AR38: Joint Program Student Cruise Cruise report

September 20-22, 2019

Introduction and General Description

Chief Scientists: Mara Freilich and Astrid Pacini
Principal Investigator: Glen G. Gawarkiewicz

RV Neil Armstrong cruse AR38 took place from 20 September to 22 September 2019. The cruise left from, and returned to, Woods Hole, MA. The goals of the cruise were as follows:

Science

- *Hydrography:* capture Shelf Break Front dynamics (T, S, velocity) and interaction with a warm core ring
- *Biology:* take phytoplankton, zooplankton and nutrient samples at Northeast LTER (Long Term Ecological Research) site, sample warm core ring

Scientific operations/instrumentation

- Water column measurements:
    - CTD for temperature, salinity, density, fluorescence, turbidity, PAR, CDOM, oxygen profiles, transmissometer
    - 24 10-liter Niskins on rosette for water sampling: O2 for Winkler titrations, nutrients, C-P lyase activity, DOM extraction, chlorophyll-a and size fractionated chl-a at surf
    - SUNA for nitrate profiles
    - IFCB and flow cytometry (FCM) measurements from rosette
    - CPICS for phytoplankton imagery
    - Incubations (and associated equipment) for community structure analysis and respiration rate experiments
- IFCB continuously sampling from diaphragm pump underway seawater system
- Bongo net tows and midwater tucker trawl
- Glider recovery

Broader Impacts

- *Education:* orientation and training on oceanographic methods for first year MIT/WHOI Joint Program students; introduction to life at sea; 4th year graduate students gain cruise planning/chief scientist training/experience
- *Outreach:* introduce first year students to science communication; write entry for JP blog

Timing and stations

Dates: 20-22 September 2019
Ship time: 49 h
Departure: Friday, 20 September 2019 10:00 EDT
Return: Sunday, 22 September 2019 11:00 EDT

Stations

20 CTD stations were occupied along the LTER line. The outbound transect (North to South) consisted of 12 CTD casts, 6 bongo net tows, and 1 mid water tucker trawl. The inbound transect consisted of 8 CTD casts and 3 bongo net tows. A glider was recovered west of station 11 (LTER station 10, near the OOI Offshore Site) for OOI. See Figure 1 for details on stations and Appendix A for all evolutions at each site.

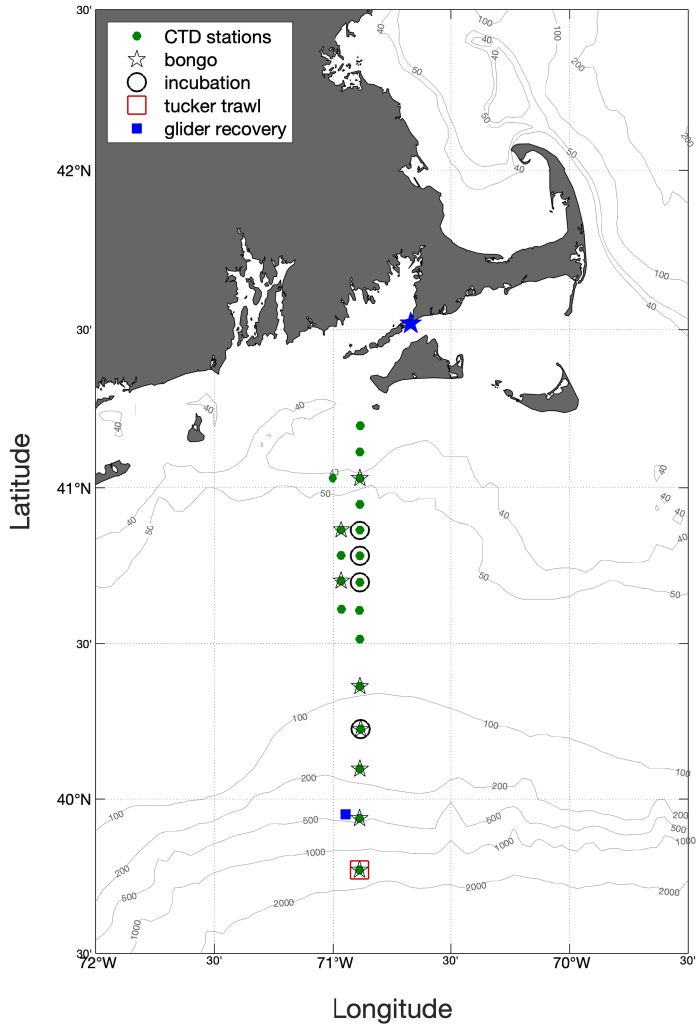

Figure 1: Station location and operations on AR38. Note that stations on the inbound transect are offset by 0.08° in longitude to the West at stations that were occupied on the outbound and inbound transects.

Personnel

Number of science berths: 24 (6 leaders, 16 students, 2 SSSG Techs)

Leaders (6):

- Glen Gawarkiewicz (Chief Scientist, PO Scientist)
- Mara Freilich (Co-chief scientist, JP student)
- Astrid Pacini (Co-chief scientist, JP student)
- Ben Granzow (Chemistry lead, JP student)
- Justin Suca (Biology lead, JP student)
- Taylor Crockford (Biology research assistant, LTER project)

SSSG Team (2):

- Amy Simoneau
- Emily Shimada

JP student science party (16):

- Jinshi Chen (1st year PO)
- Seth Cones (1st year BO)
- Faith Duffy (1st year G&G)
- Alan Gaul (1st year PO)
- Jianhua Gong (5+ year G&G)
- Cora Hersh (1st year PO)
- Max Jahns (1st year CO)
- Alexandra Jones (1st year BO)
- Arianna Krinos (1st year BO)
- Lukas Lobert (1st year PO)
- Lei Ma (4th year BO)
- Phadtaya Poemnamthip (1st year PO)
- Mira Santos (1st year BO)
- Iulia Streanga (1st year CO)
- Ruijiao Sun (2nd year BO)
- Lina Taenzer (1st year CO)

Watch assignments and tasks

	Watch 1	Watch 2
CTD, TSG, ADCP, SUNA - *Astrid*	Jianhua, Alan	Lina, Cora
IFCB, underway bio - *Taylor*	Arianna, Iulia	Mira, Jinshi
Net tows - *Justin*	Ruijiao, Alexandra	Lei, Phadtaya
Bottle samples - *Mara, Ben*	Lukas, Seth	Max, Faith

Bottle samples: nutrients, oxygen, salts, IFCB (plankton), flow cytometry, chlorophyll, incubations

Watch 1: 0600 - 1200, 1800 - 0000
Watch 2: 1200 - 1800, 0000 - 0600

Hydrographic conditions

Pre-cruise conditions: In both satellite images and OOI moorings, we noticed that there was a large warm core ring approximately 100 nm to the east of the LTER line with filaments reaching the LTER line. There were frontal waves visible in SST along the edge of the warm core ring and warm filaments extending onto the shelf up to the 80-meter isobath along the LTER line (Figure 2).

