R/V *Oceanus* Cruise #473 'Ocean Acidification Pteropod Study' Cruise Report

August 7 – September 1, 2011

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NSF Ocean Acidification Program Grant # OCE-1041068 (PIs: Lawson, Lavery, Wang, Wiebe)
"*Horizontal and Vertical Distribution of Thecosome Pteropods in Relation to Carbonate Chemistry in the Northwest Atlantic and Northeast Pacific*"

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1. Acknowledgements

The success of this cruise would not have been possible without the outstanding efforts of Captain Mello and the Oceanus' officers and crew, and we are very appreciative of their hard work. A strong sense of camaraderie and collaboration among scientists and crew pervaded. Steve Sniezak's work in the galley, and willingness to accommodate the schedule of the night watch and the dietary restrictions of the science party, wer particularly appreciated. We are also grateful for the efforts of the Port Office and Scientific Shipboard Support Group prior to the cruise with respect to planning and installing all equipment. This cruise was supported by NSF grant OCE-1041068.

2. Background

The impact of ocean acidification on marine ecosystems represents a vital question facing both marine scientists and managers of ocean resources. Thecosome pteropods are a group of calcareous planktonic molluscs widely distributed in coastal and open ocean pelagic ecosystems of the world's oceans. These animals secrete an aragonite shell and thus are highly sensitive to ocean acidification due to the water column's changing carbonate chemistry, and particularly the shoaling of the aragonite compensation depth at which seawater becomes corrosive to aragonite. In many regions, however, relatively little is known about the abundance, distribution, vertical migratory behavior, and ecological importance of pteropods. Assessing the likely ecosystem consequences of changes in pteropod dynamics resulting from ocean acidification will require a detailed understanding of pteropod distribution and abundance relative to changing aragonite saturation in the water column.

The primary objective of this project is to quantify the distribution, abundance, species composition, shell condition, and vertical migratory behavior of oceanic thecosome pteropods in the northwest Atlantic and northeast Pacific, and correlate these quantities to hydrography and concurrent measurements of carbonate chemistry, including vertical and horizontal distributions of aragonite saturation. In particular, the project is capitalizing on present-day variability in the depth distribution of aragonite saturation levels within and between the Atlantic and Pacific Oceans as a 'natural experiment' to address the hypotheses that pteropod vertical distribution, species composition, and abundance vary as the compensation depth becomes shallower. Secondary objectives are to develop acoustic protocols for the remote quantification of pteropod abundance for future integration into ocean acidification monitoring networks, and to characterize carbonate chemistry and nutrients along portions of two WOCE/CLIVAR Repeat Hydrography transects (A20 in the Atlantic and P17N in the Pacific) to identify decadal-scale changes in the carbonate system.

To this end, our inter-disciplinary team is conducting two 26-day cruises along survey transects between 35 and 50°N in the northwest Atlantic (2011 cruise) and northeast Pacific (2012 cruise) involving a combination of station-work and underway measurements, and a comprehensive array of instruments, including acoustic, optical, net, hydrographic, and carbonate chemistry sensors. The first project cruise took place from August 7 – September 1, 2011, on the R/V *Oceanus*. This is an NSF-funded project with WHOI scientists Gareth Lawson, Andone Lavery, Peter Wiebe, and Zhaohui 'Aleck' Wang as PIs.

3. Cruise Objectives

The central goal of this cruise was to sample various aspects of the biology of pteropods and other associated zooplankton concurrent to sampling of the carbonate chemistry system and hydrography, both along-track and at pre-defined stations along a survey transect extending from 35N, 52W to 50N, 42W. The specific objectives included:

1. To survey hydrographic conditions via underway sampling systems and a CTD rosette at a series of 31 pre-defined stations.
2. To sample the carbonate system along-track using underway sampling systems for surface *p*CO2, air *f*CO2, pH, and Dissolved Inorganic Carbon (DIC).
3. To sample the carbonate system and associated chemical conditions at stations via Niskin bottle sampling and shipboard analyses of pH, DIC, alkalinity, nutrients, and salinity.
4. To conduct tows with a Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS) during both daytime and nighttime at select stations to quantify the vertical and horizontal distribution and abundance of pteropods and other zooplankton.
5. To conduct VPR casts at all stations, and during both daytime and nighttime at select stations, to quantify the vertical and horizontal distribution and abundance of pteropods and other zooplankton.
6. To conduct Reeve net tows to capture live animals for respirometry studies, photography, and later gene expression studies.
7. To preserve net samples of pteropods and other zooplankton for later analyses of taxonomic composition (formalin), shell condition (70% ethanol), DNA barcoding (70 or 95% ethanol), and gene expression (flash freezing in liquid nitrogen).
8. To collect multi-frequency acoustics continuously alongtrack and at stations to characterize the distribution of zooplankton, ideally including pteropods, across spatial scales.
9. To collect broadband acoustic data via profiles at most stations and small-scale surveys at select stations, in order to assess the utility of such data for providing enhanced information on the taxonomic composition of scatterers present, and ideally enhanced information on the abundance and distribution of pteropods.
10. To conduct visual surveys for macrofauna including seabirds, marine mammals, and surface-associated fishes.

4. Survey Design

The majority of survey activities took place along a line running between 35N 52W and 50N 42W in the Northwest Atlantic (Figs 4.1, 4.2), divided into three sub-sections: Transect 1 running from 35N 52W to 41.5N 52 W (corresponding to a segment of CLIVAR/WOCE line A20), Transect 2 running from 41.5N 52W to 45N 42W, and Transect 3 running from 45N 42W to 50N 42W. The transits to and from the start and end points of the survey lines were designated Transects 0 and 4, respectively. The survey transects were designed to allow us to re-occupy a portion of CLIVAR/WOCE line A20 along 52W, while remaining off-shelf for the entire survey and avoiding sampling on the Grand Banks or Flemish Cap.

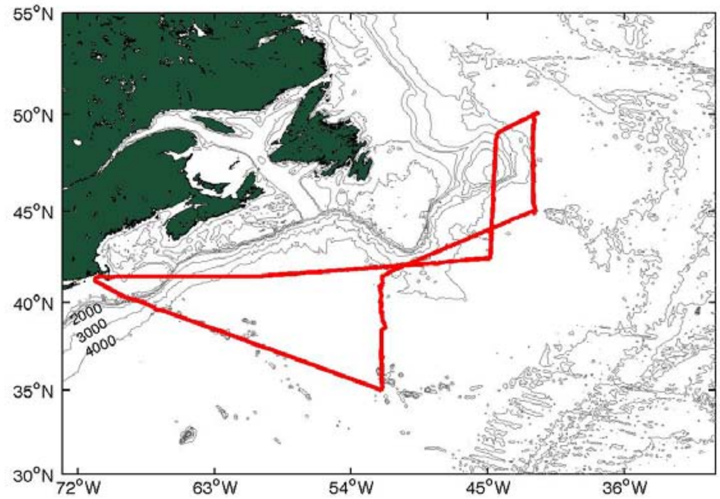


Figure 4.1 – OC473 Cruise Track

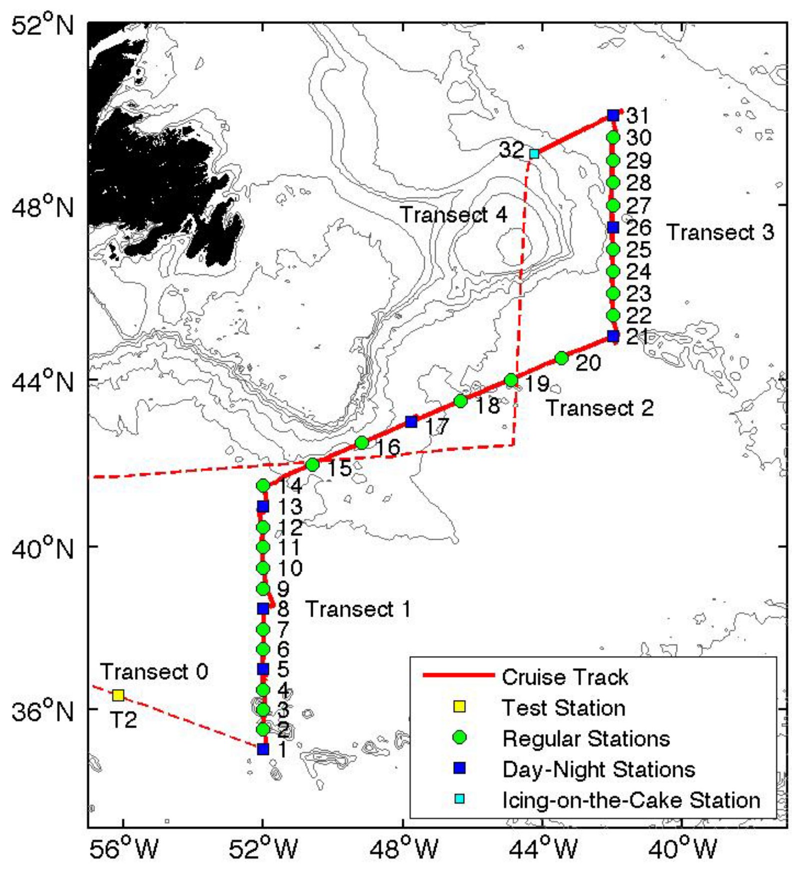


Figure 4.2 – OC473 survey transects and station locations

Surveying along the study transect involved a combination of station-based and underway activities:

1. Underway data were collected continuously along-track between stations at a survey speed of 8-11 knots using a multi-frequency acoustic system with hull-mounted transducers, a Multi-parameter Inorganic Carbon Analyzer (MICA), and the ship's underway measuring systems (sea surface and meteorological conditions). An observer conducted visual surveys of the abundance and behavior of macrofauna (seabirds, marine mammals, surface-associated fish) during daylight hours.
2. A total of 23 "regular" stations were conducted at intervals of 1/2 degree in latitude along the survey transects. Minimally at each regular station a cast was conducted to 1000m with a CTD-VPR package, including Niskin bottle samples of seawater. At select regular stations profiles were conducted with a broadband acoustic system to as deep as 500m. Water samples were processed by chemistry team personnel between stations.
3. A total of 8 "day-night" stations were conducted at intervals of 2 degrees of latitude, except in two instances where day/night stations were shifted ½ degree north or south to ensure sampling during both day and night was completed in a timely fashion and without sampling during the dusk and dawn transitions. Repeat MOCNESS 1000 m net tows, 1000 m CTD-VPR casts, and casts with the HammarHead broadband acoustic system were made during day and night. Between these day and night casts/tows and while waiting for dawn/dusk to pass, a CTD cast with Niskin bottle sampling was made to 3000 m.
4. At select stations where sufficient time was available, when waiting out either the dawn/dusk transition or tropical storms passing across our track ahead, small-scale acoustic surveys were conducted employing both the HammarHead tow-yoed broadband system and the hull-mounted multi-frequency system.
5. Once per day, at the first station reached after sunset, whether regular or day-night, a Reeve net tow was conducted to sample live organisms.
6. In addition to the 31 main stations, two test stations were conducted en route to the study transect in the Slope Waters and then Sargasso Sea southeast of Woods Hole. One additional survey station with a 1000 m MOCNESS tow, Reeve net tow, and 1000m CTD-VPR cast was also added in cold waters to the southwest of the planned survey endpoint, northeast of the Flemish Cap. Permits had been granted to sample in Canadian waters over the Scotian Shelf while in transit back to Woods Hole, but weather (specifically, Hurricane Irene) and routing precluded any such Canadian stations.

The science party was divided into 'biology' (8 members) and 'chemistry' (5 members) teams, plus the one macrofauna observer, for a total of 14 participants. The biology and chemistry team kept 12-hour watches from 0800-2000 and 2000-0800 to allow 24-hour operations. The teams combined forces and worked together in many situations, particularly for deck operations and when drawing water from the Niskin bottles.

5. Cruise Narrative

Gareth Lawson

Day 1: Sunday August 7, 2011
After a very full four days in port we sailed today at 1030, as scheduled. Clindor the bosun and team attempted to put the tow boom (aka the cannon) used with the Greene Bomber in place before sailing but didn't quite make it on the first attempt. The Captain was nervous about the idea of delaying with the boom over the side given the sailboat traffic through Eel Pond and so we sailed into Vineyard Sound and installed the boom there instead.

Skies were grey with light rain. Winds were forecast to be 15-20 but were more likely 20+. As we exited Vineyard Sound the bridge set a course for our survey transect start point at 35N 52W. The seas soon picked up and some faces started to turn a little green. Rob the marine tech gave a short debrief on the ship's electronics and then Logan the chief mate gave a safety demonstration. This was followed by a science party meeting where chief scientist Gareth Lawson covered basic details on life at sea, as well as some cruise-specific information on instruments, watches, and so on.

Most science party personnel retired to their cabins soon after these meetings. Aleck Wang worked on his underway carbonate chemistry systems. The MICA system was working well. The GO underway pCO2 system was receiving low seawater flow, leading us to check all the valves and connections. None seemed to be at issue, and the problem was quickly resolved when the chief engineer increased the flow rate. Gareth Lawson got the HTI system running with the hull-mounted transducers. The data looked reasonable, although we were in shallow (<50m) waters. The fumehood in the wetlab took on some water associated with particularly strong waves. It didn't seem like there was a solution to this problem, so a hole may be drilled in the hood counter to at least allow the water to drain. Since the deck was wet and most of the science party was getting their sea legs, we decided to postpone preparing the instruments for test deployment until the following morning.

Day 2: Monday August 8, 2011

The science party awoke this morning to a continued strong swell presumably associated with Tropical Storm Emily. On our course to the SE towards Station 1 this led to a lot of rolling and some continued green faces, with a fair number of science party members staying in their bunks. Most of the day was occupied with test deployments. The original plan had been to do test deployments at the shelf break, but since that would have been during the night and in the interest of keeping the tests short, test deployments were instead conducted along the vessel's track to the survey start at 0930 on Day 2, which worked out to be in the Slope Waters SE of Woods Hole.

After breakfast we started finalizing the HammarHead for a test deployment, which started around 0930. For this first deployment we had all of the ABs up, with Clindor the Bosun running the deck, Chief Mate Logan on the A-frame, ABs Chris and Mark on the slip lines, and AB Leo running our portable winch. The deployment went smoothly, although the towed body didn't clear the stern by very much, because the block provided to us by SSSG hung so low (due to the swivel and a series of shackles). The Edgetech system performed well. We profiled to 150mwo, testing various payout speeds (10, 20, 30 m/min). The winch was a portable Dynacon provided by the winch pool. It had only been used for ca. 24 hours in its lifetime (20+ years?). It was designed for an unusual gauge of wire (ca. 0.4") and was reconfigured for 0.322" for our use. Recovery wasn't quite as smooth as deployment and we knocked the HH's nose on the stern a couple of times. In part this was because the ABs didn't snag the fish soon enough with their snatch poles and in part because of the limited clearance below the block. Clindor indicated he would make up a fend-off pole like we've used previously on the Endeavor.

While we deployed the HammarHead, the CTD team was learning how to cock the Nisken bottles from Marine Tech Rob Hagg. Before deployment, Clindor gave a very thorough and useful tutorial. Deployment employed 2 tuggers and the winch operator ran the deck (Leo in this case). The first deployment and recovery went very smoothly. Aleck and Katherine ran the CTD during the deployment under Rob's guidance. All of the bottles were fired but water samples were only taken from a few, and were used for testing and training purposes. The VPR was attached to the CTD for this cast. It started with a battery of 26.4 V and came up at 25.0 so evidently our battery chargers were going to be well used this cruise. Alex and Nancy downloaded the data and got processing underway. Not many animals of interest were present: lots of radiolaria and blobs, but few copepods, pteropods, or euphausiids.

After a safety drill and the UNOLS safety video the next test deployment was of the MOCNESS. We had loaded the system facing downwards on the deck with the top of the frame pointed aft. This required turning it 180 degrees for deployment. After much discussion, we decided to recover by pulling it in facing forward and lay it down on its back, using the crutch and a footplate made up by the engineers. Deployment went smoothly. We had hoped to do a flowmeter calibration but conditions weren't favorable as it took the bridge a good while to find a course where the wire didn't tend under the vessel. Once on that course we fished to 100m successfully. Recovery went well. Clindor recommended not using tag lines or the tuggers because it was calm. This led to the system being a little pinned up against the rail while half-way in the gate as we pulled in the nets. This had the potential to harm the nets in the future and so we decided for future casts to use the tuggers. Once on board the biology team went to town on processing the samples. We had a number of pteropods in the catch, especially in net 4 (0-25m, where temperatures were ca. 26C), including Calvoliniidae, Periclis, Cresis, and species of gymnosomes. Amy took some for physiology studies and a number of the rest were used for photography.

Day 3: Tuesday August 9, 2011
We continued to make good progress towards our first station, passing over a series of seamounts en route. Overnight we surfed a meander in the Gulf Stream which gave us a 4 kn boost in speed. We've been maintaining a speed of 10-11 kn consistently. Skies were clear this morning and although winds were not very strong, the swells continued to be high and the ship continued to roll.

The day was mostly spent organizing data and samples from the test casts and preparing for when we arrive at the first station. The chemists also worked during the day to refine their instruments and examine the underway data. At 2030 after the sun had completely set (under a ¾ moon) we did our first Reeve net cast. After much discussion with Clindor and Rob, we arrived at a plan for deployment. The net went over the stern via the A-frame and our portable Dynacon winch. Clindor rustled up a large weight that we attached via hydrowire to the termination used for the HammarHead. We lowered that to 5m depth, then attached a clamp to the wire, to which we then attached the net via shackles and a swivel (the VPR swivel).

On this first cast, the deployment went very smoothly. We sent the system down at ca. 10m/min. The winds had picked up and the captain had to maintain 1-1.5 kn for steerage so the wire was tending at perhaps a 60 degree angle. We therefore let out 150 of wire in the hopes that we would reach ca. 75-100m depth. Recovery was at 5 m/min. Recovery of the net system and then weight went smoothly.

The cod-end was immediately taken to the wet lab where the biologists started looking for their bugs of interest. Amy Maas found a few pteropods, which she is using for her respirometry work. Work on these bugs continued into the night. A number of the science party members are well on their way to transitioning to a night schedule, as we expect to reach our first station Thursday evening.

