Atlantic Zone Monitoring Program (AZMP)
Fall Survey
HUD2020-063

Cruise Report

CCGS *Hudson*

Oct 3rd – Oct 15th, 2020

Mission highlights

Area Designation:	NAFO Regions: 5Ze, 4X, 4W, 4Vs, 4Vn, 3Ps, 3Pn Extent: 42° 22'N - 47° 34'N; 57° 31'W - 66° 23'W
Expedition Designation:	HUD2020-063
Chief Scientist:	Lindsay Beazley Ocean Monitoring and Observation Section Ocean Ecosystem Sciences Division Fisheries and Oceans Canada Bedford Institute of Oceanography PO Box 1006 Dartmouth, NS, Canada B2Y 4A2 Lindsay.Beazley@dfo-mpo.gc.ca
Ship:	CCGS *Hudson*
Commanding Officer(s):	Captain Roy Lockyer (Acting CO for South Crew) Captain Fergus Francey (CO for North Crew)
Cruise Dates:	Leg 1: Oct 3rd – Oct 6th Leg 2: Oct 8th – Oct 15th
Ports of Call:	BIO – Saturday Oct. 3rd, 2020 (Embark Leg 1) BIO – Tuesday Oct. 6th, 2020 (Disembark Leg 1) BIO – Thursday Oct. 8th, 2020 (Embark Leg 2) Sydney, NS – Thursday Oct. 15th, 2020 (Disembark Leg 2)

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Mission overview

Leg 1 - Oct 3 to Oct 6

The Atlantic Zone Monitoring Program (AZMP) fall mission – HUD2020063 - was originally scheduled to occur between September 12th to 30th, 2020. Several months prior to sailing, permission was sought from Canadian Coast Guard (CCG) to extend the end date of the mission until October 6th (day prior to crew change – Oct. 7) in the event that the preceding whale mooring mission (HUD2020-066) could not complete all mooring operations within its allotted time slot.

On September 6, on the last day of the whale mooring mission, *Hudson* experienced a critical failure in one of its service generators, which rendered the vessel non-operational. Upon inspection of the damage, CCG's anticipated return-to-service for the vessel was Oct. 8, which was beyond the time slot of the HUD2020063 AZMP mission. However, CCG engineering staff worked with local Caterpillar contractors to formulate a plan to repair the generator system. Renting a portable service generator was initially considered a viable option but ultimately found to be unfeasible due to issues with integrating the generator into *Hudson*'s existing systems. Repairing the existing generator was deemed the most practical option.

In order to mitigate loss of the HUD2020063 program, discussions with Quebec Region's AZMP resulted in the Quebec Region agreeing to provide 8 days of their time slot so that the Maritime Region AZMP could complete their core sections (Browns Bank Line, Halifax Line, Louisbourg Line, and Cabot Strait Line). As part of this agreement, the HUD2020063 mission would demobilize in Sydney on Oct. 15/16th, which was closer to the embarkation location of the Quebec Region AZMP mission (the Gaspé Region).

Repairs of the generator were completed at the beginning of October and final testing and certification by the American Bureau of Shipping (ABS) was granted on Saturday Oct. 3, after which the vessel was deemed operational. This allowed the Maritime Region AZMP to embark on its mission, and provided several days of sampling before the CCG crew change on Oct. 7.

Under the command of acting Commanding Officer Roy Lockyer, *Hudson* left the BIO wharf at approximately 1600 ADT on Saturday Oct. 3, and proceeded to the Browns Bank section (BBL) on the western Scotian Shelf. The vessel arrived on the first station of this section (BBL_01) at ~ 0500 UTC on Sunday Oct. 4. During transit, vessel speeds exceeded 15 knots at times, and was consistently between 12-13 knots while on route to station.

Both vertical ring net tows and CTDs operations were conducted at all 7 stations on the Browns Bank section. While the commanding officer Roy Lockyer was willing to continue the program until 0800 (ADT) on crew change day (Oct. 7), the chief scientist determined that there was not enough time to complete the next core section (Halifax Line –HL) in that time frame. Instead, all 10 stations on the Northeast Channel (NEC) section were sampled, as well as station PL_09 (where PL=Portsmouth), and the vessel returned to BIO in the afternoon of Tuesday Oct. 6.

Once the first leg of the mission disembarked at ~1500 ADT on Tuesday Oct. 6, DFO samples were brought ashore and the science crew prepared for the second leg of the mission, which was expected to commence on Thursday, Oct. 8.

Leg 2 - Oct 8 to Oct 16

The second leg of the mission was scheduled to disembark BIO at 1200 ADT on Thursday Oct. 8. However, due to a strong northwesterly wind (sustained winds in excess of 30 knots with gusts exceeding 40 knots), the vessel was pinned against the jetty and could not pull away safely and without the potential of striking the hull. Commanding Officer Fergus Francey delayed the mission until the winds died down. The vessel was able to depart BIO at 2000 ADT that evening.

Hudson proceeded to the Halifax Line and arrived at its first station, HL_01, at approximately 0100 UTC on Oct. 9. Strong winds impacted operations while working down the Halifax Line, and vertical ring net tows could not be conducted for the majority of stations on this section (see the section on ‘Vertical ring net tows’ below for more details). Winds speeds finally dipped below 30 knots at HL_06.3 and HL_6.7, and vertical ring net tows could safely be conducted. Operations on the Halifax Line concluded at HL_08. A mooring was recently deployed at station HL_08 on the whale mooring mission, but due to time constraints, a CTD profile could not be collected during that mission. While HL_08 was not included in the original HUD2020063 mission plan, as time allowed, this station was occupied and the ring net, CTD, and a single Argo float were deployed at this station. Argo floats were deployed at equidistant intervals along the transit from HL_08 to LL_09 during the overnight hours of Oct. 10 to 11.

Station LL_09 was occupied on Sunday Oct 11 at 0830 UTC, where ring net, CTD, and Argo float operations were conducted. LL_09 represented the deepest station of the mission, where water depths reached in excess of 3700 m. As such, the ship’s crew were directed to grease the CTD and hydrowire drums. During the CTD operation at LL_09, a critical error in the CTD system occurred and the CTD package was recovered ~100 m from bottom. The error was related to connectors between the sensors and the carousel,

and was remedied by CTD technician Terry Cormier (see section ‘CTD operations’ below for full details).

Sampling was completed on the Louisbourg Line at approximately 2200 UTC on Monday Oct. 12. The vessel proceeded to the last planned section for the program, the Cabot Strait Line. Sampling on this line was considered a high priority, as the data collected would be shared with the Quebec Region as per the agreement made between regions. Sampling was completed at the last station on this line, CSL_06, at 2000 UTC on Tuesday Oct. 13. While the official end of the program was Thursday Oct. 15 in Sydney, NS and the ship was scheduled to take on fuel on Oct. 15 and 16, Commanding Officer Fergus Francey allowed the vessel to continue its science program until 2000 ADT on Oct. 14, after which the vessel would depart for the Sydney harbour. Additional stations in the Laurentian Channel and on St. Anns Bank were occupied to utilize this additional time.

Upon conclusion of operations at CSL_06, the secondary temperature and salinity sensors were changed due to a reoccurring increase in the difference between the primary and secondary conductivity values (see ‘CTD operations’ section for full details) once the CTD package reached 100 m depth. A new station was selected in the centre of the Laurentian Channel, called LCC_01, where LCC represents ‘Laurentian Channel Centre’. The purpose of this station was to provide higher-resolution sampling of the Gulf of St. Lawrence in- and outflow. Discrete samples measuring carbonate chemistry (pCO_2, TIC/TA) were planned for this station to help provide further insight into the rising acidity of the waters flowing into the Gulf of St. Lawrence (Dave Hebert pers. comm.). A net operation was conducted at station LCC_01, and the CTD was deployed. However, the CTD operation was aborted and the CTD package recovered due to erroneous data produced by the secondary temperature and conductivity sensors. Due to strong currents, holding station while troubleshooting the issue was difficult. Therefore, the decision was made to abandon CTD operations at station LCC_01 and move towards station STAB_06. Consequently, only a ring net zooplankton sample was collected at station LCC_01. During transit to STAB_06, the issue with the CTD package was discovered and remedied. All sensors appeared to function properly for the remainder of the mission.

An additional station was added to the St. Anns Bank section, termed STAB_05.3. This station was located approximately 1/3 of the distance from STAB_05 and STAB_06 (hence the ‘5.3’ designation), and served a similar purpose of failed station LCC_01 – to sample the in- and outflow of the Gulf of St. Lawrence at a higher resolution. This station was sampled successfully. Carbonate chemistry samples were not collected on this station, but instead were collected on STAB_06. Collection of these samples was not originally planned in the water budget for this station, but was deemed necessary to better capture changes in the acidity in the waters entering the Gulf of St. Lawrence.

Furthermore, additional salinity samples were collected on stations STAB_05 through STAB_02 to provide additional data on salinity levels throughout the water column for the purpose of calibrating the new conductivity sensor after it was replaced following operations on CSL_06.

Sea state and wind started to build significantly as sampling continued on the St. Anns Bank line and the vessel traversed towards STAB_01. Upon reaching STAB_02, science staff deemed conditions unsuitable to conduct net operations, and only the CTD was deployed. Given the building sea and wind state and the need to tie up the vessel that evening, the science program was ended at approximately 1830 UTC on Wednesday Oct. 14 after operations at STAB_02 were completed. STAB_01 was not occupied.

The vessel set its course towards the Sydney harbour, and tied up at the Sydney Cruise Port directly adjacent to ‘The Big Fiddle’ after 2000 ADT on Wednesday Oct. 14. Science staff then proceeded to prepare gear and samples for offload and transport back to BIO on the following day. Science staff left the vessel in Sydney and headed back to BIO at approximately 1030 ADT on Thursday Oct. 15, transporting gear and samples back via a rented U-Haul.

Participants

A total of 13 science staff participated in each leg of the mission. Personnel consisted of 9 DFO staff and 4 Dalhousie University participants representing the labs of Drs. Carolyn Buchwald, Julie LaRoche, and Erin Bertrand. The chief scientist was Lindsay Beazley, acting Maritimes Region AZMP operational lead until April 30, 2021, while Chantelle Layton was night shift manager. One data manager (Jeff Jackson – ODIS) participated in the mission. Due to the shift in mission dates from September to October, the wildlife observer contracted by ECCC-CWS could no longer participate. Marc Ringuette replaced Jeff Spry during the second leg of the mission (Oct. 8 – 15) due to a scheduling conflict.

All science staff were split into day (0600-1800) and night (1800-0600) watches.

Table 1. Participants of the Fall AZMP Mission – HUD2020-063. Affiliation is Department-Division-Section for DFO staff. Dal = Dalhousie University.

	Name	Affiliation	Duty	Shift
1	Perry, Tim	DFO-OESD-OMOS	Lab technician	Night
2	Thamer, Peter	DFO-OESD-OMOS	Lab technician	Day
3	MacIsaac, Kevin	DFO-OESD-OMOS	Net operator	Night
4	Spry, Jeff	DFO-OESD-OMOS	Net operator	Day
5	Layton, Chantelle	DFO-OESD-OMOS	CTD computer operator, night shift captain	Night
6	Hebert, Dave	DFO-OESD-OMOS	CTD computer operator	Day
7	Beazley, Lindsay	DFO-OESD-OMOS	Chief scientist	Day
8	Jackson, Jeff	DFO-SPAD-ODIS	Data manager	Day
9	Cormier, Terry	DFO-OESD-OETS	CTD technician	Night
10	Lehmann, Nadine	Dal - Buchwald	Rosette/water	Day
11	Dempsey, Britton	Dal - Buchwald	Rosette/water	Night
12	MacNeil, Liam	Dal – Bertrand/LaRoche	Rosette/water	Night
13	Bannon, Cat	Dal – Bertrand/LaRoche	Rosette/water	Day
Replaced Jeff Spry on Leg 2 (Oct 8 – 15):				
	Ringuette, Marc	DFO-OESD-OMOS	Net operator	Day

Mission achievements

There were 12 defined objectives (Table 2) in the first iteration of the mission plan (i.e., 'Form B') sent to the ROC Atlantic and Commanding Officers on August 11, 2020. Objectives 13 and 14 were added just prior to sampling, while Objective 15 (collection of water samples for the analysis of dissolved inorganic iodate and iodide speciation in shelf and deeper slope waters), was requested by Dr. Doug Wallace (Dalhousie University) after Leg 2 had commenced.

The original ship time request for the fall AZMP survey was for a 19-day program (Sept 12 to 30), embarking and disembarking at the Bedford Institute of Oceanography (BIO) in Dartmouth, NS. Due to the failed service generator, the mission was conducted over an 11 day period (Oct. 3-6 and Oct. 8-14), with demobilization occurring in Sydney, NS on Oct. 15. Of the 89 stations outlined in the initial mission plan, only 52 (58%) were occupied and sampled during the mission. An estimated 56% of the program was lost due to the delay caused by the failure in *Hudson*'s service generator (outlined in 'Form C' sent to the ROC Atlantic on November 9, 2020).

While the reduction in ship time due to the failure of *Hudson*'s service generator significantly impacted the ability to meet the program's objectives, AZMP's primary objective to collect observations on the hydrography and distribution of nutrients, phytoplankton and zooplankton on 'core' sections was met due to the additional ship time provided by the Quebec Region. Of the 15 final mission objectives, 8 were fully met, 3 were partially met, while 4 were not completed (see Table 2). Three of the four incomplete objectives (Objectives 2, 6, and 12) directly resulted from the reduction to the program's duration and shift in mission dates, while incomplete Objective 3 was the result of inclement weather incurred while sampling the Halifax Line. The collection of data on the hydrography and nutrients distribution across the Northeast Channel and Gulf of Maine as part of NERACOOS Cooperative Agreement was only partially satisfied, as stations on the Yarmouth and Portsmouth Lines (with the exception of PL_09) were cut from the program prior to sailing. This marks the 3rd survey, and 1.5 years since these sections have been sampled by AZMP (last sampled on the spring 2019 Coriolis mission). The Northeast Channel section was fully sampled on Leg 1, the data of which will be sent to NERACOOS for distribution and archiving.

As time was available at the end of the planned science program, this allowed for the collection of data along one ancillary section (in addition to sampling on the NEC section completed on Leg 1), the St. Anns Bank section (stations STAB_02 to STAB_06; STAB_01 was not sampled due to time restraints). This section was within closest vicinity of the Cabot Strait Line, and its occupation resulting in Objective 5 being met (Table 2).

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

	Primary	Status	Comment
1	Obtain observations of the hydrography and distribution of nutrients, phytoplankton and zooplankton at standard sampling stations along "core" Atlantic Zone Monitoring Program sections within the Maritimes Region (Contact **Lindsay Beazley** - http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html)	Completed	All core stations were occupied. Due to inclement weather and wind speeds > 35 kts, vertical ring net tows could not be conducted from stations HL_03 to HL_06.
	Secondary		
2	Carry out hydrographic, chemical and biological sampling at stations in the Gully in support of Gully MPA monitoring initiatives by Oceans and Coastal Management Division (Contact **Lindsay Beazley** - http://inter-w02.dfo mpo.gc.ca/Maritimes/Oceans/OCMD/Gully/Gully-MPA)	Not completed	Due to failure in Hudson's service generator, stations in the Gully MPA were not sampled and this objective could not be met.
3	Conduct rough stratified tows with a closing ring net (bottom to 80 m and 80 m to surface) at station HL_02 to ascertain the depth distribution of zooplankton (Contact **Dr. Catherine Johnson** – Catherine.Johnson@dfo-mpo.gc.ca)	Not completed	Due to strong wind speeds in excess of 35 kts, net operations could not be conducted. Only the standard tow (202 µm) was conducted at HL_02.
4	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/)	Partially completed	Stations on the Northeast Channel line were occupied. Stations in the Gulf of Maine (YL and PL lines) were cut from the program.
5	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** - http://www.dfo-mpo.gc.ca/oceans/mpa-zpm/stanns-sainteanne-eng.html)	Completed	Station STAB_01 was not occupied due to time restraints and inclement weather.
6	Conduct hydrographic, chemical and biological sampling across the mouth of the Laurentian Channel and St. Pierre Bank. These transects have been implemented to enhance our understanding of hydrographic phenomenon in support of current modelling efforts (Contact **Dr. Dave Brickman** – David.Brickman@dfo-mpo.gc.ca)	Not completed	Due to failure in Hudson's service generator, stations in the Laurentian Channel and St. Pierre Bank were not sampled and this objective could not be met.

7	Deploy 6 ARGO floats in support of the International Argo Float Program (Contact **Dr. Ingrid Peterson** - http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html)	Completed	Argo floats were deployed in an array between stations HL_08 and LL_09.
8	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)	Partially completed	Caps were left on the conductivity sensor during initial set up the underway system. As a result, conductivity, salinity, and density were not collected on the BBL, NEC, and PL_09 sections (Leg 1).
9	Collect water samples for the Bertrand lab at Dalhousie University to evaluate whether and how organic and organometallic micronutrients influence primary productivity and phytoplankton community structure on the Scotian Shelf (Contact **Dr. Erin Bertrand** – https://www.dal.ca/faculty/science/biology/faculty-staff/our-faculty/erin-bertrand.html)	Completed	
10	Collect water samples from strategic locations and depths to support a microbial community analysis via DNA, RNA and flow cytometry, as well as the isolation of novel diazotrophs (Contact **Dr. Julie Laroche** - http://www.dal.ca/faculty/science/biology/faculty-staff/our-faculty/julie-laroche.html)	Completed	
11	Collect water samples from strategic locations and depths for neodymium isotope analyses aimed at elucidating water mass distribution and circulation on the Scotian Shelf, and quantifying of the contribution of on-shelf nutrient transport versus local biological processes (Contact **Dr. Carolyn Buchwald** - https://www.dal.ca/faculty/science/oceanography/people/faculty/carly-buchwald.html)	Completed	

12	Bird and marine mammal observations as part of ECCC-CWS sea-bird observation program and DFO Whale Group observation program, and in fulfilment of Gully and St. Anns Bank MPA occupation requirements (Contacts **Carina Gjerdrum** – carina.gjerdrum@canada.ca and **Dr. Hilary Moors-Murphy** – Hilary.Moors-Murphy@dfo-mpo.gc.ca)	Not completed	Due to the shift in mission dates, the wildlife observer contracted by ECCC-CWS could no longer participate in the mission.
13	Collect bottom water samples for eDNA metabarcoding to evaluate benthic species diversity and the presence of invasive species in the Gully MPA (Contact **Dr. Nick Jeffery** – Nick.Jeffery@dfo-mpo.gc.ca – added just prior to sailing)	Partially completed	As the Gully was not occupied, samples were instead collected from the HL and LL sections.
14	Additional nutrient samples collected at various stations for inter-regional comparison (Contact **Mr. Peter Thamer -** added just prior to sailing).	Completed	
15	Collect water samples for the analysis of dissolved inorganic iodate and iodide speciation in shelf and deeper slope waters, and compare to measurements collected in Bedford Basin (Contact **Dr. Doug Wallace –** douglas.wallace@dal.ca – objective added during sailing).	Completed	Samples were collected from near-bottom to surface on stations LL_02 and LL_08.

Summary of operations

Figure 1 and Table 3 provide a summary of operations conducted at the 52 stations occupied during the HUD2020063 mission. A total of 101 gear deployments (events) were conducted, and consisted of CTD-rosette deployments, vertical ring net tows, and Argo float deployments. The underway system was in operation during transit and while on station to measure near-surface salinity, temperature, chlorophyll *a*, coloured dissolved organic matter (CDOM) fluorescence, and pCO_2 throughout the majority of the mission. All stations on the core sections (Browns Bank Line, Halifax Line, Louisbourg Line, Cabot Strait Line) were occupied, along with ancillary Northeast Channel and St. Anns Bank sections. No mooring operations were conducted on this mission. Below represents a summary of the activities and issues encountered during deployments of each gear type.

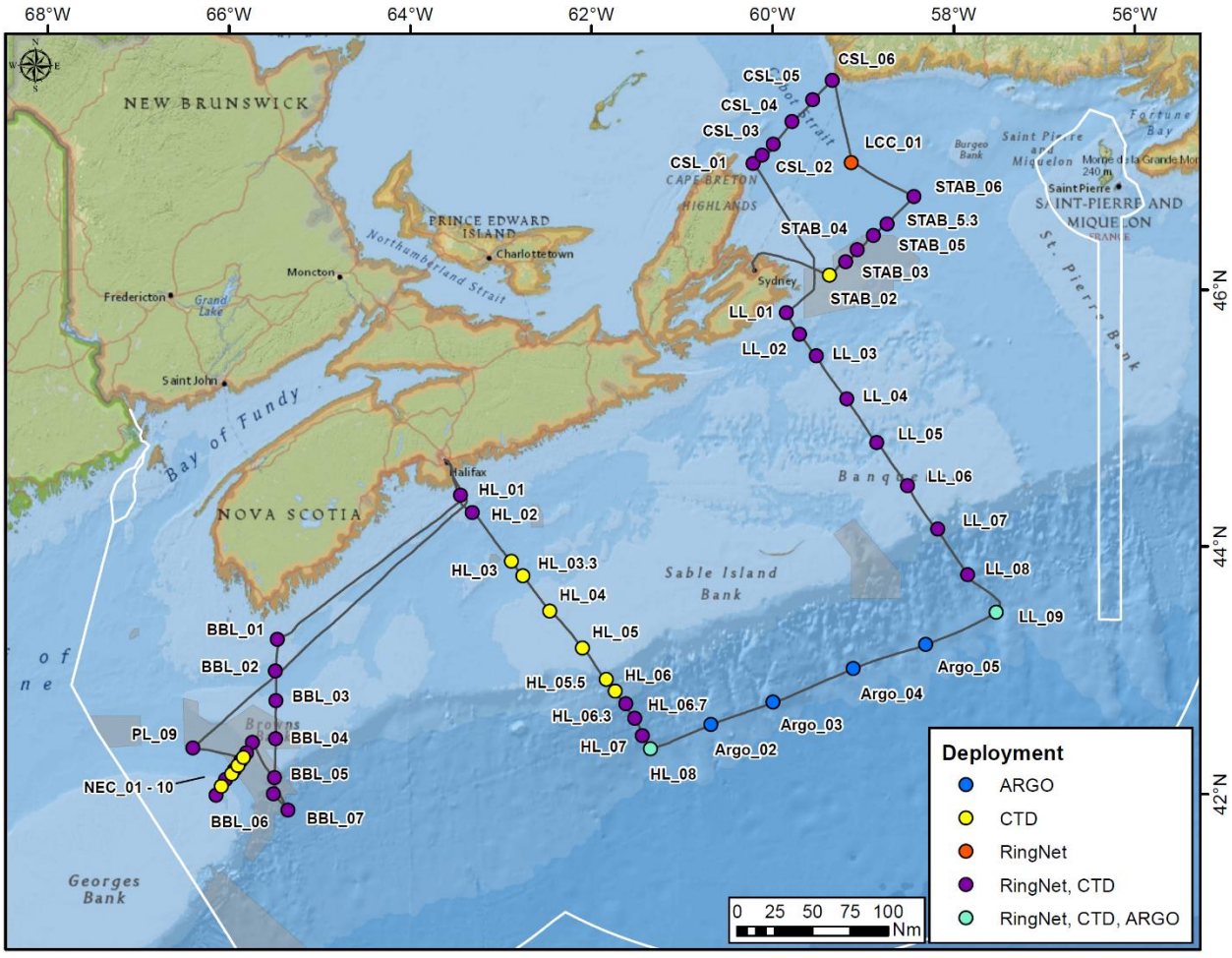

Figure 1. Location of occupied stations and gear deployed during the Fall Atlantic Zone Monitoring Program (AZMP) oceanographic mission (HUD2020063), Oct 3 – 15, 2020. Station positions are represented by the first operation conducted at each station. The exclusive economic zone is shown in white. Grey polygons indicate Maritime Region Marine Protected Areas and Other Effective Area-Based Conservation Areas.

