Mission Report for the Maritimes Region Atlantic Zone Monitoring Program 2024 Spring Survey (TEL2024880)

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MISSION REPORT FOR THE MARITIMES REGION ATLANTIC ZONE MONITORING PROGRAM 2024 SPRING SURVEY (TEL2024880)

by

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The Maritimes Region Atlantic Zone Monitoring Program 2024 spring survey was conducted from April 11 to May 1, 2024 on the Canadian Coast Guard fisheries research vessel *Teleost*. A total of 184 deployments of various oceanographic sampling equipment were conducted across a network of fixed monitoring stations, including CTD/Rosette deployments for the collection of vertical profile data and water samples to a maximum of 1500 m depth, vertical ring net tows for zooplankton sample collection, and Argo float deployments in support of the International Argo program. A flow-through system was used to collect continuous measurements of temperature, salinity, and other chemical and biological parameters from surface seawater sampled along the mission track. This report provides an overview of the mission's objectives, achievements, impacts, gear operations, and data management workflow. A summary of the seabird and marine mammal observations collected during the mission is presented, as well as the results of preliminary exercises to calculate new calibration coefficients for the dissolved oxygen and conductivity CTD sensors.

RÉSUMÉ

Beazley, L., Cardoso, D., Gordon, C., and Gjerdrum, C. 2024. Mission Report for the Maritimes Region Atlantic Zone Monitoring Program 2024 Spring Survey (TEL2024880). Can. Tech. Rep. Hydrogr. Ocean Sci. 386: vii + 102 p.

Le relevé printanier 2024 du Programme de monitorage de la zone atlantique de la région des Maritimes a été réalisé du 11 avril au 1er mai 2024 à bord du navire de recherche halieutique de la Garde côtière canadienne *Teleost*. Au total, 184 déploiements de divers équipements d'échantillonnage océanographique ont été effectués dans un réseau de stations de monitorage fixes, y compris des déploiements d'instruments de mesure de CTP/de rosettes pour la collecte de données sur le profil vertical et d'échantillons d'eau jusqu'à une profondeur maximale de 1 500 mètres, des traits de filet verticaux pour la collecte d'échantillons de zooplancton, et des déploiements de flotteurs Argo à l'appui du programme international Argo. Un système à écoulement continu a été utilisé pour collecter des mesures continues de la température, de la salinité et d'autres paramètres chimiques et biologiques de l'eau de mer de surface prélevée le long de la trajectoire de la mission. Ce rapport fournit une vue d'ensemble des objectifs, des réalisations, des répercussions, de l'utilisation des engins et du flux de travail pour la gestion des données 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

Fisheries and Oceans Canada's (DFO) Atlantic Zone Monitoring Program (AZMP) was designed to capture seasonal, interannual, and decadal variability in physical, chemical, and lower trophic-level biological conditions on the continental shelf and upper slope regions of Atlantic Canada (Therriault et al. 1998). The program's sampling strategy in the Maritimes Region is based on higher frequency biweekly or monthly sampling at two coastal fixed stations and seasonal sampling on the winter (February-March) and summer (July-August) ecosystem trawl surveys and on dedicated oceanographic surveys each spring (April) and fall (September-October). This report describes the data and samples collected on board the CCGS *Teleost* (mission ID = TEL2024880) in support of the program's 2024 spring sampling activities.

The CCGS *Teleost* is a fisheries research vessel platform used primarily for DFO's ecosystem trawl surveys in the Maritimes, Quebec, and Newfoundland and Labrador (NL) regions. Although the *Teleost* was tentatively scheduled for decommissioning on April 1, 2024, the vessel's operational window was extended at the request of DFO Science to deliver the Maritimes Region spring AZMP survey in April 2024, thereby providing critical support to Science in the wake of the decommissioning of the CCGS *Hudson*, the Atlantic zone's former offshore oceanographic research vessel, in 2022. Upon conclusion of the spring AZMP mission, the *Teleost* was tasked with CCG search and rescue efforts in the Atlantic zone for the remainder of the year.

While the *Teleost* had been previously used to conduct AZMP oceanographic surveys led by the Quebec and Newfoundland and Labrador Regions, oceanographic data collection on the vessel is limited to approximately 1500 m depth due to the size of the vessel's CTD winch and length of its conducting cable. Of the program's 82 core and ancillary stations in the Maritimes Region, only 7 stations are located on the continental slope in waters greater than 1500 m depth. Thus, while the data collected on this survey was considered to meet the program's objective to measure and describe conditions on the continental shelf, stations located on the continental slope would only be sampled to a maximum depth of 1500 m.

Mobilization of the TEL2024880 mission was scheduled to occur at the Bedford Institute of Oceanography (BIO) starting on April 3, 2024, after conclusion and demobilization of the Maritimes Region Winter Ecosystem Survey of Georges Bank and Bay of Fundy. A CCG crew change was scheduled on Wednesday April 17 at 12:00, also at BIO. This naturally parsed the mission into two separate legs, referred to as 'Leg 1' (April 10 - 17) and 'Leg 2' (April 17 - May 1). Planning exercises were conducted separately for each leg leading up to the mission.

Planned sampling activities included deployment of a CTD/Rosette and vertical ring net tows on all 82 core and ancillary AZMP stations, and Argo floats deployments on stations HL_07 and LL_09. Normally, a 24, 12-L bottle rosette would be used on the program's spring and fall surveys for water collection. However, a rosette of this size could not be accommodated in the space available in the CTD Staging Area of the *Teleost*, and consequently, only a 12-bottle rosette could be used. While the extended frame of this rosette allowed for the use of the normal 12-L bottles, two casts would have to be conducted on some stations in order to sample the program's normal nominal depths. A separate hydrowinch with galvanized steel cable was used to conduct ring net tows to the program's normal maximum depth of 1000 m.

Mobilization of science equipment began on the morning of Thursday April 4, 2024. The crew facilitated the loading of all cages of scientific equipment using the ship's main crane. On the vessel's main deck, the Instrument Workshop located interior of the gangway was set up with filtration racks for chlorophyll, phytoplankton absorption, high-performance liquid chromatography (HPLC), and coloured dissolved organic matter (CDOM). The CTD acquisition computer was set up in the Winch Compartment Staging Area next to the CTD Staging Area where the CTD/Rosette would be launched and recovered. The Biology Laboratory, located on the lower deck, was staged with the program's Portasal Salinity Autoanalyzer, Turner fluorometer, and Winkler titration system, and the ship's Dry Lab was set up with computers used for data management. The underway system was set up on a stainless steel counter in the Wet Lab, a space primarily used to process catch samples during fisheries surveys.

During the morning of Wednesday April 10, a familiarization tour of the vessel was conducted for all Leg 1 science participants from 10:00 to 11:00 ADT, and departure was planned for 12:00. Shortly after the vessel's engines were started, a significant leak in the gearbox cooler system occurred. A replacement system was located on board and the replacement process was initiated, delaying departure until tentatively 06:30 ADT on the following day, Thursday April 11.

Repairs were conducted successfully, and the vessel departed the BIO wharf at 06:30 on Thursday April 11. The vessel then headed towards the Compass Buoy Station in Bedford Basin where the CTD/Rosette would be tested. Once on site, the CTD/Rosette was deployed to near-bottom, and all 12 bottles were fired closed to ensure the trigger mechanisms of the rosette were in working order. The winch display was reconfigured during deployment, and the test was deemed successful. A ring net tow was conducted to determine if the plankton block was functioning properly, and was also deemed a success.

A significant weather system predicted to impact the region over the weekend combined with the delayed departure of the mission resulted in a reconfiguration of the planned itinerary for Leg 1. Instead of sampling the Browns Bank Line as originally planned, the Halifax Line was instead sampled after the basin test was complete. This would give enough time to complete operations on the Halifax Line before the weather system could potentially impact operations. Weather conditions worsened while operating near the end of the line. Consequently, the chief scientist (Lindsay Beazley) made the decision to sample HL_06 followed by HL_07, bypassing decimal stations HL_06.3 and HL_06.7 to ensure that all core stations on the line were sampled. Once operations at HL_07 were completed, conditions were still favourable for operations, and the vessel proceeded north back to stations HL_06.7 and HL_06.3 and successfully sampled both stations without issue. Once the Halifax Line was fully completed, the vessel proceeded northwest, towards the Bay of Fundy area, where the storm's effects were quickly dissipating.

As the vessel approached the Yarmouth area, it was determined that conditions were favourable enough to start operations on the Yarmouth Line starting with station YL_01. All stations on the Yarmouth Line were successfully completed, and the vessel proceeded to the Portsmouth Line to conduct as many stations as possible prior the morning of April 16, when the vessel was scheduled to start its transit back to BIO for crew change on April 17. All stations on the Portsmouth Line were completed by 12:07 GMT on April 16, which provided enough time to transit back to BIO for arrival on Wednesday morning, April 17, for crew change.

The vessel arrived at BIO just prior to 08:00 ADT on April 17 and berthed at the BIO finger pier. This marked the completion of Leg 1 of the mission. The CCG crew change was conducted at 12:00, and the incoming Commanding Officer, Captain Todd Mayo, conducted a boat and fire drill with all personnel from 19:00 to 20:00 ADT. The vessel departed shortly after at 20:30, marking the start of Leg 2. Station HL_02 was sampled once outside the Halifax Harbour, and the vessel then proceeded to its next work area, the Browns Bank Line (BBL). The vessel arrived at station BBL_01 at 16:00 GMT on the following day, April 18, and began science operations. Shortly after operations began, the *Teleost* was tasked as the primary vessel on SAR duty on the eastern Scotian Shelf until Saturday April 21, when the CCGS *Cape Roger* would relieve the vessel of its duties. Science operations were permitted to proceed as per normal, and no SAR calls were made during this time. After operations were completed on the Browns Bank Line, the 10 stations located across the Northeast Channel were sampled. All stations were sampled in sequence, which was more efficient than sampling every second station as done in the past.

Upon completion of the Northeast Channel line, the vessel proceeded to its next work location, the Gully MPA. Given the variable topography and strong currents, the vessel re-positioned after each operation to limit the potential of drifting towards the canyon's steep walls. All operations in the Gully were completed successfully. The vessel proceeded to its next work location, the Laurentian Channel Mouth (LCM). This line consists of 10 stations that run across the mouth of the Laurentian Channel, and are designed to capture the properties of the inflow of waters of Labrador Current origin into the Gulf of St. Lawrence, and outflow that forms the Nova Scotia Shelf Break Current. Operations on this line were quickly paced, but were all successful. As the stations were all shallower than 500 m, only single casts at each station were required.

After operations were completed at the Laurentian Channel Mouth, the vessel proceeded towards the end of the Louisbourg Line (station LL_09), with an ETA of 24:00 ADT on Tuesday April 23. At 22:00 ADT, a leak in the vessel's gearbox cooler system was discovered. As it was deemed too risky to conduct the repairs at sea, the vessel began its transit back to BIO, with an ETA of 07:00 ADT on Thursday April 25. Repairs to the gearbox cooler were completed overnight, and a new departure time of 09:00 ADT on Friday April 26 was established. Once departed, the vessel proceeded towards the end of the Louisbourg Line, and completed operations at LL_09. The final Argo float was also deployed at this station before heading northwest to station LL_08. Weather conditions began to deteriorate while operating at LL_09, and consequently neither CTD/Rosette or ring net operations were possible at station LL_08. The vessel continued north to station LL_07 to determine of operations were permittable. While conditions were too poor to operate the ring net safely, the CTD/Rosette was successfully deployed. Weather conditions improved as the vessel headed north, and all other stations on the Louisbourg Line were successfully completed.

Once station LL_01 was completed at 23:50 GMT on April 28, the vessel headed towards its next work area, the Cabot Strait Line (CSL). While operations were originally planned to start at the station located closest to Cape Breton (station CSL_01), a decision was made to start at the opposite end of the line (station CSL_06). This would allow the vessel to be partially sheltered from the strong northwest winds that were predicted to occur in the area later in the day. Conditions began to deteriorate while operating on station CSL_03. While both ring net and CTD/Rosette operations were still possible on station CSL_02, the winds had increased to above 30 knots as the vessel approached the final station on the CSL, CSL_01. Consequently, ring net operations were cancelled at CSL_01, but the CTD/Rosette was successfully deployed. Upon conclusion of the CTD/Rosette operation at CSL_01 at 01:00 GMT on April 30, the vessel began its long transit back towards Halifax. High-frequency station HL_02 was occupied one last time before entering the Halifax Harbour. The vessel arrived back at the BIO port on Wednesday May 1 at 07:00 ADT, and berthed along the main wharf. Demobilization was completed during the afternoon, marking the conclusion of the TEL2024880 spring AZMP survey.

2 Participants

A total of 12 scientific staff participated in the mission (see Table 1), including 11 DFO personnel and 1 wildlife observer from Environment and Climate Change Canada (ECCC). The chief scientist was Lindsay Beazley, operational lead of the Maritimes Region AZMP, with Chantelle Layton, physical scientist, as the night shift captain. All science staff were split into day (0600-1800) and night (1800-0600) shifts.

A CCG crew change was conducted on April 17, which split the mission into two distinct legs. The Captain of the CCGS *Teleost* during Leg 1 was Commanding Officer Kevin Jones, while the Commanding Officer of Leg 2 was Todd Mayo. A total of 3 deck hands were available 24/7 during both legs to support the launch and recovery of the CTD/Rosette and ring nets.

A planned science crew change was also conducted on April 17, where Shawn Roach was replaced by Katie Thistle (both of the Habitat Ecology Section, DFO) as CTD operator during the night watch.

Table 1. List of scientific staff that participated in the 2024 spring AZMP mission (TEL2024880). Affiliation is Department-Division-Section. OMOS = Ocean Monitoring and Observation Section; OSMS = Ocean Stressors and Modelling Section; OETS = Ocean Engineering and Technology Section; OESD = Ocean and Ecosystem Sciences Division; HES = Habitat Ecology Section; ECCC = Environment and Climate Change Canada; CWS = Canadian Wildlife Service

	Name	Affiliation	Duty	Shift
1	Peter Thamer	DFO-OMOS	Lab manager	Day
2	Kristen Wilson	DFO-OMOS	Lab manager	Night
3	Lindsay Beazley	DFO-OMOS	Chief scientist/ring net operator	Day
4	Tim Perry	DFO-OMOS	Ring net operator	Night
5	Chris Gordon	DFO-OMOS	CTD acquisition computer	Day
6	Chantelle Layton	DFO-OESD	CTD acquisition computer/night shift captain	Night
7	Adam Hartling	DFO-OETS	CTD technician	Day
8	Shawn Roach (Leg 1)	DFO-HES	CTD technician	Night
9	Katie Thistle (Leg 2)	DFO-HES	CTD technician	Night
10	Diana Cardoso	DFO-OESD	Data manager	Day
11	Nicole Smith	DFO-OSMS	Lab support	Night
12	Rick Ludkin	ECCC-CWS	Wildlife observer	Day

3 Mission Achievements

A total of 8 objectives were outlined during the planning stages of the TEL2024880 mission (see Table 2). The primary objective of the mission, to collect spring observations on physical, chemical, and biological oceanographic conditions at the AZMP's core stations on the Browns Bank, Halifax, Louisbourg, and Cabot Strait lines, was considered completed upon conclusion of the mission with the exception of CTD/Rosette and ring net sampling at station LL_08, and ring net sampling at LL_07 and CSL_01, which were cancelled due to inclement weather. A total of 6 objectives were in support of ancillary AZMP activities, including the collection of data and samples in the Gully and St. Anns Bank MPAs, and collection of measurements while underway in support of the Aquatic Climate Change Adaptation Services Program (ACCASP). All 6 ancillary objectives were completed with the exception of the objective to collect oceanographic data in the St. Anns Bank MPA. The details of this are described further in the 3.1 Program Impacts section below.

Surveys conducted by the AZMP support a number of external partnerships and programs. A wildlife observer (Rick Ludkin) collected observations of seabirds and other marine wildlife in support of the Canadian Wildlife Service (CWS) of ECCC's Eastern Canada Seabirds at Sea (ECSAS) monitoring program, established in 2005 (Gjerdrum, Fifield, and Wilhelm 2012). Just prior to sailing, a request was made by Paul Knaga (CWS) to utilize an Autonomous Recording Unit (ARU) during the mission to better understand the offshore distribution and migration patterns of bats as part of a risks assessment for offshore wind development. This fully autonomous system uses microphones to record ultrasonic signals greater than 12 kHz that are produced by bats while echolocating. Acoustic signals were recorded along with a time stamp on an SD card inside the recorder. The ARU was installed on the mast of the vessel in order to maximize its height above the sea surface. During Leg 1 of the mission a bat was sighted directly on the vessel, which also contributed to the project's observational data.

3.1 Program Impacts

The vessel experienced two failures of its gearbox cooler system, as described in the 1 Mission Overview section above. After the first failure, a spare gearbox on board was located and the engineering team immediately began its installation. Repairs were completed by 22:00 ADT on April 10. However, departure was not possible at that point as the engineers exceeded their allowable hours of work, and had to be on standby during the departure procedures in case of further issue. Departure was tentatively reset to 06:30 on Thursday April 11. At 06:30 April 11, the engines were started and the gearbox cooler repair was deemed successful. Overall, this issue resulted in a total of loss of 18.5 hours to the program.

On Tuesday April 23, a second leak from the gearbox cooler was discovered at approximately 22:00 ADT, just 2 hours prior to starting operations at station LL_09 at the end of the Louisbourg Line. While repairs may have been possible at sea, it was deemed too risky given the vessel's distance from shore, and a decision was made to return back to BIO. The vessel arrived at BIO on Thursday April 25 at 07:00 ADT. Repairs were made successfully to the gearbox cooler overnight, and a departure time of 09:00 ADT on Friday April 26 was established. The ship departed shortly after 09:00 on Friday April 26, and headed back towards station LL_09, arriving on April 27 at 18:00 GMT. Given the distance offshore of the vessel when the leak in the gearbox cooler was discovered, and the need to return to that work area after repairs were completed, this second leak resulted in a loss of 88 hours to the program. However, as the mission had a number of contingency days built in to buffer against inclement weather, the majority of the mission's objectives were still accomplished with the exception of sampling within the St. Anns Bank MPA.

Table 2. Primary and secondary objectives of the spring AZMP mission (TEL2024880), and their status upon conclusion of the mission.

Primary	**Status**	**Comment**
Obtain spring 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	CTD/Rosette and net deployments were not possible on station LL_08, and net operations were not possible on stations LL_07 and CSL_01 due to inclement weather.
Secondary	**Status**	**Comment**
Deploy ARGO floats in support of the International Argo Float Program (Contact Dr. Blair Greenan - http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html)	Completed	A total of 2 Argo floats were deployed during the mission.
Nutrients and hydrography across the Northeast Channel and Gulf of Maine as part of NERACOOS Cooperative Agreement (Contact Dr. Dave Hebert - http://www.neracoos.org/).	Completed	All stations on the Northeast Channel and Yarmouth Lines were occupied during the mission.
Carry out hydrographic, chemical and biological sampling at stations in the Gully in support of Gully MPA monitoring initiatives by Oceans and Coastal Management Division (Contact Lindsay Beazley - https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/gully/index-eng.html).	Completed	
Carry out hydrographic, chemical and biological sampling at stations in the St. Anns Bank MPA as a continued monitoring effort in support of Oceans and Coastal Management Division (Contact Lindsay Beazley - https://www.dfo-mpo.gc.ca/oceans/mpa-zpm/stanns-sainteanne/index-eng.html).	Not completed	Due to time constraints, the St. Anns Bank line could not be occupied.
Conduct hydrographic, chemical and biological sampling across the mouth of the Laurentian Channel. This transect has been implemented to enhance our understanding of hydrographic phenomena in support of current modelling efforts (Contact Dr. Dave Brickman - David.Brickman@dfo-mpo.gc.ca).	Completed	

Secondary	Status	Comment
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	
External to AZMP	**Status**	**Comment**
Record observations of seabirds and marine mammals for Canadian Wildlife Service of Environment and Climate Change Canada 'Eastern Canada Seabirds at Sea' (ECSAS) monitoring program (Contact Carina Gjerdrum - Carina.Gjerdrum@ec.gc.ca)	Completed	
Added Prior to Sailing	**Status**	
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	

4 Description of Operations

Figure 1 and Table 3 provide an overview of operations conducted on the TEL2024880 mission. A summary of the ELOG comments on various issues encountered during operations is provided in the 'Comments' field. A total of 184 gear operations (events) were conducted and 77 unique AZMP stations were occupied. Of the 184 gear events, 1 CTD and 3 ring net operations were aborted due to poor wire angle and/or issues with vessel positioning. See Table 3 for more details.

All planned stations were occupied with the exception of the 6 stations in the St. Anns Bank area (time constraints) and station LL_08 (inclement weather). Ring net operations could also not be completed on stations LL_07 and CSL_01 due to inclement weather. High-frequency station HL_02 on the Halifax Line was occupied 3 times during the mission. Argo floats were released at HL_07 and LL_09.

Although the CCGS *Teleost* has a vessel-mounted ADCP, it was not configured for use on this survey.

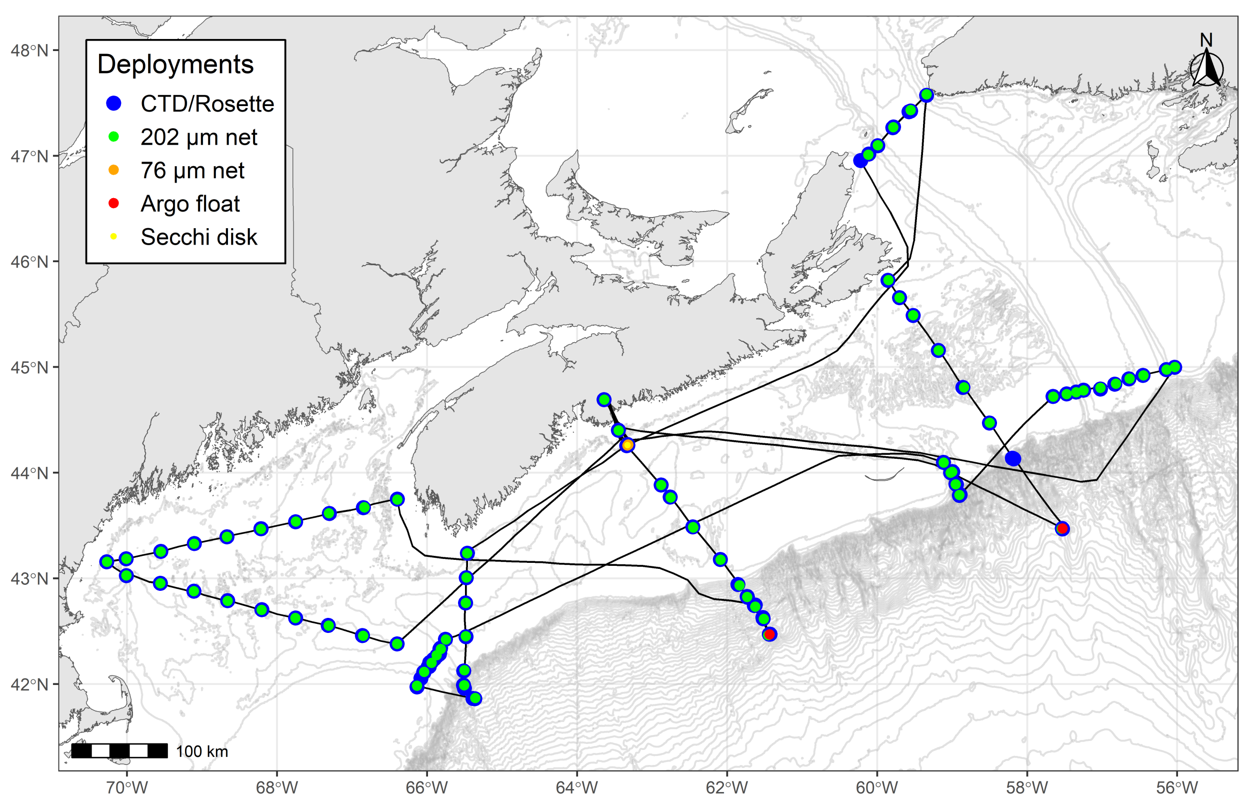

Figure 1. Location of stations sampled and gear deployments made during the 2024 spring AZMP mission (TEL2024880). Note that multiple operations at single stations may not be fully reflected in the map due to overlapping labels.

Table 3. Operations conducted at each station during the 2024 spring AZMP mission (TEL2024880), 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 deployment), Bottom (gear at the bottom), and Recovered (gear recovery). 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	HL_00	CTD/Rosette	44.6925	-63.6424	4/11/2024	62	00:15:36	
2	HL_00	202 µm net	44.6920	-63.6403	4/11/2024	71	00:10:39	
3	HL_01	202 µm net	44.4011	-63.4492	4/11/2024	86	00:08:19	
4	HL_01	CTD/Rosette	44.4025	-63.4496	4/11/2024	91	00:15:08	
5	HL_02	202 µm net	44.2620	-63.3203	4/11/2024	161	00:11:27	Aborted: wire angle astern - hooked net on bottom of ship - 5kt wind speed and flat sea state
6	HL_02	202 µm net	44.2610	-63.3248	4/11/2024	159	00:10:07	
7	HL_02	Secchi disk	44.2606	-63.3268	4/11/2024	159	00:00:13	
8	HL_02	76 µm net	44.2594	-63.3309	4/11/2024	155	00:08:50	
9	HL_02	CTD/Rosette	44.2555	-63.3402	4/11/2024	148	00:21:05	Recovered: Recovered entered early by accident.
10	HL_03	202 µm net	43.8833	-62.8818	4/11/2024	264	00:20:14	Recovered: router failed, no sounding or position, enteted manually

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
11	HL_03	CTD/Rosette	43.8846	-62.8818	4/11/2024	264	00:33:00	Deployed: router failed, no sounding or position, enteted manually Bottom: router failed, no sounding or position, enteted manually Recovered: router failed, no sounding or position, enteted manually
12	HL_03.3	202 µm net	43.7653	-62.7528	4/11/2024	206	00:13:40	
13	HL_03.3	CTD/Rosette	43.7709	-62.7615	4/11/2024	207	00:34:06	
14	HL_04	202 µm net	43.4809	-62.4523	4/12/2024	86	00:07:15	Aborted: cross bow slid down. re-doing net
15	HL_04	202 µm net	43.4856	-62.4542	4/12/2024	85	00:05:14	
16	HL_04	CTD/Rosette	43.4887	-62.4581	4/12/2024	84	00:29:16	Recovered: changed out seapoint new xmlcon file TEL2024880_April11. xmlcon
17	HL_05	202 µm net	43.1775	-62.0892	4/12/2024	101	00:06:39	
18	HL_05	CTD/Rosette	43.1803	-62.0913	4/12/2024	101	00:27:56	
19	HL_05.5	202 µm net	42.9337	-61.8362	4/12/2024	323	00:27:13	
20	HL_05.5	CTD/Rosette	42.9432	-61.8571	4/12/2024	423	00:41:39	
21	HL_06	202 µm net	42.8245	-61.7336	4/12/2024	859	00:55:52	
22	HL_06	CTD/Rosette	42.8227	-61.7305	4/12/2024	1089	01:06:19	Deployed: .xmlcon file changed to TEL2024880_April12 deckunit.xmlcon