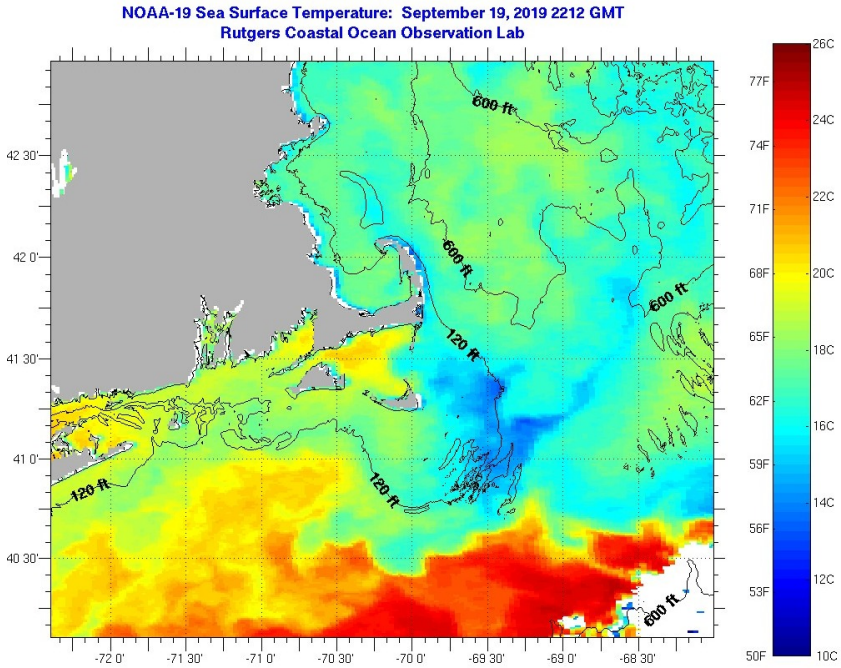

Figure 2: SST imagery from satellite September 18, 2019 2212 GMT.

This filament is associated with a distinct water mass, which is seen in the OOI Upstream Inshore mooring on September 7, as shown by the dramatic warming and salinification of upper ocean properties (Figure 3). The arrival of this water mass also changed the biogeochemical characteristics of this area. It is very unusual to have Gulf Stream water so far on the shelf, so we sought to target this feature in our study of the frontal zone.

Outbound transect

After a nice sendoff from the WHOI dock, we began steaming at 10 knots towards the LTER line. We did a training station for everyone at LTER station L1. The bottle firing mechanism was not working properly so we continued to LTER station L3. At L3, in 55 meters of water, we found that we had already crossed the front and had a cooler and fresher water mass at depth with warm and saltier water at the surface. This was much further inshore than we expected to find the front. Based on the TSG and ADCP data, the front was located near the 40 m isobath, approximately 20 km inshore of where we expected from the satellite SST imagery.

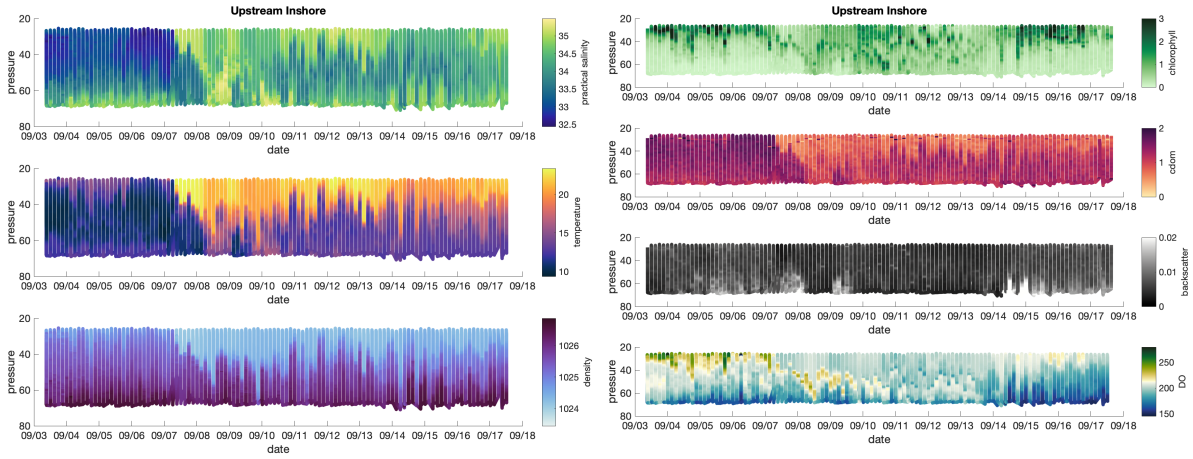

Figure 3: Salinity, temperature, density, chlorophyll, CDOM, backscatter, and dissolved oxygen time series from OOI Upstream Inshore mooring for the period September 03 through September 17.

See Figure 4 for the frontal characteristics at the surface from the underway TSG. Note the transition from cold (17-18 deg C), fresh (31.5-32.5) waters inshore of the 40 m isobath to warm (19-20 deg C), salty (33-34.5) waters offshore.

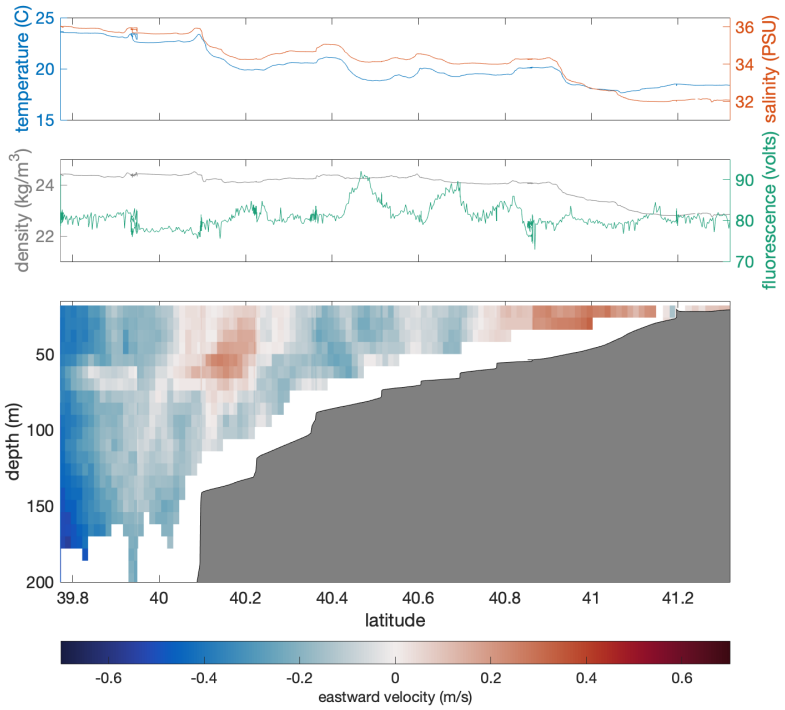

Figure 4: Surface temperature, salinity (top), density, and fluorescence (middle) and velocity profiles (bottom) along the outbound transect, measured by the underway seawater system and vessel-mounted ADCP.

Most surprisingly, this frontal zone was associated with a strong eastward jet (Figure 5). Typically, shelf waters flow to the west, and a reversal of this circulation could have significant consequences for the distribution of biological activity in the area. On the shelf, we observed a lens of cold, fresh water at the base of the shelf. This feature was evident in ~10m bottom boundary layers in the temperature and salinity profiles. The near bottom water masses are likely remnants of the Cold Pool, the water mass formed in winter that then underlies the seasonal thermocline in the spring and summer.

