Cruise Report

Sea Education Association Cruise C-276
Caribbean Reef Expedition, 2017

St. George, Grenada - Tobago Cays, St. Vincent and the Grenadines - Montserrat - Barbuda - San Juan, Puerto Rico
26 November – 23 December 2017

Sea Education Association
Woods Hole, Massachusetts

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To obtain unpublished data, contact the Chief Scientist or the SEA Data Archivist:

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Figure 1. SEA sailing school and research vessel *Corwith Cramer*.

Sampling Plan and Cruise Narrative

This cruise report describes the data collected during SSV Corwith Cramer cruise C-276 (U.S. State Department Cruise F2017-065) between November 26 and December 23, 2017. The cruise was the seagoing component of a semester program in environmental studies offered by the Sea Education Association (SEA) to university and college students. The 21 participating undergraduate students came from universities and colleges from across the United States and the Caribbean, with majors ranging from engineering to biology; their diverse research interests were directly reflected in the broad scope of the ambitious sampling program of this cruise. The curriculum of the program was designed to examine the status of Caribbean coral reefs in a multidisciplinary study of human development patterns, public policy, and environmental factors and their combined effects on the coral ecosystems. The four-week cruise followed a six-week period of study on SEA campus in Woods Hole, and a further 10-day field study conducted in Grenada. During the four-week cruise, we sampled the waters around the reefs of Grenada, the Tobago Cays (St. Vincent and the Grenadines), Montserrat, and Barbuda. At each of the visited islands, the students conducted interviews and site visits to understand the relevant policy issues and environmental stressors. Shipboard measurements and characterization of the oceanographic conditions were accomplished during a partial circumnavigation of each of the island while collecting underway data and by occupying two hydrographic research stations around each island.

After departing St. Georges in Grenada on November 27th, we spent the first 5 days in the waters between Grenada and St. Vincent and the Grenadines. The distance of travel was short, and this gave us a good opportunity to get the new ship's company oriented to all aspects of the ship's operations as well as to conduct the first four of our research stations to meet our oceanographic sampling goals for both Grenada and the first island stop of Tobago Cays. The highly dynamic nature of the region became immediately obvious as our measurements showed large local swings in chlorophyll a concentration, sea surface temperature, and surface current strength and directions.

On reaching our first island visit in Tobago Cays saw us clear in to St. Vincent and the Grenadines on Union Island, also the base for the Tobago Cays Marine Park (TCMP) office. The class was graciously received by the TCMP director, Mr. Kenneth Williams, for an orientation to the park management, while representatives from Sustainable Grenadines, an environmental NGO, gave us further tours of some sites of interest on Union Island. After these very informative interactions, we moved from the harbor anchorage out to the Tobago Cays, where we spent the following two days at different anchorages to conduct reef surveys. The small boats were in heavy rotation as teams of students went out on missions to conduct their own independent studies on reef fish, corals, and other invertebrate members of the reef community. After three fruitful, busy days in TCMP, we departed on December 5th for Montserrat.

The three-day sail to our next destination went by very quickly, but allowed us to do some more deployments and get good observations of the flow of Atlantic surface water into the Caribbean through the many passes between the islands of Lesser Antilles we sailed by. The approach to Montserrat further gave us the opportunity to do the island-specific station work in anticipation of performing the first round of nutrient analyses while in port. The contrast between the high, steep slopes of Montserrat and the Tobago Cays was striking, and the differences carried under water as well. Instead of the extensive reef structures we saw in the TCMP, the corals we observed here were growing on massive volcanic boulders close to shore as most of the seafloor was covered by volcanic sands. On shore, we were briefed by a representative from the Fisheries Office, Mr. Alwyn Ponteen, and took a field trip to the Volcano Observatory where we learned about the geological forces that shape the island both above and below the sea.

The next leg of the cruise took us a short distance to the north, where our next intended island stop of Barbuda was only some 60 nautical miles distant. Barbuda had been hit very hard by the intense Hurricane Irma in August of 2017, and our visit there had been uncertain in face of the relief efforts. Being able to see how the reefs fared in the storm was of major interest to us, and with gracious cooperation with the Antigua and Babruda Fisheries Office director, Mrs. Sheryl Appleton, we were able to secure the necessary permits to indeed visit Barbuda. In Barbuda, we were greatly aided by Mr. Kelly Burton from the Codrington Lagoon Marine Protected Area as well as Dr. Andy Estep of the

Waitt Institute, who both helped to connect interested students with the on-going relief and redevelopment efforts. It was clearly visible to all of us that Barbuda had suffered frightfully, and that only a small portion of the island population had been allowed to return after the post-storm full evacuation. This visit gave us much to talk about, as the effects of the global climate change had been common point of conversation throughout the program. Barbuda was a sobering example of what the predicted increase in hurricane frequency and strength will look like in the Caribbean.

This left us with our final leg to Puerto Rico, during which we finished our oceanographic sampling around Barbuda, but then quickly concentrated on finishing the student independent studies and necessary lab analyses. It was also a time reflect on the voyage and all the reefs, islands and people we had visited. We were joined on the last leg by Dr. Claire Morrell of St. George's University, Grenada, and benefited greatly from her perspective informed by a long commitment to coral conservation and research in the Caribbean. This inaugural Caribbean Reef Expedition was a success on many fronts. Laying a groundwork for future field work, we collected a first round of what we hope will become a longer time series of measurements. But most importantly, we started building relationships with the communities that are working actively to rebuild degraded mangroves and reefs and effect policy changes to help lift some of the anthropogenic stresses on the coastal ecosystems of these diverse islands. The Corwith Cramer will be back in 2018 to continue our engagement.

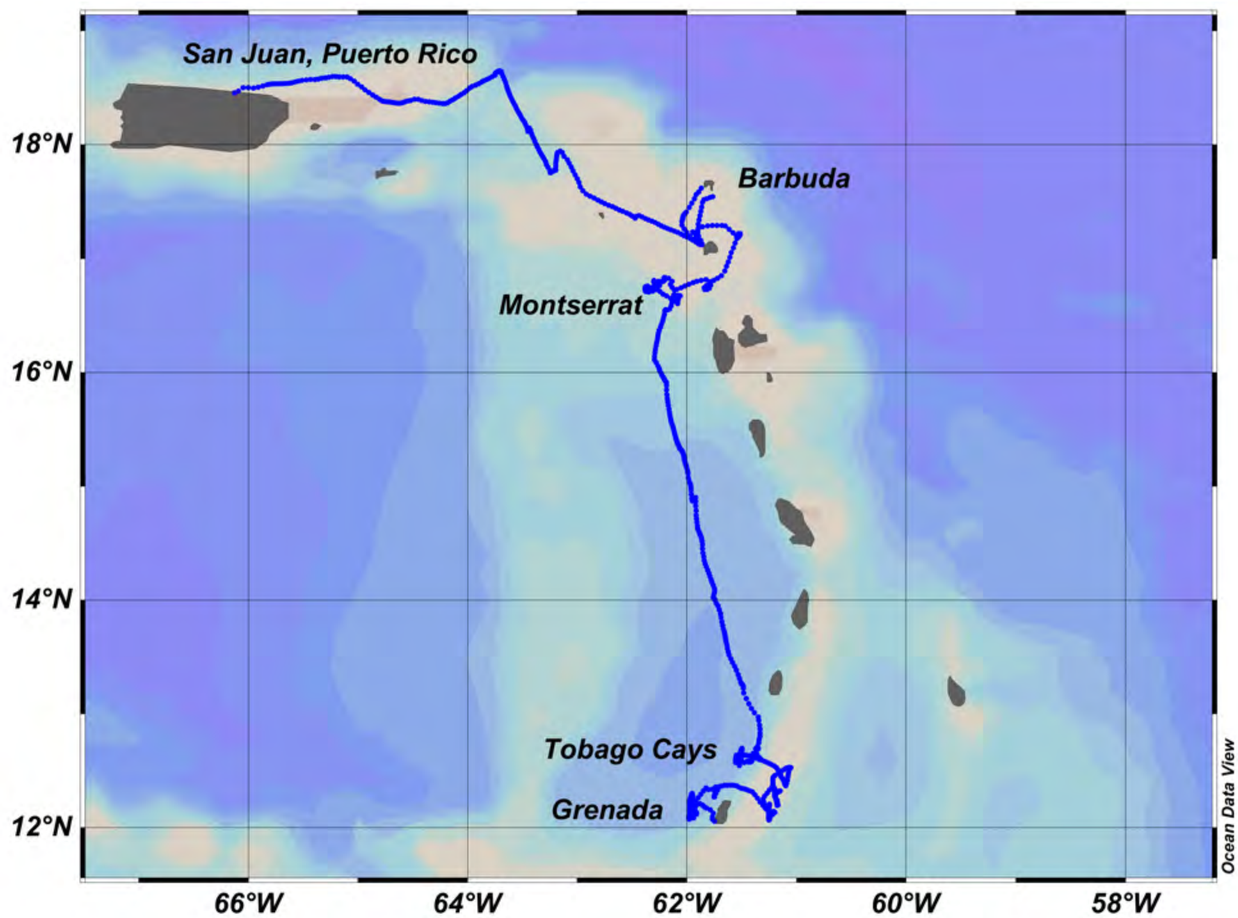


Figure 2. Ship track showing the four legs of the cruise and the ports of call visited. See Table 1 for station location coordinates.

Methods

The cruises used the Sea Education Association's SSV *Corwith Cramer* (Fig. 1), a 134' steel-hulled brigantine launched in 1987 and built to SEA specifications. The ship has accommodations for up to 38 people, carries a professional crew of 6 besides scientific and teaching personnel, and is equipped with a broad array of oceanographic research equipment. The core capabilities consist of a hydrographic research winch with 4,500 m of wire, and a rosette water sampler with multiple biological and chemical sensors integrated with a Seabird SBE 19 plus CTD. The ship also carries a variety of plankton nets, including 1- and 2-meter nets, and a Tucker-trawl. For current measurements, the ship features a hull-mounted RDI OceanSurveyor 75 kHz Acoustic Doppler Current Profiler.

Physical Water Column Parameters.