Table 3. Operations conducted at each station during the Fall AZMP mission (HUD2020-063), ordered sequentially by Event number. Event coordinates (in decimal degrees – DD) and sounding (meters) reflect the ship's position and total water column depth at the time of deployment (start), as recorded using the ELOG meta-data logger. Generalized comments associated with the events are also provided.

Event	Station	Gear	Start Lat (DD)	Start Lon (DD)	Depth (m)	Date	Duration	Comment
Browns Bank Line (BBL)								
1	BBL_01	Ring net	43.2562	-65.4675	56	10/4/2020	0:03:32	202 µm mesh.
2	BBL_01	CTD	43.2543	-65.4638	62	10/4/2020	0:20:50	
3	BBL_02	Ring net	43.0001	-65.4871	117	10/4/2020	0:06:49	202 µm mesh.
4	BBL_02	CTD	42.9989	-65.4841	114	10/4/2020	0:32:02	
5	BBL_03	Ring net	42.7606	-65.4826	97	10/4/2020	0:08:05	202 µm mesh.
6	BBL_03	CTD	42.7604	-65.4833	97	10/4/2020	0:35:27	Sampled Salinity and O_2 at 1 m instead of 10 m by accident.
7	BBL_04	Ring net	42.4516	-65.4838	97	10/4/2020	0:06:12	202 µm mesh. Salps - small species.
8	BBL_04	CTD	42.4502	-65.4833	98	10/4/2020	0:23:58	Missed bottle 4 at 50 m, fired bottle at 40 m; missed bottle at 20 m; fired bottle at 10 m. Sampled extra nutrients at surface and bottom for regional comparison.
9	BBL_05	Ring net	42.1336	-65.4979	187	10/4/2020	0:11:50	202 µm mesh.
10	BBL_05	CTD	42.1335	-65.5000	182	10/4/2020	0:33:59	
11	BBL_06	Ring net	42.0003	-65.5100	1082	10/4/2020	0:56:21	202 µm mesh.
12	BBL_06	CTD	42.0000	-65.5098	1087	10/4/2020	1:05:38	

13	BBL_07	Ring net	41.8676	-65.3496	589	10/4/2020	0:53:46	202 µm mesh. Sounding incorrect. Actual bottom depth 1884 m. Ram not down.
14	BBL_07	CTD	41.8664	-65.3493	1178	10/4/2020	1:41:10	
Northeast Channel (NEC)								
15	NEC_01	Ring net	42.4221	-65.7420	95	10/5/2020	0:06:21	202 µm mesh.
16	NEC_01	CTD	42.4233	-65.7461	94	10/5/2020	0:21:46	
17	NEC_02	Ring net	42.3375	-65.8074	197	10/5/2020	0:10:55	202 µm mesh. Strong current.
18	NEC_02	CTD	42.3381	-65.8051	203	10/5/2020	0:33:41	
19	NEC_04	Ring net	42.2712	-65.8698	224	10/5/2020	0:12:02	202 µm mesh.
20	NEC_04	CTD	42.2716	-65.8685	223	10/5/2020	0:41:02	
21	NEC_06	Ring net	42.1992	-65.9389	226	10/5/2020	0:15:02	202 µm mesh.
22	NEC_06	CTD	42.1994	-65.9379	221	10/5/2020	0:30:38	Bottle at 10 m was fired at surface; no 10 m sample. 480416 was last sample ID and was taken at surface.
23	NEC_08	Ring net	42.1178	-66.0379	203	10/5/2020	0:15:05	202 µm mesh.
24	NEC_08	CTD	42.1179	-66.0378	202	10/5/2020	0:31:58	
25	NEC_10	Ring net	41.9899	-66.1421	87	10/5/2020	0:09:18	202 µm mesh.
26	NEC_10	CTD	41.9897	-66.1420	87	10/5/2020	0:18:18	
27	NEC_09	CTD	42.0621	-66.0841	92	10/5/2020	0:20:25	
28	NEC_07	CTD	42.1636	-65.9698	180	10/5/2020	0:36:06	Extra nutrients sampled at surface and bottom for comparison study (BIO, IML, NAFC).

29	NEC_05	CTD	42.2336	-65.9030	268	10/5/2020	0:26:08	Deployed time was entered late as the entry was edited and time updated.
30	NEC_03	CTD	42.2987	-65.8394	213	10/5/2020	0:33:14	
Portsmouth Line (PL)								
31	PL_09	Ring net	42.3773	-66.3997	259	10/5/2020	0:14:41	202 µm mesh. 2 jars collected.
32	PL_09	CTD	42.3775	-66.3988	263	10/5/2020	0:40:32	
Halifax Line (HL)								
33	HL_01	Ring net	44.4018	-63.4439	89	10/9/2020	0:12:44	202 µm mesh.
34	HL_01	CTD	44.4032	-63.4292	78	10/9/2020	0:34:51	
35	HL_02	Ring net	44.2661	-63.3137	4	10/9/2020	0:09:54	202 µm mesh. Wind speeds ~40 kts. Flowmeter spinning in wind before hitting water. Recovery was dangerous for net and staff. Net was pinned against hull. The 76 µm net and 2 additional 202 µm nets could not be completed at this station.
36	HL_02	CTD	44.2685	-63.3096	148	10/9/2020	0:31:57	
37	HL_03	CTD	43.8804	-62.8828	294	10/9/2020	0:38:12	
38	HL_03.3	CTD	43.7630	-62.7546	208	10/9/2020	0:24:41	
39	HL_04	CTD	43.4820	-62.4580	79	10/9/2020	0:18:29	
40	HL_05	CTD	43.1848	-62.0980	491	10/9/2020	0:26:47	Extra nutrients sampled at surface and bottom for comparison study (BIO, IML, NAFC).
41	HL_05.5	CTD	42.9328	-61.8345	489	10/9/2020	0:42:20	

42	HL_06	CTD	42.8369	-61.7366	1236	10/9/2020	1:08:29	
43	HL_06.3	Ring net	42.7351	-61.6201	1700	10/9/2020	1:02:25	202 µm mesh.
44	HL_06.3	CTD	42.7247	-61.6134	1768	10/10/2020	1:34:33	About 5 cables off nominal station location. Would have taken ½ hr to return to station; decision was made to sample off station. Sounding depth increased when at 750 m; bottle fired about 10 m deeper than target depth.
45	HL_06.7	Ring net	42.6171	-61.5204	2306	10/10/2020	0:53:19	202 µm mesh. Wire loop at bottom of cod-end broke; codend was swinging freely.
46	HL_06.7	CTD	42.6208	-61.5186	2325	10/10/2020	1:59:06	
47	HL_07	Ring net	42.4770	-61.4371	2748	10/10/2020	0:56:51	202 µm mesh.
48	HL_07	CTD	42.4735	-61.4357	2750	10/10/2020	2:06:07	
49	HL_08	Ring net	42.3707	-61.3468	3363	10/10/2020	0:55:31	202 µm mesh.
50	HL_08	CTD	42.3662	-61.3391	3360	10/10/2020	2:35:09	CTD package was stopped at 150 m as the wire was under the hull. Extra nutrients sampled at surface and bottom for comparison study (BIO, IML, NAFC).
51	HL_08	Argo	42.3853	-61.2839	1571	10/10/2020	0:00:00	Sounding incorrect.
52	Argo_02	Argo	42.5683	-60.6801	1571	10/10/2020	0:05:00	Rope caught in holes of Argo frame. Had to redeploy. Sounding incorrect.
53	Argo_03	Argo	42.7485	-59.9938	1571	10/10/2020	0:07:13	Sounding incorrect.
54	Argo_04	Argo	43.0202	-59.1096	1571	10/11/2020	0:09:26	Sounding incorrect.

55	Argo_05	Argo	43.2156	-58.3093	1571	10/11/2020	0:10:46	Sounding incorrect.
Louisbourg Line (LL)								
56	LL_09	Ring net	43.4727	-57.5315	1571	10/11/2020	0:53:18	202 µm mesh. Sounding incorrect. Actual depth 3245 m.
57	LL_09	CTD	43.4699	-57.5257	1571	10/11/2020	2:40:40	Communications to CTD package failed. Could not initialize water sampler. Aborted 100 m above bottom. Restarted deck box at 500 m intervals on ascent. Error disappeared at 2000. Closed all bottles 1500 and shallower. Sounding incorrect.
58	LL_09	Argo	43.4682	-57.4924	1571	10/11/2020	0:00:00	Sounding incorrect.
59	LL_08	Ring net	43.7729	-57.8446	1571	10/11/2020	1:04:13	202 µm mesh. Sounding incorrect.
60	LL_08	CTD	43.7815	-57.8352	1274	10/11/2020	2:10:17	
61	LL_07	Ring net	44.1346	-58.1771	1571	10/11/2020	0:40:04	Ring net aborted as net moved under ship's hull. Sounding incorrect. Actual bottom uncertain, ~700 - 711 m.
62	LL_07	Ring net	44.1270	-58.1763	1570	10/12/2020	0:37:44	202 µm mesh. Sounding incorrect. Actual depth 635 m. Wire angle > 45º due to poor ship maneuverability. Did not try to touch weight on bottom; angle too high & shallowing quickly. Net was deemed successful upon recovery.
63	LL_07	CTD	44.1138	-58.1755	680	10/12/2020	1:00:09	CTD package held 20 m off bottom due to uncertainty with ship drift and poor altimeter readings.

64	LL_06	Ring net	44.4767	-58.5088	22	10/12/2020	0:08:24	202 µm mesh. Sounding incorrect. Actual depth 68 m.
65	LL_06	CTD	44.4760	-58.5070	68	10/12/2020	0:17:26	
66	LL_05	Ring net	44.8165	-58.8503	235	10/12/2020	0:12:01	202 µm mesh.
67	LL_05	CTD	44.8161	-58.8502	248	10/12/2020	0:27:43	
68	LL_04	Ring net	45.1562	-59.1804	100	10/12/2020	0:06:39	202 µm mesh.
69	LL_04	CTD	45.1531	-59.1848	100	10/12/2020	0:21:26	
70	LL_03	Ring net	45.4910	-59.5161	155	10/12/2020	0:08:43	202 µm mesh.
71	LL_03	CTD	45.4909	-59.5177	137	10/12/2020	0:27:12	Extra nutrients sampled at surface and bottom for comparison study (BIO, IML, NAFC).
72	LL_02	Ring net	45.6573	-59.7026	140	10/12/2020	0:08:54	202 µm mesh.
73	LL_02	CTD	45.6586	-59.7071	138	10/12/2020	0:23:01	
74	LL_01	Ring net	45.8230	-59.8463	90	10/12/2020	0:04:26	202 µm mesh.
75	LL_01	CTD	45.8250	-59.8462	95	10/12/2020	0:28:34	Misfire on bottle 17.
Cabot Strait Line (CSL)								
76	CSL_01	Ring net	46.9578	-60.2154	75	10/13/2020	0:03:38	202 µm mesh.
77	CSL_01	CTD	46.9581	-60.2166	81	10/13/2020	0:21:20	
78	CSL_02	Ring net	47.0209	-60.1151	181	10/13/2020	0:14:41	202 µm mesh.
79	CSL_02	CTD	47.0204	-60.1153	178	10/13/2020	0:29:34	
80	CSL_03	Ring net	47.1027	-59.9910	334	10/13/2020	0:18:43	202 µm mesh.
81	CSL_03	CTD	47.1060	-59.9890	333	10/13/2020	0:34:38	

82	CSL_04	Ring net	47.2736	-59.7845	466	10/13/2020	0:30:15	202 µm mesh. Net hit seabed. New net deployment required.
83	CSL_04	Ring net	47.2713	-59.7834	466	10/13/2020	0:26:50	202 µm mesh. Second net deployment at this station. Was successful.
84	CSL_04	CTD	47.2685	-59.7834	465	10/13/2020	0:43:59	During CTD descent secondary conductivity sensor jumped at 100 m relative to primary. Possible blockage. Sensors flushed.
85	CSL_05	Ring net	47.4378	-59.5573	472	10/13/2020	0:27:23	202 µm mesh.
86	CSL_05	CTD	47.4418	-59.5576	475	10/13/2020	0:35:58	Extra nutrients sampled at surface and bottom for comparison study (BIO, IML, NAFC). Secondary conductivity sensor jumped again. Sensors flushed again.
87	CSL_06	Ring net	47.5800	-59.3393	294	10/13/2020	0:16:39	202 µm mesh.
88	CSL_06	CTD	47.5863	-59.3297	234	10/13/2020	0:47:33	
Laurentian Channel Centre (LCC)								
89	LCC_01	Ring net	46.9658	-59.1308	643	10/13/2020	0:27:35	202 µm mesh. Sounding incorrect. Actual depth 474 m. Bad wire angle; possibly hit bottom. Net deemed successful upon recovery.

90	LCC_01	CTD	46.9682	-59.1270	455	10/14/2020	0:19:38	CTD aborted due to erroneous data after switching out secondary T/S sensors. Difficult to keep station due to currents; moving onto STAB_06 while troubleshooting. Since net was already done the first ID will be 480965 for the next cast. Sensor cables were reversed and some plumbing came undone after sensors were switched.
St. Anns Bank (STAB)								
91	STAB_06	Ring net	46.7083	-58.4390	460	10/14/2020	0:24:37	202 µm mesh. Sounding incorrect. Actual depth 470 m.
92	STAB_06	CTD	46.7086	-58.4428	469	10/14/2020	0:47:50	
93	STAB_5.3	Ring net	46.5018	-58.7339	407	10/14/2020	0:20:07	202 µm mesh. Actual bottom depth 409 m.
94	STAB_5.3	CTD	46.5008	-58.7390	403	10/14/2020	0:39:58	
95	STAB_05	Ring net	46.4144	-58.8860	368	10/14/2020	0:21:48	202 µm mesh.
96	STAB_05	CTD	46.4137	-58.8967	364	10/14/2020	0:47:19	Extra nutrients sampled at surface and bottom for comparison study (BIO, IML, NAFC).
97	STAB_04	Ring net	46.3059	-59.0641	160	10/14/2020	0:08:28	202 µm mesh.
98	STAB_04	CTD	46.3048	-59.0674	488	10/14/2020	0:22:06	
99	STAB_03	Ring net	46.2128	-59.1914	93	10/14/2020	0:05:54	202 µm mesh.
100	STAB_03	CTD	46.2131	-59.1957	490	10/14/2020	0:18:19	
101	STAB_02	CTD	46.1106	-59.3725	64	10/14/2020	0:16:19	

CTD operations

The CTD-rosette system was loaded on *Hudson* by the Ocean Engineering and Technology (OETS) field operations team prior to the HUD2020066 whale mooring mission, with the intention of fully testing the system and the newly-fabricated wireless block system prior to the AZMP survey. Several CTD casts were made during the HUD2020066 mission, and issues with communication between the blocks and the winch operator display identified. Attempts to address these issues were made by OETS staff prior to the AZMP mission.

As the CTD-rosette was deployed on the preceding mission, a basin test was not conducted upon departure from BIO on HUD2020063. CTD-rosette profiles and water samples were collected on 51 of the 52 stations occupied during the mission (see Figure 1 and Table 3). At the majority of stations, the full water column was sampled to within 5 m of the seabed. Inclement weather and/or poor vessel maneuverability during some deployments resulted in the CTD package being held to within 10 to 20 m from bottom, as a precaution.

The CTD system functioned properly throughout the mission, and water was collected at every station occupied. On station LL_09 (Event 57), a system error occurred when the CTD package was at approximately 3628 m depth (~100 m from bottom). The CTD deck box sounded an alarm and all communication with the CTD package was lost. The error code reported by Seasave was ‘RS232’. Upon restarting Seasave, the error code ‘Failed at initializing water sampler’ was featured, suggesting there was a broken connection with the carousel. The decision was made to recover the CTD package. During ascent, the CTD deck box was turned on by the CTD operator, and Seasave was restarted every 500 m upon ascent. The alarm continued to sound until the CTD package reached 1500 m depth. At this point, the alarm stopped and the connection to the CTD package was reestablished, suggesting the issue was pressure related. All planned bottles from 1500 m to surface were closed. Bottles designated to collect near-bottom water (BTM), 3000 m, and 2000 m (Bottle IDs 480724, 480725, and 480724, respectively) were closed at 1500 m depth. These bottles were sampled for NUTS, Winkler, TIC/TA, pCO_2, and salinity, some of which would be in duplicate to those collected on Bottle ID 480727 (the original Bottle ID designated for 1500 m depth). This issue will be apparent once the Bottle IDs are matched to the CTD data in the QAT file.

Upon recovery of the CTD package, CTD technician Terry Cormier replaced the cable that connects the carousel to the SBE 9+. This appeared to fix the issue, as no alarm was sounded on the next cast conducted at station LL_08, where the nominal station water depth was ~2930 m.

The sensors on the CTD package functioned well for the majority of the mission. During the CTD-rosette deployment at station CSL_04, an increase in the difference between the primary and secondary conductivity sensor was noted once the CTD package reached 100 m depth. As a blockage was suspected, both sensors were flushed with Triton upon recovery. During deployment of the CTD-rosette at station CSL_05, the same jump in the difference between sensors was noticed, and the plumbing was flushed again. As the issue with the sensor persisted at station CSL_06, the decision was made to replace the secondary temperature and conductivity sensors upon conclusion of operations at this station. The original secondary temperature (Serial No. 1376) and conductivity (Serial No. 1076) sensors, calibrated on October 5 and October 8, 2019, respectively, were replaced with the following sensors: temperature: Serial No. 5081 and conductivity: Serial No. 3561. These sensors were calibrated on December 4, 2019, and January 3, 2020, respectively.

During their replacement, CTD technician Terry Cormier noted that the issue was actually a clog in the pressure-release (bleeder) valve between the sensors and the pump, and not an issue with the sensors themselves. Nonetheless, the new sensors were retained on the CTD package and used for all operations following Event 88. The new XML.CON file for all CTD casts after Event 088 is called HUD2020063_20201013.xmlcon.

During the first deployment following the change in sensors (station LCC_01), the secondary temperature and conductivity sensors showed erroneous values, and the CTD operation was aborted. As holding station was difficult due to the strong currents in this area, it was decided to move on to the St. Anns Bank section while troubleshooting was performed. Consequently, only a vertical ring net sample was collected at station LCC_01. During transit to STAB_06, the issue with the CTD package was discovered and remedied. When the secondary temperature and conductivity sensors were replaced, some cables were attached in the wrong position, and plumping came undone. These issues were fixed prior to arriving at STAB_06 and both ring net and CTD operations were successful at that station.

An additional station was added to the St. Anns Bank section termed STAB_05.3. This station was placed between STAB_05 and STAB_06, at approximately ~1/3 of the distance between STAB_05 and STAB_06 (hence the ‘05.3’ station designation), and served a similar purpose of failed station LCC_01 – to collect higher resolution data on the in- and outflow of the Gulf of St. Lawrence. This station was sampled successfully. Carbonate chemistry samples were not collected on this station, but instead were collected on STAB_06. Collection of these samples was not originally planned in the water budget for this station, but was deemed necessary to better capture changes in pH of the inflow into the Gulf of St. Lawrence. Furthermore, additional salinity samples were

collected on stations STAB_05 through STAB_02 to provide additional data on salinity levels throughout the water column for calibrating the new conductivity sensor after it was replaced following operations on CSL_06.

Upon conclusion of the mission, the CTD-rosette was stripped of its sensors and bottles, which were transported back to BIO. The frame was stored on the flight deck along with the spare frame that was loaded prior to sailing.

Water sampling and data processing

Historically, near-surface salinity and oxygen bottle samples collected for the purpose of calibrating near-surface salinity and dissolved oxygen sensor data were sampled from the surface (1 m) bottle. This mission represented the first mission where near-surface samples collected for this purpose were collected from the 10-m bottle instead of the surface bottle. This change was deemed necessary by the Maritimes Region AZMP Steering Committee at its monthly meeting in May, 2020, in order to reduce the effects of bubbling at the surface on the collected bottle data, and subsequent sensor calibration. Salinity and oxygen samples were collected at nominal bottle depth of 10 m on all stations occupied except BBL_03 (Event 6). Sampling from the surface bottle at this station was a laboratory error.

Chlorophyll *a* and dissolved oxygen samples were processed at sea. However, as a remote demobilization was planned, a decision was made not to board the 'AutoSal' salinometers in order to prevent any damage that may occur to these systems during their transport from Sydney to BIO upon completion of the program. Instead, salinity samples were stored onboard and batch processed by Mat Lawson (OETS) upon return to BIO. A bath temperature of 24ºC was used, rather than the 15°C that standard conductivity was defined. The salinometer program accounted for this temperature difference so that the output sample conductivity ratios with the standard are at 15°C.

For the purpose of this report, the dissolved oxygen and conductivity sensor data were evaluated against the bottle samples, and preliminary calibrations were conducted as an initial step towards final calibration. The results of these exercises can be found at the end of this report, in Appendices 1 and 2. Actual data calibration will be conducted by ODIS oceanographic data technician Jeff Jackson prior to archival of the data on ODIS servers. The relationship between the SeaPoint fluorometer chl *a* sensor and the Turner chl *a* data was also evaluated (see Appendix 3), but was not not used to calibrate the sensor. The CTD input/output configurations for the mission can be found in Appendix 4.

Wireless block and winch operator display system

The HUD2020063 mission represented the first full mission where the recently fabricated wireless CTD and hydrowire block and winch operator display (WOD) systems were put into operation. The wireless block project was initiated in 2017 between AZMP and the OETS section with the purpose of updating the operating software, terminal hardware, and block electronics of the former blocks, which were considered aged and obsolete, and had experienced numerous failures over recent years. At the end of 2019/2020, all winch operator displays, 3 large (CTD) and 5 small (hydrowinch) blocks have been fabricated, with parts purchased for the fabrication of several more large blocks.

During the AZMP mission, several issues were noted in the communications between the wireless blocks and winch operator display system, and between the CTD package and Winch Instrumented Metering Sheave (WIMS) computer-based program. A summary of the issues encountered and short-term remedies can be found in Table 4. One main issue was that the wireless blocks appeared to 'fall asleep', both between stations and during long (deep) deployments of the CTD package. Several attempts were often made to 'wake up' the block (i.e., manually spin the block) before its wireless network (WIMS.001) would appear in the list of network options. The order of operations that were found to result in good connection (but not 100% of the time) were to A) wake up the block and start the WOD software, B) have the winch operator immediately notify the computer room once the wireless network connection was established, and C) start Seasave and WIMS in the computer room.

Another significant issue was that the power indicator for both blocks appeared to display inaccurate values. The two blocks would often read 99% charged on the winch operator display, but would actually be inoperable, indicating that the batteries were drained. During one CTD cast (see Event 67 in Table 4), the charger was plugged into the block during the CTD deployment.

