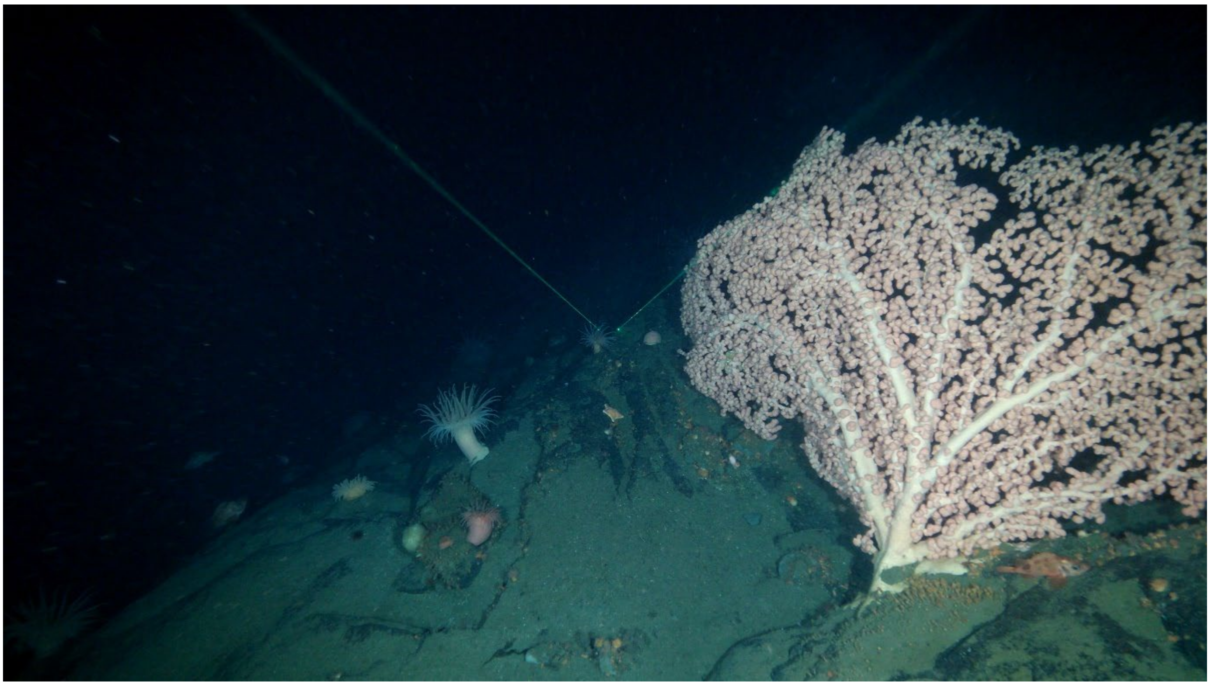
Bay D'Espoir Expedition 2024

14th to the 17th of June 2024

MV Polar Prince

Cruise ID: PP20240614



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MV Polar Prince Crew

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Expedition Rational

Fjords are complex geological features consisting of coastal incisions in which offshore deep-water species can establish (1). Benthic habitat complexity in fjords is often linked to the complex and highly sloped rocky topography interacting with currents and gradients in water column properties (e.g., temperature, salinity, and oxygenation) (2). Due to this complexity, fjord walls are known to support communities of suspension and filter feeders, including cold-water corals and other vulnerable, slow-growing taxa (3, 4). However, fjord habitats are often situated close to human activity and risk exposure to anthropogenic influence. For example, the Miawpukek First Nation traditional territory of Bay d'Espoir is the deepest fjord on the south coast of Newfoundland (5). Due to numerous sheltered bays and inlets, Bay d'Espoir offers optimal conditions for finfish cages and suspended shellfish gear culture, and planning continues for the expansion of aquaculture activities (6), Bay d'Espoir is also the location of complex and highly sloped rocky habitats, where sea anemones, sponges, stalked barnacles and the giant file clam *Acesta cryptadelphe* were observed (7). Though these observations were made over 30 years ago, very little research has taken place to understand the benthic community structure in this location. Habitat-forming cold-water coral species, *Paragorgia arborea,* has also been reported in the area (6), along with the sea pen *Pennatula aculeata* in the bottom of the Bay (8). Observations such as these indicate vulnerable benthic taxa could be more widespread than previously known. To support marine spatial management, particularly the coastal and fjord systems in around Newfoundland and Labrador where there is little to no baseline data, it is important to understand the distribution of ecologically important habitats. Efforts to address this knowledge gap aligns with the objectives set in the Fortune Bay coastal Baseline Program

The primary objectives of this research are:

Collect baseline data towards developing new Fortune Bay Coastal Environmental Baseline Program within the South Coast Fjords of Newfoundland.

Strengthen existing collaborations between the Department of Fishery and Oceans (DFO), MI (Marine Institute) and Miawpukek First Nation (MFN) by co-conducting research and outreach with youth onboard the vessel.

Operational Objectives

During this expedition, the primary operational objectives were as follows:

1. To characterize benthic habitats by collecting seabed video at target sites that may host cold-water corals and their associates.
2. Conduct CTD profiles and collect water samples to investigate cold-water carbonate production.
3. Characterize benthic fauna diversity (including functional diversity) through the collection of samples and sediment physio-chemical characteristics at specific predetermined sites in Bay d’Espoir.
4. Provide hands on experience to Indigenous youth present onboard as part of an Indigenous-led expedition through Miawpukek First Nation and Miawpukek Horizon Maritime Services.

Expedition Narrative

14 June 2024

We left the Marine Institute towards 07h30 after packing trucks and drive to Conne River arriving around 14h00. We used the Miawpukek Fisher to load gear on the Polar Prince from 16h00 to 18h00. Safety drills took place at 19h00. As we worked to mobilize the gear, it was noted that there were no freezer for samples, no GPS feed, no weak link for crane, and the fume hood had not been installed.

Luckly documents outline the strength of the crane were found as long as it was not fully extended our cable would break before the crane.

15 June 2024

Our first station was for first Van Veen grabs at 06h30. We serviced the winch and installed the block with the cable counter, but could not find the deep-water swivels. The first Van Veen was deployed at 09h08. There was an issue with the winch where the working angle with the crane was problematic for the wire, a snatch block was added to alleviate the issue, but the cable spooled on the drum was not aligned properly. The First Van Veen grab did not fire, we might not have reached the bottom even though the cable counter recorded 660m payout. Attempted two more grabs, and saw that Van Veen had mud on it and we could see a seapen getting washed away. We tried a different grab system in case it was not being triggered, and hooked up a Star Odi to check the depth (max depth recorded 440m). No successful Van Veen were obtained. The first CTD was not deep enough the trigger the bottles, but second attempt worked. There was no hose for nutrients so these were not collected. We carried the first live SubC camera drop. We saw a large yellow *Paragorgia*, but the camera memory was full and was not actually recording. We carried a second drop at the same location, but did not see another coral. The fjord sides are very steep and the camera cannot winch up fast enough to compensate for the speed at which we are drifting despite to weak surface currents. We got a third operator trained on the winch and continued from the evening into the night with bathycam drops. During the first drop, there was an issue with the recording script and nothing was captured. As we cannot easily tell if we have reached bottom from slack on the wire, all drops ended up with only blue water. A few issues were encountered with the cable counter block and the winch. The pull cord has broken twice while various components of the block became loose and needed to be zip tied.

16 June 2024

The morning was dedicated to Van veen grabs in Little Goblin Bay, we went with the unmodified version of the system. The first drop did not trigger, so we went well past the payout read on the second drop and finally collected mud. The third drop triggered but was empty, while the fourth one was successful. The smaller vessel to carry out shallow camera drops came up at 09h30, and we realized then that it did not have the expected 110 power. We decided to send it back to Conne River to carry out the drops over there after picking up the battery pack left in the truck. The fume hood is somewhat installed, but the power cord seems to have gone missing.

The first CTD did not fire, we probably had not reached bottom. It seems like our cable counter is off by 30m or so and the charts for this area are very poor. There also seems to be an offset in our GIS. The second CTD fired, but at the end of the recovery the winch started to smoke and we decided to let it rest and have the engineers take a look. The youth were able to practice collecting water samples as well as sieve mud for macrofauna. The CTD also had the cups they had drawn earlier. We transited to live cam drops at around 16h00, and carried out two transects where we found walls at ~350m. The walls were covered in anemone, with many soft corals. The technique developed to capture the imagery was to drift the ship slowly toward the wall, as soon as the wall was observed, we started winching up as quickly as possible. As a result of issues with the winch, we are unsure about using it for bathycam deployments overnight. As such, we selected a set of points near Butter Cove to acquire imagery of the sea pen fields.

17 June 2024

Unfortunately, during the night, the SubC tow cam cable got snagged coming off its roller. Luckily only the outer casing was damaged, it was fixed with electric tape and KR decided to continue with deployment since ship cost higher than cable replacement cost. We carried camera drops in Bay D'Espoir near Patrick's Habour in a sea pen area. It was less dense than expected around Butter Cove based on the Van Veen grabs obtained during the previous year. The weather is sunny and calm. We moved to near Patricks Harbour around site of historic *Paragorgia* by-catch. The seafloor is dominated by sponges and a different soft coral, but no *Paragorgia* seen. We followed up with a successful Van Veen drop. The small vessel returned after conducting 10 successful drops at shallower sites, but an injury occurred upon boarding. The skipper cut his head on the door frame and the injury required bandaging. The wind was up and there were waves with small white caps. A few more Van Veen drops were necessary to complete a sampled, small rocks were caught in the jaw, but mud was still obtained. We transited back to the walls near where the *Paragorgia* was observed on the first dive around dinner time as the wind was predicted to drop and the direction should allow the ship to drift away from land. One imagery drop was attempted on the wall opposite goblin head. At ~200 m three large *Paragorgia* colonies were observed (>1m tall). There were also lines that were observed in the water. As the captain was off shift at 20h00, we proceeded to download the videos and move on to the seapen field for over night camera drops.

18 June 2024

Four successful live cam drops were carried out overnight, with the one located near a prior Van Veen grab being very densely populated with sea pens. After an early morning live cam drop near aquaculture leases, we transited to North Bay near the Devil's dancing table to carry out CTD drops. Since the winch could not handle the CTD, we attached ONC's AML community fisher's CTD to the wire with a single Niskin above and build a messenger using 4 large cotter pins and cable ties. All depths were collected as individual drops and all were successful (surface, 310m, 250m, 100m, 50m). The wind was being funnelled within the Bay and was stronger than we had seen so far during the expedition. We moved on the collect Van Veen grabs from the same site as last year. The Evening was spent trying to get imagery from bathycam since the winch had performed ok earlier in the day, and we decided it would be worth trying to collect some data from deeper sites. During the first deployment, we touched bottom, but subsequent retrievals were not sufficient to lift the camera system back off the seabed. On the second drop, we lifted higher, and we believe that we can now see when in touches bottom on the block. However, during this second deployment there was an issue with the recording and our time on the bottom was not recorded. We later learned that we need to leave the camera on deck for 10min after recovery to ensure that the last useful file has had time to complete before removing the plug otherwise there is a risk of corruption.