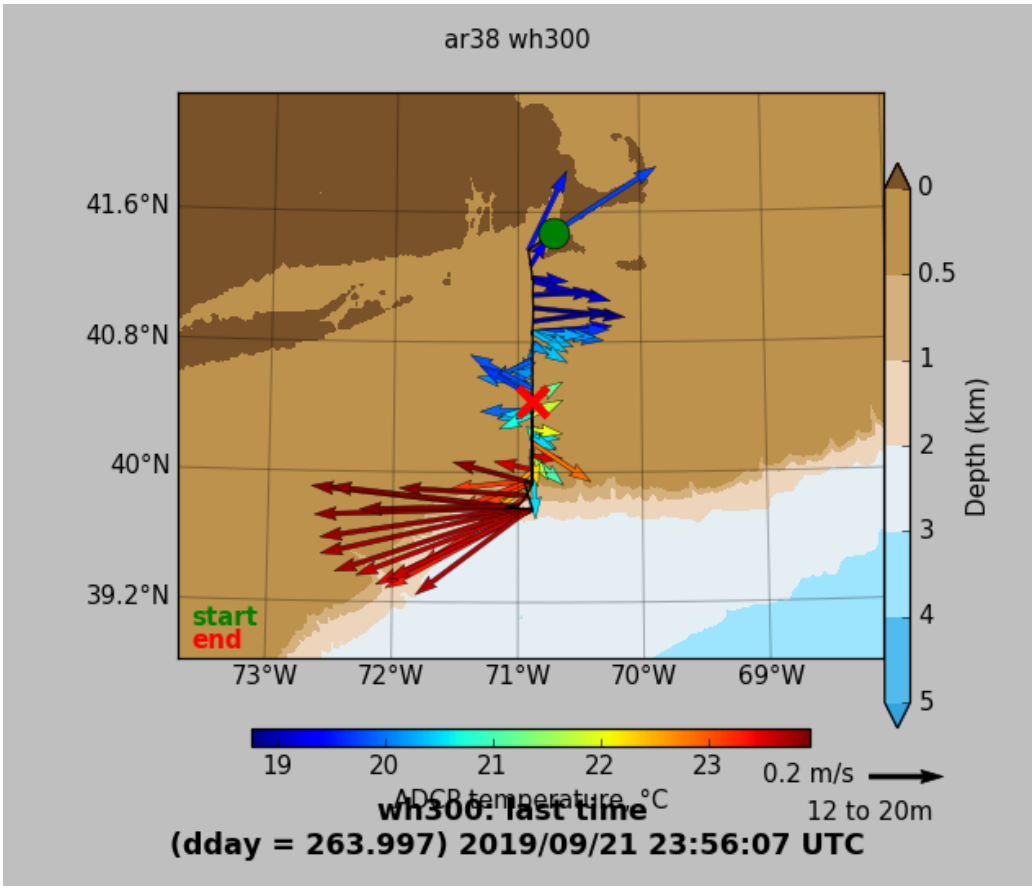

Figure 5: Velocity vectors from the workhorse 300 ADCP

Interestingly, there appears to be a second frontal zone near the shelfbreak, as waters become warmer (up to and exceeding 24 deg C) and saltier (36), indicating the presence of ring water. This is associated with the outcropping of the 24.5 isopycnal at station 9 (Figure 6). This is associated with a strong shelfbreak jet, flowing from east to west.

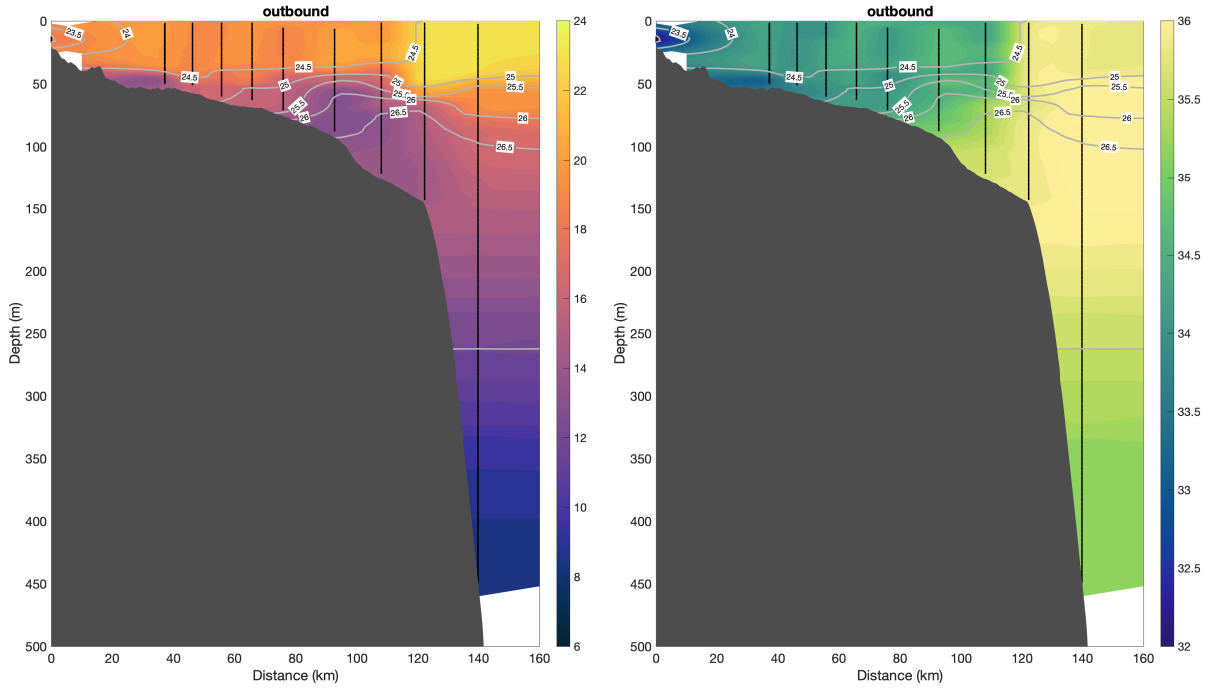

Figure 6: Vertical sections of temperature and salinity, with isopycnals contoured, of the outbound transect. Y-axis is depth (in meters), x-axis is distance along transect (in kilometers).

Inbound transect

The goal of the inbound transect was to re-sample the frontal zone, in order to capture the on-shelf side of the feature, as well as to understand its evolution in the intervening 24 hours between first and second sampling. Our efforts were concentrated on the shelf, where we again observed the frontal zone along the 40m isobath. However, its velocity signature was no longer a strong (order 20-30 cm/sec) current to the east. Instead, the flow was weakly to the west (Figure 7).

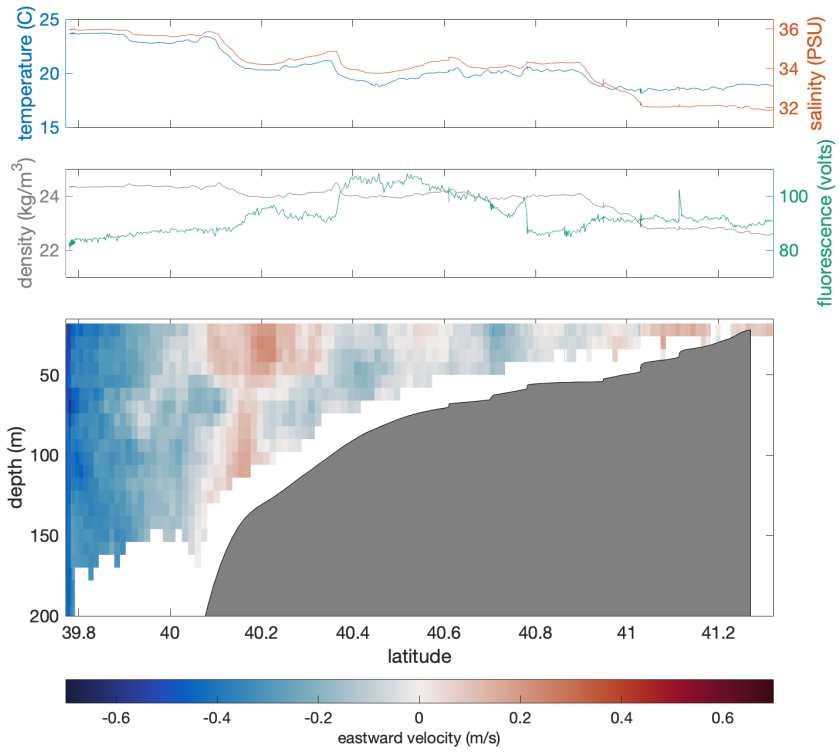

Figure 7: Surface temperature, salinity (top), density, and fluorescence (middle) and velocity profiles (bottom) along the inbound transect, measured by the underway seawater system and vessel-mounted ADCP.