We used a SeaBird Electronics SBE 19+ v.2 conductivity, temperature, and depth (CTD) profiler mounted on our 12-bottle rosette water sampler to measure the physical parameters of the water column. The CTD was interfaced to a SeaBird Electronics SBE 45 Oxygen probe, a Seapoint Chlorophyll Fluorometer, a Biospherical Instruments Photosynthetically Active Radiation (PAR) radiometer, and a WetLabs Chromophoric Dissolved Organic Material (CDOM) fluorometer. These instruments produced a near-continuous vertical profile of their respective parameters.

Currents.

Ocean currents were measured using a hull-mounted Teledyne RDI OceanSurveyor 75 kHz Acoustic Doppler Current Profiler (ADCP). The data was collected in 10 m averaged depth bins, and further averaged every 20 min to 600 m depth.

Chemical Parameters.

We used the rosette water sampler to recover 2.7-liter water samples from multiple discrete depths at each station. A portion of these samples were analyzed in the shipboard lab for nitrate nitrogen and phosphate phosphorus using standard spectrophotometric methods (Parsons et al. 1984). pH measurements were done using the m-cresol purple spectrophotometric method (Clayton 1993). Oxygen measurements were obtained from the SBE 45 oxygen probe.

Biological Parameters.

The concentration of the primary photosynthetic pigment chlorophyll *a* is an often-used indicator for phytoplankton biomass (Chavez 1996). We measured chlorophyll *a* using an un-calibrated Seapoint in-situ fluorometer on the rosette sampler to gather continuous profiles of relative chlorphyll *a* at each station. We used a calibrated Turner 10-AU bench top fluorometer to measure concentration of chlorophyll *a* in a known volume of sample water retrieved from the Niskin bottles of the rosette sampler to yield a calibrated measurement of chlorophyll *a* in the water column.

Zooplankton samples were retrieved using four different plankton nets. The Neuston net skims the water and is designed to sample the plankton living at the water surface. Although this neuston community is but a small fraction of the total zooplankton biomass in the water column, it is useful as an indicator in marine habitat classification (Costello 2009). Neuston tows were conducted twice a day at hours closest to noon and midnight. A meter net with a 0.79 m^2 round opening was used to sample the total plankton community in a mixed layer by towing obliquely through the mixed layer at night.

Plankton biomass was measured using the displacement volume method (Postel 2000) and calculated to density using total filtered volume measured by net-mounted GeneralOcean flow meter. Qualitative analysis was done under a microscope in the shipboard laboratory underway. Taxonomic analysis was done on a varying basis—for example, to subclass level with copepods and to order level with pteropods and amphipods. Shannon-Weaner Index was used to calculate a diversity index. The same taxonomic resolution was used on both years, making the diversity indexes directly comparable in this data set. They should not, however, be compared directly with other studies.

Bathymetry.

A continuous profile of the sea floor was recorded using a Knudsen 3260 CHIRP profiler (Knudsen Engineering Limited, Perth ON, Canada). This data was used during the cruise to record station-by-station seafloor depth.

Data analysis.

All of the analysis and visualization in this report was performed using the freely available Ocean Data View (ODV, Schlitzer, R., Ocean Data View, http://odv.awi.de, 2018).

Data Description and Results

While underway data was collected from the EEZs of all the countries from whom we had obtained a research clearance (in addition to the countries mentioned in the cruise narrative, this included St. Lucia, France,United Kingdom, St. Kitts and Nevis), all of the 12 hydrocasts and 20 plankton tows took place within the EEZs of countries we cleared in and visited. During the hydrocast stations we deployed a 12-bottle rosette sampler to recover subsurface water samples for nutrient and chlorophyll a analyses. These casts also produced vertical CTD profiles with chlorophyll a fluorescence, oxygen concentrations, CDOM fluorescence, transmissivity and PAR irradiance were also recorded with onboard instruments.

Plankton samples were gathered using a neuston net, and 1-meter and 2-meter circular hoop nets, and analyzed for biovolume and 100-count diversity. A continuous record of the sea surface salinity, temperature, chlorophyll a concentration, turbidity, and CDOM concentration via the ship's flow-through system was also kept. In addition, surface currents to 600 meters were recorded with the ADCP, and a record of the seafloor profile was kept with a CHIRP sub-bottom profiler.

These data are summarized in figures 3-6, with numerical results and coordinates of plankton and hydrocast stations provided in Tables 1-6. The results are presented by the visited islands, and in order by which our visits took place. Although the lengthy

CHIRP and flow-through data are not part of this report, all unpublished data will be made available by arrangement with the Sea Education Association (SEA) data archivist (contact information, p. 2). The information in this report is not intended to represent final interpretation of the data and should not be excerpted or cited without written permission from SEA.

Figure 3 a-d. Grenada data summary.

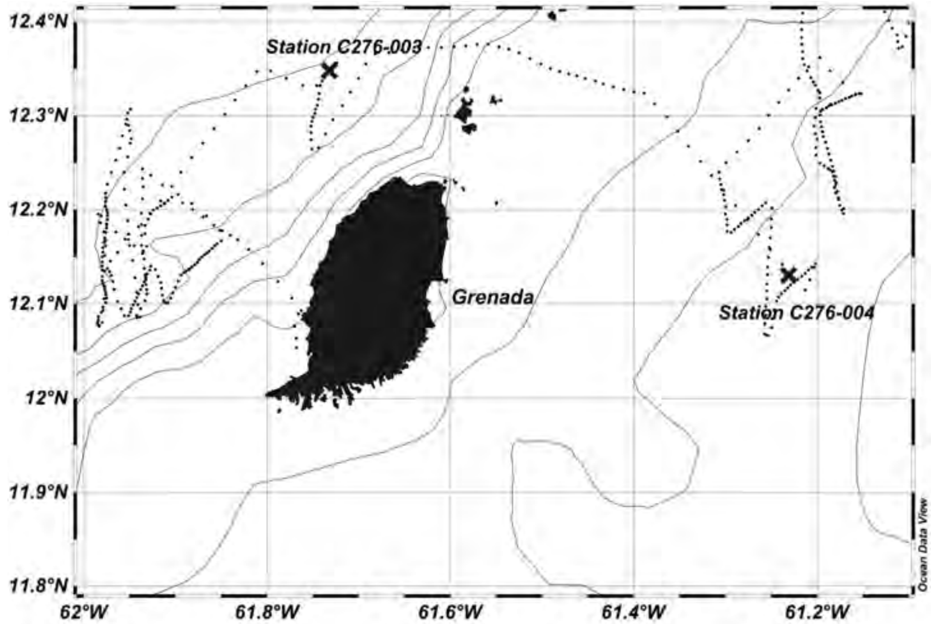


Figure 3a. Cruise track and station locations within the EEZ of Grenada.

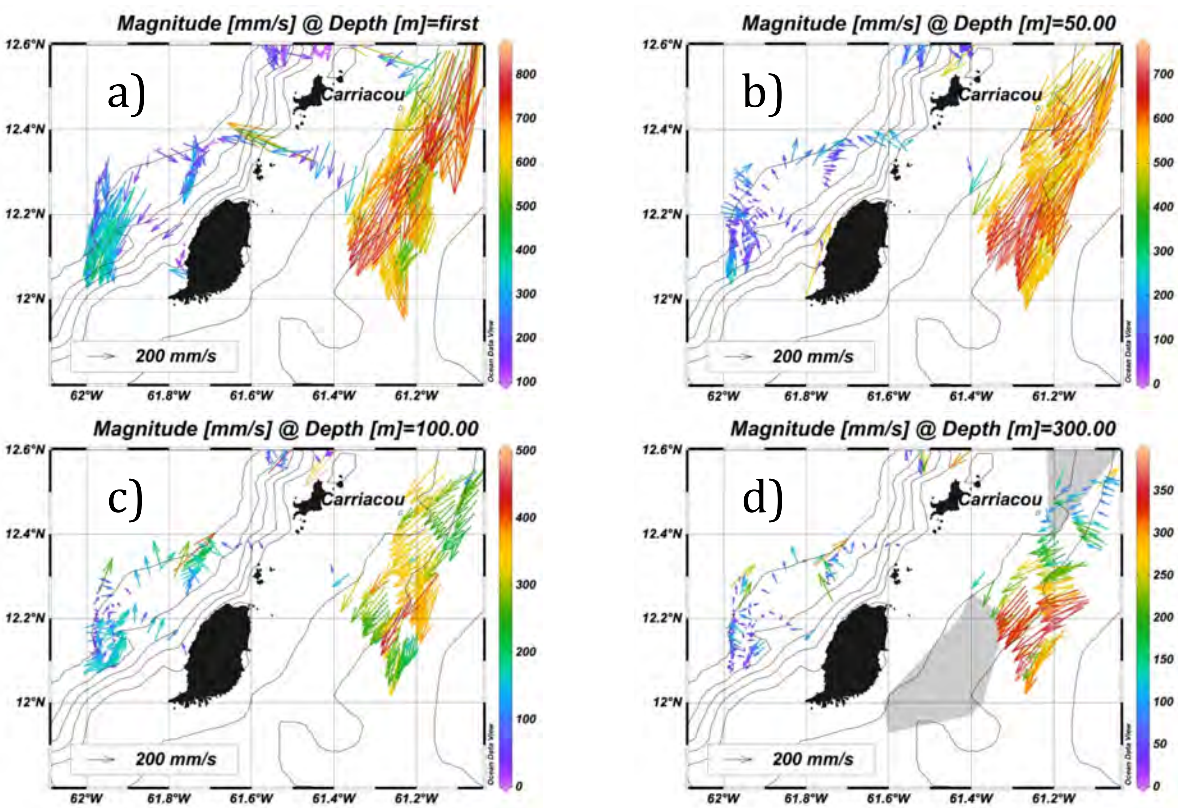


Figure 3b. Ocean currents at a) surface, b) 50m, c) 100m, and d) 300 depth. Data collected using ship mounted ADCP, each arrow represents 20 min. average value. Speed is represented both by length and color of the current arrows.