Day 4: Wednesday August 10, 2011
T heday was spent on further preparations for our first station. We tidied up the VPR processing area, and re-arranged things in the wet lab. The Reeve Net deployment yesterday was successful but the net had been twisted, suggesting that the lines from the cod-end to the ring were too short. We therefore hung the net from the hydro-boom today to adjust the line length. We also rigged the tow and data lines for the Greene Bomber, in case we need to use that system. Tim the macrofauna observer spotted a pilot whale at one point during the day, as well as a couple of tropic-birds, which look more like they should be roosting in the top of a palm tree than flying hundreds of miles from nearest land.

At 1930 we stopped for a second test station. The Captain wanted to check out the payout meter on the oceanographic winch control, so we did a CTD to 500m. This also gave more practice to the science party. The VPR initially turned on then shut itself off, which Gareth quickly realized was because the hard-drive had not been attached. After turning that on, it was a successful cast.

Next up was a Reeve net, which started at 2100. In this case we paid out to 200m at 10-20 m/min and then back in at 5 m/min. On the way up we held it at 100 mwo (ca 75m at the wire angle) in order to fish the chrolophyll max for a while longer. The level wind did not perform very well and had to be manually adjusted a fair bit. Once on board Leo and Amy went to work. Leo found some salps for Paula Batta Lona back in his lab. Amy found a few pteropods of the same species as at the day before's Reeve cast, including Diacria trispinosa, Cuverina columnella, and Clio pyramidata. Photography and respirometry ensued.

The chemistry team got some more practice out of the CTD samples and otherwise have been calibrating and preparing instruments. The MICA (Multiparameter Inorganic Carbon Analysis system) air CO2 measurements have been high, on the order of 700ppm. Katherine noticed that the measurements spiked in the morning when people started occupying the lab, suggesting that the leak was inside. They tightened up and then put splicing tape on all the connectors but no change. During the night, Jon helped them out and they found a crack in the air pump. Sealing that up with super glue led to more reasonable air measurements of ca. 400 ppm.

Day 5: Thursday August 11, 2011

At 0200 the ship changed its clock forward by an hour; technically we were two time zones away from EST, but since we were at the western edge of the time zone, the Captain decided to only change by one hour. This was the last day of preparations before Station 1 at the start of the main survey transect. Seas were calm and winds light to non-existent. Most of the science party had transitioned to their day or night watch. All of the instruments were performing well. Gareth spent much of the day conducting noise tests at various ship speeds, leading to the conclusion that a transit speed of 10 kn is only slightly more noisy than 8 or 2 kn. The Oceanus does seem to be a noisier vessel than the Endeavor or Connecticut.

We arrived at the first station, a day-night station, at 2021 and began with a Reeve net. The night team immediately and smoothly moved on to a MOCNESS tow. Deployment and recovery went very smoothly, although one net was torn slightly upon recovery by a spike hanging off the gate through which the net is deployed/recovered. During the tow the flowmeter stopped working below 500m; upon recovery Wiebe replaced the Reed switch. Following the MOC tow was a HammarHead cast, leaving only back to back 1000m and 3000m CTD casts for the wee hours of the morning, and allowing the bosun to get a little sleep.

Day 6: Friday August 12, 2011

Overnight the station activities proceeded ahead of schedule. As planned, the 3000m CTD cast spanned the dawn transition. Daytime sampling also went smoothly with the CTD/VPR, MOCNESS, and HammarHead. The schedule had allotted 18 hours for the station and all activities were completed in 16hr 23min!

During transit between stations 1 and 2 the chemistry team proceeded with their analyses. They got a little behind but caught up during the 2000 watch change. The biology team has been helping with water sampling but will start doing more, including running the CTD on some casts.

Next up was our first 'regular' station (#2), involving only a 1000m CTD cast with VPR and a HammarHead cast. Both of these proceeded exactly on schedule. The cast was done over one of the Corner Seamounts, and the bottom was only just deeper than the maximum cast depth. During the CTD cast, bottle #6 stuck. Rob examined it and thought that it was just a mechanical hang-up. He cleaned off the rosette and the decision was to keep an eye on it. When possible, the plan was that Aleck and team would sample bottle 5 or 7 as a backup. We sent this VPR cast down with a battery voltage of 25.7, which proved to be insufficient as it came up with 15 file pairs! The fend-off pole that Clindor rigged up for recovery of the HammarHead worked well and it avoided hitting the stern successfully.

Last night on one of the casts the CTD hit the side of the vessel. Inspection of the hose clamps attaching the CTD frame to the yellow subframe that housed the VPR suggested that some were loose, which Jon later tightened up. Later in the night at station 3 the VPR came up with the strobe off, and it turned out this was because the hard-drive was full.

Day 7: Saturday August 13, 2011
The day started with light (5 kn) winds and warm, muggy, weather. Overnight Wiebe and the night watch kept exactly to schedule and knocked off stations 3 and 4, and so when the day watch started up we were right on time to start Station 5 as planned at 0900. This was the second day-night station of the cruise. First up was a 1000m CTD cast. To lighten the load on the chemistry team and free them up to continue their analyses of earlier samples, Gareth ran the cast (which didn't have any bottles).

At station 4 the CTD had a problem where they fired 14 bottles but it came up with 15 closed. Similarly, today during the day 1000m CTD Gareth fired one bottle but it came up with 2 closed. We're not clear on why. Rob has never seen this before, but thought it might be human error – apparently if someone hits the 'fire' button for too long it can fire two bottles without the software registering them both. Rob and Katherine tested the rosette on deck and it worked fine. The next cast (3000m) also worked fine. A later test firing of a bottle at the surface also confirmed it worked.

Next up was the MOCNESS. Deployment went very smoothly. We put out the nets in order (0 to 8) and they were streaming nicely as it went down. As with previous casts we shot quite fast (35 m/min) to get the nets down quickly. Also as with previous casts though, when we went to haul in the nets they were tangled up with one another. Looking over the side as the net came up it didn't seem like they were tangled and so we were surprised when they were. Otherwise the tow went very well.

The HammarHead was deployed next. By this time it was clear that we would have to extend station 5 at least until 0900 tomorrow (as opposed to the originally scheduled 0200) because of Tropical Storm Franklin passing in our path. We therefore took the opportunity to do a deep HammarHead cast – to 330m, which is the deepest it's ever been. A deep scattering layer, not very strong but with nice individual targets, was present just below the fish.

The 3000m CTD cast went smoothly, with a number of biology party members helping out with water sampling. After the cast, the ship repositioned as we had drifted 10 nm to the south, so we headed back to the actual station. Planned for the night were a tintinnid tow for Leo's collaborator, a Reeve Net, a MOCNESS, a 200m CTD with the VPR set to S0, a 1000m CTD with the VPR set to S1 (with bottle sampling to do day – night comparisons), and then an acoustic bowtie survey with the HammarHead and HTI.

Day 8: Sunday August 14, 2011
Despite Tropical Storm Franklin passing to the north of us (at ca. 40.5N) last night at 0300, conditions at the latitudes we worked today (37-38) were very pleasant, with light winds (ca. 15 kn) and seas of 2-4 feet.

Overnight operations went well. The comparison of the S0 to S1 VPR suggested that the S1 should be fine for our purposes. The S0 picked up more of the very small copepods, forams, and fecal pellets, but also has a much smaller sample volume. The S1 should have sufficient resolution for the size of pteropods in the nets. Presumably our not seeing very many in the VPR data simply indicated that they are sparse in these waters. The acoustic bowtie also went smoothly. A decent layer was evident on the Edgetech, which was initially towed at the surface, until the layer dissipated, at which point it was sent to 50m.

By 0900 the Captain felt it was appropriate to continue to the next station. Given how much Edgetech data we had collected during the bowtie, we decided to cut the HammarHead casts from the daytime regular stations. This left only 1000m CTD-VPR casts, which went fine. On some of these casts, since we were taking bottle samples and they lasted >1.5 hrs, the battery appeared to be running low and we were coming up with multiple files. Presumably this was just because of low battery and not because of any power connection problem. The down-cast was all that we were interested in though, and we always managed to collect that part of the cast.

Station 6 went smoothly. At station 7, 16 bottles were fired in software but the rosette came up with 17 bottles closed. The previous 3 casts had worked fine. It's not clear why this is the case. Rob sent an email in to Seabird for advice.

Tim was consistently doing his top predator surveys when we were in transit between stations during daytime. He was mostly seeing the same community of birds, particularly Corey's shearwaters, at varying abundances. Today was quite sparse. We did hit a pod of spotted dolphins, which the bridge called out over the PA system so everyone went up to the bow to watch them ride our bow wave.

The next day-night station was scheduled to be #9, but we would have been hitting that location (39N) a couple of hours before dawn, too late to do a night MOC/CTD but too soon to start daytime operations. We therefore decided that station #8 would be a day-night station, and #9 a regular station. In the interest of getting the nighttime operations done cleanly before dawn we also cut the HammarHead cast from the night. Jon is working on spectra from some of the previous casts, so that we could assess the quality of the data and whether/when it made sense to continue doing HammarHead casts.

Day 9: Monday August 15, 2011

Good weather continued today, with calm seas and light winds. Overnight the night watch had a successful series of operations at station #8 (day-night). The Reeve net sampled pteropods sufficient for Amy's physiological studies. The MOCNESS deployment went smoothly with all of the nets streaming cleanly. Wiebe had to pay out a lot of wire to get the net to 1000m though, and then in hauling in was reaching speeds of 40 m/min. He (and the bridge) think they were in an eddy of some kind. The nets contained some interesting animals – net 1 in particular had a number of deep sea fish, as well as a big deep sea pteropod, *Clio polita*. Clindor the bosun was up for the MOCNESS operation, but allowed the night watch to run the show. The night watch similarly did the Reeve net on their own.

The 3000m CTD was done over the dawn transition, followed by a HammarHead deployment. Clindor again observed but otherwise the science party handled the deployment with only one AB, Leo. Unlike most other HammarHead deployments, Jon felt on this one there was some zooplankton-like scattering. The daytime MOCNESS was also very successful. The nets streamed cleanly, and came up untangled (they were also not tangled during the night). During both day and night we used two slip-lines on the net system for deployment, rather than just one on the inboard side as had been the previous system (at the bosun's recommendation). The station ended with a 1000m CTD cast.

Overnight they again had a problem with the CTD rosette coming up with more bottles closed than they had fired. Today during the 1000m daytime cast the day team did some tests, firing most but not all of the bottles. Everything worked fine (and on later casts this day too). Rob was in touch with Marshall, and neither of them have seen this before, but apparently it was an issue the last cruise too, according to the marine tech from that cruise. Rob initially thought it was a software issue, but now thinks it's that the bottles are not being cocked properly. Today Katherine was very careful in checking the cocking, and Rob double-checked, and they worked fine. Rob will keep checking, and the night watch will do likewise. Hopefully this will resolve the issue. Mohammad has also been running some of the salinities, and they were very close to what the conductivity sensor measures, which was encouraging.

All day long the Captain was keeping an eye on tropical storm Gert, which was to the SW of us. He suggested after the day-night station that we could proceed to stations 9 and 10. Station 9 had only a 1000m CTD cast, which went smoothly. The VPR only collected data to 500m because the hard-drive filled up; interestingly this was because the recycler folder on the drive was up to 27 Gig! We therefore reformatted the drive entirely.

Gert was scheduled to be due west of us by about 1500 the following day. The Captain therefore suggested we stay put at Station #10 at least until the next morning. In addition to the 1000m CTD, we therefore decided to do 2 Reeve net tows, to get Amy more pteropods, and to kill time by doing a HammarHead bowtie survey.

Day 10: Tuesday August 16, 2011
Conditions today were again favorable, with light winds (to 15 kn by evening) from the south and very calm seas. We spent the day at station 10 waiting for Tropical Storm Gert to pass by, making work to pass the time. Overnight the night watch had made two passes of the bowtie small-scale acoustic survey, and some zooplankton-like scattering was evident. During the day this scattering persisted and at times was extremely intense on both the HTI and Edgetech. Some of the patches were so high we almost took them for noise; it was not clear for those patches whether the frequency response was zooplankton-like, similar to the layer.

After lunch, having completed a few bowtie passes we decided to do some repeat CTD-VPR casts to see if we would sample any pteropods. We therefore made 2 passes through the 40-120m layer of enhanced scattering, followed by 3 passes to 500m. Following the VPR casts we re-deployed the HammarHead and resumed acoustic surveying.

The chemistry team spent the extended time at this station catching up on samples, which they welcomed as they had accumulated a backlog from the past 10 stations. They also inventoried their supplies and were concerned they were a little low on the acid they needed for the DIC and alkalinity measurements.

After dinner at 2000 we had a screening of an ocean acidification documentary, with good science party turnout and a few crew as well. At 2100 the HammarHead was recovered and the Reeve net deployed. The plan for the rest of the night was further bowties.

Day 11: Wednesday August 17, 2011
The night watch broke off the bowtie survey and departed Station 10 on schedule at 0400. The bridge took things a little slow just to make sure Tropical Storm Gert had passed by and so we arrived at Station 11 at 0800. Conditions were favorable for our operations, with a residual swell from the SSW left over from Gert but fairly light winds and mild temperatures. We therefore promptly deployed the CTD-VPR for a 1000m cast, the only activity at this station.

During CTD operations, the protocol was for two of our science party to handle the sliplines and one person to go up to the 01 deck to handle the wire of the other oceanographic winch attached to the MOCNESS. At this station, Nancy handled the wire and noticed that water was coming out of the 01 deck science van. It turned out that the stopper had fallen into the sink and worked its way into position so the sink was overflowing. Water was all over the counter and floor, but none of the electronics were affected and only a few totes were wet. Katherine and Gareth handled the clean up, and the plan was to keep a closer eye on things in the van. To that end, a couple of hours later Gareth poked his head in and the sink had a few inches of water in it. It was draining and the level didn't appear to be increasing but it was disconcerting nonetheless. Rob fixed it by putting a hose as a catheter into the fire hose used to drain the sink outside the van. In transit Rob also fixed the power connector on the inside of one of the VPR battery endcaps where the crimp had corroded and the wire broken loose.

The VPR images had been somewhat blurry on many of the recent casts, so we started re-setting the camera focal distance each cast by turning it to a different setting then back again. We also decided as of Station 12 to increase the field of view from S1 (14x14mm) to S2 (24x24mm). This made it harder to identify small organisms but increased our sample volume substantially, with the goal of hopefully sampling more pteropods.

As we approached Station 12 there was a medical emergency as Liz Boyle the Messman had reportedly been found lying prone on the floor of the galley. The Captain and Chief Mate attended to her while the science party with AB deployed the CTD-VPR for a 1000m cast. By the time the cast was over the Captain was conferring with doctors on shore, and shortly after the decision was made to head to St. John's Newfoundland. After steaming north for 3 hours, however, and with further consultations with the doctors and with Liz, as well as repeated monitoring of her vital signs, it was decided that we could proceed with science at least for the time being.

We therefore began Station 13, our fourth day-night station of the cruise. We started less than an hour before sunset, not enough time for a daytime CTD/VPR or MOC but sufficient for a HammarHead cast. We then did a 3000m CTD cast over the day-night transition.

Day 12: Thursday August 18, 2011
Winds were light today (5 m/s), seas calm and skies mostly clear with a few clouds. Overnight operations at day-night station 13 went smoothly, with the second MOCNESS starting as planned shortly after 0600 to sample daytime conditions. Both the daytime and nighttime MOCNESS tows captured a variety of pteropods. The Reeve net didn't catch many pteropods, and so Amy drew animals for her study from the MOCNESS. A total of 6 storm petrels landed on the deck at various points in the night. Tim got up for a few of these to measure beak and forearm length, and to sample a few breast feathers for stable isotope/diet analysis.

After the daytime MOCNESS we had to reposition slightly before doing the daytime 1000m CTD because a container ship was just off our port bow, passing some time before heading in to Newark NJ. Once we repositioned, the CTD went smoothly. The night watch had noticed water in the LED of the VPR indicator light dummy plug. This didn't seem like a good thing so we replaced it with a regular dummy and planned not to use it for the rest of the cruise. We broke station only 5 minutes behind schedule at 1100, for a total of 17 hours at this day-night station.

Our usual 30 nm / 3 hr transit then saw us at station 14, the last station along transect 1. The 1000m CTD cast went quickly and we were soon back in transit, now along transect 2, the leg running to the NE between 41.5N 52W and 45N 42W. Since we were traveling so far to the east for the next 6 stations that fell between 52 and 42W, the transit time between stations increased ca. 7 hours, allowing the chemistry team to catch up on their samples and the biology team to get some writing/analysis done too. The various chemical analysis instruments were working mostly fine, according to Katherine. At sunset (1926) the majority of the science party gathered on the back deck to watch the sun go down, which was very pleasant.

Day 13: Friday August 19, 2011 (Hump Day)
The day began with a heavy fog that developed into a light rain during the recovery of the 1000m CTD cast at station 16. The fog persisted off and on for most of the day, but seas were wonderfully calm.

Overnight the night watch had light duties as we were mostly steaming between stations 14, 15, and 16. Again a number of petrels landed on the deck (14 of them), including one that vomited; its stomach contents were preserved in alcohol, and included fish and zooplankton, possibly krill. Since ca. 1800 yesterday evening as we moved north (and now northeast) we have been in very low salinity waters (32 PSU). As we transitioned across the salinity front yesterday evening Tim first saw a pilot whale and then a large number of birds. The front occurred without any large change in surface temperature. Stations 15 and 16 passed uneventfully, with just a CTD and Reeve net at the former and CTD at the latter. Shortly before Station 16 we crossed another front into surface temperatures of ca. 15 degrees and again Tim saw large numbers of surface-associated animals. At Station 16 the temperature at 50-60m depth went down to an impressive 0.3C. The acoustic scattering also changed a great deal since transitioning into these fresh and cold waters, with surface waters during day devoid of any scattering at 43 kHz and much more zooplankton-like scattering at shallow depths during day and night, including some krill-like layers around 150m depth and below in day. The chemistry team was catching up on samples; they got up to date on pH, were one station behind on DIC, and were on stations 7/8 for alkalinity.

Station 17 was our first day-night station along Transect 2, the leg of the survey running NE from 41.5N/52W to 45N/42W. We arrived in sufficient time to do our daytime 1000m CTD as well as a HammarHead cast. The scattering was very interesting with multiple zooplankton-like layers in the upper 150m, a dense zooplankton layer from 150-170m and fish-like scattering (including individual targets) below.

For hump day fun we sent Styrofoam cups down on the 3000m CTD. Pretty much all science party personnel and a few crew decorated a cup or two.