19 June 2024

For the third drop, we tried a deeper site, but the current was higher and it was clear based on the angle of the wire (we could see the cable being pulled away from the ship instead of going straight down) that we had not touched bottom even when 700m of wire was out. Considering that the winch was warm and to make sure it would not be broken for the second leg, we stopped operations at ~2am. We arrived early in vicinity of Conne River and demobilization occurred without issues at ~8h30 using the Endeavour. We drove back to St John’s arriving in the afternoon.

Equipment and Sampling Report

1. Summary of Activity

During the 2024 Bay D'Espoir expedition (PP20240614, 14-17th of June 2024), a total of 71 stations (53 onboard the *Polar Prince* and 18 the *Miawpukek Fisher*) were carried out (Figure 1), including the following activities: three different benthic imaging system (a shallow drop camera system for depths <150m, a SubC system for depths <400m, and a BathyCam system for depths >400m), Van Veen grabs and CTDs. Deck setup for the expedition is shown in Figure 2 while camera specifications are provided in Table 2.

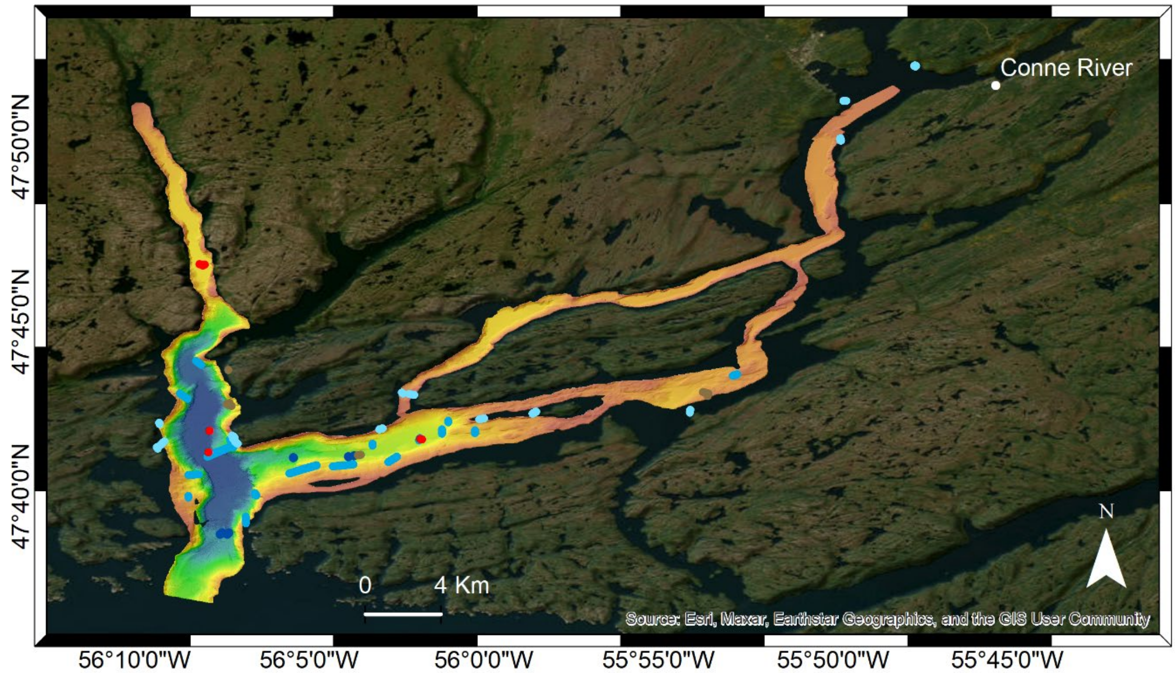

Figure 1: Station location of all activities carried our during the 2024 Bay D'Espoir expedition onboard the MV Polar Prince: CTD (red points), Van Veen grabs (brown points), shallow camera drops (light blue lines), SubC camera system (medium blue lines), BathyCam (dark blue points), overlain on the multibeam dataset acquired during the 2023 expedition..

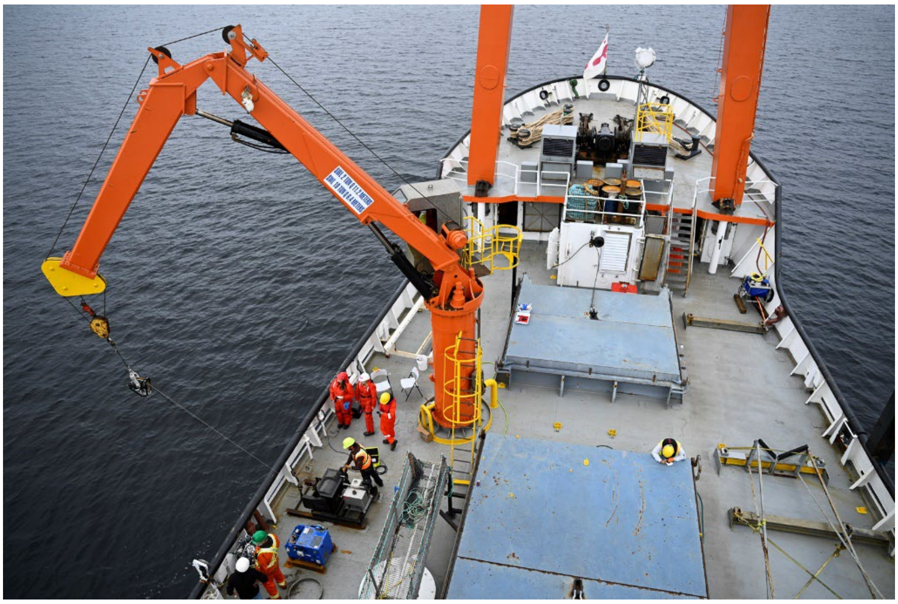

Figure 2: Deck set up on the MV Polar Prince for the 2024 Bay D'Espoir expedition (photo from Fred Cattroll, Cattroll Photo Inc), with the crane and both the scientific winch (black) and the winch (blue) for the SubC drop camera system vible of the port side and the sieving table used for the Van Veen grabs on the starboard side toward the bow.

2. SubC camera system

The camera is a towed system build by SubC, but deployed without the foam and chain, and used as a simple drop camera. It houses a coastal Rayfin as well as two Aquorea lights and lasers spaced 10 cm apart deployed at an oblique angle (Figure 3). It is deployed using an associated winch with 415 m of wire which provides live feed using SubC's software and enables real time control of the distance to the seabed for better imagery. The system was setup on the port side of the vessel on the other side of the scientific winch near the stairs. A table outside was set up to house the computer with the live feed and the winch controls. This was very exposed to the elements (rain, sun glare, wind, cold). Through the use of a Roku system, we were also able to cast the live imagery inside the vessel's lounge for engagement with the youth. When deploying this system, it is important to have the crane position the block directly in line with the mid-point on the which so that the cable does not fall off the roller and get damaged. It is also important to use a line to deploy the system and a long gaff to retrieve it as too much spinning will damage the live-feed cable. The system was setup to record in 4k.

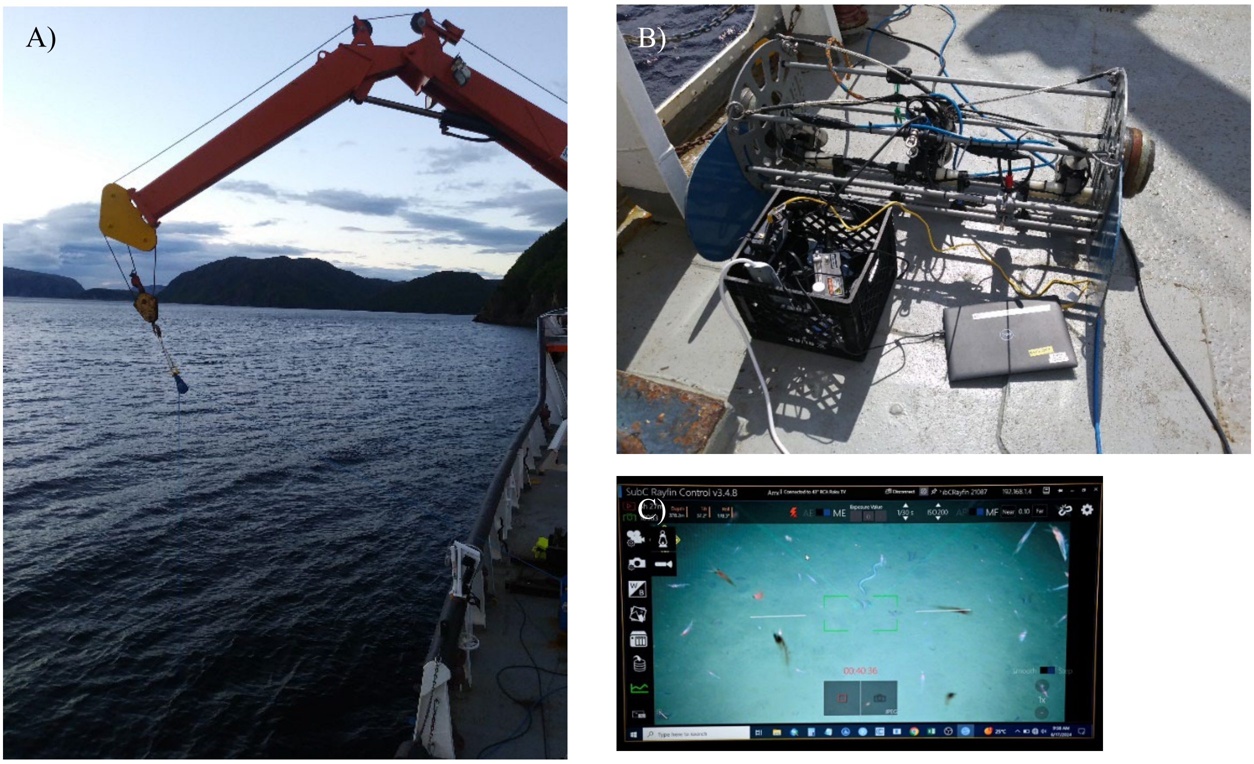

Figure 3: SubC camera system as used on the MV Polar Prince for the 2024 Bay D'Espoir expedition, A) crane deployment from the port side of the vessel, B) set up camera system, C) example of live feed from the SubC software (photo from Fred Cattroll, Cattroll Photo Inc)

3. BathyCam

BathyCam is a seabed imaging system used to capture data on the presence, distribution, and abundance of benthic species and substrate types. The weight of BathyCam in the air is ~50 kg. Four weights are attached to help camera orientation during deep deployments (1.13 kg each), increasing the system to ~55 kg in air. BathyCam can be deployed to 6000 m depth. It consists of one SubC benthic camera, a SubC battery, two lights, and a set of lasers attached to a metal frame. There is no data cable, power is provided by a waterproof battery system. The settings for the camera are pre-set using commands within the SubC software and commence when a starter plug is inserted into the battery on deployment, recording was done in HD. The angle of the field of view can be adjusted to 5°, 25° and 40° below the horizontal (Figure 4 A). The distance between the lights and the camera is adjustable but usually set to the furthest position apart. Standard deployment is to drift at an estimated altitude of 1 - 2.5 meters above the seabed along a 30-minute-long transect, with the vessel drifting slowly without engine power at < 1 knot.