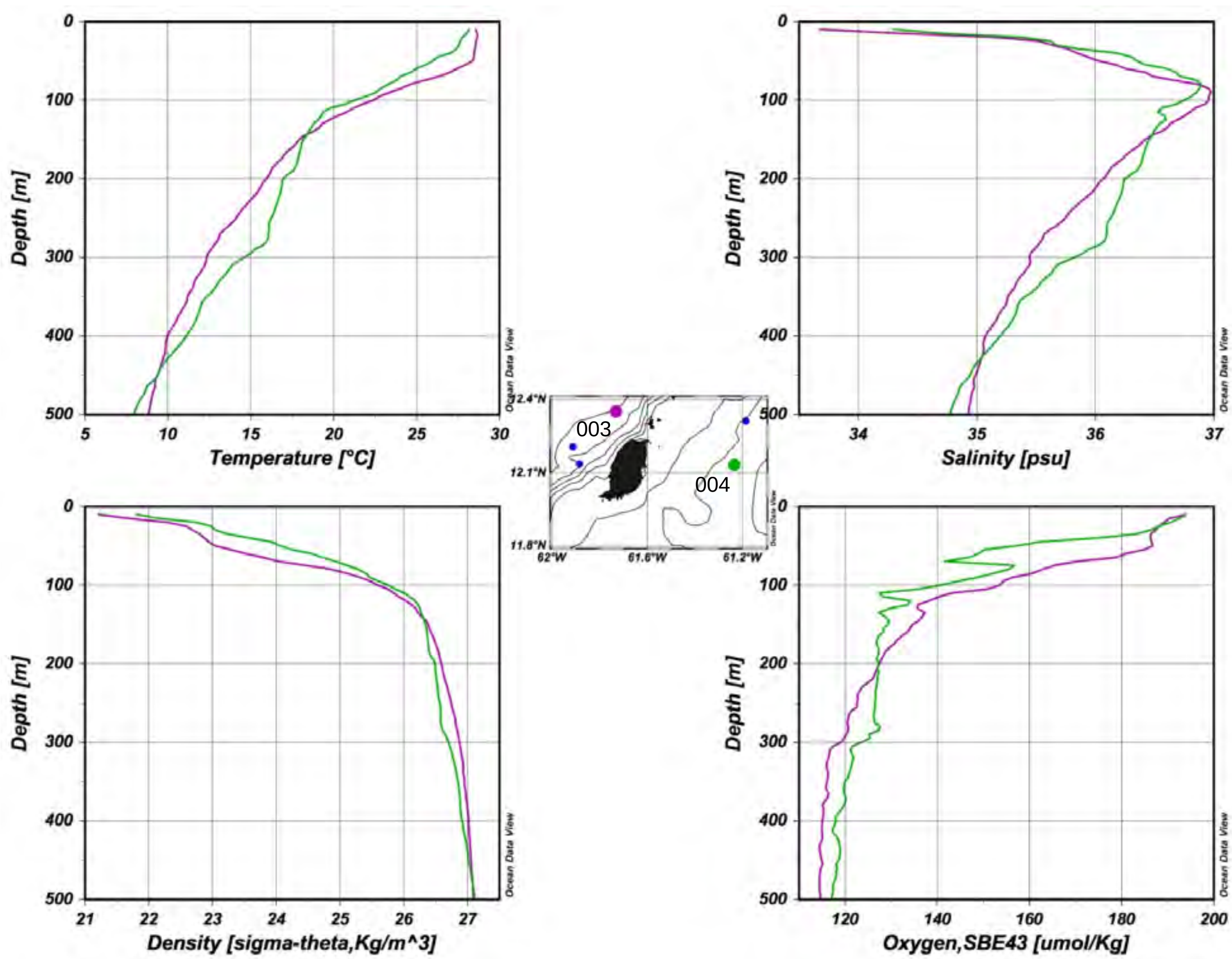


Figure 3c. Vertical profiles of a) temperature, b) salinity, c) density, and d) oxygen concentration from stations C276-003 and C276-004. The profiles show a clear differences between the two locations (see Table 1 for station coordinates) in all measured parameters. Most notable is the shoaling of the pycnocline (c), in turn with significant consequences for vertical mixing in the water column made visible in the changes in oxygen concentrations (d).

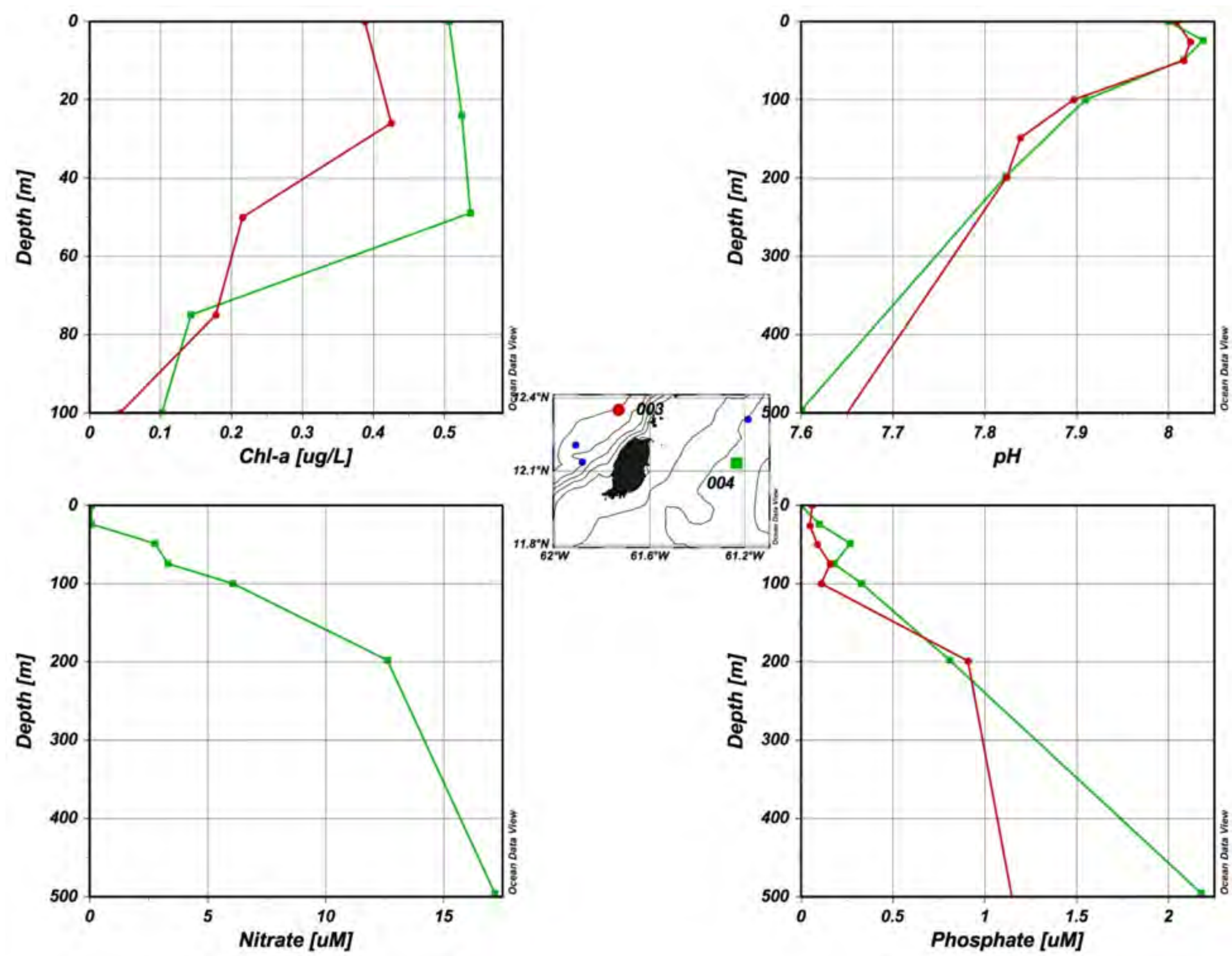


Figure 3d. Vertical profiles of a) chlorophyll a concentration, b) pH, c) Nitrate concentration, and d) phosphate concentration from stations C276-003 (red) and C276-004 (green). The profiles reflect similar differences as the underlying water columns stratification (Fig. 3c); note in particular the elevated chlorophyll a concentration of station 004. See Table 1 for station coordinates.

Figure 4 a-d. Tobago Cays Data Summary.

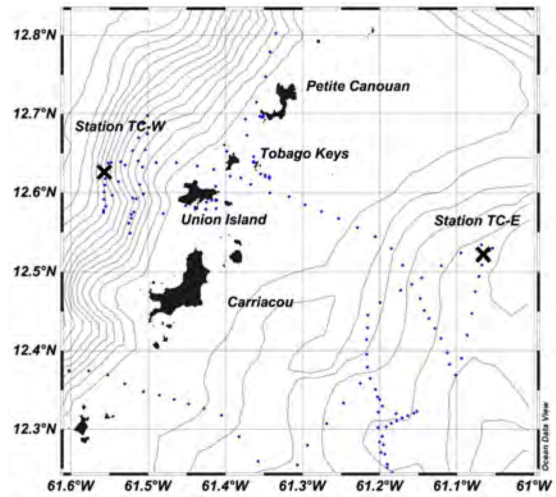


Figure 4a. Cruise track and station locations within the EEZ of Grenada.