Day 14: Saturday August 20, 2011

The day was again foggy with very calm seas. The night team had a busy watch, with most of the activities for day-night station 17 occurring during their 8pm-8am watch. The Reeve net came up full of phytoplankton, a lot of big amphipods, 3 Meganyctipanes norvegica (which Leo preserved in liquid nitrogen), and a handful (perhaps 6) of Limacina retroversa. The MOC however had a large catch of retroversa in net 7 (0-25m) along with a large number of Nematoscelis megalops. A Limacina helicoides, which is a deep species, was also caught in net 2 (600-800m) and some Pericle in the deepest net. Fish, including some larger ones, were also present. The daytime MOCNESS showed similar catches. Because we had squeezed in the daytime 1000m CTD before sunset the previous day we wrapped up at station 17 by 0900 and continued along transect 2.

Next up was a series of regular stations (18-20), which were becoming routine for both science party and crew. Shortly after deploying the CTD at station 18 Chief Engineer Gary and Junior Engineer Paul brought out some welding gear as the triangular piece on net bar 1 had broken one of its welds; it was soon repaired.

At each of the 2000 watch changes we were doing a short all-hands meeting to bring everyone up to speed on the current sampling plan, schedule, and any other items people wanted to raise. Overall these went very well and were a useful thing. We also had a small white board where Gareth wrote up the schedule in ca. 18-24 hr increments, listing the time and order of events at the next few stations. This also was a very useful thing, and some of the crew even commented on how they likewise appreciated it.

Day 15: Sunday August 21, 2011

This morning saw slightly increased winds (8 m/s) and an increased swell out of the North. The fog had mostly lifted and visibility was much improved. A weak low pressure system was making its way from Nova Scotia towards us, but otherwise the weather was highly favorable.

Overnight the night team had a nice calm watch, with just one station (19) falling in the middle of the 12 hour period. The Reeve net sampled a very large number of Limacina retroversa, as well as some Calanus hyperboreus and Clione limacina. The day team took care of the 1000m CTD at station 20 and then focused on photographing and videoing the Clione for much of the morning.

On our present course towards the NE along Transect 2 the ship was making 10.5-11 kn and so the 70 nm transit took slightly less than the 7 hours we had anticipated. The last of these transits took us to station 20, which sat at the start of Transect 3 and was a day-night station. The timing on these last stations was getting very precise as we hoped to add a station at 51 N with the time saved.

We arrived right on schedule at station 21 at 1600, just in time to deploy the CTD-VPR in order to get the VPR to depth before 2 hours before sunset (1846), which was our cutoff for 'daytime' sampling. The wind had picked up slightly, to 10 m/s out of the west, and the seas were a little bigger. The 1000m CTD cast went smoothly though, and was followed promptly by a HammarHead cast. Overall the transitions to/from the HammarHead were very smooth, as ere the transitions between other operations, and at this point a transition time of 15 minutes is on the long side. Overnight operations were unhurried, since the daytime MOCNESS couldn't start until 0600.

Day 16: Monday August 22, 2011

The morning began with light occasional rain showers, winds now reduced to 3-4 m/s, and overall calmer seas, perhaps 2-4 feet. Activities at Station 21 overnight went smoothly. Some interesting patches were observed on the Edgetech, perhaps consistent with pteropods. This had also been true for some of the layers/patches observed with the HTI, particularly in some of the areas where we were catching very large abundances of Limacina retroversa. Both the Reeve net and the nighttime MOCNESS caught reasonable numbers of pteropods, and the community composition was back to what it had been in the Sargasso (Clio pyramidata, Styliola subula, Diacria), rather than the highly retroversa-centric composition that was evident in colder waters. On Transect 2 we were cutting in and out of cold waters along the northern edge of the Gulf Stream, hence the variability in community composition. Now that we were on Transect 3 we were soon to be transitioning back into colder waters. Overnight the night watch had to put a tarp over the CTD, since when the hydroboom is extended/retracted during MOCNESS operations there was grease falling onto the CTD and Niskin bottles. Some of this grease also fell onto the nets.

The daytime MOCNESS, deployed by the night watch and recovered by the day team, required a lot of wire to be put out because of current. The nets came up in a horrendous tangle and we had to haul the entire knot in on board to untie them. The nets required careful rinsing with the hose but the catches for the most part seemed all right, perhaps a little low. Only one net (2) had a lot of catch stuck just above the tangle. Peter later commented that the ship hadn't had any way on when the net was deployed, which could have led to the tangle. The Captain also commented that he had done some maneuvering shortly before we recovered the net system, which might have led to tangling too.

At around 5am this morning Aleck went to check on the General Oceanics underway CO2 system and in saving the data ran into some trouble. There was some kind of an issue, either with the software, the connection between the laptop and system, or on the first board fired up that controls things like the fan, such that the system was not starting up. Unfortunately the software did not provide any diagnostics or error messages. Aleck and Jon did some trouble-shooting first thing this morning but with no luck. Katherine later gave the manufacturer a call, and their support people got to work on possible solutions; they were able to tunnel in to the control computer remotely, in order to check on some of the software and configuration files. Given that the MICA continued to make pCO2 measurements that were a little high (presumably the leak in the pump wasn't completely fixed), the loss of the GO system was unfortunate as it had become the primary pCO2 measuring device, despite having originally been envisaged as a backup.

Over the course of the day and night we completed stations 23-25, all regular stations, the first two through some rain. Station 25 was originally scheduled to be a day-night station but we would have been hitting it at 0330, which was not conducive to getting the night sampling done before dawn. We thus made Station 26 a day-night station. We also decided to shift the final day-night station to #31, such that Transect 3 had evenly spaced day-night stations.

Day 17: Tuesday August 23, 2011

The day began with fog, light occasional rain, and slightly increased winds (9.5 m/s out of the NE) and seas (ca. 3-5'). Station activities overnight went smoothly and by this morning we were only 7 minutes behind the planned schedule, arriving at day-night station 26 at 0807. The first activity was a 1000m CTD/VPR that went smoothly; later analysis of the VPR images found a very nice image of a Clio pyramidata. The CTD was followed directly by a MOCNESS, with a very smooth transition between operations. The nets went in without tangles, other than two nets that were looped around one another once, and came up with no knots. The catch included a large number of pteropods, including a very large catch of C. pyramidata in net 3 (400-600m). The cod-end for net 5 (100-200m) was full of salps, so much so that we lost some in taking the collar off. Unfortunately, the cod-end for net 4 (200-400m) came off entirely; presumably the hose clamp was loose. We later replaced the collar and cod-end, and tightened the hose clamps for all the other nets too.

At 1300, just as we started washing down the nets and the CTD team started getting set to deploy for the 3000m cast, the safety drill started. As many science party as were available participated in the drill, which included an abandon ship drill and instruction on deploying the life rafts.

The 3000m CTD went smoothly and was followed directly by a HammarHead cast. On this cast we sent the fish down to 470m, immediately above the deep scattering layer, which was deep red on the A1. The winch operator went up to the bridge to help out the chief mate, just as the ship speed started to slow so the fish started to sink. As it reached 500m, Gareth went out to haul in on the winch. This makes it the deepest cast ever for the HammarHead. There was unusual interference on the HammarHead though: large streaks on the A1. On two occasions, we also had the Net go off, even though we could still communicate with the bottle via the remote desktop. This suggests some kind of connection issue.

The HammarHead came up immediately before sunset so that we could do a Reeve net. The Reeve caught a very large number of pteropods, Diacria, Cuverina, Clio, and more. The night team next had to do a MOCNESS, 1000m CTD/VPR and HammarHead cast, then we were on our way. We were exactly on schedule to complete the stations.

Jon and Gareth spent some time trouble-shooting the HammarHead system, cleaning up and checking all of the connections, including the bulkhead on the can, the connector cable to the termination, the termination, the winch J-box, and the connector at the back of the deck unit. Everything seemed clean and fine. There was a slight pinch in the 0.322" cable where the C-clamp gets attached for the Reeve net deployments. We detached the CTD/pump/fluorometer cable and ran the system on deck for a while. We found that with the usual rate of data collection (ie with raw on, collecting to 70/70/50m) we were getting regular overflows. When we changed to 50/50/50m we got no overflows, so we decided to proceed with those settings. Overall it seemed that we were losing bandwidth on the wire. We saw similar unusual increased overflows on the RV Connecticut when the wire started to fray at the cable termination…although in that case we still got overflows when the raw was turned off and when the range was reduced, suggesting it was some kind of intermittency in the connection, rather than whatever bandwidth reduction we were seeing here.

Day 18: Wednesday August 24, 2011

The weather was much unchanged, with patches of fog, light winds (5.4 m/s out of 167), and calm seas. Overnight operations went smoothly; no tangles in the MOCNESS nets as it came on board, which Peter credited to having a decent amount of way on during deployment and recovery. The station ended with a successful HammarHead deployment, where no overflows nor 'net off' issues were evident.

The HammarHead and other actitivities went a little long and so by the next station, #27, we were ½ hour behind schedule. Another ½ hour was added due to a medical issue – Jon Fincke was experiencing shortness of breath, lightheadedness, and tingling in the extremities, consistent with some kind of allergic reaction. Consultation with the Medical Advisory Service led to him taking benadryl and getting some bedrest. We continued to monitor his situation throughout the day.

For the previous three days the GO CO2 system wasn't working. Repeated phone calls and emails to the one technician responsible for these systems at GO resulted in very slow progress on figuring out the problem. During a remote session with the technician tunneling in to the control laptop and fiddling with the files, a config file turned up that had somehow been renamed. The system was once again operational.

Between stations we picked up the speed a little, to 11-13 kn, and by the end of stations 28 and 29 (both regular station) we were caught up and back on schedule. Our goal was to reach station 31, the final scheduled station and a day-night one, in sufficient time to complete the MOCNESS and 1000m CTD before dawn (0454); failing this we intended to simply commence station activities wherever we were at midnight.

Day 19: Thursday August 25, 2011

Winds picked up overnight and the seas became rougher with whitecaps. By morning, however, the winds had shifted by nearly 180 degrees and the seas were relatively calm again, ca. 2-4'. The sun also made a very welcome appearance, after many days of fog and clouds.

Station 30, with a Reeve net and 1000m CTD, went smoothly. Station 31 started promptly on time and the CTD came up at ca. 0430. Unfortunately, the VPR battery hadn't been changed since the last cast so there weren't many data from the night VPR cast. The MOCNESS was successful, and these operations were followed by a HammarHead cast that spanned the dawn transition. Overall the HammarHead cast was less interesting than at previous stations: low scattering and weak layers. The daytime activities went smoothly, although the MOCNESS ran into some snags. Both the night and daytime MOCNESS tows were hindered by strong currents at depth. During the day, the net sank rapidly but at an overly low angle and efforts to correct it led to the net rocketing upwards even without hauling in on the winch. By net 2 things had settled down. Either as a result of the downcast, or due to the ship having to maneuver substantially at the end of the cast with the net at <10m, the nets had worked themselves into a terrible tangle again. We tried but failed to untangle them while they were over the side with a boat-hook, reasoning that hauling them up would only tighten the knot. Perhaps due to the boat-hook net 8 came up with a large tear just above the cod-end.

Station 31 ended an hour ahead of schedule with a 1000m CTD cast. This completed the planned stations and the work we had proposed to complete, but left us with sufficient time to tackle a 32nd station. We had hoped to add a station at 51N, but given that Hurricane Irene was approaching, the Captain was reluctant to move north. The interest in 51N was reaching colder waters to sample cold conditions and sub-polar communities. We instead decided to move to the SW to a station off the Flemish Cap where from SST imagery we expect to see water temperatures of ca. 11 degrees. We planned to do a Reeve net, MOCNESS, and 1000m CTD, and then science activities would be completed for the cruise!

Day 20: Friday August 26, 2011

The day began with clear skies, calm seas, and brisk temperatures (ca 15C) due to our being over colder seas. The night watch reported a beautiful sunrise. Departing Station 31 last night the ship made ca. 11kn in order to get us to the cold waters (ca. 11 C) we hoped to target at Station 32. The timing worked out just right to allow a Reeve net and then MOCNESS tow to be completed before 0400, an hour before dawn at 0454. A 1000m CTD/VPR cast wrapped up the station. The Reeve net unfortunately came up with a large tear in the mesh, and net 1 of the MOCNESS also had a large tear just above the cod-end and no catch. Nonetheless, these net tows were highly successful, with large numbers of pteropods sampled, especially Limacina retroversa. We had hoped for Limacina helicina in these cold waters, but no luck. Large numbers of Calanus finmarchicus and various euphausiids (Meganyctiphanes norvegica, Nematoscelis megalops, Euphausia krohni) were also sampled, which was great for Leo who had been hoping all cruise for C. finmarchicus to flash freeze for gene expression work.

Station 32 wrapped up just before 0600. This represented the end of station-based science operations, although a variety of science activities of course continued, including processing of outstanding DIC/alkalinity samples, macrofauna observations, and acoustic data collection with the hull-mounted HTI system. With the stations all completed, the ship set a course to the south for 40N 45W, at the recommendation of the Navy forecasters in order for us to avoid Hurricane Irene.

With station activities complete, official watch keeping ended and the night team started to transition back to diurnal rhythms. The day watch woke up to Station 32 having been completed, and therefore spent the day breaking down all of the gear on deck and securing things for the transit home; 12’ swells were forecast to accompany the wake of Hurricane Irene and so preparations needed to be made. By dinnertime we had the MOCNESS broken down, lanolined up and stored away in the crates we brought along for the purpose with the nets all washed, dried, and packed up; the Reeve net washed and disassembled; and the HammarHead and Greene Bomber both disconnected and ready to be craned off the vessel. Alex and later Leo and Amy handled the last swapping of preservatives – replacing the ethanol and checking the buffer on the formalin-preserved samples. Overall these swaps went extremely smoothly throughout the entire cruise and had become part of the routine of watch-keeping.

Unfortunately Mohammad started experiencing problems with the salinometer this evening. Trouble-shooting by Robb suggested that there was a small capillary that allowed inflow of seawater that appeared to be blocked or otherwise broken. Mohammad had 6 stations, ca. 30 samples, still to run. We decided to transport these to shore for later analysis, unless the unit could be repaired in transit.

Much of the science party gathered to watch the sunset; overall morale was high, people were catching up on rest, but continuing to plug away at analyses and other tasks.

Day 21: Saturday August 27, 2011

Skies were clear with warmer temperatures, up to 20C, as the previous night we had passed over the Flemish Cap and were now back into the transition waters north of the Gulf Stream. Winds were initially up to 9 m/s. By late morning, however the skies had clouded and winds were lighter, around 5-6 m/s.

The daily all-hands science party had been shifted from 2000 to 0830, and most science personnel were up at 0830 for the first of these, where we went over the various tasks to be completed before we returned to WHOI, including packing, inventorying materials and identifying other needs for next year’s cruise, planning for data archiving and management, and the cruise report.

A few remaining tasks were taken care of on deck, including putting a tarp and shrink wrap over the CTD rosette. Alex and Katie got to work on tidying up the Wet Lab, stowing samples and packing things up for when we hit the dock. Shortly after lunch Robb got the salinometer working again: he had noticed a drop of water hanging off one of the capillaries, which he guessed might have been impeding them from venting, which is apparently how they draw the water in. Turning the capillaries around and away from the droplet led to the system working.

The evening was more relaxed than when science operations were at full speed, and much of the science party mustered in the galley at 2000 to watch the movie Oceans. Since breaking with science we took a course to the south with the intention of turning to the west at 40N 45W. At 2200, however, we turned the corner early, ca. 120 nm before the waypoint, putting us on a course towards WHOI.

Day 22: Sunday August 28, 2011
Favorable weather continued, with light winds (5 m/s out of 263), calm seas, and slightly overcast skies. With air pressure at 1021 mbar, we continued to be in the large stable high that we had been in or skirting for a few days. Hurricane Irene was working its way up the east coast. The likely impact on Woods Hole remained unclear. There was also concern that it would also leave large swells in its wake that we would have to deal with as we got closer to home.

The day started with our science party meeting at 0830, where the Captain addressed the science party to give an update on Hurricane Irene, including its likely consequences to us and to our ETA in Woods Hole. We were all tracking the progress of the hurricane closely, contacting family and friends back home to make sure they were all right. The Captain also provided some very generous praise on how impressed he was with our team's diligence and what we accomplished.

Robb Hagg and Mohammad continued to work with the salinometer and managed to run a few samples, before it again broke. Robb contacted people on shore, who agreed to run our remaining samples with a unit at Clark after our return.

At 1100 the science party mustered on the bow for a group photo, taken by the Captain. At 1300 the ship stopped so that the ABs, Bosun, and Chief Mate could disassemble the 'Cannon' tow boom, so that we wouldn't have to deal with it when we get back to WHOI nor have to worry about it taking out any sailboats on their way in to Eel Pond. The majority of the science party again mustered on the bow to admire the sunset. A few hours later we passed within 23 nm of the final resting place of the Titanic, the closest point during the cruise. We were making good progress towards WHOI, although swells associated with the hurricane threatened to slow our progress.

Day 23: Monday August 29, 2011
The forecast the previous day had been for increased seas, but as of early morning we remained in a persistent high (1024 mbar at present) with mostly clear skies, warm temperatures (24.5C), light winds (5 m/s out of 201), and calm seas. We fully expected to see bigger seas in the next 24-hours, however, associated with the wake of Hurricane Irene. Tropical Storm Jose, which spun up suddenly quite far north, was also forecast to dissipate shortly before it crossed our path. Overall we successfully dodged a number of cyclones on this cruise: Emily, Franklin, Gert, Irene, and Jose!

Preparations for when we might meet bigger seas, including securing all gear and our precious samples, were made and much of the packing was complete; the plan was to complete packing once we got within 24-hours of WHOI. The team was mostly working on the cruise report, data/sample analysis, and other tasks unrelated to the cruise that mounted up during the business of science operations.

The day passed uneventfully until late afternoon when the seas started getting rougher and the ship started to roll quite heavily, due to the swells coming of Jose and/or Irene. A few science party personnel started to get a little queasy and some hit their racks early. Unfortunately, as those remaining started to muster to watch the sun go down just after 1900, Cris Luttazi was hit by a wave coming over the bow while walking on the fo'c'sle, knocked off her feet and swept along the deck a distance. She ended up with a couple of contusions on her head, abrasions on her back, and a series of bruises. Immediate medical attention from the Captain and chief mate persisted into the night, along with consultations with MAS. Overall while she was shaken, wet, and in some discomfort, the injuries did not appear as severe as they might.