The vertical sections for temperature and salinity are presented in Figure 8. As in the underway data, the vertical sections reveal two frontal zones, one concentrated at the 40m isobath associated with a wedge of cold, salty water, and another located offshore, with the outcropping of the 24.4 and 24.5 isopycnals. There remains a region of stratified bottom boundary layers associated with cold, fresh shelf waters. Additionally, station 14 (LTER4) demonstrates an anomalously cold, fresh subsurface water mass at the surface, which was associated with significant biological production that was observed in the surface fluorescence signal (Figure 7), underway IFCB data, and bongo net tow (section Plankton net tows). More work is required to understand the source and circulation of this water mass. From SST imagery it is possible that this is a continuation of the shelfbreak flow from Georges Bank which created a local minimum in temperature near the shelfbreak south of the clockwise rotating warm ring water mass penetrating to the 40 m isobath (near 40° 30’ North in Figure 2).

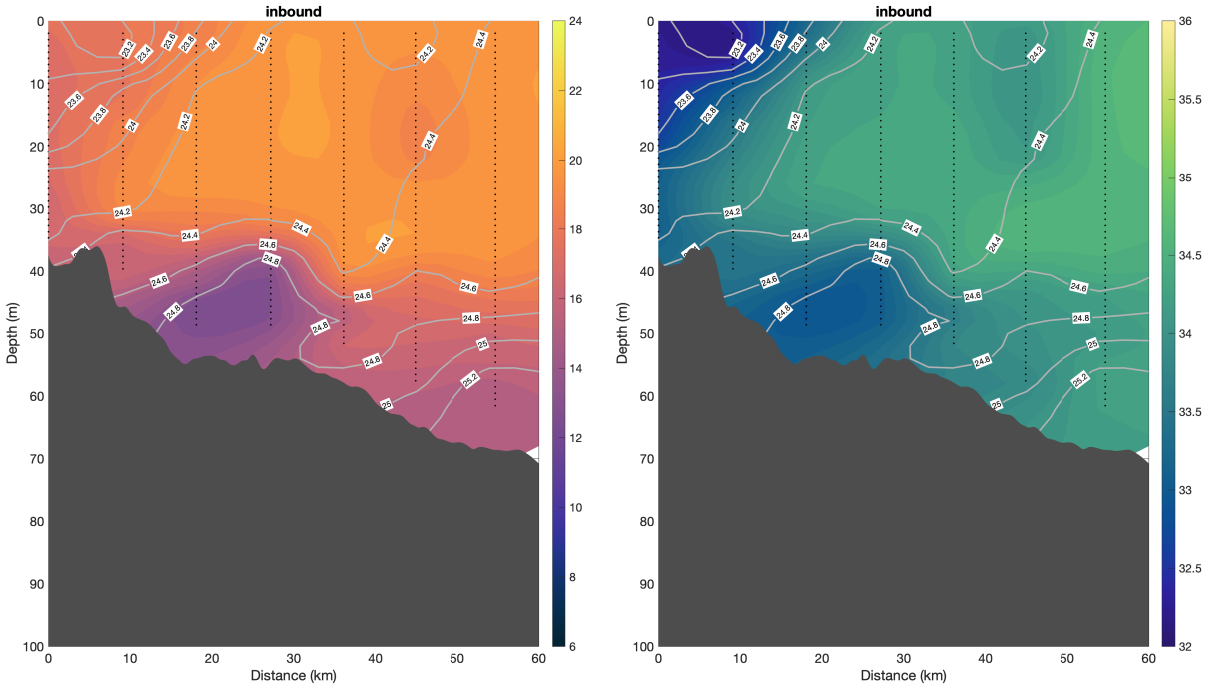

Figure 8: Vertical sections of temperature and salinity, with isopycnals contoured, of the inbound transect. Y-axis is depth (in meters), x-axis is distance along transect (in kilometers).

Plankton net tows

Lead: Justin Suca

Total Number of Bongo Net Tows: 9
Total Number of Mid Water Trawls: 1

Gear description & Methodology

Bongo Net: A 61-cm bongo was deployed to collect multiple size fractions of zooplankton for morphological identification, DNA barcoding, and stable isotope analyses (Figure 9). The bongo was fished in a single oblique tow astern of the ship to 5 m from the bottom (estimated from wire angle) or 200 m, which ever was less. Bongos were deployed at every LTER station after the CTD, weather permitting. General Oceanics flowmeters were used to estimate volume filtered through each net. The ship's 140 lb weight was used as a down weight in replacement of the standard 100 lb clump weight. Pay out and pay in speed was 20 m/min at stations shallower than 50 m, and 30 m/min for deeper tows.

Figure 9: Photograph from a bongo net recovery.

Mid-water tucker trawl: A 3-mm mesh 10 m^2 MOCNESS net was attached to two net bars connected with spectra line (Figure 10). This net was fished in a single oblique tow to 1000 m as estimated from a wire angle. One-hundred-pound clump weights were attached to each side (port and starboard) of the bottom net bar as down weights.

Figure 10: Photograph from mid-water tucker trawl evolution.

Results

Bongo Cast Summaries:
L1 B1 – No cast because of fishing gear in the area.
L3 B2 – Started to see characteristics of the front. Some spillage (~5%) of 150 µm sample. Towed oblique with starboard aft winch hydrowire worked for this station.

L6 B8 – Hydrowire jumped the starboard winch sheave, so most of the sampling was done on the surface. Labels in the jars are wrong, 1 hour ahead of correct time (UTC time).
L7 B9 – Towed from the A-frame. Smooth deployment.
L9 B10 – 335 µm spillage (~5-10mL). Small tear found in 150 µm net. Replaced for the next deployment. Tuna larvae found.
L10 B11 – Cast with new 150 µm net. Smooth deployment.
L11 B12 – Thin sample. Offshore ring water.
L4 B14 – Nets were "salped". The complete 335 µm net sample was split into 3 jars, we were unable to sift out the salps. The 150 µm sample was split in half, and one half was discarded. Salps included in all samples.
L3 B16 – Salps in this tow, but not as bad as cast B14. Salps included in samples.
L2 B19 – Diatom and copepod bloom.