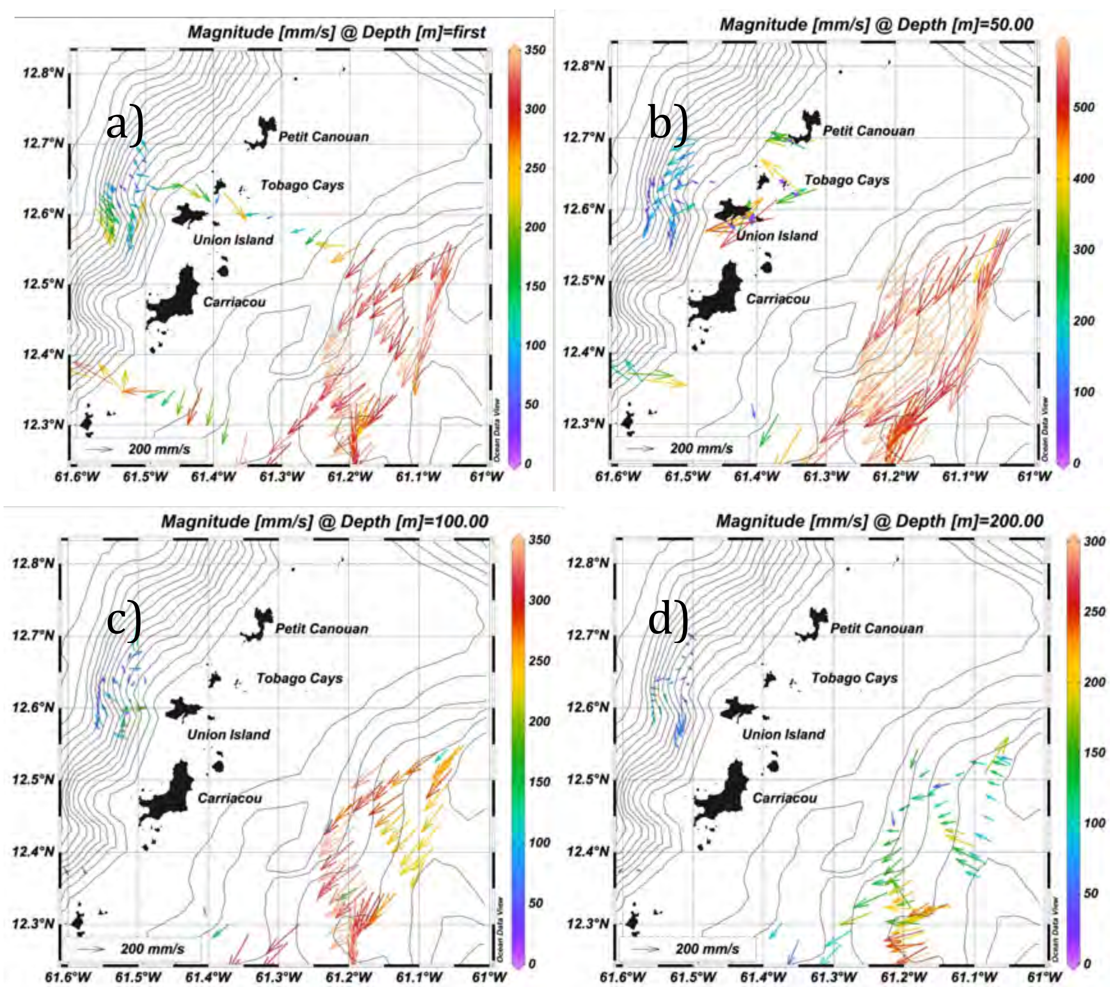


Figure 4b. Ocean currents at a) surface, b) 50m, c) 100m, and d) 200 depth. Data collected using ship mounted ADCP, each arrow represents 20 min. Average value. Speed is represented both by length and color of the current arrows.

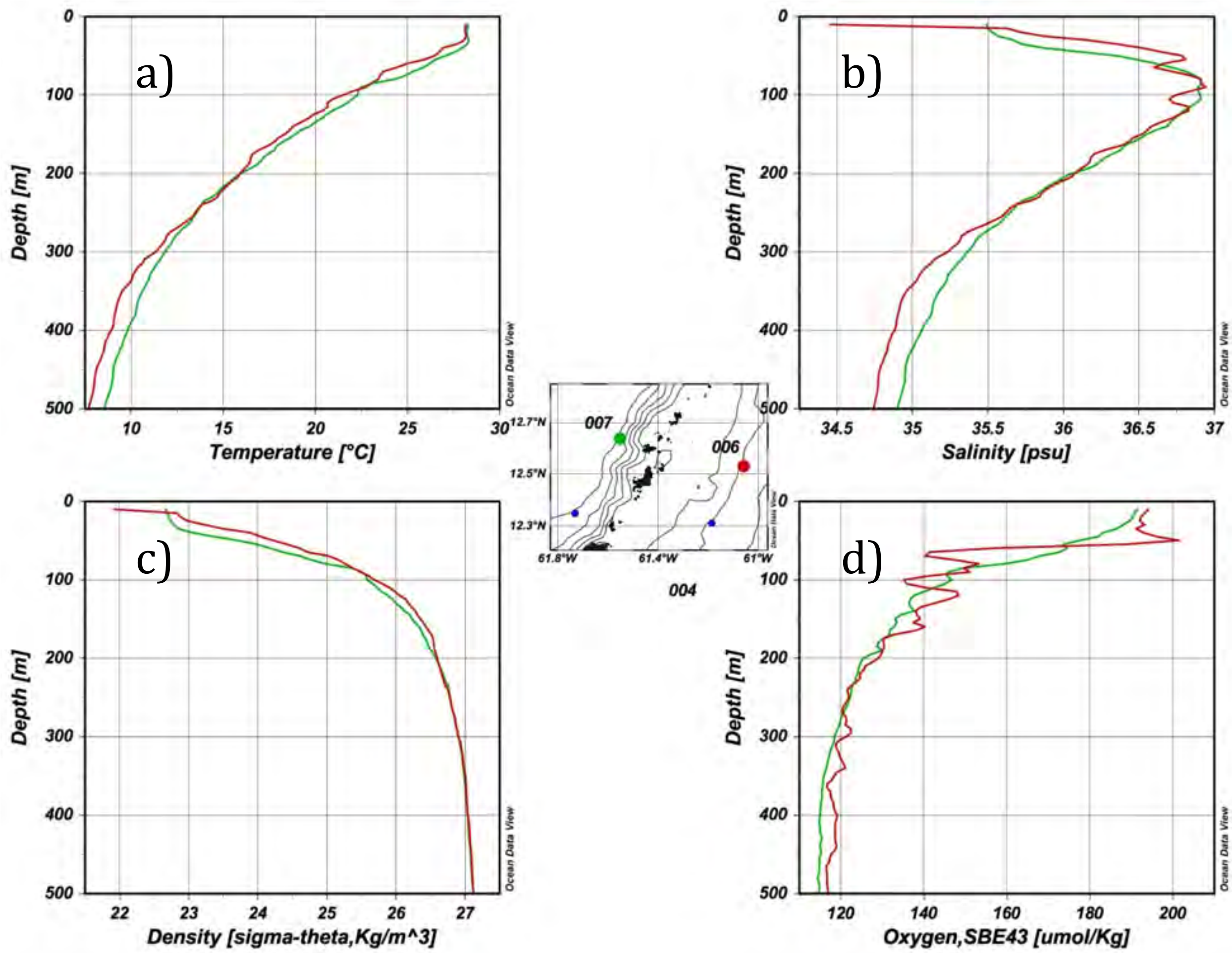


Figure 4c. Vertical profiles of a) temperature, b) salinity, c) density, and d) oxygen concentration from stations C276-006 and C276-007. As in the Grenada stations, there were considerable differences between the two locations (see Table 1 for station coordinates), particularly in the salinity and oxygen concentrations. The implication is a presence of considerable turbulent shear east of the island arc.

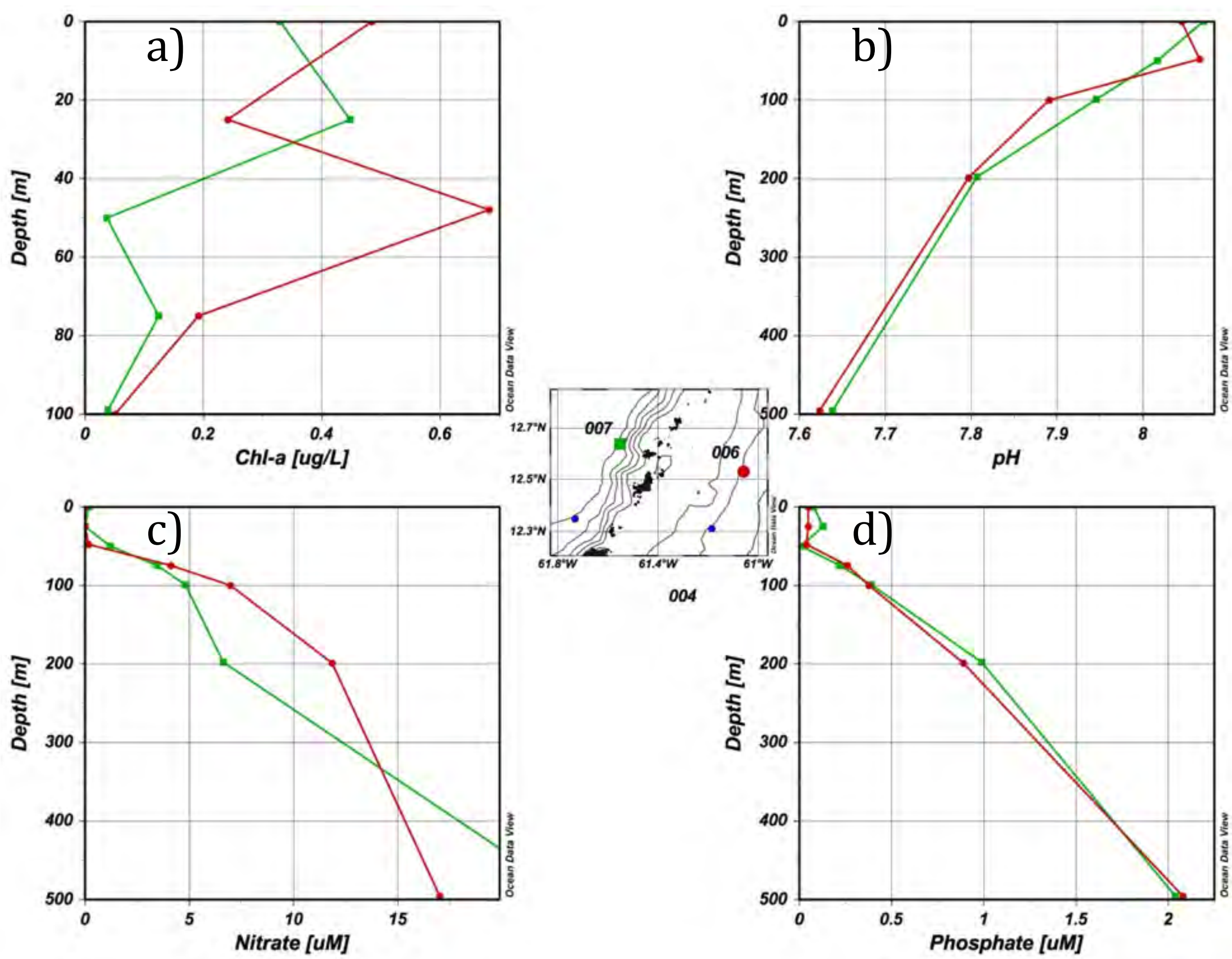
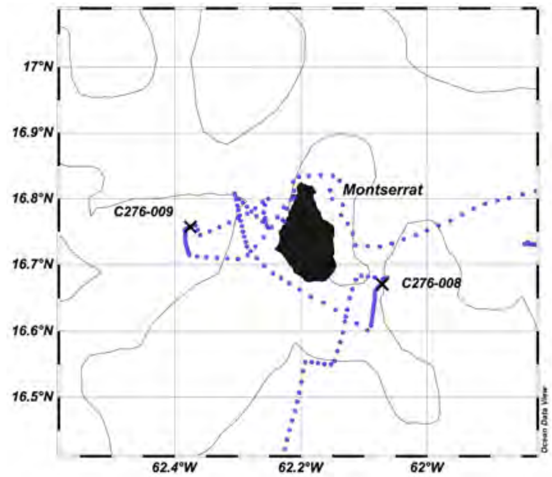


Figure 4d. Vertical profiles of a) chlorophyll a concentration, b) pH, c) Nitrate concentration, and d) phosphate concentration from stations C276-006 (red) and C276-007 (green). The large differences in Chlorophyll a (a) and nitrate concentrations between the stations is likely due to the same physical mixing processes seen in Fig. 4b. See Table 1 for station coordinates.