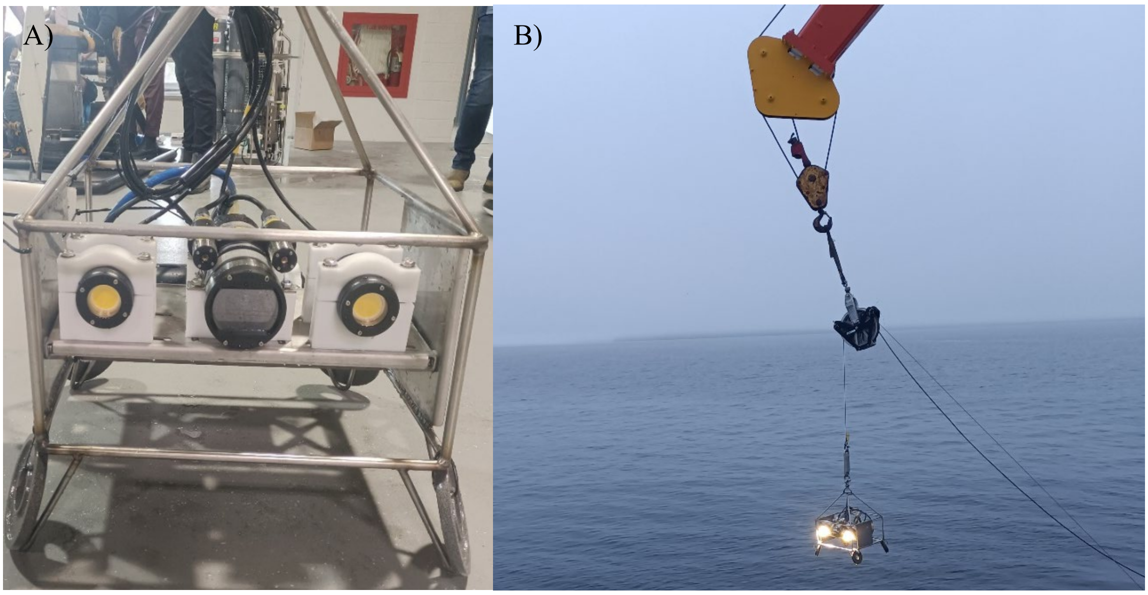

Figure 4: BathyCam system set up with the angle of the field of view set up to 5 degrees A) and B) deployment set up using the port side crane on the MV Polar Prince. Equipment attached to BathyCam in this configuration includes SubC Benthic Rayfin camera, Manta lasers, and battery, and SubC Aquorea lights.

Table 1: Gear specifications for the camera deployments during the MV Polar Prince for the 2024 Bay D'Espoir expedition

Gear	**Specifications**
SubC Coastal Rayfin	500 m depth rating. Sensor: Type 1/2.4" CMOS 10-bit Image size: 21MP - 5344 x 4008 Shutter speed: AUTO ISO: AUTO Lens: 4.62mm f/2.2 Focal range: 0.5m to infinity Weight: 0.8kg in water, 2.4kg in air
SubC Benthic Rayfin	6000 m depth rating. Sensor: Exmor CMOS 12-bit Image size: 12.3MP – 4056 x 3040 Shutter speed: AUTO ISO: AUTO Lens: 4.52 mm (f/2.0) Focal range: 15 mm to infinity Weight: 3.2 kg in air, 1.6 kg in water
SubC Aquorea LED lights	6000 m depth rating. 80˚ beam angel (circular), 15000 lumens (max), Weight: 1.5 kg in air 0.9 kg in water.
SubC Manta lasers	6000 m depth rating. 10 cm apart, green Weight: 0.7 kg in air, 0.4 kg in water
DeepTrekker	Resolution: 1920 x 1080 HD, 30 FPS, Color, 0.001 Lux (low light) JPG 2 mp Lighting: 1000 Lumens – Dimmable Lasers: 2.5cm apart, red Weight: 10 kg (22 lb) Depth Rating: 305 m (1000 ft)

BathyCam was deployed blind (without data cable) over the port side of the *Polar Prince* using the ship's Crane and a wire winch (Figure 4 B). The depth of the station was estimated using previously collected multibeam and the ship-based echosounder. The winch line was paid out at < 50 m/min to deploy the system. The speed was reduced to ~ 10 m/min at 20 meters before the estimated bottom depth. The BathyCam was deployed to rest on the seabed (confirmation of the reduced tension on the winch wire and movement of the winch block), then pulled up by paying in line 2-3 meters, to drift for 30 minutes. Deployment of the system was limited to low complexity seabed habitats to reduce the risk of entanglement. The video was set to record automatically once the starter plug is plugged into the battery. The videos were split into ten-minute segments with a 5-second interval when there was a file change.

NOTE: The light refraction around the lens visible on deployment disappeared when on or hovering above the seabed

NOTE: The settings on the SubC software are set to 50% for the lights, and to automatically adjust iso – these seemed to work the best.

NOTE: if the starter plug was removed when the system was recovered before reaching the 10 min video length the last video will become corrupted. The system must sit after recovery on the deck for 10 min to ensure this is avoided.

<u>15th-16th June – initial testing</u>

The field of view (FOV) was set and fixed at the 40˚oblique view, and the first deployment (station 9) was at 657 meters on station in the southern basin of Bay d'Espoir Lower Bay (47.6486, -56.1223) > 700 m. We aborted the deployment due to part of the winch becoming undone, we retrieved the system so the winch block could be lowered and fixed.

Station 10 was deployed at the same location as station 9, but did not reach the seabed. We had issues with a pin working loose in the winch block, which was fixed with the camera suspended over the side. When re-starting the winch the pull cord snapped, which took just under an hour to fix.

When we finally got to deploy the system, we had paid out enough line to reach the seabed, but the winch wire was still under tension. As the vessel was drifting into shallower waters we aborted. On retrieval, there were no obvious signs that the system had reached the seabed, and we also discovered that the automatic script to record (10 min segments with 5-second intervals) did not execute. After retrieval, we conducted on-deck tests of the recording script, which worked without problem.

Station 11 was deployed in the same location as stations 9 and 10. On deployment the ship's echosounder indicated 668 m below the keel, we paid out 715 m and we did not see slack in the wire. We could not confirm if the system reached the seabed as the video again did not record. After retrieval, we conducted two more deck tests and found a potential issue with the SubC script (the execute on start button was unchecked).

Station 12 was deployed in the same location as stations 9,10 and 11 but we only suspended the camera at 10m to see if the script for video recording would work without issue. After 20 minutes we tried to retrieve the camera and the starter cord for the winch broke again. After it was fixed, we retrieved the system, the video worked but the light was slightly refracted around the camera lens causing an artifact across the field of view. We altered the down-facing angle to 25˚. We did not deploy again because we would have delayed the start of Van Veen grabs planned at the start of the day shift on the 16th.

<u>18th-19th June – testing in a shallower area ~ 400m</u>

As we could not tell if the system was off the seabed consistently, we opted to amend the deployment to more like a bounce camera. BathyCam was deployed in the same way as before, and once the tension slacked on the cable, the winch was paid in by 5 meters for 30 seconds before paying the wire out to touch the system to the seabed again, and we tried to run this for 30 minutes. This had mixed results as often we could not tell if the tension on the wire had changed confidently. Additionally, several videos we retrieved from the camera were corrupted. We finally understood that this is associated with the starter plug being removed from the battery during the recording of a ten-minute video segment just after the system is recovered,

Station 51: FOV 25˚ - The system did not move off the seabed meaning too much line was out. There is one video showing that the seabed was muddy sand with a dense sea pen community.

Station 52: FOV 5˚- The bouncing here was more successful as the camera was picked up and set down again in different areas. Because the seabed was flat, the lasers were of no use to the imagery as the FOV was not orientated downfacing. The seabed is muddy sand with a dense sea pen community.

Station 53: FOV 25˚- The bouncing was better here but the camera was sinking into the muddy sand almost tipping forward. Some imagery was captured – muddy sand with sea pens again similar to stations 51 and 52.

The imagery could be used for ground truthing, however, the inconsistency between the FOV, number of corrupted videos and mixed success of the deployment means that the imagery is not appropriate for annotation.

4. Shallow Camera

To conduct the shallow water survey, two drop camera systems were brought to Bay D' Espoir: a SubC Rayfin Coastal mounted on an in house built frame with a 300m data cable wrapped around a steel bullhorn frame and a Deep Trekker DTPod with 150m of cable on a spool (Figure 5).

Sites were plotted on ArcGIS prior to the expedition and sites selected based on seafloor characteristics seen from multibeam sonar data. The sites selected had depths ranging from 6 m to 259 m, not exceeding 300m to ensure enough cable and allow for drift. The videos were collected by positioning the Miawpukek Fisher (MF) at the preliminary site coordinates based on a hand-help GPS system (Garmin GPSMAP 78), lowering the camera until the seafloor could be seen and then drifting with the current until five minutes of video was collected.

<u>16th June</u>

We were picked up from the Polar Prince positioned at Goblin head, Lower Bay D'Espoir, by the *Miawpukek Fisher* at 09:50. The *Miawpukek Fisher* did not have enough fuel to visit sites within this area so we returned to Conne River to fuel up. The *Miawpukek Fisher* was not equipped with 120V power to supply the camera. We loaded a rechargeable battery pack and backup generator onto the *Miawpukek Fisher* to supply power to the SubC camera. We intended to sample sites between Conne River and Lower Bay D'Espoir, where the Polar Prince was stationed, but ran into technical difficulties. Station 1 drop 1 failed and no video was collected because the connection was lost. Drop 2 was successful and collected video. Station 2 drop 1 failed because the connection was lost. The second drop was successful. The SubC camera was unsuccessful in collecting video at Station 3. When the camera was fully submerged the interface would be lost instantly and would not regain connection to the SubC software until the camera was out of the water. Restarting the program while the camera was hanging in the water did not restore the connection. Cleaning the ports did not resolve the issue. Switching from the battery pack to the generator did not resolve the issue either. The DTPod was left on the Polar Prince so there was no backup option. We returned to the Polar Prince and offloaded at 14:00. All equipment was hosed off with freshwater and video files were uploaded to an external hard drive. The DTPod was prepared for the next day.

<u>17th June</u>

We disembarked from the Polar Prince positioned at Goblin Head, Lower Bay D'Espoir, at 09:30 on the MF to Lampidoe's passage. The SubC camera was dropped (Station 4 drop 1) and successfully collected video. At King Cove (Station 5 drop 1) the connection issue began again and the SubC was deemed unusable after several troubleshooting efforts. We resorted to the DTPod and were now limited to the sites that were no deeper than 150 m and collecting video in 1080p rather than 4k. Stations 5-14 are spread between Lampidoes Passage, Lower Bay D'Espoir and Bois Island East and were sampled without issue using the DTPod. We returned to the Polar Prince at 14:45, offloaded and rinsed all equipment. Video files were uploaded to an external hard drive. Due to an injury during offloading we could not sample on the 18th.