Trawl Cast Summary:
L11 MWT1 – Towed down to ~1200 meters, 1500 meters wire out. Wire angle 45-50°. Towed at 2.5 knots. Frozen – packet 1: 9 leptos, packet 2: jellies & salps, packet 3: crustaceans, packet 4: 11 myctophids, packet 5: 9 gonostomatids, packet 6: 2 hatchet fish, packet 7: dragonfish, packet 8: 1 fang-tooth, packet 9: 1 cutlass fish, packet 10: 7 myctophids

Table 1: Bongo deployment meta-data

Date	Seq. Station	Fixed Station	Bongo #	Time In (UTC)	Time Out (UTC)	Latitude	Longitude	Bottom Depth (m)	150 µm Flow Start	150 µm Flow End	335 µm Flow Start	335 µm Flow End
190920	2	L3	2	21:33	21:39	40.51805	-70.52964	55	600649	622563	439818	499256
190921	8	L6	3	05:06	05:25	41.5240	-70.6723	93	622560	660599	499256	547568
190921	9	L7	4	07:10	07:25	40.2225	-70.8826	125	660594	687551	547571	575057
190921	10	L9	5	09:09	09:27	40.0956	-70.8840	145	687554	718549	575060	606604
190921	11	L10	6	11:32	11:59	39.9349	-70.9037	450	718545	769193	606673	656777
190921	12	L11	7	15:18	15:43			1600	769193	806102	656778	693499
190922	14	L4	8	02:12	02:20	40.702398	-70.8819	68	806104	816761	693499	713997
190922	16	L3	9	04:37	04:43	40.8679	-70.8805	53	816766	826788	713993	724318
190922	19	L2	10	08:25	08:30	41.304	-70.8932	45	826790	834309	724319	734594

Table 2: Trawl deployment meta-data

Date	Seq. Station	Fixed Station	Trawl #	Time In (UTC)	Time Out (UTC)	Latitude	Longitude	Bottom Depth (m)
190922	12	L11	1	16:07	18:38	39.7219	-70.9150	1628

Table 3: Bongo sample preservation meta-data

Seq. Station	Fixed Station	Bongo #	335 µm Split	Preservative	150 µm Split	Split1 Preservative	Split2 Preservative	Comments
2	L3	2	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	
8	L6	3	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	
9	L7	4	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	
10	L9	5	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	
11	L10	6	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	
12	L11	7	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	
14	L4	8	3	5% Formalin	2	95% ethanol	Frozen (-20°C)	Dumped 1/2 of 150 µm sample
16	L3	9	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	
19	L2	10	1	5% Formalin	2	95% ethanol	Frozen (-20°C)	

CTD operations and Water Sampling

Lead: Benjamin Granzow & Taylor Crockford

CTD Operations

Teams of two students, under the guidance of the SSSGs, were in charge of preparing the CTD package and rosette for each cast, deploying the instruments, operating the CTD console, communicating with the winch operator, selecting the sampling depths (with a rubric and guidance), recovering the package, and rinsing and securing it on deck.

Dissolved Oxygen

Water samples were taken on 12 casts (stations 2-13) for DO analysis via the Winkler titration method. Samples were taken in duplicate in BOD bottles and analyzed on 9/21-9/22 on board. Samples were collected at depths where the CTD O_2 sensor indicated constant O_2 levels. Additional samples were taken to calibrate the O_2 sensor and to correlate with incubation samples run by Mara Freilich. Most of these samples are in areas of high oxygen variability. One depth was chosen for most casts with the exception of stations 9, 11, and 12 where two depths were samples to measure features in the O_2 profile.

Plankton and nutrient samples

Nutrient and plankton samples were collected for the Sosik lab as part of the LTER program. Samples were collected at every depth (1 to 9 depths per station with an average of 5) on 14 of 19 CTD casts. Selected depths were the target depth, the surface, chlorophyll max, and where interesting features such as haloclines, oxyclines or extrema in oxygen, fluorescence, salinity, and temperature were observed during the down cast. In all cases, the nutrient, chlorophyll, flow cytometry, and imaging flow cytobot (IFCB) samples were collected from the same Niskin for a given depth.

Samples were collected for nutrients in duplicate except for cast 18 to be analyzed on shore in the WHOI Nutrient Analytic Facility. Single samples were collected at cast 18 due to limited bottle availability. Samples were filtered straight from the Niskin bottles into acid washed vials using an AcroPak 200 Capsule with Super Membrane (0.2um) filter.

Samples were collected for chlorophyll in duplicate to be extracted on shore and analyzed by the Sosik lab. These samples were collected on GFF filters. Samples were stored in a LN_2 dewar.

Samples were collected for flow cytometry and fixed with glutaraldehyde. These samples were stored in a LN_2 dewar.

Imaging flowcytobot (IFCB) samples were typically collected at the DCM, and at the surface on all casts where LTER samples were taken. Additional samples were taken in conjunction with incubation depths or if additional interesting fluorescence features were observed. IFCB samples were taken at deeper depths on the 1,000 m cast at L11 to investigate possible interesting particles triggering on side scattering.

Samples were collected at station 12 at a depth of 48 meters for C-P lyase activity analysis utilizing a novel fluorescent assay. 28 samples were collected and spiked with the tracer to conduct a kinetic study of C-P lyase.

One 20 L whole water sample was collected at station 12 from 1,000 m for DOM extraction via solid phase extraction (SPE). Sample was acidified and extracted on board. Additionally, DOM was collected continuously throughout the cruise via SPE attached to the flow through system.

SUNA

Lead: Taylor Crockford

A Submersible Underwater Nitrate Analyzer (SUNA) was mounted on the CTD rosette and deployed on every CTD cast. The SUNA gives high resolution nitrate measurements through the water column during casts and transmits an estimated reading back to the CTD console to be plotted in SeaSave during the cast. Students were assigned to plug and unplug the sensor for each CTD cast and rinse the optical window with DI water and isopropyl alcohol between casts. Data were periodically downloaded during the cruise to check for initial data quality and battery status. The nutrient samples collected from niskins during the cruise will be used to ground truth the SUNA data during post-cruise analysis in the Sosik lab.

Imaging FlowCytobot and Underway Biology

Lead: Taylor Crockford

Summary: During this 49-hour cruise, our team was responsible for the Imaging FlowCytobot (IFCB) and processing the incubation samples for IFCB and FCM. There were two IFCB's aboard, one for continuous underway sampling and one for discrete sampling from CTD casts. Early on in the cruise, we also took over flow cytometry (FCM) sampling.

Discrete IFCB: We ran 86 discrete IFCB samples run in total over 14 CTD casts. However, in the second cast, we sampled from the IFCB from bottles 5 and 12 in the midst of a bottle misfiring. As a result, although we believe these samples to be from the surface and the chlorophyll maximum, we are not entirely sure that these are the correct depths. We prioritized

running samples aligned with interesting features in the water column such as chlorophyll maxima and changes in the oxygen profile.

Underway IFCB: We monitored the underway IFCB that was continuously analyzing seawater from the diaphragm underway science seawater. The ship's non-standard diaphragm pump was used for the underway science seawater supply because it is gentler on plankton particles than the ship's standard impeller pump (Figure B8). We periodically checked that the underway IFCB instrument was producing images of reasonable quality. We observed high concentrations of diatoms in surface waters along a substantial portion of both the outbound and inbound transect (Figure 11).

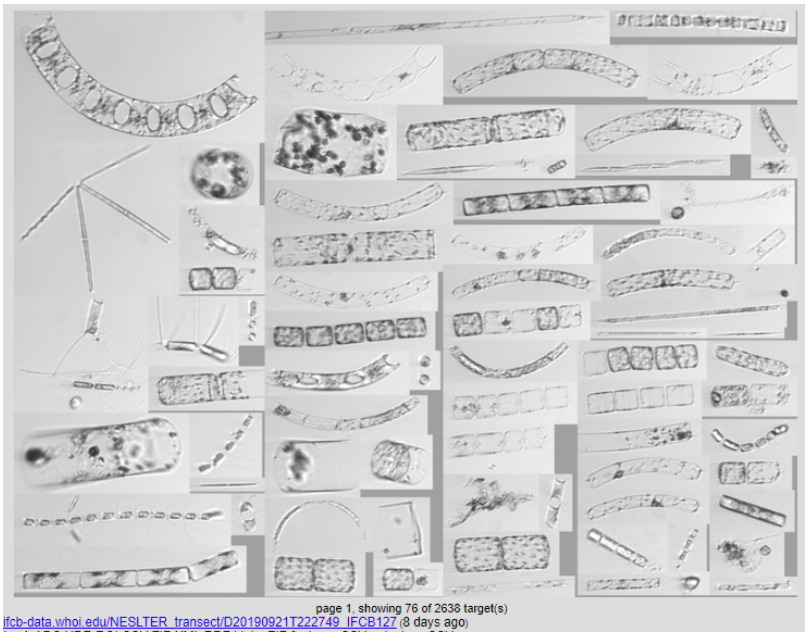

Figure 11: Example screenshot of IFCB dashboard mosaic sample (D20190921T222749_IFCB127) of numerous intact diatom chains observed using the underway IFCB.