Upon conclusion of the mission, all encountered issues were discussed with OETS designer Merle Pittman, who will continue to make improvements to the power indicator and connection issues over the coming winter and prior to the spring 2021 AZMP mission. Additional suggestions for the improvement of the WIMS software were also suggested by the HUD2020063 mission CTD operators:

1. Have WIMS default on startup be depth 10 m, speed 30 m/m. The default is currently 1000 m at 60 m/m

2. Have the option to select ‘Altimeter’ instead of ‘Depth’ and ‘5 m from bottom’, ‘10 m from bottom’, etc.

Table 4. Summary of issues incurred with the new wireless blocks and winch operator display (WOD) system used during the Fall AZMP survey. Comments were recorded in the ELOG metadata logger as both event comments and full observations.

Event	Station	Comment
4	BBL_02	Issues with WOD at the beginning of cast during the soak period. WIMS was not connecting to CTD, so the WOD was not getting depth or altimeter. Problem was noticed during the 10 m soak period. To try to resolve the problem, the CTD operator attempted to restart WIMS software on computer, but it would not quit without quitting out Seasave. The following steps are what seemed to resolve the problem: 1. Closing out of Seasave and WIMS on CTD computer. 2. Restarting WIMS software on WOD. 3. Open Seasave first, then WIMS. If CTD still not connected to WIMS, close out of it, and open it back up.
10	BBL_05	WIMS GUI would not close when prompted. Window turned black and task manager was used to end the program.
20	NEC_04	WOD display was not receiving depth data from the CTD computer. Issue identified when CTD deployed. WOD was restarted and the connection was established.
34	HL_01	WOD was not receiving information from CTD computer at the beginning of the cast. Remained at the surface for a period to allow for troubleshooting. Computer room received all data after restarting.
40	HL_05	WOD lost CTD computer data in winch room. Both winch room and CTD computer systems were restarted multiple times until the connection was reestablished.
46	HL_06.7	When the CTD package was at 2222 m, the WOD stopped receiving depth and altimeter data. Connection between the computer room PC and WOD ceased. Rebooted WOD software which fixed the problem but the cable out was reset. Suspect that the block went to sleep mode on the way down.
50	HL_08	Depth and altimeter are reading 0 in WIMS, but both connections were green.

67	LL_05	Upon the start of CTD operations on station LL_05, science staff had difficulty 'waking up' the wireless block for the CTD. The network for the wireless block (WIMS.001) was not showing up in the list of network options. Staff plugged in the power cable to charge the system and after restarting the block several times, were able to get a connection. However, once the power cable was removed the wireless block disconnected. The power indicator bar showed that the system was 99% charged. Since the system would lose connection once the power cable was removed, we determined that the block was dead and required charging. Crew left the power cable plugged into the block during the CTD deployment on this station. The power cable is not long enough for the boom to fully extend, so we recommend that longer cables are purchased and taken on subsequent missions.
73	LL_02	Communications issued with WIMS and CTD computer. It appears the order of operations is critical. Block has to be woken up and the winch system connected, then Seasave needs to be set up. This requires inputting the name of the data file name and entering the metadata. Seasave data collection starts and communication with the CTD and NMEA feed. Then, the WIMS on the CTD computer is started and it takes a few seconds before the connection show as good.
75	LL_01	Issues with WOD at beginning of cast. Had to restart WOD software then restart Seasave.
92	STAB_06	Issues waking up and charging blocks. Blocks were reading 99% charged but were dead.

Vertical ring net tows

In order to estimate the mesozooplankton community abundance and biomass, a conical ring net of 202 *µm* mesh size with an aperture of 75 cm in diameter (filtering ratio 1:5) equipped with a KC Denmark flow-meter was towed vertically from the bottom to the surface (or from a maximum depth of 1000 m – AZMP standard) at the majority of stations. All contents of the cod end were preserved in 4% buffered formaldehyde.

A total of 43 vertical ring net tows were attempted during the mission, 41 of which were successful (see Figure 1 and Table 3). Net operations were repeated at stations LL_07 and CSL_04 due to contact between the net and the ship’s hull and seabed on stations

LL_07 and CSL_04, respectively. On the Halifax Line, strong winds impacted net operations on stations HL_02 to HL_06. At station HL_02, the standard AZMP ring net deployment (202 µm mesh net, preserved in formalin) was conducted. However, strong winds made recovery of the net into the winch room difficult, and it was deemed a hazard for both science staff and the net itself. Wind speeds were in excess of 35 knots, which appear to be the operating threshold for this gear type. As a result, the additional net operations at station HL_02 (76-µm mesh ring net and stratified net samples; see Objective 3, Table 2) were cancelled, and no net operations could be conducted from stations HL_03 through HL_06. Winds speeds finally dipped below 30 knots at HL_06.3 and HL_6.7, and vertical ring net tows could safely be conducted.

At STAB_02, ring net operations were cancelled due to wind speeds in excess of 35 knots.

Argo float deployments

A total of 6 Argo floats were deployed during the mission (see Figure 1 and Table 5) as part of the international Argo program (https://argo.ucsd.edu/). The first float was deployed at station HL_08 upon conclusion of the CTD operations at that station, while the remaining floats were deployed at approximately equidistance intervals (stations Argo 2 through Argo 5; Tables 3 and 5) while on route from HL_08 to LL_09. The 6th and final float was deployed at station LL_09. The current location of the floats (as per Nov. 22, 2020) is shown in Figure 2. The floats will remain active for approximately 5 years, collecting profiles of temperature and salinity from the surface to 2000 m every 10 days.

The ELOG entries required for Argo float deployments were recently revised to include entries for when the magnet is removed, when the plugs are removed, and when the unit is deployed. The ELOG configuration file should be revised prior to subsequent missions so that only 1 entry is required for the removal of the magnet and plugs combined, as this operation is done simultaneously. Two-way radios would also allow science staff to better coordinate the various actions so that the entries can be promptly logged in ELOG.

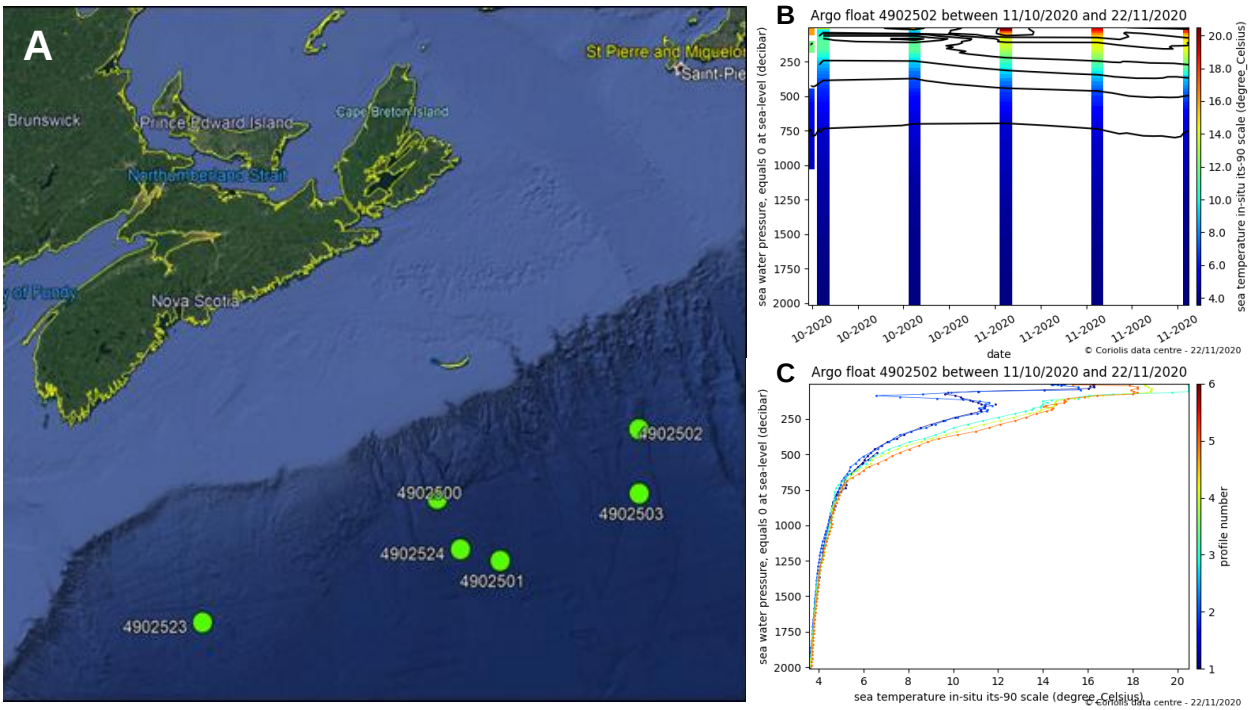

Figure 2. A) Location (as of Nov. 22, 2020) of the six Argo floats deployed between stations HL_08 and LL_09 during the HUD2020063 AZMP fall survey. Floats are displayed by their WMO number (see Table 5). Right panels show the temperature profiles collected by float 4902502 since its deployment. Data were accessed from the OceanOps platform: https://www.ocean-ops.org/board?t=argo.

Table 5. Metadata associated with the deployment of six Argo floats during the Fall AZMP HUD2020063 survey. The IMEI, WMO, and serial numbers (S/N) of each float are provided, along with the time of magnet removal (and first beep, signaling the unit can be deployed) and deployment (UTC), and associated date, event, station, and latitude and longitude (in decimal degrees) of deployment. Checklist results are provided for the magnet and plug removal, and photo (photo taken of IMEI and S/N of each float). 'Deployed by' column represents the individual(s) who deployed the unit, where LB = Lindsay Beazley, DH = Dave Hebert, and CL = Chantelle Layton.

IMEI	S/N	WMO	Time magnet removed (GMT)	Time of deployment (UTC)	Date	Event	Station	Lat.	Lon.	Deployed by
300534060227420	A12600-20CA011	4902523	171100 (beep time: 171600)	171749	10/10/20	051	HL_08	42.3853	-61.2839	LB/DH
300234067675250	A12600-19CA030	4902501	193100 (beep time: 193600)	194306	10/10/20	052	Argo_02	42.5683	-60.6801	LB/DH
300534060223420	A12600-20CA012	4902524	223100 (beep time: 223600)	223609	10/10/20	053	Argo_03	42.7485	-59.9938	CL
300234067675120	A12600-19CA029	4902500	020400 (beep time: 020930)	021318	10/11/20	054	Argo_04	43.0202	-59.1096	CL
300534060900640	A12600-19CA032	4902503	051130 (beep time: 051630)	052042	10/11/20	055	Argo_05	43.2156	-58.3093	CL
300234067676110	A12600-19CA031	4902502	124900 (beep time: 125700)	125831	10/11/20	058	LL_09	43.4682	-57.4924	LB/DH

Underway system

On Oct. 5, it was discovered that the salinity readings from the underway system were giving erroneous values (~0.09 PSU). As the conductivity values were also erroneous, this sensor was suspected to be the cause of the issue. Members of OETS responsible for the setup of the underway system prior to the whale mooring mission HUD2020066 were notified. Given that the appropriate staff were not present at sea to facilitate troubleshooting of the system, the unit was left as-is until conclusion of Leg 1. Upon return to BIO, OETS staff disassembled the system and found that the plugs to the conductivity sensor were not removed prior to sailing. Therefore, conductivity, and thus salinity or density were not collected during Leg 1 (western Scotian Shelf – BIO to BBL, NEC, and PL_09 to BIO). The plugs were removed and the salinity and conductivity values were reading accurate values for Leg 2 (BIO to HL, LL, CSL, and STAB to Sydney) of the mission.

On Monday Oct. 12, it was discovered by the mission data manager that the SCS logging software had not been properly initialized. SCS supports two primary types of data logging – continuous and event-triggered data logging, and integrates the values recorded by different oceanographic sensors with its corresponding navigational and time information. SCS is also the only software that records the rate of flow of water pumping through the system. Information on flow rate is useful during post-cruise data processing, as it may provide context to unrealistically-high pCO2 values, which often occur during instances when the rate of flow suddenly decreased. The SCS software was initialized at approximately 13:50:01 (UTC) on Monday Oct. 12, while the vessel was conducting operations at station LL_04. Flow rate data are available for the cruise from that point forward.

Discrete samples of pCO_2, TIC, and chlorophyll were collected once per day on Oct. 5 and 6, and from Oct. 9 to 14 (see Table 6). A single salinity sample was collected on Oct. 6 to provide some information on salinity when the conductivity sensor was reading erroneous values. The paper log that summarized the metadata associated with the collected samples can be found on the R drive, and is reproduced in Table 6 below.

Table 6. Metadata associated with the collection of water samples from the underway system during the Fall AZMP HUD2020063 survey. 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 (ºC) and salinity were recorded by the thermosalinograph. 'X' and 'XX' indicate single and duplicate sampling, respectively. The TSG and pCO_2 files associated with the discrete sample are also shown. Duplicate TSG files occurred when sampling on subsequent days occurred within a 24-hour time period (new TSG files are generated every 24 hours).

Date	Time	Latitude	Longitude	Temp. (ºC)	Sal.	Sample ID	pCO_2	TIC	CHL	SAL	TSG filename (.hex)	pCO_2 filename (.log)
10/5/20	132956	42.0443	-66.1046	15.87	N/A	480251	X	X	XX		20201004_165411	tsg_day2
10/6/20	093248	43.6928	-64.3838	16.26	N/A	480252	X	X	XX	X	20201005_165425	tsg_day3
10/9/20	151730	43.2253	-62.1448	15.58	32.57	480253	X	X	XX		20201008_174319	tsg_day5
10/10/20	183941	42.4904	-60.9285	15.15	32.38	480254	X	X	XX		20201010_174349	tsg_day6
10/11/20	151923	43.6579	-57.6640	16.60	32.79	480255	X	X	XX		20201010_174349	tsg_day7
10/12/20	155523	45.3855	-59.4268	12.83	30.33	480256	X	X	XX		20201011_174404	tsg_day8
10/13/20	215027	47.1696	-59.1895	8.79	31.33	480257	X	X	XX		20201013_174433	tsg_day9
10/14/20	173925	46.1304	-59.3354	10.91	30.30	480258	X	X	XX		20201013_174433	tsg_day10

Data management

Written by: Diana Cardoso (OESD)

Data collection

The suite of digital data collected during the mission included CTD sensor data, continuous recordings of T/S, fluorescence, pH and pCO_2 by the underway system, 75 kHz Ocean Surveyor shipboard ADCP, Knudsen depth sounder, and GIS. NavNet, a ship-based navigational data collection system, was used to collect GPS data associated with the ship's position, sounder data, gyro data, and wind and motion data. All digital data were backed up hourly or daily, and at the end of the mission were sent to ODIS for archival. Hard-copy paper logs included the bridge log, CTD and ring net logs, and logs for discrete samples collected from the underway system. All hard-copy log sheets were scanned upon conclusion of the mission, and sent to ODIS for archival.

In addition to hard copy log sheets, 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 all computers connected to the ship's science network, and one terminal dedicated to ELOG logging was set up in the computer room, forward and GP labs, and in the winch room. An ELOG itinerary logbook was used to list all upcoming activities, and an observations logbook was also utilized to record detailed comments and observations on cruise activities. All digital logbooks were backed up hourly, and at the end of the mission were sent to ODIS for archival.

The water sampling plan was revised this year so that the nominal depths sampled on each station were sorted in descending order to reflect the order that the bottles are closed (bottom-to-surface, instead of the former surface-to-bottom) during CTD operation. This eased their use by both computer-based and laboratory staff, and is a practice that should be carried into the future. Digital filtration logs were also used by laboratory staff for logging details associated with the processing of collected water. This represented only the second AZMP mission where digital filtration logs were used over paper logs, and was considered a success by laboratory staff. These filtration logs are generated using the R statistical software program, and their templates modified using an Excel macro. Given that DFO computers no longer support the use of Excel macros, a new method should be investigated to modify the templates of the filtration logs prior to future missions. This could possibly be done using excel plugins in R.

Lab staff noted with the chief scientist that it would be helpful to reorganize the layout of the water sampling plan in the future so that 'like' variables/measurements are grouped together. For instance, all the gases should be grouped together (O_2, pCO_2) and listed first, as they are the first samples extracted from the Niskin bottles. The gases should be followed by TIC/TA, nutrients, chlorophyll, salinity, and finally POC/PON, HPLC, ABS, and CYTO.

Hardware

Regulus/Aldebaran computers supplied by NRCAN were placed in the computer room to provide positioning and station name information to operations and ELOG. ELOG was run from a Windows 10 laptop in the computer lab and other PCs used this laptop IP to connect to ELOG in a web browser. A laptop was used in the GP lab for logging data into the digital filtration logs.

Data input template

Summary reports were generated from shipboard input data in the AZMP Template Microsoft Access Database that link the CTD sensor data with their corresponding bottle measurements. These reports were used to conduct the preliminary calibrations included in this report (see Appendices 1 – 3). Input data included CTD QAT files, ELOG files, chlorophyll and oxygen data. While the salinity report is normally generated at sea, this year salinity samples were processed upon return to BIO and the salinity report was generated at a later date.

Operational issues of note

Data collected by the AZMP greatly enhances Canada's ability to understand, describe, and forecast the state of the marine ecosystem and quantify changes in physical, chemical and biological ocean properties and the predator-prey relationships of marine resources, allowing Canada to make informed decisions regarding the sustainable management of Canadian marine ecosystems and fisheries. Consequently, the fall AZMP survey was identified as a departmental priority and given approval to proceed during the height of the Covid-19 pandemic, following that certain precautions be taken both prior to and during sailing to prevent the spread of Covid-19. The Ecosystems and Ocean Science Sector released a 'Return to Science At-Sea Operations Guidance – COVID-19' guidance on relevant safe-work procedures articulated by DFO and Coast Guard for the purpose of preventing or mitigating the spread of Covid-19 during field work (see Appendix 5). In addition, the Ocean and Ecosystem Sciences Division (OESD) released self-isolation guidelines to help operationalize current health authority advice to prevent the spread of Covid-19. These guidelines were followed in advance of the mission in order to reduce the risk of contracting the virus and bringing it onboard. Also included in Appendix 5 is a series of best practices that were drafted to mitigate the spread of Covid-19 while onboard. These best practices were drafted by chief scientists of the whale mooring (Dr. Hilary Moors-Murphy) and AZMP missions (Lindsay Beazley) at the request of the OESD management team.

In addition to the divisional protocols and policies, CCG also required that various protocols be undertaken while onboard to prevent the spread of Covid-19. On Leg 1, masks were required to be worn by science staff when in shared spaces with the ship's crew. Staggered seating during meal times were also required in the officer's galley. While understandable in areas of close quarters, the use of masks in the winch room raised safety concerns, where both verbal and visual communication between staff and the crew is critical. Eye protection is also required while near an armed CTD, which would 'fog up' when masks were worn. On Leg 2, such measures were not required. Instead, temperature was taken daily for all science staff for the first few days of the mission.

The -20º chest freezer owned by DFO, and Dalhousie University's -80º freezer were accidentally unplugged in the GP lab from approximately 1400 ADT on Oct. 7 to 0930 ADT Oct. 8. The majority of DFO samples were removed from the freezer upon completion of Leg 1 with the exception of POC/PON and chlorophyll samples. The chlorophyll samples have since been analyzed and the resulting data did not appear to be impacted by the thaw (T. Perry pers. comm.). At the time this report was published, the POC/PON samples had not yet been analyzed. Dalhousie University's samples were thawed and may have been compromised.

There were challenges throughout the mission with keeping station, and more importantly, keeping a straight wire angle during CTD and net deployments. While sea-state, wind and currents contributed in part to this, issues were raised to Commanding Officer Fergus Francey and Chief Officer Jeff Marchant, who made all efforts to work with CCG staff to ensure safe operation of the science equipment. Issues with maneuvering the vessel are understandable, given the long refit Hudson had recently underwent. The bridge staff were always approachable and willing to work with science crew when issues arose.

On the very last operation, one science staff member was involved in a near-miss incident while recovering the CTD package. The vessel started to move forward before the CTD package was docked in its cradle and the winch room doors closed. This caused the package to swing seaward. If the package swung into the winch room, staff could have been seriously harmed. The incident was brought to the attention of Chief Officer, Jeff Marchant, who responded with commendable professionalism and took the situation very seriously. Mr. Marchant fully investigated the situation and filed a CCGS Incident Investigation Report (IIR). Officially documenting this situation provides an opportunity to review the existing protocols for launch and recovery of equipment to ensure its safe operation on future missions. This report was logged with OESD division manager Sherry Niven upon conclusion of the mission.

The camera overlooking winch room shuttered consistently throughout the mission. This camera allows operators of the CTD computer to see when the CTD package is deployed and recovered, information which is logged in ELOG. This was noted in the ‘Form C’ CCGS Operation Report.

Additional sample collection, processing, and data submission

Data submission to Global Telecommunications Systems

Global Telecommunications Systems (GTS) houses oceanographic data that modellers assimilate into their climate forecasting. The initiative was originally for weather forecasting, but the data collected are also used for ocean monitoring initiatives. More information on the GTS initiative can be found here: https://www.wmo.int/pages/prog/www/TEM/GTS/index_en.html. DFO's representative in GTS is Environment Canada.

AZMP submits data to GTS via MEDS (Marine Environmental Data Section, Oceans Sciences Division), using the following email address: MEDS-SDMM.XNCR@dfo-mpo.gc.ca (note that Luc Bujold (Luc.Bujold@dfo-mpo.gc.ca) has requested to be copied on all data submissions to MEDS). The data must be sent within 30 days of collection.

After each CTD cast is processed using CTDDap, cast data are appended to a .txt file located on the CTD computer in the following folder:

OS (C:) > CTD_PROCESSING > 2020063HUD (cruise ID) > IGOS.

An example of the contents of the text file is shown in Figure 3. In this instance, 002 and 004 indicate the Event number.

```
KKYY CGDG     HUDSON    2020063 002 43.2538 -65.4660 0530 278 2020 CTD 8877
    4. 13.21   31.77  5.58  2.26
   17. 13.21   31.78  5.56  2.26
   21. 12.89   32.00  5.49  2.25
   25. 12.10   32.12  5.51  2.30
   29. 11.83   32.18  5.45  2.33
   33. 11.32   32.19  5.29  2.36
   34.  9.76   32.08  5.52  2.40
   36.  7.46   31.98  5.75  2.61
   41.  7.27   32.09  5.58  2.69
   45.  6.68   32.23  5.62  2.68
   53.  6.49   32.28  5.55  2.70
   55.  6.40   32.29  5.54  2.83
   58.  5.94   32.35  5.59  2.70
   60.  5.87   32.37  5.57  2.74
END
KKYY CGDG     HUDSON    2020063 004 42.9993 -65.4818 0751 278 2020 CTD 8877
    5. 15.06   30.80  5.51  2.30
   26. 14.95   30.83  5.41  2.30
   28. 14.50   30.97  5.44  2.33
   29. 14.09   31.04  5.47  2.35
   34. 13.59   31.11  5.34  2.42
   35. 13.02   31.29  5.39  2.46
   37. 12.70   31.51  5.45  2.45
   41. 12.48   31.81  5.37  2.38
   42. 12.10   31.88  5.39  2.37
   46. 11.86   31.97  5.31  2.40
   50. 11.02   32.07  5.34  2.45
   53. 10.33   32.07  5.35  2.50
```

Figure 3. Example of data served to the IGOS folder after processing of each CTD cast using CTDDap. Layout of the data follows a standard template required by GTS.

Once a cast is processed, the data are sequentially appended to the bottom of the text file. However, if the data manager reprocesses the data, 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 particular station should be submitted to MEDs, and the original cast deleted.