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
23	HL_06	CTD/Rosette	42.8287	-61.7333	4/12/2024	1093	00:08:48	Recovered: Soak depth > 10 m
24	HL_07	202 µm net	42.4644	-61.4522	4/12/2024	963	00:54:56	
25	HL_07	CTD/Rosette	42.4719	-61.4382	4/12/2024	971	01:12:45	
26	HL_07	CTD/Rosette	42.4717	-61.4281	4/12/2024	1042	00:10:15	Recovered: Soak depth > 10 m.
27	HL_07	Argo float	42.4698	-61.4349	4/12/2024	939	00:08:01	
28	HL_06.7	202 µm net	42.6167	-61.5134	4/12/2024	1475	00:53:52	
29	HL_06.7	CTD/Rosette	42.6301	-61.5259	4/12/2024	1660	01:33:59	Bottom: soak at 20m. spike in secondary salinity around 50m on decent. difference in salinity went to about -0.31 below 70m. difference got better at 150m. sounding was an estimate
30	HL_06.7	CTD/Rosette	42.6190	-61.5201	4/13/2024	1230	00:15:09	Deployed: .xmlcon file changed to TEL2024880_April12_du_pH.xmlcon
31	HL_06.3	202 µm net	42.7319	-61.6249	4/13/2024	1483	00:57:03	
32	HL_06.3	CTD/Rosette	42.7446	-61.6398	4/13/2024	1569	01:51:48	Recovered: recovered sent later. bottle 11 (sample ID 503172) didn't close fully. got caught on the frame.
33	HL_06.3	CTD/Rosette	42.7480	-61.6261	4/13/2024	1575	00:10:12	Recovered: Soak depth > 10 m
34	YL_01	202 µm net	43.7470	-66.3987	4/14/2024	76	00:06:34	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
35	YL_01	CTD/Rosette	43.7506	-66.3980	4/14/2024	74	00:22:58	
36	YL_02	202 µm net	43.6738	-66.8368	4/14/2024	120	00:15:35	Deployed: moved 0.25 Nm off station to safely avoid fishing gear
37	YL_02	202 µm net	43.6709	-66.8358	4/14/2024	113	00:06:04	Deployed: moved 0.25 Nm off station to safely avoid fishing gear Recovered: Flow meter start slightly inaccurate due to aborted tow prior to this tow.
38	YL_02	CTD/Rosette	43.6699	-66.8502	4/14/2024	122	00:21:19	
39	YL_03	202 µm net	43.6167	-67.3090	4/14/2024	182	00:11:26	
40	YL_03	CTD/Rosette	43.6155	-67.3045	4/14/2024	170	00:26:42	
41	YL_04	202 µm net	43.5373	-67.7493	4/14/2024	203	00:12:08	
42	YL_04	CTD/Rosette	43.5352	-67.7525	4/14/2024	239	00:31:51	
43	YL_05	202 µm net	43.4682	-68.2168	4/14/2024	178	00:08:33	
44	YL_05	CTD/Rosette	43.4703	-68.2153	4/14/2024	178	00:04:13	Aborted: bridge wanted to reposition
45	YL_05	CTD/Rosette	43.4703	-68.2138	4/14/2024	177	00:25:53	
46	YL_06	202 µm net	43.3938	-68.6703	4/14/2024	126	00:07:29	
47	YL_06	CTD/Rosette	43.3934	-68.6701	4/14/2024	130	00:28:22	
48	YL_07	202 µm net	43.3286	-69.1065	4/15/2024	151	00:08:06	
49	YL_07	CTD/Rosette	43.3306	-69.1049	4/15/2024	149	00:29:32	
50	YL_08	202 µm net	43.2540	-69.5502	4/15/2024	149	00:09:38	
51	YL_08	CTD/Rosette	43.2552	-69.5509	4/15/2024	144	00:28:12	
52	YL_09	202 µm net	43.1852	-70.0094	4/15/2024	92	00:06:39	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
53	YL_09	CTD/Rosette	43.1859	-70.0141	4/15/2024	89	00:22:25	
54	YL_10	202 µm net	43.1571	-70.2698	4/15/2024	122	00:07:16	
55	YL_10	CTD/Rosette	43.1574	-70.2725	4/15/2024	124	00:18:48	
56	PL_01	202 µm net	43.0277	-70.0106	4/15/2024	129	00:08:08	
57	PL_01	CTD/Rosette	43.0272	-70.0092	4/15/2024	134	00:21:50	
58	PL_02	202 µm net	42.9543	-69.5578	4/15/2024	163	00:08:38	
59	PL_02	CTD/Rosette	42.9548	-69.5565	4/15/2024	164	00:24:06	
60	PL_03	202 µm net	42.8790	-69.1093	4/15/2024	169	00:03:42	Recovered: deployment action not logged on tablet.
61	PL_03	CTD/Rosette	42.8805	-69.1092	4/15/2024	174	00:25:10	
62	PL_04	202 µm net	42.7882	-68.6585	4/15/2024	197	00:10:31	
63	PL_04	CTD/Rosette	42.7899	-68.6605	4/15/2024	200	00:26:34	
64	PL_05	202 µm net	42.7029	-68.2062	4/15/2024	185	00:11:35	
65	PL_05	CTD/Rosette	42.7047	-68.2032	4/15/2024	180	00:30:59	
66	PL_06	202 µm net	42.6254	-67.7566	4/16/2024	199	00:14:59	
67	PL_06	CTD/Rosette	42.6254	-67.7527	4/16/2024	193	00:33:43	
68	PL_07	202 µm net	42.5542	-67.3142	4/16/2024	292	00:17:08	
69	PL_07	CTD/Rosette	42.5547	-67.3199	4/16/2024	291	00:44:39	
70	PL_08	202 µm net	42.4578	-66.8550	4/16/2024	326	00:20:43	
71	PL_08	CTD/Rosette	42.4584	-66.8627	4/16/2024	327	00:50:07	
72	PL_09	202 µm net	42.3801	-66.4017	4/16/2024	264	00:16:55	
73	PL_09	CTD/Rosette	42.3805	-66.4017	4/16/2024	263	00:32:54	
74	HL_02	202 µm net	44.2666	-63.3195	4/18/2024	154	00:10:54	
75	HL_02	76 µm net	44.2670	-63.3205	4/18/2024	157	00:09:08	
76	HL_02	CTD/Rosette	44.2671	-63.3264	4/18/2024	160	00:36:27	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
77	BBL_01	202 µm net	43.2381	-65.4670	4/18/2024	70	00:02:26	Deployed: Moved off station to avoid fishing gear Bottom: deployed submitted slightly late
78	BBL_01	CTD/Rosette	43.2379	-65.4636	4/18/2024	70	00:18:52	Bottom: started seasave late - almost at soak Bottom: around 50m on descent appear to have sucked somthing into primary sensor plumbing - primary PSAL and DOXY unreliable for remainder of cast
79	BBL_02	202 µm net	43.0094	-65.4764	4/18/2024	120	00:06:44	
80	BBL_02	CTD/Rosette	43.0071	-65.4778	4/18/2024	120	00:23:12	
81	BBL_03	202 µm net	42.7677	-65.4839	4/18/2024	109	00:05:41	
82	BBL_03	CTD/Rosette	42.7688	-65.4889	4/18/2024	108	00:22:01	
83	BBL_04	202 µm net	42.4531	-65.4841	4/18/2024	102	00:06:23	
84	BBL_04	CTD/Rosette	42.4481	-65.4830	4/18/2024	102	00:27:10	
85	BBL_05	202 µm net	42.1312	-65.5031	4/19/2024	167	00:12:26	
86	BBL_05	CTD/Rosette	42.1252	-65.5131	4/19/2024	193	00:37:01	
87	BBL_06	202 µm net	41.9886	-65.5064	4/19/2024	1106	00:55:24	
88	BBL_06	CTD/Rosette	41.9609	-65.5027	4/19/2024	1196	01:21:02	Bottom: pH sensor appeared to stop working around 960m on downcast
89	BBL_06	CTD/Rosette	41.9910	-65.5157	4/19/2024	1103	00:11:15	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
90	BBL_07	202 µm net	41.8687	-65.3577	4/19/2024	1826	01:03:10	Recovered: Net was towed up at 30 m/min instead of 50 m/min due to winch communication error
91	BBL_07	CTD/Rosette	41.8645	-65.3908	4/19/2024	1813	01:19:15	
92	BBL_07	CTD/Rosette	41.8619	-65.3636	4/19/2024	1837	00:08:27	Recovered: winch operator overshot 10m bottle - had to go back down a couple metres
93	NEC_10	202 µm net	41.9832	-66.1356	4/19/2024	93	00:00:32	Recovered: Elog entries made late. variable wire angle.
94	NEC_10	CTD/Rosette	41.9732	-66.1357	4/19/2024	92	00:19:34	Deployed: New .xmlcon file TEL2024880_April19_pH .xmlcon for change in pH sensor to 1258
95	NEC_09	CTD/Rosette	42.0544	-66.0821	4/19/2024	95	00:20:14	
96	NEC_08	202 µm net	42.1150	-66.0401	4/19/2024	196	00:11:12	
97	NEC_08	CTD/Rosette	42.1119	-66.0416	4/19/2024	201	00:29:27	
98	NEC_08	CTD/Rosette	42.1125	-66.0457	4/19/2024	194	00:03:15	
99	NEC_07	CTD/Rosette	42.1617	-65.9859	4/19/2024	221	00:40:23	
100	NEC_07	CTD/Rosette	42.1662	-65.9711	4/19/2024	221	00:03:43	
101	NEC_06	202 µm net	42.2017	-65.9427	4/19/2024	224	00:11:57	
102	NEC_06	CTD/Rosette	42.2021	-65.9644	4/19/2024	225	00:41:48	
103	NEC_06	CTD/Rosette	42.2050	-65.9477	4/19/2024	225	00:04:04	
104	NEC_05	CTD/Rosette	42.2339	-65.9152	4/20/2024	233	00:41:28	
105	NEC_05	CTD/Rosette	42.2387	-65.9047	4/20/2024	234	00:04:16	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
106	NEC_04	202 µm net	42.2733	-65.8724	4/20/2024	225	00:13:26	
107	NEC_04	CTD/Rosette	42.2716	-65.8684	4/20/2024	223	00:37:59	
108	NEC_04	CTD/Rosette	42.2698	-65.8649	4/20/2024	224	00:03:50	
109	NEC_03	CTD/Rosette	42.2835	-65.8368	4/20/2024	213	00:44:51	
110	NEC_03	CTD/Rosette	42.2958	-65.8335	4/20/2024	213	00:05:28	
111	NEC_02	202 µm net	42.3325	-65.8179	4/20/2024	205	00:13:03	
112	NEC_02	CTD/Rosette	42.3323	-65.8299	4/20/2024	205	00:39:44	
113	NEC_02	CTD/Rosette	42.3411	-65.8203	4/20/2024	204	00:03:55	
114	NEC_01	202 µm net	42.4213	-65.7495	4/20/2024	99	00:05:57	
115	NEC_01	CTD/Rosette	42.4249	-65.7558	4/20/2024	99	00:22:42	
116	GUL_01	202 µm net	44.0975	-59.1143	4/21/2024	552	00:33:24	
117	GUL_01	CTD/Rosette	44.0978	-59.1174	4/21/2024	662	00:46:59	Deployed: New .xmlcon file TEL2024880_April21_O2.xmlcon for this cast. Secondary O2 sensor replaced.
118	GULD_03	202 µm net	44.0013	-59.0223	4/21/2024	418	00:20:56	
119	GULD_03	CTD/Rosette	44.0001	-59.0205	4/21/2024	440	00:51:17	
120	GUL_02	202 µm net	44.0096	-59.0000	4/22/2024	1101	00:46:08	
121	GUL_02	CTD/Rosette	44.0108	-58.9972	4/22/2024	1061	01:13:06	
122	GUL_02	CTD/Rosette	44.0089	-58.9947	4/22/2024	1123	00:04:13	
123	GUL_03	202 µm net	43.8904	-58.9526	4/22/2024	1659	00:50:22	
124	GUL_03	CTD/Rosette	43.8924	-58.9505	4/22/2024	1542	01:18:47	
125	GUL_03	CTD/Rosette	43.8895	-58.9440	4/22/2024	1599	00:03:51	
126	GUL_04	202 µm net	43.7893	-58.9049	4/22/2024	1957	00:53:14	
127	GUL_04	CTD/Rosette	43.7855	-58.9050	4/22/2024	2018	01:16:51	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
128	GUL_04	CTD/Rosette	43.7916	-58.8951	4/22/2024	1977	00:03:01	
129	LCM_01	202 µm net	44.7202	-57.6543	4/22/2024	34	00:02:05	
130	LCM_01	CTD/Rosette	44.7216	-57.6556	4/22/2024	34	00:09:36	Deployed: replaced secondary oxygen sensor - new xmlcon named TEL2024880_April22_ O2.xmlcon
131	LCM_02	202 µm net	44.7450	-57.4742	4/22/2024	55	00:03:52	
132	LCM_02	CTD/Rosette	44.7465	-57.4742	4/22/2024	56	00:17:21	
133	LCM_03	202 µm net	44.7628	-57.3484	4/22/2024	74	00:04:35	
134	LCM_03	CTD/Rosette	44.7641	-57.3471	4/22/2024	77	00:21:19	
135	LCM_04	202 µm net	44.7803	-57.2504	4/22/2024	397	00:20:28	
136	LCM_04	CTD/Rosette	44.7817	-57.2503	4/22/2024	400	00:46:23	
137	LCM_05	202 µm net	44.8038	-57.0246	4/23/2024	425	00:24:19	
138	LCM_05	CTD/Rosette	44.7923	-57.0252	4/23/2024	424	00:45:25	
139	LCM_06	202 µm net	44.8430	-56.8181	4/23/2024	418	00:24:23	
140	LCM_06	CTD/Rosette	44.8379	-56.8334	4/23/2024	418	00:47:46	
141	LCM_07	202 µm net	44.8906	-56.6370	4/23/2024	407	00:22:59	
142	LCM_07	CTD/Rosette	44.8895	-56.6469	4/23/2024	407	00:41:16	
143	LCM_08	202 µm net	44.9216	-56.4503	4/23/2024	387	00:24:05	
144	LCM_08	CTD/Rosette	44.9207	-56.4582	4/23/2024	388	00:42:00	
145	LCM_09	202 µm net	44.9775	-56.1434	4/23/2024	271	00:12:09	
146	LCM_09	CTD/Rosette	44.9761	-56.1471	4/23/2024	234	00:33:26	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
147	LCM_09	202 µm net	44.9998	-56.0322	4/23/2024	113	00:05:55	Aborted: End flow rate unknown. Net aborted and did not write down flow rate before sending net down again.
148	LCM_10	202 µm net	44.9996	-56.0313	4/23/2024	102	00:05:28	Recovered: No start flow rate. Had to abort net before this and did not write down flow rate before sending it down again.
149	LCM_10	CTD/Rosette	44.9984	-56.0344	4/23/2024	102	00:23:22	
150	LL_09	202 µm net	43.4706	-57.5426	4/27/2024	3586	00:55:17	
151	LL_09	CTD/Rosette	43.4691	-57.5307	4/27/2024	3355	01:15:50	Deployed: extended soak and went deeper during soak (20m) to allow ship to safely come about to correct wire angle
152	LL_09	CTD/Rosette	43.4727	-57.5316	4/27/2024	3852	00:06:53	
153	LL_09	Argo float	43.4721	-57.5298	4/27/2024	3009	00:11:06	
154	LL_07	CTD/Rosette	44.1383	-58.1997	4/28/2024	825	01:07:02	Recovered: net was cancelled for this station due to weather. we designated 503794 prior to getting on station so there will be nothing associated with that ID.
155	LL_07	CTD/Rosette	44.1312	-58.1811	4/28/2024	707	00:05:04	
156	LL_06	202 µm net	44.4721	-58.5011	4/28/2024	65	00:03:54	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
157	LL_06	CTD/Rosette	44.4715	-58.5052	4/28/2024	65	00:17:16	
158	LL_05	202 µm net	44.8081	-58.8443	4/28/2024	258	00:15:13	
159	LL_05	CTD/Rosette	44.8078	-58.8583	4/28/2024	259	00:33:26	
160	LL_04	202 µm net	45.1582	-59.1805	4/28/2024	104	00:05:56	
161	LL_04	CTD/Rosette	45.1591	-59.1861	4/28/2024	105	00:22:15	
162	LL_03	202 µm net	45.4902	-59.5200	4/28/2024	140	00:06:58	
163	LL_03	CTD/Rosette	45.4883	-59.5196	4/28/2024	139	00:25:43	
164	LL_02	202 µm net	45.6582	-59.7025	4/28/2024	139	00:10:26	
165	LL_02	CTD/Rosette	45.6569	-59.7038	4/28/2024	137	00:25:12	
166	LL_01	202 µm net	45.8242	-59.8522	4/28/2024	94	00:06:28	
167	LL_01	CTD/Rosette	45.8220	-59.8565	4/28/2024	90	00:22:11	
168	CSL_06	202 µm net	47.5811	-59.3410	4/29/2024	262	00:14:07	
169	CSL_06	CTD/Rosette	47.5727	-59.3412	4/29/2024	266	00:39:03	
170	CSL_05	202 µm net	47.4319	-59.5550	4/29/2024	468	00:24:52	
171	CSL_05	CTD/Rosette	47.4243	-59.5564	4/29/2024	470	00:47:53	
172	CSL_05	CTD/Rosette	47.4162	-59.5777	4/29/2024	470	00:15:42	
173	CSL_04	202 µm net	47.2696	-59.7859	4/29/2024	463	00:22:56	
174	CSL_04	CTD/Rosette	47.2660	-59.7924	4/29/2024	460	00:45:45	
175	CSL_04	CTD/Rosette	47.2715	-59.7831	4/29/2024	462	00:05:06	
176	CSL_03	202 µm net	47.1003	-59.9913	4/29/2024	346	00:16:14	
177	CSL_03	CTD/Rosette	47.0943	-59.9914	4/29/2024	328	00:44:13	
178	CSL_03	CTD/Rosette	47.0957	-59.9917	4/29/2024	325	00:04:51	
179	CSL_02	CTD/Rosette	47.0167	-60.1138	4/29/2024	185	00:32:46	
180	CSL_02	202 µm net	47.0102	-60.1202	4/29/2024	171	00:08:38	

Table 3. *(continued)*

Event	Station	Gear	Start Lat. (DD)	Start Lon. (DD)	Date	Mean Depth (m)	Duration	Comments
181	CSL_01	CTD/Rosette	46.9548	-60.2208	4/30/2024	81	00:21:11	Recovered: messed up filename in seasave. put 880a180 should be 880a181
182	HL_02	202 µm net	44.2657	-63.3178	5/1/2024	151	00:10:29	
183	HL_02	76 µm net	44.2641	-63.3195	5/1/2024	155	00:09:19	
184	HL_02	CTD/Rosette	44.2604	-63.3248	5/1/2024	160	00:29:44	

4.1 CTD/Rosette Operations

Two SBE 9plus Conductivity-Temperature-Depth (CTD) systems and associated sensors were configured for use on the mission; one that would serve as the primary system, and one spare. Table 4 provides details on the sensors mounted on the primary CTD used on the mission and any replacement sensors. The CTD and its associated sensors were configured in a horizontal position within its stainless steel protective cage, and mounted within the extension stand located at the bottom of the bottle mount stand. This configuration would allow for easy removal and replacement of the CTD system should malfunction occur. The SBE 9plus was used with the SBE 11 deckbox, completing the SBE 911plus package. The deckbox was installed in a rack along with the CTD acquisition computer, and mounted on a counter in the Winch Staging Area.

Wireless CTD and plankton block systems fabricated by the Ocean Engineering and Technology Section (OETS) were used for CTD/Rosette and ring net deployments during the TEL2024880 mission. The OETS Winch Instrumented Metering Sheave (WIMS) computer-based software was used on the CTD acquisition computer to send commands to the winch operator that could be read from the operator display in the CTD Staging Area. A router was installed near the CTD acquisition computer to create a local network that would facilitate the use of the wireless block systems. The CTD and plankton blocks were switched out between operations by the ship's crew, and charging of the blocks was overseen by mission CTD technicians Adam Hartling, Shawn Roach (Leg 1) and Katie Thistle (Leg 2).

General CTD/Rosette standard operating procedures were followed during the mission. The CTD/Rosette was launched and lowered to 10 m for a 3-minute 'soak' period, which triggers the pump to turn on and allows the sensors to acclimate. After the soak period, the CTD was raised to the surface, and then sent on its downcast. Downcast speed was 60 m/min with the exception of the top 200 m and bottom 200 m, where speeds were decreased to 30 m/min. The CTD/Rosette was lowered to within 5 m from the bottom in good weather, and to 7 or 10 m from bottom during periods of inclement weather. The order of operations at each station was ring net first, followed by CTD/Rosette, in order to allow the water samplers to sample the rosette during the transits between stations, thereby maximizing efficiency.

The rosette carousel and trigger mechanisms functioned exceptionally well throughout the mission, with zero misfires. While the CTD generally performed well, several sensors were replaced during the mission, which resulted in multiple configuration (.xmlcon) files being generated. The original chlorophyll sensor (Seapoint SCF SN 3668) output appeared noisy and consistently increased at approximately 80 m depth. The sensor was changed prior to Event 016. The original pH sensor (SBE 18 SN 1221) failed on Event 022 (station HL_06), and was replaced on Event 026 with another SBE 18 sensor (SN 1214). The replacement sensor also failed and was replaced with SBE 18 SN 1258 on Event 094 (station NEC_10). The original secondary dissolved oxygen sensor (SN 4366) appeared to be drifting relative to the corresponding winkler titration values and primary sensor, and was replaced with sensor SN 0042 prior to Event 117 (station GUL_01). However, upon deployment in the Gully MPA the new secondary oxygen sensor appeared noisy. Although the output seemed to track that of the primary oxygen sensor well, it was decided to change this sensor after Event 128 (station GUL_04) to SN 0133. The procedures used for the evaluation of the dissolved oxygen sensor data relative to the Winkler titration values are detailed in Appendix B.

The Seasave acquisition software was originally configured with the 'NMEA device connected to

PC' setting, which introduced an error in the 'Start_Date_Time' field in processed files. This error was fixed by changing the setting to 'NMEA device connected to deck box'. These issues are further described in section 7 Operational Issues of Note.

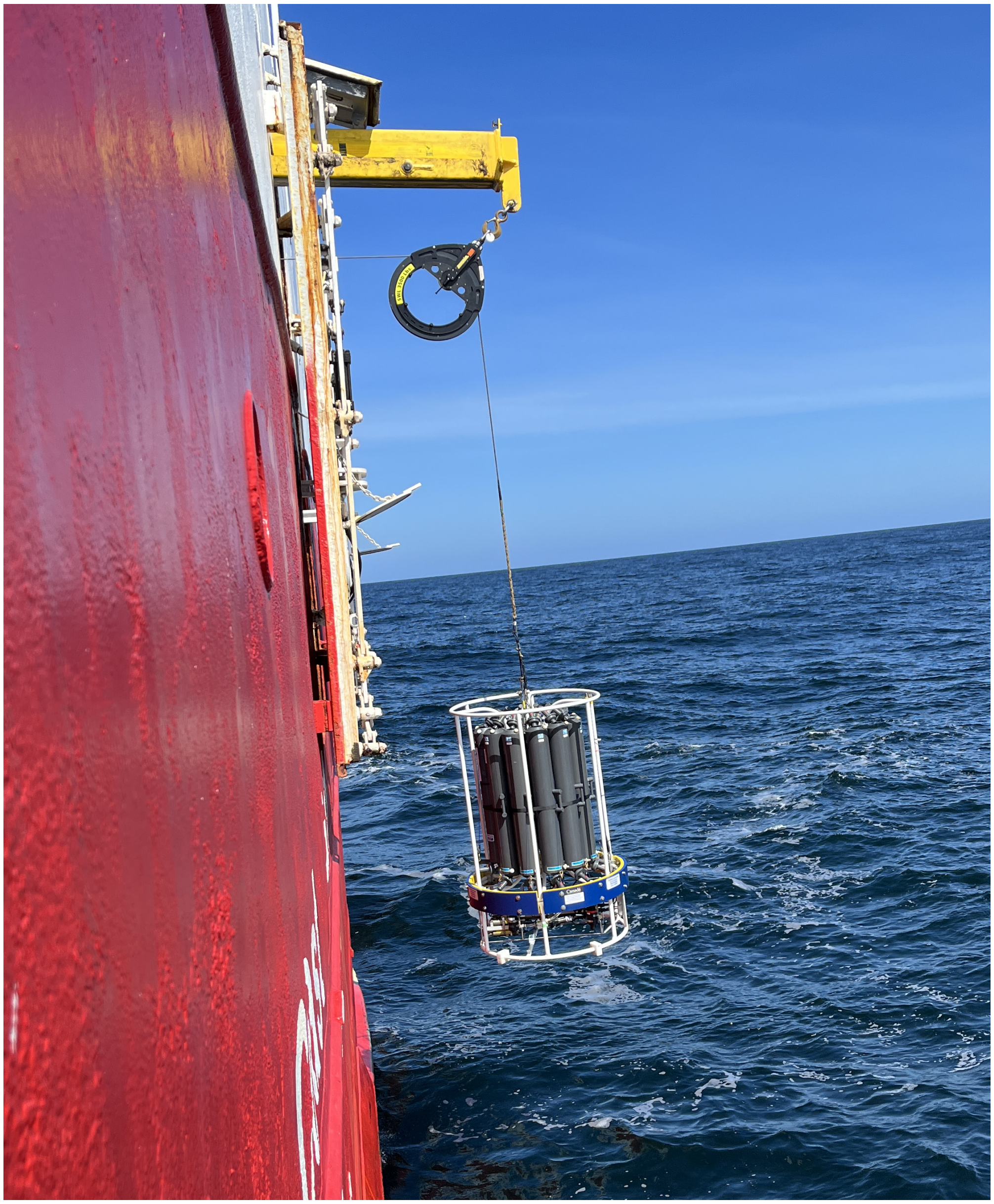

Figure 2. The SeaBird Electronics (SBE) 12-bottle CTD/Rosette system used during the 2024 spring AZMP mission (TEL2024880). The system is pictured being deployed from the CTD Staging Area on board the CCGS *Teleost* using the ship's CTD boom and a custom wireless CTD block.

Table 4. List of sensors included on the CTD system used during the 2024 spring AZMP mission on board the CCGS *Teleost* (TEL2024880). Model number and date of last calibration is shown.

Sensor	Model	Output Parameter	QAT Output Variable Name	Serial No.	Calibration Date	Event Range
Primary temperature	SBE 3	ITS-90 temperature, Celsius	t090C	4807	12/8/2023	001 - 184
Primary conductivity	SBE 4	Conductivity, S/m	c0S/m	4361	12/22/2023	001 - 184
SBE9plus pressure	SBE 9	dbar	prDM	1217	3/24/2023	001 - 184
Secondary temperature	SBE 3	ITS-90 temperature, Celsius	t190C	5081	2/29/2024	001 - 184
Secondary conductivity	SBE 4	Conductivity, S/m	c1S/m	1874	12/14/2023	001 - 184
Altimeter	VA500	metres	altM	62184	11/30/2018	001 - 184
Irradiance (PAR-log)	SAT-QR-99019	micromoles photons/m2/s	par	1043	12/1/2015	001 - 184
Primary dissolved oxygen	SBE 43	Dissolved oxygen, ml/l	sbeox0V	3026	1/3/2024	001 - 184
Secondary dissolved oxygen	SBE 43	Dissolved oxygen, ml/l	sbeox1V	4366	3/1/2024	001 - 115
Secondary dissolved oxygen	SBE 43	Dissolved oxygen, ml/l	sbeox1V	42	3/9/2024	117 - 128
Secondary dissolved oxygen	SBE 43	Dissolved oxygen, ml/l	sbeox1V	133	3/9/2024	130 - 184
CDOM fluorescence	SUVF	ppb	flspuv0	6225	2/1/2024	001 - 184
Chlorophyll fluorescence	SCF	micro g/L	flsp	3668	2/1/2024	001 - 013
Chlorophyll fluorescence	SCF	micro g/L	flsp	3867	2/1/2024	016 - 184

Table 4. *(continued)*

Sensor	Model	Output Parameter	QAT Output Variable Name	Serial No.	Calibration Date	Event Range
pH	SBE 18	NA	ph	1221	3/7/2024	001 - 026
pH	SBE 18	NA	pH	1214	3/22/2024	029 - 092
pH	SBE 18	NA	pH	1258	3/7/2024	094 - 184
Turbidity	WetLabs ECO BBRTD	m-1/sr-1	TurbWETbb0	1490	2/10/2024	001 - 184
Surface PAR	SPAR (Satlantic)	micromoles photons/m2/s	Spar	1168	11/27/2018	001 - 184

4.1.1 CTD Data Post-Processing

Once a CTD cast was completed, the raw .hex files were post-processed by the CTD Data Acquisition and Processing System (CTDDAP), a wrapper application developed in-house to facilitate the downloading and processing of CTD data collected by various Sea-Bird Scientific (SBE) CTD instruments. CTDDAP applies both the standard SBE processing modules, plus a number of in-house-developed processing modules to the collected data. In particular, CTDDAP facilitates the creation of BIO's in-house CTD file format 'ODF' (Ocean Data Format) through the application of the 'seaODF' module, and other files necessary for the archival and upload of data to DFO's national repository for discrete bottle and plankton data, BioChem. CTDDAP was run after the completion of each CTD cast on the CTD acquisition computer, and the resulting cast profile data was evaluated using the 'seaplot' module.

New configuration files (.xmlcon) were created each time a sensor was changed and loaded into CTDDAP for post-processing. Table 5 provides the range of events associated with each configuration file (.xmlcon) used on the mission, and the reason for creation of each new file.

Table 5. Range of CTD events associated with each CTD configuration file used during the TEL2024880 mission, and the reasoning for file creation.

Configuration File	Event Range	Reason
TEL2024880.xmlcon	001 - 015	Original
TEL2024880_April11.xmlcon	016 - 020	Seapoint chlorophyll fluorometer SN 3668 replaced with SN 3867
TEL2024880_April12 deckunit.xmlcon	022 - 026	NMEA device connected to deck unit instead of PC to fix Start_Date_Time issue in ODFs
TEL2024880_April12_du_pH.xmlcon	029 - 092	pH sensor SN 1221 replaced SN 1214
TEL2024880_April19_pH.xmlcon	094 - 115	pH sensor SN 1214 replaced with SN 1258
TEL2024880_April21_O2.xmlcon	117 - 128	Secondary dissolved oxygen SN 4366 replaced with SN 0042
TEL2024880_April22_O2.xmlcon	130 - 184	Secondary dissolved oxygen SN 002 replaced with SN 0133

4.1.2 Water Sampling

Bottle ID label range for underway sampling: 503002 – 503021
Bottle ID label range for CTD Niskin bottle sampling: 503022 - 503958

Water samples were collected from each station and either preserved on board or processed in the laboratory. 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) were consistently sampled at stations 100 m or less, while deeper bottles were 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, Sabine, and Christian (Eds.). (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 occupations of AZMP high-frequency station HL_02, 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).

On 22 stations, two CTD casts were required in order to sample all planned nominal depths. On stations where two deployments occurred, the deeper cast was conducted first and the shallower cast second, to maximize efficiency. Sampling the rosette and preparing it for subsequent deployment took approximately 25 minutes for most stations. Table 6 shows the total number of samples collected for each parameter measured and evaluated by the AZMP. Bottle samples collected for salinity determination were analyzed at sea using a Guildline Portasal 8410A Salinometer with the corresponding water bath set to 24°C. 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.

4.1.3 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 at the end of this report, in Appendices B and C. Final data calibration will be conducted by DFO's Ocean Data Information Section (ODIS) members 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 6. Summary of water samples collected for each parameter sampled on the 2024 spring AZMP mission (TEL2024880). 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	Cast	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/ PON	HPLC	ABS	CDOM	CYTO
HL_01	4	1	3	5	5	16	2	16	2	1	1	1	16
HL_02_Occupation1	9	1	3	6	6	20	2	18	2	2	2	2	18
HL_03	11	1	3	7	7	22	2	18	2	1	1	1	20
HL_03.3	13	1	3	0	0	20	2	18	2	2	2	2	18
HL_04	16	1	3	5	5	16	2	16	2	1	1	1	16
HL_05	18	1	3	5	5	18	2	18	2	2	2	2	18
HL_05.5	20	1	4	7	7	22	3	18	2	1	1	1	20
HL_06	22	1	7	8	8	22	7	10	0	0	0	0	14
HL_06	23	2	2	3	3	8	1	8	2	2	2	2	8
HL_07	25	1	7	9	9	22	7	10	0	0	0	0	14
HL_07	26	2	1	3	3	8	1	8	2	2	2	2	6
HL_06.7	29	1	7	0	0	22	7	10	0	0	0	0	14
HL_06.7	30	2	2	0	0	8	1	8	2	1	1	1	8
HL_06.3	32	1	3	0	0	22	3	10	0	0	0	0	14
HL_06.3	33	2	1	0	0	6	1	6	2	1	1	1	6
YL_01	35	1	3	5	5	14	2	14	2	1	1	1	14
YL_02	38	1	3	0	0	20	2	18	2	1	1	1	18
YL_03	40	1	3	7	7	22	2	18	2	1	1	1	18
YL_04	42	1	3	0	0	22	2	18	2	1	1	1	18
YL_05	44	1	3	7	7	22	2	18	2	1	1	1	18
YL_06	47	1	3	0	0	20	2	18	2	1	1	1	18

Table 6. *(continued)*

Station	Event	Cast	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/ PON	HPLC	ABS	CDOM	CYTO
YL_07	49	1	3	6	6	20	2	18	2	1	1	1	18
YL_08	51	1	3	6	6	20	2	18	2	1	1	1	18
YL_09	53	1	3	0	0	16	2	16	2	1	1	1	16
YL_10	55	1	3	5	5	18	2	18	2	1	1	1	18
PL_01	57	1	3	5	5	20	2	18	2	1	1	1	18
PL_02	59	1	3	0	0	20	2	18	2	1	1	1	18
PL_03	61	1	3	7	7	22	2	18	2	1	1	1	18
PL_04	63	1	3	0	0	22	2	18	2	1	1	1	18
PL_05	65	1	3	6	6	20	2	18	2	1	1	1	18
PL_06	67	1	3	0	0	22	2	18	2	1	1	1	18
PL_07	69	1	4	8	8	24	3	18	2	1	1	1	18
PL_08	71	1	4	0	0	24	3	18	2	1	1	1	18
PL_09	73	1	4	7	7	24	3	18	2	1	1	1	18
HL_02_Occupation2	76	1	3	6	6	20	2	18	2	2	2	2	18
BBL_01	78	1	3	4	4	14	2	14	2	2	2	2	14
BBL_02	80	1	3	0	0	18	2	18	2	1	1	1	18
BBL_03	82	1	3	5	5	18	2	18	2	2	2	2	18
BBL_04	84	1	3	0	0	18	2	18	2	1	1	1	18
BBL_05	86	1	3	6	6	22	2	18	2	2	2	2	18
BBL_06	88	1	3	7	7	24	2	12	0	0	0	0	14
BBL_06	89	2	1	2	2	6	1	6	2	1	1	1	6
BBL_07	91	1	2	8	8	24	2	12	0	1	1	1	18
BBL_07	92	2	2	2	2	6	1	6	2	1	1	1	6
NEC_10	94	1	3	0	0	18	2	18	2	1	1	1	18
NEC_09	95	1	3	5	5	18	2	0	0	0	0	0	0

Table 6. *(continued)*

Station	Event	Cast	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/ PON	HPLC	ABS	CDOM	CYTO
NEC_08	97	1	3	0	0	24	2	16	0	0	0	0	16
NEC_08	98	2	0	0	0	2	0	2	2	1	1	1	2
NEC_07	99	1	3	6	6	24	2	0	0	0	0	0	0
NEC_07	100	2	0	1	1	2	0	0	0	0	0	0	0
NEC_06	102	1	3	0	0	24	2	16	0	0	0	0	16
NEC_06	103	2	0	0	0	2	0	2	2	1	1	1	2
NEC_05	104	1	3	5	5	24	2	0	0	0	0	0	0
NEC_05	105	2	0	1	1	2	0	0	0	0	0	0	0
NEC_04	107	1	3	0	0	24	2	16	0	0	0	0	16
NEC_04	108	2	0	0	0	2	0	2	2	1	1	1	2
NEC_03	109	1	3	5	5	24	2	0	0	0	0	0	0
NEC_03	110	2	0	1	1	2	0	0	0	0	0	0	0
NEC_02	112	1	3	5	5	24	2	0	0	0	0	0	0
NEC_02	113	2	0	1	1	2	0	0	0	0	0	0	0
NEC_01	115	1	3	0	0	18	2	18	2	1	1	1	18
GUL_01	117	1	4	1	1	24	3	18	2	1	1	1	20
GULD_03	119	1	4	1	1	22	3	18	2	1	1	1	18
GUL_02	121	1	4	1	1	24	3	16	0	0	0	0	18
GUL_02	122	2	0	0	0	2	0	2	2	1	1	1	2
GUL_03	124	1	4	1	1	24	3	16	0	0	0	0	20
GUL_03	125	2	0	0	0	2	0	2	2	1	1	1	2
GUL_04	127	1	4	4	4	24	3	16	0	0	0	0	20
GUL_04	128	2	0	1	1	2	0	2	2	1	1	1	2
LCM_01	130	1	3	3	3	8	2	8	2	1	1	1	8
LCM_02	132	1	3	0	0	12	2	12	2	1	1	1	12

Table 6. *(continued)*

Station	Event	Cast	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/ PON	HPLC	ABS	CDOM	CYTO
LCM_03	134	1	3	2	2	16	2	16	2	2	2	2	16
LCM_04	136	1	3	6	6	22	2	18	2	1	1	1	18
LCM_05	138	1	3	6	6	22	2	18	2	2	2	2	18
LCM_06	140	1	3	0	0	22	2	18	2	1	1	1	18
LCM_07	142	1	4	5	5	22	3	18	2	1	1	1	20
LCM_08	144	1	4	0	0	22	2	18	2	1	1	1	20
LCM_09	146	1	3	5	5	20	2	18	2	2	2	2	18
LCM_10	149	1	3	4	4	18	2	18	2	1	1	1	18
LL_09	151	1	1	7	7	24	1	14	0	1	1	1	18
LL_09	152	2	2	2	2	4	1	4	2	1	1	1	4
LL_07	154	1	4	6	6	24	3	16	0	1	1	1	18
LL_07	155	2	0	1	1	2	0	2	2	1	1	1	2
LL_06	157	1	3	0	0	14	2	14	2	1	1	1	14
LL_05	159	1	3	7	7	20	2	20	2	2	2	2	20
LL_04	161	1	3	7	7	18	2	16	2	1	1	1	17
LL_03	163	1	3	7	7	20	2	18	2	2	2	2	18
LL_02	165	1	3	7	7	20	2	18	2	1	1	1	18
LL_01	167	1	3	6	6	18	2	18	2	2	2	2	18
CSL_06	169	1	3	9	9	24	2	18	2	1	1	1	18
CSL_05	171	1	2	9	9	24	2	14	0	1	1	1	16
CSL_05	172	2	2	2	2	4	1	4	2	1	1	1	4
CSL_04	174	1	3	9	9	24	2	14	0	0	0	0	16
CSL_04	175	2	1	2	2	4	1	4	2	1	1	1	4
CSL_03	177	1	4	9	9	24	3	16	0	1	1	1	16
CSL_03	178	2	0	1	1	2	0	2	2	1	1	1	2

Table 6. *(continued)*

Station	Event	Cast	O2	pCO2	TIC/TA	NUTS	SAL	CHL	POC/ PON	HPLC	ABS	CDOM	CYTO
CSL_02	179	1	3	8	8	22	2	18	2	1	1	1	18
CSL_01	181	1	3	6	6	16	2	16	2	2	2	2	16
HL_02_Occupation3	184	1	3	6	6	20	2	18	2	2	2	2	18
NEC_01	NA	1	3	0	0	18	2	18	2	1	1	1	18

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 a hydrostatic winch operated from the winch compartment on the *Teleost*. This winch was fitted with a galvanized steel hydrowire with a thickness of 0.16 inches. Ring nets were equipped with a KC Denmark flow meter, which was used to record the start and end flow for each tow.