All of the IFCB data are hosted on the publicly available IFCB Dashboard (https://ifcb-data.whoi.edu/NESLTER_transect) and have been backed up on a removable hard drive. The data are awaiting further analysis. A spreadsheet was used to keep track of discrete IFCB samples from the CTD. Each sample's filename was recorded with its associated cast, Niskin, and comments about the identity of the sample or the circumstances under which the sample was obtained.

We collected 72 FCM samples from CTD casts, which are associated with the IFCB samples plus additional samples at depths of interest. The FCM vials have been cryopreserved and are awaiting analysis by an Attune NxT flow cytometer on shore in the Sosik Lab.

By the end of the cruise, all the 24h incubation samples and three of the four 36h incubation samples had been processed. These samples were obtained from the 20°C incubator, and analyzed using IFCB, FCM, and nutrient methods as described above.

Incubations

Lead: Mara Freilich

Samples were collected at four stations for incubation experiments that seek to quantify the rate of change of the size structure of the photosynthetic community during decomposition. The incubations were conducted in an incubator kept in the wet lab. The incubator was kept at 20^{o}C for the duration of the experiment. At each station, water was sampled into nine BOD bottles. Three of these were used to measure the oxygen respiration rate with an optical instrument referred to as an autoBOD (Ben van Mooy), which was kept in the incubator. The remaining six bottles were stored on the shelf below the autoBOD in the incubator in a cardboard box (Figure 12).

Figure 12: Photograph of incubator with autoBOD (top shelf) and bottles incubating on the bottom shelf. Extra BOD bottles are in the door of the incubator.

Samples were taken from the incubations at 24 hour, 36 hour, 48 hour, 60 hour, and 72 hour time points (time referenced from sample time) and run on the 'discrete' IFCB and preserved for flow cytometry. At each time point, samples were taken from three different bottles. The 24 hour and 36 hour samples were taken from the same bottles. The 48 hour and 72 hour samples were taken from the same bottles. The 72 hour samples were taken from the bottles that were on the autoBOD. At 72 hours, the water was also preserved for nutrient analysis. The water was filtered into acid washed vials using a Sterivex (0.22µm) filter attached to a B-D 60 ml LUER-LOK^{TM} syringe. After the cruise ended, the LN_2 dewar was taken off the ship and which necessitated some flow cytometry samples being stored in the -80^{o}C chest freezer in the main lab on board the ship.

Table 4: Incubation sample details

Cast and niskin	Depth (feature)	Sample date and time
C3N6	32 m (DCM)	9/20 22:26
C4N2	50 m (shelf water on bottom)	9/20 23:30
C5N7	30 m (salinity maximum)	9/21 00:40
C9 N11	37 m (intrusion below S max)	9/21 07:29

Education

One of the main goals of this cruise was education of Joint Program students in observational oceanography at sea on a modern research vessel. Students made decisions and problem-solved throughout the cruise and cruise planning, in addition to receiving training on operating equipment on board the ship. In addition, the observations that we collected about the physical and biological conditions in the region provided the opportunity for extensive discussions about biological and physical processes.

A major aspect of the cruise training was training and experience for the student co-chief scientists, who received mentorship from the PI, Glen Gawarkiewicz, during the cruise planning process and at sea.

The educational aspects for cruise participants began prior to the start of the cruise. The student co-chief scientists held a meeting with all of the student participants during which they discussed both life at sea and the science goals of the cruise. Students read journal articles related to the biology and physics of the region before boarding the ship. They also read about their assigned sampling type (see Watch Assignments and Tasks). In addition, students assisted with preparation for going to sea by preparing sampling supplies and downloading satellite and OOI data. The co-chief scientists sent around briefs in the days leading up to the cruise to help students prepare and to engage them in discussion of the physical conditions that were affecting cruise planning decisions.

At sea, students were trained in their assigned sampling type and took on leadership for that sampling while at sea under the mentorship of all of the cruise leaders. This included recording data, selecting the sampling depths during CTD casts with guidance, and training other students as necessary. As the observations began to come in, students participated in conversations about the biology and physics of the region. These conversations started from questions that the students asked (e.g. “how can we know where the high productivity water came from?” lead to a discussion of water mass characteristics) and from analyses presented by the cruise leadership.

After the cruise, students may engage further with the data in course work (Elements of Modern Oceanography) or through research.

The SSSG techs, Amy and Emily, did an outstanding job in training students. The entire crew of the R/V Neil Armstrong were supportive of student efforts throughout the short cruise, and welcomed questions and interactions.

Ancillary operations

Glider Recovery

We were contacted by the Ocean Observatories Initiative (OOI) 2 days before the cruise with a request to recover a glider that was quickly running out of battery in the vicinity of the OOI Offshore mooring. After occupying station 011 (LTER10, OOI OS), the glider was kept at the surface and the ship steamed west to the last reported GPS coordinates (39 57.013'N, 70 56.637'W). The glider was spotted at the surface and the ship performed a bail recovery.

CPICS

Scott Gallagher in the WHOI biology department requested to send his Continuous Particle Imaging and Classification System (CPICS) for phytoplankton, zooplankton (and particulate matter) imagery profiles of the water column. It was mounted at the base of the rosette and was turned on before each cast. The strobe from this instrument interfered with the optical chlorophyll fluorometer and CDOM fluorometer measurements from the CTD package. After multiple troubleshooting attempts, the SSSGs successfully moved the CDOM and fluorometer sensors higher on the frame to remove them from the CPICS plane of light. This helped the signal immensely and we were able to run all instruments without interference for the inbound transect. This she be noted for any future cruises where the CPICS is mounted on the rosette frame.