Chief scientist Lindsay Beazley sent the cast data collected on Leg 1 to MEDS on Oct. 8. The cast data collected on Leg 2 (Oct. 8 to 14) were also sent to MEDS on Oct. 14.

Microbial Protein and Organic Micronutrient Sampling

Principal Investigator: Dr. Erin Bertrand (Dalhousie University, Department of Biology)

Sampling by: Liam MacNeil, Cat Bannon, Nadine Lehmann & Britton Dempsey (Dalhousie University)

Objective

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

Microbial Protein Sampling:

Purpose

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

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

Sampling Methods

10L samples: A total of 83 size-fractionated microbial protein samples (~10L of water each) were taken from the CTD rosette at depths ranging from the surface to the bottom (Table 7) along AZMP transects located in Canadian waters. Water was filtered

sequentially through 3 and 0.2 µm polycarbonate filters via peristaltic pumping. Filters were then frozen immediately at -80°C.

Vitamin Sampling:

Purpose

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

Sampling Methods

A total of 86 particulate and 24 dissolved vitamin samples (1L each) were taken from the CTD rosette at depths ranging from the surface to the bottom along lines of the AZMP in Canadian waters (Table 7). Samples were protected from light and gently vacuum filtered through 0.2 µm nylon filters. Filters were frozen at -80°C and dissolved samples were frozen in amber HDPE bottles at -20°C.

Enrichment Cultures:

Cultures collected from surface water for the Bertrand Lab were enriched with 4 different nutrient amendments (+B_{12}, +B_{12}Si, +Si and +FePN) and maintained at 6°C on a 12:12 light cycle. These cultures will be used to isolate phytoplankton and bacteria from regional oceans for laboratory-based experiments investigating microbial interactions and the marine cobalamin cycle.

Table 7. Protein and vitamin samples – Bertrand lab – AZMP Fall 2020 – HUD2020-063.

Station	Event	Depth (m)	ID#	Protein (size-fractionated)	Particulate Vitamin	Dissolved Vitamin (2*500mL)	Nutrient Enrichments
BBL-01	1	1	480271	1	1	-	-
		40	480265	1	1	-	-
BBL-03	6	1	480299	1	1	1	4
		20	480295	1	1	1	-

		40	480291	1	1	1	-
		80	480285	1	1	1	-
BBL-05	10	1	480328	1	1	-	-
		20	480324	1	1	-	-
		40	480320	1	1	-	-
		80	480315	1	1	-	-
BBL-07	14	1	480368	1	1	1	4
		20	480364	1	1	1	-
		50	480357	1	1	1	-
		80	480352	1	1	1	-
PL-09	32	1	480505	1	1	-	-
		20	480501	1	1	-	-
		80	480494	1	1	-	-
		250	480489	1	1	-	-
HL-01	34	1	480521	1	1	-	-
		20	480517	1	1	-	-
		40	480513	1	1	-	-
		60	480507	1	1	-	-
HL-02	36	1	480542	1	1	1	4
		20	480536	1	1	1	-
		40	480532	1	1	1	-
		80	480528	1	1	1	-
		BTM	480524	1	-	-	-
HL-04	39	1	480579	1	1	1	-
		20	480575	1	1	1	-
		40	480572	1	1	1	-
		60	480567	1	1	1	-
HL-5.5	41	1	480611	1	1	-	-
		20	480607	1	1	-	-
		40	480603	1	1	-	-
		60	480596	1	1	-	-
HL-06	42	1	480635	-	1	1	-
		20	480631	1	1	1	-
		50	480626	1	1	1	-
		80	480622	1	1	1	-
HL-07	47	1	480698	1	1	1	-
		20	480695	1	1	1	-
		50	480690	1	1	1	-
		80	480687	1	-	-	-

HL-08	50	1	480723	-	1	-	4
		20	480720	-	1	-	-
		100	480713	-	1	-	-
		250	480711	-	1	-	-
LL-09	57	1	480746	1	1	-	-
		20	480742	1	1	-	-
		80	480736	1	1	-	-
		250	480731	1	1	-	-
LL-07	63	1	480790	1	1	1	-
		20	480786	1	1	-	-
		80	480779	1	1	-	-
		250	480774	1	1		-
LL-04	68	1	480825	1	1	-	-
		20	480821	1	1	-	-
		40	480817	1	1	-	-
		80	480812	1	1	-	-
LL-01	75	1	480864	-	-	-	4
		20	480859	1	1	-	-
		40	480855	1	1	-	-
		60	480850	1	1	-	-
CSL-01	77	1	480879	1	1	-	-
		20	480875	1	1	-	-
		40	480871	1	1	-	-
		60	480867	1	1	-	-
CSL-04	82	1	480927	1	1	-	-
		20	480923	1	1	-	-
		60	480917	1	1	-	-
		300	480908	1	1	-	-
CSL-06	87	1	480963	1	1	-	4
		20	480957	1	1	-	-
		60	480951	1	1	-	-
		200	480945	1	1	-	-
STAB-06	91	1	480986	1	1	-	-
		20	480982	1	1	-	-
		60	480974	1	1	-	-
		200	480969	1	1	-	-
		BTM	480966	1	1		-
STAB-05	96	1	481022	1	1	-	4
		20	481018	1	1	-	-

		80	481011	1	1	-	-
		300	481005	1	1	-	-
STAB-03	100	1	481048	1	1	-	-
		20	481044	1	1	-	-
		80	481036	1	1	-	-
STAB-02	101	1	481058	1	1	-	4
		40	481052	1	1	-	-

Microbial Community Analysis

Principal Investigator: Dr. Julie LaRoche (Dalhousie University)

Sampling by: Liam MacNeil, Cat Bannon, Nadine Lehmann & Britton Dempsey (Dalhousie University)

Objective

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

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

Sampling Methods

Genomics:

Samples were taken for genomics at 23 select stations along the AZMP transects located in Canadian waters. At most stations, duplicate 4L water samples were collected from the CTD rosette at each of 4 depths ranging from the surface to 1000m (Table 8). Several stations deviated from this pattern (Table 8): at select stations, more (up to 8) or less depths were sampled, for a total of 98 water masses sampled. Each water sample was sequentially filtered through 3 and 0.2µm polycarbonate filters by peristaltic pump until the water was depleted or the filters clogged. Filters were immediately frozen at -80°C.

Flow Cytometry:

At each station and depth where genomic samples were collected, duplicate 2mL water samples were fixed with 2% paraformaldehyde (PFA) for 10 minutes at room temperature,

then frozen at -80°C for later enumeration of bacteria and characterization of the naturally fluorescent microbial community via the Accuri C6 flow cytometer.

Enrichment Cultures:

At select stations (Table 8), 500mL water samples were also collected for enrichment cultures. These samples were spiked with phosphate (200nM) and iron (2nM) and maintained at 6°C on a 12:12 light cycle.

Table 8. Microbial community samples – LaRoche lab – AZMP Fall 2020 – HUD2020-063.

Station	Event	Depth (m)	ID#	DNA samples (size-fractionated)	Flow cytometry	250mL culture
BBL-01	1	1	480271	2	2	-
		40	480265	2	2	-
BBL-03	6	1	480298	2	2	-
		20	480294	2	2	-
		40	480290	2	2	-
		80	480284	2	2	-
BBL-05	10	1	480327	2	2	-
		20	480323	2	2	-
		40	480319	2	2	-
		80	480314	2	2	-
BBL-07	14	1	480367	2	2	1
		20	480363	2	2	-
		50	480356	2	2	-
		80	480351	2	2	-
PL-09	32	1	480504	2	2	1
		20	480500	2	2	-
		80	480493	2	2	-
		250	480488	1	2	-
HL-01	34	1	480520	2	2	-
		20	480516	2	2	-
		40	480512	2	2	-
		60	480506	2	2	-
HL-02	36	1	480541	2	2	1
		5	480539	2	2	1
		20	480535	2	2	-
		40	480531	2	2	-
		80	480527	2	2	-

HL-04	39	1	480578	2	2	1
		20	480574	2	2	-
		40	480571	2	2	-
		60	480566	2	2	-
HL-5.5	41	1	480610	2	2	-
		20	480606	2	2	-
		40	480602	2	2	-
		60	480599	2	2	-
		80	480597	2	2	-
		100	480594	2	2	-
		250	480592	2	2	-
		BTM	480590	2	2	-
HL-06	42	1	480634	2	2	1
		20	480630	2	2	1
		50	480625	2	2	-
		80	480621	2	2	-
		250	480618	2	2	-
		500	480617	2	2	-
		750	480616	1	2	-
		BTM	480614	2	2	-
HL-07	47	1	480697	2	2	-
		20	480694	2	2	-
		50	480689	2	2	-
		80	480687	1	2	-
HL-08	50	1	480722	2	2	-
		20	480719	2	2	-
		100	480712	2	2	-
		250	480710	2	2	-
LL-09	57	1	480745	2	2	1
		20	480741	2	2	-
		80	480735	2	2	-
		250	480730	2	2	-
LL-07	63	1	480789	2	2	1
		20	480785	2	2	-
		80	480778	2	2	-
		250	480773	2	2	
		500	480771	1	2	-
LL-04	68	1	480824	2	2	-
		20	480820	2	2	-
		40	480816	2	2	-
		80	480811	2	2	-

LL-01	75	1	480862	2	2	-
		20	480858	2	2	-
		40	480854	2	2	-
		60	480849	2	2	-
CSL-01	77	1	480878	2	2	1
		20	480874	2	2	-
		40	480870	2	2	-
		60	480866	2	2	-
CSL-04	82	1	480926	2	2	-
		20	480922	2	2	-
		60	480916	2	2	-
		300	480907	2	2	-
		BTM	480906	1	2	-
CSL-06	87	1	480960	2	2	-
		20	480956	2	2	-
		60	480950	2	2	-
		200	480944	2	2	-
STAB-06	91	1	480986	2	2	-
		20	480982	2	2	-
		60	480974	2	2	-
		200	480969	2	2	-
STAB-05	96	1	481021	2	2	-
		20	481017	2	2	-
		80	481010	2	2	-
		300	481004	2	2	-
STAB-03	100	1	481047	2	2	-
		20	481043	2	2	-
		80	481035	2	2	-
STAB-02	101	1	481057	2	2	-
		40	481051	2	2	-

Nitrate Isotope Sampling

Principle Investigator: Dr. Carolyn Buchwald (Dalhousie University, Department of Oceanography)

Sampling by: Britton Dempsey and Dr. Nadine Lehmann (Dalhousie University)

Objective

The objective of this sampling was to collect water column samples for nitrate isotope analysis to investigate the controls on bioavailable nitrogen on the Scotian Shelf and to determine the contribution of water mass transport versus local nitrogen transformation processes on the overall nitrogen budget. Sampling depths and locations for nitrate stable isotope ratios were adapted after the BIO sampling scheme for nutrient measurements.

Purpose

Nitrate is an essential nutrient in the marine ecosystem, not only controlling primary production but also influencing food web dynamics and carbon sequestration in the ocean. On the Scotian Shelf, the main supply mechanisms of bioavailable N are still debated, with studies highlighting both the importance of advection and on-shelf transport of nutrient-rich waters versus the local recycling of organic matter in the water column and sediment.

One of the major uncertainties when using nutrient concentrations to constrain the occurrence and extent of individual N cycling processes (e.g., N assimilation, remineralization, denitrification) arises from the simultaneous occurrence of different N transformation processes, both spatially and temporally. In contrast, coupled analyses of $^{15}N/^{14}N$ and $^{18}O/^{16}O$ ratios of nitrate allow the distinction between overlapping N transformation processes due to process-dependent fractionation between the heavier and lighter isotopes. As such, nitrate stable isotopes act as a tracer for individual N transformations while allowing to track the origin and history of a distinct water mass.

Sampling Methods

A total of 361 seawater samples were collected throughout the water column at a subset of stations (Table 9) using the rosette water samples mounted to the CTD. Seawater samples were collected unfiltered directly from the Niskin bottles into pre-rinsed 60 mL high-density polyethylene bottles (HDPE) and stored frozen at -20°C. Post-cruise, all

samples were filtered through a 25-mm diameter 0.45-µm surfactant-free cellulose acetate membrane prior to isotope analyses.

Table 9. Nitrate isotope samples collected during the Fall AZMP cruise 2020.

Cruise	Event	Station	Bottles	Depth (m)	Sample #	d15N
HUD2020063	2	BBL_01	1	BTM	480263	x
			2	50	480264	x
			5	40	480267	x
			6	30	480268	x
			7	20	480269	x
			8	10	480270	x
			11	1	480273	x
HUD2020063	6	BBL_03	1	BTM	480283	x
			5	80	480287	x
			6	60	480288	x
			7	50	480289	x
			10	40	480292	x
			11	30	480293	x
			14	20	480296	x
			15	10	480297	x
			18	1	480300	x
HUD2020063	10	BBL_05	1	BTM	480310	x
			3	150	480312	x
			4	100	480313	x
			7	80	480316	x
			8	60	480317	x
			9	50	480318	x
			12	40	480321	x
			13	30	480322	x
			16	20	480325	x
			17	10	480326	x
			20	1	480329	x
HUD2020063	12	BBL_06	1	BTM	480330	x
			3	1000	480332	x
			4	750	480333	x
			5	500	480334	x
			6	250	480335	x
			7	150	480336	x
			8	100	480337	x
			9	80	480338	x
			10	60	480339	x
			11	50	480340	x
			12	40	480341	x
			13	30	480342	x
			14	20	480343	x
			15	10	480344	x

			16	1	480345	x
HUD2020063	14	BBL_07	1	BTM	480346	x
			2	1500	480347	x
			3	1000	480348	x
			4	750	480349	x
			5	500	480350	x
			8	250	480353	x
			9	150	480354	x
			10	100	480355	x
			13	80	480358	x
			14	60	480359	x
			15	50	480360	x
			16	40	480361	x
			17	30	480362	x
			20	20	480365	x
			21	10	480366	x
			24	1	480369	x
HUD2020063	32	PL_09	1	BTM	480487	x
			4	250	480490	x
			5	150	480491	x
			6	100	480492	x
			9	80	480495	x
			10	60	480496	x
			11	50	480497	x
			12	40	480498	x
			13	30	480499	x
			16	20	480502	x
			17	10	480503	x
			20	1	480506	x
HUD2020063	34	HL_01	1	BTM	480507	x
			4	60	480510	x
			5	50	480511	x
			8	40	480514	x
			9	30	480515	x
			12	20	480518	x
			13	10	480519	x
			16	1	480522	x
HUD2020063	36	HL_02	1	BTM	480523	x
			3	100	480525	x
			6	80	480528	x
			7	60	480529	x
			8	50	480530	x
			11	40	480533	x
			12	30	480534	x
			15	20	480537	x
			16	10	480538	x
			21	1	480543	x
HUD2020063	37	HL_03	1	BTM	480544	x
			2	200	480545	x

			3	100	480546	x
			4	80	480547	x
			5	60	480548	x
			6	50	480549	x
			7	40	480550	x
			8	30	480551	x
			9	20	480552	x
			10	10	480553	x
			11	1	480554	x
HUD2020063	39	HL_04	1	BTM	480565	x
			4	60	480568	x
			5	50	480569	x
			6	40	480570	x
			9	30	480573	x
			12	20	480576	x
			13	10	480577	x
			16	1	480580	x
HUD2020063	40	HL_05	1	BTM	480581	x
			2	80	480582	x
			3	60	480583	x
			4	50	480584	x
			5	40	480585	x
			6	30	480586	x
			7	20	480587	x
			8	10	480588	x
			9	1	480589	x
HUD2020063	42	HL_06	1	BTM	480613	x
			2	1000	480614	x
			4	750	480616	x
			5	500	480617	x
			6	250	480618	x
			7	150	480619	x
			8	100	480620	x
			11	80	480623	x
			12	60	480624	x
			15	50	480627	x
			16	40	480628	x
			17	30	480629	x
			20	20	480632	x
			21	10	480633	x
			24	1	480636	x
HUD2020063	48	HL_07	1	BTM	480676	x
			2	2000	480677	x
			4	1500	480679	x
			6	1000	480681	x
			7	750	480682	x
			8	500	480683	x
			9	250	480684	x
			10	150	480685	x

			11	100	480686	x
			12	80	480687	x
			13	60	480688	x
			16	50	480691	x
			17	40	480692	x
			18	30	480693	x
			20	20	480695	x
			21	10	480696	x
			24	1	480699	x
HUD2020063	50	HL_08	1	BTM	480700	x
			3	3000	480702	x
			4	2500	480703	x
			5	2000	480704	x
			7	1500	480706	x
			9	1000	480708	x
			10	500	480709	x
			12	250	480711	x
			14	100	480713	x
			15	80	480714	x
			16	60	480715	x
			17	50	480716	x
			18	40	480717	x
			19	30	480718	x
			21	20	480720	x
			22	10	480721	x
			24	1	480723	x
HUD2020063	57	LL_09	1	1500	480724	x
			2	1500	480725	x
			3	1500	480726	x
			4	1500	480727	x
			5	1000	480728	x
			6	500	480729	x
			9	250	480732	x
			10	150	480733	x
			11	100	480734	x
			13	80	480736	x
			14	60	480737	x
			15	50	480738	x
			16	40	480739	x
			17	30	480740	x
			20	20	480743	x
			21	10	480744	x
			24	1	480747	x
HUD2020063	63	LL_07	1	BTM	480769	x
			4	500	480772	x
			7	250	480775	x
			8	150	480776	x
			9	100	480777	x
			12	80	480780	x

			13	60	480781	x
			14	50	480782	x
			15	40	480783	x
			16	30	480784	x
			19	20	480787	x
			20	10	480788	x
			23	1	480791	x
HUD2020063	67	LL_05	1	BTM	480800	x
			2	100	480801	x
			3	80	480802	x
			4	60	480803	x
			5	50	480804	x
			6	40	480805	x
			7	30	480806	x
			8	20	480807	x
			9	10	480808	x
			10	1	480809	x
HUD2020063	69	LL_04	1	BTM	480810	x
			4	80	480813	x
			5	60	480814	x
			6	50	480815	x
			9	40	480818	x
			10	30	480819	x
			13	20	480822	x
			14	10	480823	x
			17	1	480826	x
HUD2020063	73	LL_02	1	BTM	480837	x
			2	100	480838	x
			3	80	480839	x
			4	60	480840	x
			5	50	480841	x
			6	40	480842	x
			7	30	480843	x
			8	20	480844	x
			9	10	480845	x
			10	1	480846	x
			1	BTM	480847	x
			2	80	480848	x
			6	60	480852	x
			7	50	480853	x
			10	40	480856	x
			11	30	480857	x
			14	20	480860	x
			15	10	480861	x
			18	1	480864	x
HUD2020063	77	CSL_01	1	BTM	480865	x
			4	60	480868	x
			5	50	480869	x
			8	40	480872	x

			9	30	480873	x
			12	20	480876	x
			13	10	480877	x
			16	1	480880	x
HUD2020063	81	CSL_03	1	BTM	480892	x
			2	250	480893	x
			3	200	480894	x
			4	150	480895	x
			5	100	480896	x
			6	80	480897	x
			7	60	480898	x
			8	50	480899	x
			9	40	480900	x
			10	30	480901	x
			11	20	480902	x
			12	10	480903	x
			13	1	480904	x
HUD2020063	84	CSL_04	1	BTM	480905	x
			6	300	480910	x
			7	250	480911	x
			8	200	480912	x
			9	150	480913	x
			10	100	480914	x
			11	80	480915	x
			14	60	480918	x
			15	50	480919	x
			16	40	480920	x
			17	30	480921	x
			20	20	480924	x
			21	10	480925	x
			24	1	480928	x
HUD2020063	86	CSL_05	1	BTM	480929	x
			2	300	480930	x
			3	250	480931	x
			4	200	480932	x
			5	150	480933	x
			6	100	480934	x
			7	80	480935	x
			8	60	480936	x
			9	50	480937	x
			10	40	480938	x
			11	30	480939	x
			12	20	480940	x
			13	10	480941	x
			14	1	480942	x
HUD2020063	88	CSL_06	1	BTM	480943	x
			4	200	480946	x
			5	150	480947	x
			6	100	480948	x

			7	80	480949	x
			10	60	480952	x
			11	50	480953	x
			12	40	480954	x
			13	30	480955	x
			16	20	480958	x
			17	10	480959	x
			20	1	480962	x
HUD2020063	92	STAB_06	1	BTM	480965	x
			3	400	480967	x
			4	300	480968	x
			7	200	480971	x
			8	150	480972	x
			9	100	480973	x
			12	80	480976	x
			13	60	480977	x
			15	50	480979	x
			16	40	480980	x
			17	30	480981	x
			20	20	480984	x
			21	10	480985	x
			24	1	480988	x
HUD2020063	94	STAB_5.3	1	BTM	480989	x
			2	300	480990	x
			3	250	480991	x
			4	200	480992	x
			5	150	480993	x
			6	100	480994	x
			7	80	480995	x
			8	60	480996	x
			9	50	480997	x
			10	40	480998	x
			11	30	480999	x
			12	20	481000	x
			13	10	481001	x
			14	1	481002	x
HUD2020063	96	STAB_05	1	BTM	481003	x
			4	300	481006	x
			5	200	481007	x
			6	150	481008	x
			7	100	481009	x
			10	80	481012	x
			11	60	481013	x
			12	50	481014	x
			13	40	481015	x
			14	30	481016	x
			17	20	481019	x
			18	10	481020	x
			21	1	481023	x

HUD2020063	98	STAB_04	1	BTM	481024	x
			2	100	481025	x
			3	80	481026	x
			4	60	481027	x
			5	50	481028	x
			6	40	481029	x
			7	30	481030	x
			8	20	481031	x
			9	10	481032	x
			10	1	481033	x
HUD2020063	100	STAB_03	1	BTM	481034	x
			4	80	481037	x
			5	60	481038	x
			6	50	481039	x
			7	40	481040	x
			8	30	481041	x
			9	20	481042	x
			12	10	481045	x
			13	1	481046	x
HUD2020063	101	STAB_02	1	BTM	481049	x
			2	50	481050	x
			5	40	481053	x
			6	30	481054	x
			7	20	481055	x
			8	10	481056	x
			11	1	481059	x

Neodymium Isotope Sampling

Principle Investigator: Dr. Doug Wallace (Dalhousie University, Department of Oceanography)

Sampling by: Britton Dempsey and Dr. Nadine Lehmann (Dalhousie University)

Purpose

Neodymium is one of the Rare Earth Elements (REE) and has a predominantly lithogenic source. As such, its isotopic signature largely reflects the age and chemical composition of its continental source. In contrast to nitrate, neodymium behaves conservatively in regard to biological processes, which makes it an ideal complementary tracer to study water mass transport and mixing on the Scotian Shelf.

Sampling Methods

A total of 42 samples (10L each) were taken from the CTD rosette throughout the water column at a subset of stations (Table 10). The samples were filtered sequentially through 3µm and 0.2µm polycarbonate filters using peristaltic pumps. Duplicate samples (xx; Table 10) were also filtered through AcroPak500 (0.8/0.45µm) filter cartridges to allow for a filter comparison. Filtered seawater was collected in acid-cleaned 10L low-density polyethylene cubitainers, acidified with 10 mL ultra-clean (Optima grade) HCl and stored in double plastic bags on deck. The neodymium sampling was coordinated with the Bertrand lab to minimize sampling and filtration efforts.

Table 10. Neodymium isotope samples collected during the Fall AZMP cruise 2020.