During operation, the winch was zeroed once the ring net was submerged at the surface. For casts $<$ 1000 m, the net was lowered to within 4-5 m of the seabed at a speed of 30 metres per minute, which would allow the weight to touch the bottom or hover just over the bottom. The net was then towed up at a speed of 50 metres per minute. The contents of the net were washed down into the cod end using surface seawater either as the net was raised to the doors, or after the net was removed from the hydrowire. The contents were preserved in plastic 500 ml jars with 4% buffered formaldehyde (10% formalin). Net operations at station HL_02 consisted of the standard (202 µm) net deployment and a 76 µm net deployment preserved in formalin. Vertically-stratified zooplankton samples normally collected during occupations of high-frequency station HL_02 were not collected during this mission.

A total of 80 ring net operations were conducted during the mission (see Table 3), including the 76 µm net deployments at station HL_02. Station keeping during net operations, particularly during inclement weather, requires the ship to continuously manage its position to ensure the angle of the hydrowire remains close to zero. Oblique ring net tows may bias sample collection towards certain depths as the net makes its way to the surface. Ring net operations were aborted at station HL_02 (Event 005) and YL_02 (Event 036) due to a strong aft wire angle that resulted in the net being caught on the bottom of the vessel; at station HL_04 (Event 014) after the crossbow slid down the wire during operation; and again on station LCM_10 (Event 147) due to poor wire angle. In all cases, the net was recovered, washed, reset and redeployed. Apart from these aborted events, wire angles typically ranged from 0 to 15 degrees throughout the mission.

The ring net conducted on station BBL_07 (Event 090) was towed up at 30 metres/minute instead of 50 metres/minute, due to a winch room communication error. Due to time contraints the net was not redone, but the issue was documented in ELOG and in the net logsheet for this station.

Historically, the data management routine for 202 µm ring net samples involved assigning the 6-digit sample ID (‘sticky label’) associated with the bottom bottle from the station’s CTD cast to the net sample. Similarly, when a 76 µm ring net sample was collected, the sample ID from the surface CTD bottle was applied. However, this has resulted in confusion in the past, especially in cases when the ring net is conducted prior to the CTD cast. Starting on the TEL2024880 mission, all ring net samples were each given their own unique label. This is described further in the Data Management section below.

4.3 Argo Floats

Two profiling Argo floats were deployed on AZMP stations HL_07 and LL_09, with WMO numbers 4902622 and 4902676 respectively (Table 7). The floats were NKE PROVOR floats equipped with a CTD, oxygen optode, an ECO sensor measuring chlorophyll and optical backscattering. These floats will record vertical profiles from 2000m to the surface every 10 days, with data being delivered and quality controlled in real time, openly available within 24 hours of its collection. The floats should survive for 5 years before their batteries are depleted.

The first profile recorded by each float is shown in Figure 3. Comparison with analogous sensors on the shipboard CTD package are shown except for backscatter. For salinity, oxygen, and chlorophyll, water samples are shown as well.

The CTD profiles were taken just before the time of deployment of the floats. However, the first profile reported by the floats is about 2 days afterwards as the floats take approximately 2 days to sink to depth, and record their profile on the ascent. This is important to keep in mind during comparisons between the CTD sensor data and water samples with the Argo measurements. In general, the float measurements aligned well with the CTD data. At both stations, temperature and salinity sensor data were well aligned across the two platforms in the surface and deep waters. Divergence of the two datasets occurred in the more dynamic parts of the water columns, which can likely be attributed to the temporal and spatial differences between the two. Salinity water samples were well aligned with the CTD data in all cases, and only greatly diverged from the Argo data in two places - in the mid depth at station HL_07 and at the surface of LL_09. At HL_07 there was a corresponding divergence in temperature and oxygen, so these are likely two different parcels of water being measured. At station LL_09, the surface water measured by the CTD and water samples was fresher than the Argo profile data at 10 m depth.

Table 7. Metadata associated with the Argo floats deployed during the Spring AZMP TEL2024880. The WMO and Serial Numbers of each float are provided along with the time and location of deployment.

Station	Model	Deploy. Date	Deploy. Time	Lat. (DD)	Lon. (DD)	WMO	Serial Number
HL_07	PROVOR	4/12/2024	20:42:00	43.4698	-61.4349	4902622	P41305-22CA003
LL_09	PROVOR	4/27/2024	21:23:00	43.4721	-57.5224	4902676	P41305-23CA003

The Argo oxygen data shown here was adjusted using a gain factor calculated by comparing the Argo surface data to the nearest available surface data in the World Ocean Atlas, as described by (Bittig et al. 2018). Argo dissolved oxygen sensor data was very well aligned with the Winkler titration data, with the only major exception being where there were large divergences in temperature data. This is shown more directly in Figure 4 where scatterplots of Argo vs. bottle data can be seen for salinity, oxygen, and chlorophyll.

While the Argo data and chlorophyll fluorometer bottle data do not quantitatively line up particularly well, it is encouraging that the general structure of the profile is agreed upon between the two measurements. Despite best efforts, the manufacturer-provided conversion factor between fluorescence and pigment concentration is variable (Roesler et al. 2017) and absolute values should be considered carefully. Agreement occurred across all measurement platforms of high surface chlorophyll on the Halifax line and comparatively lower concentration on the Louisbourg line.

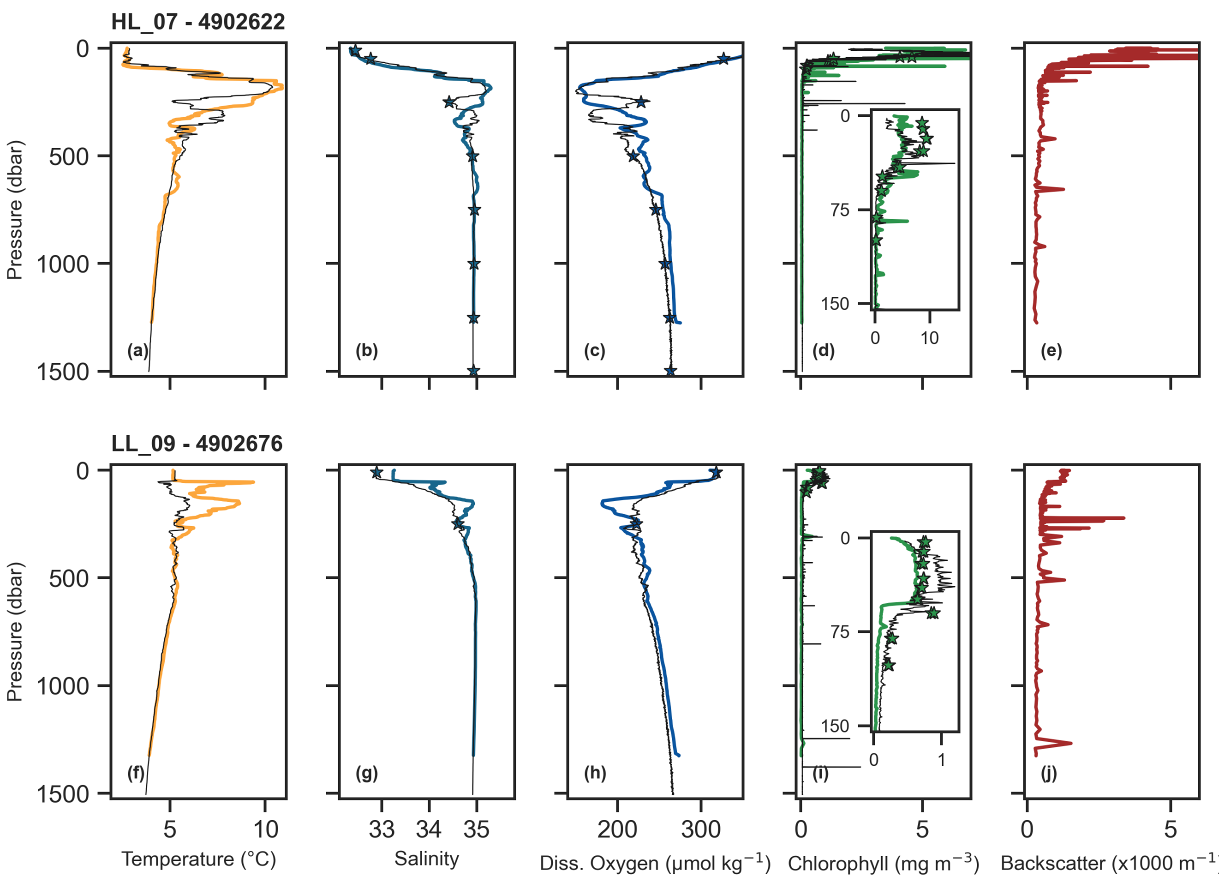

Figure 3. Initial profile for Argo floats 4902622 and 4902676 deployed at stations HL_07 and LL_09 respectively. Solid coloured lines show float data, thin black lines show analogous sensor data from the shipboard CTD package, and stars show water sample data for salinity (Portasal), oxygen (Winkler titrations), and chlorophyll (Turner fluorometry). Insets on the chlorophyll plots (d, i) show the surface layer.

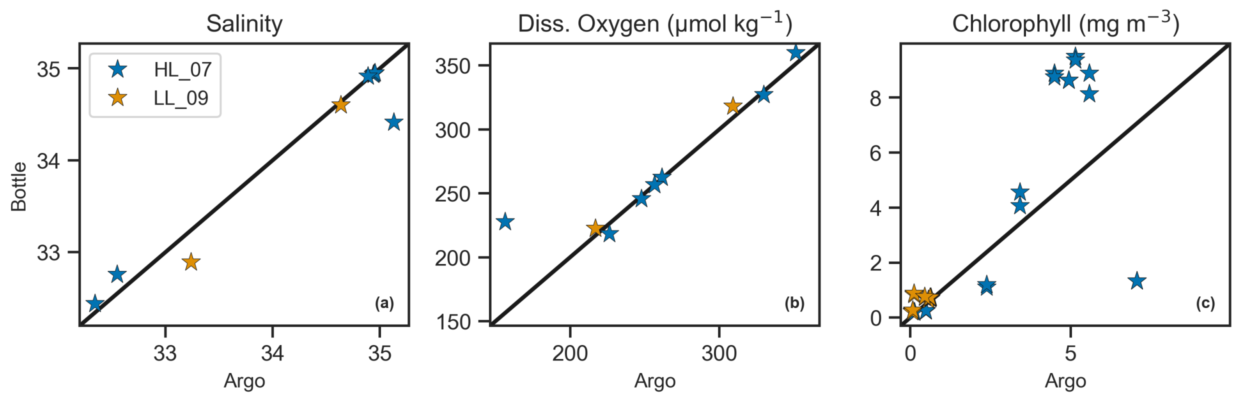

Figure 4. Comparison of Argo sensor data with water samples for the Argo floats deployed and water samples collected at stations HL_07 (blue stars) and LL_09 (orange stars). The black line represents the 1:1 reference line.

4.4 Underway System

The BIO underway system was installed in the Wet Lab on board the *Teleost* (see Figure 5). This system is comprised of three portable tanks containing the following sensors/instrumentation: 1) SBE 21 SeaCAT Thermosalinograph (TSG, tank 1), 2) pH, dissolved oxygen, coloured dissolved organic matter (CDOM), and chlorophyll sensors (tank 2), and a pCO_2 sensor (tank 3). The debubbler was also installed, but a decision was made not to install the air intake line due to the complexity of its installation.

The 'processing' seawater outlet was used as the supply to the underway system, which is the surface seawater outlet normally used for fish catch processing during ecosystem trawl surveys. The outflow of the system was diverted over the side via the ofal shoot, which is used to discard catches. The depth of the intake on the vessel is approximately 7 m below the surface on the bow. The vessel does not have a temperature probe installed at the intake location.

The rate of flow of water through the system was adequate throughout the survey. The flow rate to the TSG was on average 14.43 L/min, while the flow to the pCO_2 sensor was 2.19 L/min.

The uninterrupted power supply (UPS) connected to the TSG computer failed on April 14, and was replaced with a spare UPS. This resulted in a brief pause in data collection. Seasave also failed to acquire the NMEA feed upon daily start-up on several occasions, which also resulted in brief pauses in data collection. These issues are detailed further in the Operational Issues of Note section below.

4.4.1 Daily Underway System Sampling

Daily water samples were collected from the outflow of the underway system for pCO_2, TIC/TA, chlorophyll, dissolved oxygen, salinity, and CDOM determination (see Table 8). The collection of dissolved oxygen and salinity samples will allow for future calibration of the corresponding sensor data. Sample collection occurred at approximately 12:00 ADT each day, depending on the availability of laboratory staff and whether the ship was on station or in transit (with sample collection only occurring during the latter). Samples were not collected on April 13, 17, 25, and 26 as the vessel was either in port or in close proximity to land, or laboratory staff did not have time to collect and process the samples in between stations.

4.4.2 Data Management

Daily .csv files were logged for four data streams (flow rates, NMEA, pCO_2, TSG) separately with a time stamp field based on computer time (in UTC), and encompassed the following variables: intake temperature, TSG temperature, conductivity, fluorescence UV (CDOM), pH, chlorophyll fluorescence, calphase from the optode, and calculated salinity and pCO_2. Routine validation of all sensor data was conducted every 2-3 days to ensure the sensors were performing optimally and that outputs were within the expected range. This was done by running custom R scripts developed by mission data manager Diana Cardoso that included the conversion of optode calphase to dissolved oxygen concentration in ml/L, whilst correcting for *in situ* salinity, and the creation of hourly interpolations that were used for data visualization and plotting (see Figures 6 and 7 below). These plots revealed that the outputs from the Aanderaa oxygen sensor suddenly became noisy starting on April 14. As it was the only optode sensor on board, the sensor could not be replaced. Instead, CTD technician Adam Hartling cleaned Tank 2 and the optode's window, which appeared to remedy the issue and the data returned to normal.

As chlorophyll, dissolved oxygen, and salinity samples were measured on board, these were plotted against the corresponding underway sensors throughout the mission using R scripts (see Figure 8). Daily dissolved oxygen Winkler titration measurements were, on average 0.7067 ± 0.1754 ml/L higher than the corresponding Aanderaa optode sensor values throughout the mission, while there was good congruence between sensor salinity and bottle salinity measurements. Turner chlorophyll *a* measurements were consistently higher than the corresponding sensor values for the first two-thirds of the mission, but were more consistent during the final days of the mission. Higher Turner chlorophyll *a* measurements relative to sensor values is a common observation from CTD cast data, particularly for samples collected at the chlorophyll maximum (~30 m depth; see Appendix D).

Figure 5. The BIO Underway system installed on a bench in the Wet Lab on board the CCGS *Teleost* during the 2024 spring AZMP survey (TEL2024880).

Additional code was developed on this mission to compare and plot the TSG data to the CTD data collected at approximately 7 m (figures not shown). There was good congruence between the salinity bottle data, TSG sensor data, and CTD salinity data, and between the CTD and underway pH sensors. However, the CDOM CTD sensor outputs were variable relative to its corresponding underway sensor, which showed relatively consistent values across the mission. Temperature from the CTD was typically lower than the TSG temperature values, which was likely the result of the warming of water as it passed through the ship and into the TSG tank. The CTD dissolved oxygen and chlorophyll sensor outputs at 7 m depth were consistently higher than their corresponding underway sensor values, but were closer to the bottle measurements.

Table 8. Metadata associated with the collection of water samples from the underway system during the spring 2024 AZMP survey (TEL2024880). 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 (℃) and salinity 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)	pCO2 Flow Rate (L/min)	pCO2	TIC/ TA	CHL	SAL	O2	CDOM
4/11/2024	18:18	44.0491	-63.0796	3.65	31.37	503002	19.0	2.98	X	X	XX	X	X	X
4/13/2024	14:43	43.1230	-63.2950	3.77	31.05	503003	13.0	2.09	X	X	XX	X	X	X
4/14/2024	18:44	43.4892	-68.0528	5.45	31.87	503004	14.2	2.39	X	X	XX	X	X	X
4/15/2024	15:34	42.9041	-69.3050	6.27	31.71	503005	14.4	2.25	X	X	XX	X	X	X
4/16/2024	15:12	42.7349	-65.8561	5.09	31.79	503006	14.0	3.35	X	X	XX	X	X	X
4/18/2024	17:20	43.0955	-65.4779	4.61	31.16	503007	14.8	1.87	X	X	XX	X	X	X
4/19/2024	13:08	41.8994	-65.6217	5.44	31.67	503008	14.9	1.92	X	X	XX	X	X	X
4/20/2024	14:47	42.7010	-64.8781	5.58	31.69	503009	14.6	2.10	X	X	XX	X	X	X
4/21/2024	15:29	44.1805	-59.7157	3.89	31.70	503010	13.2	2.16	X	X	XX	X	X	X
4/22/2024	15:35	44.3010	-58.2510	3.13	31.12	503011	13.3	1.93	X	X	XX	X	X	X
4/23/2024	17:22	44.8353	-56.1896	2.99	32.19	503012	14.8	2.22	X	X	XX	X	X	X
4/24/2024	16:03	44.2798	-60.6731	4.21	31.65	503013	12.4	1.87	X	X	XX	X	X	X
4/27/2024	14:49	43.6679	-58.0805	4.69	32.71	503014	14.9	2.00	X	X	XX	X	X	X
4/28/2024	15:03	45.0381	-59.0593	3.38	31.08	503015	15.2	2.02	X	X	XX	X	X	X
4/29/2024	16:35	47.3083	-59.7341	2.83	30.92	503016	14.1	1.99	X	X	XX	X	X	X
4/30/2024	15:05	45.1370	-60.8971	4.16	30.91	503017	14.1	1.91	X	X	XX	X	X	X

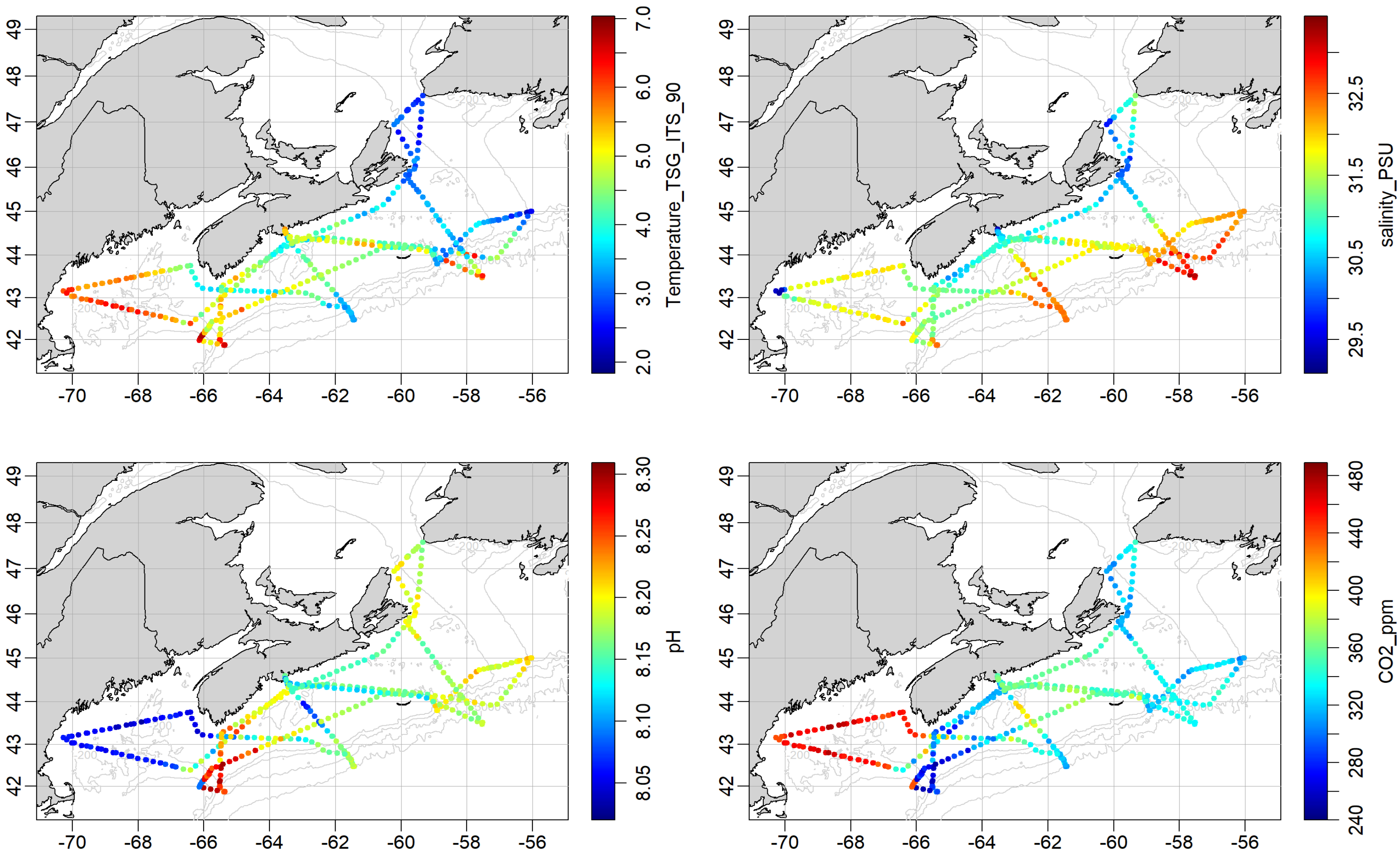

Figure 6. Surface temperature (°C; top left), salinity (PSU; top right), pH (lower left), and the partial pressure of carbon dioxide (pCO_2; lower right) measured along the cruise track during the 2024 spring AZMP mission (TEL2024880). Data are measured at variable intervals and presented as hourly interpolations.

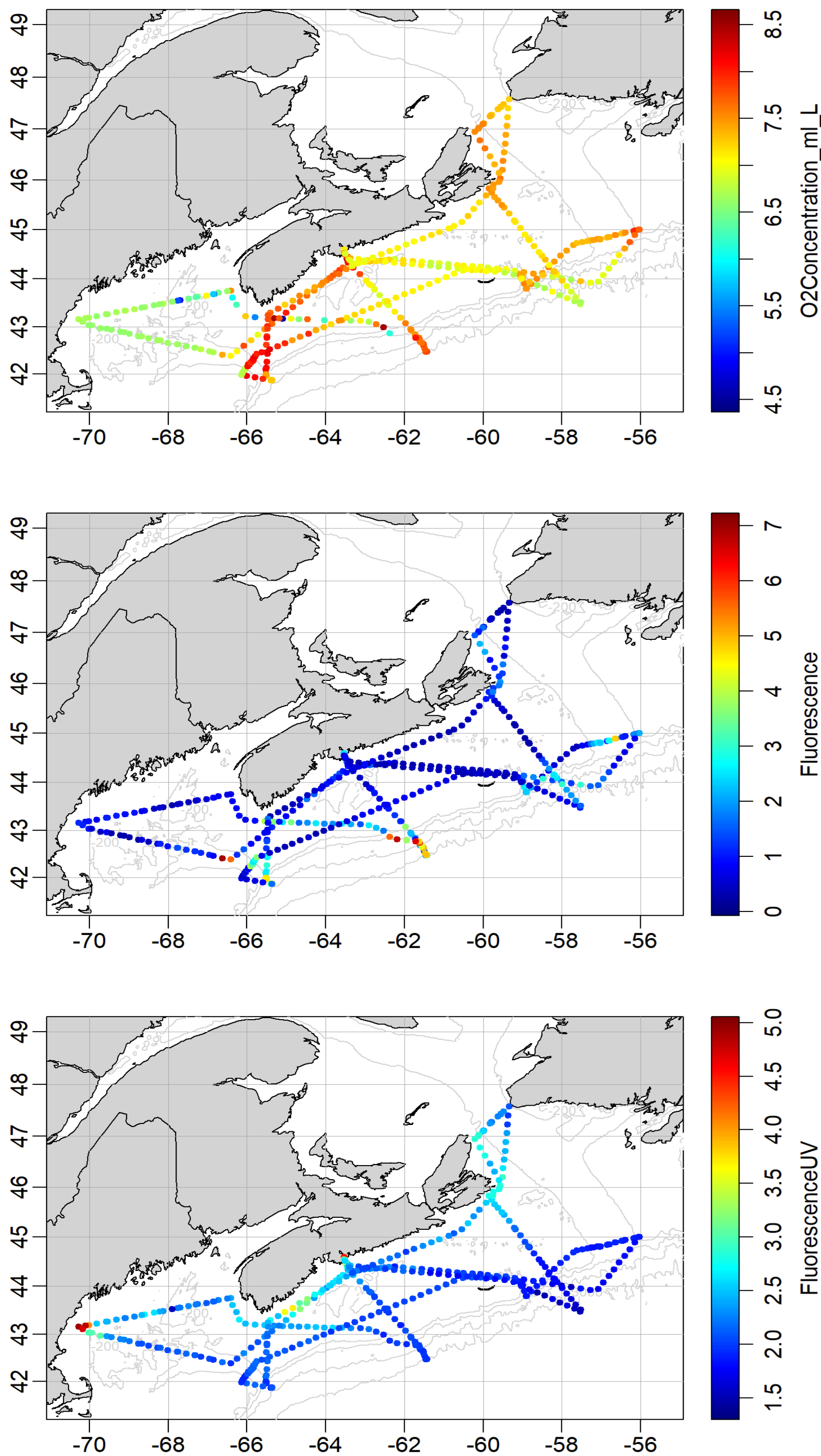

Figure 7. Dissolved oxygen concentration (ml/L; top), chlorophyll fluorescence (μg/L; middle), and CDOM (μg/L; bottom) measured along the cruise track during the 2024 spring AZMP mission (TEL2024880). Data are measured at variable intervals and presented as hourly interpolations.

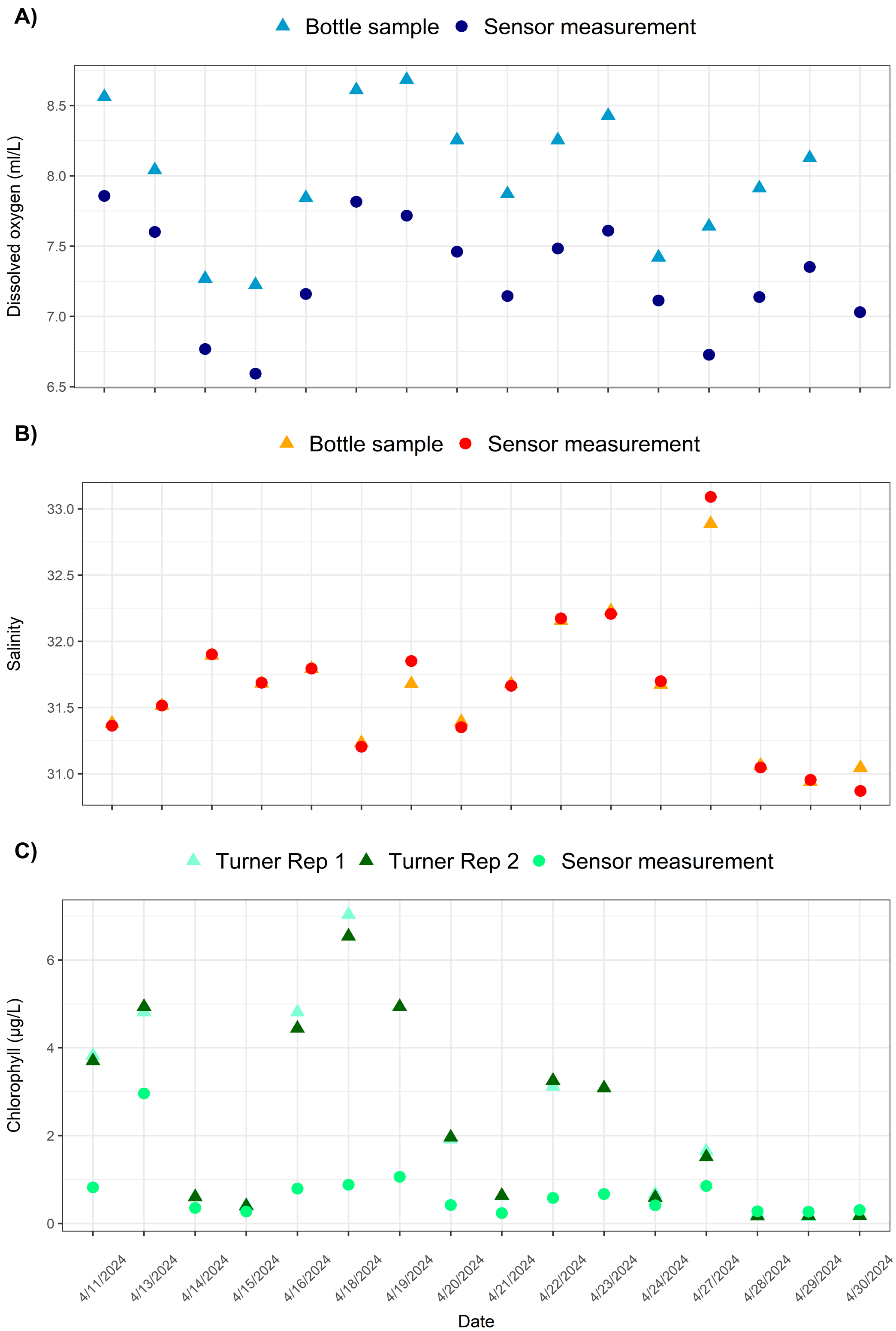

Figure 8. Comparison between bottle samples and sensor measurements of A) dissolved oxygen, B) salinity, and C) chlorophyll collected using the underway system installed on the CCGS *Teleost* during the 2024 spring AZMP survey.

5 Data Management Summary

5.1 Data Collection

The suite of digital data collected during the mission included: CTD sensor data, continuous recordings of surface T/S, pH, pCO_2 and fluorescence by the underway system, digital logs (filter, ELOG), on board analysis of water samples collected at standard depths for salts, oxygen and chlorophyll and GIS. All digital data were backed up daily on external hard drives. At the end of the mission all data were copied and sent to ODIS for archival. Hard-copy paper logs included the CTD deck sheets, ring net and Argo float deployment logs, chlorophyll laboratory logbook and log for samples collected from the underway system. All hard-copy log sheets were scanned upon conclusion of the mission, and sent to the BIO Data Services (DFO.BIODataServices-BIOServicesdeDonnees.MPO@dfo-mpo.gc.ca) archives managed by ODIS.

ELOG, an electronic logbook system for collecting event metadata, was used to log the time, ship's position, and sounding associated with certain logistical aspects of each gear deployment (e.g., deployed, on bottom, and recovered). This electronic logbook was accessible on mobile devices and was run on a laptop in the CTD computer room. In addition an ELOG observations log was used to record detailed comments and observations on cruise activities and an underway log was used to record the samples collected, time and position. All digital logbooks were backed up daily, and at the end of the mission were sent to ODIS for archival.

Digital filtration logs were used by laboratory staff for logging details associated with the processing of collected water. These filtration logs were generated using R scripts, and at the end of the mission a summary of filter volumes was generated for use in laboratory analysis.

Data issues to note:

1. Ring nets were given a unique sample ID instead of the bottom or surface sample ID from the CTD as done on previous missions.
2. The clock for the various computers used to log data (TSG, CTD, ELOG) were not synchronized and therefore time drifted during the mission, up to 20 min by the end.
3. A bridge log was not completed for this mission.