Figure 5 a-d. Montserrat Data Summary.



5a. Cruise track and station locations within the EEZ of Montserrat (UK).

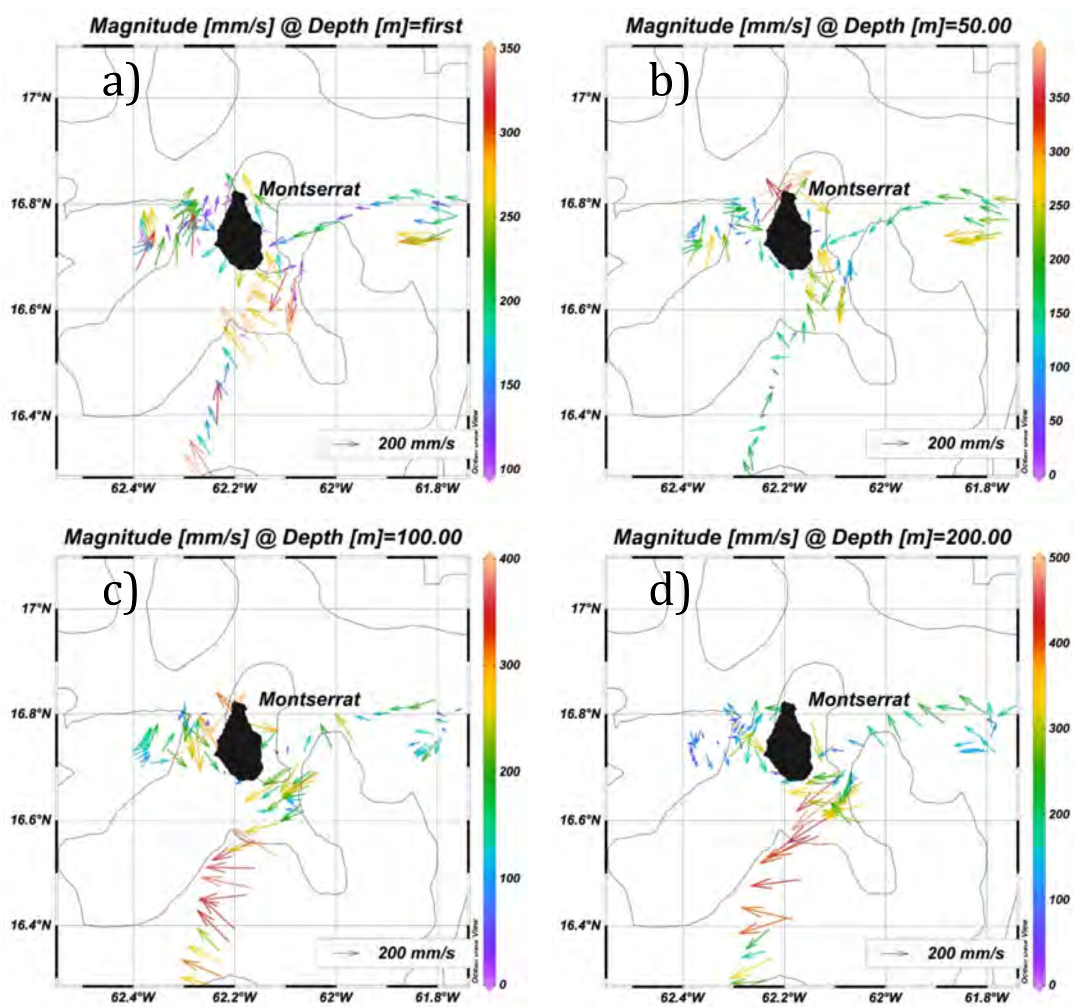


Figure 5b. Ocean currents at a) surface, b) 50m, c) 100m, and d) 200 depth. Data collected using ship mounted ADCP, each arrow represents 20 min. average value. Speed is represented both by length and color of the current arrows.

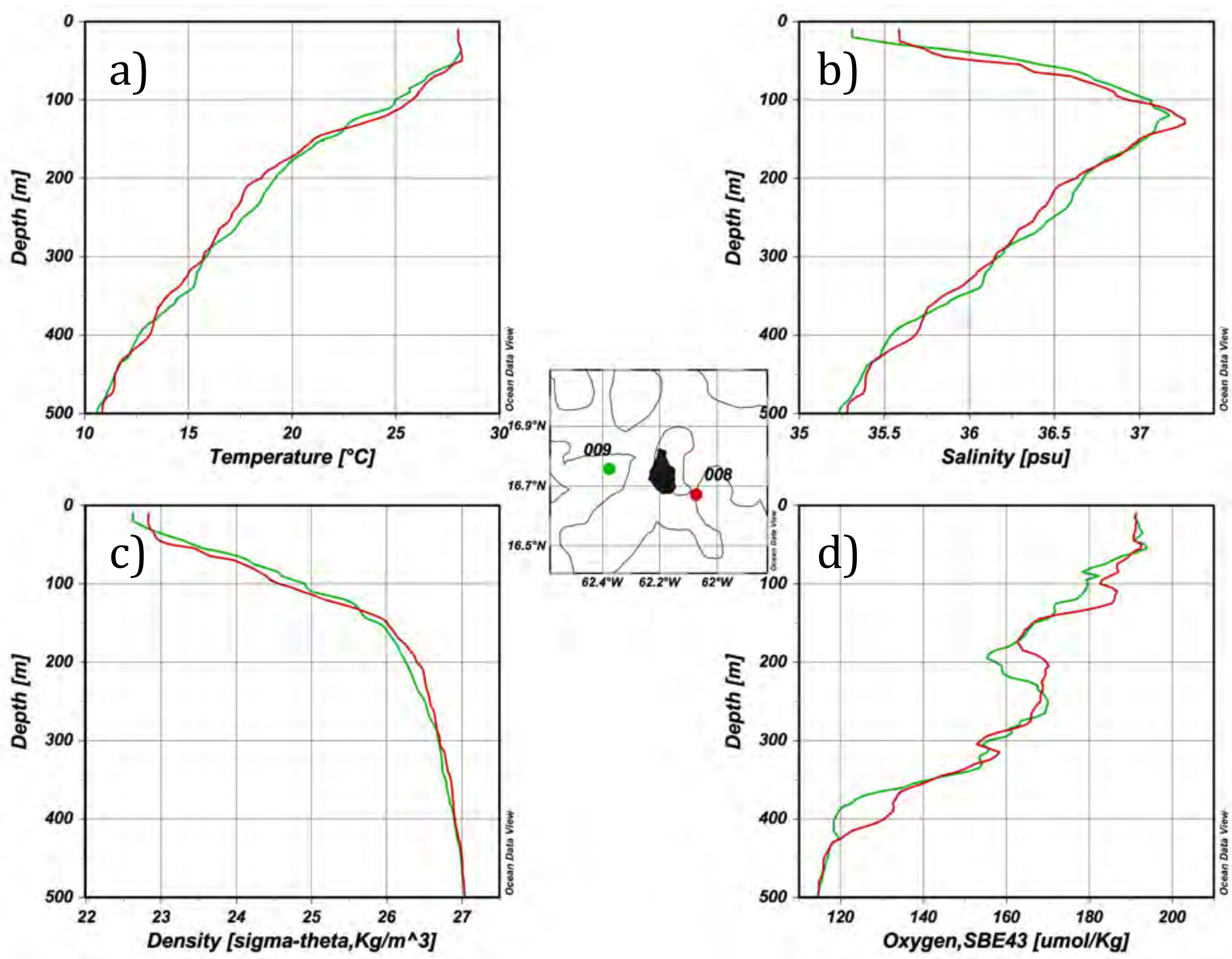


Figure 5c. Vertical profiles of a) temperature, b) salinity, c) density, and d) oxygen concentration from stations C276-008 (red) and C276-009 (green). Unlike the previous two islands, the stations by Montserrat did not exhibit significant differences. See Table 1 for station coordinates.

