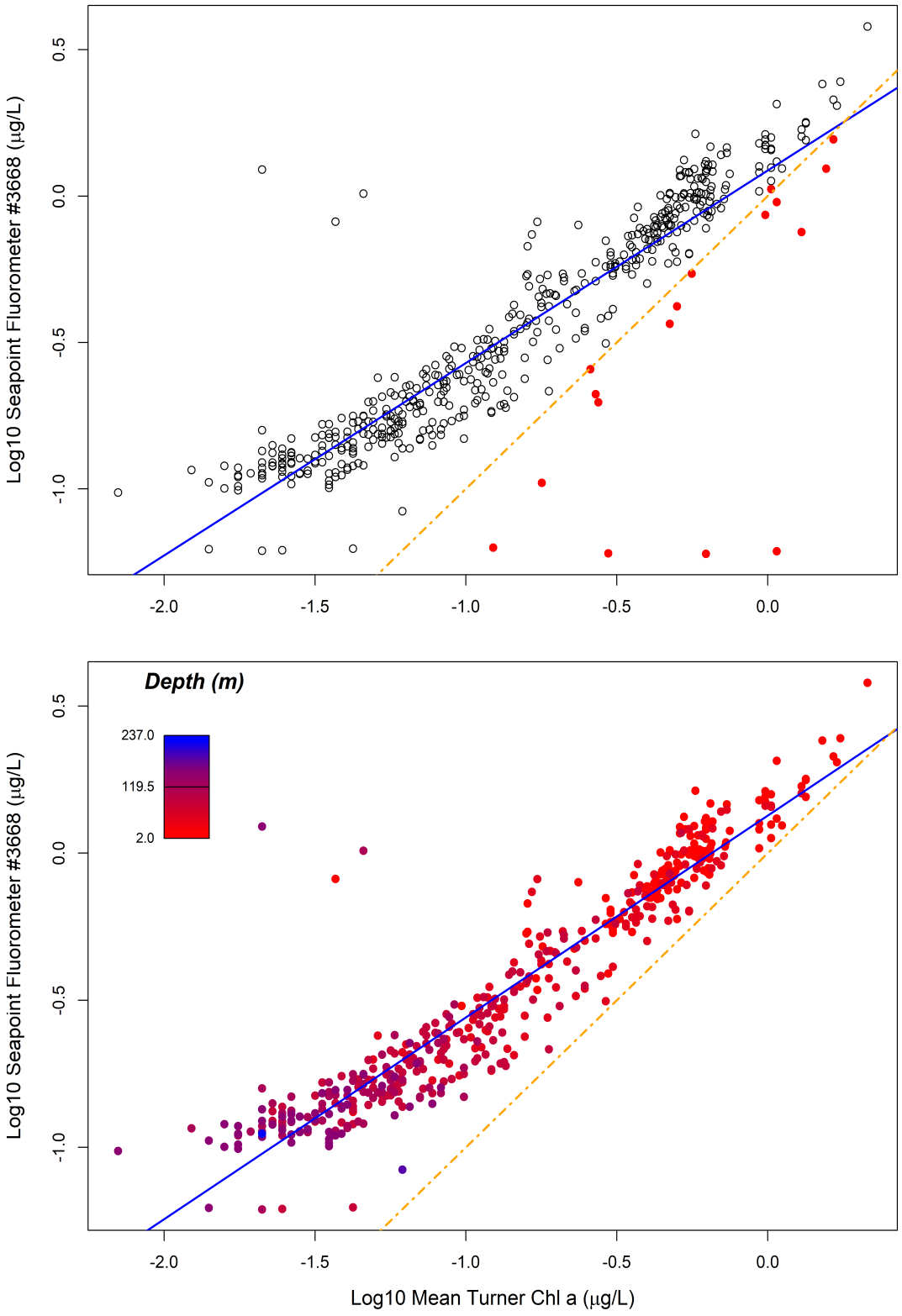

Figure D.3. Top: log10 scale of sensor fluorometer values against mean replicate Turner fluorometer values for Events 001 to 193. Outliers from Figure D.2. are indicated in red. Bottom: log10 plot of sensor fluorometer values and replicate Turner fluorometer values (outliers removed), colour-coded by depth, where red and dark red are shallow and purple and blue are deep (closer to 100 m). In both plots, the blue line represents the line of best fit, while the orange dashed line is the 1:1 reference line.