5.2 Hardware and Software

ELOG was run from a Windows 10 laptop in the CTD computer room. A second laptop was placed in the Deck Laboratory and used to populate the digital filtration logs. The GPS and sounder feeds for ELOG were taken from a local network established using a router and existing cables installed between the CTD Staging Area where the CTD/Rosette was deployed and the Winch Compartment Staging Area where the CTD acquisition computer was installed. GPS data was fed into the network through the installation of a GPS system independent of the ship's GPS, and sounder data was read in from the ship's EK80. To read the GPS and sounder feed for ELOG, Python scripts called from the ELOG config. file were used.

5.2.1 DART

Patrick Upson was hired for 2 years as a developer to update the current AZMP Microsoft Access 'Template' database using a more modern programming language with better developer tool support. The resulting application, called the DFO At-Sea Reporting Template (DART) was used to manage all CTD and bottle metadata and measured bottle samples during the TEL2024880 mission. CTD and bottle data checks and all 'bottle' reports were generated using DART. DART performed well and was able to perform all functions required.

5.3 Data Submission to Global Telecommunications Systems

Global Telecommunications Systems (GTS) houses oceanographic data for the primary purpose of weather forecasting. However, the data are also available for modellers to assimilate into their climate forecasting. DFO's representative in GTS is Environment and Climate Change Canada.

AZMP submits data to GTS via MEDS (Marine Environmental Data Section, Ocean Sciences Division) at regular intervals throughout each mission. The data are sent to MEDS-SDMM.XNCR@dfo-mpo.gc.ca, with Luc.Bujold@dfo-mpo.gc.ca in copy. The data must be sent within 30 days of collection.

After each CTD cast is processed using CTDDAP, certain elements of the cast data (depth, temperature, salinity, dissolved oxygen, chlorophyll) are appended to a customized .txt file called an IGOSS (.IGS) file. The cast data are sequentially appended to the bottom of the .IGS file. However, if the data are reprocessed, the second iteration of the cast will also be appended, in addition to the original, resulting in duplicate cast data for the same event. Only the last event for a given station is submitted to MEDS.

Cast data for all CTD events in IGOSS format were sent to MEDS over the course of the mission by chief scientist Lindsay Beazley.

6 Seabirds and Marine Mammal Observations

6.1 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.

6.2 Methods

Seabird surveys were conducted from the port side of the bridge of the CCGS *Teleost* during the Scotian Shelf AZMP from 11 April to 1 May, 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 the snapshot approach for flying birds (intermittent sampling based on the speed of the ship) was used 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, Fifield, and Wilhelm 2012).

6.3 Results

A total of 2945.5 km of ocean was surveyed over 22 days. A total of 2450 marine birds were observed in transect (4287 in total) from 9 families (Table 9). An additional 21 terrestrial birds were also documented (Table 10). Bird density ranged from 0 – 209.7 birds per km^2. The highest densities of birds (> 50 birds per km^2) were observed at the mouth of the Laurentian Channel, southeast of the Gully MPA, on Misaine Bank, in Halifax Harbour, and at the edges of Browns and Georges Banks (Figure 9).

The most abundant family observed were those from Alcidae (42% of the observations), most of which were Common Murre (Table 9). Gulls (primarily Herring Gull and Black-legged Kittiwake) made up 31% of the observations, and Northern Fulmar accounted for 13%. Most of the species observed in high numbers are breeders in the area. A total of 129 marine mammals were also observed during the surveys (Table 11).

Table 9. List of marine bird species observed during visual surveys conducted during the 2024 spring AZMP survey from April 11 to 1 May 2024.

Family	Common Name	Latin	Total No.	No. Observed in Transect
Marine Birds				
Gaviidae	Common Loon	*Gavia immer*	9	4
	Red-throated Loon	*Gavia stellata*	4	3
Procellariidae	Northern Fulmar	*Fulmarus glacialis*	368	276
	Sooty Shearwater	*Ardenna griseus*	139	50
Hydrobatidae	Leach's Storm-Petrel	*Oceanodroma leucorhoa*	129	77
Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*	54	8
Sulidae	Northern Gannet	*Morus bassanus*	166	55
Anatidae	Common Eider	*Somateria mollissima*	165	106
	Surf Scoter	*Melanitta perspicillata*	4	4
	Black Scoter	*Melanitta nigra*	9	6
	White-winged Scoter	*Melanitta fusca*	2	2
	Red-breasted Merganser	*Mergus serrator*	7	1
	American Black Duck	*Anas rubripes*	2	0
	Mallard	*Anas platyrhynchos*	2	0
	Unidentified Ducks	*All duck genera*	49	0
Scolopacidae	Red Phalarope	*Phalaropus fulicaria*	84	84
Laridae	Pomarine Jaeger	*Stercorarius pomarinus*	5	4
	Unidentified Jaegers	*Stercorarius Jaegers*	1	0
	Black-legged Kittiwake	*Rissa tridactyla*	337	133
	Herring Gull	*Larus argentatus*	900	511
	Great Black-backed Gull	*Larus marinus*	107	55
	Lesser Black-backed Gull	*Larus fuscus*	6	2
	Laughing Gull	*Larus atricilla*	4	4
	Bonaparte's Gull	*Larus philadelphia*	2	2
	Ring-billed Gull	*Larus delawarensis*	1	1
	Iceland Gull	*Larus glaucoides*	54	35
	Unidentified Gull	*Larus*	51	0
	Common Tern	*Sterna hirundo*	6	2
Alcidae	Common Murre	*Uria aalge*	1100	843
	Thick-billed Murre	*Uria lomvia*	8	8

Table 9. *(continued)*

Family	Common Name	Latin	Total No.	No. Observed in Transect
	Unidentified Murres	*Uria*	183	13
	Razorbill	*Alca torda*	4	3
	Atlantic Puffin	*Fratercula arctica*	18	8
	Black Guillemot	*Cepphus grylle*	3	3
	Dovekie	*Alle alle*	156	136
	Unidentified Auks	*Alcidae*	148	11
Total			**4287**	**2450**

Table 10. List of terrestrial bird species observed during visual surveys conducted during the 2024 spring AZMP survey from April 11 to May 1, 2024.

Family	Common Name	Latin	Total No.
Terrestrial Birds			
Falconidae	American Kestrel	*Falco sparverius*	1
Regulidae	Golden-crowned Kinglet	*Regulus satrapa*	1
Turdidae	American Robin	*Turdus migratorius*	3
Emberizidae	Song Sparrow	*Melospiza melodia*	2
	White-throated Sparrow	*Zonotrichia albicollis*	2
	Chipping Sparrow	*Spizella passerina*	1
	Dark-eyed Junco	*Junco hyemalis*	8
Icteridae	Eastern Meadowlark	*Sturnella magna*	1
	Common Grackle	*Quiscalus quiscula*	1
Fringillidae	Pine Siskin	*Carduelis pinus*	1
Total			**21**

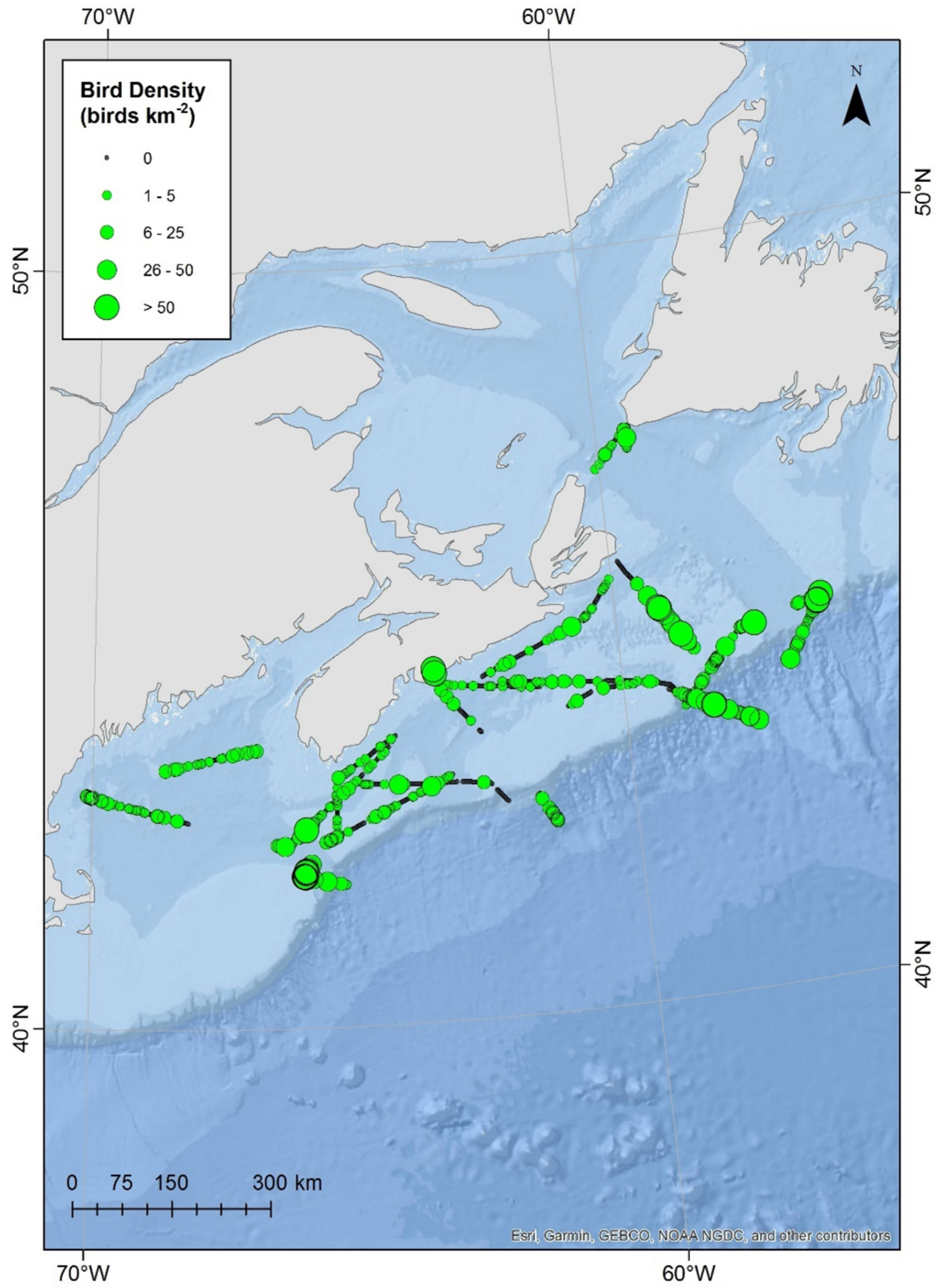

Figure 9. Density of birds (all species combined) observed during visual surveys conducted during the 2024 spring AZMP survey from April 11 to May 1, 2024.

Table 11. List of non-avian species observed during visual surveys conducted during the 2024 spring AZMP survey from April 11 to May 1, 2024.

Common Name	**Latin**	**Total No.**
Marine mammals		
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*	59
Unidentified Dolphin	*Delphinidae*	7
Long-finned Pilot Whale	*Globicephala melas*	20
Humpback Whale	*Megaptera novaeangliae*	9
Minke Whale	*Balaenoptera acutorostrata*	1
Unidentified cetacean	*Cetacea*	5
Gray Seal	*Halichoerus grypus*	1
Unidentified seal	*Phocidae*	7
Total		**129**

7 Operational Issues of Note

This section contains a brief summary of the various operational issues encountered with science equipment and/or data and sample post-processing during the TEL2024880 mission. This information should help to guide both CTD and laboratory post-processing procedures, and future interpretation of the data collected on the mission.

7.1 CTD Operations

1. The 'Start_Date_Time' field in the ODF files was output as '01-JAN-2000' for CTD casts conducted from Events 001 to 020. This was caused by selecting the 'NMEA device connected to PC' option in the 'Configuration for the SBE 911plus/917plus CTD' tab in Seasave. After consultation with Flo Hum, maintainer of the CTDDAP post-processing software, this setting was changed to 'NMEA device connected to deckbox' and the correct 'Start_Date_Time' was output in the ODF files.
2. Event 078 (station BBL_01) occurred in an area with a significant concentration of comb jellies (Phylum Ctenophora). One appeared to have been sucked into the primary sensor pump at the surface during the CTD cast, as the primary temperature, conductivity, and oxygen sensor data suddenly spiked. The pump was flushed upon recovery of the CTD, which remedied the issue. The primary sensor data from this cast should be flagged and the secondary sensor data used.
3. The surface PAR sensor used on the mission was a Satlantic PAR/Log sensor. However, the .xmlcon files were setup with the Satlantic PAR/Log sensor listed as a SPAR Biospherical/Licor sensor. This is because CTDDAP was built on the Seabird Data Processing v7.26.6, which does not support entry of the conversion units for the Satlantic PAR/Log. The output in Seasave was just the voltage of the sensor. CTDDAP should be upgraded in the future to conform with SeaBird's Data Processing v7.26.7, and the CTD data should be reprocessed.
4. The winch brake slipped on a number of CTD casts and had to be re-adjusted. This was noticed while closing bottles during the upcast on several events, and was reported to the chief engineer. No impacts resulted to operations.

7.2 Ring Net Operations

1. The ring net tow conducted on station BBL_07 was towed up at a speed of 30 metres/minute instead of 50 metres/minute, due to a winch room communication error.

7.3 Data and Sample Post-Processing

1. For the second casts conducted at stations in the Northeast Channel (NEC) and Gully MPA (GUL), a surface soak at 10 m depth was not completed as only the surface bottle at

2-3 m depth was required. This caused the following error during post-processing using CTDDAP: “Error:pump status ON was not found determining number of scans to skip in PreProc function. . . ”. PreProc is a setting under the Data Conversion (DATCNV) module that if selected, adds two lines of surface scan information to the header (.hdr) file. The first line written to the .hdr file is the “Pressure Offset”, defined as the first group of 5 consecutive records with salinity values >= 5. The second line is the 24th record after the “Pressure Offset” record. For SBE911plus CTDs, PreProc determines the last scan number where the pump status is off. This is used as the number of scans to skip over in the call to DATCNV. In order to bypass this error in CTDDAP, the PreProc setting was checked off. The ‘Remove the surface soak’ setting under the LoopEdit module was also turned off, given that there was no surface soak. However, it was noted that surface soaks should be completed on all future casts to ensure that the .QAT files contain the highest-quality sensor data as possible for BioChem records.

2. The raw CTD cast data for Event 181 was accidentally labelled as Event 180 in Seasave prior to acquisition, and will require modification prior to final post-processing.

7.4 Underway System

1. The underway system re-starts its logging software every 24 hours, including Seasave. Throughout the mission, Seasave had difficulty acquiring the ship’s NMEA feed after restart, and would not initialize. This resulted in several data gaps throughout the mission. Effort was made to conduct regular checks to ensure the system was operational and logging data.

2. Bottle samples of chlorophyll, salinity, and dissolved oxygen were routinely compared to the sensor values to determine their similarity, and the TSG sensor data was also compared to the CTD sensor data during deployments. These comparisons revealed poor congruence between the TSG chlorophyll fluorometer and both the CTD fluorometer and chlorophyll sample data. Future surveys should aim to collect water samples from the TSG system while a CTD cast is being conducted, in order to remove spatial bias in the comparison to better evaluate the performance of the TSG sensors.

8 Acknowledgements

We would like to thank all science staff of the TEL2024880 mission for their dedication and hard work to make the mission a success. We also thank Commanding Officers Kevin Jones and Todd Mayo, as well as the officers, engineers, and crew of the CCGS *Teleost* 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 arrival and berthage at BIO. 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 would also like to thank Stephanie Clay and Emily O'Grady (DFO Ocean and Ecosystem Sciences Division) for their review of this report. This document was produced using the csasdown R package using RStudio version 2023.12.0 (Team 2023).

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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 to their corresponding laboratory measurements as a means of sensor validation, and B) evaluate the laboratory measurements for outliers.

Plots were generated for each CTD cast using R scripts applied to the ‘bottle reports’ created using the DART application. As the bottle reports are based on the QAT files, the profiles only show the CTD sensor data associated with each bottle closure, and 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.

CTD deployments to collect surface water only (Events 098, 100, 103, 105, 108, 110, 113, 122, 125, 128, 155, and 178) were not included in this assessment, as oxygen and salinity bottle samples were not collected from the surface bottle on these casts. Note that the plot for CTD Event 001, which was a test deployment in the Bedford Basin, displays only the near-bottom cast data, as all bottles were closed near the bottom to test the triggering mechanism of the rosette. No oxygen or salinity bottle samples were collected on this cast.

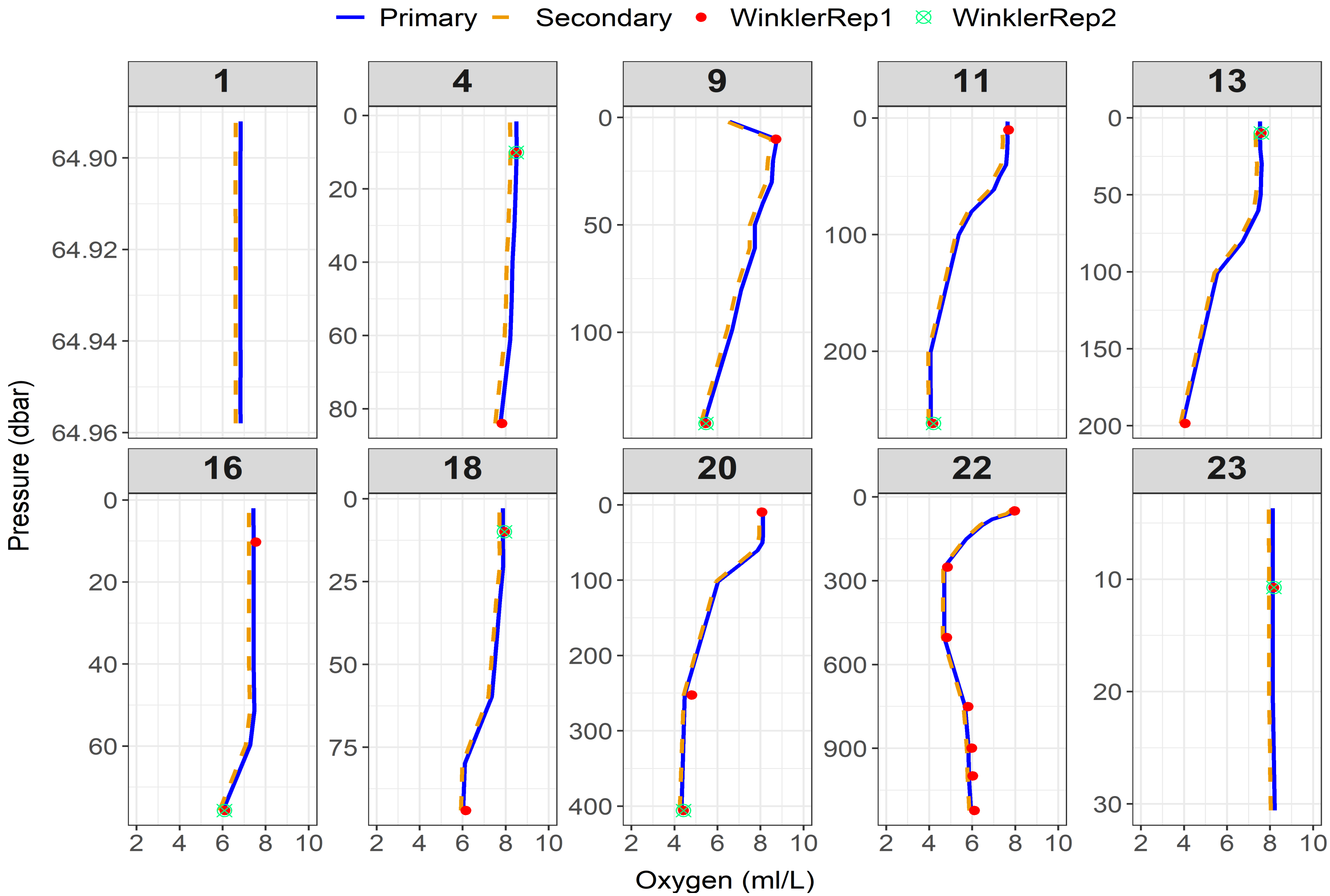

Figure A.1. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 1 to 23. Note the variable range in the y-axis.

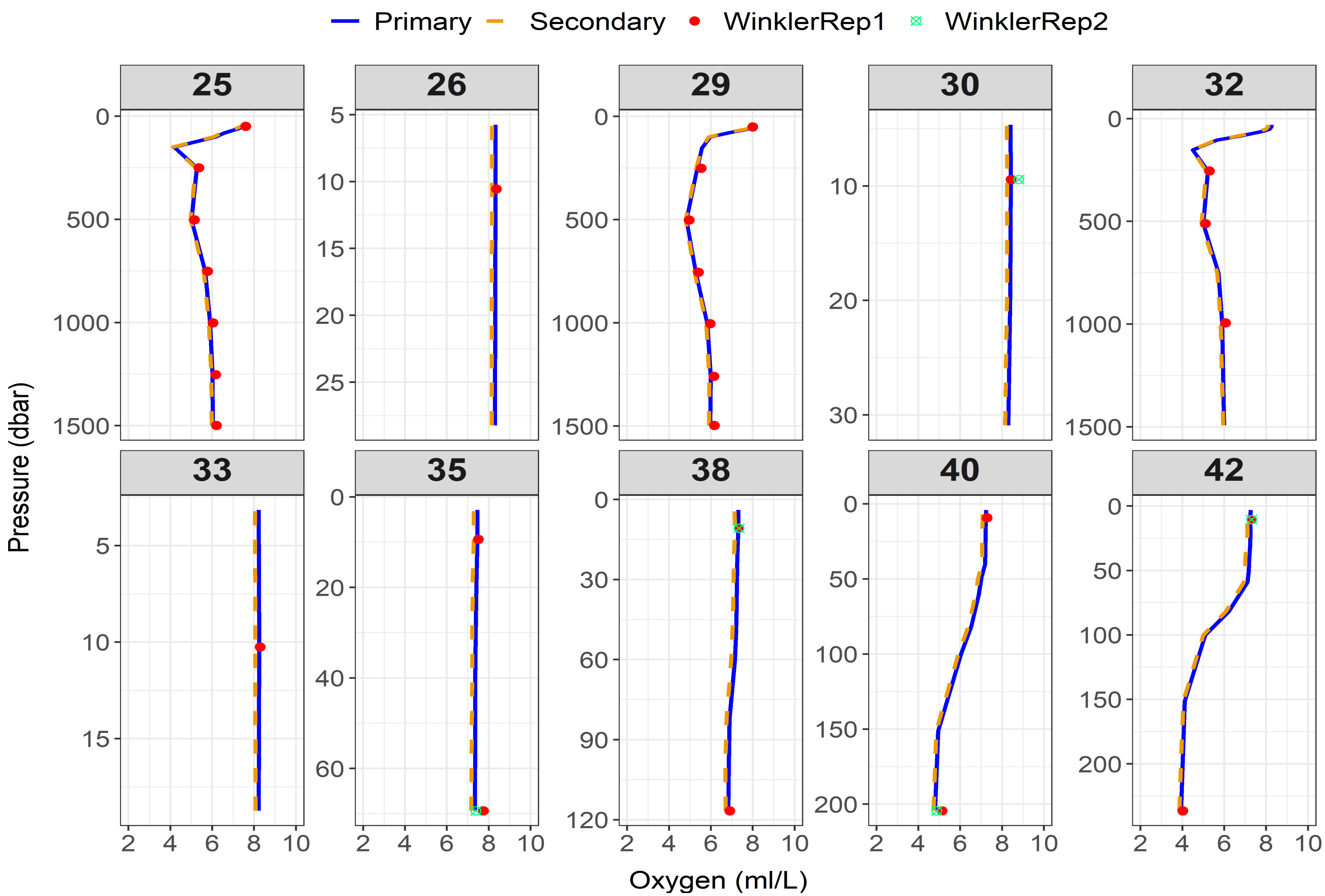

Figure A.2. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 25 to 42. Note the variable range in the y-axis.

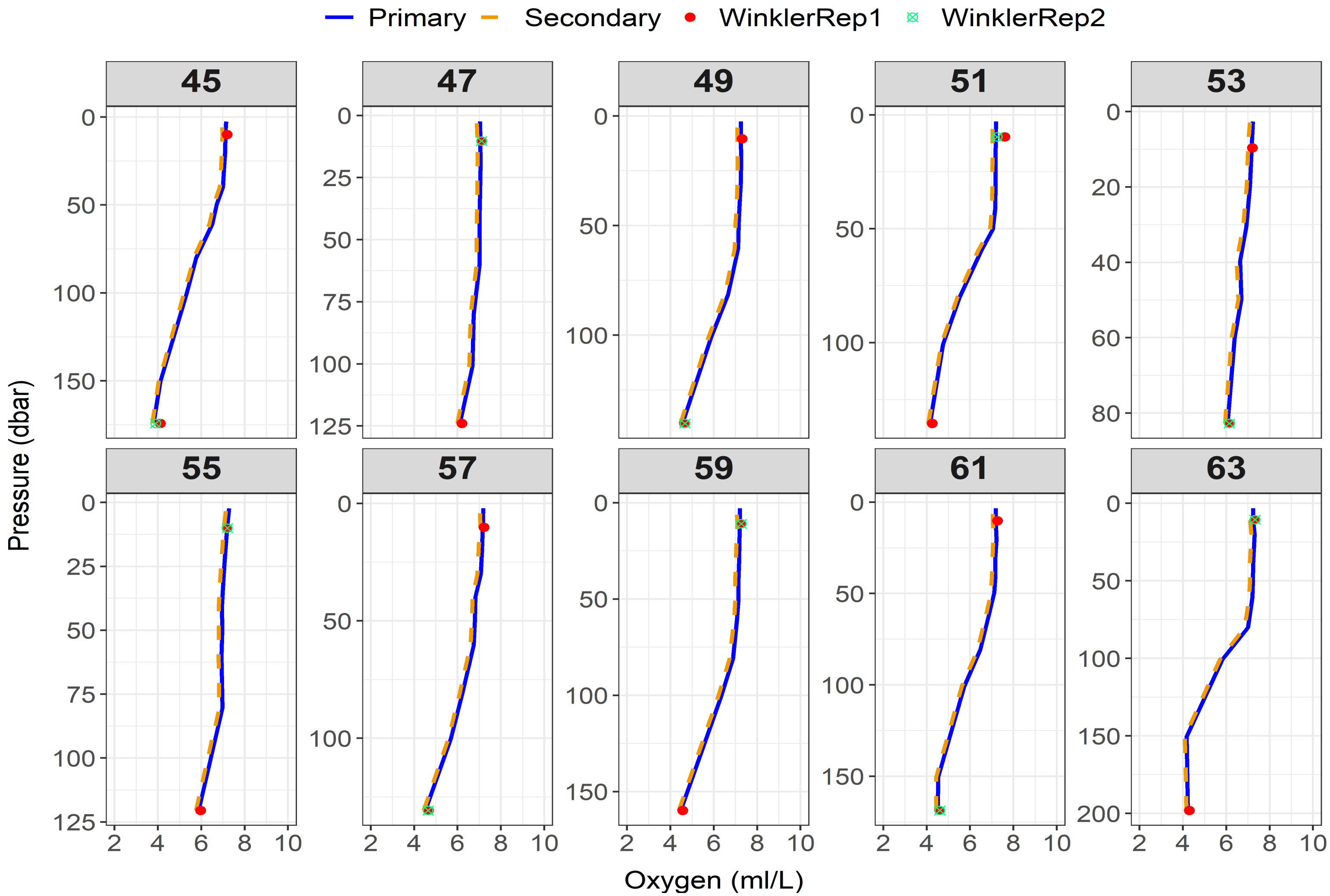

Figure A.3. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 45 to 63. Note the variable range in the y-axis.

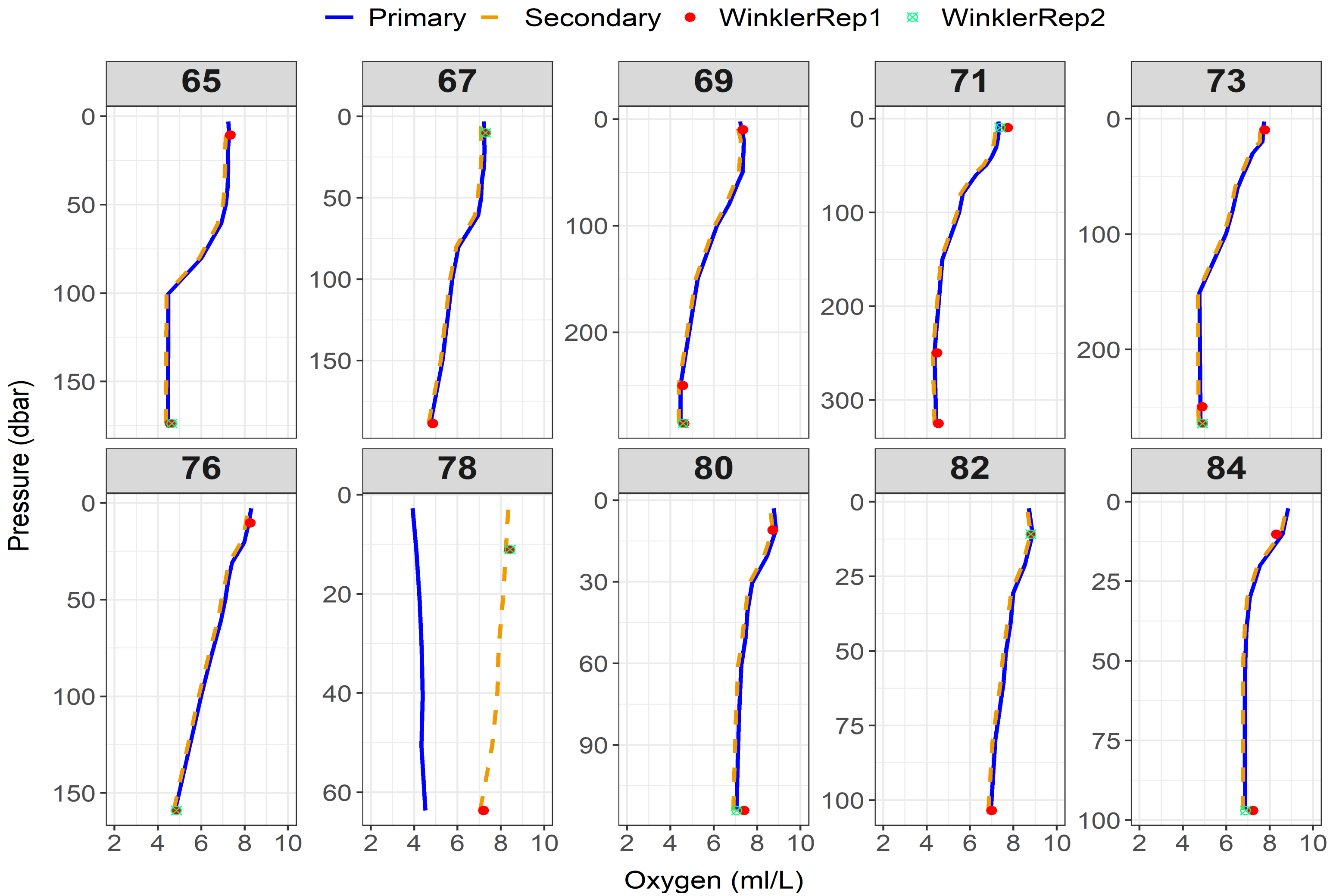

Figure A.4. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 65 to 84. Note the variable range in the y-axis.