Day 24: Tuesday August 30, 2011
The day began with clear skies, mostly light winds (8 ms/ out of 184 degrees) but continued swells and a rolling boat. Cris Luttazi had a mostly sleepless night but thankfully did not appear to have suffered serious injury. Many of the science party had stayed up for much of the night keeping her company, and coupled with the rougher seas and queasy stomaches, the number of active science party members was diminished.

At 0200 the ship's clock changed back to EST, where it remained for the rest of the cruise. Despite the seas, the ship was making good time, 10-11+ kn, and although our ETA remained uncertain we were optimistic that it would be sometime on September 1st.

The cruise report began to take a more full form, with sections coming in from multiple directions. We were well on track to have a full draft completed by the time we reached WHOI. Other than cruise report writing, the day was mostly uneventful. Tim continued his observations, noting a number of sea turtles, perhaps associated with Gulf Stream rings. The HTI multi-frequency system, GO PCO2 underway system, and MICA, of course continued to collect data. By late afternoon the seas had mostly subsided, the ride was more comfortable, and we were making good time towards home.

Day 25: Wednesday August 31, 2011
By morning the seas had subsided substantially and we had reached colder waters to the east of Georges Bank. Skies were sunny and winds light (1.4 m/s). Shortly after dawn Tim and the bridge saw a series of convergences and divergences, probably associated with a shelf break soliton.

This morning marked our last meeting of the science party. Gareth took the opportunity to express his thanks to all science party personnel and to say how impressed he was at the level of dedication. This was a long but incredibly successful cruise, due entirely to the efforts of the science party and crew.

The day was mostly spent with cruise report writing and packing. Much of the biology team's gear was ready to be off-loaded, but there were a few final loose items to stow away. The chemistry team broke down their discrete sample analysis equipment. Overall we were in good shape to demob promptly.

As the ship made its way up onto and across Georges Bank we encountered a variety of macrofauna that kept the science party and crew entertained, including a large pod of dolphins, a group of fin whales, and a series of sharks thought to be makos. Unfortunately, we also appeared to have struck and probably killed a leatherback turtle. In late morning we heard a sudden series of thuds from the main lab. Running out onto the deck, Leo saw a lot of blood and a large flipper sticking out of the water. Talking to the bridge, AB Leo reported seeing a very large leatherback immediately before, too late to divert course, and sufficiently close that he and the captain went out to see if they could see it next to the ship. The Captain notified the authorities.

Day 26: Thursday September 1, 2011
Much of the science party woke up early to catch one last sunrise before the end of the cruise. By early morning we were in Nantucket Sound. People took the opportunity to pack, clean their cabins, and capitalize on the return to cell phone coverage.

We reached the dock at 0843 to a small welcoming group. Off-loading proceeded very smoothly with the science party hand carrying gear from the main and wet labs while the crew off-loaded heavier items with the ship's crane. By 1300 most of the gear was off and the entire science party went to the Captain Kidd for lunch, except for Mohammad, who had to leave early to get back to New Hampshire. Final items were dismantled and carried off by mid-afternoon and the cruise was over!

Instrumentation, Methodologies, and Preliminary Results

6. Equipment Configuration

6.1. *Deck configuration*

The CTD was located immediately aft of the wet lab bulkhead, with the MOCNESS and its stanchion immediately aft of that (Figure 6.1). Two air tuggers used in deployment/recovery of these systems were located on either side of the CTD. Aft of the tuggers, alongside the house, was the 140L liquid Nitrogen tank, protected from the sun by a tarp. A Dynacon portable winch for use with the HammarHead towed fish was installed aft of the main house, just to port of the center line; a remote control for this winch was located inside, in the aftmost section of the main lab. A series of inter-connected deck plates were necessary to bolt the winch down, given the rating of the 0.322" wire being used. The Greene Bomber

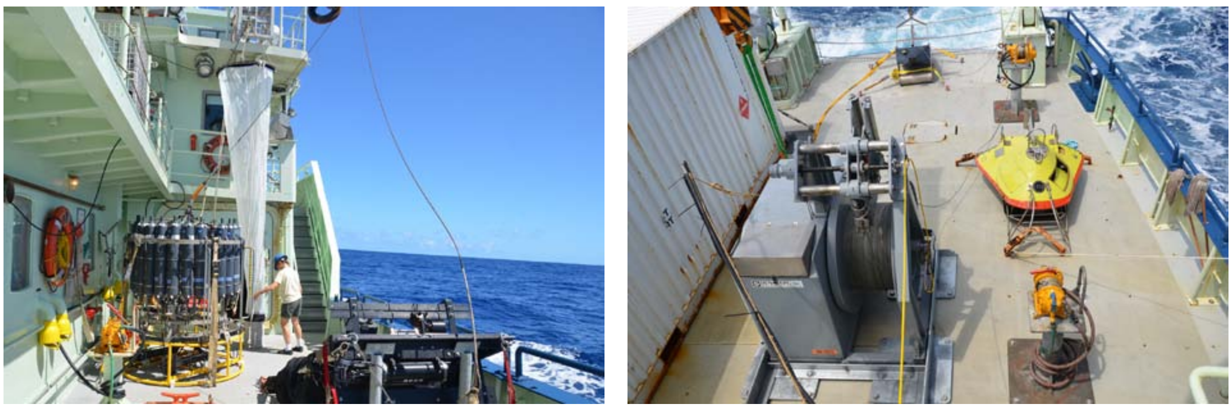


Figure 6.1 – Main deck layout. Left: Working deck layout, with CTD aft of wet lab and MOCNESS propped up on its crutch next to the starboard rail. Right: Fantail layout, showing storage van (starboard side), Dynacon portable winch, HammarHead towed body (aftmost), and Greene Bomber towed body (port side). [Photos: P. Wiebe]

was located on the port side just aft of the portable winch, along with three tuggers (one large, two small) for use in deployment/recovery. Two portable vans were installed for the cruise, one for storage on the main deck starboard side aft and the other a science van on the 01 deck where the personnel van would otherwise go. Also on the 01 deck was the large tow boom designed by Terry Hammar for use with the Greene Bomber, aka the Cannon. Tied to the rail alongside the staircase coming up from the main deck were two 55 gallon drums, one full of 95% ethanol and one empty, for storage of used ethanol (i.e., after the ethanol was replenished in the sample jars).

6.2. *Lab configuration*

The main lab housed, in order of increasing proximity to the stern on the athwartship benches, Amy Maas' respirometry gear, the salinometer and DIC analyzer, the alkalinity titration system and pH analyzer, and the broadband and multi-frequency echosounders (Figure 6.2). Also in the forward section of the main lab were the MICA (along the port side) and chest freezer (along the starboard side). Aft of the main section on the alongship benches were 3 microscopes on the starboard side, and the VPR/MOCNESS computers along the port side. The wet lab had two benches installed, one for chemistry (sample processing, bottle staging) and one for biology (net sample processing) as well as the regular counter next to the sink (splitting and preserving). The science van housed the General Oceanics underway CO_2 analysis system, and had space/internet for general use. Two stations suitable for laptops were also available for general use in the 01 deck "top lab."

Figure 6.2 – Lab layouts. Clockwise from top left: Forward portion of main lab with acoustic and chemistry areas; aft portion of main lab with microscopes (right) and VPR/MOCNESS computers (left); wet lab; science van with GO PCO2 system. [Photos: G. Lawson, except P. Wiebe for van shot]

7. Hydrography and Meteorology

7.1. *Underway*

Peter Wiebe

Along-track measurements were made continuously during the course of the cruise, to provide information on environmental conditions and for certain calculations made by the chemistry team. After the end of science activities on the previous cruise, while en route back to WHOI, the engineers put chlorine pucks into the filter baskets for the uncontaminated seawater line. These were designed to kill any organisms in the line and thus to minimize any changes that might occur to the seawater en route to the instruments to measure PCO_2 and other chemical properties underway on this cruise

7.1.1. Along-track Sea Surface Data

Sea surface temperature, salinity, and fluorescence data were collected once a minute upon leaving port (Figure 7.1). These data were saved on the ship's data server in several different file formats on a daily basis. The "csv" files were converted to "xls" files and then data of interest read directly into Matlab for further processing and plotting. The daily files were aggregated for display to correspond to the transect sections sampled on this cruise (Figure 7.1). After leaving the continental shelf south of New England, sea surface temperatures averaged 25 C and salinities averaged 35.4 PSU on transect 0 (Table 7.1). At the beginning of transect 1 in the Sargasso Sea that ran from south to north along longitude 52 W, salinities were above 36 PSU. On the northern half of this section, temperatures and salinities dropped precipitously as we crossed into what appeared to be a cold-core ring and then rose again towards the end of the section (Figure 7.1). Surface fluorescence values along transects 0 and 1 were generally low in absolute value and in variability, after leaving the New England Shelf. Transect 2 was a northeast section that cut across a meandering Gulf Stream with high temperatures and salinities juxtaposed with what appeared to be shelf water of very low salinity coming from the Grand Banks and Labrador Sea water of intermediate salinities coming around the Flemish Cap and through the channel between the Grand Banks and the Flemish cap (the Flemish Pass) with varying temperature, salinity, and fluorescence values (Figure 7.1). Average salinity along this transect was quite low (32.7 PSU). Similar variability in temperature and salinity was observed on the northerly transect 3 along longitude 42 W with some changes taking place abruptly in frontal regions. Transect 4, which went west from the end of transect 3 and then southwest across the Flemish Cap was characterized by relatively low temperatures and salinities (average 14.2 C, 33.0 PSU), and relatively high and variable fluorescent values (Figure 7.1; Table 7.1).

Table 7.1 Summary of along-track data statistics aggregated by transect on Oceanus Cruise 473.

	Year Day	Sea Temp (C)	Salinity	Fluorescence	Air Temp (C)	Wind Speed (kts)	Barometric Pressure (mbar)	Latitude	Longitude
Transect 0									
mean	221.85	25.65	35.39	127.72	24.76	10.72	1006.45	38.03	-61.53
max	224.01	28.33	36.70	640.50	27.10	39.89	1018.02	41.37	-52.00
min	219.69	14.82	31.02	55.00	19.70	0.11	999.12	35.00	-70.89
Transect 1									
mean	227.40	25.48	35.72	100.86	24.91	11.92	1019.99	38.23	-51.99
max	230.78	27.37	36.53	135.04	26.50	26.87	1023.12	41.50	-51.70
min	224.01	23.00	34.39	87.76	20.30	0.21	1016.42	35.00	-52.12
Transect 2									
mean	232.28	19.99	32.73	135.94	20.83	12.67	1019.24	43.19	-47.23
max	233.79	24.35	35.16	210.40	22.90	24.67	1022.42	44.99	-42.02
min	230.78	14.62	31.55	92.32	18.90	4.78	1017.22	41.47	-51.95
Transect 3									
mean	235.74	18.95	34.06	131.96	18.25	11.51	1017.95	47.38	-41.95
max	237.70	22.75	34.82	603.20	23.00	26.71	1020.22	50.10	-41.70
min	233.79	16.04	32.07	99.60	15.00	0.11	1013.12	44.83	-42.05
Transect 4									
mean	238.35	14.18	33.03	179.77	14.37	14.30	1019.26	48.69	-43.94
max	239.00	17.51	33.82	684.64	16.70	24.10	1021.82	50.10	-41.70
min	237.70	11.83	32.23	110.96	12.60	6.23	1016.42	46.62	-44.62

Figure 7.1 Oceanus Cruise 473 along-track sea surface temperature, salinity, and fluorescence measurements made along transects 0 to 4. Principal station work took place along transects 1 to 3 with one station (#32) occurring at the start of transect 4. CTD stations are indicated by the filled circle at the top of each plot.

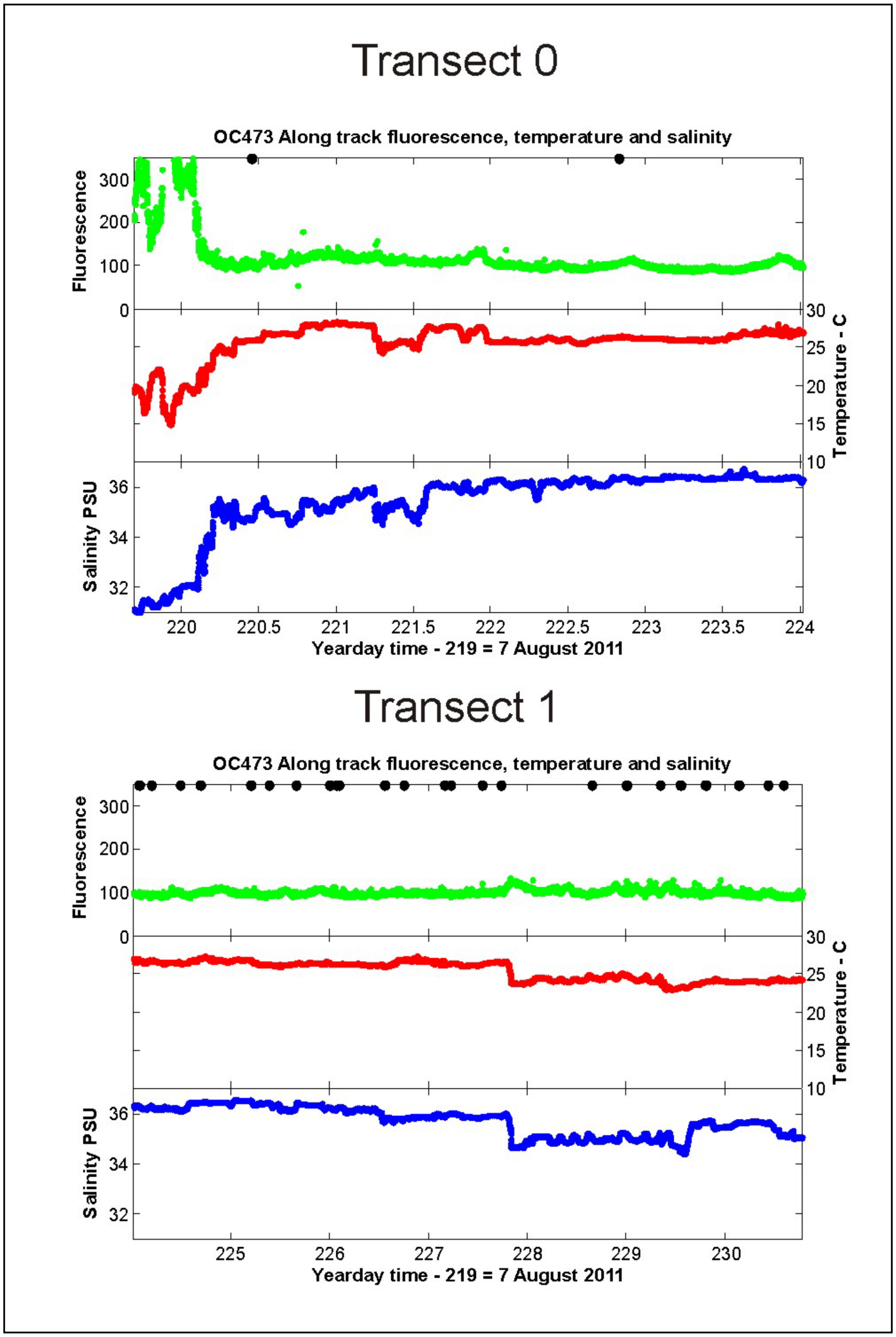


Figure 7.1 Continued.

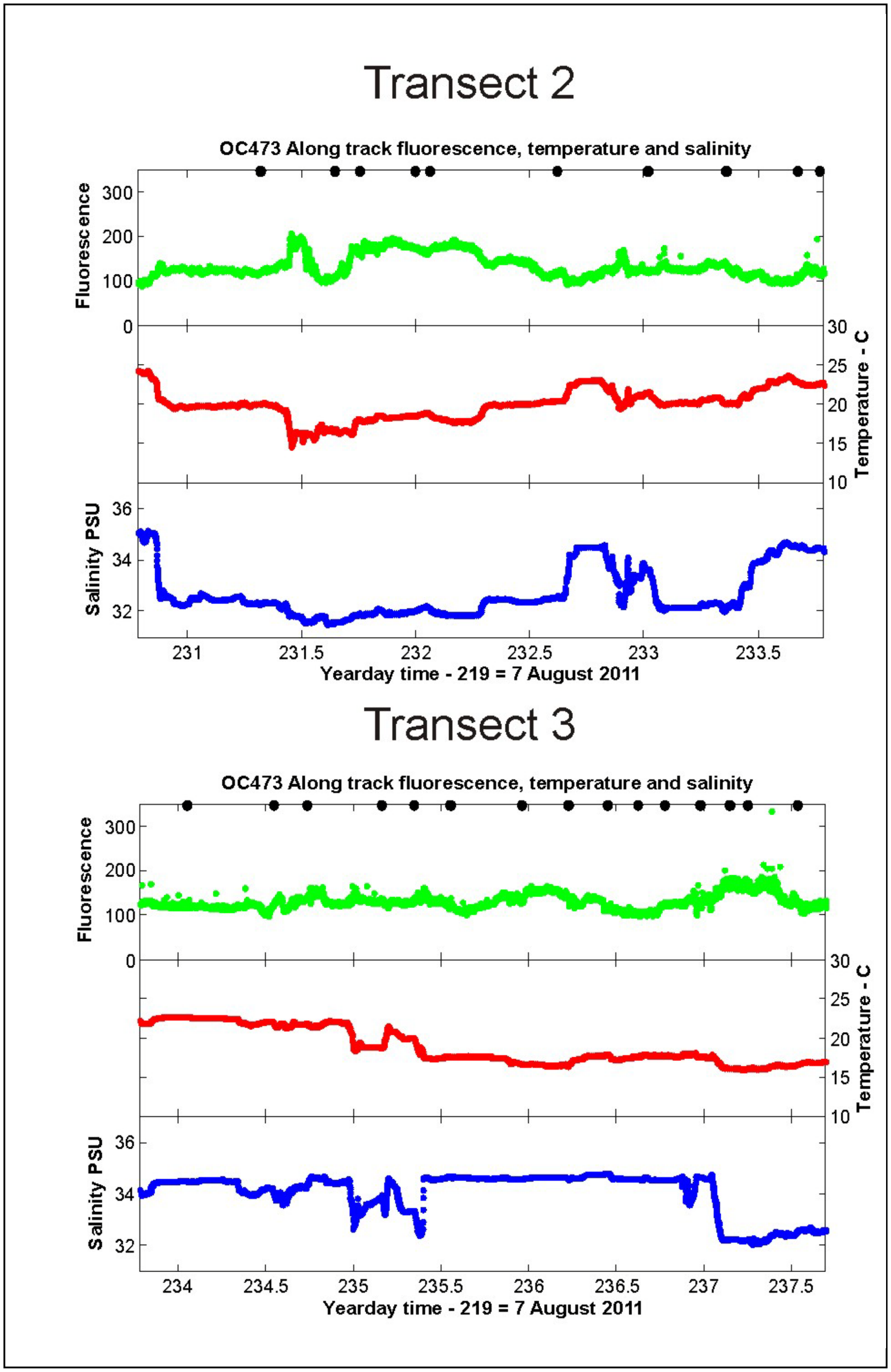


Figure 7.1 Continued.