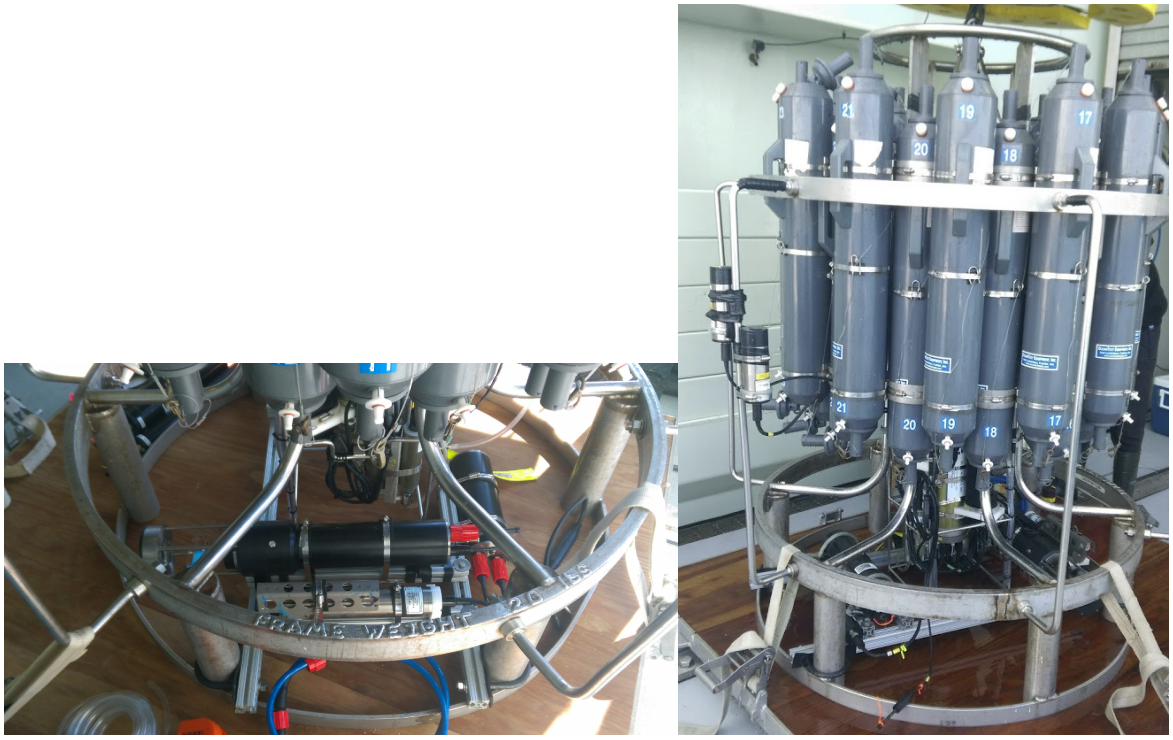

Figure 13: Final CTD rosette configuration for effective sampling of all instrumentation. Left: The CPICS instrument, associated battery pack, and associated CTD mounted on a T-slot aluminum frame at the past of the Armstrong rosette. Right: The chlorophyll and CDOM fluorometers mounted higher on the frame (left center) on the opposite side of the CTD frame from the CPICS (lower right). The SUNA was mounted on the opposite side of the CTD facing away relative to the CPICS.

Appendix A: Cruise timeline

JP student cruise AR38 operations							
	Station Number	**Station Name**	**Latitude (deg/min N)**	**Longitude (deg/min W)**	**Corrected Depth (m)**	**Station Notes**	**Post-station Notes**
DEPART 20-Sep-2019 10:00:00 and transit WHOI to LTER1							
	1	LTER1	41 11.82	070 52.91	29	CTD	Bottle firing did not work (random three bottles came up closed, Seabird did not register Fire Bottle command)
							Decided not to do bongo net because too much fishing gear in the water
	2	LTER2	40 51.80	070 52.97	53	CTD, bongo	Again, bottles did not fire
							Working on the bottle firing mechanism. Held station at LTER2 because we think this is the front
	3	LTER3	40 51.76	070 52.97	53	CTD, incubation started	
	4	B1	40 46.86	070 53.01	55	CTD, incubation started	
	5	LTER4	40 41.75	070 53.05	64	CTD, incubation started	
	6	B2	40 36.34	070 53.07	66	CTD	No bottles fire
	7	LTER5	40 30.88	070 53.01	75	CTD	
	8	LTER6, OOI IS	40 21.76	070 53.04	90	CTD, bongo	Again, bottle firing communciation failed but not a problem, the expected bottles did fire. Issue with the bongo net. Got blocked off the sheave but it was recovered. This was off the starboard side arm.
	9	LTER7, OOI CI	40 13.51	070 52.87	125	CTD, bongo, incubation started	
	10	LTER9, OOI CO	40 05.84	070 53.02	145	CTD, bongo	
	11	LTER10, OOI OS	39 56.27	070 53.14	450	CTD, bongo	
			39 57.030	070 56.607		glider	Glider recovery
	12	LTER11	39 46.29	070 53.07	1000	CTD, bongo, SOCNESS	
	13	B2	40 36.62	070 52.88	65	CTD	
	14	LTER4	40 42.06	070 52.93	61	CTD, bongo	
	15	B1	40 46.90	070 52.98	55	CTD	
	16	LTER3	40 51.85	070 53.00	52	CTD, bongo	
	17	B3	40 56.86	070 52.98	53	CTD	

	18	W1	41 01.81	070 59.99	42	CTD	
	19	LTER2	41 01.81	070 52.99	43	CTD, bongo	
	20	B4	41 06.84	070 52.97	38	CTD	
End science operations 22-Sep_2019 5:45:00 and transit to WHOI							

Appendix B: Photos of equipment set-up

Photos of lab setup for future JP student cruises sampling LTER stations

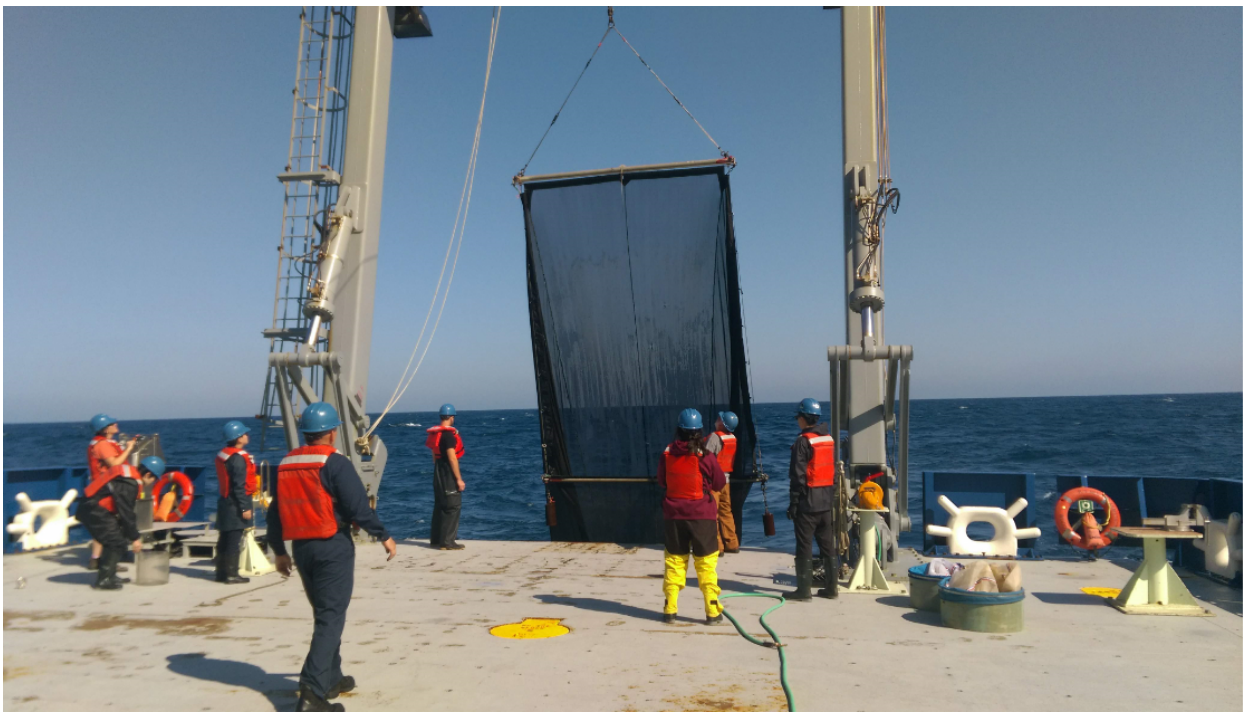

Figure B.1: Midwater tucker trawl being deployed off the stern of the Armstrong.

Figure B.2: Water filtration area in the Wet Lab on the aft port bench

Figure B.3: Water sampling supplies and dewar storage in the aft of the Wet Lab.