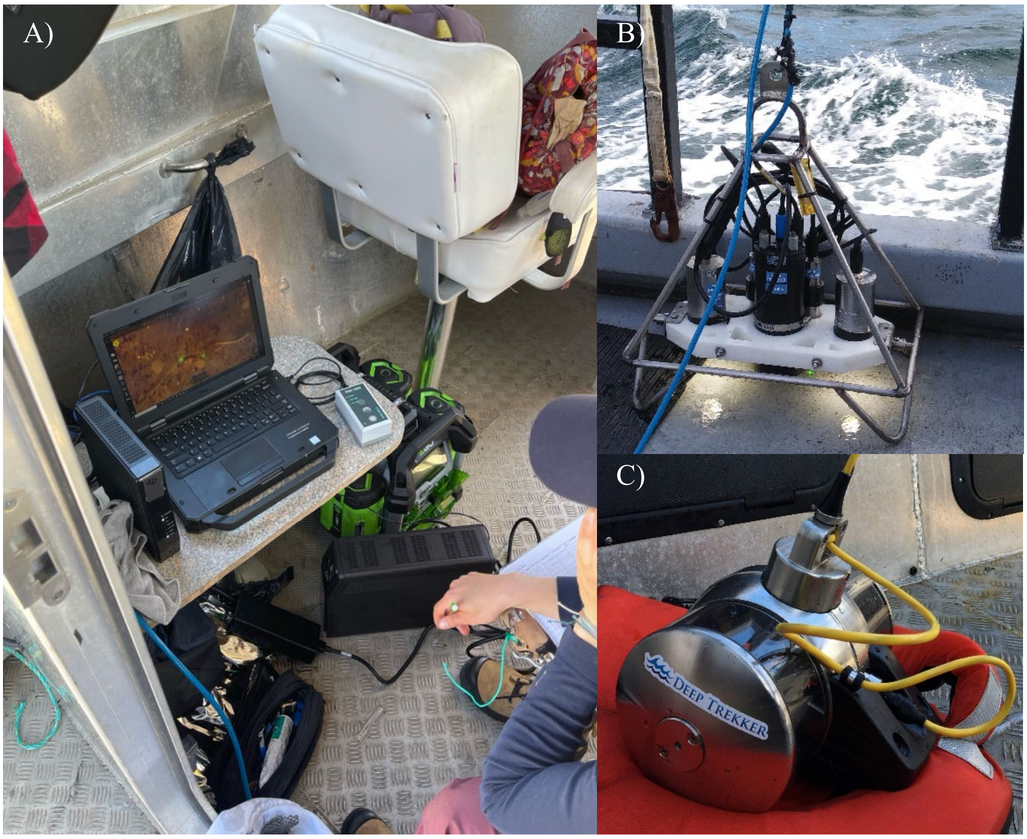

Figure 5: A) Shipboard computer system for shallow drop camera systems when onboard the Miawpukek Fisher, B) SubC costal camera on small drop frame and B) DeepTrekker DTPod.

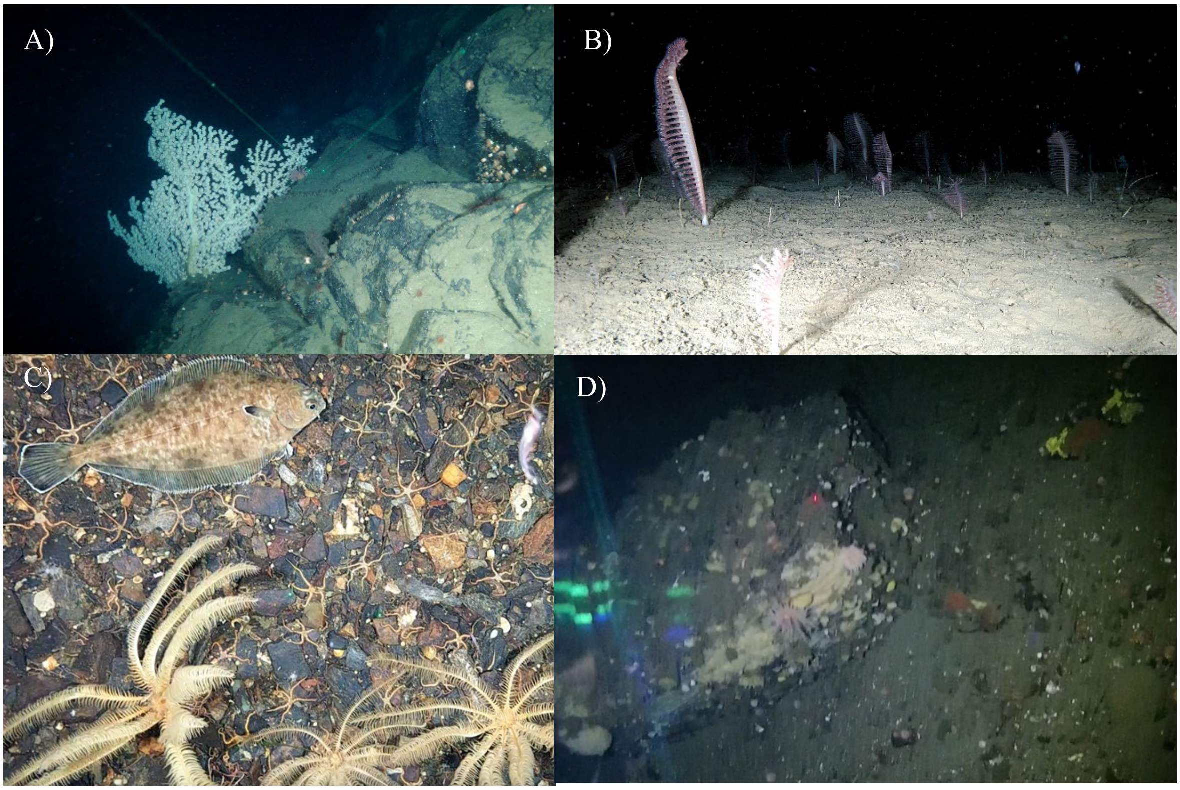

Figure 6: Example of seabed imagery capture for the different camera system employed during the MV Polar Prince for the 2024 Bay D'Espoir expedition, A) SubC camera system – Paragorgia colony across from Goblin Head, B) BathyCam – seapen field from Lower Bay D'Espoir, C) SubC shallow-water drop camera – flatfish and feather stars near King Cove and D) DeepTrekker DTPod – Boulders near Goblin Head.

5. Van Veen Grab

During the expedition, sediment was successfully obtained using Van Veen grabs (Figure 7). Triplicate grabs were planned at all stations within Bay d'Espoir. Samples from the first replicate grab at each station were returned to the Northwest Atlantic Fisheries Centre (NAFC) for analyses of their physiochemical properties including chlorophyll a, organic content, grain size, drugs and pesticides, metals, and microplastics. The other replicate grabs were sieved with material preserved for macrofauna quantification.

16 June 2024 – Butter Cove

The first site for Van Veen deployment was Butter Cove with a depth of 415-420 m. Weather was overcast with low ceiling and sea state was calm with small ripple waves. Four deployments were conducted at this site, but all were unsuccessful because the Van Veen failed to fire. While retrieving the third Van Veen deployment (BE-2024-ST3-VV3-R1), mud was observed on top of the equipment along with a large *Pennatula aculata* sea pen, which was washed away. The equipment appeared to be dragged across the sea floor but failed to fire and as a result the equipment was switched to a second Van Veen, and a STAR ODDI was attached to confirm depth. Due to equipment issues and time constraints, the third replicate could not be completed for this site at this time.

17 June 2024 – Little Goblin Bay

The second site for Van Veen deployments was Little Goblin Bay with a depth of 477 m. Weather was overcast with sea state calm and flat. Six deployments were conducted at this site with two successfully collecting sediment; 10 cm of sediment collected (BE-2024-ST15-VV7-R1), and 15.5 cm of sediment collected (BE-2024-ST17-VV9-R2). Due to equipment issues and time constraints, the third replicate could not be completed for this site.

The third site for Van Veen deployment was near Goblin at a depth of 441 m. Two deployments were conducted at this site (BE-2024-ST19-VV11-R3, BE-2024-ST20-VV12-R3). Both deployments were unsuccessful due to hard substrates, and as result operations were cancelled for this area.

17 June – Bois Island East

The fourth site for Van Veen deployment was Bois Island East with a depth of 130 m. Weather was sunny with some clouds, with sea state consisting of small waves with white capes. Five deployments were conducted at this site with two successful; 5 cm of sediment collected (BE-2024-ST33-VV13-R1), and 7.5 cm of sediment collected (BE-2024-ST37-VV17-R2). Based on the small sample size and the presence of rocks and gravel, it is suspected that the substrate is too hard and as a result not suitable for benthic grabs. The third replicate was not attempted and benthic operations were halted for this site.

18 June – Butter Cove

We returned to the first site at Butter Cove for the last set of Van Veen deployments with 411 m depth. Weather was sunny but hazy with sea state consisting of medium sized waves with white caps. Four deployments were conducted at this site with two successful (BE-2024-ST45-VV18-R1, BE-2024-ST48-VV21-R2). Note grabs were full with 17 cm of sediment collected for the first grab (BE-2024-ST45-VV18-R1), and 18 cm of sediment collected for the second grab (BE-2024-ST48-VV21-R2). Sea pens (*Pennatula aculata*) were captured in both grabs and were visible protruding from the base of the Van Veen during retrievals. The Van Veen equipment struggled at these depths > 400 m and as a result the third replicate for this site could not be completed.

Figure 7: Van Veen sample deployment from the post side of the MV Polar Prince using the scientific winch and crane (photo from Alexandria Fudge).

Sediment physiochemical analyses

Sediment samples were collected from Van Veen grabs deployed at 3 stations within Bay d'Espoir (Table 2). For all sites, only two replicates could be completed with the first successful grab (R1) sampled for physiochemical analyses and the second preserved for infauna. Excess water was siphoned out of the Van Veen prior to sediment collection. Samples were processed internally for chlorophyll (n = 3 replicates per station), organic content (n = 3 replicates per station) and grain size (n = 3 replicates per station). Unless otherwise mentioned, all methods followed standard DFO-NL Benthic protocols. Samples for drugs/pesticides (n =1 per station) and metals (n = 1 per station) were collected and processed by Olivia Gibbs, Aquaculture section (DFO-NL). Samples for microplastic exploration were collected at the two Bay d'Espoir stations (n = 1 per station) and will be processed under Dr. Uta Passow (MUN).

Table 2: Location of each Van Veen from which sediment samples for physiochemical properties were collected.