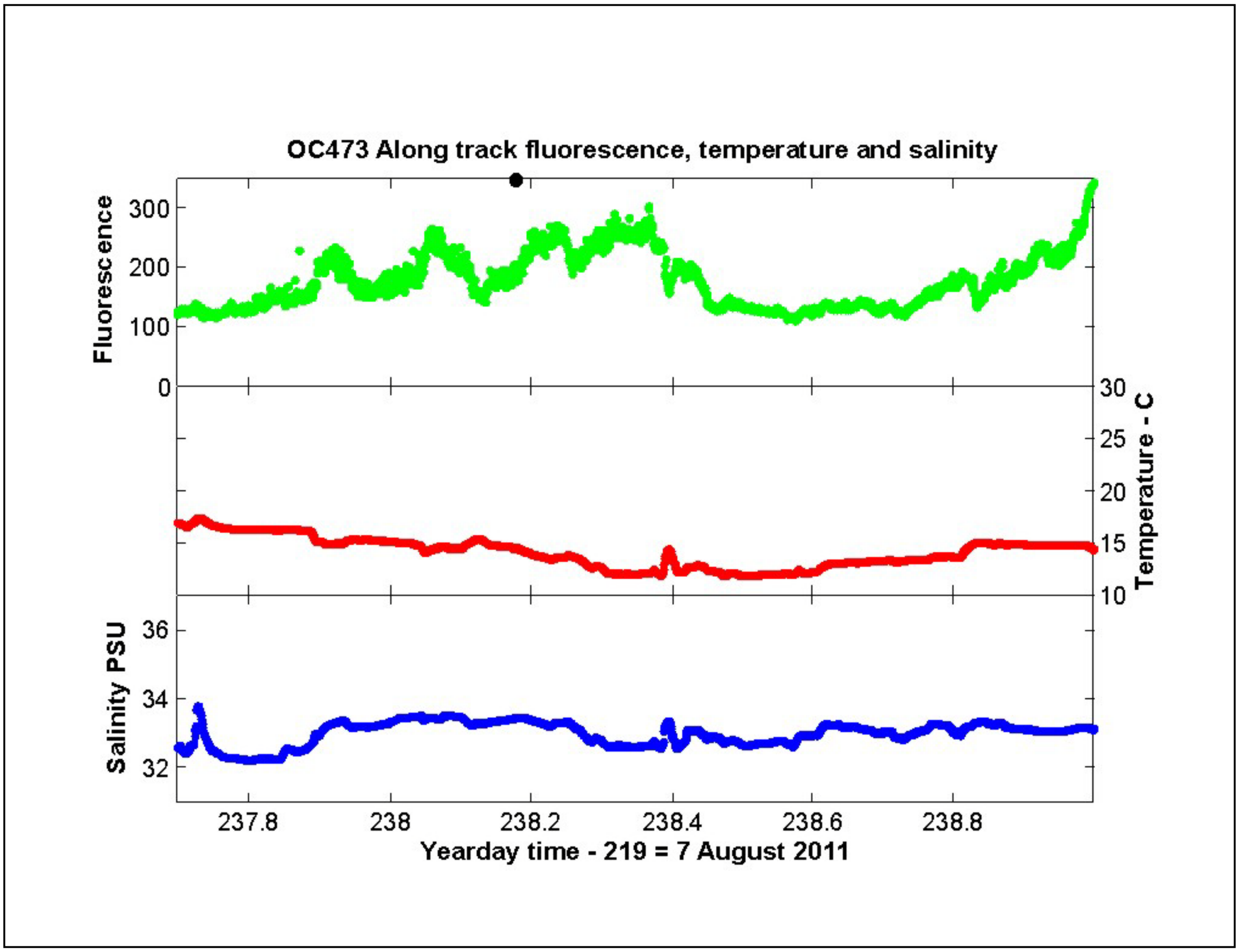


Figure 7.2 Oceanus Cruise 473 along-track meteorological data: barometric pressure, air temperature, and wind speed measurements made along transects 0 to 4. Principal station work took place along transects 1 to 3 with one station (#32) occurring at the start of transect 4. CTD stations are indicated by the filled circle at the top of each plot.

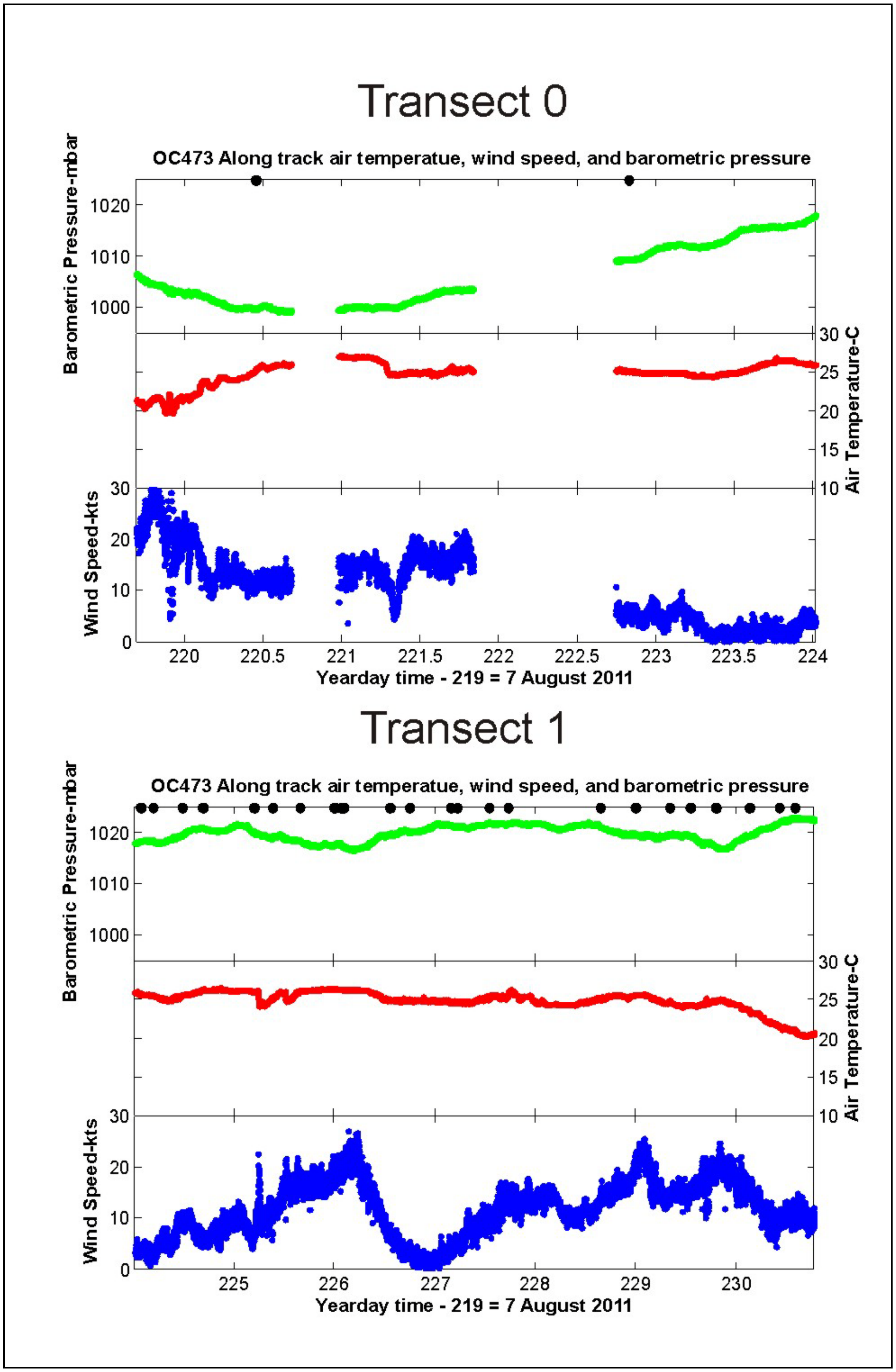


Figure 7.2 Continued.

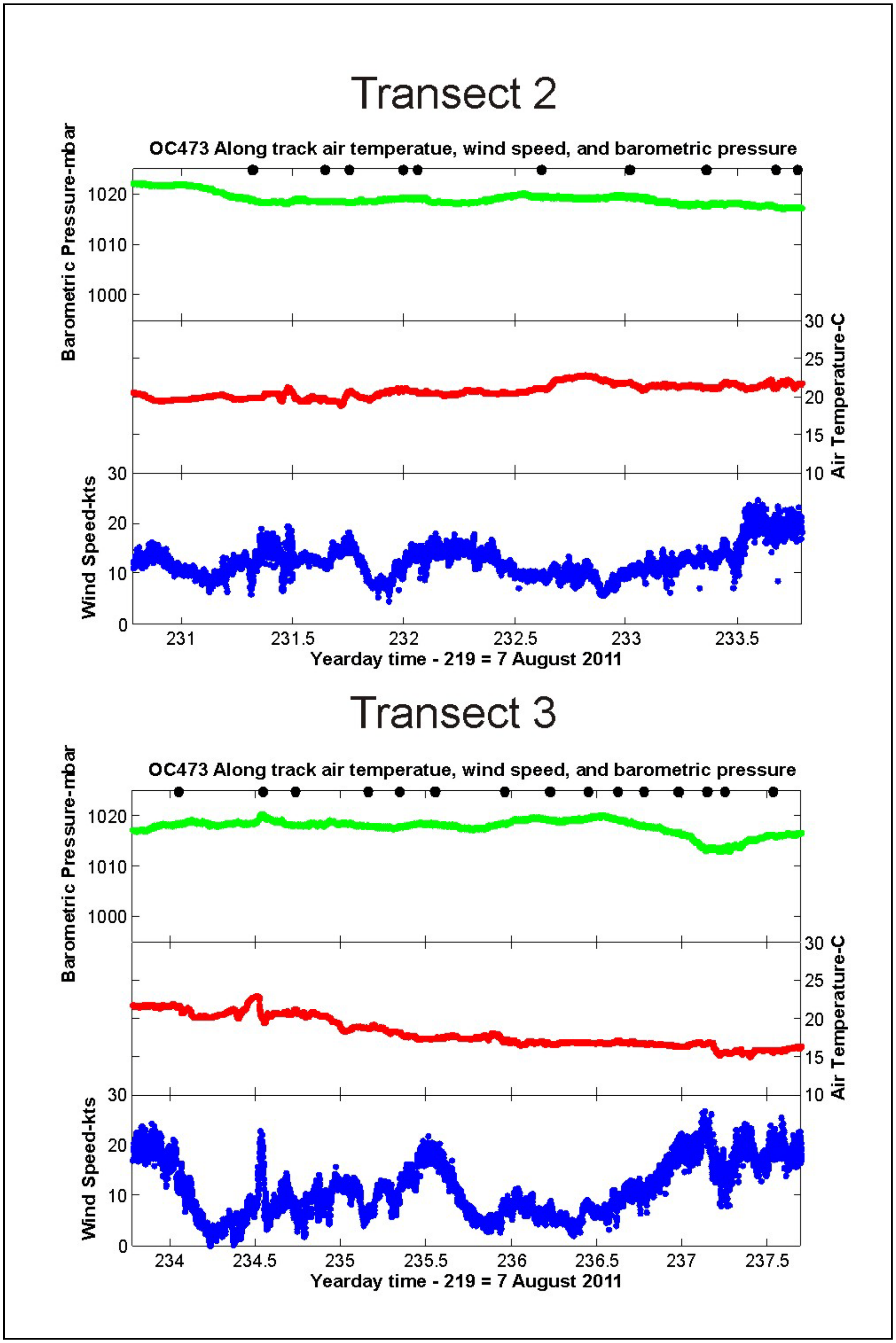
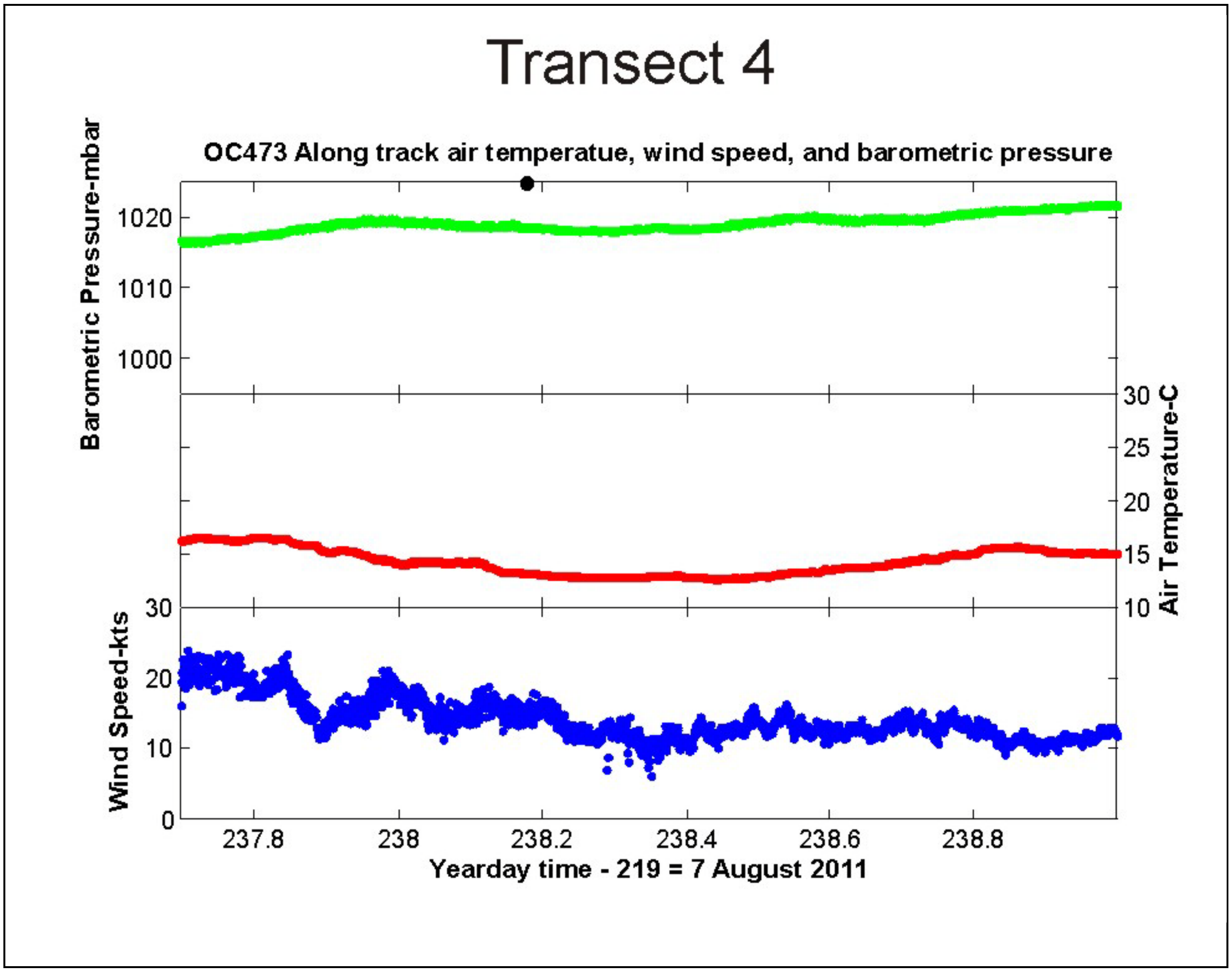


Figure 7.2 Continued.



7.1.2. Along-track Meteorology Data

Atmospheric measurements of air temperature, barometric pressure, wind speed and direction, and other meteorological variables were also collected along with time, latitude, and longitude once per minute (Figure 7.2). Except for the first day of steaming along transect 0, when wind speeds were up over 30 kts (max was 39 kts), they were generally 20 kts or lower during most of period of sampling (Table 7.1). Winds were somewhat higher during the passage of tropical storms Franklin and Gert, which passed to our north while work was taking place on transect 1, but never high enough to curtail work at a station. Barometric pressure was also relatively constant during transects 1 to 3 and the first portion of transect 4 varying between 1022 and 1015 (Table 7.1). Air temperature closely followed sea surface temperature and averaged above 20 C on Transects 1 and 2, declined to an average of 18.5 C on transect 3 was still lower on the northern portion of transect 4 (14.4 C), which was where Labrador Sea water was present.

7.2. *CTD*

Peter Wiebe

7.2.1. Introduction

CTD rosette casts were an integral component of the sampling design for the Niskin bottle sampling for the chemistry team. In addition, CTD measurements of environmental conditions provided key correlates of the distribution, abundance, and species composition of pteropods and other sampled zooplankton.

7.2.2. Methods

The CTD rosette had the full 24 10-L Niskin bottle rosette, CTD with dual T/C sensors, SBE43 DO sensor, biospherical underwater PAR with surface reference PAR, Seapoint STM turbidity sensor, Wet Labs C-Star transmissometer (660nm wavelength), and Wet Labs ECO-AFL fluorometer. A custom sub-frame housed the VPR, which was bolted to a set of rails that allowed the VPR to be removed quickly for casts deeper than the VPR's depth rating of 1000m. Ray Schmitt also had a small potted CTD that was attached to the frame for testing and comparison to the larger CTD's measurements (see later section). Only the downcast data were used for the VPR since on the upcast the water passing by the camera had been influenced by the CTD rosette.