Cruise	Event	Station	Bottles	Depth (m)	Sample #	eNd
HUD2020063	6	BBL_03	3	80	480285	x
			4	80	480286	xx
			9	40	480291	x
			13	20	480295	x
HUD2020063	14	BBL_07	7	250	480352	x
			12	80	480357	x
			19	20	480364	x
HUD2020063	32	PL_09	3	250	480489	x
			8	80	480494	x
			15	20	480501	x
HUD2020063	36	HL_02	2	BTM	480524	x
			5	80	480527	x

			10	40	480532	x
			14	20	480536	x
HUD2020063	42	HL_06	10	80	480622	x
			14	50	480626	x
			19	20	480631	x
HUD2020063	44	HL_06.3	3	1000	480639	x
			5	750	480641	x
			7	500	480643	x
			9	250	480645	x
HUD2020063	60	LL_08	3	BTM	480750	x
			4	2000	480751	x
			6	1500	480753	x
			8	1000	480755	x
HUD2020063	63	LL_07	3	500	480771	x
			6	250	480774	x
			11	80	480779	x
			18	20	480786	x
HUD2020063	75	LL_01	4	60	480850	x
			5	60	480851	xx
			9	40	480855	x
			13	20	480859	x
HUD2020063	84	CSL_04	2	BTM	480906	x
			4	300	480908	x
			5	300	480909	xx
			13	60	480917	x
			19	20	480923	x
HUD2020064	93	STAB_06	2	BTM	480966	x
			6	200	480970	x
			11	80	480975	x
			19	20	480983	x

Sampling for eDNA metabarcoding in Gully (DFO)

Principle Investigator: Dr. Nick Jeffery (Coastal Ecosystem Science Division (CESD), Bedford Institute of Oceanography)

Sampling by: DFO mission participants Kevin MacIsaac, Tim Perry, Marc Ringuette, Peter Thamer

Dr. Nick Jeffery, Aquatic Science Biologist in the Coastal Ecosystem Science Division (CESD) submitted a request for water samples from the Gully MPA for the purpose of detecting invasive benthic tunicates in the shallow parts of the Gully MPA using eDNA metabarcoding or quantitative real-time PCR. A secondary objective of this request was to assess Gully MPA fish and invertebrate diversity at AZMP stations using eDNA metabarcoding.

The sampling strategy, materials required, and general protocol are listed below. Due to the reduction in mission duration, sampling in the Gully was cancelled prior to sailing. However, Mr. Jeffery requested that samples be collected on core AZMP stations as a 'proof of concept' for their methodology. Stations BBL_05 through BBL_07, and LL_08 through LL_06 were chosen for sampling. Bottom water was collected from stations BBL_05 through BBL_07 (see Table 11), stored in the provided 1.2 L Nalgene bottles and stored in the -20 freezer onboard. Due to a laboratory error, water was accidentally collected from stations LL_08, LL_06, and LL_03 instead of LL_08, LL_07, and LL_06.

Table 11. Metadata associated with the water samples collected for the purpose of eDNA metabarcoding. A 1.2 L Nalgene bottle was filled with bottom water from the stations below and frozen in a -20 freezer.

Event	Station	Bottle ID	Nominal Depth	Date	Lat	Long	Depth	Temp	Sal
10	BBL_05	480310	BTM	10/4/2020	42.1335	-65.5000	182	10.10	35.27
12	BBL_06	480331	BTM	10/4/2020	42.0000	-65.5098	1091	4.43	34.99
14	BBL_07	480346	BTM	10/4/2020	41.8664	-65.3493	1887	3.68	34.94
60	LL_08	480749	BTM	10/11/2020	43.7815	-57.8352	2933	2.83	34.91
65	LL_06	480793	BTM	10/12/2020	44.4760	-58.5070	57	4.36	32.32
71	LL_03	480827	BTM	10/12/2020	45.4910	-59.5177	138	3.16	32.84

eDNA Sample Strategy

Six Nalgene bottles are provided. Preference would be for water samples primarily from shallower stations, where invasive tunicates might occur. However, deep stations are also useful for studying overall biodiversity. If there are 2 shallow and 2 deep stations for example, preference would be for 4 samples from the shallow stations and 2 from deep stations. This is a pilot study, and doesn't require replicates per site.

Materials

- Six 1.5 L Nalgene bottles (clean)
- 2 boxes of nitrile gloves

Protocol

1) **Please wear nitrile gloves** at all times when handling the Nalgene bottles. If a bottle falls on the ground or is touched with bare hands, please use another bottle.
2) All water samples should come from the bottom of the water column, at the deepest the Niskin bottle will be.
3) Drain 1200ml (1.2L) of seawater directly from the Niskin spigot into a Nalgene – please leave room for the bottle to expand when it freezes. A consistent volume for each sample is needed. We will filter 1.0 L of this sample, while the extra 200ml is used to flush the filter tubing lines. Keep bottles out of the sun as much as possible, as UV light degrades eDNA.
4) Label each bottle with the station identification number or other information to allow for matching up to other metadata, such as a CTD cast for example.
5) Freeze each bottle at -20 or -80°C until the return to BIO. Avoid multiple freeze/thaw cycles.
6) Please coordinate with Nick to retrieve samples when the Hudson returns and keep frozen until then.

Any questions please call Nick Jeffery at 226-979-4712 or email at nick.jeffery@dfo-mpo.gc.ca

Appendix 1 – Calibration of oxygen sensor data using collected samples

A preliminary exercise was undertaken to calculate new dissolved oxygen calibration coefficients based on the relationship between the CTD oxygen sensor data and bottle dissolved oxygen measurements calculated using the Winkler titration method. The purpose of this preliminary exercise was to highlight potentially erroneous sensor data, and calculate preliminary calibration coefficients that could then guide the final post-calibration process (to be conducted by ODIS Ocean Data Technician Jeff Jackson). The calculated coefficients will be applied to all sensor data prior to their archival in ODIS servers. All sensors underwent pre-cruise calibration prior to the mission, as outlined in Appendix 4.

The adjusted linear slope scaling coefficient, or 'Soc' value, is calculated in a 2 step process. First, a "threshold field" is produced that subtracts the mean difference between the sensor and the average Winkler value for all samples, from the individual sample difference between the sensor and Winkler:

Equation 1: (SBE sensor O_2 – Winkler O_2) - mean(SBE sensor O_2 – Winkler O_2)

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

Equation 2: NewSoc = mean(previousSoc*([Winkler O_2]/[SBE sensor O_2]))

The primary (Serial No. 2524) and secondary (Serial No. 3030) oxygen sensors were calibrated on Jan. 30, 2020, and Dec. 3, 2019, respectively. These sensors remained on the CTD package for the duration of the mission, and appeared to function properly for all CTD deployments. However, during the CTD deployment on station CSL_04 (Event 84), CTD operators noted an increase in the difference between the primary and secondary conductivity sensors when the CTD package reached ~100 m. The sensors were flushed several times, but the issue persisted until finally the secondary temperature and conductivity sensors were replaced after operations at CSL_06 (Event 88). During replacement, the cause of the erroneous data was found to be a clog in the pressure-release (bleeder) valve, and not an issue with the sensors themselves. While the impact of this clog was most obvious in the conductivity data during data collection at sea, the lack of water flow could also greatly affect the accuracy of the dissolved oxygen sensors. Depending on when the valve started to clog and water flow to the sensors diminished, events prior to Event 84 when the issue was first noted may have also been affected. During this exercise, the oxygen data collected between Events 81 and 88 were therefore

examined more carefully to determine whether the oxygen sensors were impacted by the clogged pressure-release valve.

Figure A1.1 shows a comparison between the primary and secondary sensor values for each CTD profile collected across the entire mission. The values of both sensors increased over the duration of the mission, indicating that dissolved oxygen was, on average, higher on the eastern Scotian Shelf compared to the western. The secondary sensor values were consistently higher relative to the primary sensor. The average difference between sensor values across the mission was -0.4184 ± 0.098 (mean ± SD) and remained relatively consistent for CTDs conducted during the first half of the mission. However, the magnitude of this difference increased and became more variable for CTD profiles collected after Event 77 (mean ± SD: -0.4501 ± 0.1289; see Table A1.1). This approximately coincides with the time period when the spike in conductivity was noticed, and suggests that one sensor may have diverged or drifted relative to the other.

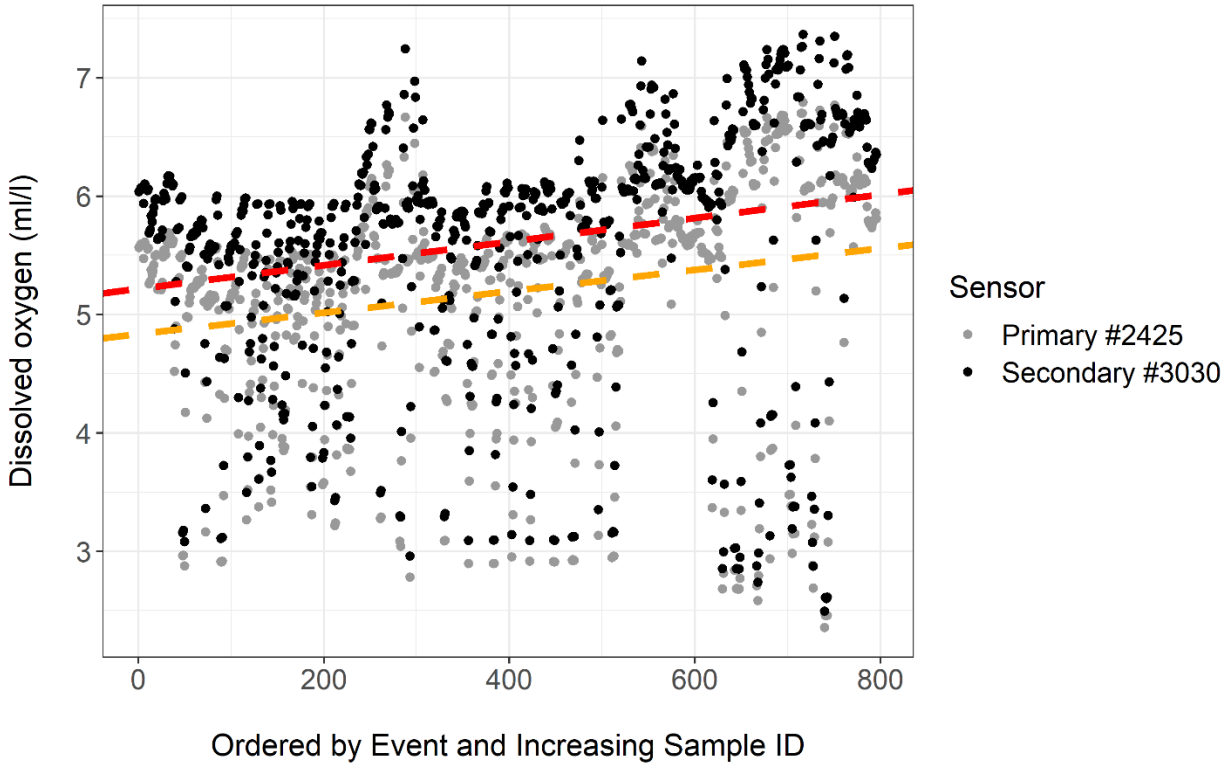

Figure A1.1. Comparison of raw primary and secondary sensor values for each CTD cast conducted during the HUD2020063 mission. Dashed lines represent the regression between sensor values and Sample ID for the primary (orange) and secondary (red) sensors, respectively.

Table A1.1. Mean and standard deviation (SD) of the difference between the primary and secondary sensors for groupings of CTD profiles based on sequential Event ID.

Event ID	Mean	SD
2 – 24	-0.4034	0.0746
26 - 50	-0.3961	0.0886
57 - 75	-0.4387	0.0721
77 - 101	-0.4501	0.1289

The next step in the process is to compare the Winkler replicates throughout the mission and evaluate the data for outliers. A data point was considered an outlier when it's value fell above or below 1.5*IQR (interquartile range), which was extracted from boxplot metrics. The average Winkler values would be used as a reference to judge how accurate the primary and secondary oxygen sensors were, and help identify on which Event erroneous sensor values may have occurred.

Of the 51 data points where Winkler replicates were taken, 4 (~8%) fell above or below 1.5*IQR (Figure A1.2). These 4 records were subsequently removed from the calculation

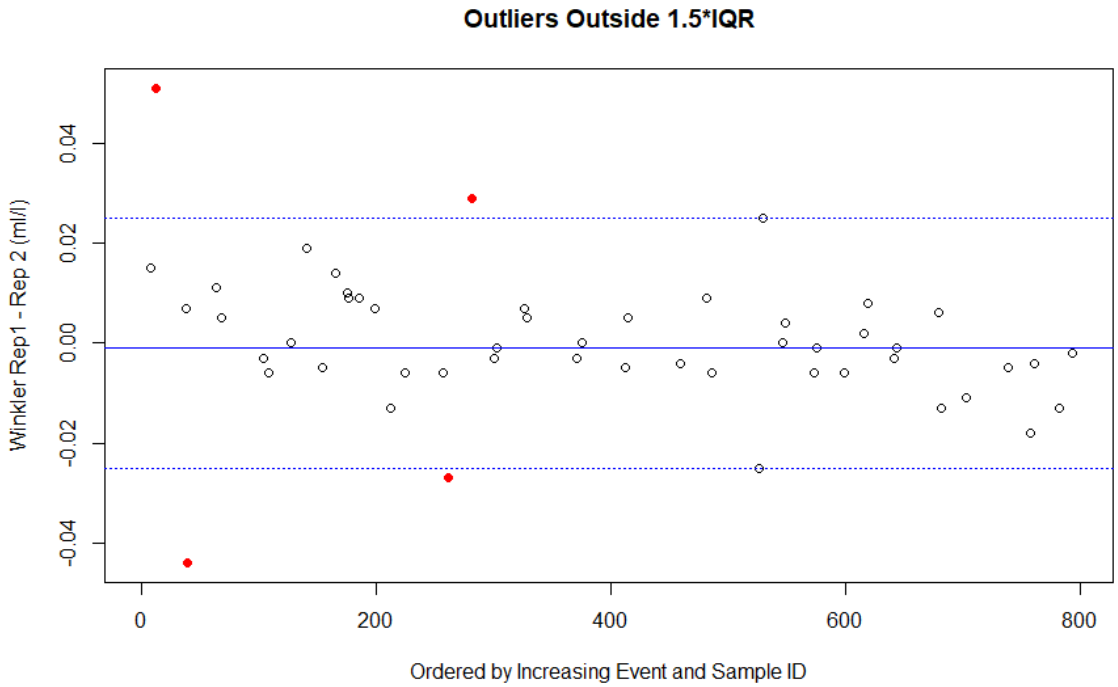

Figure A1.2. Comparison of winkler replicates (Mean = -0.001, IQR min = -0.025, IQR max = 0.025). Red dots are outliers beyond the 1.5 IQR.

of the average titration values. The average Winkler value across the mission (where average is based on a single value for those bottles where only single samples were taken) was 5.3334 ± 1.1644 ml/l.

Figure A1.3 shows the difference between the primary and secondary oxygen sensor values and the average Winkler titration values as a function of Event ID. The secondary sensor values were more similar to their associated Winkler values compared to the primary sensor. The difference between sensor and average Winkler values was relatively high and much more variable between Events ~35-57 for both sensors. However, from Event 81 onward, the primary sensor values greatly deviated from the Winkler values. This phenomenon was not observed in the secondary sensor data, suggesting that the primary sensor was affected by the clogged pressure-release valve.

Outliers in the sensor data were then evaluated using the 1.5* interquartile range method. The data from Events 81 – 88 were kept in the dataset, as their presence was deemed to have a minimal effect on the determination of outliers between the primary and secondary

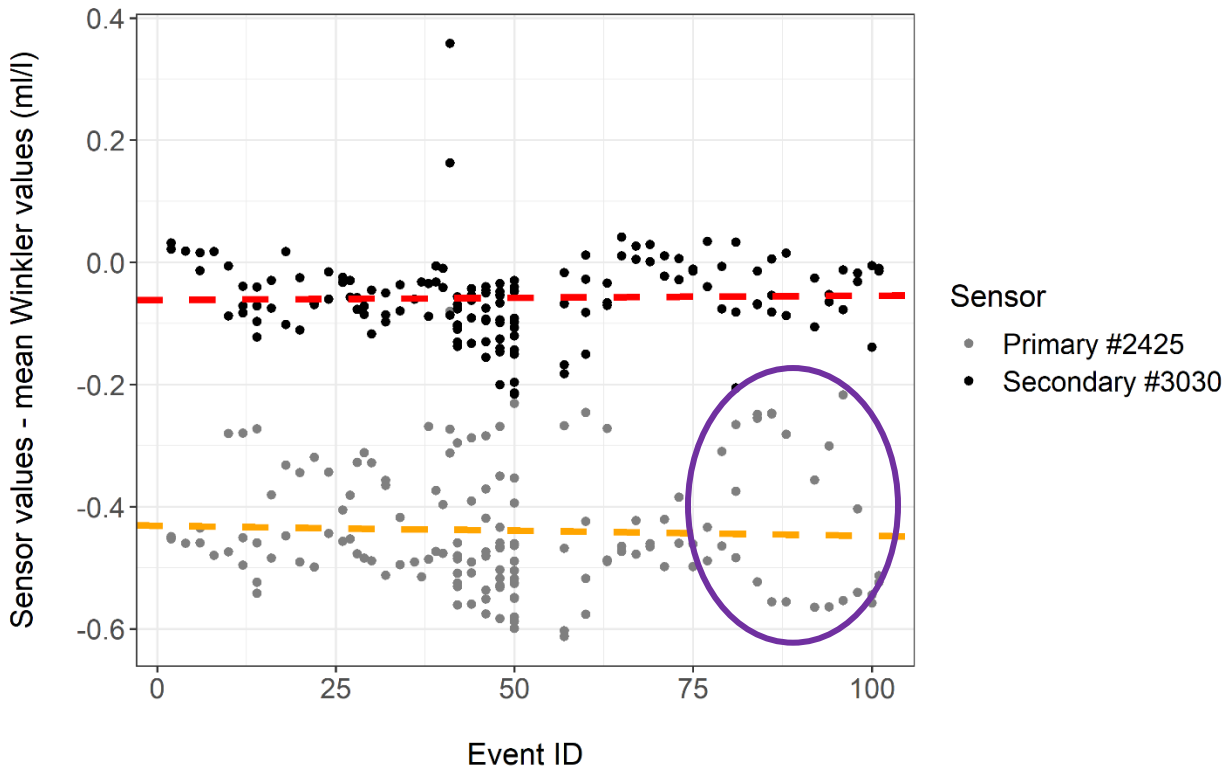

Figure A1.3. Difference between the sensor values and average Winkler titration values for both the primary and secondary oxygen sensors. Dashed lines represent the regression between difference values and Event ID for the primary (orange) and secondary (red) sensors, respectively. Purple oval highlights variability in the primary sensor data collected after Event 81.

sensor. Figure A1.4 depicts the outliers in the sensor differences, i.e., those difference values that fell beyond the 1.5*IQR threshold. Of the 68 outliers identified, 66 were located above the maximum IQR (-0.2489), and were spread across the entire mission. Two outliers fell below the minimum IQR (-0.5829). The largest of the two (-1.0104) corresponded to station NEC_03 when the CTD package was at the surface (4.061 m). The second outlier (-0.7882) occurred when the CTD package was at 31.822 m depth on station HL_03.3.

The next step was to calculate the new Soc values for each sensor. For the primary sensor, the data from Events 81 through 88 were removed, and Equation 1 was then applied to the sensor data to identify threshold outliers for removal (4 outliers identified) prior to the calculation of the new Soc values. Equation 2 was used to calculate the new Soc value (see Table A1.2). For the secondary sensor, data from Events 81 through 88 remained in the dataset, outliers were identified (4) and removed, and the new Soc value was calculated. The ratios between the new and old Soc values (Table A1.2) for each sensor were then used to correct the primary and secondary sensor data (Events 81 – 88 included for both sensors). The corrected sensor data now rougly demonstrates a 1:1 relationship with the Winkler data (Figure A1.5). Corrected secondary sensor values were below and above its 1:1 reference line at low and high Winkler values, respectively.

Figure A1.6 shows the relative difference between corrected and uncorrected sensor values (with sensor outliers removed – Fig A1.4, Events 81 – 88 included). Before correction, there was a mean difference between sensors of -0.4377 ± 0.0697 ml/l (mean ± SD) in the dataset, but after correction this was reduced to -0.011 ± 0.0267 ml/l.

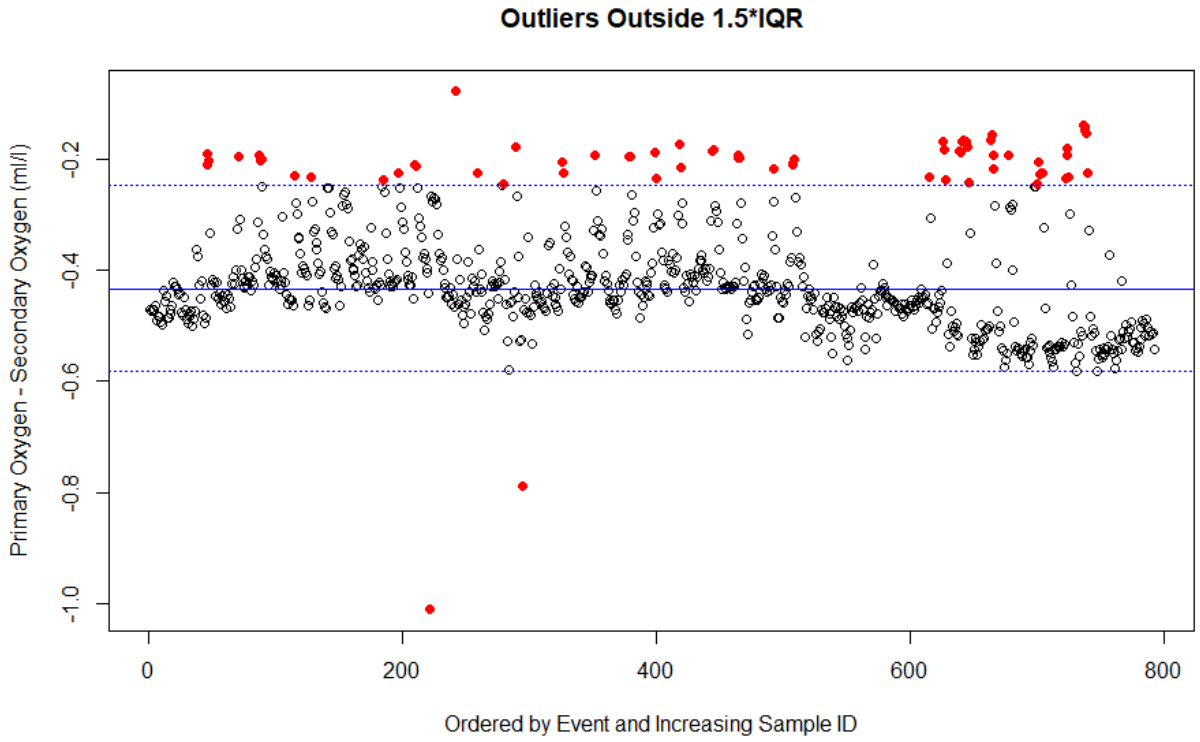

Figure A1.4. Comparison between the primary and secondary oxygen sensor values throughout the mission (Mean = -0.4357, IQR min = -0.5829, IQR max = -0.2489).

Table A1.2. Previous and new Soc values for the primary and secondary oxygen sensors.