Site	Station ID	Position	Depth (m)	Date
Little Goblin Bay	BE-2024-ST15-VV07-R1	47.71050˚ N 56.12045˚ W	~477	June 17, 2024
Bois Island East	BE-2024-ST33-VV13-R1	47.71602˚ N 55.89222˚ W	130	June 17, 2024
Butter Cove	BE-2024-ST45-VV18-R1	47.68760˚ N 56.05878˚ W	411	June 17, 2024

6. CTD

The CTD rosette assembly consisted of a SBE 55 ECO Water Sampler carousel with six 4 L sample bottles and a SBE 19plus CTD outfitted with two auxiliary sensors: fluorescence and dissolved oxygen. The SBE 19plus continuously measures pressure, temperature, and conductivity as it moves through the water column. The WET Labs ECO-AFL/FL fluorometer measures chlorophyll-a fluorescence while the SBE 43 sensor measures dissolved oxygen concentrations. The CTD operates at 4 Hz and collects data four times per second throughout the cast.

This CTD rosette assembly was configured to operate autonomously to allow for deployment with a non-conductive cable. The package was deployed midship on the portside with a gas powered hydrographic winch using the ship's primary crane and a metering block. The station depth was determined by the bridge's echosounder reading and the maximum wire out (or final package depth) was approximately 10 to 15 m above this sounding. Once the package reached max wire, the first bottle was fired — this was considered the 'bottom' sample. As the package ascended through the water column at approximately 40 m/min, the remaining bottles were automatically fired at discrete, pre-programmed depths. Once the package was safely recovered, the water samples were collected and the cast data was extracted from the CTD using Seaterm V2 software.

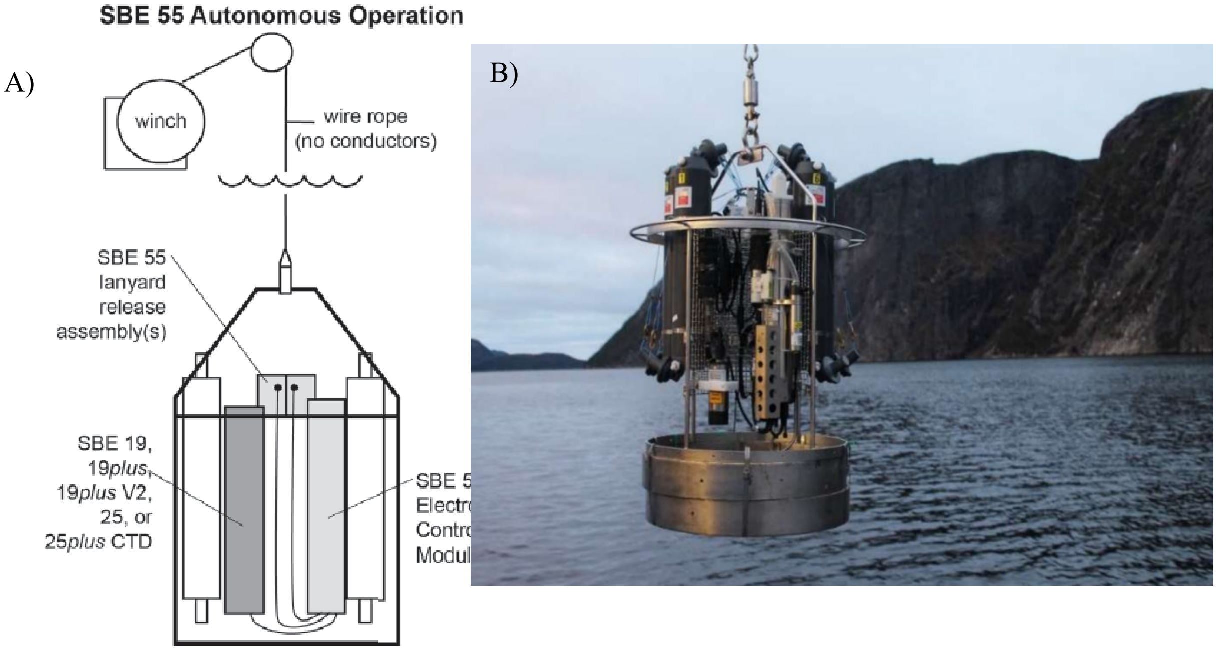

Figure 8: CTD rosette autonomous operation (left). Source: Sea-Bird Electronics. CTD rosette deployment in Bay d'Espoir, Fall 2023 (right). Photo: K. Murray.

Water Sampling

Water sampling depths were determined based on bottom depth data from the previous year and Fisheries and Oceans Canada's (DFO) standard protocols for ocean biogeochemical monitoring. The first bottle was always fired at 'bottom' which is the deepest point in the water column that the CTD rosette occupied — typically 5 to 10 m above the seafloor. The remaining bottles were fired at pre-programmed depths while the CTD rosette ascended through the water column. Standard depths for DFO oceanographic sampling are as follows: 5, 10, 20, 30, 40, 50, 75, 100, 150, 250, 500, 1000 m, and bottom. The final water sampling depths were constrained by the number of sample bottles on the CTD rosette (six 4 L bottles). Characterizing the near surface (5, 10 m), intermediate (50 m), and deepest (100, 250, 500 m, bottom) levels of the water column is ideal, so the final sampling depths were selected with this in consideration.

A variety of water samples were collected to support DFO's ocean biogeochemical monitoring — a collaborative effort between the DFO NL Region Northwest Atlantic Fisheries Centre (NAFC) and the DFO Maritimes Region Bedford Institute of Oceanography (BIO). Each research facility provided the equipment and supplies required for sample collection, preservation, storage, and transportation. Water samples were collected for the following biogeochemical variables:

Table 3: Biogeochemical water sampling details for PP240614.

Variable	Primary Investigator	Research Facility
Nutrients	Gary Maillet	NAFC
Carbonates (DIC and TA)	Gary Maillet	NAFC
pCO_2 and methane	Kumiko Azetsu-Scott	BIO
Salinity	Kumiko Azetsu-Scott	BIO
O18	Kumiko Azetsu-Scott	BIO

These variables are particularly relevant to characterize ocean conditions with regards to ocean acidification monitoring. Ocean acidification is the process by which the seawater's chemical composition is altered due to the absorption of atmospheric CO_2, resulting in increased ocean acidity (ie. decrease in seawater pH). This has direct negative impacts on calcifying marine organisms including corals and mollusks. Some marine regions are more susceptible to ocean acidification due to local water temperature and chemical composition. The solubility of calcium carbonate increases with lower seawater temperature, counterintuitively and colder water temperatures allow for higher atmospheric CO_2 absorption rates than that of warmer temperatures; therefore, higher latitude shelf regions are more susceptible than the tropics.

Measuring the concentration of nutrients in seawater is a key component of ocean biogeochemistry. Common macronutrients such as nitrate/nitrite, phosphorus, silicate, and ammonium greatly influence marine primary productivity. Phosphorous and silicate concentrations also influence seawater alkalinity — an important aspect of monitoring ocean acidification. Seawater samples for nutrient analysis are typically collected in duplicate at each sampling depth with 50 ml centrifuge tubes. Due to a miscommunication, centrifuge tubes were not available for this mission and 20 ml plastic scintillation vials were used instead.

Samples for carbon parameters were collected following the standard operating procedures described in Dickson et al. (2007). Specifically, dissolved inorganic carbon (DIC) and total alkalinity (TA) samples were collect in 500 mL borosilicate glass bottles. DIC and TA are variables used to characterize the seawater carbonate chemistry system — an important part of monitoring ocean acidification. Carbonate samples are carefully collected in a single 500 ml glass bottle from each sampling depth while minimizing air exchange and CO_2 absorption. A small headspace, approximately 1% by volume or 5 ml, is created to account for thermal expansion at room temperature. A small amount (200 µL) of saturated mercuric chloride solution is added to prevent biological activity, and the sample bottle is sealed with a greased stopper to further prevent CO_2 exchange. The greased stopper is secured using a rubber band and a plastic hose clamp.

The partial pressure of CO_2 (pCO_2) is a direct measure of the CO_2 concentration in seawater and frequently used in conjunction with DIC and TA measurements to characterize the seawater carbonate chemistry system. A 160 ml glass serum bottle is used to collect one sample from each depth. A small amount (50 µL) of saturated mercuric chloride solution is added to prevent biological activity, and the sample bottle is sealed with a septum cap and a hand crimper. These samples must remain refrigerated (4°C) as there is no headspace to allow for thermal expansion.

Salinity samples were collected at each depth in 200 ml glass bottles to calibrate the CTD's conductivity sensor. Salinity plays a key role in biogeochemical cycles in coastal regions, so it is critical to ensure that the in situ sensor data is in agreement with salinity data measured by a salinometer.

Determining the proportion of isotopes oxygen-18 to oxygen-16 (δO18) in seawater provides data for use as an oceanographic tracer. Each freshwater in the ocean has its own distinct isotopic composition, which is used to track the movement, mixing, and source area for each water mass. O18 samples are collected from each depth in a 60 ml amber glass bottle and stored at room temperature. The cap was sealed with two turns of black electrical tape and re-tightened the following day.

Water samples were collected from each sample bottle in the order presented below:

Table 4: Description of sample container and preservation for each water sample type.

	Variable	Container	Preservation & Storage	Replicates
1	pCO_2	160 ml clear glass serum bottle with septa	50 µL mercuric chloride Refrigerate (4°C)	1
2	Carbonates (DIC and TA)	500 ml clear glass bottle with stopper, clamp, and rubber band	200 µL mercuric chloride Store at room temperature	1
3	Salinity	200 ml clear glass bottle with twist cap	Store at room temperature	1
4	O18	60 ml amber glass bottle with twist cap	Store at room temperature	1
5	Nutrients	~~50 ml centrifuge tube~~ 25 ml plastic scintillation vial	Freeze (-20°C)	2

Three CTD stations were successfully completed, see Table 5, below, for station details and appendix two for individual sample details.

Table 5: Summary of CTD rosette deployments.

Date (d/m/yyyy)	**Site + Station No**	**Start Time UTC**	**Start Lat (DD)**	**Start Long (DD)**	**Start Depth (m)**	**Comments**
15/6/2024	BDE-005	16:44	47.69403	-56.03090	384	Misfire
15/6/2024	BDE-006	18:08	47.69375	-56.02935	384	Successful, 6 sample depths
16/6/2024	BDE-021	15:33	47.69745	-56.13083	781	Misfire
16/6/2024	BDE-022	16:18	47.69811	-56.13070	785	Successful, 6 sample depths
18/6/2024	BDE-044	12:40	47.77715	-56.13396	309	ctd @ 7 m, niskin @ 5 m
18/6/2024	BDE-044	12:58	47.77743	-56.13646	309	ctd @ 325 m, niskin @ 323 m
18/6/2024	BDE-044	13:31	47.77768	-56.13426	309	ctd @ 252 m, niskin @ 250 m
18/6/2024	BDE-044	14:11	47.77680	-56.13345	309	ctd @ 102 m, niskin @ 100 m
18/6/2024	BDE-044	14:32	47.77676	-56.13372	309	ctd @ 52 m, niskin @ 50 m

During the first CTD cast at station BDE-005, the bottles failed to trigger as they did not reach the specified depth which was determined based on the bridge's echosounder reading. The depth requirement was adjusted slightly which resulted in a successful CTD cast at station BDE-006. The third CTD deployment at station BDE-021 was also unsuccessful due to an unreliable depth sounding. The specified depth requirement was adjusted and after a second attempt at BDE-022, the CTD cast was a success. While the CTD rosette was at surface for recovery at BDE-022, the hydrographic winch began to overheat. The package was being brought onboard by the crane when the winch shut off but fortunately, the package was recovered safely. Due to this near-miss, the CTD rosette was not used going forward as the hydrographic winch was not powerful enough. As a result, the third CTD station near the Devil's Dancing Table, was conducted with an AML-6 LGR CTD provided by ONC's digital fisher project and a single sample bottle attached directly to the winch wire. A separate cast (n = 5) was conducted for each depth. Cast profiles are presented in Appendix three.