The CTD rosette was deployed from the starboard side hydroboom using the Desh-5 oceanographic winch. Between casts it was either tied down immediately below the block with the boom in the retracted position or was pulled with the air tuggers closer to the house, to allow the MOCNESS to be deployed. For deployment, two slip-lines were used, tied to eyebolts bolted into large cleats. Recovery was with snap hooks at the end of the air tuggers. Two people tended the sliplines/tuggers for deployment/recovery, while a third tended the wire from the other oceanographic winch, which was attached to the MOCNESS.

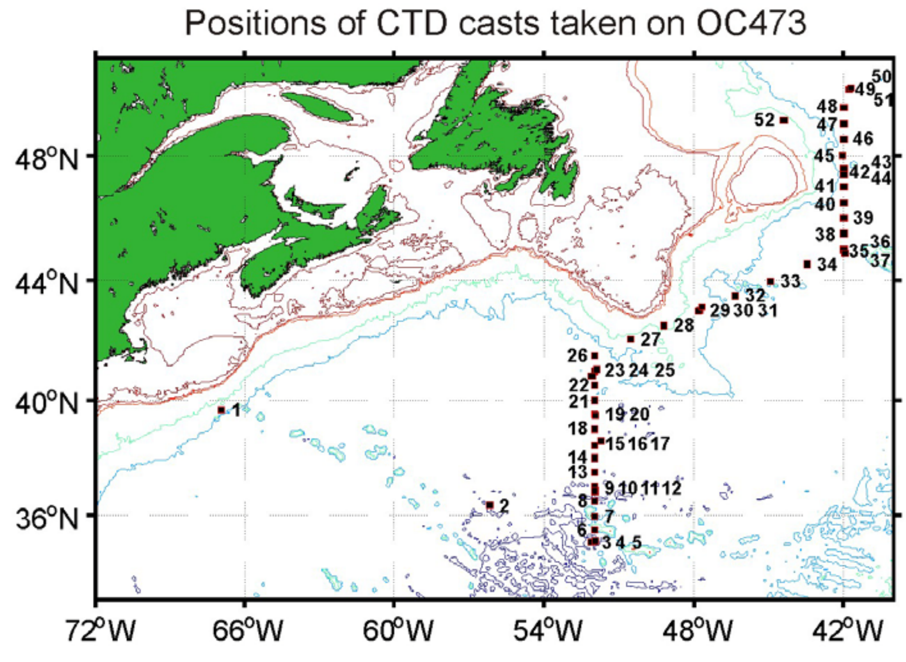


Figure 7.3 Positions of CTD/VPR casts taken on Oceanus 473 (7 August to 1 September 2011)

CTD-VPR casts were to 1000m at the regular stations (every ½ degree of latitude), with additional casts to 3000m with the VPR removed at the day-night stations (every 2 degrees of latitude)(Figure 7.3; Table 7.2). When the VPR was attached, the package was deployed on the down-cast with the winch paying out at 30 m/min, while the up-cast was done at a speed of 60 m/min, aside from the last ca. 20m which were at 20 m/min. With the VPR removed for the deep casts, the package was sent down and up at 60 m/min.

7.2.3. Preliminary Results

A subset of the 52 CTD profile data were used to create an interpolated (kriged) view of the temperature, salinity, oxygen, and fluorescence fields for each of the primary transect lines (1 to 3). The casts used for section 1 were 3, 6, 7, 8, 9, 13, 14, 15, 18, 19, 21, 22, 24, 26; for section 2, they were: 27, 28, 29 32, 33, 34, 35; for section 3, they were: 37, 38, 39, 40, 41, 42, 45, 46, 47, 48, 49. The positions (Lat, Lon) of each cast were used to create a distance from origin (the first station on a section). These distances were used as the x-axis. The GLOBEC Kriging Software Package – EasyKrig3.0 (Chu, 2004 - ftp://globec.whoi.edu/pub/software/kriging/easy_krig) was used to compute the interpolated fields.

The first half of section 1 was dominated by warm and saline Sargasso Sea water with a large vertical zone of “18 degree” water extending from below the seasonal pcynocline at about 100 m to 400 to 500 m depth (Figure 7.4A). Salinities in this zone were above 36.5 PSU. The 15^{o}C isotherm was at 700 m and the 10^{o}C isotherm was at 900 m. What appeared to be a cyclonic (cold-core ring) eddy was encountered in the second portion of the section. The 15^{o} and 10^{o} C isotherms rose abruptly in the core of the eddy and were at 200 m and 500 m respectively and the eddy diameter was approximately 150 km. Oxygen values ranged from about 150 to greater than 200 umols/kg with the oxygen minimum centered at 900 to 1000 m in the Sargasso Sea water and 400 to 600 m in the eddy. In the upper 200 m (Figure 7.4B), fluorescence values peaked in a deep chlorophyll layer centered between 50 and 100 m across the entire section. Highest oxygen values were located above the maximum chlorophyll values.

Section 2 was much more variable than section 1 (Figure 7.4C), with zones of warm saline Gulf Stream water interposed with mixture of western Slope Water and cold fresh water of Labrador shelf and sea origin. A very fresh <32 PSU surface layer was present in the upper 25 m between 100 km and 400 km from the start of the section. Satellite images of SST indicated this water originated from the area south of the Flemish Cap and Flemish Pass. Further to the east centered at 650 km was what appeared to be another cyclonic eddy with a cold-core. Salinities below 100 m ranged from 34.5 to 36.5 reflecting the presence of Gulf Stream when they were high and Slope Water/Labrador Sea water when lower. The 5^{o} C isotherm also reflected these water types being deep in the Gulf Stream waters and much shoaler in waters of northern origin. Oxygen values paralleled these patterns being low at mid-depths in Gulf Stream waters and higher in northern waters. In the upper 200 m (Figure 7.4D), fluorescence values were very high in the Slope Water/Labrador Sea water section centered at 300 km, but lower in the eddy at 600 km. Oxygen were very high in a area coincident with the high fluorescence.

Satellite imagery indicated that Section 3 run to the north along longitude 42 was in a retroflection of the Gulf Stream in the southern portion of the Labrador Sea. The temperature salinity and oxygen values throughout the water column reflected the presence of this water type down to about 600 m (Figure 7.4E). There was an abrupt change in these water properties at about 250 km from the start of the section with the 10 C isotherm and the 35.5 PSU isohaline dropping down about 200 m and the oxygen minimum zone centered at about 350 to 450 m in the southern portion of the section dropping to between 500 to 650 m in the northern portion. Maximum values of fluorescence and oxygen in the upper 200 m of Transect 3 were higher than in Transect 1, but lower than in Transect 2. One “hot spot” occurred in the region of the abrupt transition in the water properties noted above just below a layer of low salinity in the surface waters. The other was around 450 km and was not associated with any other dramatic hydrographic feature.

At station 32, CTD cast 52 showed the most the hydrographic properties characteristic of Labrador Sea Water encountered on this cruise and provided a hydrographic end-point similar to that provided by the

CTDs taken at the first station on Transect 1 (Figure 7.4G). Below the seasonal mixed layer and pcynocline (~150 m), a nearly isothermal, isohaline body of water existed to 1000 m with temperatures were between 4 and 5 C and salinities around 34.8 PSU and oxygen values were uniformly above 225 umol/kg.

Table 7.2 Starting times and positions of CTD casts made on OC473 August 2011

event #	Transect	station	cast #	Time Local +3	Year-day Time	Latitude	Longitude	Seafloor	Cast Depth
20110808.1448.001	0	0	1	10:48	220.4500	39.6537	-66.9579	3785	575
20110810.2354.001	0	0	2	19:54	222.8292	36.34585	-56.1726	5345.7*	500
20110812.0531.001	1	1	3	01:30:00	224.0625	35.05747	-52.0999	5465	1000
20110812.0738.001	1	1	4	04:37:00	224.1924	35.05285	-52.0821	5467	3000
20110812.1437.001	1	1	5	11:36:00	224.4833	35.11558	-51.9447	5465	1000
20110812.1924.001	1	2	6	16:24:00	224.6833	35.47455	-51.9907	1021	1000
20110813.0256.001	1	3	7	23:55:00	225.9965	35.9549	-51.9738	4857	1000
20110813.0745.001	1	4	8	04:44:00	225.1972	36.50023	-51.9996	5387	1000
20110813.1213.001	1	5	9	09:12:00	225.3833	36.99752	-51.995	5421*	1000
20110813.1846.001	1	5	10	15:45:00	225.6563	36.84368	-51.9640	5436.3*	3000
20110814.0436.001	1	5	11	01:35:00	226.0660	36.86968	-52.0154	5385	200
20110814.0510.001	1	5	12	02:09:00	226.0896	36.86033	-52.0149	5438.6*	1000
20110814.1614.001	1	6	13	13:14:00	226.5514	37.50058	-52.0028	5457.8*	1000
20110814.2058.002	1	7	14	17:58:00	226.7486	38.00067	-52.0003	5398.8*	1000
20110815.0639.001	1	8	15	03:38:00	227.1514	38.44468	-51.9912	5314	1000
20110815.0813.001	1	8	16	05:12:00	227.2167	38.44727	-51.9788	5314	3000
20110815.1552.002	1	8	17	12:52:00	227.5361	38.57045	-51.7441	NaN	1000
20110815.2037.001	1	9	18	17:30:00	227.7292	38.99772	-51.9912	5300	1000
20110816.0254.001	1	10	19	23:53:00	228.9951	39.48297	-51.9854	5274	1000
20110816.1840.001	1	10	20	15:40:00	228.6528	39.44013	-51.9712	5318.8*	500
20110817.1100.001	1	11	21	08:00:00	229.3333	39.9963	-52.0071	5174.2*	1000
20110817.1603.002	1	12	22	13:03:00	229.5438	40.47855	-52.0087	5220.1*	1000
20110817.2203.001	1	13	23	19:05:00	229.7951	40.97293	-52.0013	4864.8*	3000
20110818.0620.001	1	13	24	03:18:00	230.1375	40.81657	-52.0921	3679.5*	1000
20110818.1312.001	1	13	25	10:12:00	230.4250	41.03623	-51.8981	5151.9*	1000
20110818.1710.001	1	14	26	14:09:00	230.5896	41.49705	-51.9922	4721.2*	1000
20110819.0255.001	2	15	27	23:55:00	231.9965	42.03952	-50.5438	3378	1000
20110819.1037.001	2	16	28	07:37:00	231.3174	42.49937	-49.1995	2748.9*	1000
20110819.1825.001	2	17	29	15:25:00	231.6424	43.00342	-47.7733	3576	1000
20110819.2101.001	2	17	30	18:02:00	231.7514	42.97128	-47.7994	3627	1000
20110820.0422.001	2	17	31	01:21:00	232.0563	43.11242	-47.6687	3502	1000

event #	Transect	station	cast #	Time Local +3	Year-day Time	Latitude	Longitude	Seafloor	Cast Depth
20110820.1751.002	2	18	32	14:51:00	232.6188	43.49707	-46.3539	4528.1*	1000
20110821.0320.001	2	19	33	00:19:00	233.0132	43.94952	-44.9047	4558	1000
20110821.1133.002	2	20	34	08:33:00	233.3563	44.50593	-43.4634	4762	1000
20110821.1904.001	3	21	35	16:04:00	233.6694	44.99832	-42.0019	4679.5*	1000
20110821.2124.001	3	21	36	18:24:00	233.7667	44.97033	-42.0015	4693.6*	3000
20110822.0419.001	3	21	37	01:16:00	234.0528	44.84627	-41.9158	4692	1000
20110822.1608.002	3	22	38	13:08:00	234.5472	45.50022	-41.9964	4462	1000
20110822.2035.002	3	23	39	17:35:00	234.7326	45.9978	-42.0006	4639	1000
20110823.0202.001	3	24	40	23:01:00	235.9590	46.50243	-41.9672	4170	1000
20110823.0648.001	3	25	41	03:47:00	235.1576	47.00183	-42.0007	4222	1000
20110823.1117.002	3	26	42	08:17:00	235.3451	47.50057	-42.0013	4235.7*	1000
20110823.1613.001	3	26	43	13:13:00	235.5507	47.57433	-41.9781	4325	3000
20110824.0225.001	3	26	44	23:24:00	236.9750	47.38468	-41.9710	4196	1000
20110824.0826.001	3	27	45	05:25:00	236.2257	47.99787	-42.0042	4269	1000
20110824.1347.001	3	28	46	10:47:00	236.4493	48.5061	-42.0017	4365.7*	1000
20110824.1753.001	3	29	47	14:53:00	236.6201	49.00005	-42.0015	4269	1000
20110824.2135.001	3	30	48	18:35:00	236.7743	49.5044	-41.995	4485	1000
20110825.0629.001	3	31	49	03:27:00	237.1438	50.06558	-41.7683	4356	1000
20110825.0901.001	3	31	50	06:00:00	237.2500	50.05923	-41.7470	4356	3000
20110825.1541.001	3	31	51	12:40:00	237.5278	50.08977	-41.7141	4360.4*	1000
20110826.0720.001	4	32	52	04:15:00	238.1771	49.07912	-44.3628	2563	1000

* Depth estimated from Etopo2 bathymetry data.

Figure 7.4A. Kriged plot of Oceanus Cruise 473 CTD temperature, salinity, and oxygen data for transect 1 upper 1000 m. CTD stations are indicated by the filled circle at the top of each plot.

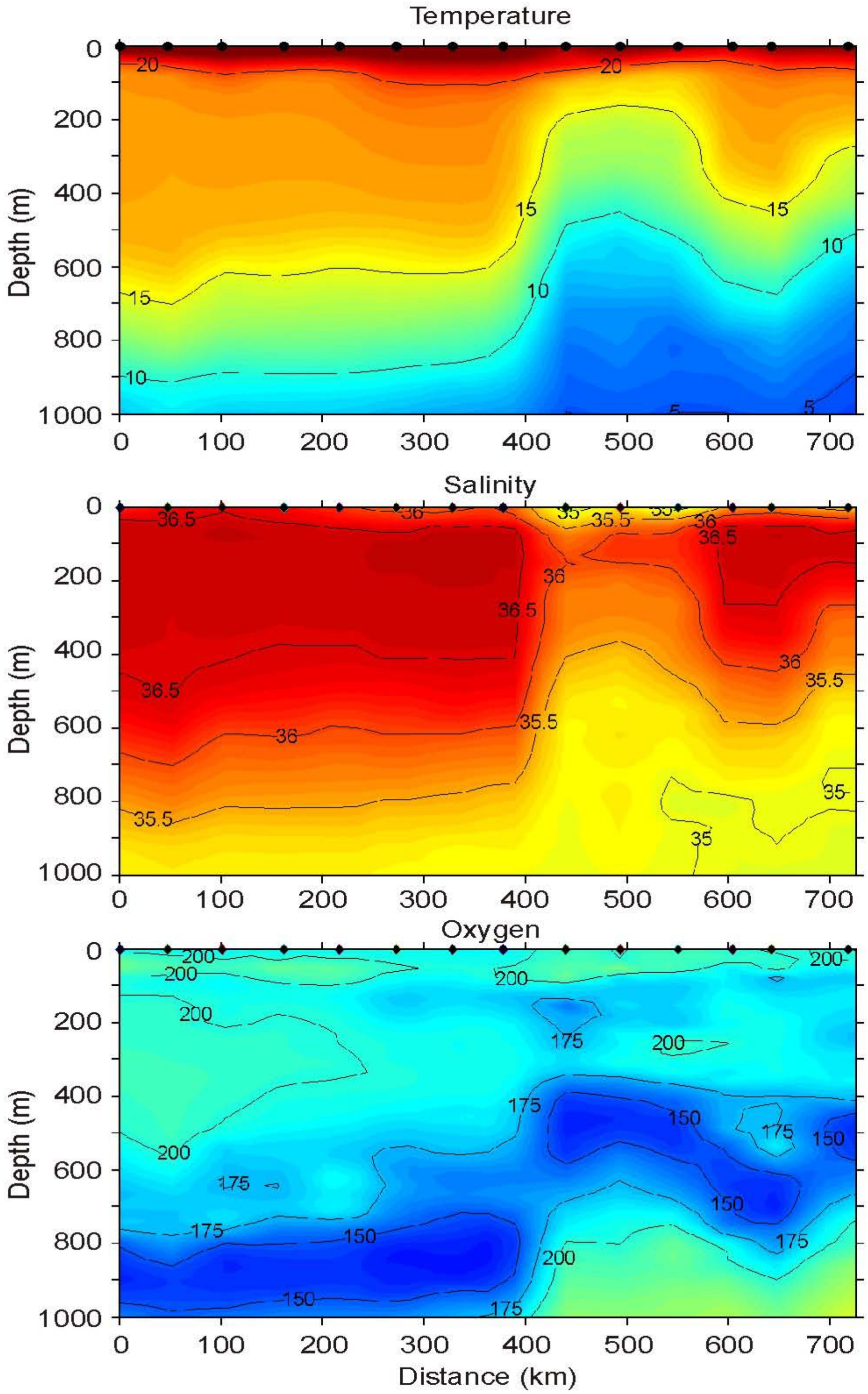


Figure 7.4B. Kriged plot of Oceanus Cruise 473 CTD oxygen and fluorescence data for transect 1 in the upper 200 m. CTD stations are indicated by the filled circle at the top of each plot.