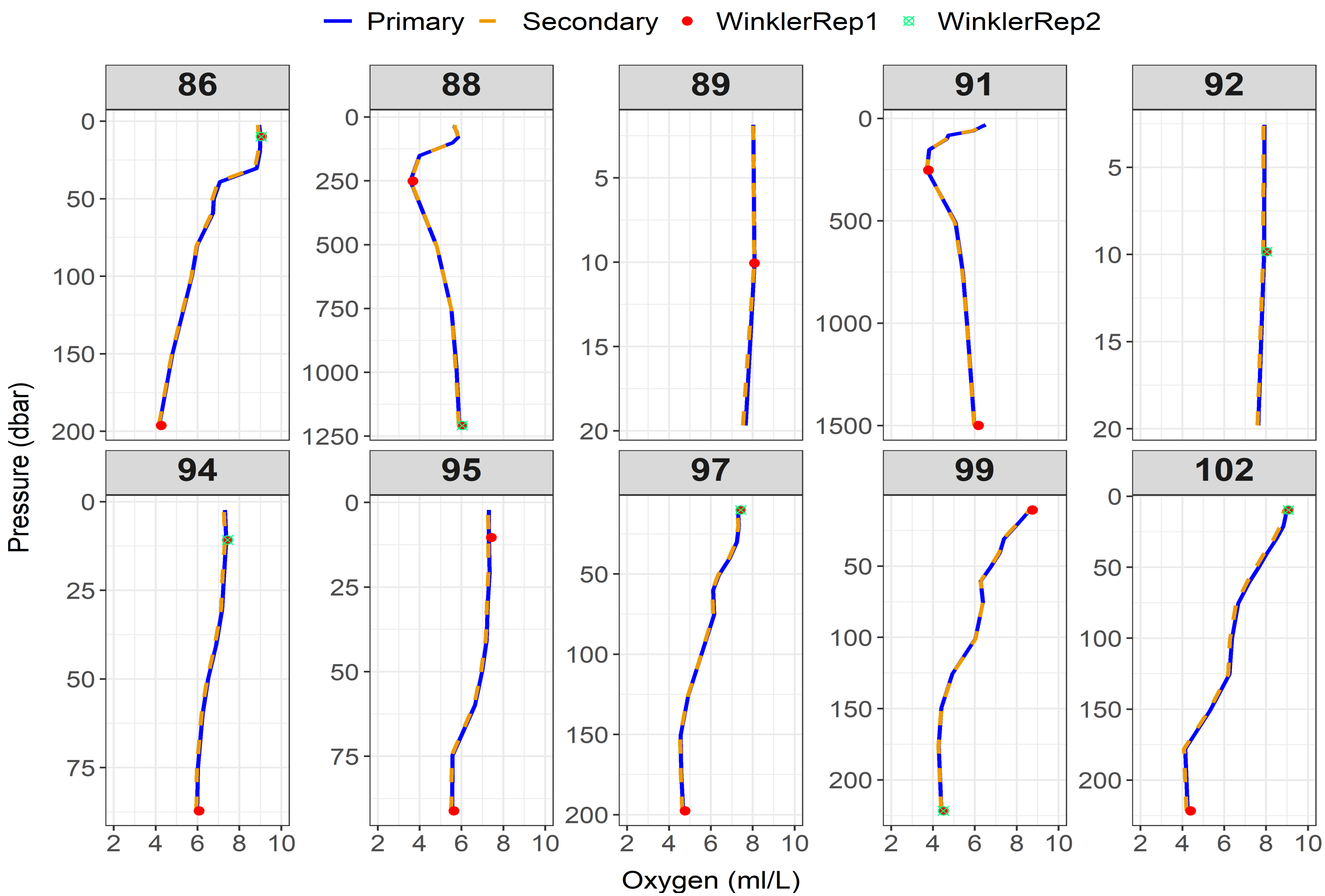

Figure A.5. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 86 to 102. Note the variable range in the y-axis.

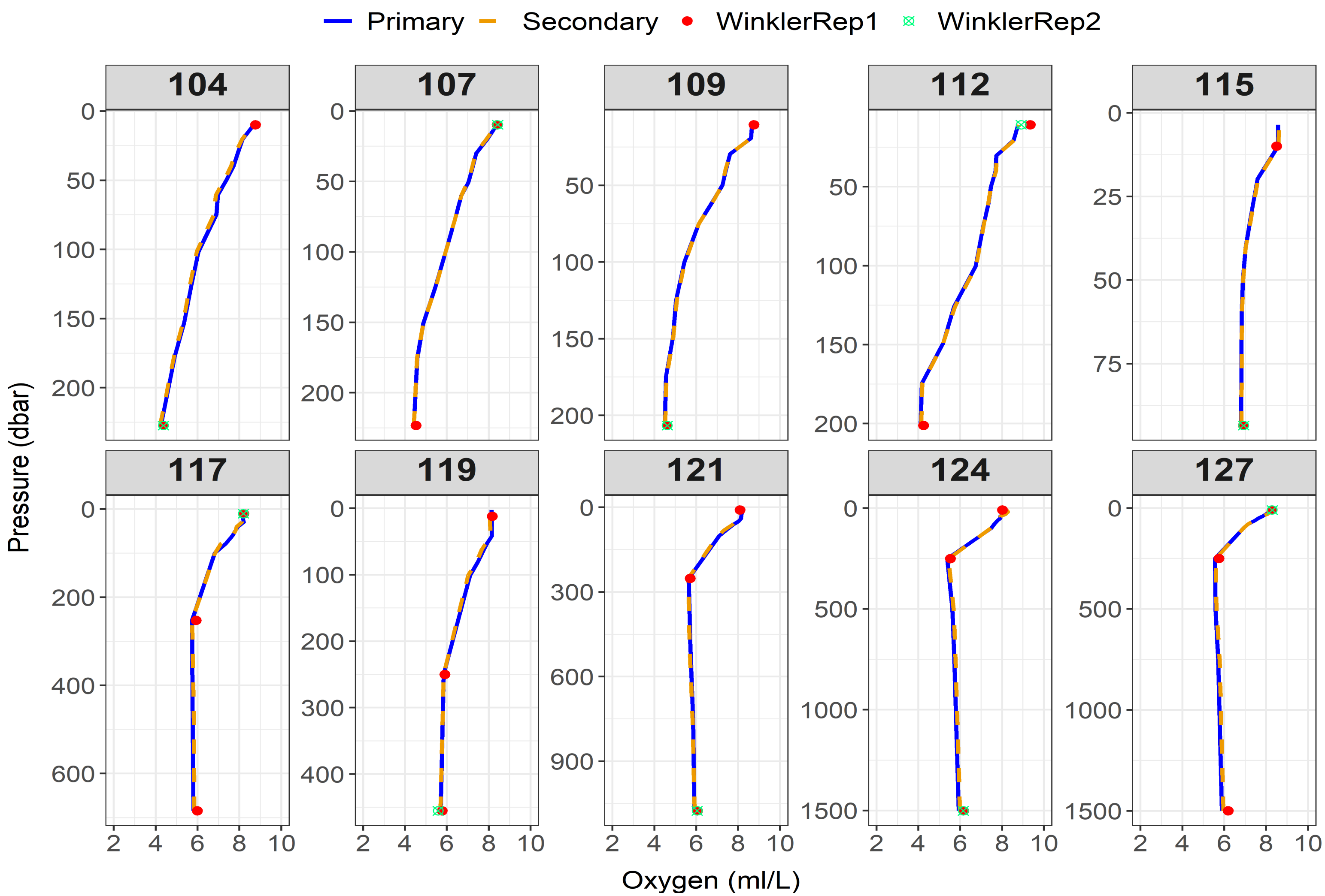

Figure A.6. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 104 to 127. Note the variable range in the y-axis.

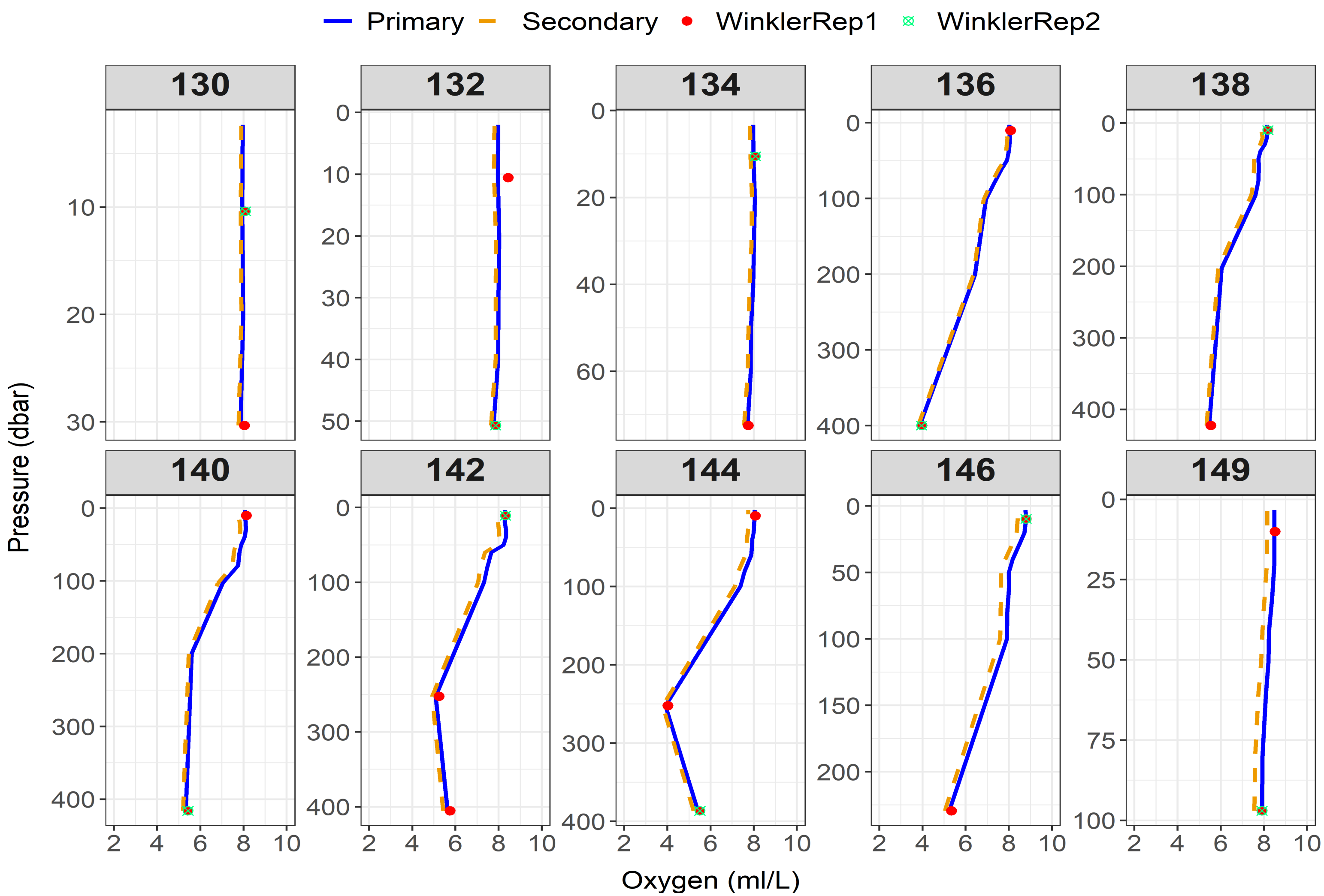

Figure A.7. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 130 to 149. Note the variable range in the y-axis.

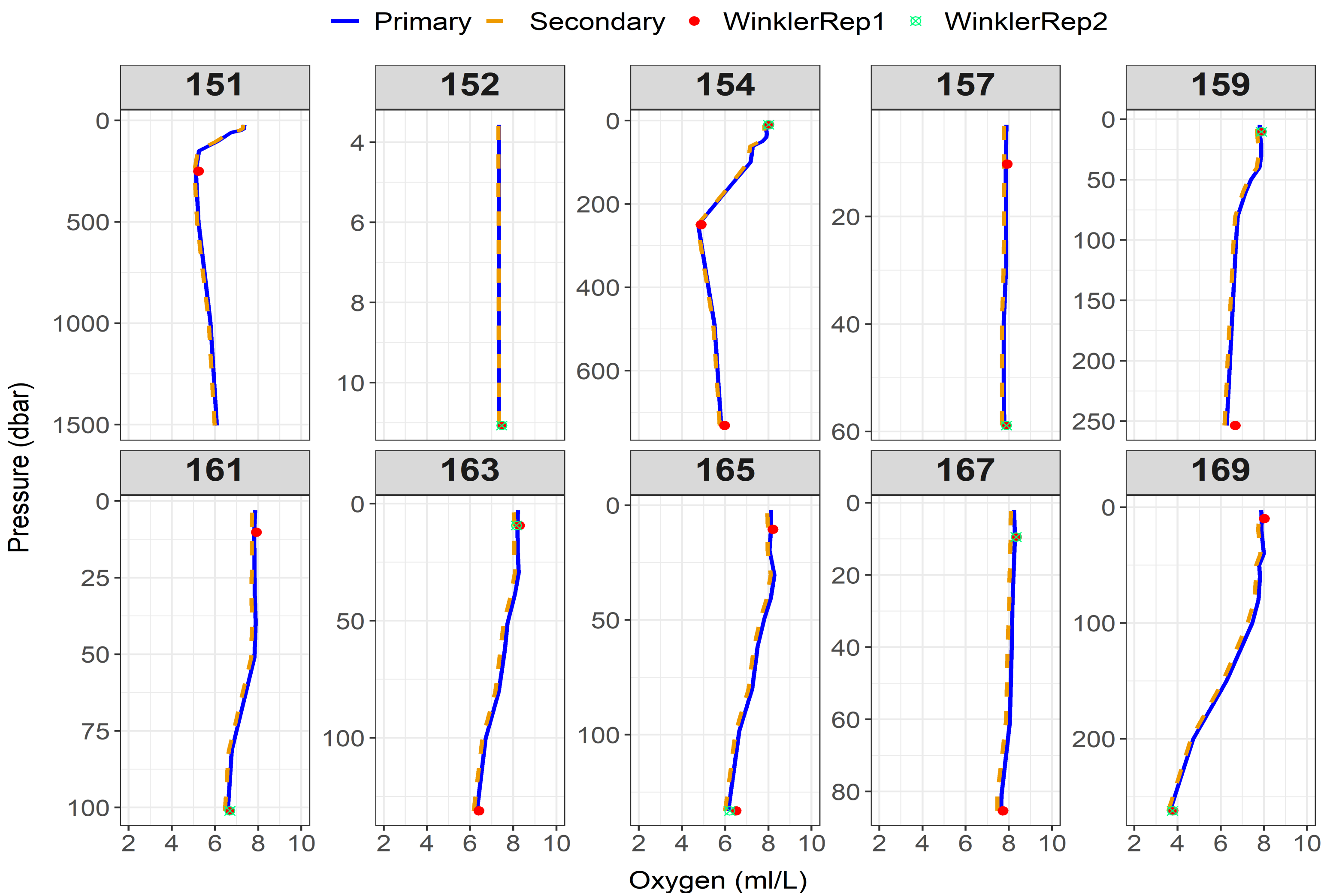

Figure A.8. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 151 to 169. Note the variable range in the y-axis.

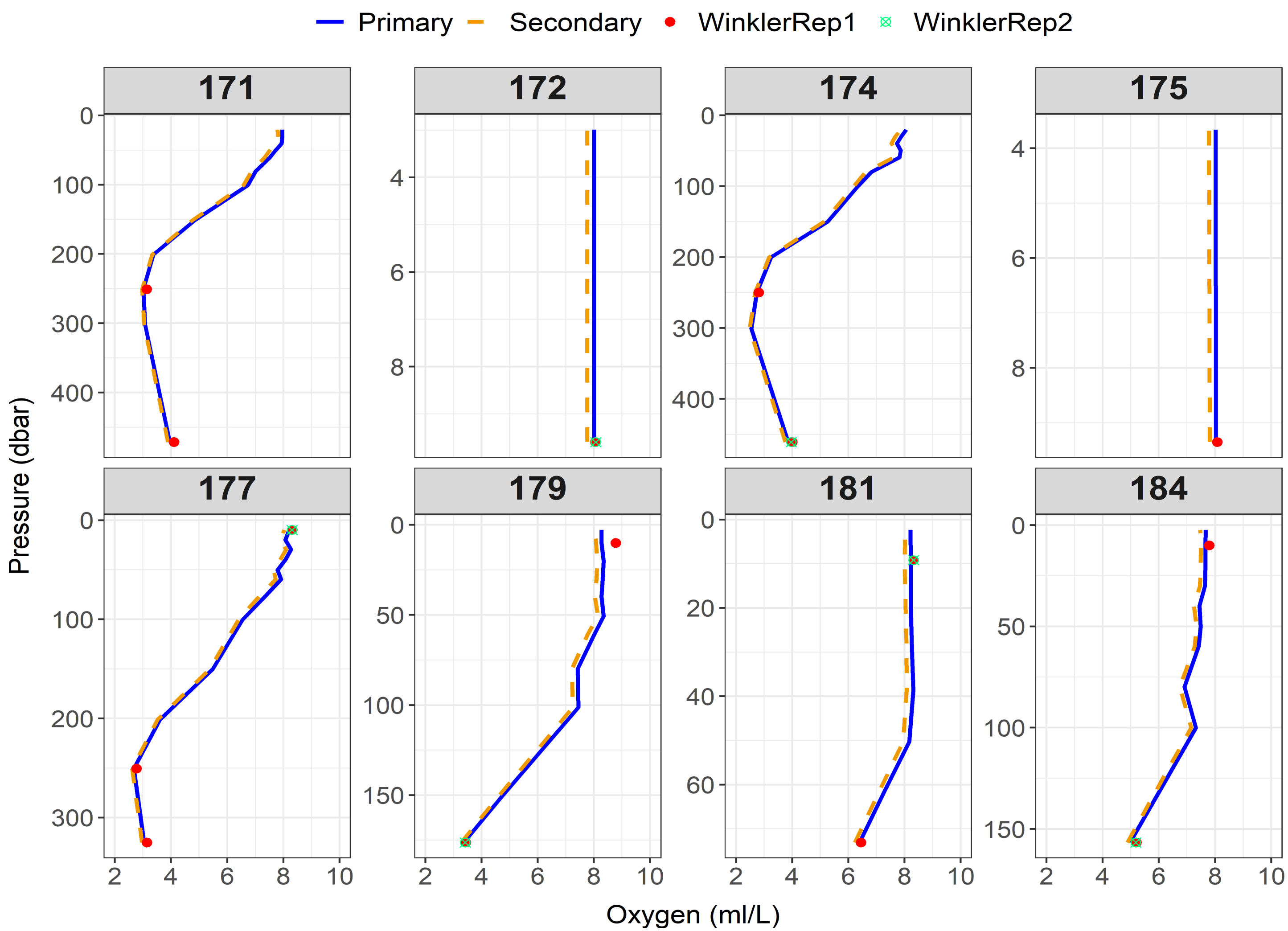

Figure A.9. Relationship between primary (blue) and secondary (orange) dissolved oxygen sensors and dissolved oxygen measurements (replicate 1 = red, replicate 2 = green) from the Winkler titration method for Events 171 to 184. Note the variable range in the y-axis.

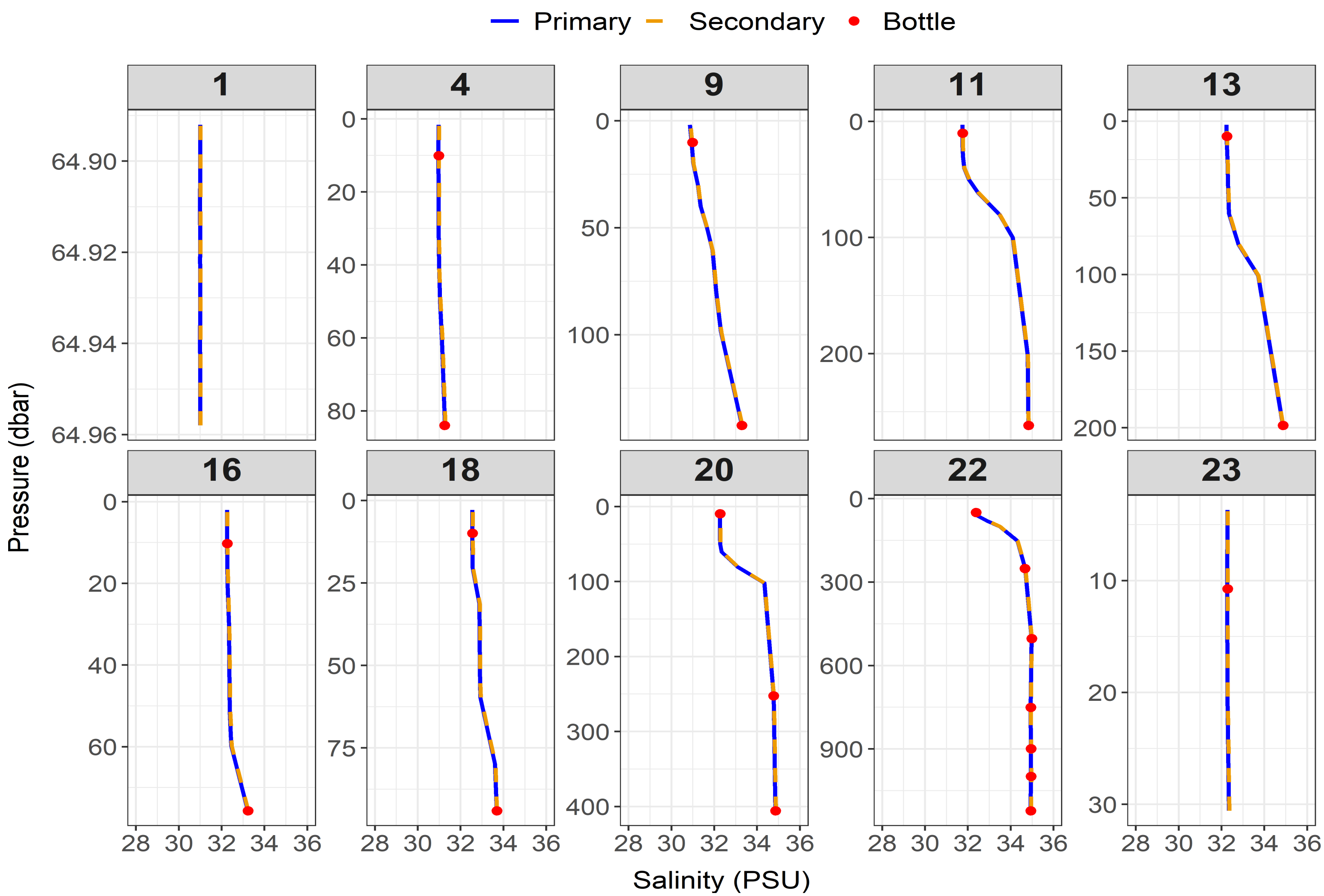

Figure A.10. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 1 to 23. Note the variable range in the y-axis.

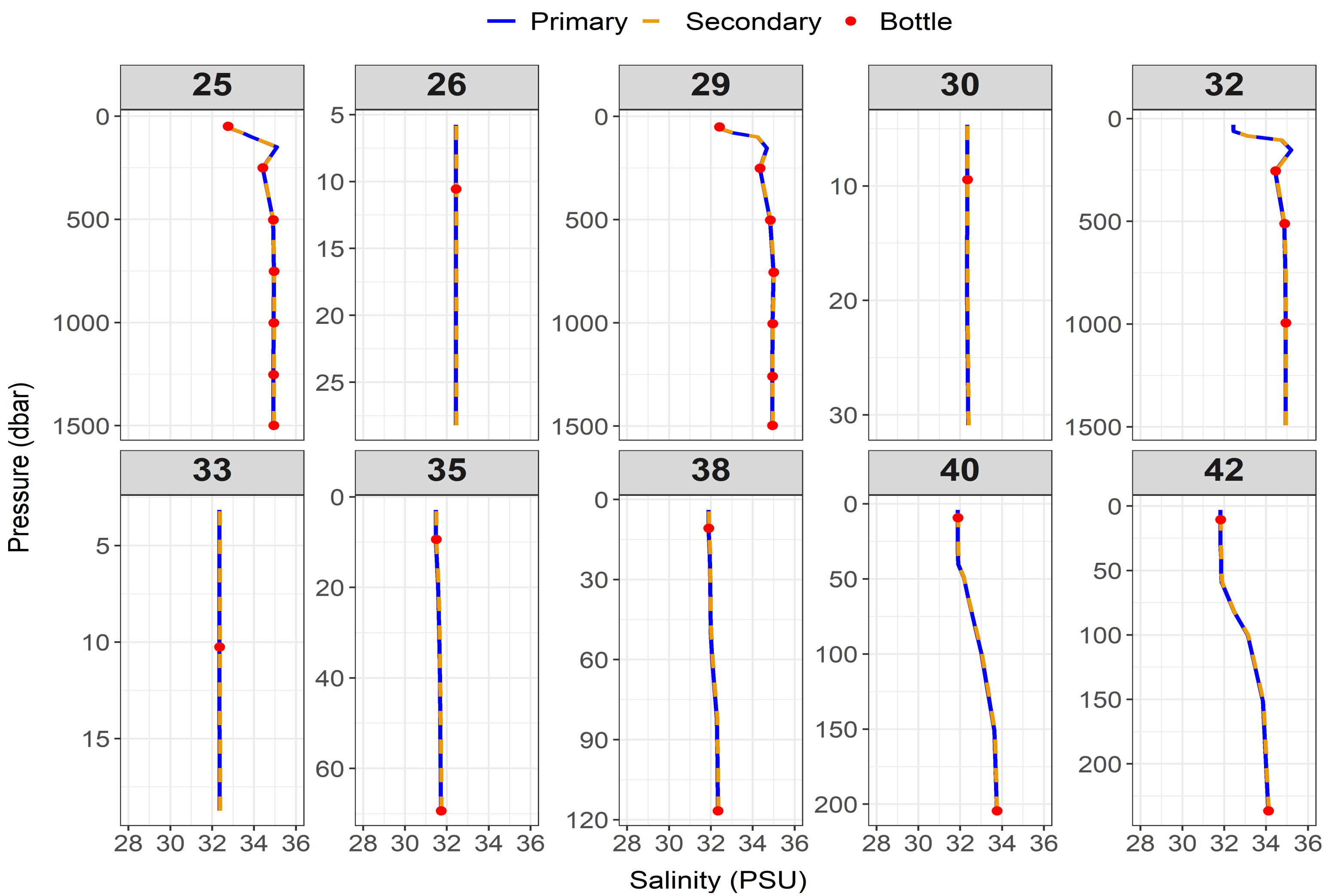

Figure A.11. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 25 to 42. Note the variable range in the y-axis.

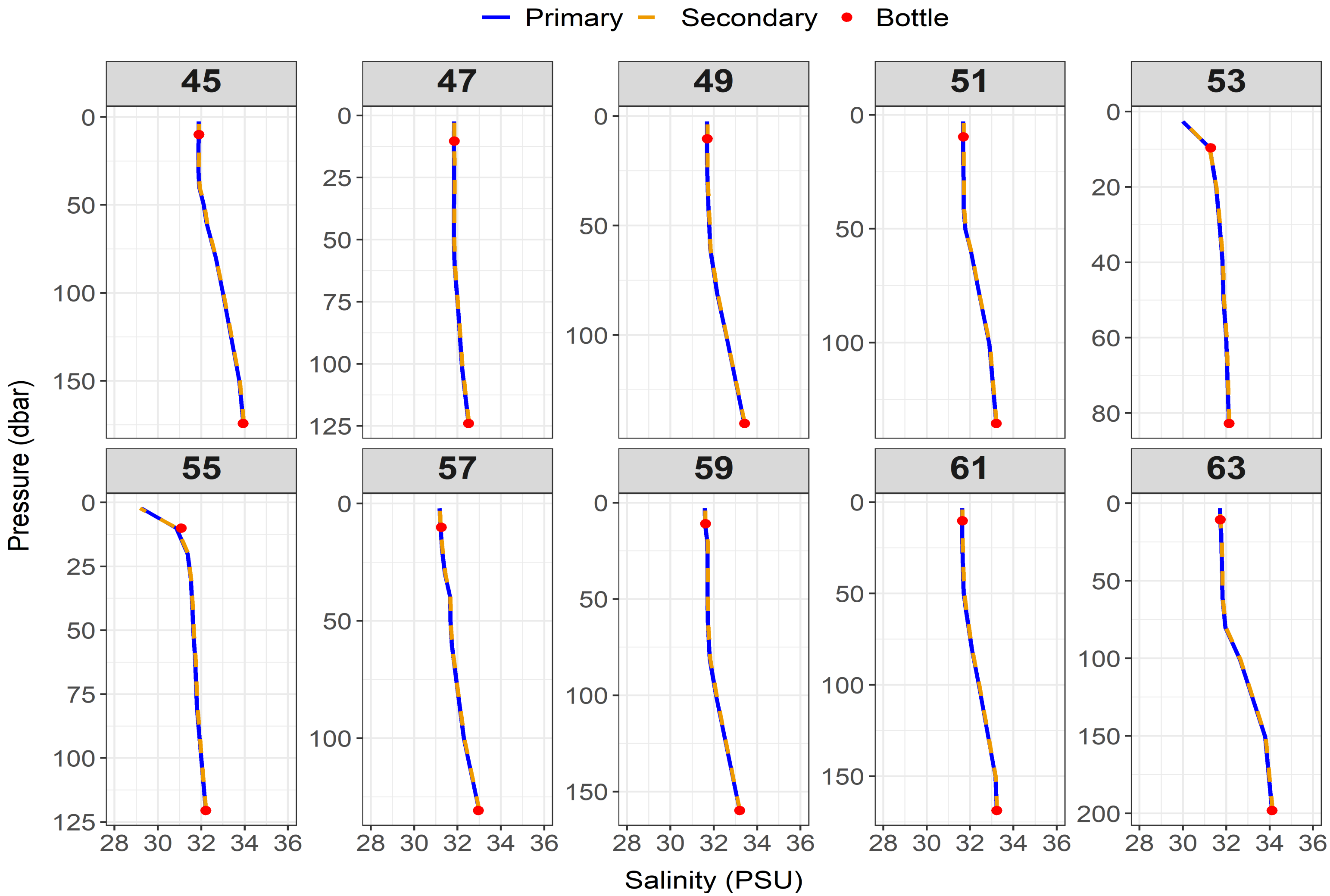

Figure A.12. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 44 to 63. Note the variable range in the y-axis.

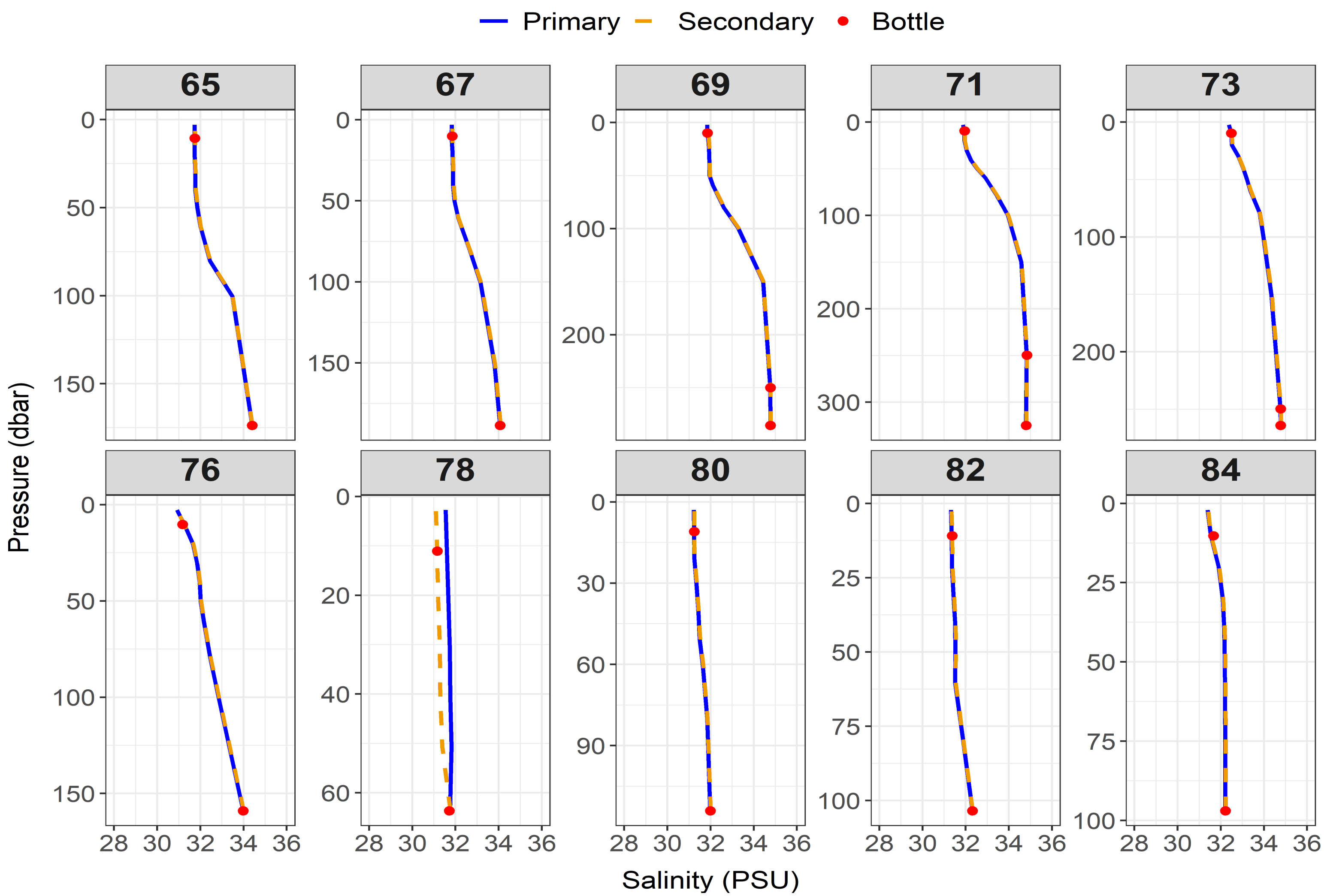

Figure A.13. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 65 to 84. Note the variable range in the y-axis.