The largest hurdle associated with CTD operations was easily the hydrographic winch. The gas-powered winch was not capable of handling the weight of the CTD rosette for sustained periods of time. This was particularly evident during a deep station and/or immediately after an unsuccessful cast. The metering block also proved unreliable and was not able to provide an accurate 'wire out' reading. This significantly slowed CTD deployments as the winch operators were extremely cautious paying out wire as they wanted to avoid 'bottoming out' the CTD.

The bridge's echosounder also proved unreliable at times during CTD operations. For the first two CTD stations, the bridge provided the deck crew with a sounding upon arrival at a station. Twice, this resulted in the CTD not reaching the specified depth that was required to trigger the sample bottles. Once the CTD was recovered after an unsuccessful cast, a new sounding would be provided by the bridge to prepare for a second attempt— this sounding was usually ±20 m of the initial sounding. Once the CTD was reconfigured based on the updated sounding, the second deployment attempt was successful. The bridge crew later admitted that the propeller interfered with the echosounder and provided unreliable soundings while the propellor was operational. The initial sounding provided upon arrival to a station would be collected while the propeller was in use which explains the failed attempts.

The unreliable metering block in addition to the inaccurate depth soundings significantly slowed CTD deployments. These issues could have easily caused some considerable damage to the CTD rosette as well if the package was run into the bottom. A more reliable, preferably hydraulic or electric, hydrographic winch in addition to an accurate metering block would address these issues.

7. Vessel Positioning

As a direct feed from the ship's GPS could not be recorded. A GlobalSat GPS receiver (G-STAR IV) connected to a laptop located in the dry lab was recorded to a shapefile in ArcMap. Coordinates were taken every second and timestamped in GMT. A different shapefile was created for each station, but these were started and ended before/after the start/end of specific activities. Times for activities are recorded in local (Newfoundland Daylight Time, NDT).

8. Outreach

Concurrently to scientific activities onboard, a team of six Indigenous youth as well as mentors and educators took part in an Indigenous-led expedition organised by Miawpukek First Nation and Miawpukek Horizon Maritime Services. The youth were able to take part in every type of scientific activity which occurred on board (Figure 8) while scientists were also able to present their work as well as join in all the other activities organised. This provided for an extremely positive experience for the scientists, and we hope for the youth as well.

Figure 9: Example of hands on learning provided during the 2024 Bay D'Espoir expedition onboard the MV Polar Prince.

9. Funding

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Appendix One: Station List

Cruise	Station No	Gear No	Start Date (DD:MM:YYYY)	Start Time NDT (HH:MM:SS)	Start Lat (DD, N)	Start Long (DD, W)	Start Water Depth (m)	End Date (DD:MM:YYYY)	End Time NDT (HH:MM:SS)	End Lat (DD, N)	End Long (DD, W)	End water Depth (m)	Comments
PP240614	1	VVV-1	15.06.2024	09:08:00	47.68611667	56.06040000	417	15.06.2024	10:09:00	47.68640000	56.06010000	422	Failed
PP240614	2	VVV-2	15.06.2024	10:12:00	47.68641667	56.06003333	421	15.06.2024	10:54:00	47.68650000	56.05930000	420	Failed
PP240614	3	VVV-3	15.06.2024	11:11:00	47.68636667	56.05886667	418	15.06.2024	11:42:00	47.68630000	56.05880000	415	did not tiggered, brough up mud with a seapen which washed away
PP240614	4	VVV-4	15.06.2024	12:05:00	47.68636667	56.05853333	414	15.06.2024	12:22:00	47.68670000	58.05880000	418	Failed
PP240614	5	CTD-1	15.06.2024	14:14:00	47.69403333	56.03090000	384	15.06.2024	14:38:00	47.69380000	56.02940000	383	did not tiggered
PP240614	6	CTD-2	15.06.2024	15:38:00	47.69375000	56.02935000	384	15.06.2024	15:08:00	47.69360000	56.02900000	384	
PP240614	7	TOW-1	15.06.2024	17:10:00	47.66743333	56.10861667	210	15.06.2024	17:30:00	47.66696667	56.10861667	351	Saw Yellow Parageorgia but video did not record
PP240614	8	TOW-2	15.06.2024	19:10:00	47.66820000	56.10910000	179	15.06.2024	19:22:00	47.66743333	56.10910000	369	Ended before 30 min transect as we were over the sill, the seabed depth was out of reach of the camera
PP240614	9	BTH-1	15.06.2024	21:02:00	47.64860000	56.12230000	657	15.06.2024	21:18:00	47.72941667	56.13471500		aborted, issue with winch, part of it flopped open, we cable tied it back.
PP240614	10	BTH-2	15.06.2024	21:02:00	47.64911667	56.12148333	674	15.06.2024	22:30:00	47.64895000	56.12260000	NA	aborted, issues started with the winch block
PP240614	11	BTH-3	16.06.2024	01:10:00	47.64848333	56.12556667	668	16.06.2024	01:57:00	47.64848333	56.12440000	666	ships depth sounder recorded 668m, we paid out 715m of cable and didn't get slack so perhaps bathycam didnt touch bottom, Video also didn't work
PP240614	12	BTH-4	16.06.2024	03:14:00	47.64926667	56.12475000	10	16.06.2024	03:59:00	47.63651667	56.12720000	10	camera test
PP240614	13	VVV-5	16.06.2024	06:21:00	47.71020000	56.12126667	442	16.06.2024	06:40:00	47.68510000	56.12051667	442	Failed
PP240614	14	VVV-6	16.06.2024	06:57:00	47.71006667	56.12019667	390	16.06.2024	07:13:00	47.68615000	56.12018333	351	Failed
PP240614	15	VVV-7	16.06.2024	07:20:00	47.71050000	56.12045000	484	16.06.2024	07:41:00	47.69650000	56.11889833	332	Grab rep1

PP240614	16	VVV-8	16.06.2024	08:30:00	47.70980000	56.12161833	525	16.06.2024	08:52:00	47.71080333	56.12188333	530	Failed
PP240614	17	VVV-9	16.06.2024	09:02:00	47.71016667	56.12186667	525	16.06.2024	09:22:00	47.71052833	56.12208333	540	Grab rep 2
PP240614	18	VVV-10	16.06.2024	10:14:00	47.71086500	56.12132333	512	16.06.2024	10:36:00	47.71080333	56.12097500	459	Failed
PP240614	19	VVV-11	16.06.2024	10:50:00	47.71040167	56.12085000	446	16.06.2024	11:09:00	47.71052833	56.12148667	441	Failed
PP240614	20	VVV-12	16.06.2024	11:18:00	47.71107667	56.12175167	540	16.06.2024	11:40:00	47.71005833	56.12208167	527	Failed
PP240614	21	CTD-3	16.06.2024	13:03:00	47.69745500	56.13083167	781	16.06.2024	13:45:00	47.69800000	56.13060000	788	bottom 13:28, Missfire
PP240614	22	CTD-4	16.06.2024	13:48:00	47.69811833	56.13070000	785	16.06.2024	14:31:00	47.69810000	56.13050000	786	bottom 14:07, All bottles triggered
PP240614	23	TOW-3	16.06.2024	16:04:00	47.73110833	56.13721333	530	16.06.2024	17:29:00	47.72940000	56.13470000	551	Current direction change, contact with wall at 235m
PP240614	24	TOW-4	16.06.2024	19:00:00	47.69131667	56.11863333	269	16.06.2024	19:40:00	47.68550000	56.13166667	420	aborted as drifted in
PP240614	25	TOW-5	16.06.2024	20:04:00	47.68983333	56.11950000	340	16.06.2024	21:46:00	47.69380000	56.12096667	280	bottom 20:41, Recording stopped by itself
PP240614	26	WINCH TEST-1	16.06.2024	22:54:00	47.67433333	56.09083333	380	16.06.2024	23:10:00	47.67366667	56.09133333	380	chain in water 22:54. test for winch
PP240614	27	WINCH TEST-2	16.06.2024		47.67926667	56.09858333	394	16.06.2024		47.00000000	56.00000000	NA	second winch test to bottom. Wind blew smoke
PP240614	28	TOW-6	17.06.2024	15:58:00	47.68138333	56.07961667	298	17.06.2024	05:03:00	47.67756667	56.09268333	336	bottom 04:27. muddy bottom, sea pens
PP240614	29	TOW-7	17.06.2024	06:57:00	47.68186667	56.06206667	305	17.06.2024	08:02:00	47.68100000	56.07201667	302	bottom 07:21 at 325m. Seapens muddy bottom at 07:47. extended error back 07:55
PP240614	30	TOW-8	17.06.2024	08:49:00	47.68553333	56.04135000	234	17.06.2024	09:48:00	47.68291667	56.04543333	227	bottom 09:18 at 289m. Muddy with rocky patches
PP240614	31	TOW-9	17.06.2024	09:01:00	47.69443333	56.03026667	376	17.06.2024	10:00:00	47.69321667	56.03071667	376	bottom 09:22. 47 41.640 056 01.825
PP240614	32	TOW-10	17.06.2024	12:05:00	47.72421667	55.88090000	105	17.06.2024	12:43:00	47.72475000	55.87876667	101	bottom 12:15. 47 43.501 055 52.744
PP240614	33	VVV-13	17.06.2024	13:12:00	47.71601667	55.89221667	130	17.06.2024	13:27:00	47.71513333	55.89221667	119	bottom 13:18. 47 42.940 055 53.552 , Grab rep 1
PP240614	34	VVV-14	17.06.2024	14:53:00	47.71636667	55.89365000	163	17.06.2024	15:01:00	47.71558333	55.89365000	139	bottom 14:56. 47 42.969 055 53.646 failed
PP240614	35	VVV-15	17.06.2024	15:05:00	47.71558333	55.89290000	139	17.06.2024	15:12:00	47.71483333	55.89290000	129	bottom 15:09. 47 42.910 055 53.594 , Failed
PP240614	36	VVV-16	17.06.2024	15:10:00	47.71483333	55.89291667	129	17.06.2024	15:19:00	47.71458333	55.89291667	129	bottom 15:15. 47 42.875 055 53.575 Failed
PP240614	37	VVV-17	17.06.2024	15:47:00	47.71451667	55.89510000	142	17.06.2024	15:55:00	47.71461667	55.89510000	151	bottom 15:50. 47 42.979 055 53.700 ,,, Grab rep 2
PP240614	38	TOW-11	17.06.2024	20:46:00	47.65375000	56.11358333	135	17.06.2024	21:47:00	47.65696667	56.11358333	320	bottom 20:59. GPS log is "station 39"
PP240614	39	TOW-12	17.06.2024	23:43:00	47.69806667	56.00401667	215	17.06.2024	00:27:00	47.69683333	56.00401667	236	bottom 23:57 at 221m