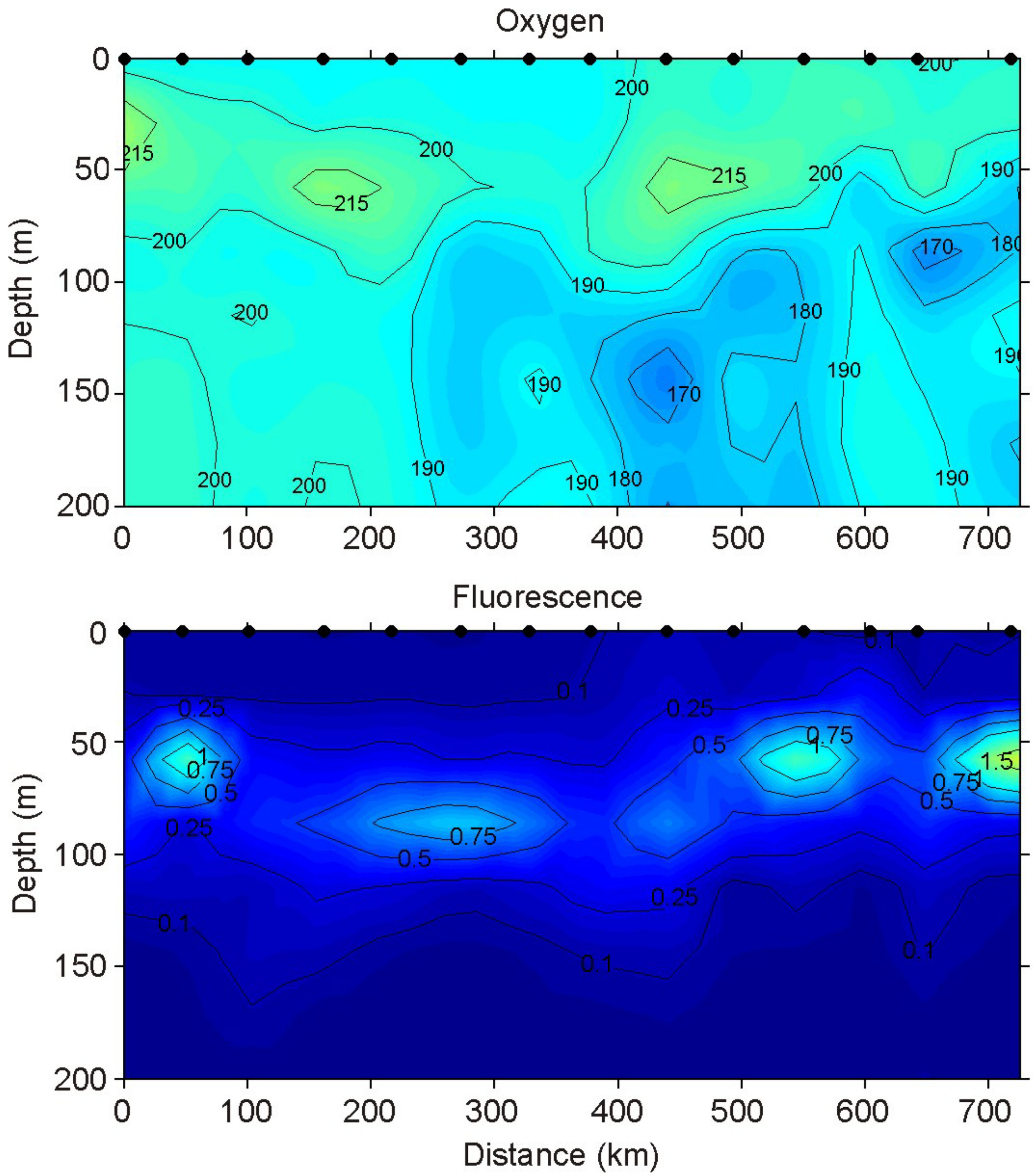


Figure 7.4C. Kriged plot of Oceanus Cruise 473 CTD temperature, salinity, and oxygen data for transect 2 upper 1000 m. CTD stations are indicated by the filled circle at the top of each plot

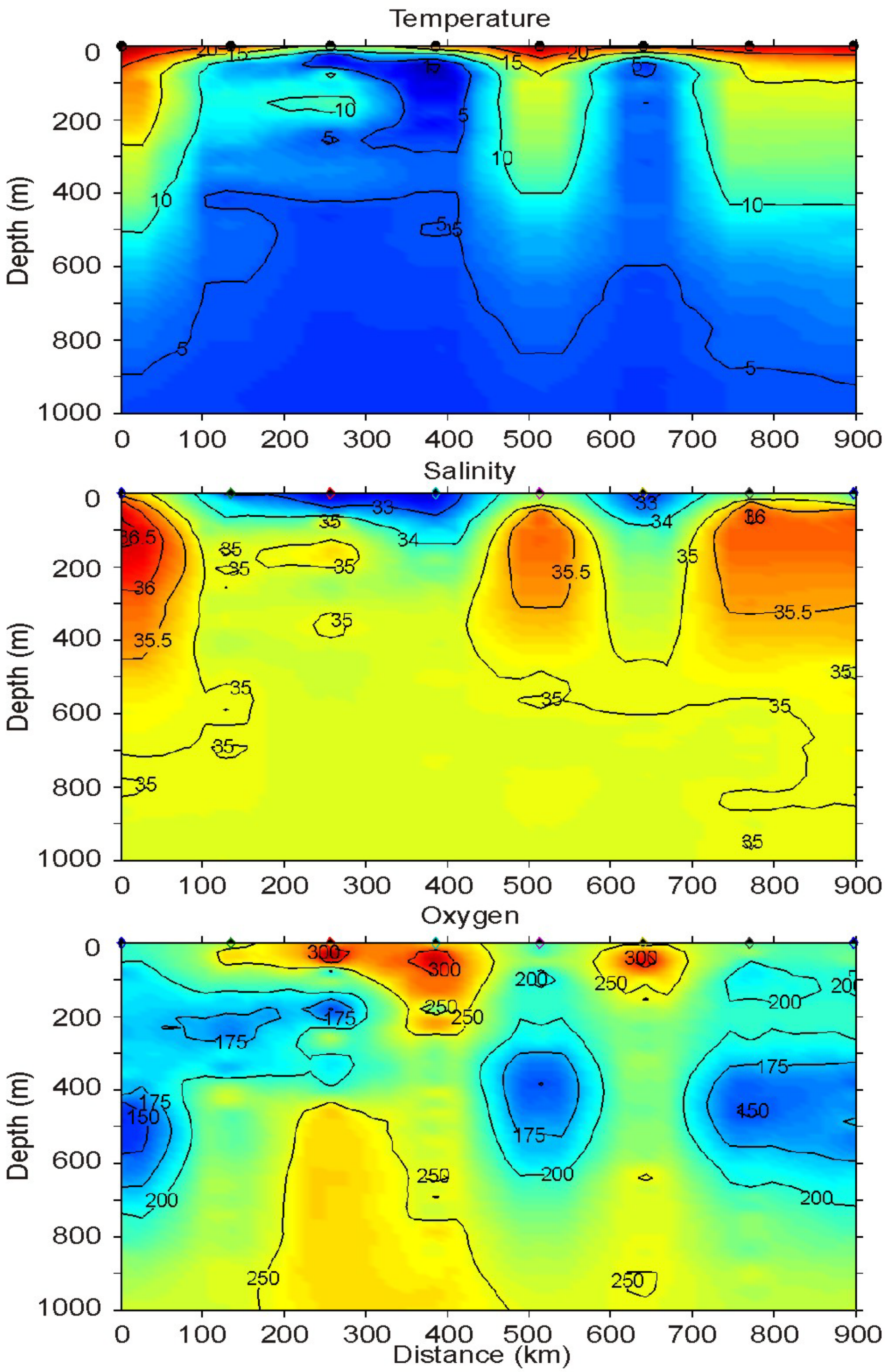


Figure 7.4D. Kriged plot of Oceanus Cruise 473 CTD oxygen and fluorescence data for transect 1 in the upper 200 m. CTD stations are indicated by the filled circle at the top of each plot.

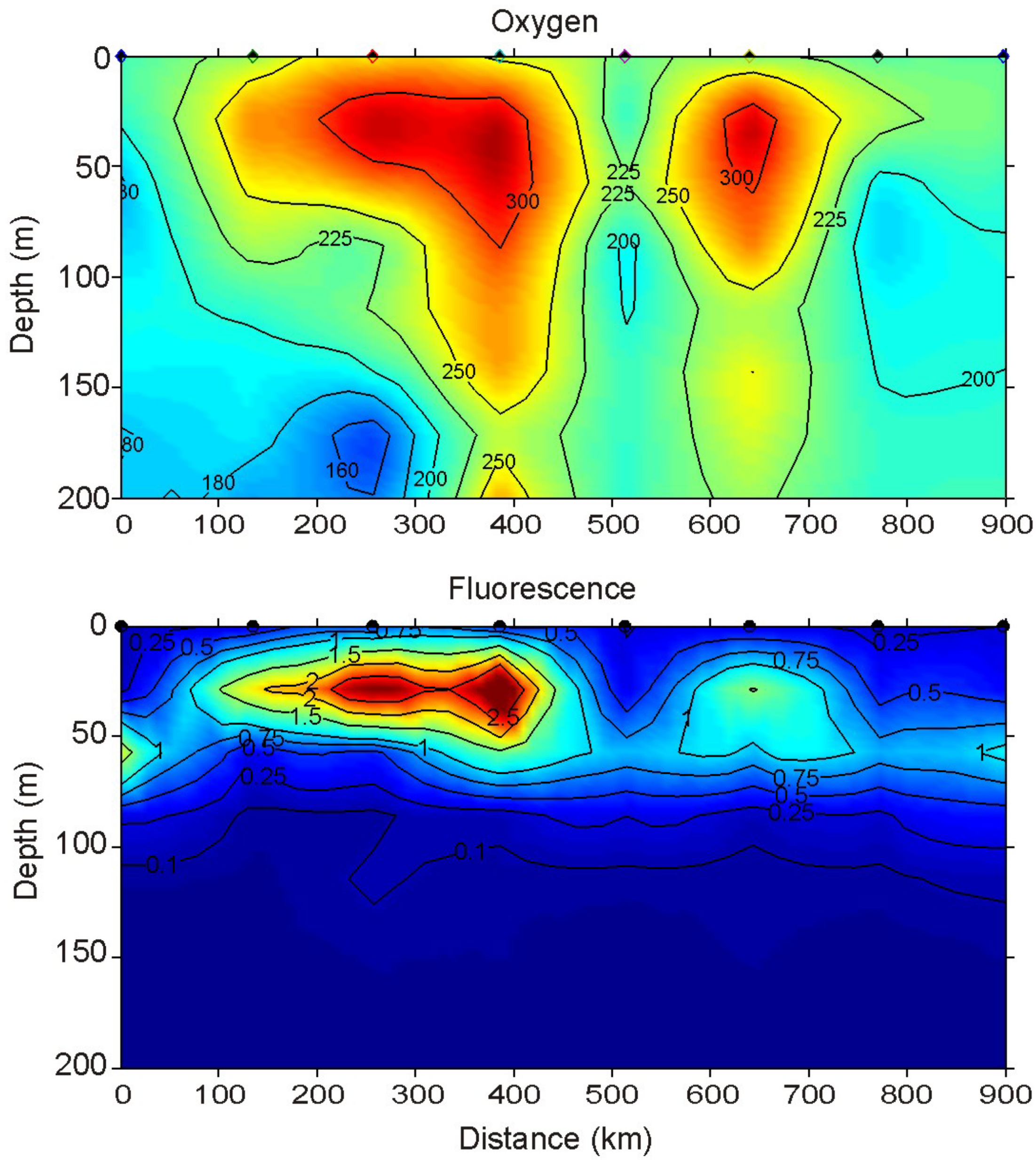


Figure 7.4E. Kriged plot of Oceanus Cruise 473 CTD temperature, salinity, and oxygen data for transect 3 upper 1000 m. CTD stations are indicated by the filled circle at the top of each plot.

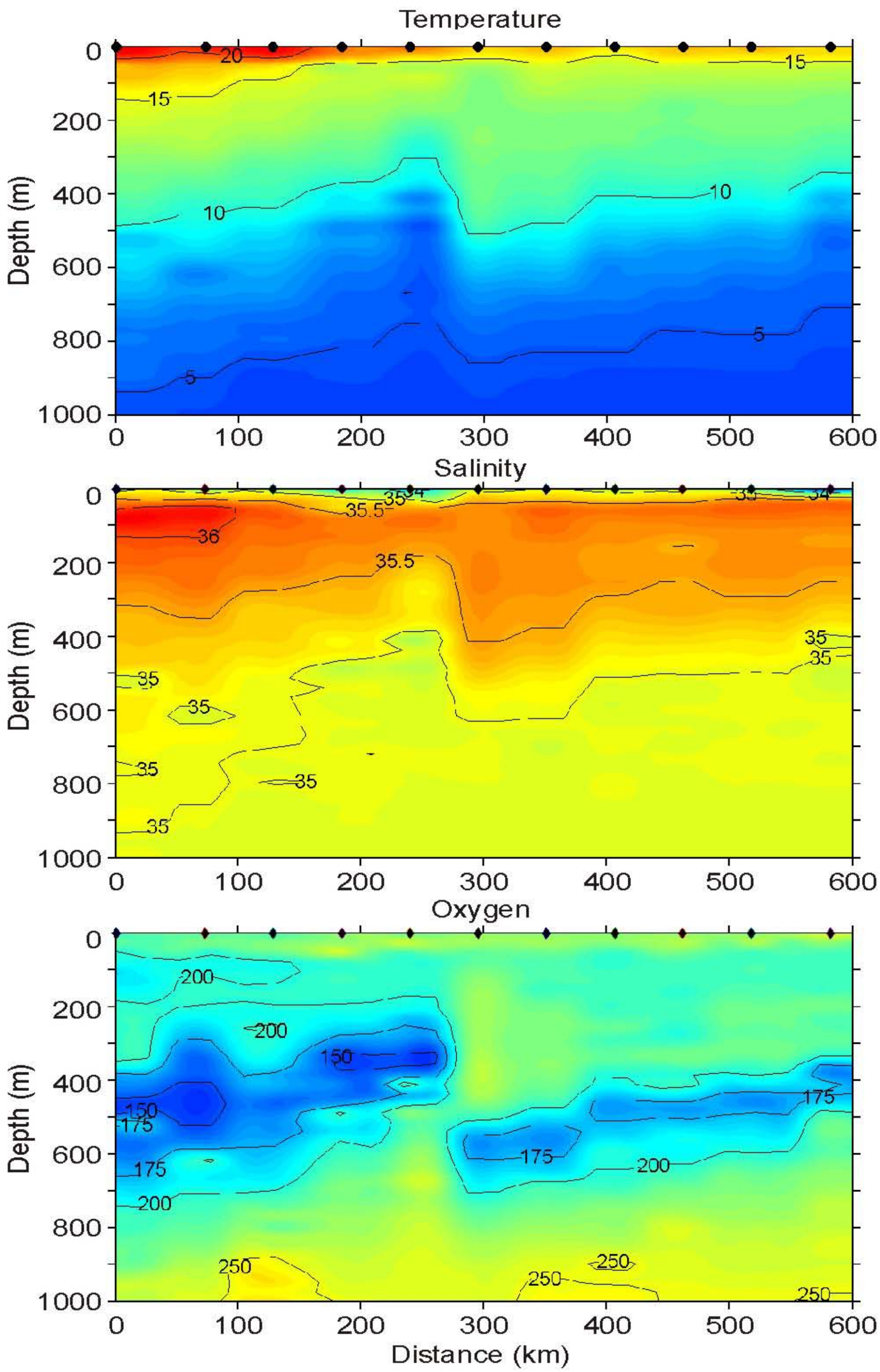


Figure 7.4F. Kriged plot of Oceanus Cruise 473 CTD oxygen and fluorescence data for transect 3 in the upper 200 m. CTD stations are indicated by the filled circle at the top of each plot.

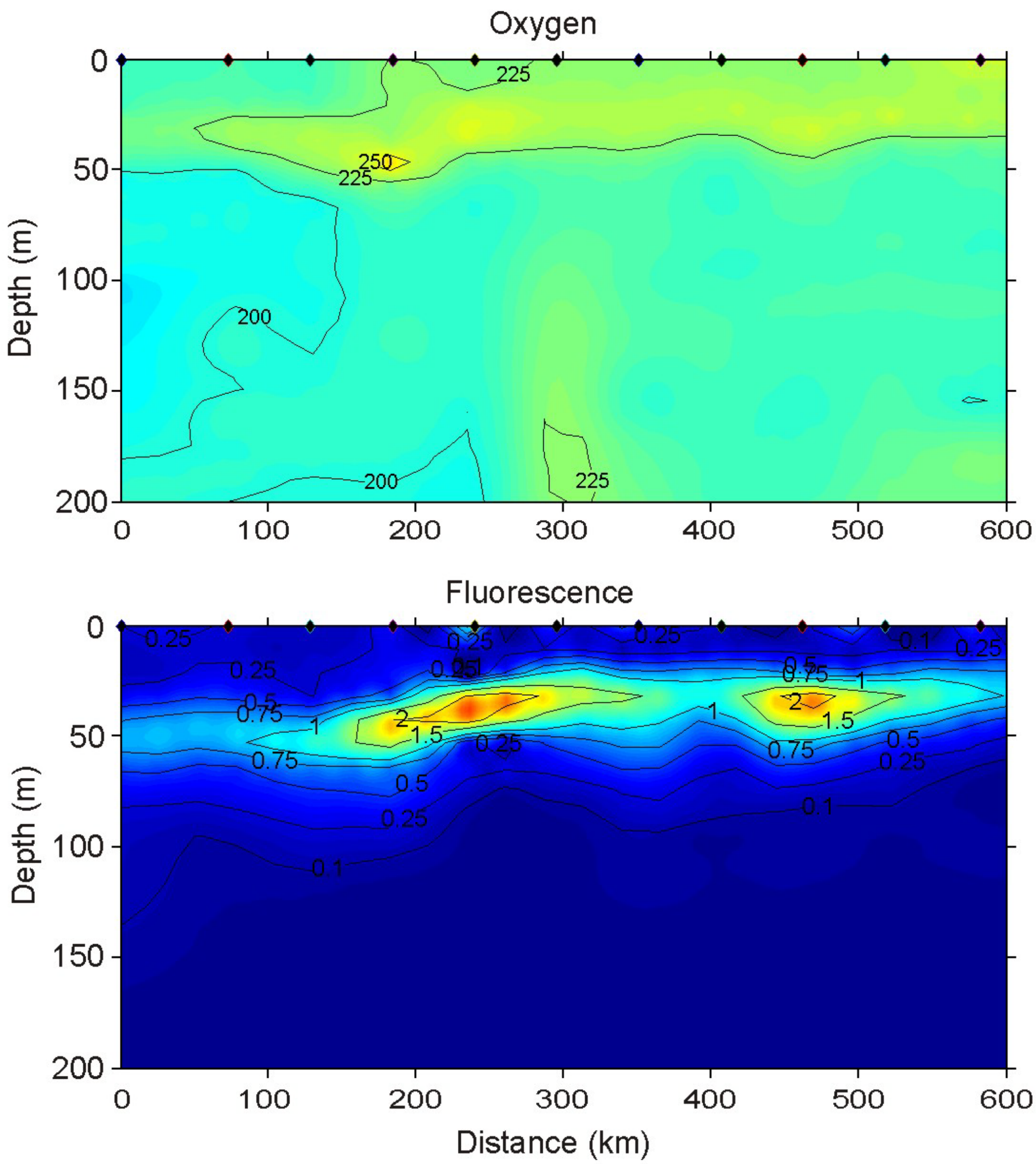
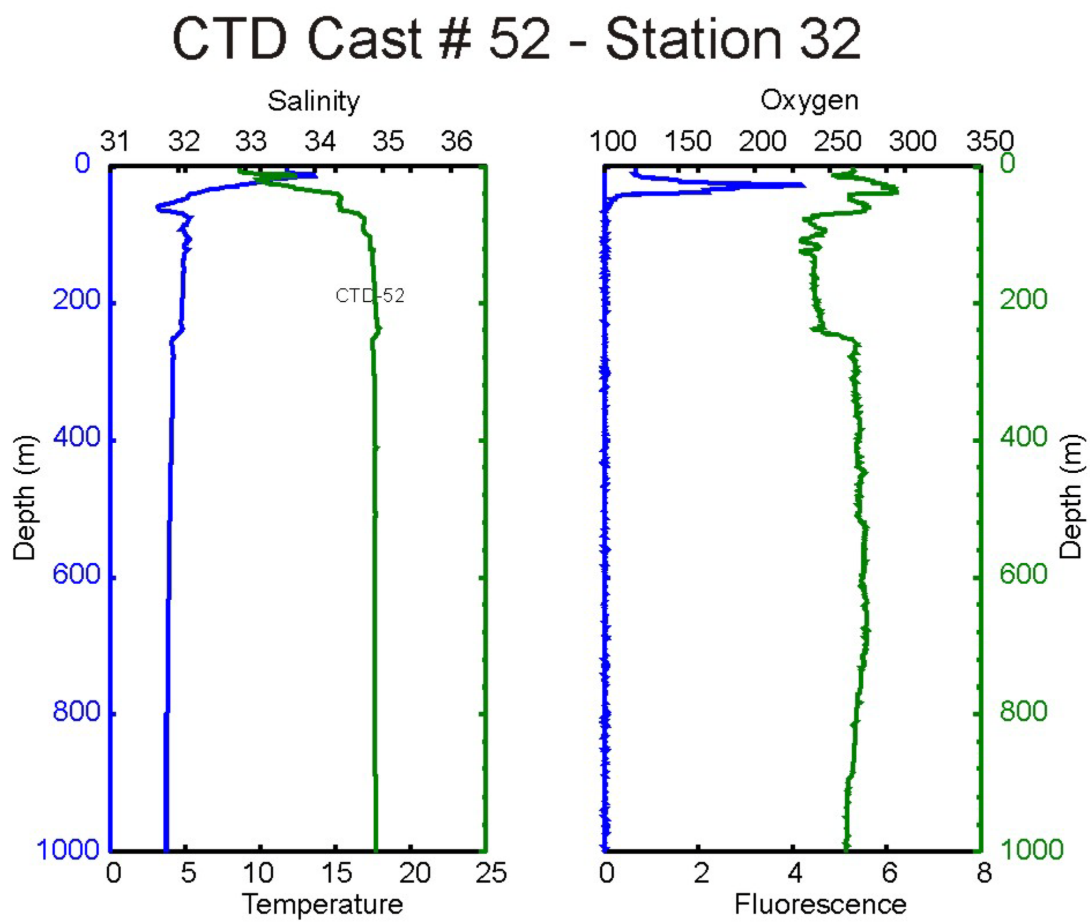