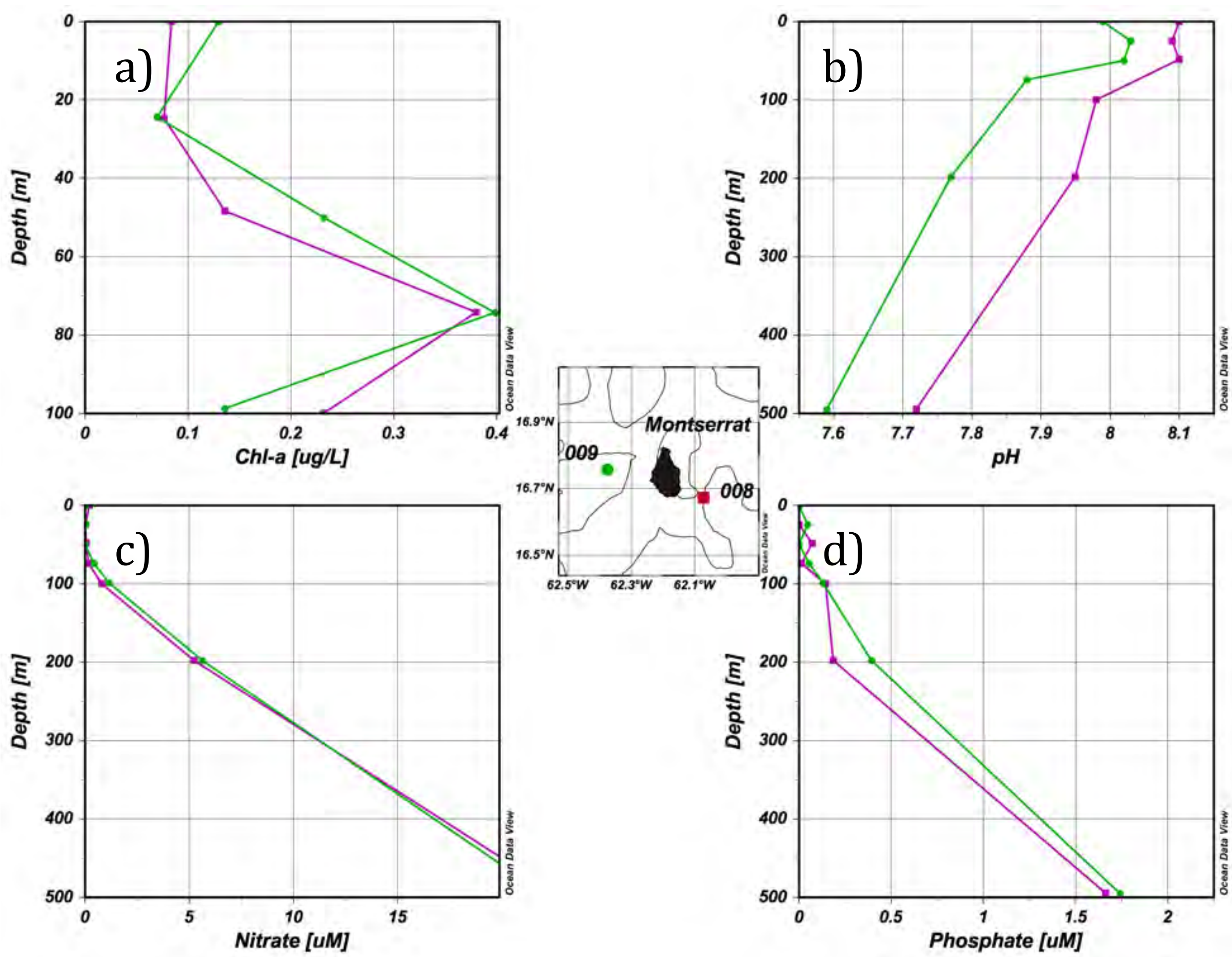
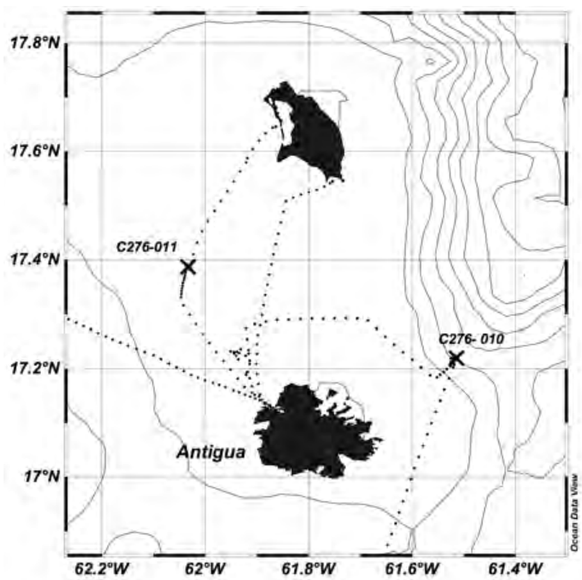


Figure 5d. Vertical profiles of a) chlorophyll a concentration, b) pH, c) Nitrate concentration, and d) phosphate concentration from stations C276-008 (red) and C276-009 (green). As with the profiles of physical parameters (Fig. 5c), the chemical and biological parameters are similar on both stations. An exception is pH, which could be a result of on-going volcanic activity of the Mt. Soufriere volcano on the island. See Table 1 for station coordinates.

Figure 6 a-d. Grenada data summary.



6a. Cruise track and station locations within the EEZ of Antigua and Barbuda.

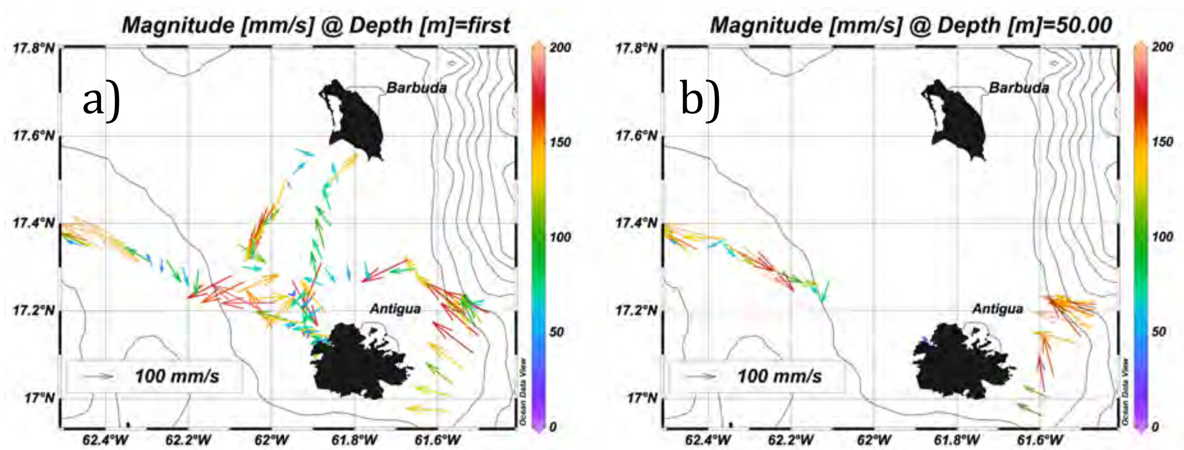


Figure 6b. Ocean currents at a) surface, b) 50m depth. The depth of the Barbuda Bank is less than 100m, so only the shallow depths are shown. Data collected using ship mounted ADCP, each arrow represents 20 min. average value. Speed is represented both by length and color of the current arrows.

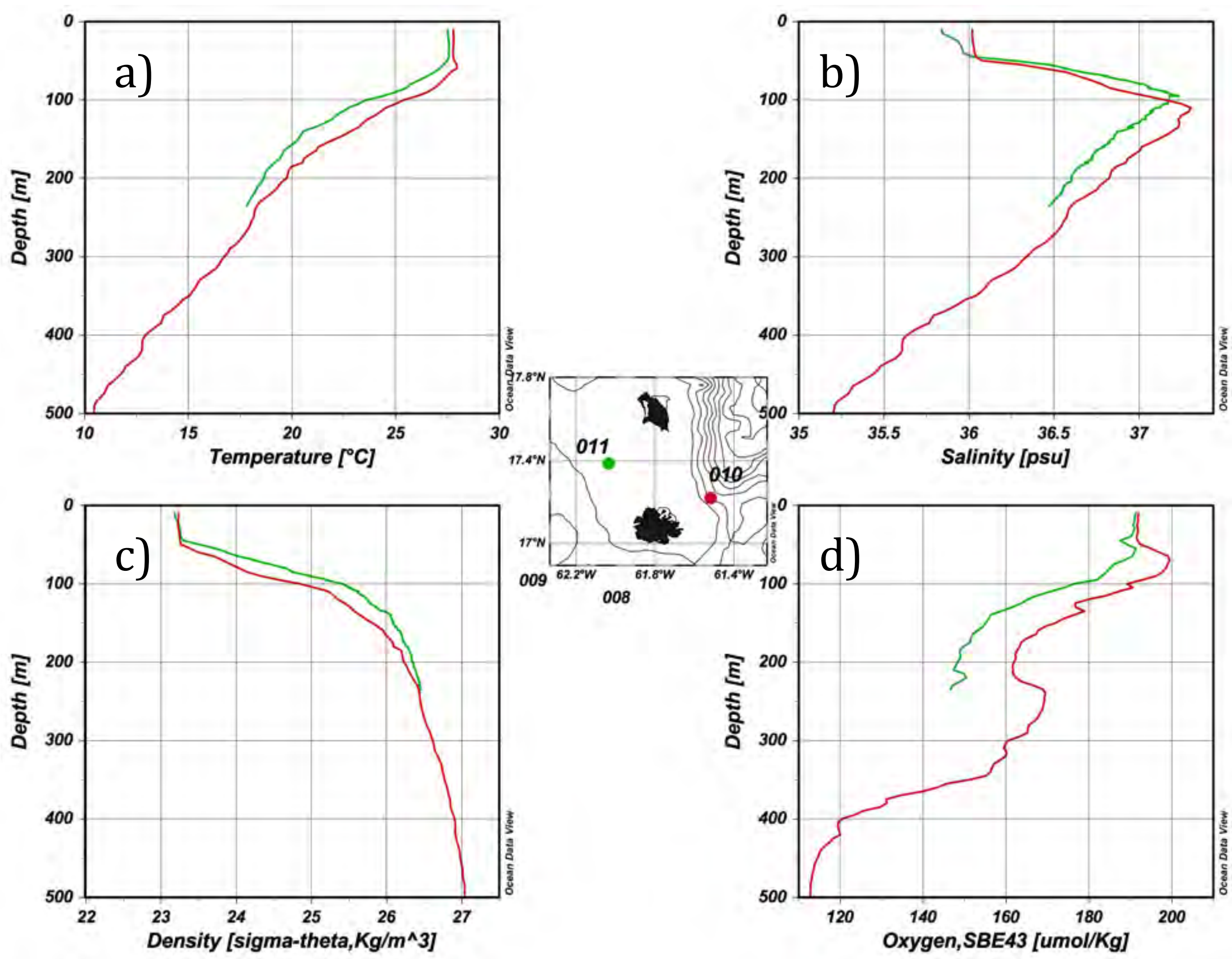


Figure 6c. Vertical profiles of a) temperature, b) salinity, c) density, and d) oxygen concentration from stations C276-010 (red) and C276-011 (green). Unlike with previous islands, the width of the shallow Barbuda Bank prevented us from sampling at equivalent 1000m isobath. The effects of the bank are readily seen in the warmer water and resulting shallower pycnocline and lower oxygen concentration. See Table 1 for station coordinates.