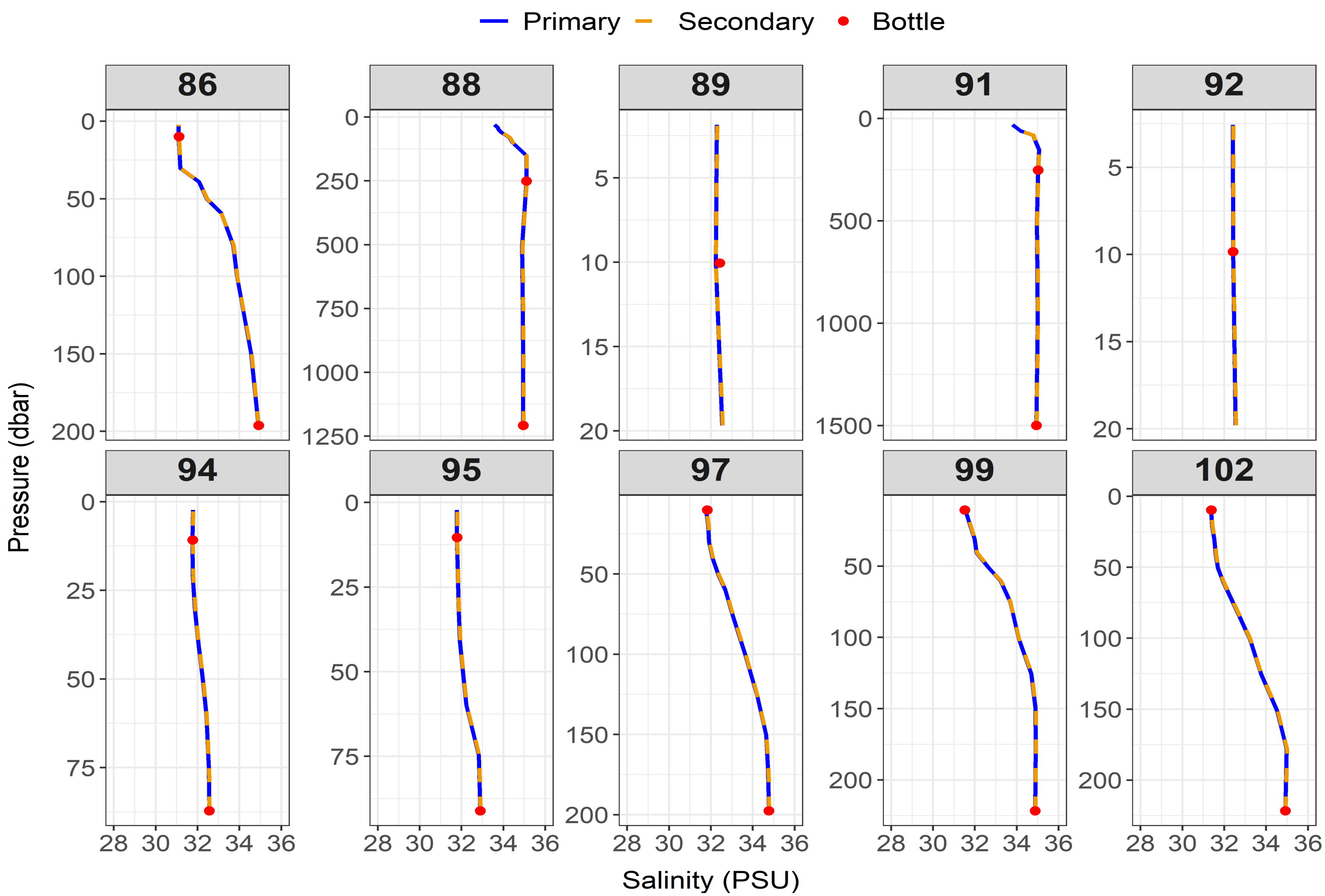

Figure A.14. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 86 to 102. Note the variable range in the y-axis.

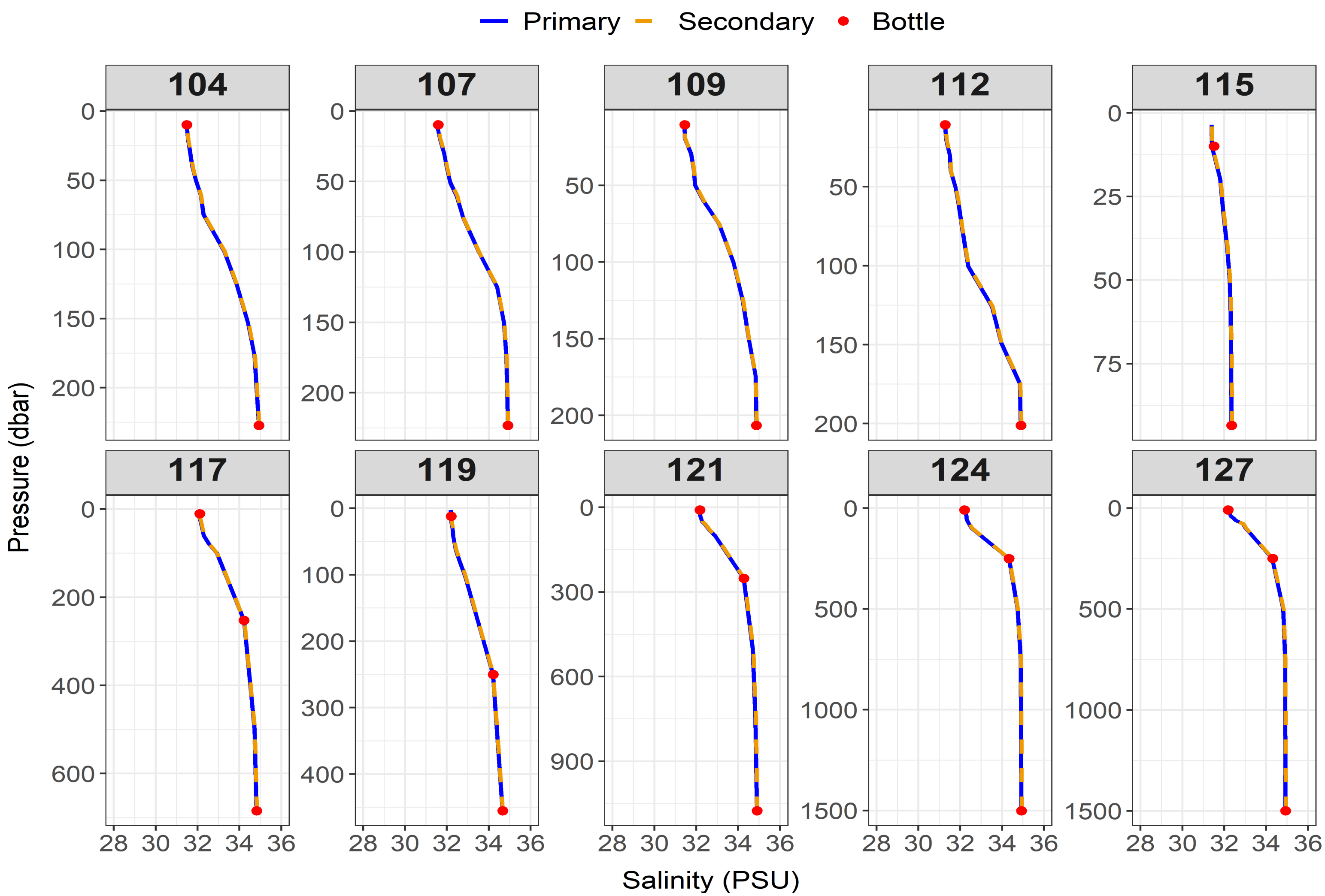

Figure A.15. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 104 to 127. Note the variable range in the y-axis.

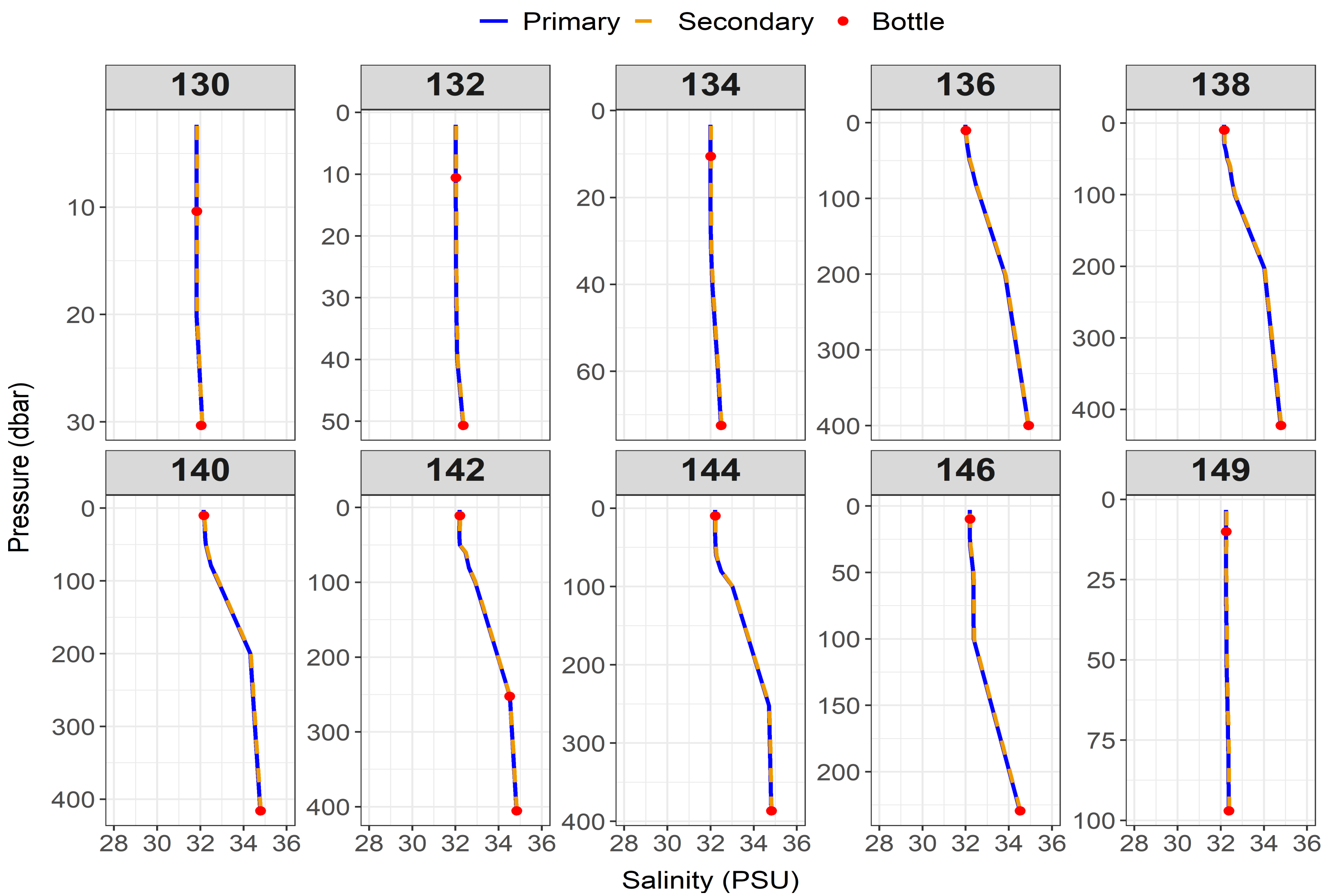

Figure A.16. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 130 to 149. Note the variable range in the y-axis.

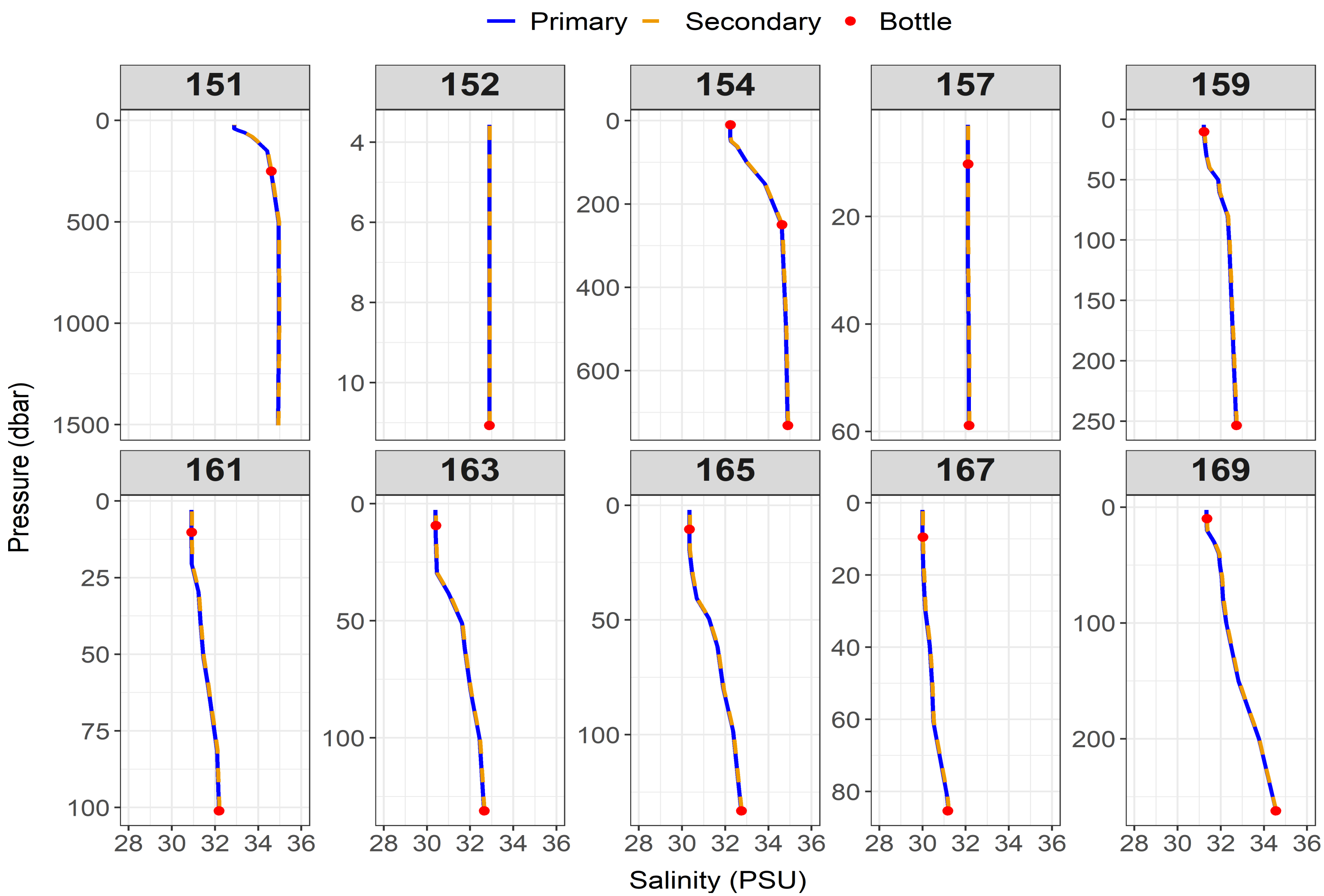

Figure A.17. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 151 to 169. Note the variable range in the y-axis.

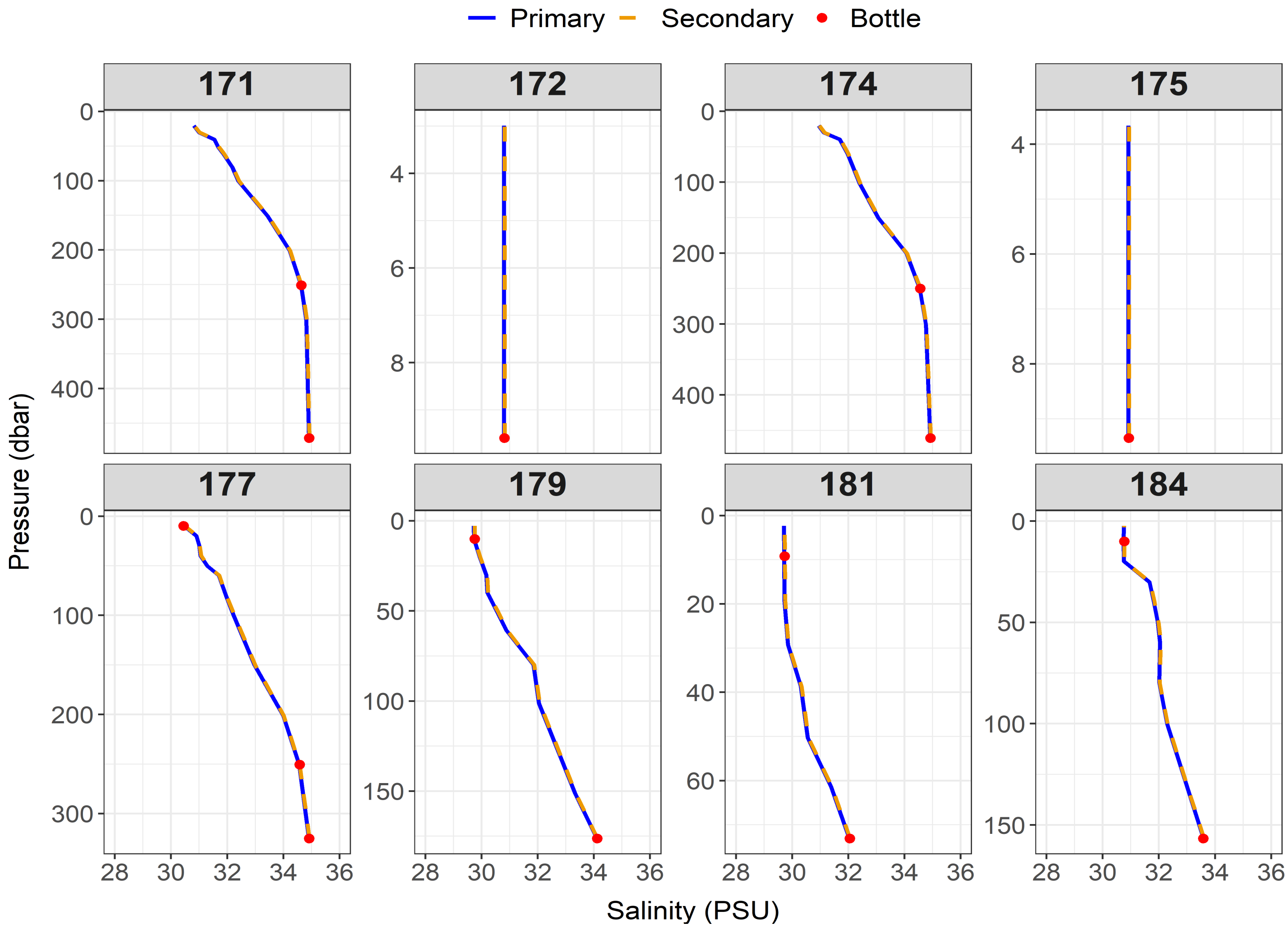

Figure A.18. Relationship between primary (blue) and secondary (orange) salinity (from conductivity) sensor data and salinity bottle values (red) for Events 171 to 184. Note the variable range in the y-axis.

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 final calibration coefficients 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, n.d.) 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, and were updated upon sensor changes. 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 TEL2024880 dissolved oxygen data evaluation

Real-time validation of the primary oxygen sensor (SBE 43 SN 3026) was conducted during the mission in two ways: 1) using a calibrated secondary oxygen sensor (SBE 43 SN 4366) mounted on the CTD, and 2) against bottle samples measured via Winkler titration (see Appendix A). Part way through the mission, the secondary oxygen sensor appeared to be drifting with respect to the primary sensor. Figure B.1 shows the relationship between the mean sensor difference (primary - secondary sensor values) per event, from events 001 to 115. The average difference in values between the two sensors was 0.0917 $\pm$ 0.0736 ml/l (mean $\pm$ SD). The slope of this relationship was negative, suggesting that either the primary sensor was decreasing, or the secondary oxygen sensor was increasing. In order to determine which sensor was drifting, the relationship between the sensor outputs and average Winkler values was evaluated, and a linear model was fitted to the data (see Figure B.2). These results showed that the secondary sensor increased relative to the primary sensor and bottle data. In response to this, both the primary and secondary oxygen sensors were cleaned using Triton X to remove any potential fouling material. However, this did not appear to remedy the issue, and the secondary sensor continued to drift on subsequent casts. Consequently, a decision was made to change the secondary oxygen sensor.

Upon review of the profile data from the new secondary sensor (SBE 43 SN 0042), its outputs appeared noisy relative to the primary sensor. Although its output tracked that of the primary sensor fairly consistently, a decision was made to change the secondary sensor again after Event 128.

Potential drift in the third secondary sensor (SBE 43 SN 0133) relative to the Winkler data was assessed across Events 130 to 149. While this sensor showed a decreasing relationship between its corresponding Winkler values across Events 130 to 149 (equation of linear model between the sensor and mean Winkler values was y = 0.23 - 0.00375x; figure not shown), this sensor was left on the CTD package for the remainder of the mission as the primary sensor appeared relatively stable, and no other spare sensors were available. When taking into account the remainder of events (130 to 184) the relationship between secondary sensor SN 0133 and its corresponding Winkler values showed was slightly increasing but relatively stable (130 to 184; y = -0.325 + 0.000393x; figure not shown).

For the purpose of this exercise, new calibration coefficients were computed for the primary sensor across the full range of events, while the secondary sensor data was parsed into three event sequences corresponding to each sensor (SBE 43 SN 4366 = Events 001 to 115, SBE 43 SN 0042 = Events 117 to 128, and SBE 43 SN 0133 = Events 130 to 184), and separate calibration coefficients were calculated for each group of events. The details of these calibration procedures are documented below.

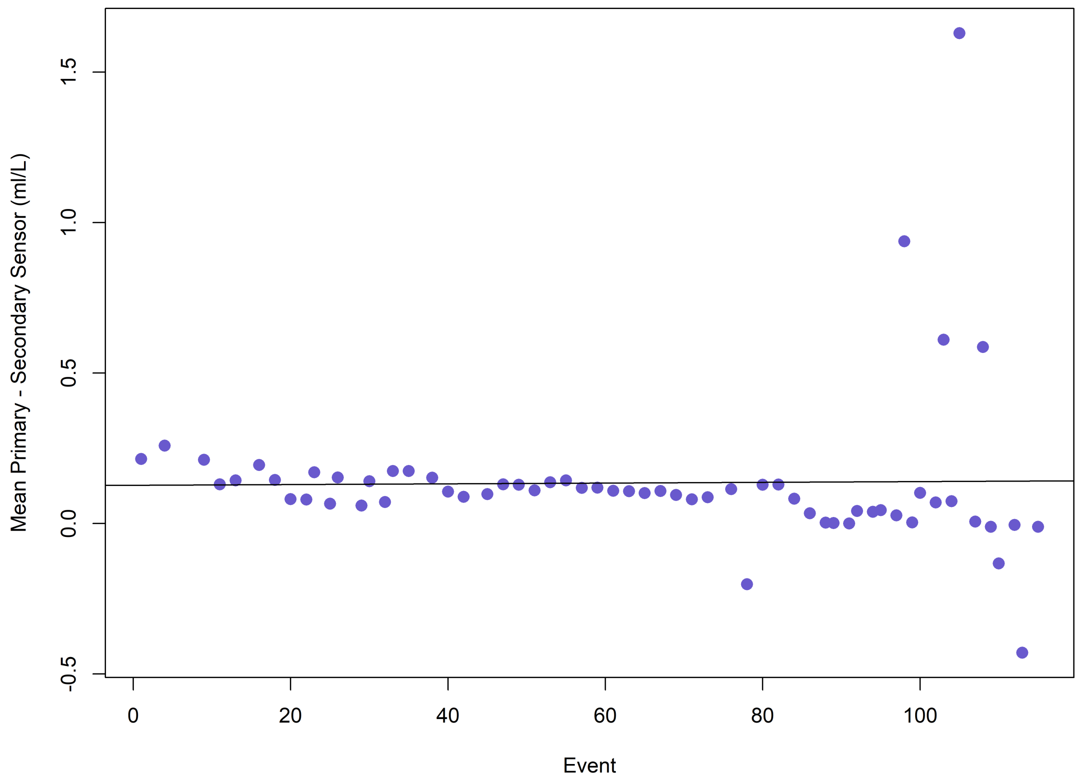

Figure B.1. Mean difference between the primary and secondary dissolved oxygen sensor values across CTD casts Events 001 to 115, before the secondary dissolved oxygen sensor was changed for the first time during the 2024 spring AZMP mission (TEL2024880).

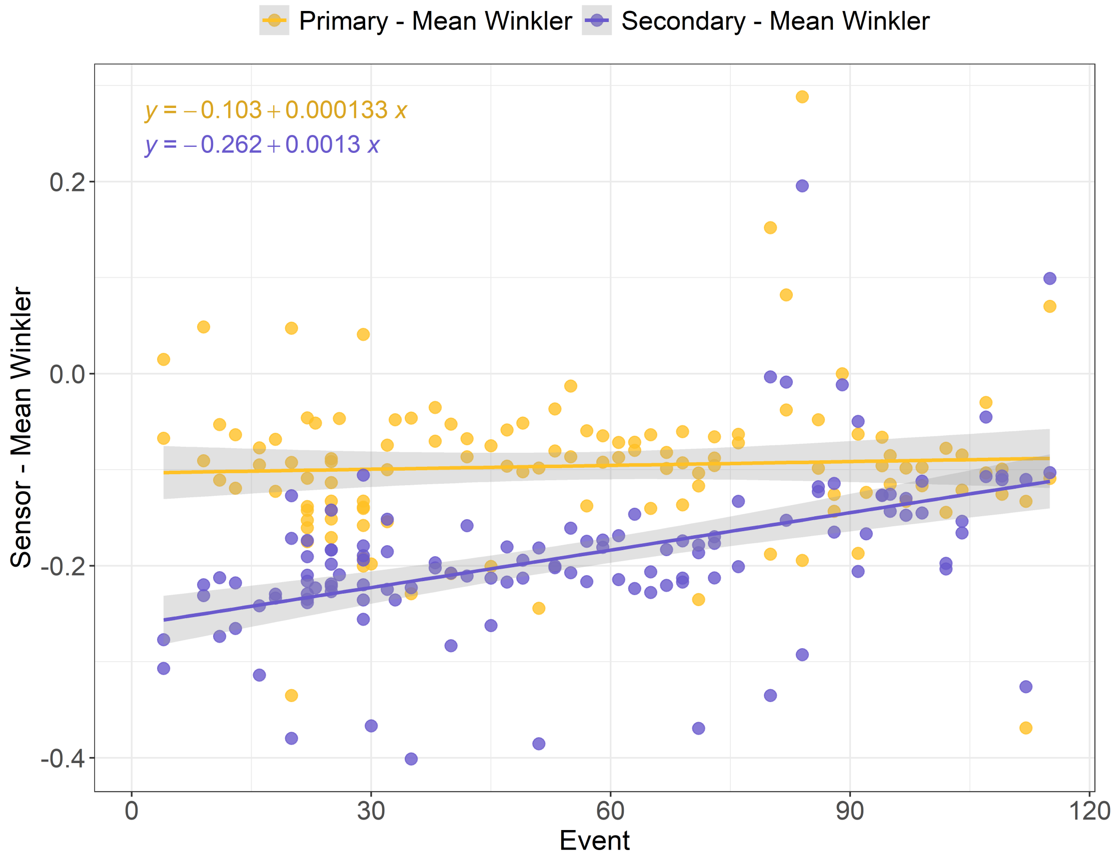

Figure B.2. Difference between the dissolved oxygen sensor and corresponding bottle measurements for both the primary (yellow) and secondary (purple) sensor data collected across Events 001 and 115. Equations of the linear models between the primary (yellow) and secondary (blue) sensor values and their 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, n.d.). 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 75 data points where Winkler replicates were collected, 13 (17.3%) had difference values that fell outside 1.5*IQR and were considered outliers (Figure B.3). These 13 records were subsequently removed. The mean Winkler value was 6.4821 ± 1.5981 ml/l (mean ± SD) after outlier removal.

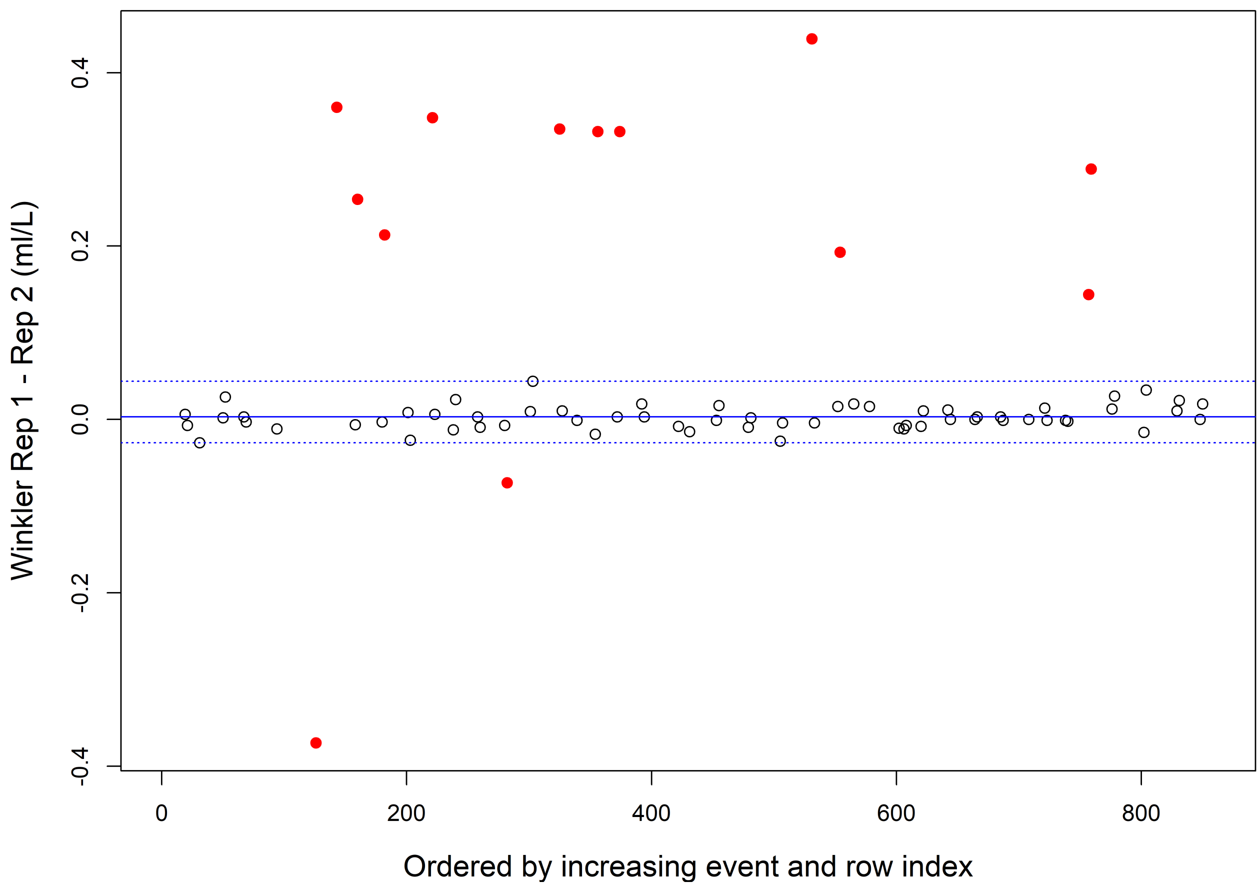

Figure B.3. Comparison of Winkler replicates measured during the 2024 spring AZMP mission (TEL2024880). Differences outside 1.5*IQR (horizontal dashed blue lines) are considered outliers (red dots) and were removed from the calibration process. Boxplot statistics are as follows: Median = 0.0030, IQR min = -0.0270, IQR max = 0.0440.

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 14 outliers were identified for the primary sensor (see Figure B.4), and were subsequently removed from further analysis.