	Old Soc	New Soc	Ratio
Primary SBE O_2 sensor #2524	0.4790	0.5219	1.0897
Secondary SBE O_2 sensor #3030	0.5060	0.5110	1.0098

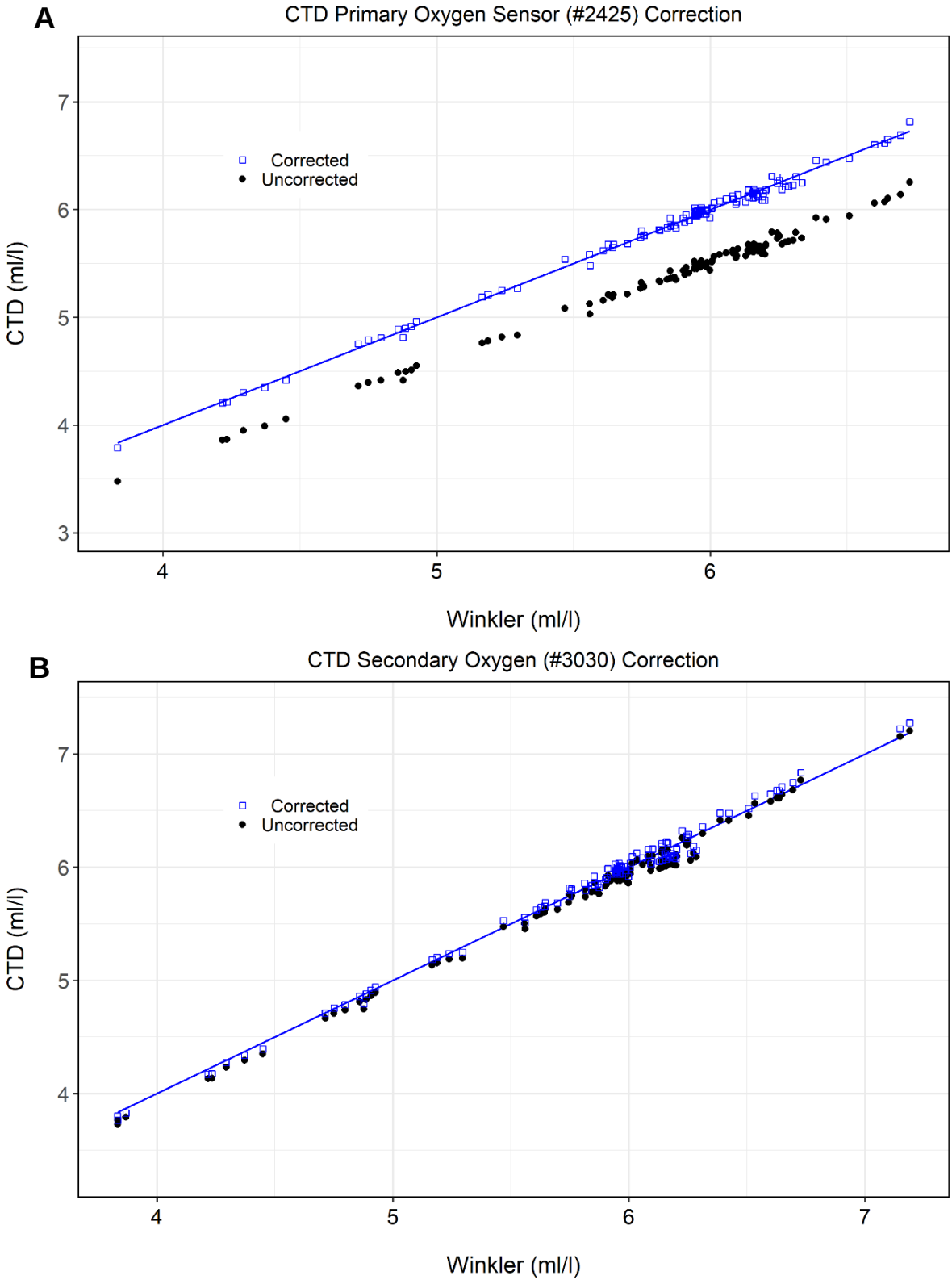

Figure A1.5. The Soc corrected **A)** primary oxygen sensor #2425, and **B)** secondary oxygen sensor #3030. Black dots represent uncorrected, outlier-free sensor data, while the blue squares represent the outlier-free, Soc-corrected sensor data.

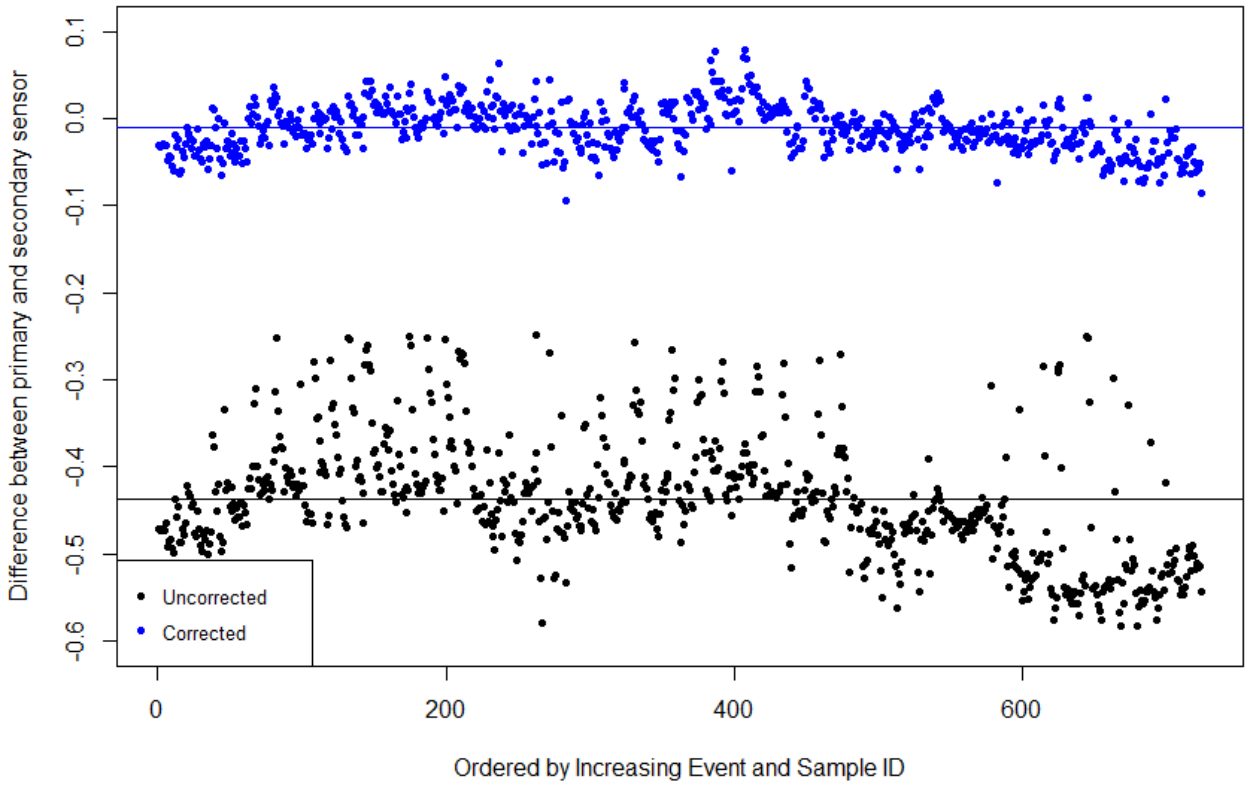

Figure A1.6. Corrected (blue) versus uncorrected (black) outlier-free primary and secondary sensor values. Data from Events 81 – 88 were included in the correction.

Appendix 2 – Calibration of conductivity sensor data using collected samples

(With portions of the text extracted from COR2019001 Cruise Report)

The ‘AutoSal’ salinometer outputs the conductivity as a ratio with standard seawater. Therefore, some conversions are required in order to determine the actual conductivity of the bottle sample. Each standard has a given K15 value, where:

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

Two different standard batches, P161 and P163, each with their own K15 values (P161: K15 = 0.99988 and P163: K15 = 0.99985; conductivity = 42.914 mS/cm for the KCl solutions of both batches), were used for the analysis of the bottle data collected during the HUD2020063 mission. By knowing each K15 value and the conductivity of the KCl solutions, the conductivity of the standard seawater batches can be determined. Then, by multiplying by the conductivity ratio from the salinometer, the conductivity of the samples can be determined.

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

Now we have the conductivity of the sample at 15°C and at the pressure of the bath in the salinometer. However, this needs to be converted to conductivity at the temperature and pressure of the CTD. This conversion is computed using functions implemented in the R statistical software package ‘oce’:

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

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

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

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

This now gives conductivity values that can be compared to the CTD values. To correct the CTD conductivity a linear regression is computed using the following equation:

$$Bottle\_conductivity = b1 + b2*CTD\_conductivity,$$

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

The primary conductivity sensor (Serial No. 3562, calibrated Oct. 4, 2019) remained on the CTD-rosette package for the entire duration of the mission. As noted in the 'CTD operations' section above and in Appendix 1, the secondary temperature (Serial No. 1376, calibrated Oct. 5, 2019; see Appendix 4) and conductivity sensors (Serial No. 1076, calibrated Oct. 8, 2019) were replaced after station CSL_06 (Event 88), after spikes in the difference between the primary and secondary conductivity sensors were noted starting at Event 84. The secondary conductivity sensor (Serial No. 3561) applicable to Events 92 through 101 was calibrated on January 3, 2020. Consequently, the data were parsed and this exercise to calculate new conductivity coefficients was done separately for Events 2 – 88 and Events 92 to 101. Depending on when the clog started to form and water flow to the sensors diminished, the secondary sensor data collected on events prior to Event 84 when the issue was first noted may have also been affected. During this exercise, the conductivity data collected between events 81 and 88 were examined more closely for outlying values.

Recalibration of conductivity sensor data from Events 2 - 88

After the conductivity sensor values were converted to salinity (PSU) as per the methods described above, a comparison of the primary (#3562) and secondary (#1076) conductivity sensor data was performed for data collected on Events 2 through 88 to highlight and remove any outliers beyond 1.5 * the inter-quartile range (IQR) of the data. This revealed 69 outliers (out of 677 data points) that were removed from the analysis (see Figure A2.1).

Next, the difference between the primary sensor and salinometer (bottle) values was compared in a similar manner to identify outliers that should be removed from analysis (13 outliers; Figure A2.2). Note that unlike dissolved oxygen, replicate salinity samples are not collected, therefore exercises to compare replicates are not required here. The same process was completed for the secondary sensor, with 8 outliers identified and removed before proceeding (Figure A2.3). After outliers were removed, the difference between the primary and secondary sensor values versus the salinometer data were, on average, -0.0125 and -0.0063 PSU from Events 2 through 88 (Figure A2.4).

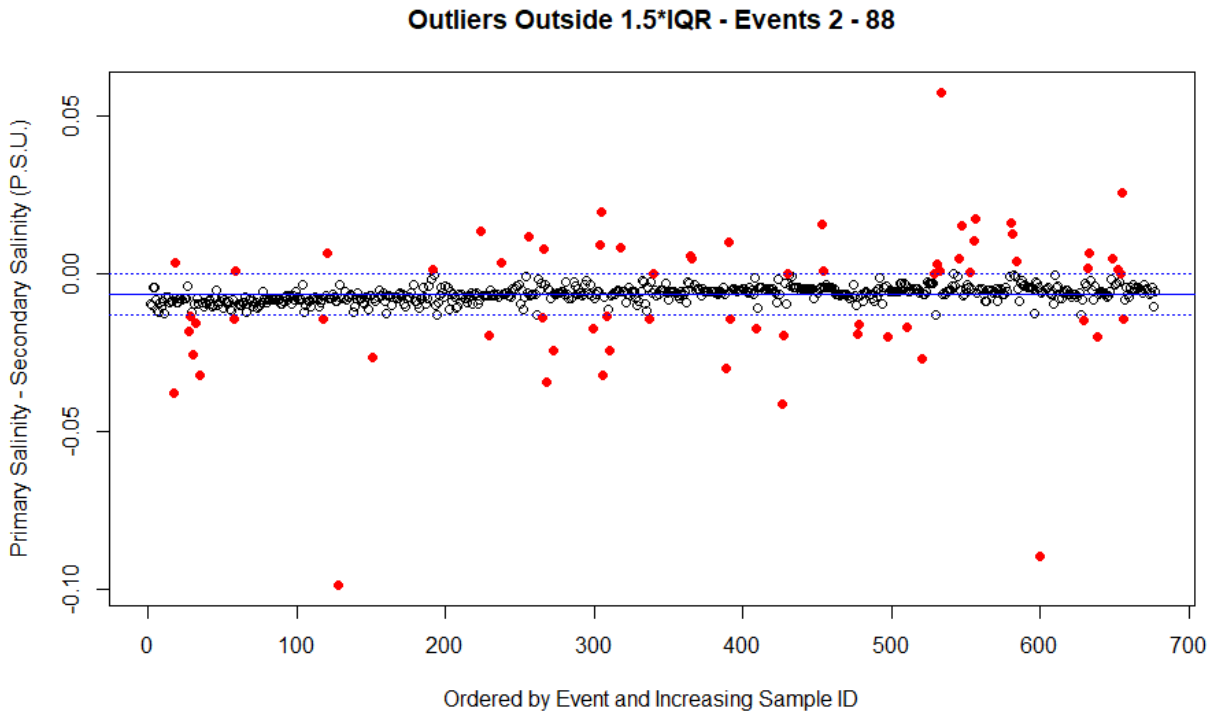

Figure A2.1. Comparison between salinity values derived from the primary and secondary conductivity sensor values collected between Events 2 and 88 (Mean = -0.0062, IQR min = -0.0131, IQR max = -0.0001). Differences above or below the min/max IQR are considered outliers (red dots) and are removed from further analyses.

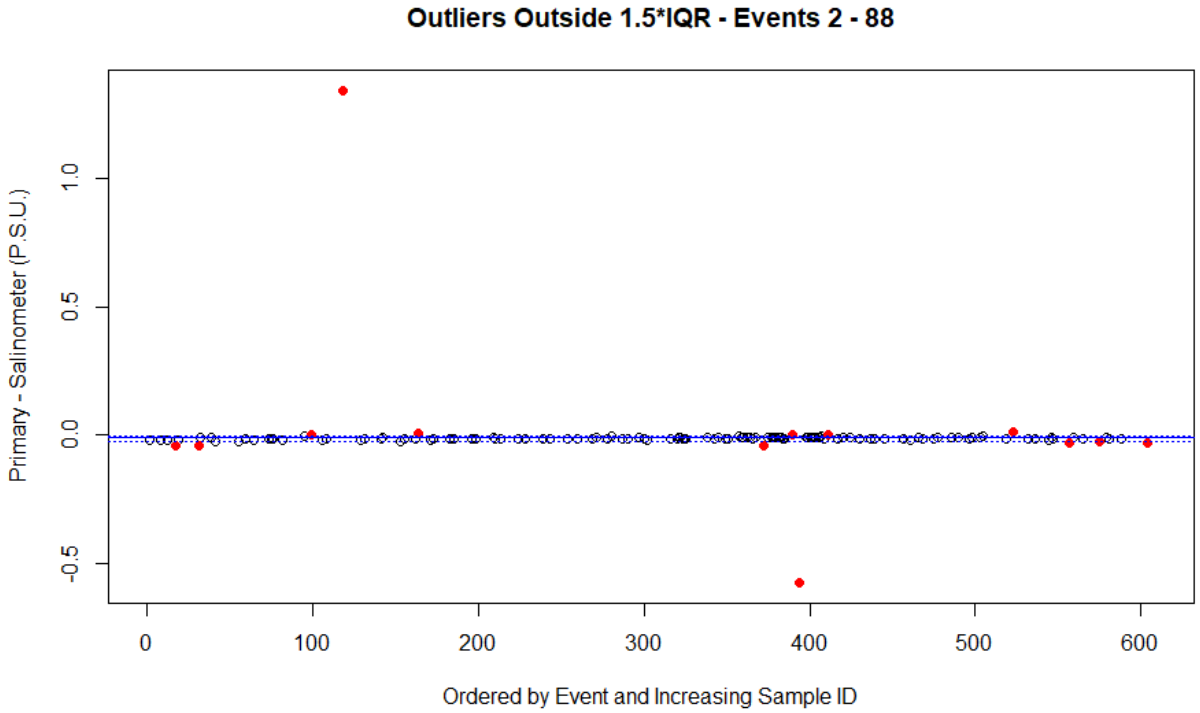

Figure A2.2. Comparison between primary sensor and salinometer values collected between Events 2 and 88 (Mean = -0.0126, IQR min = -0.0230, IQR max = -0.0019). Differences above or below the min/max IQR are considered outliers (red dots) and are removed from further analyses.

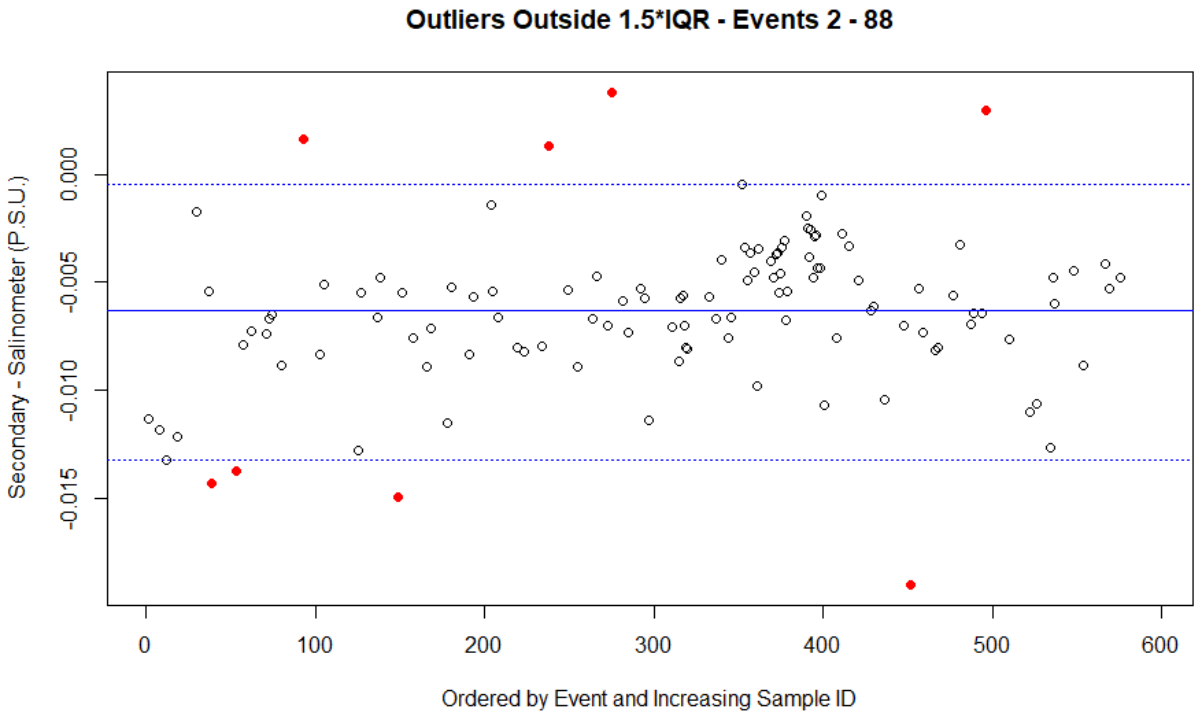

Figure A2.3. Comparison between secondary sensor and salinometer values collected between Events 2 and 88 (Mean = -0.0059, IQR min = -0.0133, IQR max = -0.0005). Differences above or below the min/max IQR are considered outliers (red dots) and are removed from further analyses.

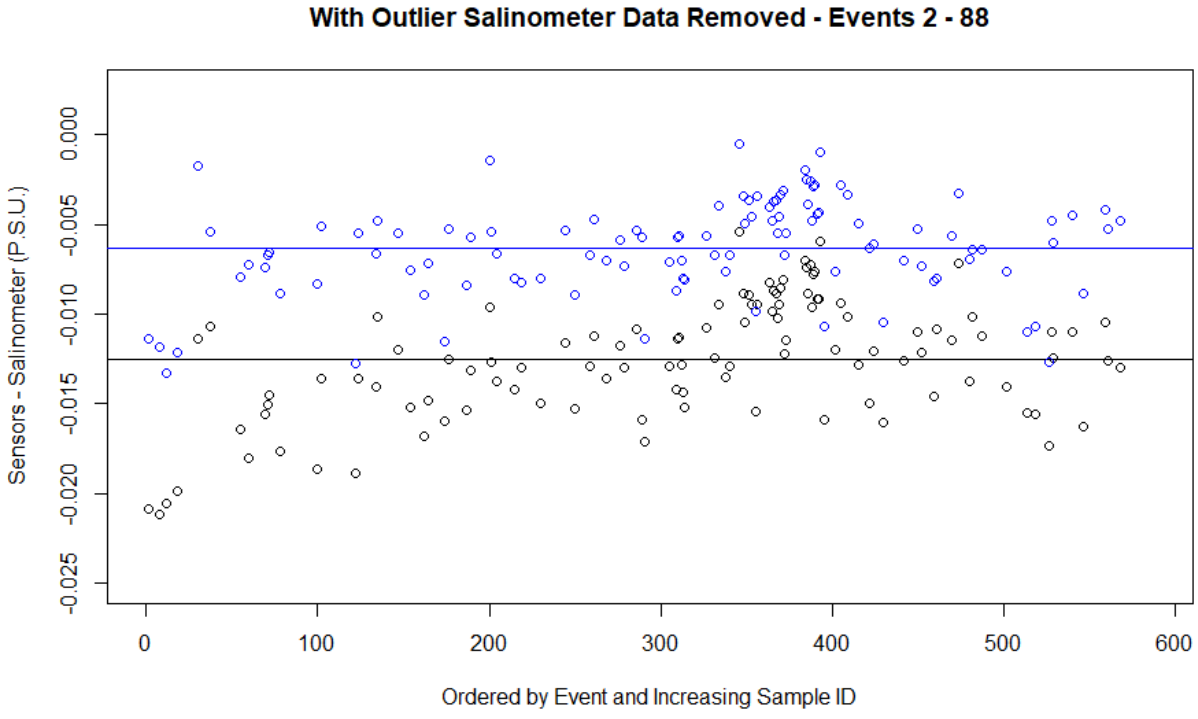

Figure A2.4. Difference between primary (#3562; black dots) and secondary (#1076; blue dots) sensor values and their corresponding salinometer values for Events 2 – 88. The average difference between primary and secondary sensor values and their corresponding salinometer values is -0.0125 (black line) and -0.0063 (blue line), respectively.

Next, the R function ‘swCSTp’ from package ‘oce’, which uses the Gibbs-Sea Water (gsw_C_from_SP) formulation, was used to convert the salinity of the bottle sample to conductivity (mS/cm). These data were filtered and used to fit a linear regression for both the primary and secondary CTD sensor conductivity cells. The intercept (b1) and slope (b2) values for both primary and secondary sensor regressions were extracted from the linear regression summary. These terms (Table A2.1) were used to calibrate the primary and secondary sensor salinity values. Figure A2.5 shows the relationship between the primary and secondary sensor before correction (black circles), and after correction using the revised b1 and b2 coefficients (blue squares) from Table A2.1.