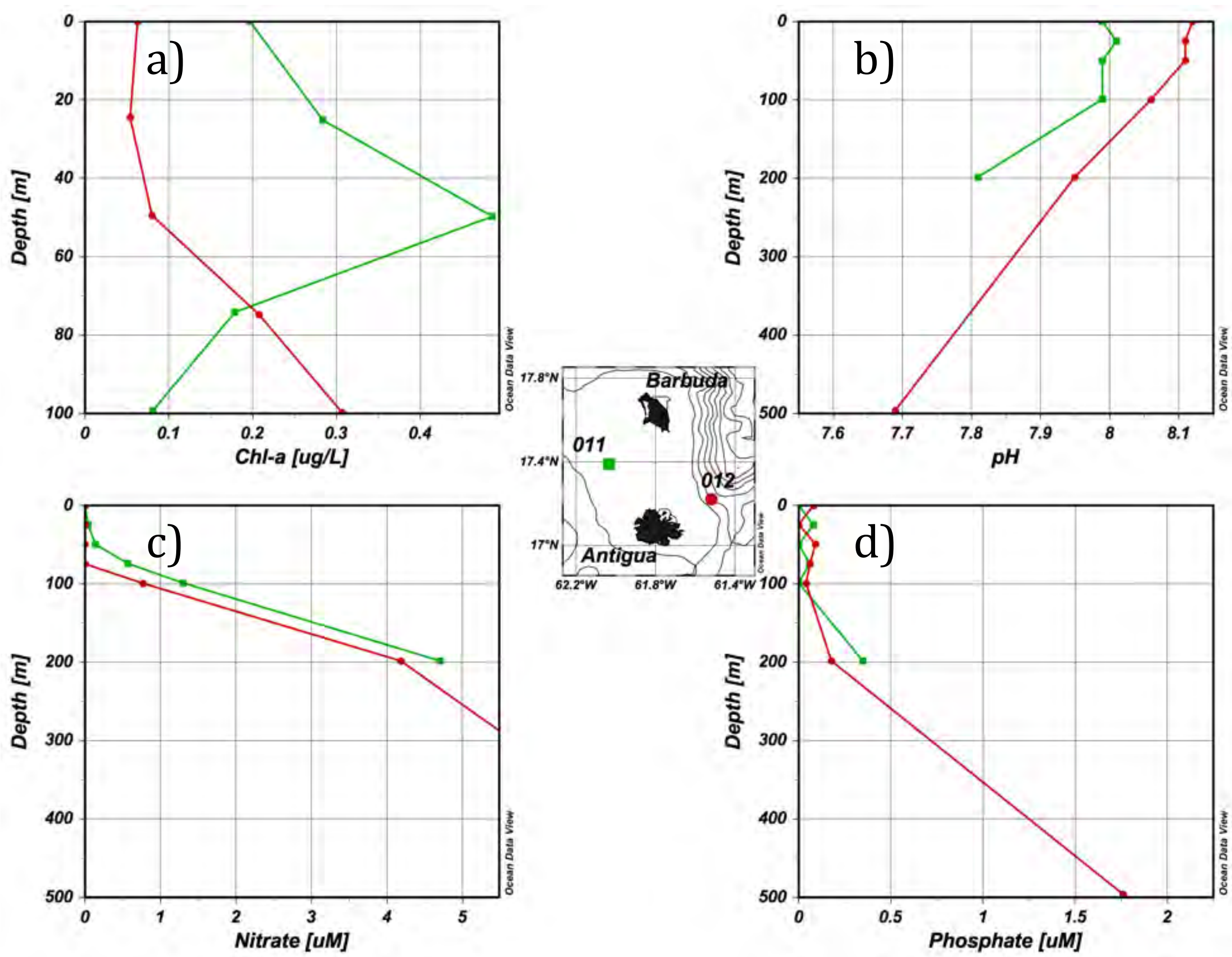


Figure 6d. Vertical profiles of a) chlorophyll a concentration, b) pH, c) Nitrate concentration, and d) phosphate concentration from stations C276-012 (red) and C276-011 (green). As with the physical water column structure, the presence of the shallow Barbuda Bank is readily detected in the elevated chlorophyll a concentration at station 011. The depressed pH signal at the downstream (011) station suggests increased net community respiration in the shallow bank over the oceanic, pelagic condition of station 012.

Table 1. Hydrocast (HC) station locations

Station	Date	Time (UTC)	Lat (˚N)	Lon (˚W)
C276-001-HC	27-Nov-17	14:56	12.207	-61.912
C276-002-HC	28-Nov-17	11:29	12.137	-61.918
C276-003-HC	28-Nov-17	21:42	12.350	-61.730
C276-004-HC	29-Nov-17	10:01	12.132	-61.232
C276-005-HC	29-Nov-17	21:38	12.312	-61.685
C276-006-HC	30-Nov-17	10:03	12.530	-61.058
C276-007-HC	30-Nov-17	21:36	12.638	-61.550
C276-008-HC	7-Dec-17	22:12	16.672	-62.072
C276-009-HC	8-Dec-17	8:57	16.757	-62.375
C276-010-HC	13-Dec-17	21:55	17.220	-61.517
C276-011-HC	19-Dec-17	11:10	17.387	-62.033

Table 2. Neuston Net Stations

Station	Date	Time (UTC)	Lat (˚N)	Lon (˚W)
C276-002-NT	28-Nov-17	12:19	12.122	-61.898
C276-003-NT	28-Nov-17	23:45	12.295	-61.752
C276-004-NT	29-Nov-17	10:54	12.090	-61.248
C276-005-NT	29-Nov-17	23:45	12.255	-61.185
C276-006-NT	30-Nov-17	11:00	12.510	-61.072
C276-007-NT	30-Nov-17	23:23	12.600	-61.557
C276-008-NT	8-Dec-17	0:08	16.615	-62.087
C276-009-NT	8-Dec-17	10:47	16.728	-62.382
C276-010-NT	13-Dec-17	23:48	17.202	-61.548
C276-011-NT	19-Dec-17	12:29	17.353	-62.043
C276-012-NT	20-Dec-17	1:50	17.375	-62.473
C276-013-NT	20-Dec-17	11:39	17.940	-63.182
C276-014-NT	20-Dec-17	23:10	18.140	-63.450

Table 3. Meter Net and 2-Meter Net Stations

Station	Date	Time (UTC)	Lat (˚E)	Lon (˚W)
C276-003-MN	28-Nov-17	22:45	12.323	-61.743
C276-005-MN	29-Nov-17	22:34	12.295	-61.197

Station	Date	Time (UTC)	Lat (˚E)	Lon (˚W)
C276-007-MN	30-Nov-17	22:25	12.623	-61.555
C276-008-MN	7-Dec-17	23:03	16.652	-62.082
C276-009-MN	8-Dec-17	9:49	16.747	-62.383
C276-010-MN	13-Dec-17	22:52	17.212	-61.523
C276-011-MN	19-Dec-17	11:40	17.378	-62.038

Table 4. Hydrocast Data Summary.

Blank cells indicate no analysis was performed. DNF indicates bottle did not close.

Station	Depth (m)	Temp (˚C)	Sal. (psu)	Oxygen (ml/l)	PO4 (µmol/Kg)	Nitrate (µmol/Kg)	Chl a (µg/l)
C276-001-HC	0.0	28.9	33.51	-			
C276-001-HC	10.028	28.6621	33.6504	4.50822			
C276-001-HC	25.143	28.6959	34.7015	4.36628			
C276-001-HC	50.399	28.412	35.9924	4.28562			
C276-001-HC	74.896	25.8253	36.6194	3.8613			
C276-001-HC	99.563	23.4878	36.9437	3.58238			
C276-001-HC	124.371	21.7423	36.9381	3.47855			
C276-001-HC	149.502	20.4414	36.8096	3.38011			
C276-001-HC	198.79	17.3105	36.3218	3.03092			
C276-001-HC	248.632	14.2648	35.7938	2.83663			
C276-001-HC	298.055	12.4265	35.4622	2.76589			
C276-001-HC	397.165	10.4633	35.1668	2.65736			
C276-001-HC	474.856	9.1454	34.9789	2.64811			
C276-002-HC	0	28.7	33.94		0.021	0.011	0.403
C276-002-HC	24.65	28.6	35.43		0.016	0.011	0.521
C276-002-HC	49.942	27.9	36.17		0.000	0.348	0.226
C276-002-HC	74.617	24.2	36.89		0.197	3.419	0.102
C276-002-HC	99.207	22.2	37.00		0.286	5.042	0.045
C276-002-HC	124.15	20.4	36.79				
C276-002-HC	149.039	18.5	36.51				
C276-002-HC	198.8	16.1	36.09		0.912	15.337	
C276-002-HC	248.722	13.9	35.73				
C276-002-HC	297.913	12.3	35.44				
C276-002-HC	397.096	10.1	35.10				
C276-002-HC	DNC	8.5	34.90				
C276-002-HC	537.153	8.0	34.82				

Station	Depth (m)	Temp (˚C)	Sal. (psu)	Oxygen (ml/l)	PO4 (µmol/Kg)	Nitrate (µmol/Kg)	Chl a (µg/l)
C276-003-HC	0	28.7	33.60	-	0.060		0.388
C276-003-HC	25.5	28.6	35.55	4.29437	0.046		0.425
C276-003-HC	49.939	28.4	36.02	4.28444	0.090		0.216
C276-003-HC	74.997	25.4	36.74	3.81853	0.163		0.178
C276-003-HC	99.532	22.4	36.97	3.52967	0.114		0.043
C276-003-HC	125.23	19.9	36.75	3.12864			
C276-003-HC	149.3	18.0	36.45	3.09629			
C276-003-HC	198.673	16.0	36.09	2.9371	0.912		
C276-003-HC	248.388	14.2	35.77	2.82219			
C276-003-HC	197.655	12.3	35.46	2.74473			
C276-003-HC	397.523	10.0	35.10	2.64975			
C276-003-HC	496.4	8.8	34.94	2.63359			
C276-003-HC	516.225	8.7	34.92	2.63425	1.159		
C276-004-HC	0	28.3636	34.2753	-	0.000	0.085	0.507
C276-004-HC	24.375	27.6389	35.6349	4.3132	0.100	0.069	0.525
C276-004-HC	48.859	26.0491	36.3584	3.66877	0.271	2.765	0.537
C276-004-HC	74.847	23.8018	36.8901	3.62752	0.183	3.325	0.143
C276-004-HC	99.508	21.3158	36.8135	3.23277	0.325	6.084	0.102
C276-004-HC	124.491	19.1361	36.61	3.10256			
C276-004-HC	148.913	18.1849	36.4783	2.97882			
C276-004-HC	197.994	16.9277	36.2681	2.92503	0.814	12.631	
C276-004-HC	247.056	16.2784	36.1647	2.90994			
C276-004-HC	298.301	14.7854	35.9069	2.87042			
C276-004-HC	397.447	11.1744	35.2241	2.71638			
C276-004-HC	496.363	7.9443	34.788	2.69277	2.179	17.187	
C276-004-HC	549.429	7.2492	34.725	2.71352			
C276-005-HC	0	28.5	33.29	-	0.051		0.527
C276-005-HC	24.536	27.9561	35.7888	4.30792	0.080		0.457