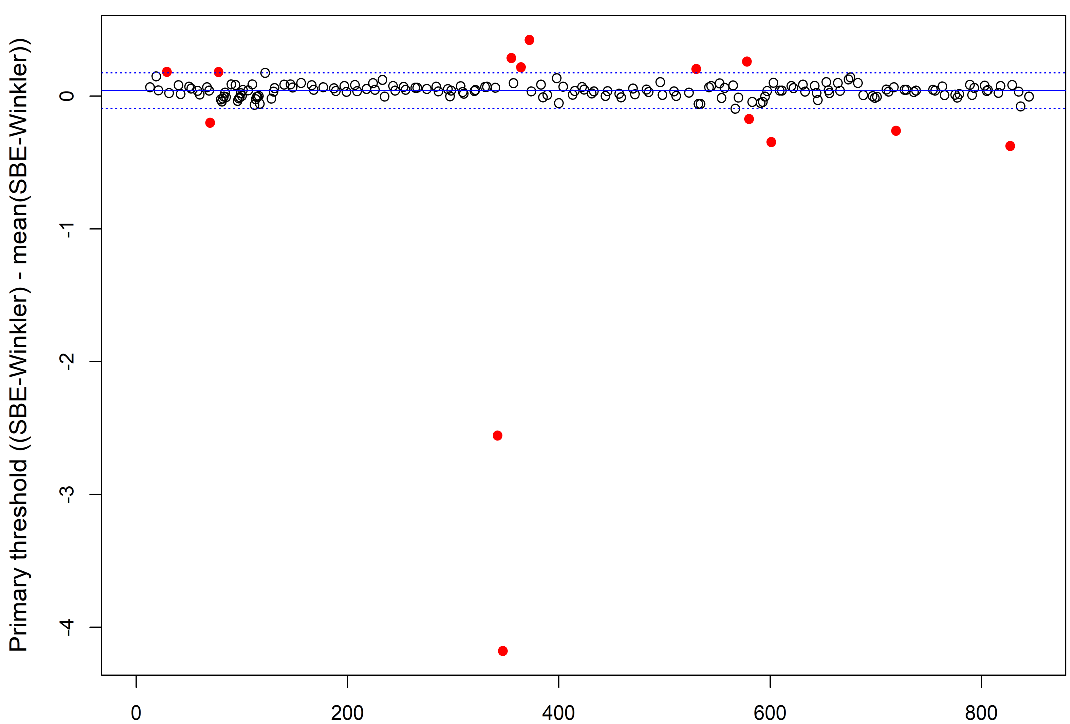

Figure B.4. Outliers (red dots) outside the 1.5*IQR (horizontal dashed blue line) of the threshold fields for the primary oxygen sensor. Boxplot statistics are as follows: Median = 0.0416, IQR min = -0.0953, IQR max = 0.1752

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* (0.5335 and 0.5428 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 demonstrates a 1:1 relationship with the Winkler data. Before correction, the mean difference between the CTD sensor data and mean Winkler values was -0.0962 ± 0.0457 ml/L (mean ± SD). After correction, the mean difference was reduced to 0.0122 ± 0.0624 ml/L.

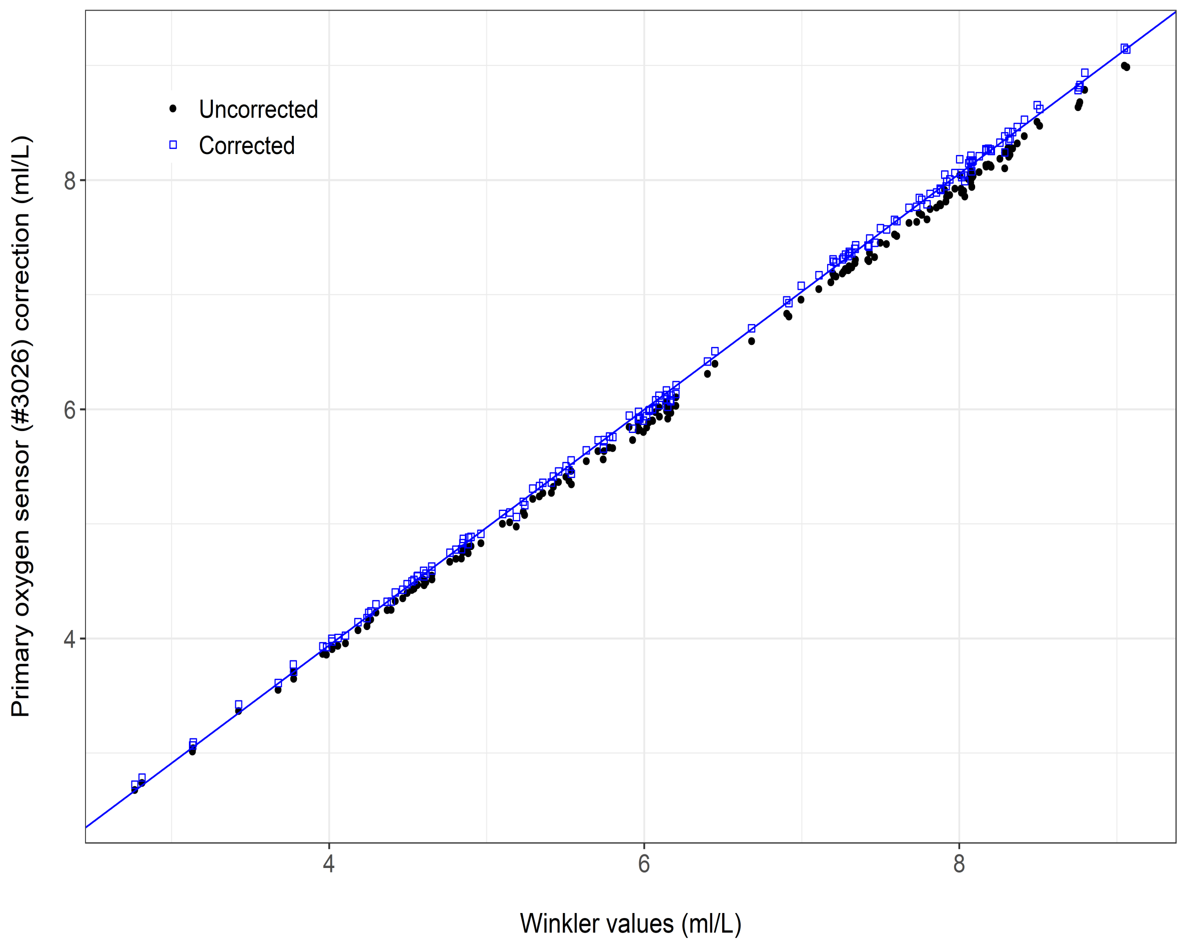

Figure B.5. Primary oxygen sensor data before (black dots) and after (blue squares) correction using the slope correction ratio. The blue line represents the 1:1 reference line of the corrected data.

B.5 Secondary oxygen sensor calibrations

B.5.1 Outlier detection between secondary sensor SN 4366 and Winkler values

Outliers in the difference between the first secondary sensor (SN 4366) and mean Winkler values collected between Events 001 and 115, 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 7 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 4366 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 demonstrates a 1:1 relationship with the Winkler data. Before correction, the mean difference between the CTD sensor data and mean Winkler values was -0.1875 ± 0.0459 ml/L (mean ± SD). After correction, the mean difference was reduced to 0.0077 ± 0.0564 ml/L.

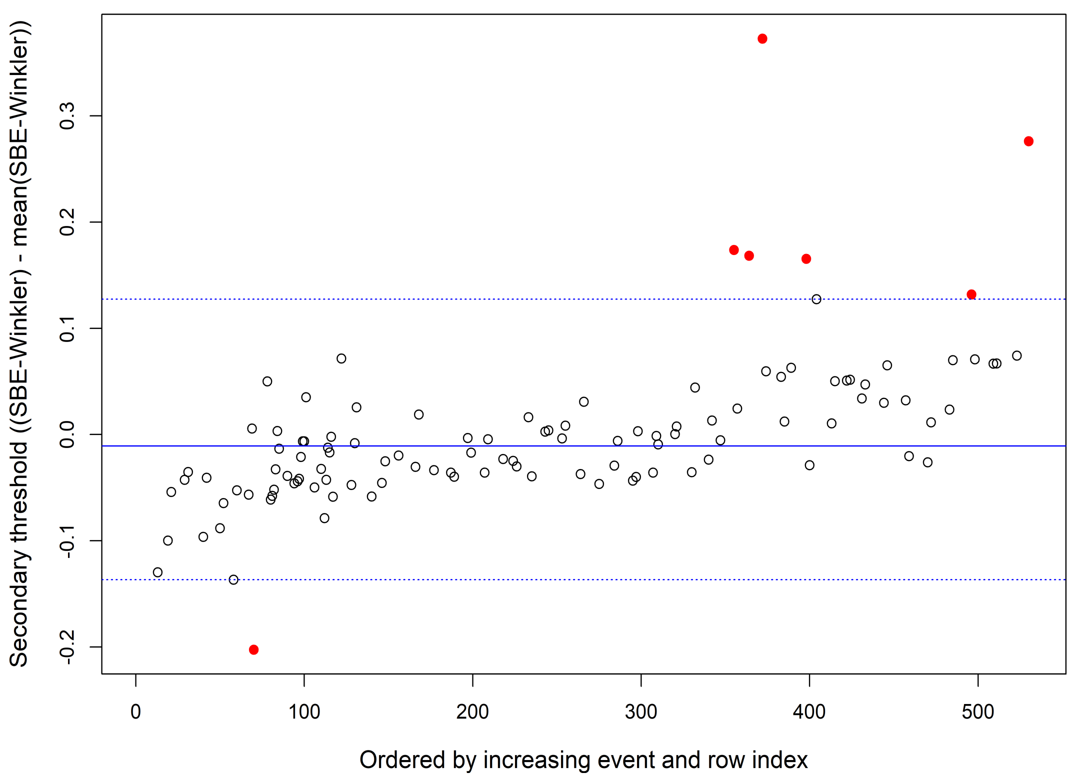

Figure B.6. Outliers (red dots) outside the 1.5*IQR (horizontal dashed blue line) of the threshold fields for the secondary oxygen sensor (SN 4366) used between Events 001 and 115. Boxplot statistics are as follows: Median = -0.0108, IQR min = -0.1367, IQR max = 0.1274.

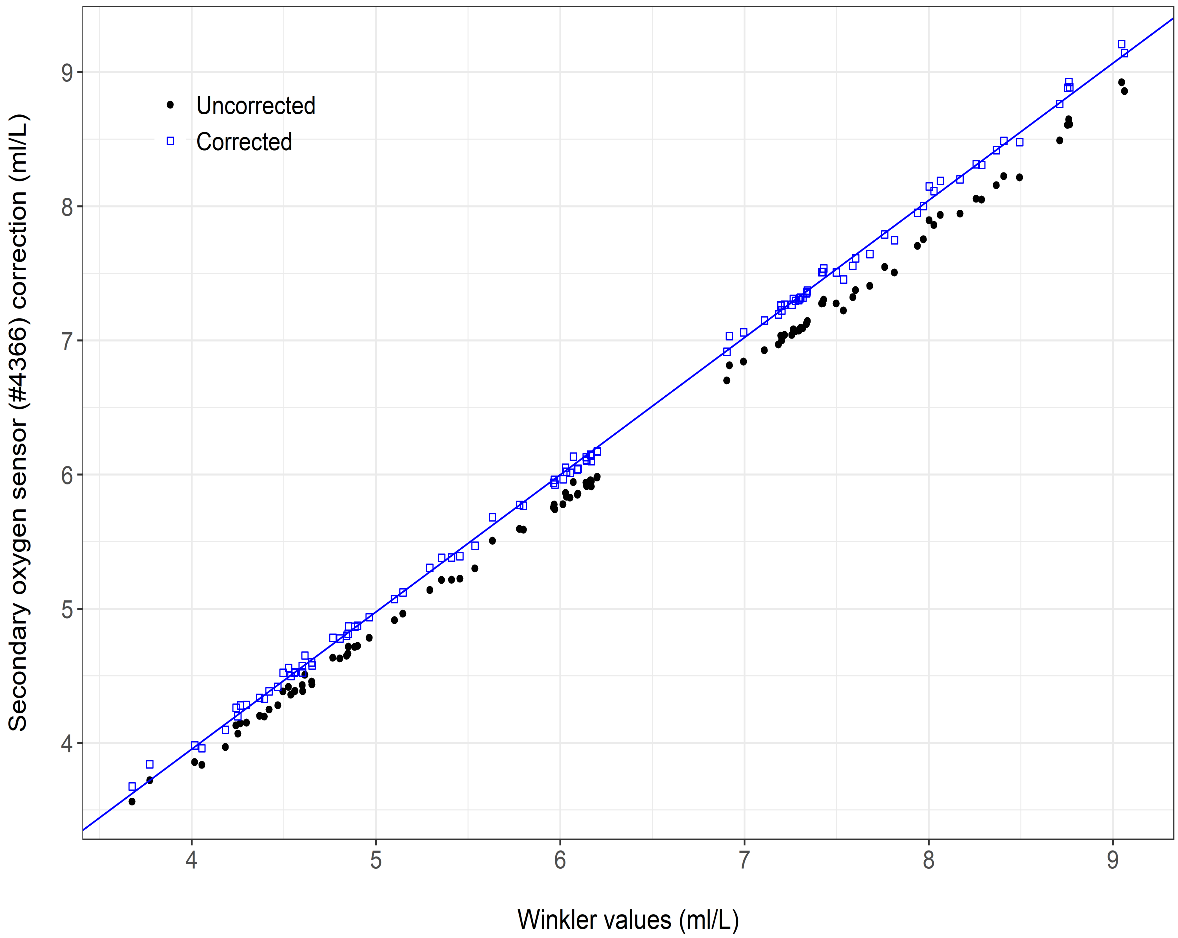

Figure B.7. Secondary oxygen sensor (SN 4366) from Events 001 to 115 before (black dots) and after (blue squares) correction using the slope correction ratio. The blue line represents the 1:1 reference line of the corrected data.

B.5.3 Outlier detection between secondary sensor SN 0042 and Winkler values

Outliers in the difference between the second secondary sensor (SN 0042) and mean Winkler values collected between Events 117 and 128, 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. Only 1 outlier was identified for this secondary sensor (see Figure B.8), and was removed.

B.5.4 NewSoc and slope correction ratio calculation

The *NewSoc* value for secondary sensor SN 0042 is shown in Table B.1. Figure B.9 shows the relationship between the corrected and uncorrected sensor data against the mean Winkler values. The corrected sensor data (in blue) roughly demonstrates a 1:1 relationship with the Winkler data. Before correction, the mean difference between the CTD sensor data and mean Winkler values was -0.1392 ± 0.0493 ml/L (mean ± SD). After correction, the mean difference was reduced to 0.0030 ± 0.0541 ml/L.

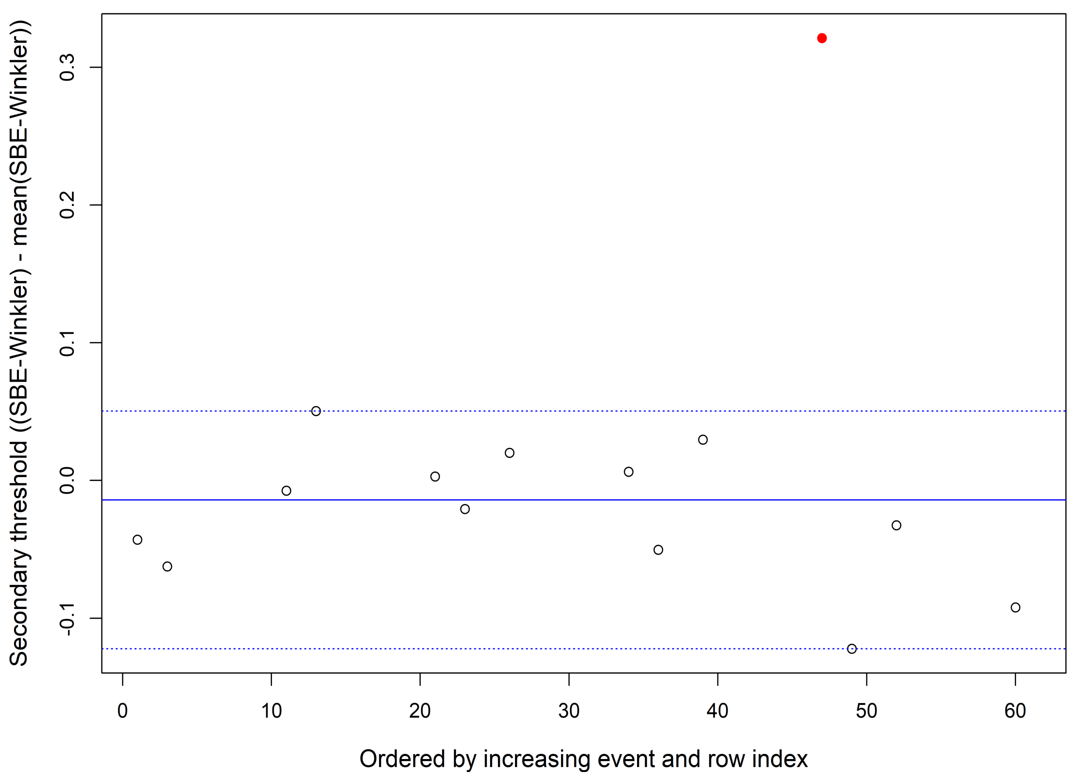

Figure B.8. Outliers (red dots) outside the 1.5*IQR (horizontal dashed blue line) of the threshold fields for secondary oxygen sensor SN 0042 (Events 117 - 128). Boxplot statistics are as follows: Median = -0.0141, IQR min = -0.1222, IQR max = 0.0504.

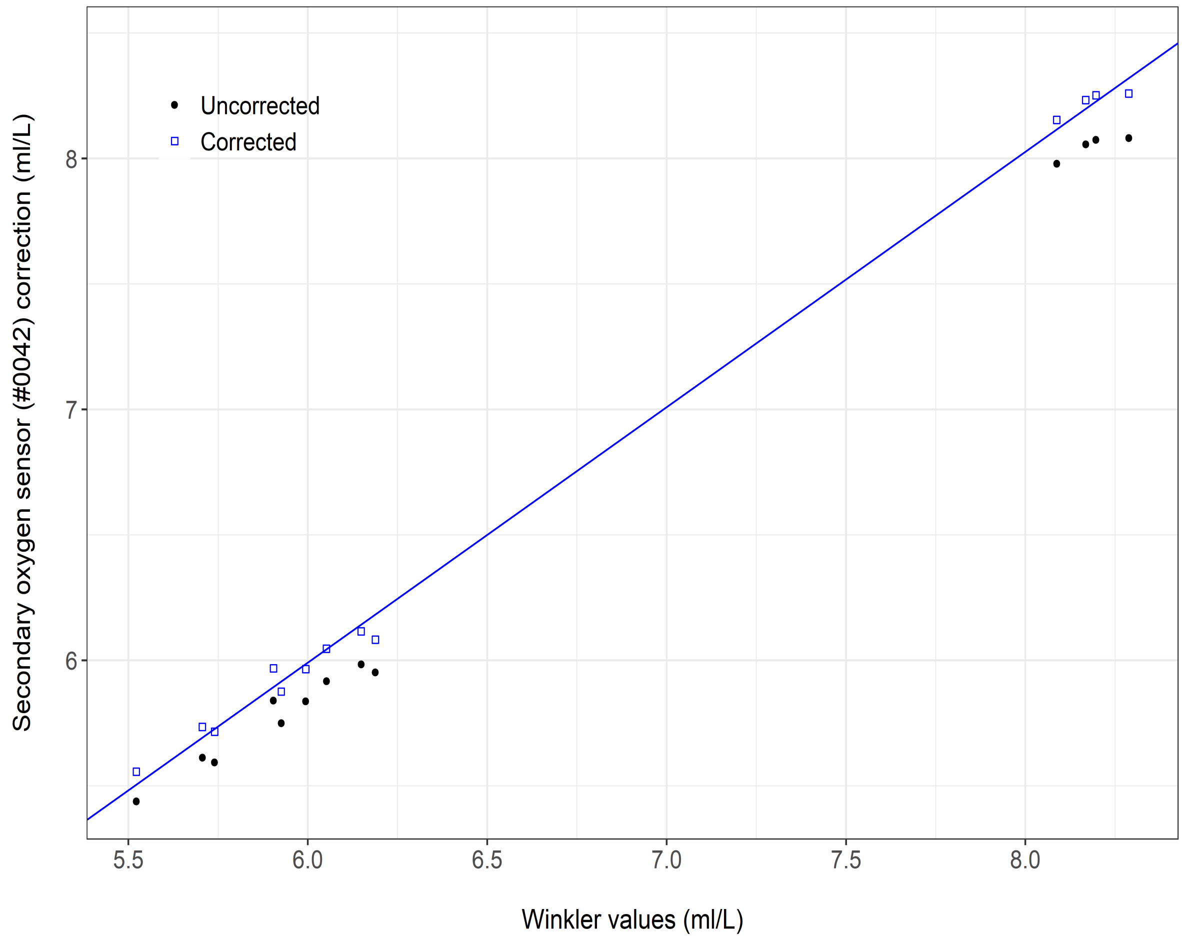

Figure B.9. Secondary oxygen sensor (SN 0042) from Events 117 to 128 before (black dots) and after (blue squares) correction using the slope correction ratio. The blue line represents the 1:1 reference line of the corrected data.

B.5.5 Outlier detection between secondary sensor SN 0133 and Winkler values

Outliers in the difference between the third secondary sensor (SN 0133) and mean winkler values collected between Events 130 and 184, 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. Only 3 outliers were identified for this secondary sensor (see Figure B.10), and were removed.

B.5.6 NewSoc and slope correction ratio calculation

The *NewSoc* value for secondary sensor SN 0133 is shown in Table B.1. Figure B.11 shows the relationship between the corrected and uncorrected sensor data against the mean Winkler values. The corrected sensor data (in blue) roughly demonstrates a 1:1 relationship with the Winkler data. Before correction, the mean difference between the CTD sensor data and mean Winkler values was -0.2424 ± 0.0659 ml/L (mean ± SD). After correction, the mean difference was reduced to 0.0155 ± 0.0730 ml/L.

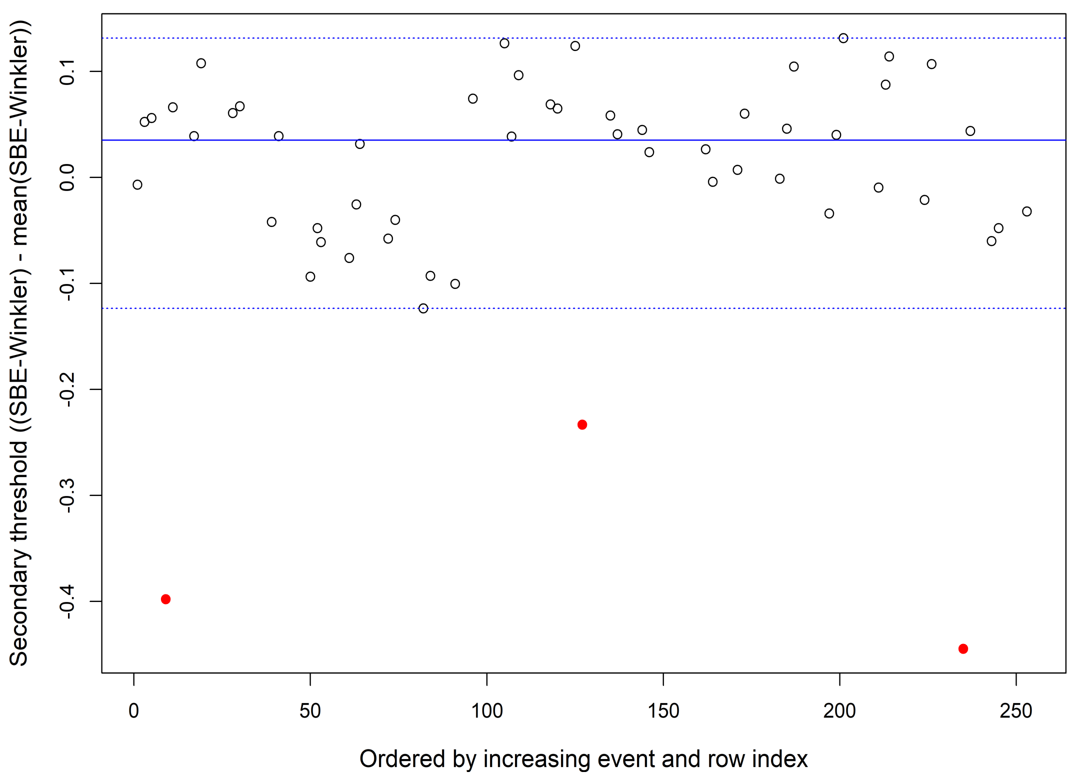

Figure B.10. Outliers (red dots) outside the 1.5*IQR (horizontal dashed blue line) of the threshold fields for secondary oxygen sensor SN 0133 (Events 130 - 184). Boxplot statistics are as follows: Median = 0.0351, IQR min = -0.1234, IQR max = 0.1315.

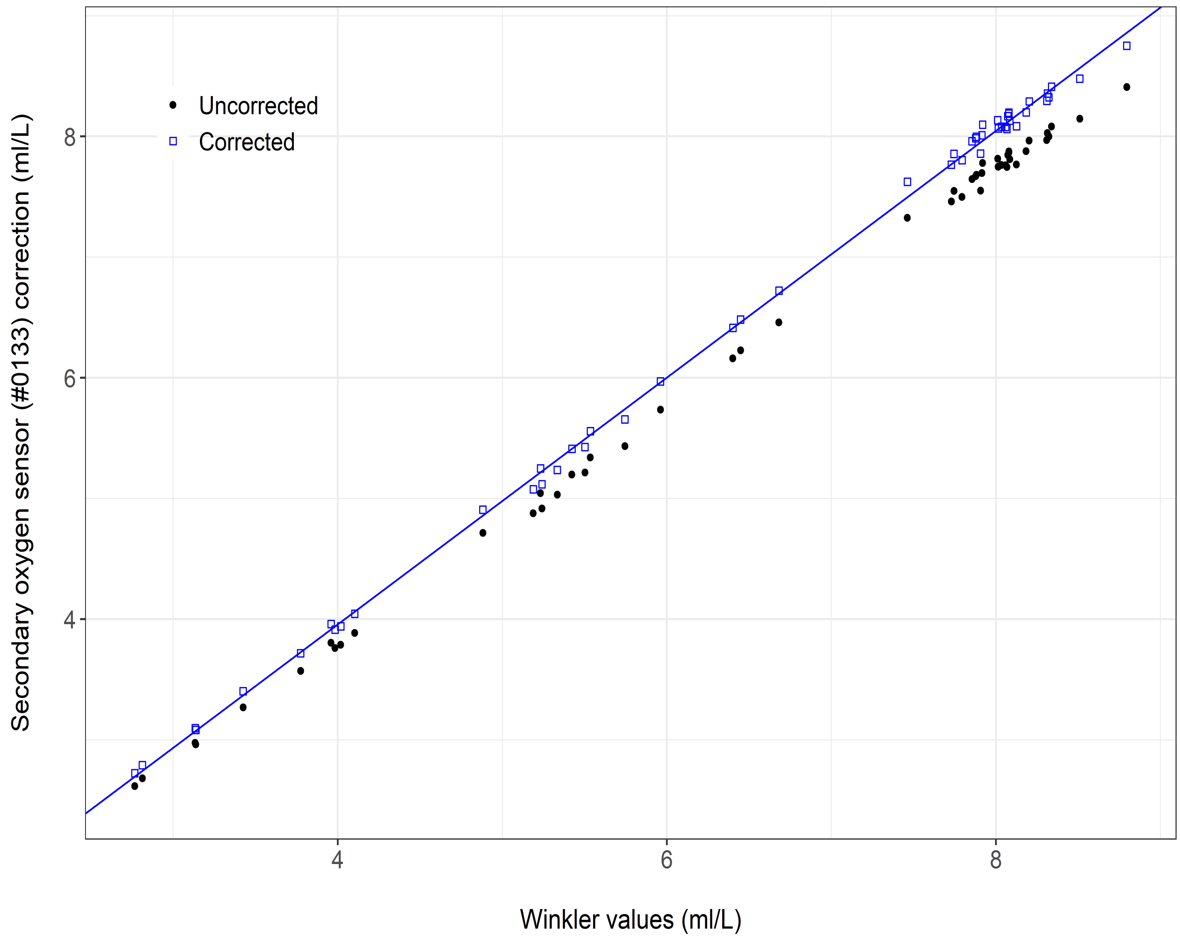

Figure B.11. Secondary oxygen sensor (SN 0133) from Events 130 to 184 before (black dots) and after (blue squares) correction using the slope correction ratio. The blue line represents the 1:1 reference line of the corrected data.

Table B.1. PreviousSoc, NewSoc, and the ratio between the two for the primary and secondary oxygen sensors used during the 2024 spring AZMP mission (TEL2024880).

Sensor	PreviousSoc	NewSoc	Ratio
Primary SBE 43 O2 sensor (3026)	0.5336	0.5428	1.0173
Secondary SBE 43 O2 sensor (4366)	0.5064	0.5226	1.0321
Secondary SBE 43 O2 sensor (0042)	0.4470	0.4568	1.0220
Secondary SBE 43 O2 sensor (0133)	0.3696	0.3847	1.0408

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 2024). 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 mission for the purpose of salinity determination were analyzed at sea using a Guildline 'Portasal' portable bench top salinometer. The Portasal 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 Portasal 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 (Intergovernmental Oceanographic Commission 2010). The Portasal was set up in the Biology Lab on board the CCGS *Teleost*, and salinity bottle samples were analyzed using a bath temperature set to 24°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 Portasal 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, therefore 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. 3361, calibrated on December 22, 2023) and secondary (Serial No. 1874, calibrated December 14, 2023) conductivity sensors remained on the CTD/Rosette package for the entire duration of the mission. As the sensors were not changed, slope and offset values were calculated across the full range of CTD events (001 to 184).

C.2 Evaluation of outliers in TEL2024880 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 95 of 859 data points fell outside the 1.5*IQR and were removed from the calibration process (Figure C.1), leaving a total of 764 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 21 outliers were identified (Figure C.2) and subsequently removed from the dataset. For the secondary sensor and bottle data, 25 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, -0.0009 ± 0.0003 S/m (mean ± SD) and 0.0006 ± 0.0003 S/m for the primary and secondary sensors, respectively.

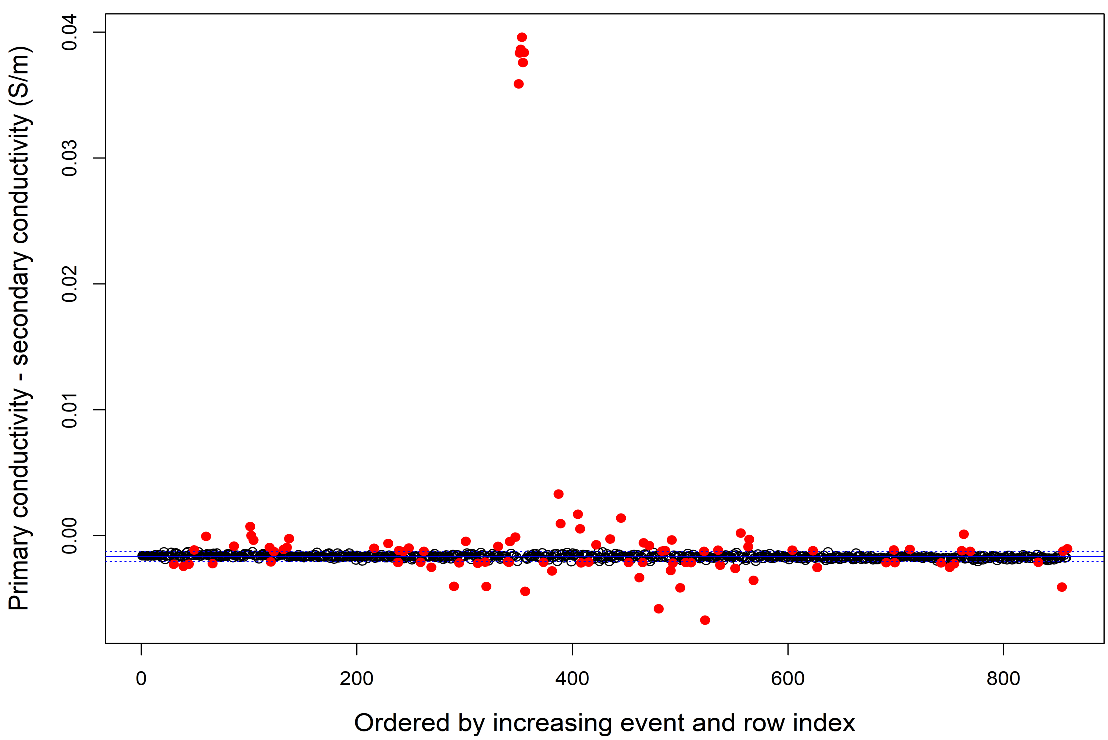

Figure C.1. Comparison between salinity values derived from the primary and secondary conductivity sensor data collected during the 2024 spring AZMP mission (TEL2024880). Differences outside 1.5*IQR (horizontal dashed blue lines) are considered outliers (red dots) and were removed from the calibration process. Boxplot statistics are as follows: Median = -0.0017, IQR min = -0.0020, IQR max = -0.0013.