Table A2.1. The revised intercept (b1) and slope (b2) terms calculated for the primary and secondary conductivity sensors for Events 2 through 88 of the HUD2020063 mission.

Conductivity Sensor	b1	b2
Primary (#3562)	-0.01323007	1.000706
Secondary (#1076)	-0.00671931	1.000357

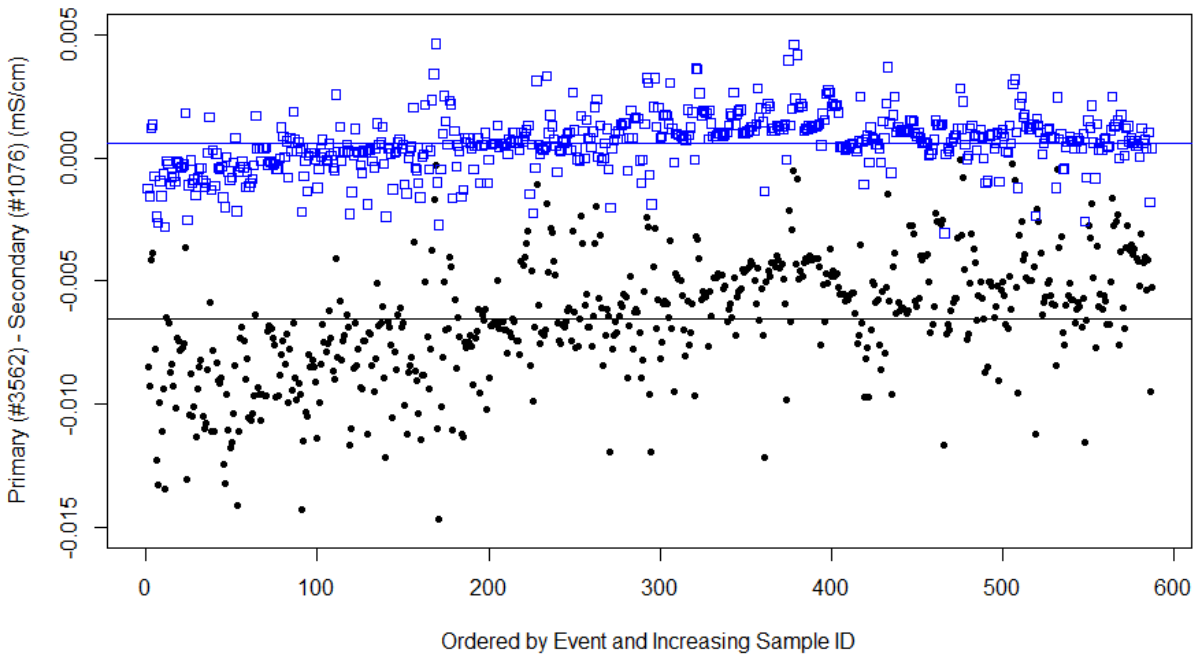

Figure A2.5. Corrected (blue) versus uncorrected (black) sensor difference of the outlier-free data collected on Events 2 – 88. Black dots – the difference between the uncorrected primary and secondary sensors (mean = -0.0065 mS/cm). Blue squares – the difference between the corrected primary and secondary sensors (mean= -0.0003 mS/cm).

Recalibration of conductivity sensor data from Events 92 - 101

Additional salinity bottle samples were collected throughout the water column during CTD operations on stations STAB_02 through STAB_05 (Events 92 through 101) for the purpose of providing additional data points for which to calibrate the new secondary conductivity sensor after it was replaced following operations on CSL_06 (Event 88). After the conductivity sensor values were converted to salinity (PSU), a comparison of the primary (#3562) and the new secondary (#3561) conductivity sensor data was performed for data collected on Events 92 through 101 to highlight and remove any outliers beyond 1.5 *IQR of the data. This revealed 17 outliers (out of 95 data points), which were subsequently removed from further analyses (see Figure A2.6).

Differences between the primary sensor and salinometer (bottle) values were compared in a similar manner, and the outliers evaluated and removed (3 outliers; Figure A2.7). The same process was completed for the secondary sensor; however, no outliers were identified (Figure A2.8). The difference between the salinometer data and the primary and secondary sensor values were, on average, -0.0087 and 0.0040 PSU, respectively (Figure A2.9).

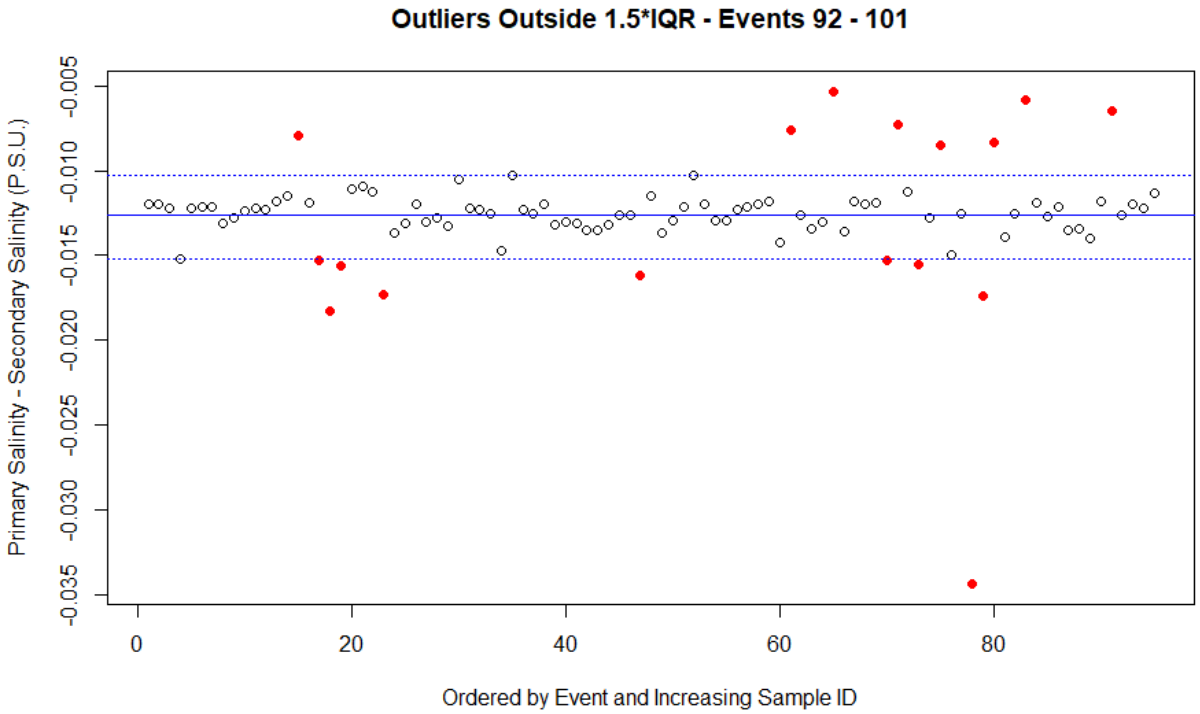

Figure A2.6. Comparison between salinity values derived from the primary and secondary conductivity sensor values collected between Events 92 and 101 (Mean = -0.0124, IQR min = -0.0103, IQR max = -0.0152). Differences above or below the min/max IQR are considered outliers (red dots) and were removed from further analysis.

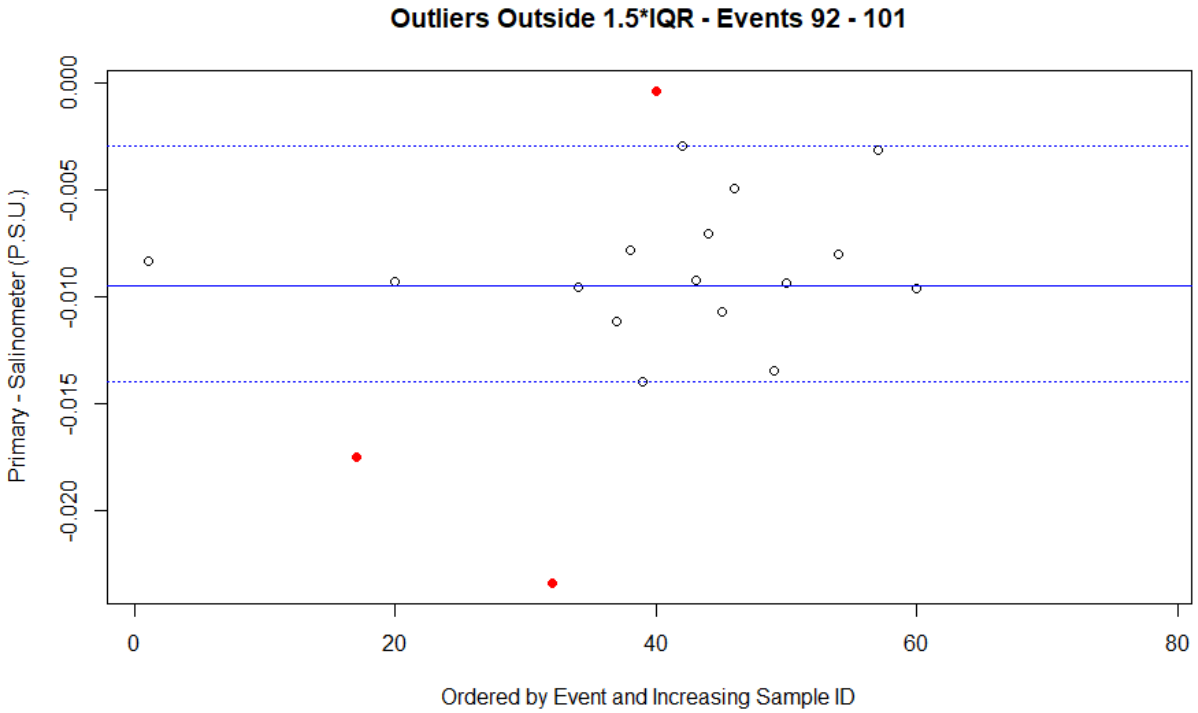

Figure A2.7. Comparison between primary sensor and salinometer values collected between Events 92 and 101 (Mean = -0.0093, IQR min = -0.0140, IQR max = -0.0029). Differences above or below the min/max IQR are considered outliers (red dots) and are removed from further analyses.

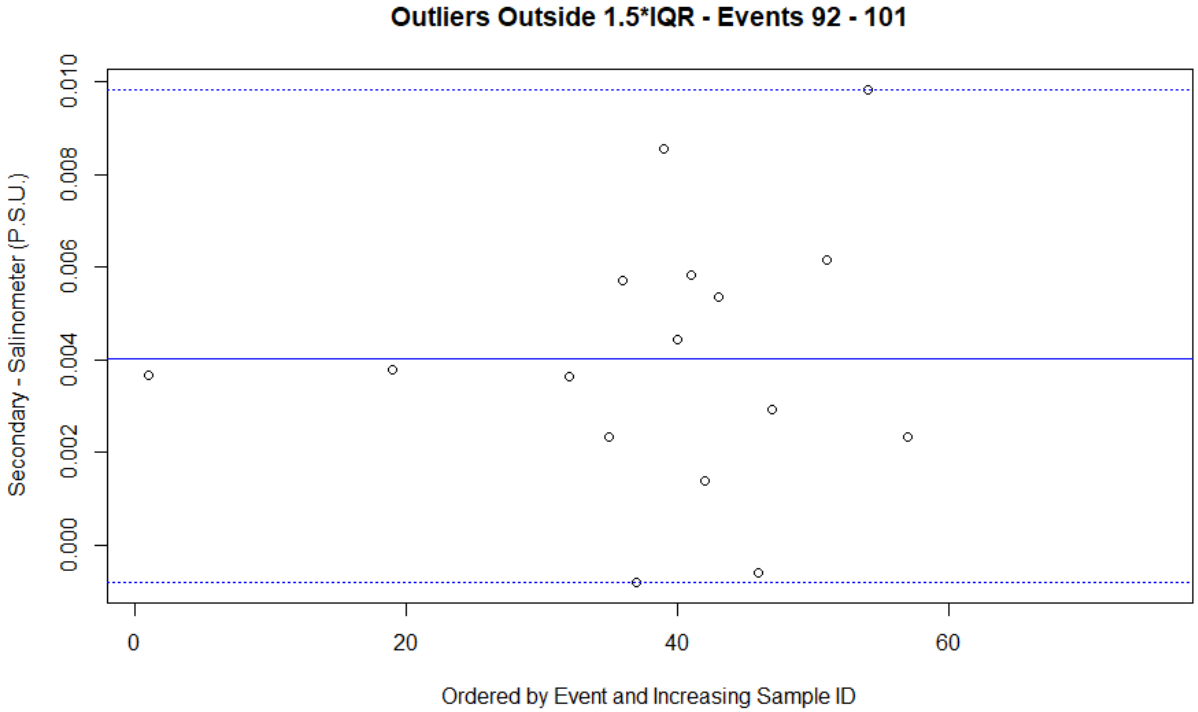

Figure A2.8. Comparison between secondary sensor and salinometer values collected between Events 2 and 88 (Mean = -0.0059, IQR min = -0.0133, IQR max = -0.0005). Differences above or below the min/max IQR are considered outliers (red dots) and are removed from further analyses.

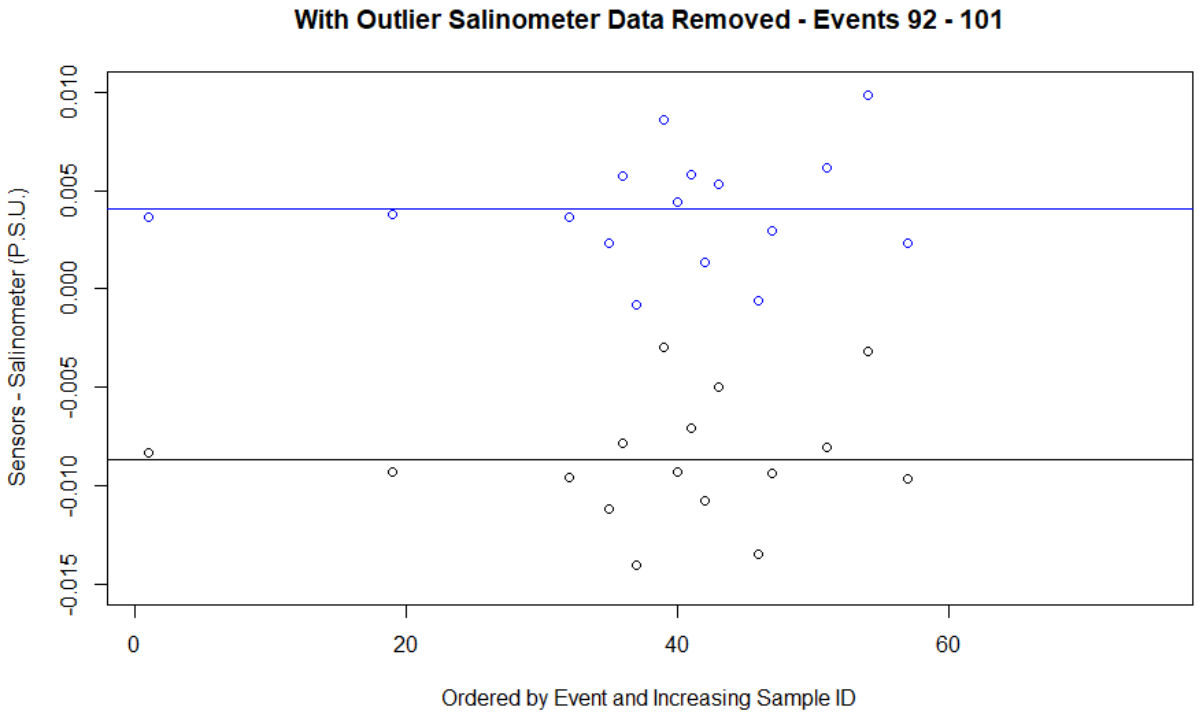

Figure A2.9. Difference between primary (#3562; black dots) and secondary (#3561; blue dots) sensor values and their corresponding salinometer values for Events 92 – 101. The average difference between primary and secondary sensor values and their corresponding salinometer values is -0.0087 (black line) and 0.0040 (blue line), respectively.

R function 'swCSTp' from package 'oce' was used to convert the salinity of the bottle sample to conductivity. These data were filtered and used to fit a linear regression for both the primary and secondary CTD sensor conductivity cells. The intercept (b1) and slope (b2) values (Table A2.2) for both primary and secondary sensor regressions were extracted from the linear regression summary and used to calibrate the primary and secondary sensor salinity values. Figure A2.10 shows the relationship between the primary and secondary sensor before correction (black circles), and after correction using the revised b1 and b2 coefficients (blue squares) from Table A2.2.

Table A2.2. The revised intercept (b1) and slope (b2) terms calculated for the primary and secondary conductivity sensors for Events 92 through 101 of the HUD2020063 mission.

Conductivity Sensor	b1	b2
Primary (#3562)	-0.01687332	1.000751
Secondary (#3561)	-0.02012705	1.000504

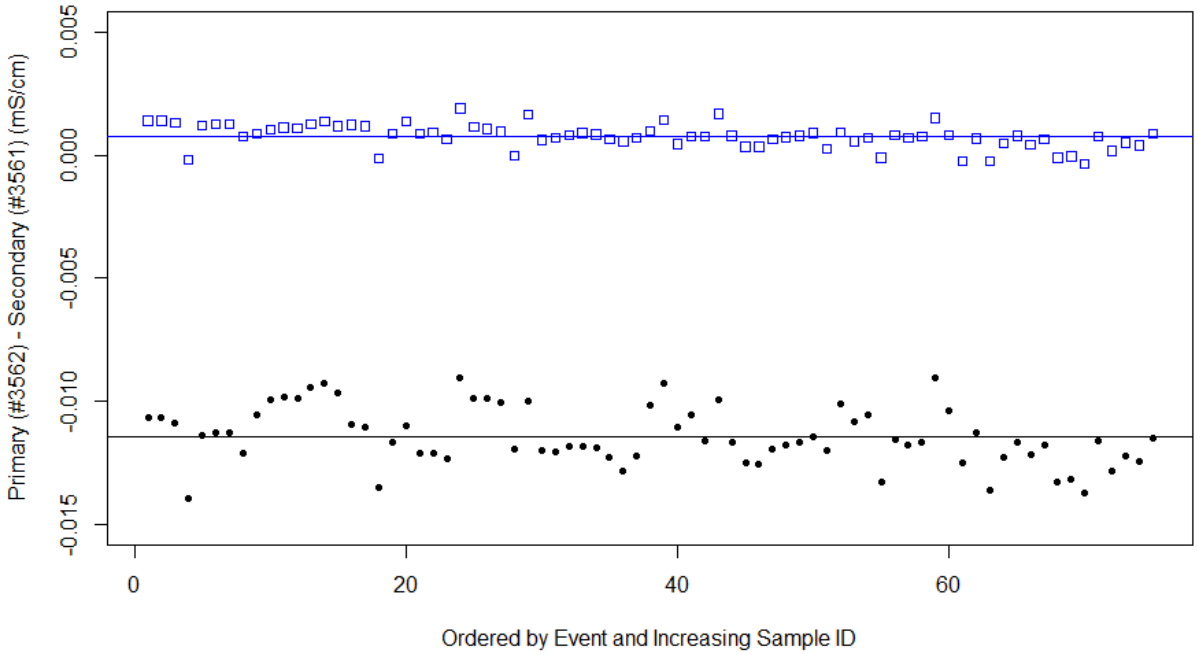

Figure A2.10. Corrected (blue) versus uncorrected (black) sensor difference of the outlier-free data collected on Events 92 – 101. Black dots – the difference between the uncorrected primary and secondary sensors (mean = -4.1272×10^{-5} mS/cm). Blue squares – the difference between the corrected primary and secondary sensors (mean= -0.0114 mS/cm).

Appendix 3 – Evaluation of relationship between sensor chlorophyll *a* and Turner fluorometer

(With portions extracted from COR2019001 Cruise Report)

A SeaPoint fluorometer ultraviolet sensor (Serial No. 6229) is mounted to the CTD-rosette that measures coloured dissolved organic matter (CDOM), while a second fluorometer (SeaPoint fluorometer Serial No. 3867, calibrated January 1, 2015) measures *in situ* chlorophyll *a*. For the purpose of this exercise, chlorophyll *a* data from the SeaPoint fluorometer was evaluated against its corresponding Turner chlorophyll concentration values to determine the how closely the sensor data matched the bottle data. Note that while the fluorometer sensor 3867 is labelled 'fluorometer2' in the CTD ODF files, it is identified as the primary sensor (Chl_Fluor_CTD_P) in the chlorophyll report generated using the Access database template.

A total of 400 bottle samples were taken in duplicate (800 samples in total) during deployments of the CTD-rosette for subsequent chl *a* analysis using a Turner fluorometer. Using the 1.5 interquartile range method discussed in the previous oxygen and salinity sections of this report, a total of 67 of 400 replicates were identified outliers (Figure A3.1).

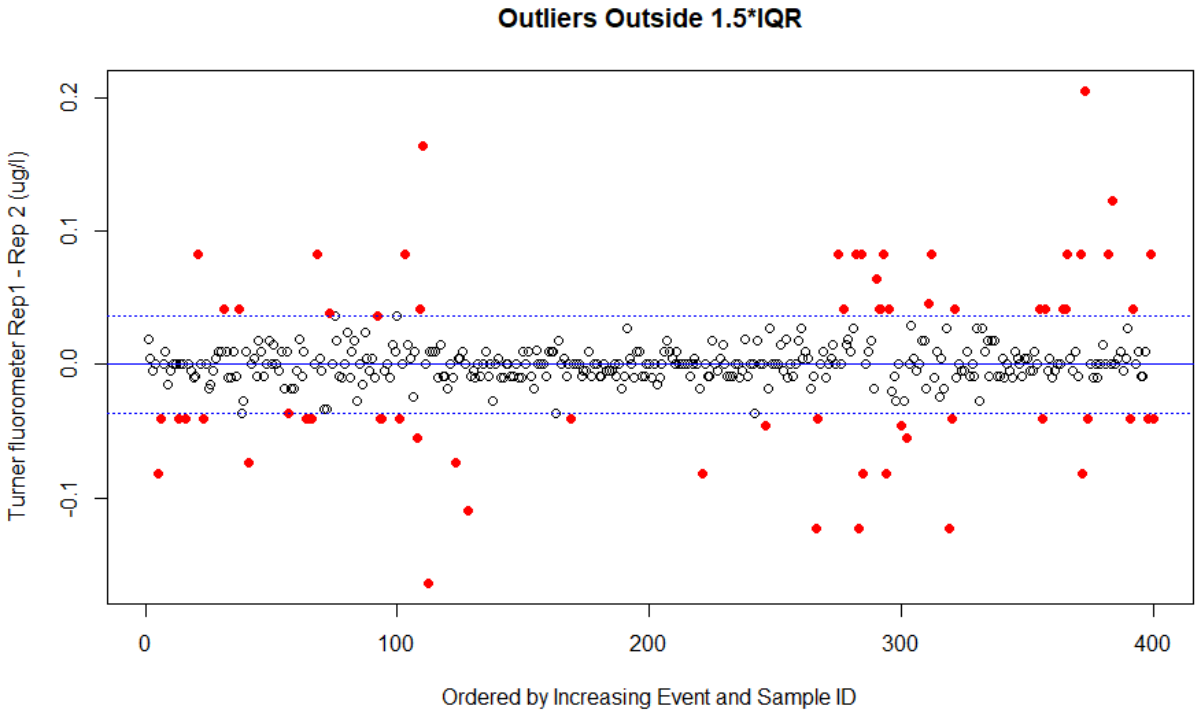

Figure A3.1. Comparison of Turner fluorometer replicates (Mean = 0, IQR min = -0.0365, IQR max = 0.0365). Red dots are outliers beyond the 1.5 IQR.