Station	Depth (m)	Temp (˚C)	Sal. (psu)	Oxygen (ml/l)	PO4 (µmol/Kg)	Nitrate (µmol/Kg)	Chl a (µg/l)
C276-005-HC	49.682	25.3449	36.5212	3.59456	0.193		0.460
C276-005-HC	74.78	23.5065	36.8419	3.4124	0.237		0.102
C276-005-HC	99.23	21.704	36.7534	3.16063	0.423		0.059
C276-005-HC	124.271	20.127	36.6827	3.12803			
C276-005-HC	149.418	18.4751	36.5151	3.07881			
C276-005-HC	198.555	16.2534	36.144	2.91454	0.917		
C276-005-HC	247.883	15.2613	35.964	2.88506			
C276-005-HC	297.75	12.9771	35.5462	2.80537			
C276-005-HC	397.083	9.7708	35.0101	2.64559			
C276-005-HC	496.7	8.4469	34.8223	2.68922	2.077		
C276-005-HC	569.282	7.635	34.7381	2.70846			
C276-006-HC	0	28.4	33.29		0.046	0.025	0.485
C276-006-HC	24.988	28.2083	35.8718	4.40333	0.051	0.000	0.241
C276-006-HC	48.419	26.5485	36.7928	4.60636	0.041	0.184	0.683
C276-006-HC	75.238	23.5326	36.8303	3.38261	0.261	4.117	0.192
C276-006-HC	99.803	21.5013	36.8244	3.08743	0.383	6.986	0.051
C276-006-HC	123.871	19.9236	36.7967	3.36757			
C276-006-HC	149.376	18.4374	36.607	3.20567			
C276-006-HC	198.892	15.9493	36.0988	2.97412	0.892	11.858	
C276-006-HC	248.371	13.5239	35.6308	2.81094			
C276-006-HC	298.072	11.4454	35.254	2.80749			
C276-006-HC	396.945	9.0305	34.8945	2.72829			
C276-006-HC	496.297	7.7383	34.7529	2.68707	2.082	17.011	
C276-006-HC	561.966	7.2256	34.7084	2.72411			
C276-007-HC	0	28.5	35.51		0.080	0.191	0.330
C276-007-HC	24.807	28.2583	35.5586	4.35286	0.134	0.008	0.448
C276-007-HC	49.73	27.098	36.4029	4.09547	0.011	1.196	0.037
C276-007-HC	74.591	24.9731	36.8899	3.79205	0.217	3.463	0.125

Station	Depth (m)	Temp (°C)	Sal. (psu)	Oxygen (ml/l)	PO4 (µmol/Kg)	Nitrate (µmol/Kg)	Chl a (µg/l)
C276-007-HC	99.255	22.3192	36.9076	3.36185	0.393	4.808	0.039
C276-007-HC	123.898	20.6344	36.7833	3.1407			
C276-007-HC	149.073	18.9839	36.5886	3.05359			
C276-007-HC	198.44	16.0732	36.1163	2.88959	0.985	6.646	
C276-007-HC	248.359	13.61	35.6777	2.81501			
C276-007-HC	297.979	11.9037	35.3771	2.73034			
C276-007-HC	396.906	9.8759	35.0797	2.64552			
C276-007-HC	496.364	8.5899	34.9106	2.64153	2.038	23.277	
C276-007-HC	583.025	7.5653	34.7989	2.697			
C276-008-HC	0	28.1	35.56		0.000	0.219	0.084
C276-008-HC	24.712	28.0219	35.5898	4.38746	0.000	0.027	0.077
C276-008-HC	48.405	28.1821	35.986	4.40853	0.072	0.073	0.136
C276-008-HC	74.169	26.6658	36.6541	4.28333	0.013	0.182	0.380
C276-008-HC	99.95	25.8169	36.9063	4.16207	0.145	0.814	0.232
C276-008-HC	124.677	24.1042	37.327	4.27465			
C276-008-HC	148.652	21.0983	37.0293	3.84542			
C276-008-HC	198.119	18.5483	36.6466	3.88884	0.188	5.244	
C276-008-HC	248.937	17.078	36.3913	3.87138			
C276-008-HC	297.519	15.7519	36.1599	3.54985			
C276-008-HC	395.913	13.2115	35.7126	3.02301			
C276-008-HC	494.962	10.8638	35.288	2.64221	1.663	22.626	
C276-008-HC	561.63	10.3578	35.2426	2.61037			
C276-009-HC	0	28.1	35.29	-	0.000	0.000	0.130
C276-009-HC	24.358	28.0159	35.4308	4.39159	0.047	0.042	0.070
C276-009-HC	50.018	27.866	36.3009	4.42655	0.000	0.005	0.232
C276-009-HC	74.307	26.4508	36.7327	4.22833	0.057	0.445	0.398
C276-009-HC	98.773	24.9679	37.0574	4.13817	0.130	1.150	0.136
C276-009-HC	123.976	22.9967	37.1625	3.95066			

Station	Depth (m)	Temp (˚C)	Sal. (psu)	Oxygen (ml/l)	PO4 (µmol/Kg)	Nitrate (µmol/Kg)	Chl a (µg/l)
C276-009-HC	148.323	21.8472	37.1253	3.87787			
C276-009-HC	198.266	19.2186	36.6809	3.57891	0.393	5.636	
C276-009-HC	248.593	17.6646	36.5176	3.90517			
C276-009-HC	297.724	15.9086	36.2121	3.62942			
C276-009-HC	397.161	12.6761	35.5714	2.73448			
C276-009-HC	495.495	10.5564	35.2387	2.63258	1.741	22.007	
C276-009-HC	553.979	9.6854	35.1189	2.62241			
C276-010-HC	0	27.9	35.99	-	0.081	0.000	0.063
C276-010-HC	24.47	27.8027	36.0216	4.39044	0.000	0.000	0.054
C276-010-HC	49.439	27.804	36.046	4.3989	0.091	0.000	0.080
C276-010-HC	74.776	27.3112	36.7212	4.56283	0.062	0.000	0.208
C276-010-HC	99.712	25.3239	37.2049	4.31105	0.042	0.772	0.307
C276-010-HC	124.532	23.6151	37.2525	4.06119			
C276-010-HC	148.554	22.1182	37.1276	3.95929			
C276-010-HC	198.399	19.7381	36.8368	3.7247	0.179	4.184	
C276-010-HC	248.309	18.1485	36.5809	3.89224			
C276-010-HC	297.784	16.7803	36.3761	3.70256			
C276-010-HC	396.899	13.0322	35.6797	2.81593			
C276-010-HC	496.286	10.4208	35.2079	2.59458	1.761	8.541	
C276-010-HC	581.692	8.747	34.9615	2.60865			
C276-011-HC	0	27.7	35.80	-	0.000	0.001	0.197
C276-011-HC	25.202	27.5563	35.93	4.36252	0.082	0.045	0.284
C276-011-HC	49.722	27.4888	36.2575	4.32644	0.000	0.144	0.486
C276-011-HC	74.188	26.1532	36.9017	4.28337	0.060	0.570	0.179
C276-011-HC	99.313	23.5801	37.1759	4.04782	0.000	1.303	0.081
C276-011-HC	123.748	21.9803	37.0357	3.78085			
C276-011-HC	149.213	20.341	36.8502	3.57774			
C276-011-HC	198.61	18.6469	36.6103	3.41228	0.349	4.703	

Station	Depth (m)	Temp (˚C)	Sal. (psu)	Oxygen (ml/l)	PO4 (µmol/Kg)	Nitrate (µmol/Kg)	Chl a (µg/l)
C276-011-HC	227.909	17.9246	36.5089	3.40183			
C276-011-HC	230.618	17.889	36.5014	3.3834			
C276-011-HC	232.46	17.8481	36.4887	3.36682			
C276-011-HC	233.844	17.8138	36.4881	3.36261			
C276-011-HC	235.158	17.7839	36.4775	3.36591			

Table 5. Neuston net data summary

Station	Tow distance	Biovolume (ml)	Density (ml*m-2)	Shannon-Weaver diversity
C276-002-NT	2104	28.5	0.0135	0.42
C276-003-NT	2141	16.0	0.0075	0.64
C276-004-NT	2929	11.0	0.0038	0.73
C276-005-NT	1898	57.0	0.0300	0.31
C276-006-NT	1891	5.5	0.0029	0.61
C276-007-NT	1719	29.0	0.0169	0.55
C276-008-NT	2092	13.0	0.0062	0.35
C276-009-NT	1426	1.8	0.0013	0.48
C276-010-NT	2769	6.5	0.0023	0.46
C276-011-NT	1712	2.5	0.0015	0.47
C276-012-NT	1677	15.0	0.0089	0.67
C276-013-NT	1840	2.5	0.0014	0.44
C276-014-NT	2781	13.0	0.0047	0.52

Table 6. Meter net data summary

Station	Tow distance	Tow Depth	Biovolume (ml)	Density (ml*m-2)	Shannon-Weaver diversity
C276-003-MN	2099	120.0	56.0	0.0340	0.36
C276-005-MN	1163	205.6	68.5	0.0750	0.50
C276-007-MN	1390	192.0	49.5	0.0454	0.34
C276-008-MN	1319	222.0	37.5	0.0362	0.30
C276-009-MN	1388	256.6	8.0	0.0073	0.45
C276-010-MN	1316	248.9	18.0	0.0174	0.31
C276-011-MN	1542	217.0	75.0	0.0620	0.60