PP240614	40	TOW-13	18.06.2024	01:22:00	47.70266667	56.01681667	341	18.06.2024	02:24:00	47.70191667	56.01681667	254	bottom 01:55 at 345m. cable issue fixed in water. Seapens. Benthis syphonophore?
PP240614	41	TOW-14	18.06.2024	03:55:00	47.69655000	56.01976667	373	18.06.2024	04:47:00	47.69858333	56.01976667	361	bottom 04:20 at 367m. GPS log fail. Aconella seapens
PP240614	42	TOW-15	18.06.2024	05:57:00	47.69080000	56.05291667	366	18.06.2024	06:53:00	47.69173333	56.05291667	374	bottom 06:23 at 374m. Seapen garden
PP240614	43	TOW-16	18.06.2024	08:33:00	47.66680000	56.14090000	206	18.06.2024	09:16:00	47.66616667	56.14090000	211	bottom 08:46 at 214m. Aconella
PP240614	44	CTD-5	18.06.2024	10:10:00	47.77715000	56.13396667	309	18.06.2024	10:16:00	47.77723333	56.13458333	310	bottom 10:14
PP240614	44	CTD-6	18.06.2024	10:28:00	47.77743333	56.13646667	NA	18.06.2024	10:55:00	47.77803333	56.13538333	310	bottom 10:41, CTD 300m-305m, niskin 298m-303m
PP240614	44	CTD-7	18.06.2024	11:01:00	47.77768333	56.13426667	NA	18.06.2024	11:28:00	47.77735000	56.13325000	311	bottom 11:16, CTD, ctd 265m, niskin 262.7m
PP240614	44	CTD-8	18.06.2024	11:41:00	47.77680000	56.13345000	NA	18.06.2024	11:49:00	47.77675000	56.13420000	311	bottom 11:44, CTD 104m, niskin 102m, no samples
PP240614	44	CTD-9	18.06.2024	12:02:00	47.77676667	56.13371667	NA	18.06.2024	12:09:00	47.77713333	56.13353333	311	bottom 12:06, CTD 52 m, niskin 50.28
PP240614	45	VVV-18	18.06.2024	13:34:00	47.68760000	56.05878333	410	18.06.2024	13:49:00	47.85393500	56.05883667	411	bottom, 13:41, bottom depth 413m, Grab rep 3
PP240614	46	VVV-19	18.06.2024	14:30:00	47.68674500	56.05926500	413	18.06.2024	14:47:00	47.68590000	56.05863333	396	bottom 14:38@412 m, Failed
PP240614	47	VVV-20	18.06.2024	14:51:00	47.68601500	56.05977500	403	18.06.2024	14:51:00	47.68708333	56.06000000	415	bottom, 15.00, @417m, Failed
PP240614	48	VVV-21	18.06.2024	15:35:00	47.68733333	56.05875000	412	18.06.2024	15:55:00	47.68733333	56.05888333	412	bottom 15:43, @411 Grab rep 2
PP240614	49	TOW-17	18.06.2024	17:09:00	47.71577333	56.14497167	301	18.06.2024	NA	47.71306667	56.14130000	475	bottom 17:30, NOTES NOT CLEAR
PP240614	50	TOW-18	18.06.2024	missing	47.67688333	56.14100000	226	18.06.2024	22:45 UTC	47.67700000	56.13591667	372	bottom 23:10 UTC, seapens,
PP240614	51	BTH-5	18.06.2024	21:37 UTC	47.68560000	56.06450000	421	18.06.2024	22:06 UTC	47.68510000	56.06185000	378	bottom 21:30 UTC
PP240614	52	BTH-6	18.06.2024	22:45 UTC	47.68588333	56.06158333	410	18.06.2024	23:40:00	47.68620000	56.06358333	426	bottom 23:00 GPS log may be incorrect (changed plate to 40 degrees)
PP240614	53	BTH-7	18.06.2024	missing	47.68498333	56.09071667	540	18.06.2024	missing	47.69650000	56.08483333	466	We were not sure if we reached the seabed (changed plate to 40 degrees)

Appendix Two: Water Sample List

Table 6: Sample details for 15/6/2024, 16:44 UTC, BDE-006.

Sample ID	Sounder Depth (m)	Target Depth (m)	Actual Depth (m)	pCO_2 (n = 1)	Carbonates (n = 1)	Salinity (n =1)	O18 (n = 1)	Nutrients (n = 2)
447940	384	377	358.053	x	x	x	x	x
447941	384	250	250.453	x	x	x	x	x
447942	384	100	100.578	x	x	x	x	x
447943	384	50	50.511	x	x	x	x	x
447944	384	10	10.527	x	x	x	x	x
447945	384	5	5.584	x	x	x	x	x

Table 7: Sample details for 16/6/2024, 16:18 UTC. BDE-022.

Sample ID	Sounder Depth (m)	Target Depth (m)	Actual Depth (m)	pCO_2 (n = 1)	Carbonates (n = 1)	Salinity (n = 1)	O18 (n = 1)	Nutrients (n = 2)
447946	785	770	762.727	x	x	x	x	x
447947	785	500	500.509	x	x	x	x	x
447948	785	250	250.566	x	x	x	x	x
447949	785	100	100.496	x	x	x	x	x
447950	785	50	50.519	x	x	x	x	x
447951	785	5	5.536	x	x	x	x	x

Table 8: Sample details for 18/6/2024, BDE-044.

Sample ID	Sounder Depth (m)	Target Depth (m)	Actual Depth (m)	pCO_2 (n = 1)	Carbonates (n = 1)	Salinity (n = 1)	O18 (n = 1)	Nutrients (n = 2)
447952	309	5	5.071	x	x	x	x	x
447953	309	300	305.809	x	x	x	x	x
447954	309	250	266.402	x	x	x	x	x
447955	309	100	103.914	x	x	x	x	x
447956	309	50	49.426	x	x	x	x	x

Appendix Three: CTD profiles

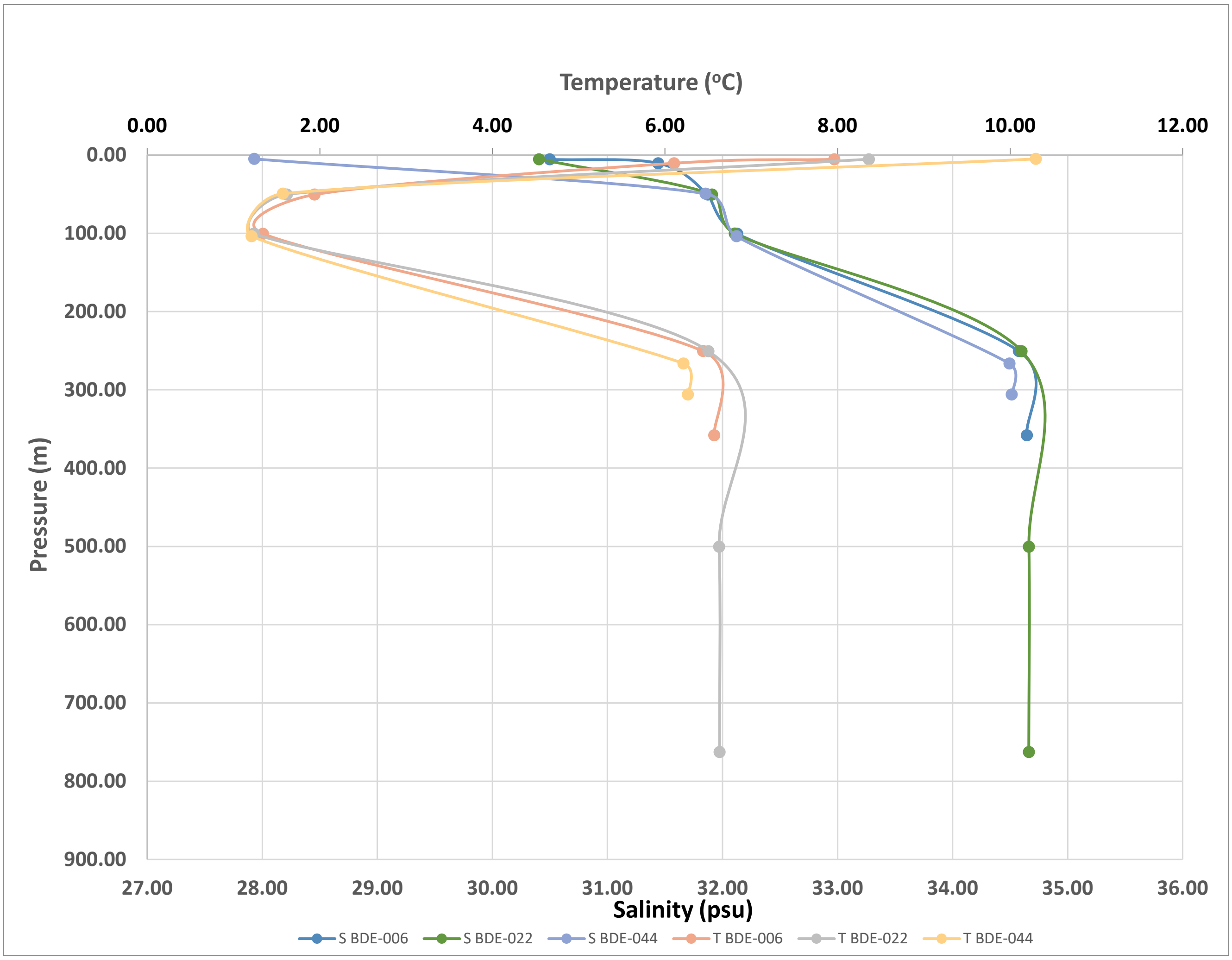

Figure 10: Temperature (T) and salinity (S) profiles for PP240614.