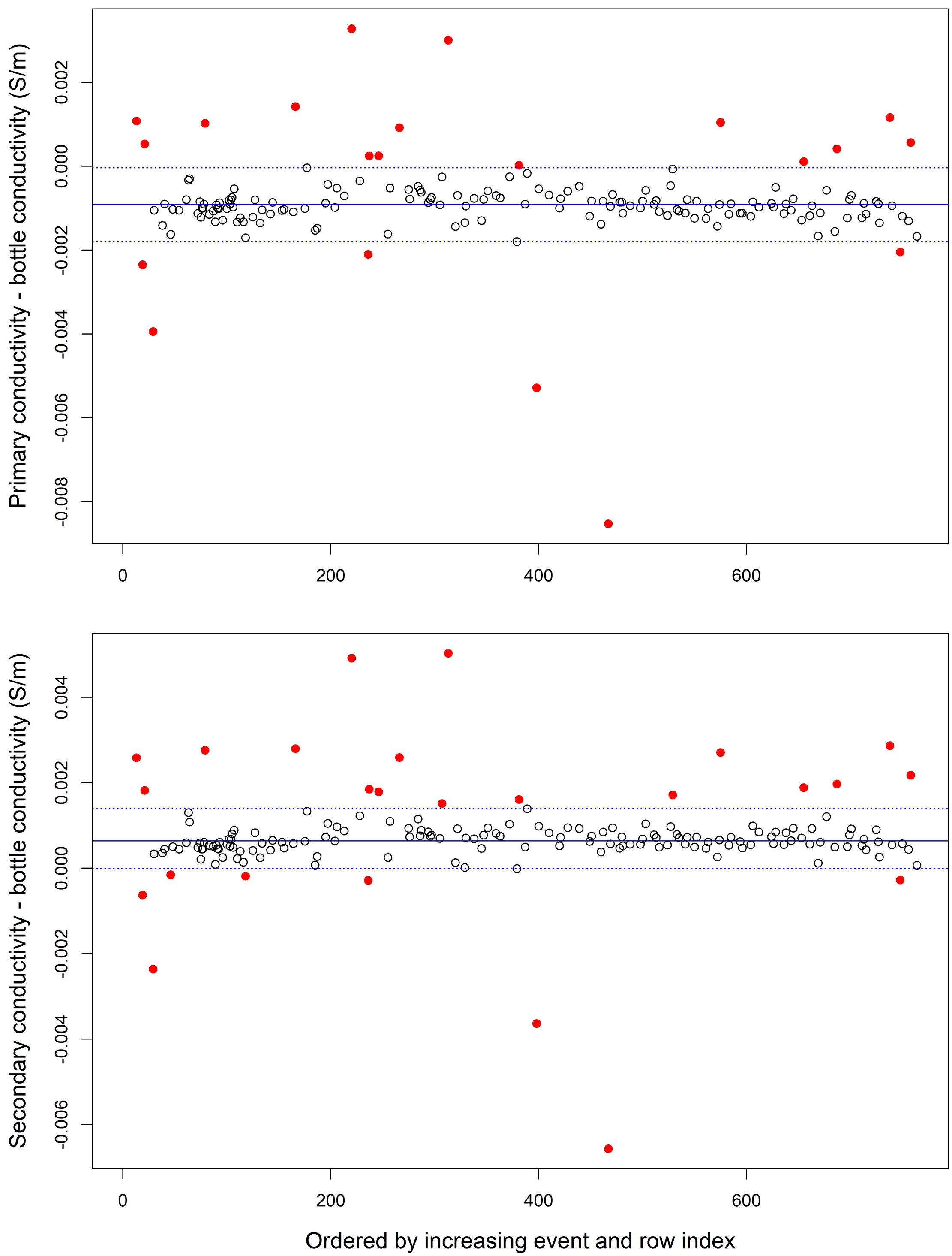

Figure C.2. Comparison between primary (top) and secondary (bottom) conductivity sensor data and bottle conductivity (S/m) collected during the TEL2024880 mission. Differences outside 1.5*IQR (horizontal dashed blue lines) are considered outliers (red dots) and were removed from the calibration process. Boxplot statistics are as follows: A) Median = -9.1418 x 10^{-4}, IQR min = -1.7983 x 10^{-3}, IQR max = -3.5604 x 10^{-5}; B) Median = 6.3786 x 10^{-4}, IQR min = -7.3273 x 10^{-6}, IQR max = 1.3920 x 10^{-3}.

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; 764 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. The mean difference between the sensor and bottle data was higher before correction for both the primary and secondary sensors. Figure C.4 shows the relationship between the corrected and uncorrected sensor data against their corresponding bottle conductivity values (in S/m). The difference between corrected and uncorrected sensor data appeared negligible.

Table C.1. Revised offset and slope terms calculated for the primary and secondary conductivity sensors used during the 2024 spring AZMP mission (TEL2024880).

Sensor	Offset	Slope
Primary SBE 4 Conductivity Sensor (4361)	0.0027	0.9994
Secondary SBE 4 Conductivity Sensor (1874)	0.0002	0.9997

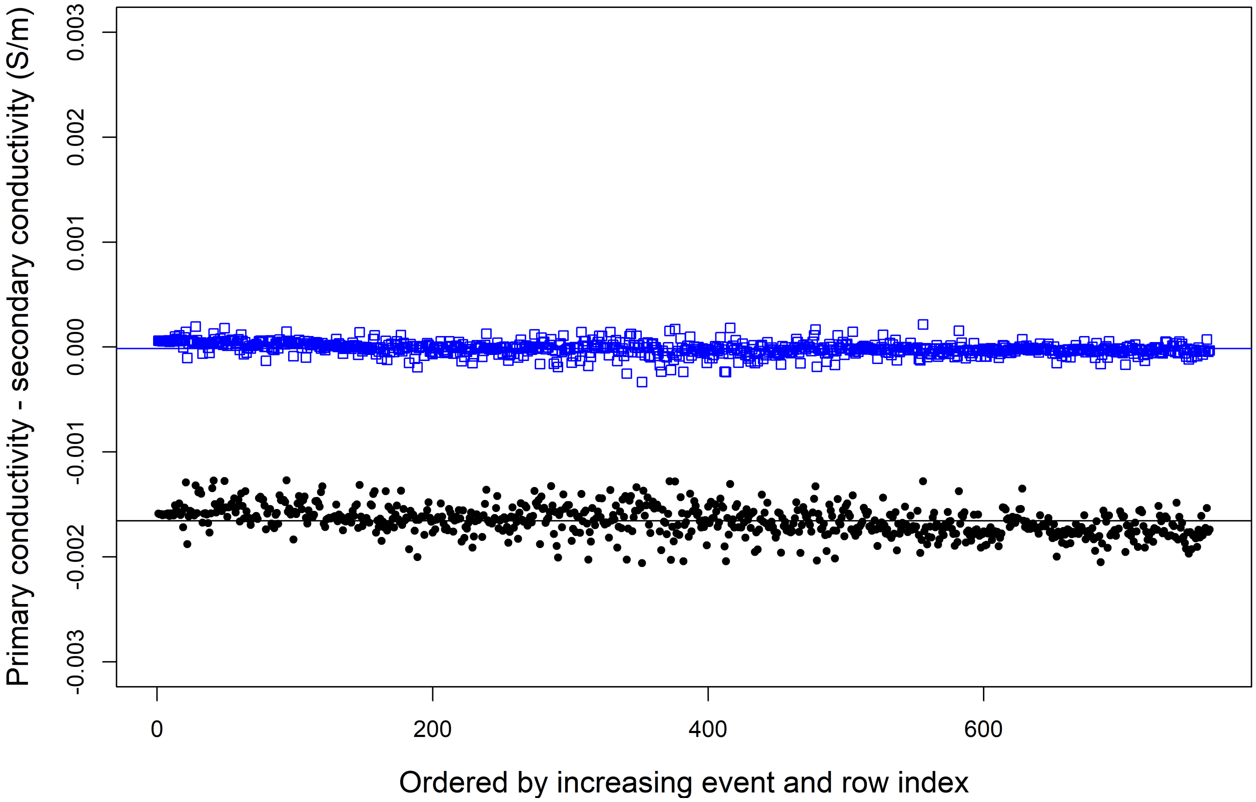

Figure C.3. Primary (top) and secondary (bottom) conductivity sensor data before (black dots) and after (blue squares) correction using the determined slopes and offsets. The blue line represents the 1:1 reference line of the corrected data.

Table C.2. Mean difference between uncorrected and corrected sensor conductivity versus their corresponding bottle conductivity values for the 2024 spring AZMP mission (TEL2024880).

Sensor	Mean Difference - Uncorrected	Mean Difference - Corrected
Primary Conductivity Sensor (4361)	-0.00089	7e-05
Secondary Conductivity Sensor (1874)	0.00071	8e-05

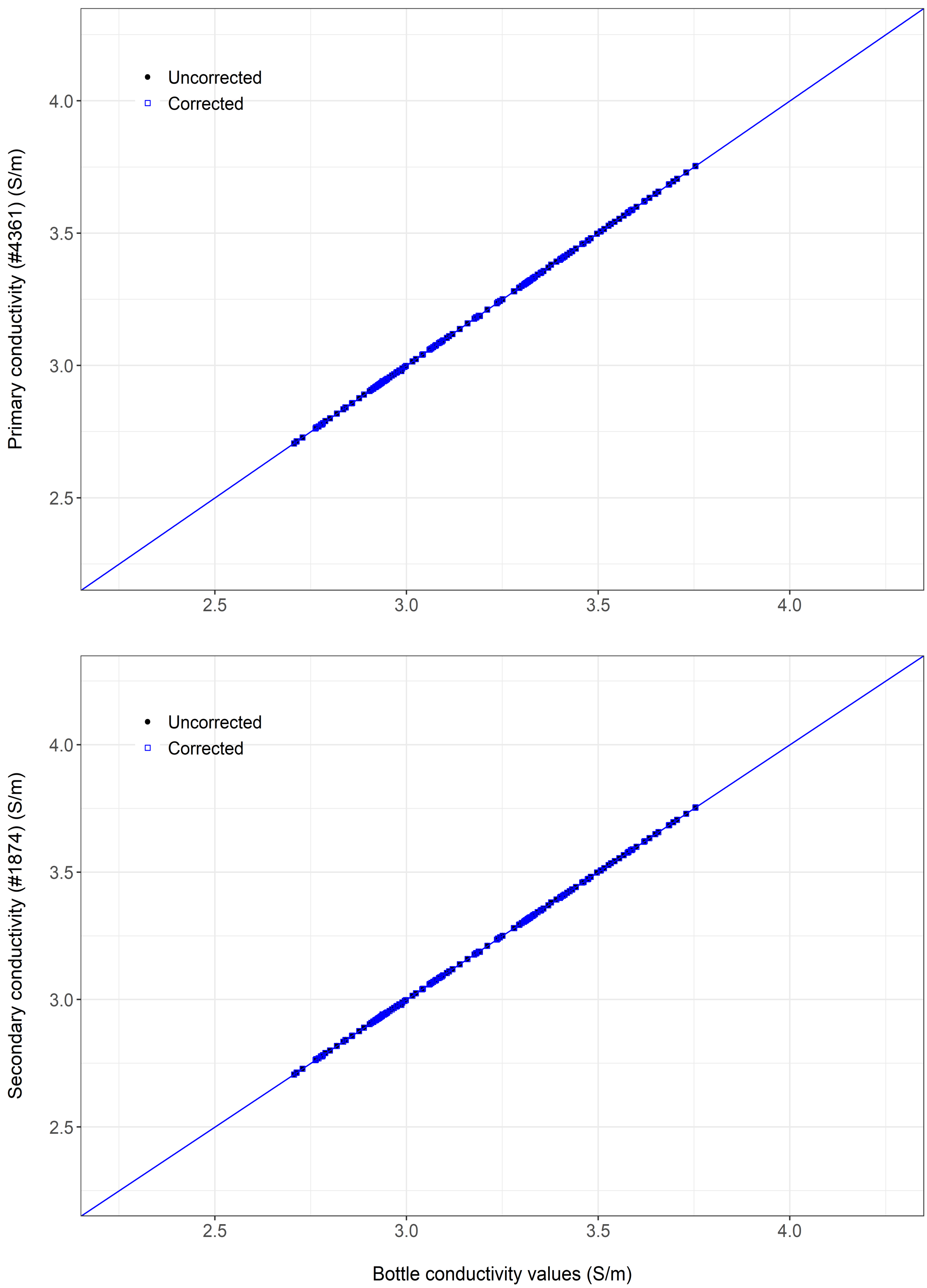

Figure C.4. Primary (top) and secondary (bottom) conductivity sensor data before (black dots) and after (blue squares) correction using the determined slopes and offsets. The blue line represents the 1:1 reference line of the corrected data.

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

D.1 Background

Two Seapoint chlorophyll fluorometers were used on the CTD during the TEL2024880 mission. The outputs from the first fluorometer (SN 3668) appeared noisy, and consequently the sensor was changed to another Seapoint sensor (SN 3867) on Event 015. Both fluorometers were factory assessed prior to use (see Table 4).

For the purpose of this exercise, chlorophyll *a* data from the *in situ* chlorophyll fluorometers were 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.

Comparisons were conducted for each sensor and event sequence (Events 001 to 013, and 016 to 184) separately. A total of 637 water samples were collected for chlorophyll *a* determination during the TEL2024880 mission. Replicate chlorophyll filters were processed and read from all 637 samples, resulting in 1274 measurements. 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, 129 of 637 samples were identified as outliers (Figure D.1). The average difference between replicates was 0.0025 $\pm$ 0.0546 μg/L (mean $\pm$ SD) after removal. The dataset was then parsed by event number, and the two fluorometer sensors were evaluated against the Turner measurements separately.

Similar outlier detection methods were used to remove outliers between the chlorophyll sensors 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

Out of 23 comparisons between the first chlorophyll sensor (Seapoint SCF SN 3668) and mean Turner fluorometer replicate data from Events 001 to 013, 3 outliers 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

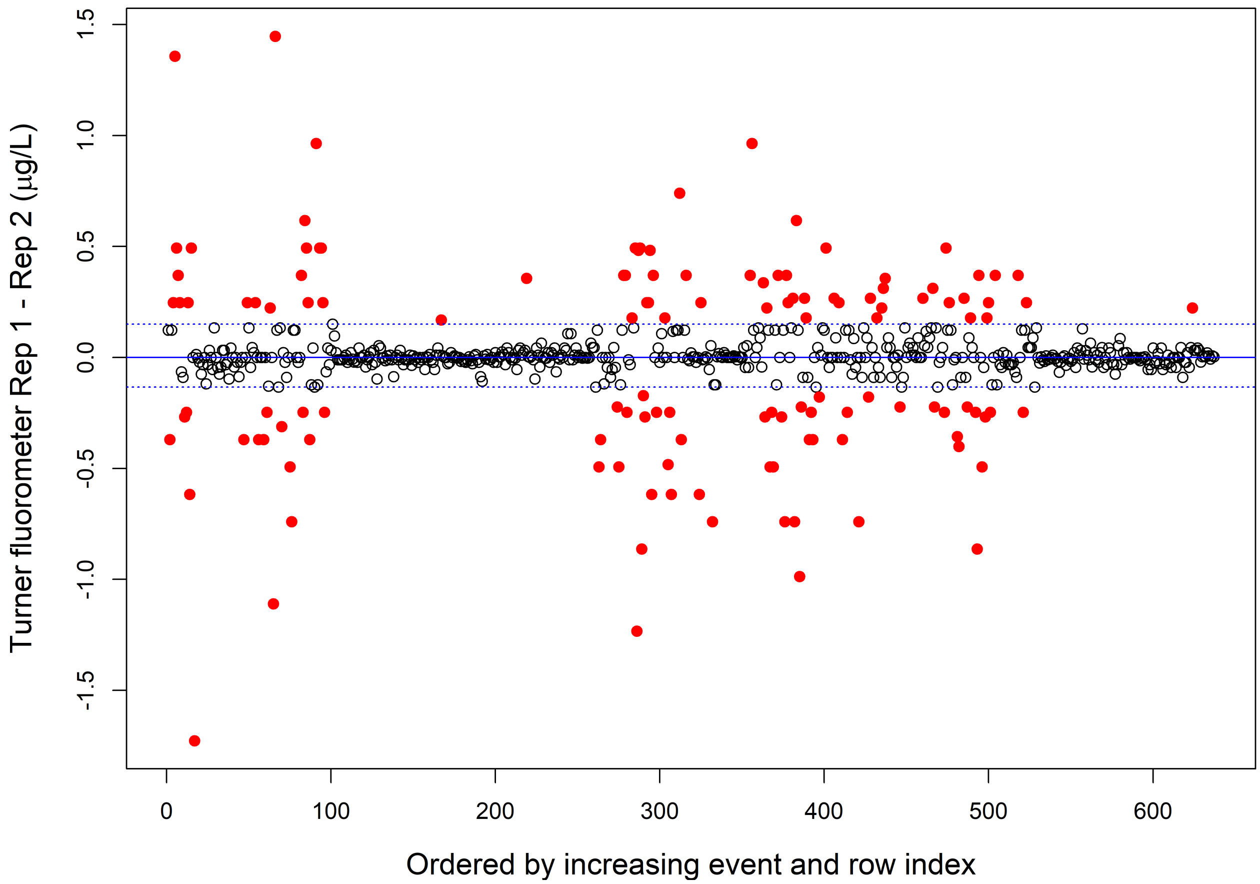

Figure D.1. Comparison of Turner fluorometer replicates. Differences above or below the IQR min/max are considered outliers (red dots) and were removed from the evaluation process. Boxplot statistics are as follows: Median = 0.0000, IQR min = -0.1337, IQR max = 0.1506.

Turner chlorophyll replicate, with the 3 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 = 0.0183). However, the R^2 value was low (0.2317), suggesting a poor relationship between the fluorometer sensor outputs and Turner chlorophyll measurements. It is likely that the cast sample size (4) in this comparison was not enough to accurately evaluate the fit between the sensor and bottle data.

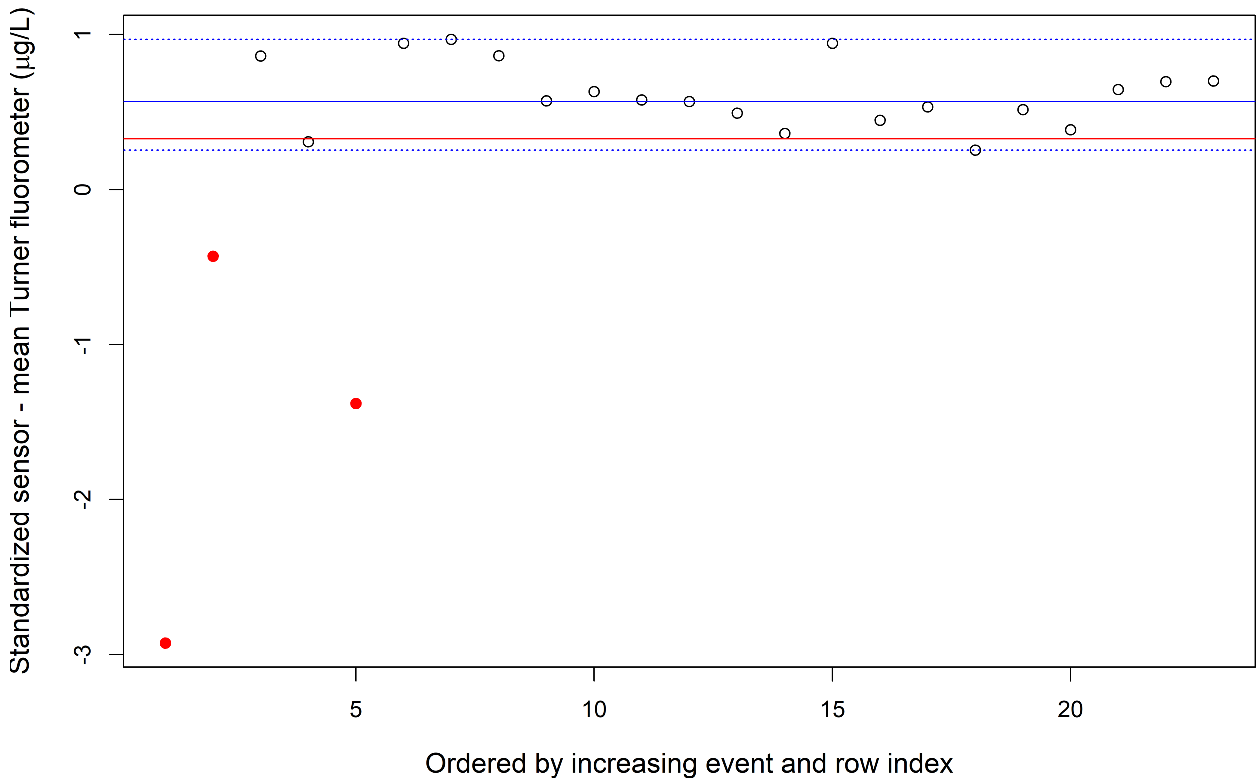

Figure D.2. Outliers identified from calculating the percent (%) difference between standardized chlorophyll sensor values and Turner fluorometer values (mean Turner fluorometer values divided by the chlorophyll sensor values). Boxplot statistics are as follows: Median = 0.5678, IQR min = 0.2554, IQR max = 0.9694. The solid red line indicates the mean (-1.8651).

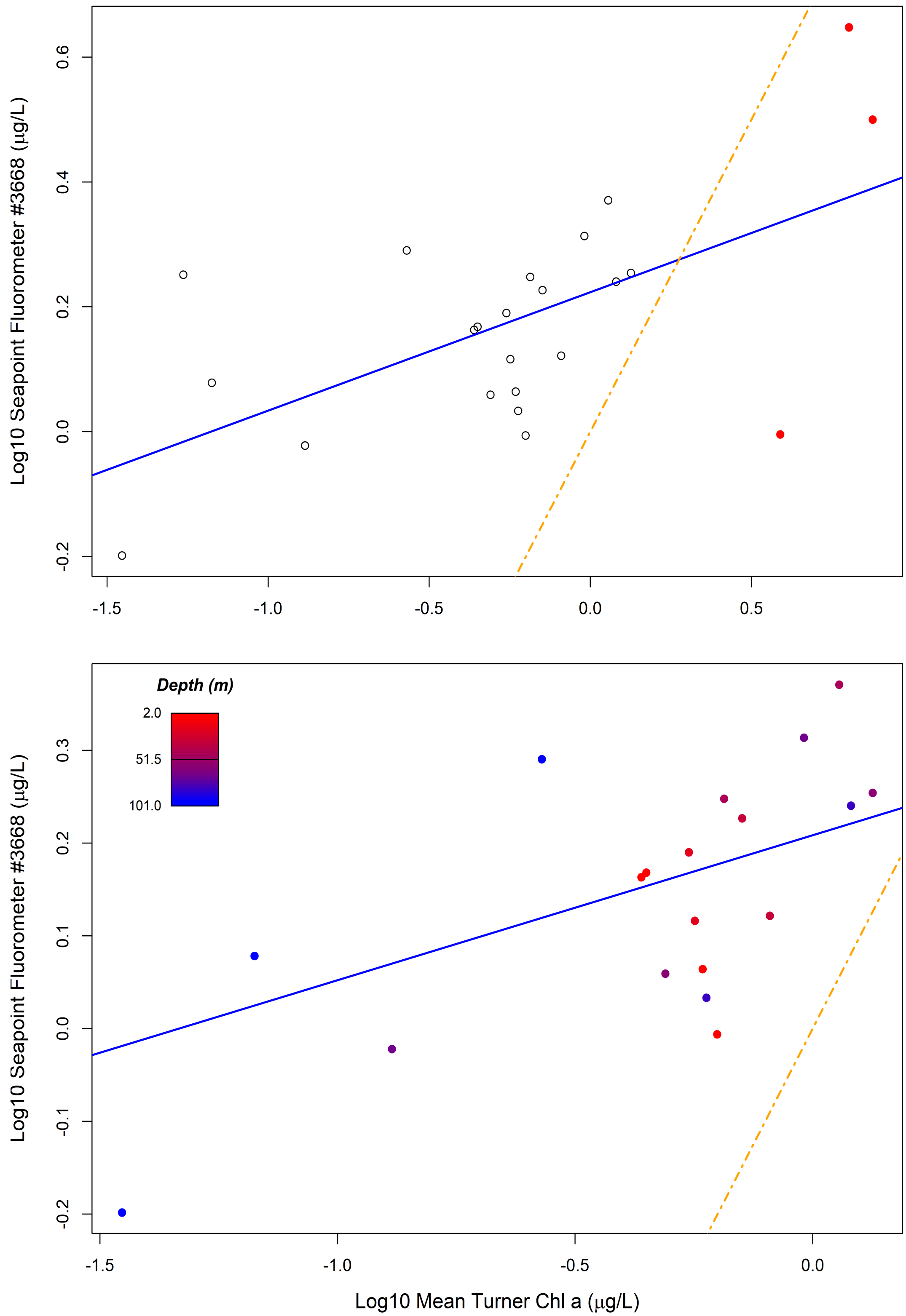

Figure D.3. Top: log10 scale of sensor fluorometer values against mean replicate Turner fluorometer values for Events 001 to 013. Outliers from Figure D.2. are indicated in red. Bottom: log10 plot of sensor fluorometer values and replicate Turner fluorometer values (outliers removed), colour-coded by 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.

D.3 Seapoint SCF Fluorometer SN 3867

Out of 485 comparisons between the second Seapoint chlorophyll sensor (SN 3867) and mean Turner fluorometer replicate data collected across Events 016 to 184, 12 outliers were identified and subsequently removed (Figure D.4). Figure D.5 shows the log relationship between the chlorophyll sensor values and the mean Turner chlorophyll replicate, with the 12 outliers from Figure D.4 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 (R^2 = 0.7831, p value = <0.001). This suggests that the Seapoint fluorometer sensor data closely fit the chlorophyll *a* measurements from bottle samples. However, the 1:1 reference line in Figure D.3 suggests that the CTD fluorometer sensor is under-representing chlorophyll concentration relative to the Turner chlorophyll values. Routine validation of the sensor data using the Turner bottle measurements at sea corroborated the underestimation of chlorophyll *a* by the sensors, particularly at depths where the chlorophyll maximum was observed.

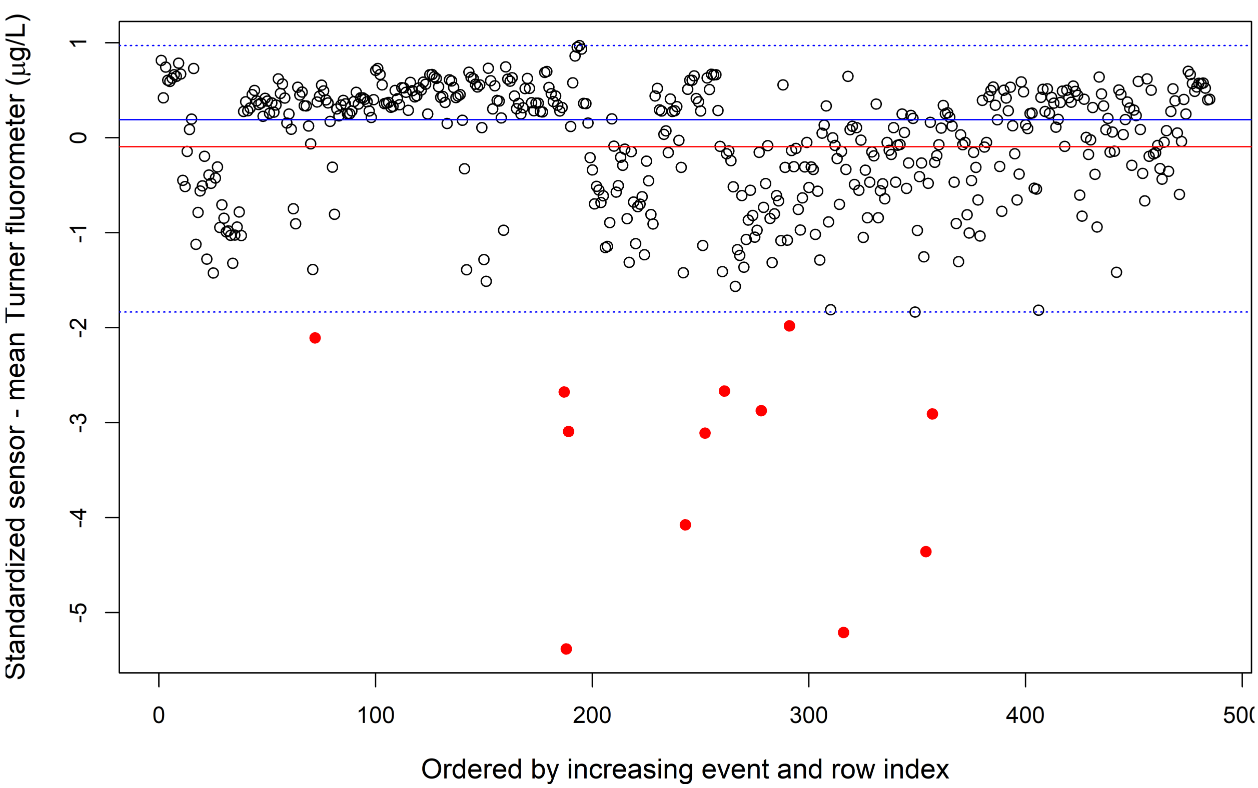

Figure D.4. Outliers identified from calculating the percent (%) difference between standardized chlorophyll sensor values and Turner fluorometer values (mean Turner fluorometer values divided by the chlorophyll sensor values). Boxplot statistics are as follows: Median = 0.5678, IQR min = 0.2554, IQR max = 0.9694. The solid red line indicates the mean (-1.8651).

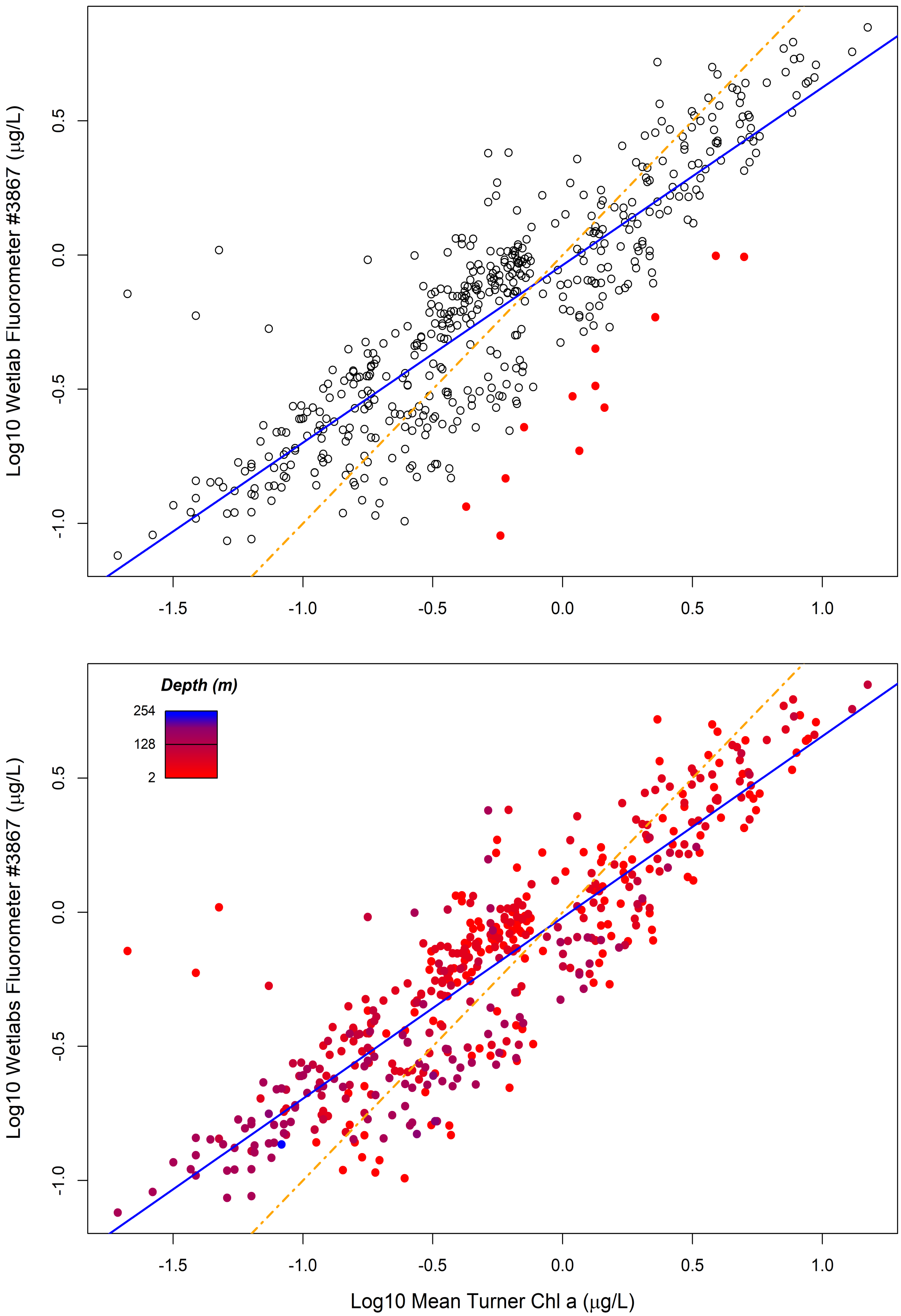

Figure D.5. Top: log10 scale of sensor fluorometer values against mean replicate Turner fluorometer values for Events 016 to 184. Outliers from Figure D.4. are indicated in red. Bottom: log10 plot of sensor fluorometer values and replicate Turner fluorometer values (outliers removed), colour-coded by depth, where red and dark red are shallow and purple and blue are deep (closer to 254 m). In both plots, the blue line represents the line of best fit, while the orange dashed line is the 1:1 reference line.