Comparison of the replicates showed that the mean difference between replicates was -1.6776 x 10^{-4} ± 0.0322 µg/L. The 67 outliers were removed prior to making the comparison between the SeaPoint fluorometer and the Turner values.

Similar outlier detection methods were employed to remove data that showed larger-than-expected differences between the SeaPoint fluorometer (#3867) and the Turner fluorometer data (Figure A3.2). First, both the SeaPoint data and the Turner data were standardized by dividing both data sets by the SeaPoint data value. This made each SeaPoint data value for a bottle fire equal to 1, and the corresponding mean replicate Turner fluorometer value a percentage of the SeaPoint value. A value of 1.15 means that the Turner Fluorometer value was 15% greater than its corresponding SeaPoint value, and a value of 0.85 means that the Turner value was 15% less than the SeaPoint value. This approach was taken because calculating the straight difference between values was influenced greatly by their magnitude. The difference between 0.01 and 0.1 and the difference between 6.31 and 6.40 are both 0.09, but the relative difference is ~90% and ~1.4% respectively. Figure A3.2 shows the outliers calculated in this way. Out of 333 (67 outliers removed) comparisons between the primary SeaPoint fluorometer sensor and the mean of the Turner fluorometer replicates, 9 outliers were identified and removed before proceeding. The blue line shows that on average, SeaPoint sensor concentration values are ~24.11% higher than their corresponding Turner fluorometer values.

Figure A3.3 shows the log relationship between the SeaPoint fluorometer values and the Mean Turner Chl *a* values with the outliers from Figure A.3.2 highlighted in red. The blue line corresponds to the line of best fit from a linear regression between the log SeaPoint sensor data and Turner chl *a*, while the orange dashed line represents the 1:1 reference line. When the outliers were removed and a linear regression was applied to the primary SeaPoint sensor and mean Turner chl *a* data (Figure A3.4), the relationship was strong and significant (R^2 = 0.91, *p*-value <0.001). This suggests that the fluorometer sensor data closely fit chlorophyll *a* measured from the bottle samples.

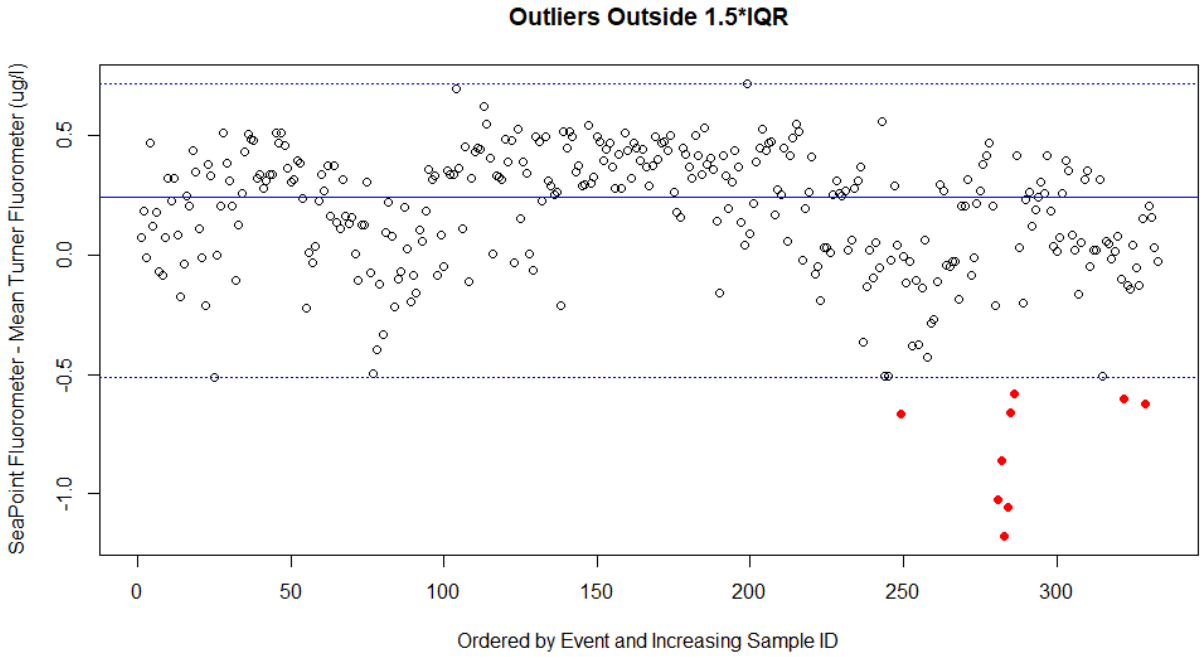

Figure A3.2. Outliers (n=9) identified from calculating the % difference between the standardized Turner fluorometer values (mean Turner fluorometer values divided by the SeaPoint primary sensor values) and the standardized SeaPoint sensor values. Mean = 0.2411, IQR min = -0.5148, IQR max = 0.7174). Red dots are outliers beyond the 1.5 IQR.

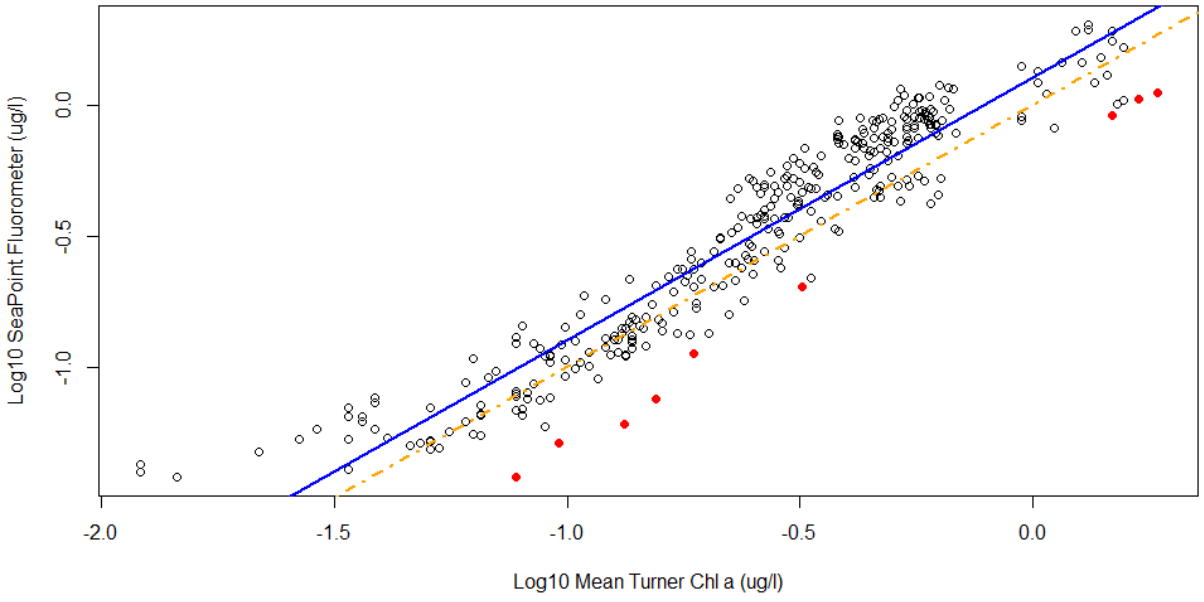

Figure A3.3. The log10 scale plot of SeaPoint primary fluorometer values and the corresponding mean replicate Turner fluorometer values. Note the highlighted 1.5 * IQR outliers from Figure A3.2 in red. Blue line represents the line of best fit, while the orange dashed line is the 1:1 reference line.

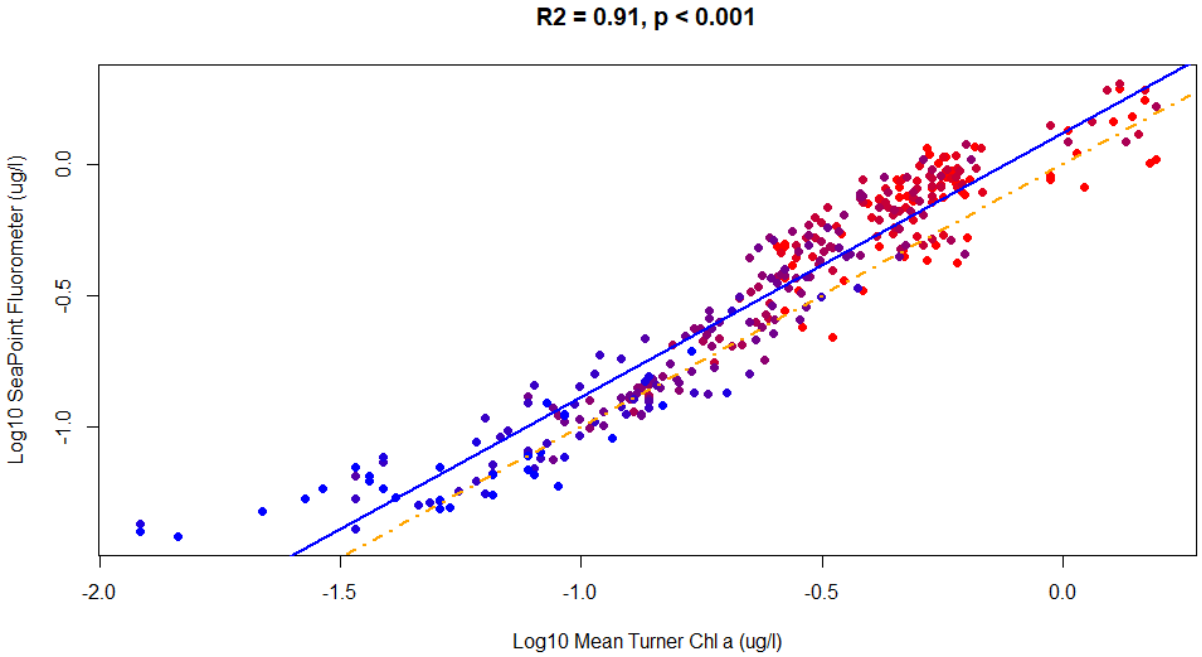

Figure A3.4. The log10 plot of SeaPoint primary fluorometer values and the corresponding mean replicate Turner fluorometer values (outliers removed) colour coded by depth, where red and dark red are shallow (closer to the surface) and purple and blue are deep (closer to 100 m). Blue line represents the line of best fit, while the orange dashed line is the 1:1 reference line.

Appendix 4 – CTD configuration (Flo Hum)

Original Request [X] Update [ ]
Information Supplied By: Terry Cormier

Mission: **HUD2020-063** Departure Date: **12 September, 2020**
Chief Scientist: **Lindsay Beazley**

CONFIGURE INPUTS

Instrument Configuration

Frequency channels suppressed = **0**
Voltage words Suppressed = **0**
Deck unit or SEARAM = **SBE11plus Firmware Version >=5.0**
Computer interface = **RS-232**
Scans to average = 1

	Yes	**No**	
NMEA position data added	**X**		
NMEA device added to deck unit	**X**		
NMEA device added to PC		**X**	
NMEA depth date added		**X**	Only applicable when device added to PC
NMEA time added		**X**	Only applicable when device added to PC
Surface PAR voltage added	**X**		
Scan time added		**X**	

Channel Designation

SBE9 Connector	Channel Designation	Parameter	Model Number	Serial Number	Calibration Date	System Number	RMA
JB1	Frequency 0	Temperature – Primary	SBE3	5083	05 Oct 2019	**TS14**	1005508958
JB2	Frequency 1	Conductivity – Primary	SBE4	3562	04 Oct 2019	**CS14**	1005508958
Internal Connection	Frequency 2	Pressure – SBE9*plus*	410K-135	51403-370	21 Dec 2018	**PP04**	1005500510
			Modulo 12P	0105	31 Dec 1992		
JB4	Frequency 3	Temperature - Secondary	SBE3	1376	5 Oct 2019	**TS03**	1005500686
JB5	Frequency 4	Conductivity - Secondary	SBE4	1076	8 Oct 2019	**CS03**	1005508958
JT2	Voltage 0	Altimeter	VA500	59017	01 Mar 2017	**VA01**	
	Voltage 1	Irradiance (PAR-Log)	SAT-QR-99019	1043	1 Dec 2015	**P03**	87785R
JT3	Voltage 2	Oxygen	SBE43	2524	30 Jan 2020	**D03**	1005509451
	Voltage 3	Oxygen	SBE43	3030	3 Dec 2019	**D05**	1005509451
JT5	Voltage 4	Fluorescence	SUVF	6229	1 Jan 2015		
	Voltage 5	Fluorescence	SCF	3867	1 Jan 2015		
JT6	Voltage 6	-PH	SBE18	1129	06 Jan 2020		1005509451
	Voltage 7	Transmissometer	BBRTD	1490	9 Aug 2016	**TM01**	
	SPAR voltage	Unavailable					
	SPAR voltage	SPAR	SAT-QR-99019	1168	27-Nov-2018		

Serial Ports

CTD Serial Port

COM port = **COM 1**
Baud rate = **19200**
Data bits = **8**
Parity = **None**

Water Sampling and 911 Pump Control Serial Port

COM port = **COM 2**

Serial Data Output Serial Port

COM port = **COM 7**
Baud rate = **19200**
Data bits = **8**
Stop bits = **1**
Parity = **None**

SBE 14 Remote Display Serial Port

COM port = **COM 5**
Baud rate = **4800**

NMEA Serial Port

COM port = [not applicable unless 'NMEA device connected to PC' is selected in the instrument configuration file]
Baud rate = **9600**

Note: although not specific to the Seabird Seasave configuration, the CTD data acquisition PC - COM port 4 with a baud rate of 9600, has been configured for IMS Block Data.

Water Sampler

Water Sampler Type = **SBE Carousel**
Number of Water Bottles = **24**
Firing Sequence = **Sequential**

	Yes	**No**
Enable remote firing		**X**

Bottle Positions For Table Driven = < See CTD System Administrator if REQUIRED >

CONFIGURE OUTPUTS

Serial Data Out

	Yes	No
Output data to serial port	X	
XML format		X

Number of seconds (data time) between updates = **0.0**

Column	Variable	Decimal Digits
#1	**scan number**	**0**
#2	**Depth (saltwater,m)**	**4**
#3	**Pressure (dbar)**	**4**
#4	**Decent Rate (m/s)**	**4**
#5	**none**	**3**
#6	**none**	**3**
#7	**none**	**3**
#8	**none**	**3**

Column	Variable	Decimal Digits
#9	**none**	**3**
#10	**none**	**3**
#11	**none**	**3**
#12	**none**	**3**
#13	**none**	**3**
#14	**none**	**3**
#15	**none**	**3**

Shared File Out

	Yes	No
Output data to shared file	X	
XML format (required for Seasave Remote)	X	

File Name = **C:\Metering Sheave\shared.dat**

Number of seconds (data time) between updates = **0.5**

Column	Variable	Decimal Digits
#1	**scan number**	**0**
#2	**pressure**	**2**
#3	**altimeter**	**2**
#4	**none**	**3**
#5	**none**	**3**
#6	**none**	**3**
#7	**none**	**3**
#8	**none**	**3**

Column	Variable	Decimal Digits
#9	**none**	**3**
#10	**none**	**3**
#11	**none**	**3**
#12	**none**	**3**
#13	**none**	**3**
#14	**none**	**3**
#15	**none**	**3**

TCP/IP Out

Raw Data

	Yes	No
Output RAW data to socket using TCP/IP		X
XML wrapper and settings		X

Number of seconds (data time) between raw updates: **0.5**

Converted Data

	Yes	No	
Output converted data to socket using TCP/IP	X		Required for SBE fixed Display
XML format (required for Seasave Remote)	X		Required for SBE fixed Display

Number of seconds (data time) between converted updates: **0.200**

Column	Variable	Decimal Digits
#1	**Depth**	**0**
#2	**Altimeter**	**0**
#3	**none**	**3**
#4	**none**	**3**
#5	**none**	**3**
#6	**none**	**3**
#7	**none**	**3**
#8	**none**	**3**

Column	Variable	Decimal Digits
#9	**none**	**3**
#10	**none**	**3**
#11	**none**	**3**
#12	**none**	**3**
#13	**none**	**3**
#14	**none**	**3**
#15	**none**	**3**

TCP/IP Ports

Ports for communicating with remote bottle firing client

Not applicable

Ports for publishing data to remote clients

Send converted data (default 49161) = **6202**

Send raw data (default 49160) = **49000**

Header Form

Header Choice = **Prompt for Header Information**

Line #	Prompt	Value
1	Ship:	**HUDSON**
2	Cruise:	**HUD2020063**
3	Chief Scientist:	**LINDSAY BEAZLEY**
4	Organization:	**BIO**
5	Area_of_Operation:	**SCOTIAN SHELF**
6	Cruise_Description:	**ATLANTIC ZONE MONITORING PROGRAM (AZMP)**
7	Station:	
8	Sounding:	
9	Event_Comments:	

SPARES

Parameter	Model Number	Serial Number	Calibration Date	System Number	RMA
Temperature	SBE3	4807	19 Dec 2019	TS11	1005509451
Conductivity	SBE4	4361	14 Feb 2020	CS11	1005509451
Temperature	SBE3	5081	04 Dec 2019	TS13	1005509451
Conductivity	SBE4	3561	03 Jan 2020	CS13	1005509451
Temperature	SBE3	2303	04 Dec 2019	TS10	1005509451
Conductivity	SBE4	1874	03 Jan 2020	CS10	1005509451
Temperature	SBE3	5064	05 Dec 2019	TS12	1005509451
Conductivity	SBE4	4362	03 Jan 2020	CS12	1005509451
Pressure – SBE9*plus*	410K-05	50601-370	08 Nov 2018	PP03	10055006184
	Modulo 12P	0105	51403-289		
Altimeter	VA500	62184	30 Nov 2018	VA02	
Oxygen	SBE43	3026	27 Nov 2019		1005509451
Oxygen	SBE 43	3030	03 Dec 2019		1005509451
Oxygen	SBE43	2524	30 Jan 2020		
PH	SBE 18	1159	15 Jan 2020		1005509451
PH	SBE-18	1214	19 Dec 2019		1005509451
PH	SBE-18	0920	02 Jan 2020		1005509451
PH	SBE-18	1221	15 Jan 2020		1005509451
Irradiance (PAR)	SAT-QR-99019	1069	24 June 2016		
Pump	SBE-5T	1770			
Pump	SBE-5T	1047			
Pump	SBE-5T	1399			
Pump	SBE-5T	1768			

Appendix 5 – Measures to mitigate the potential spread of Covid-19

In June 2020, DFO's Ecosystems and Ocean Science Sector released the 'Return to Science At-Sea Operations Guidance – COVID-19' with the purpose of providing national guidance to Managers of Ecosystems and Ocean Science Sector (EOSS) responsible for planning and executing science at-sea operations during the COVID-19 pandemic. Considerations for mobilization/demobilization, accommodations, and mission operations were provided based on current public health guidance and emerging evidence and experience.

The document offers guidance on relevant safe-work procedures articulated by DFO and Coast Guard for the purpose of preventing or mitigating the spread of Covid-19. The guidance recommends that all staff joining vessels should follow current health authority advice in the 14 days prior to joining any mission. DFO's Ocean and Ecosystem Sciences Division (OESD) developed further guidelines on how to operationalize this current health authority advice (see 'Self-isolation Guidelines for Science Staff Joining Research Vessels below). The purpose of these self-isolation guidelines is to provide guidance to staff on how to reduce high-risk behavior prior to boarding which may increase the risk of contracting Covid-19.

Self-isolation guidelines for science staff joining research vessels

1. Stay at home as much as possible for 14 days prior to the mission and monitor yourself for symptoms, even just one mild symptom. Discuss options with your supervisor for working from home during this period.

2. Minimize contact with people outside of your home to help prevent transmission of the virus prior to developing symptoms or at the earliest stage of illness.

3. Do your part to prevent the spread of the disease by practicing proper hygiene (e.g., frequent hand washing).

4. Keep surfaces clean at home and avoid sharing personal items.

5. Only leave your home for essential services (e.g., groceries, medical appointments) or for outdoor exercise where physical distancing is possible. Please consider a asking a family member or friend to do errands to minimize your interactions outside your home.

6. Do not have visitors.

7. If possible, do not go to your workplace in the 14 days prior to mobilization. If you are required to complete a task in that time window, first try to develop a plan with your supervisor to have another staff member (who is not joining the mission) do the work. If this is not possible, make sure that your section head is notified of your entry into the BIO complex, limit your workplace interactions to those essential to your job function and return to your home upon completion.

Best practices to mitigate the spread of Covid-19 while onboard

Additional recommendations on the best practices used to mitigate the spread of Covid-19 while working **onboard** the CCGS *Hudson* have also been developed for participants of the whale mooring (HUD2020-066) and AZMP (HUD2020-063) missions. These guidelines are meant to supplement the information presented in the Safe Work Procedure developed by Science Branch, Maritimes Region for working offsite (see Annex D – SWP Working Offsite), and focus on conducting science safely while onboard *Hudson*. At any point in time these may be updated by the chief scientist and CO.

General best practices:

1. Maintain a minimum of 2 meters physical distancing as best as you can. If physical distancing is not possible, non-surgical masks and gloves are recommended (but not required) and will be made available in laboratory, operational, work and common spaces should you need to access them.

2. Wash hands and/or use alcohol-based hand sanitizer regularly, particularly when entering designated work spaces.

3. Avoid touching any surfaces unnecessarily.

4. Avoid touching eyes, nose and mouth with unwashed hands.

5. Follow any COVID-related procedures/guidelines/best practices put in place by the CCG crew on the ship (including around use of work spaces, common spaces, meal times, etc).

Shared laboratory, operation and work spaces (e.g. benches, taps/sinks, desks):

1. When entering or re-entering a shared laboratory, operation or work space, sanitize hands using the provided hand sanitizer.

2. Shared work spaces/surfaces should be cleaned and disinfected before and after each use (or at a minimum, at the beginning and the end of each work day or work shift). Keep in mind that others may be accessing these spaces even when they are not being used by science staff.

3. Clean and disinfect surfaces using the provided soap, sanitizer or disinfectant (eg., isopropyl alcohol), either by wiping with pre-soaked hand or paper towels, or by spraying while wearing protective gloves. Allow sufficient contact time according to the manufacturer's instructions. Air dry unless otherwise specified according to instructions. Discard soiled wipes in a wastebasket.

When using shared equipment (e.g. tools, computers, keyboards and pointing devices, binoculars, cameras):

1. Avoid sharing tools and equipment if/when possible.

2. If tools and equipment must be shared, they should be cleaned and disinfected before and after each use. If not possible to disinfect equipment before/after each use (as may be the case with equipment that has rubber components that can be negatively affected by alcohol-based disinfectants), those sharing equipment should sanitize hands with the provided hand sanitizer before using shared equipment - at a minimum, all equipment should be cleaned and disinfected at the end of each work day or work shift before being stored away.

3. Clean and disinfect using the provided soap, sanitizer or disinfectant (e.g., isopropyl alcohol), either by wiping with pre-soaked hand or paper towels, or by spraying while wearing protective gloves. Allow sufficient contact time according to the manufacturer's instructions. Air dry unless otherwise specified according to instructions. Discard soiled wipes in a wastebasket.