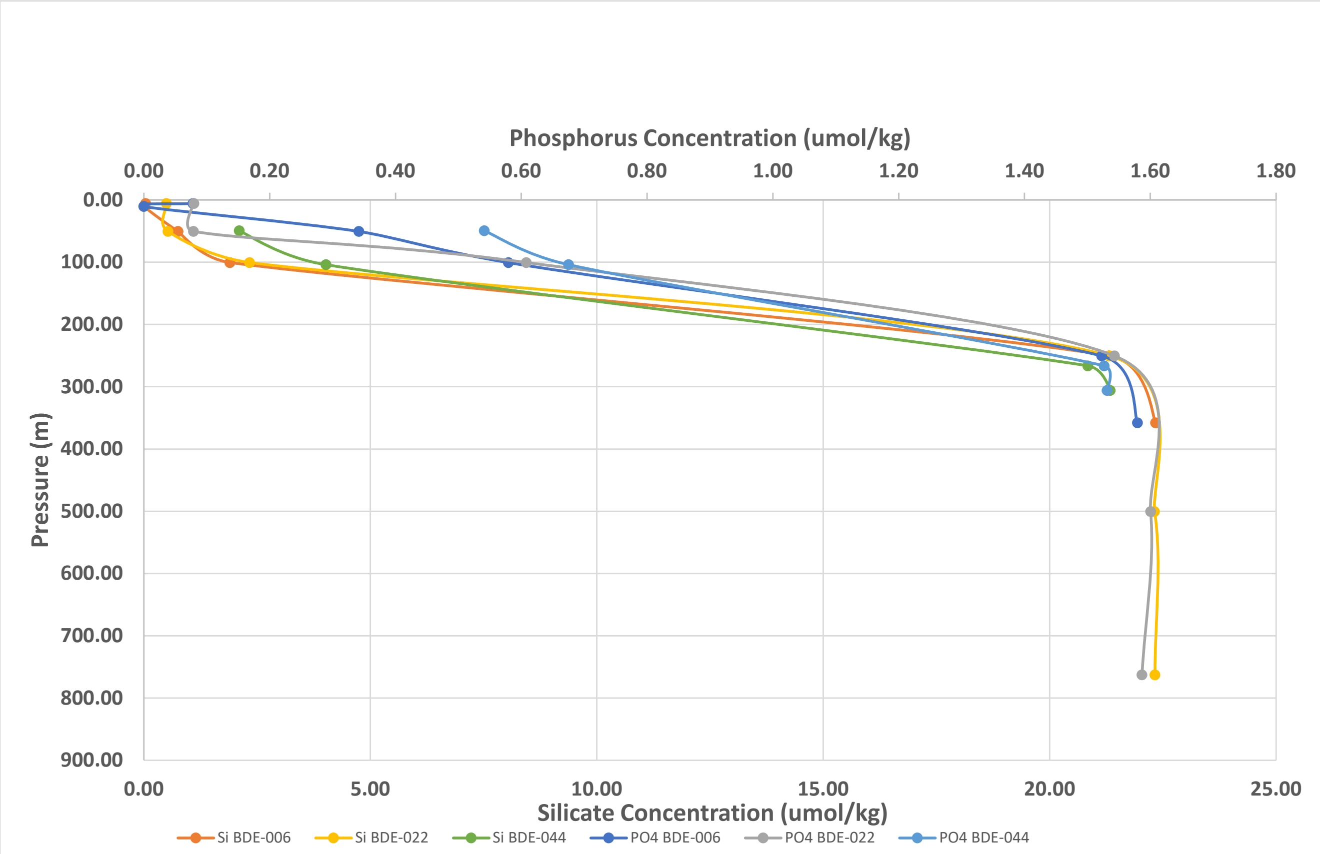

Figure 11: Nutrient profiles for PP240614.

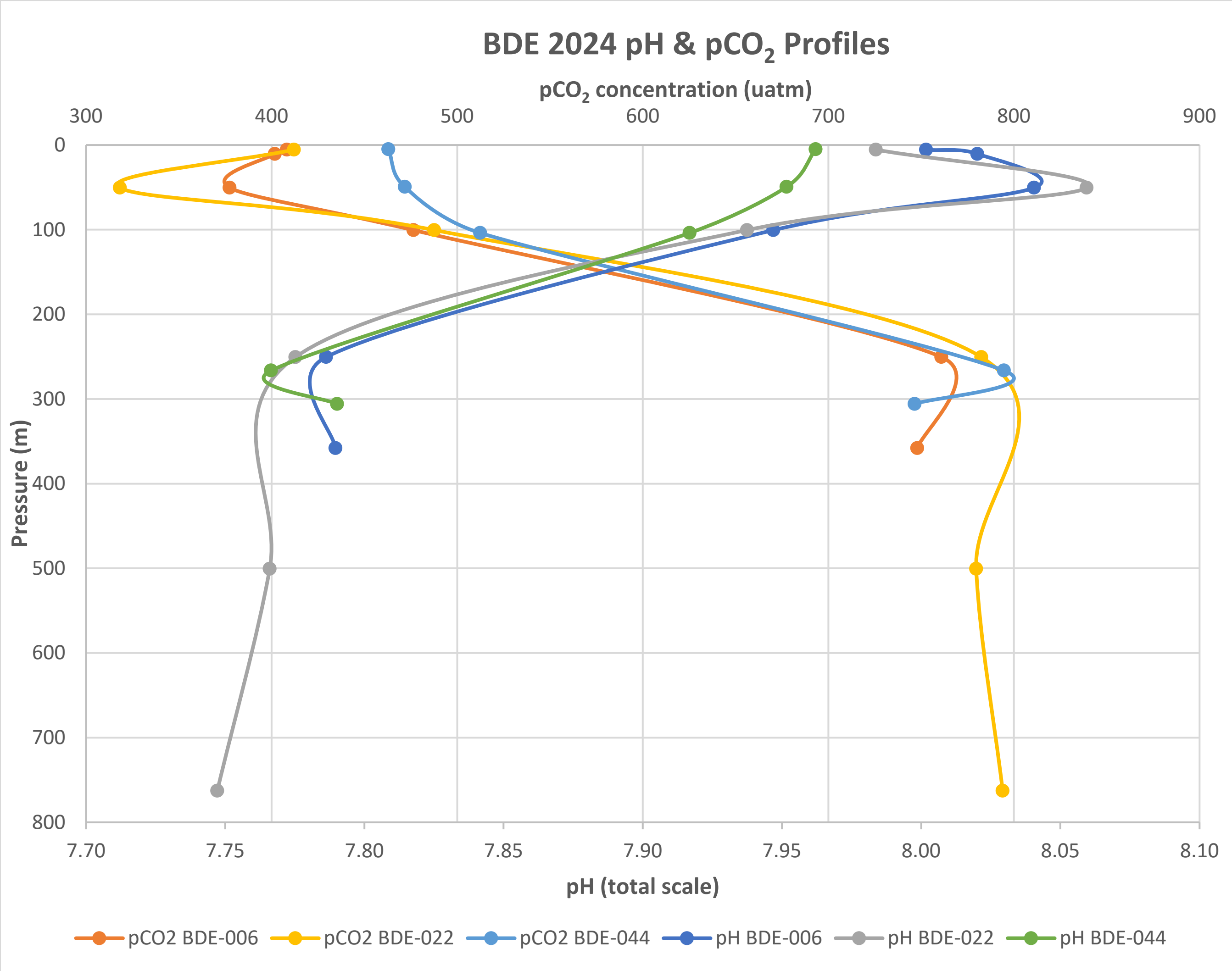

Figure 12: pH and pCO_2 profiles for PP240614.

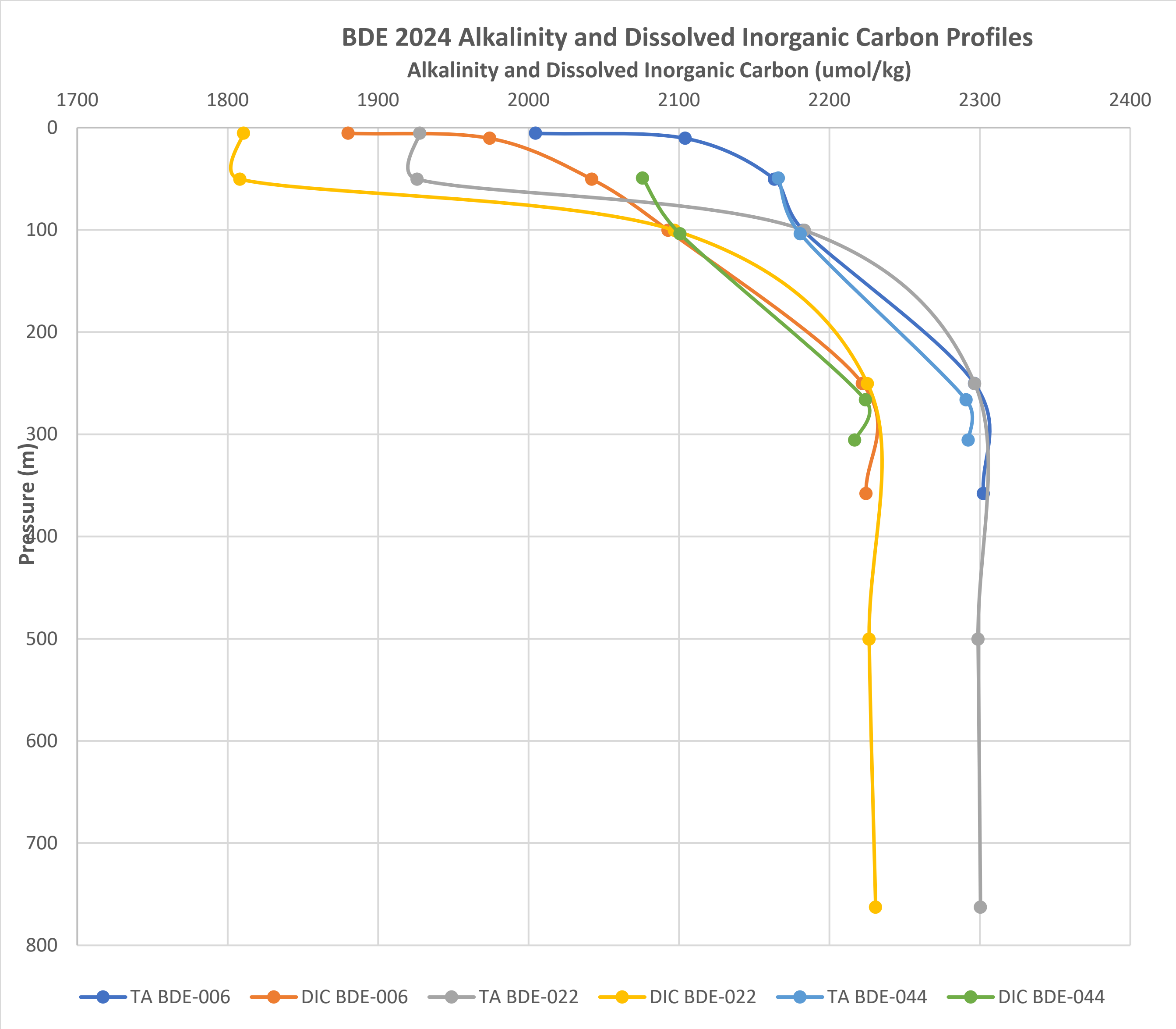

Figure 13: Alkalinity (TA) and Dissolved Inorganic Carbon (DIC) profiles for PP240614.