Figure B.4: Net sample processing at the Wet Lab sink.

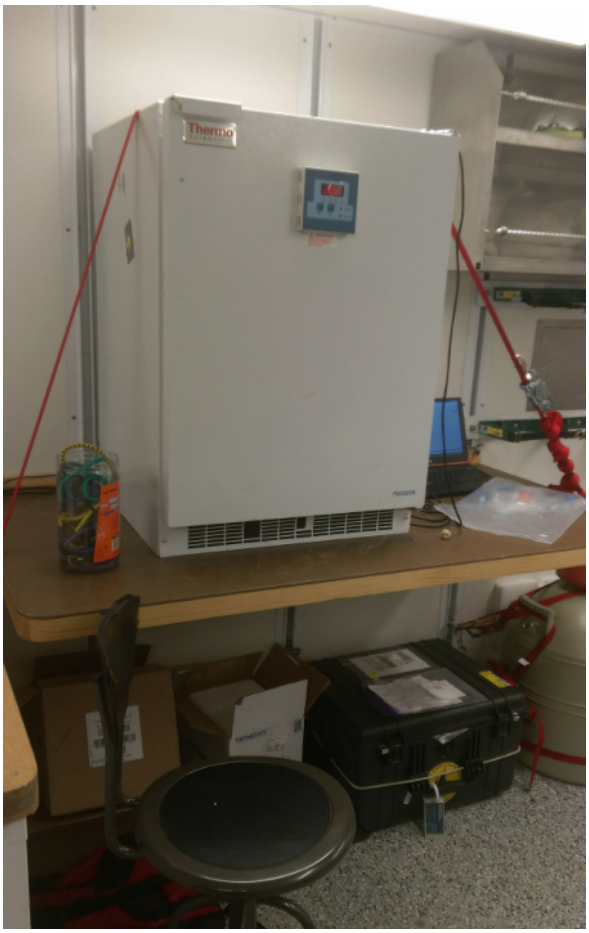

Figure B.5: The incubator secure on the aft starboard bench in the Wet Lab.


Figure B.6: Net tow microscope secured in Main Lab on aft port bench.

Figure B.7: Chemistry setup for Winkler titration, C-P lyase activity analysis, and DOM extraction via SPE.

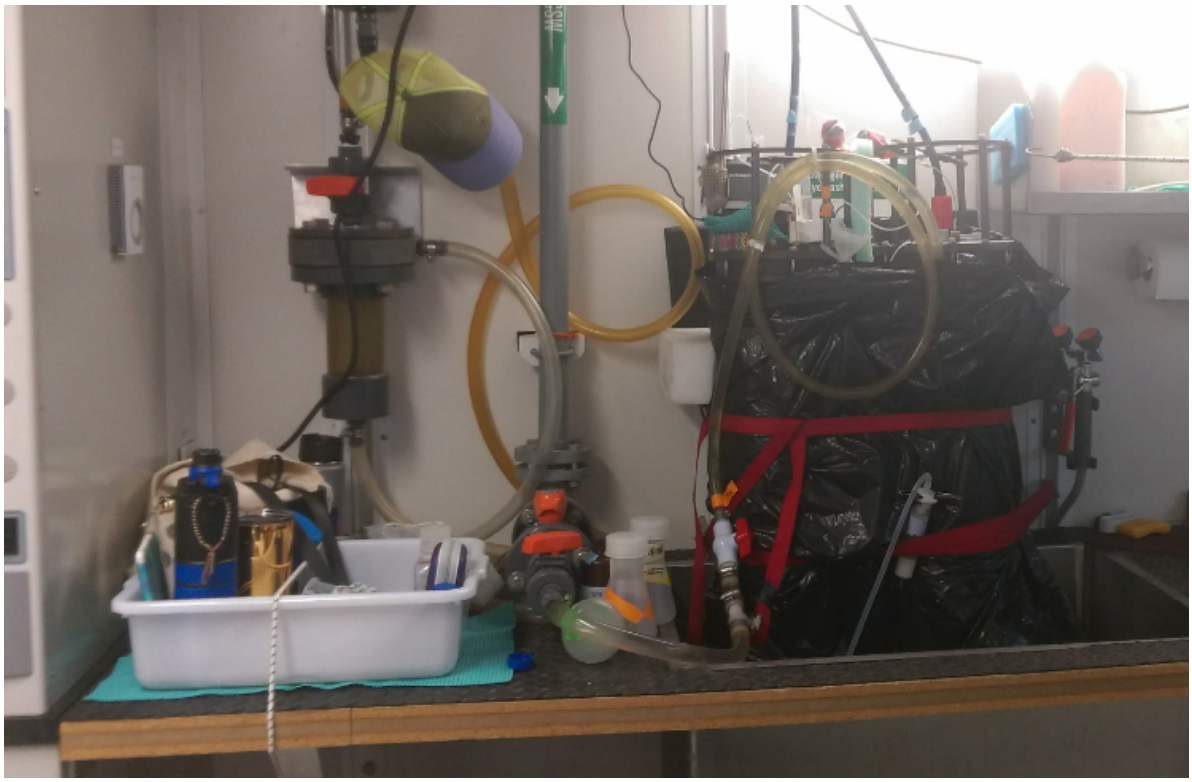

Figure B.8: The underway and discrete IFCB's secured in the forward Main Lab sink.

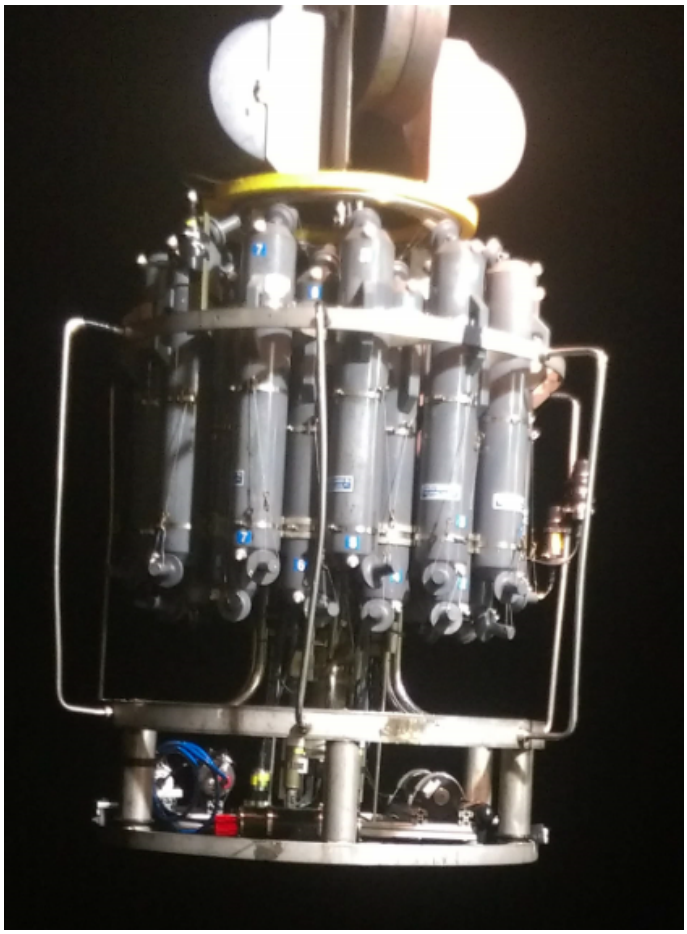

Figure B.9: A 2nd view of the CPICS (bottom left), SUNA (bottom right), and fluorometers (right, centered vertically) mounted in a working configuration during a CTD deployment.