Figure 7.4G. Vertical distribution of temperature, salinity, oxygen, and fluorescence data at Station 32 in the Labrador Sea (CTD # 52, Oceanus Cruise 473)..



8. Chemistry

Zhaohui Aleck Wang, Katherine Hoering

8.1. *Introduction*

Dr. Zhaohui Aleck Wang's group from the Department of Marine Chemistry and Geochemistry at WHOI measured carbonate chemistry parameters with both discrete and underway parameters during the OC473 cruise on board R/V Oceanus. Measuring these parameters allows us to calculate the carbonate compensation depth and the calcium carbonate saturation state, two important variables that determine the formation of aragonite shells by pteropods. These data will be used to analyze how the distribution, abundance, species composition, shell condition, and vertical migratory behavior of pteropods vary with carbonate chemistry. In addition, the collected carbon data will be very valuable to evaluate the rate of ocean acidification in the N. Atlantic Ocean by comparing new data with historical data sets (e.g. CLIVAR A20 2003 data set).

Discrete Samples

Discrete bottles samples were collected at 32 CTD-Rosette stations, among which 24 stations (regular stations) were sampled to 1000m depth, and the rest (day-night stations) were sampled to 3000m. Samples were taken for pH, total dissolved inorganic carbon (DIC), total alkalinity (TA), nutrients, and salinity. These data will be used to resolve the vertical distribution of carbonate chemistry in the North Atlantic.

Underway Measurements

Two underway systems were used during the cruise to measure the spatial variability in carbonate chemistry. The automated Multi-parameter Inorganic Carbon Analyzer (MICA) was used to simultaneously measure underway surface sea water fCO_2, DIC, pH, and air pCO_2. The Automated Flowing pCO_2 Measuring System by General Oceanics, Inc. (GO system) was used to measure air pCO_2 and seawater fCO_2. The measurements by the two underway instruments were used for cross-comparison to ensure high data quality. The CO_2 air-sea flux will also be estimated using these underway measurements and metrological data.

8.2. *Discrete pH measurements*

8.2.1. Methods

Summary

Seawater pH was measured during the OC473 cruise on board R/V Oceanus based on the spectrophotometric procedures outlined in SOP 6b of Dickson (2007) and in Clayton and Byrne (1993) using m-cresol purple (mCP) as the indicator. The pH on the total scale (pH_T) was calculated using the following equation:

$$pH_T = 1245.69/T + 3.8275 - 0.00211(35-S) + \log((R-0.00691)/(2.222-0.1331R)) \quad (1)$$

where T is the measurement temperature (T = 273.15 + t) and S is salinity.

Discrete pH samples were collected for all 32 stations at all sampling depths, and the measurements were completed within 4 hours of sample collection. Duplicate samples were collected at selected depths of each station to evaluate the precision of the measurements.

Principle of pH measurements

Measurements of seawater pH were obtained using m-cresol purple as indicator. Solution pH in seawater, on the total hydrogen ion concentration ($[H^+]_T$) scale, was calculated from the equation

$$\mathrm{pH_T} = -\log_{\mathrm{T}}\mathrm{K_I} + \log\frac{\mathrm{R} - e_1}{e_2 - \mathrm{R}e_3}, \qquad (2)$$

where e_1 = 0.00691; e_2=2.222; and e_3=0.1331. The temperature (T) and salinity (S) dependence of the m-cresol purple equilibrium constant ($_{\mathrm{T}}\mathrm{K_I}$) is given as:

$$-\log_{\mathrm{T}}\mathrm{K_I} = \frac{1245.69}{\mathrm{T}} + 3.8275 + 0.00211(35 - \mathrm{S}), \qquad (3)$$

and pH_T is related to pH on the free hydrogen ion concentration scale (pH = $-\log[H^+]$) as follows:

$$\mathrm{pH_T} = -\log[\mathrm{H^+}]_{\mathrm{T}} = -\log[\mathrm{H^+}] - \log(1 + \frac{\mathrm{S_T}}{\mathrm{K_{HSO_4}}}), \qquad (4)$$

where S_T is the total sulfate concentration and K_{HSO4} is the HSO_4^- dissociation constant.

Reagents
A stock solution of m-cresol purple (4 mM) was prepared with m-CP sodium salt (Acros Organics) in Milli-Q water. The R ratio (absorbance of the base form (I^{2-}) divided by the absorbance of the acid form (HI^-) of the stock solution was adjusted to 1.6 with a NaOH solution to minimize pH perturbation of adding indicator to a sample. The dye solution was stored in a borosilicate glass bottle wrapped with aluminum foil to exclude gas exchange and light from the indicator.

Sampling and Measurements
At each station pH samples were taken from Niskin bottles directly to 10 cm cylindrical glass cells via a silicone tubing. After flushing each cell for 20 seconds and ensuring that there was no trapped air, the cell was sealed with PTFE caps. The cells were then dried with Kimwipes or paper towels, and put into a 24-position metal cell holder that was temperature controlled by flowing-through thermostatic water at 25±0.1°C. After the cells had been thermostated for about one hour, the pH measurements started.

For each pH measurement, the exterior of the cell was carefully cleaned and then the cell was placed in the thermostated sample compartment of the spectrophotometer (Agilent 8453 UV-VIS). The baseline was recorded at three wavelengths (434, 578 and 700). The cell was then taken out from the spectrophotometer, and 20 µL of m-CP was added into the sample with a Gilmont pipette. The cell was briefly shaken to mix the seawater sample and the indicator. The cell was returned to the spectrophotometer and absorbances at the three selected wavelengths were recorded.

The measurements were computer controlled with a macro code for sample information input, data acquisition, and storage. The program also implemented quality controls for baseline stability and measurement precision.

8.2.2. Preliminary Results

Figure 8.1 shows the preliminary results of pH profiles from selected stations during the cruise.

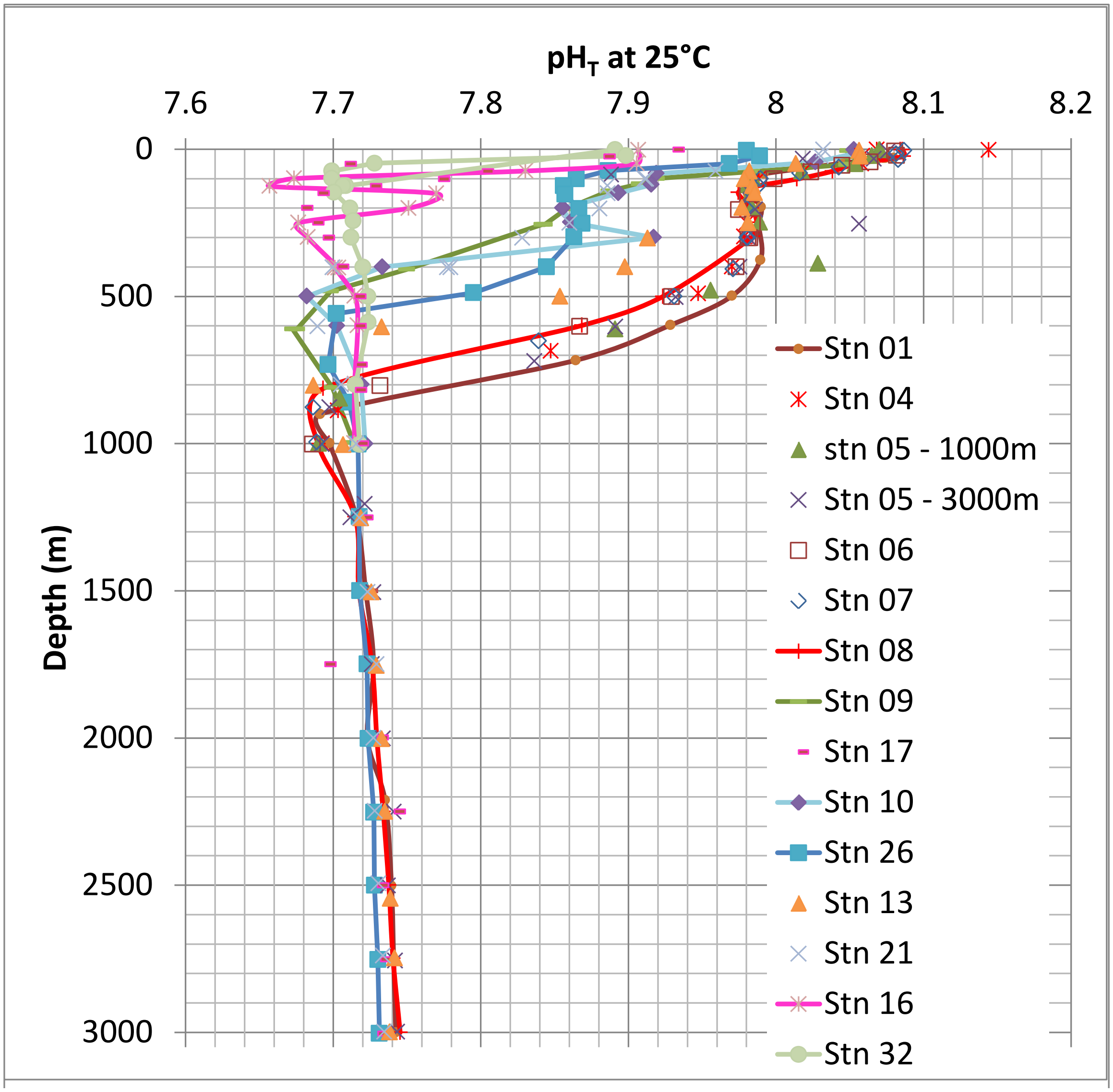


Fig. 8.1. pH_T (25°C) profiles from selected stations during the cruise.

Data Processing

Correction for pH perturbation resulting from addition of indicator

The indicator perturbation to seawater sample will be evaluated empirically after the cruise. A pair of additions of indicator (4 mM m-CP, 10 µL and 20 µL) will be made to a series of seawater samples that have the pH range of 7.6 – 8.1 encountered during the cruise. pH perturbation (ΔpH) to each sample will be determined as the difference between measured pH and the 'true' pH, which will be evaluated by extrapolating the measured pH of the two additions of m-CP to the pH at zero volume addition. After all seawater samples are measured this way, the relationship between pH and ΔpH will be determined. This relationship will be applied to all measured pH during the cruise.

Temperature consideration

Temperature of the samples was controlled by a circulating water bath which was set to 25°C. As soon as a sample was measured, the temperature of the sample was measured with a Fluke reference temperature probe (traced to NIST standard). The majority of the sample were measured at 25±0.1°C.

The small temperature difference from 25°C will not add error to measurement due to the inherent properties of m-CP and the CO_2 chemistry. For example, if a sample is measured at 24.9°C, but t = 25°C was assumed to calculate pH based on Eq. 1, this would result in pH = 8.0000. The same sample will have a calculated pH = 7.9985 if using the true t = 24.9°C in Eq. 1. Based on the CO_2 system thermodynamic relationships (Lewis and Wallace, 1998), when pH measurements at 24.9°C are corrected to 25°C, the correction factor is 0.0014. This will result in a corrected pH value (in the example above) of 7.9999 (7.9985 + 0.0014). The difference between the corrected and non-correct pH is only 0.0001, which is below the detection limit of the method. When temperature differs by as much as 0.2°C, the error by assuming t = 25°C is less than 0.0002. Therefore no temperature corrections were made to the cruise dataset.

8.2.3. References

Clayton, T. D., and R. H. Byrne. 1993. Spectrophotometric Seawater Ph Measurements - Total Hydrogen-Ion Concentration Scale Calibration of M-Cresol Purple and at-Sea Results. Deep-Sea Res Pt I **40:** 2115-2129.

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Lewis, E., and D. W. R. Wallace. 1998. Program developed for CO_2 system calculations. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy.

8.3. *Discrete Measurements of Dissolved Inorganic Carbon and Total Alkalinity*

8.3.1. Methods

Discrete DIC and TA samples were collected for all 32 stations at all sampling depths. A portion of the collected samples were measured during the cruise and the rest were brought back to the lab for analyses. Duplicate samples were collected at random depths of selected stations to evaluate the precision of the measurements.

Sample Collection

Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA) samples were collected in 250mL Pyrex borosilicate glass bottles after being filtered with a .45um in-line capsule filter. Each bottle was rinsed three times, filled completely, and then the sample was overflowed by another one and one half bottle volume. Air head space of about one percent of the bottle volume (~3 ml) was left in each sample bottle to allow room for expansion. Each sample was then poisoned with 80uL of saturated mercuric chloride, capped with a Apiezon-L greased stopper, thoroughly mixed, and then tied with a rubber band over the glass stopper.

8.3.2. Dissolved Inorganic Carbon

Dissolved Inorganic Carbon (DIC) is defined as:

$$DIC = CO_3^{2-} + HCO_3^{-} + H_2CO_3.$$

The samples were analyzed using an Apollo SciTech DIC auto-analyzer. The sample was first acidified using 10% phosphoric acid in 10% sodium chloride media to convert all of the carbonate species to CO_2. High purity nitrogen gas was then used to purge the CO_2 from the acidified sample and direct it through a cooling system and a magnesium perchloride plug to remove water vapor. The dried CO_2 gas was then measured with a LI-COR 7000 infrared analyzer.

Certified Reference Material (CRM) from Dr. A. Dickson at Scripps Oceanography was used to calibrate the instrument daily. Four volumes of CRM between 0.4 and 1.2 mL were measured for standardization. The slope and intercept coefficients of area versus volume were determined so that the DIC concentration of the samples, measured at 0.75 mL, could be determined after volume correction. Figure 8.2 shows the calibration curve using CRM.

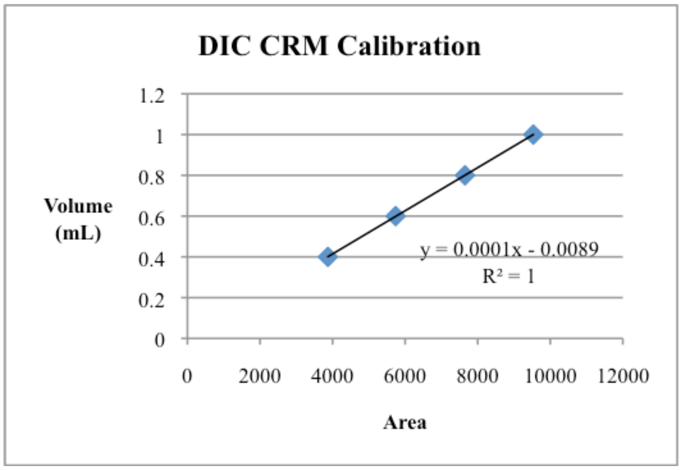

Fig. 8.2. Calibration curve of the DIC measurement.

A density correction was applied to each sample based on the temperature at which the measurement was made. Each sample was measured at least twice to obtain two parallel readings, the difference which was within 0.1% of each other. The CRM was measured as a sample every 12 hours to check the stability of the instrument. If there was a large shift in the DIC concentration (>2umol/kg), then the instrument was recalibrated. Duplicate samples were also measured to confirm that the field precision was ~0.1%.

8.3.3. DIC Preliminary Results

Figure 8.3 displays DIC data from selected stations during the cruise.

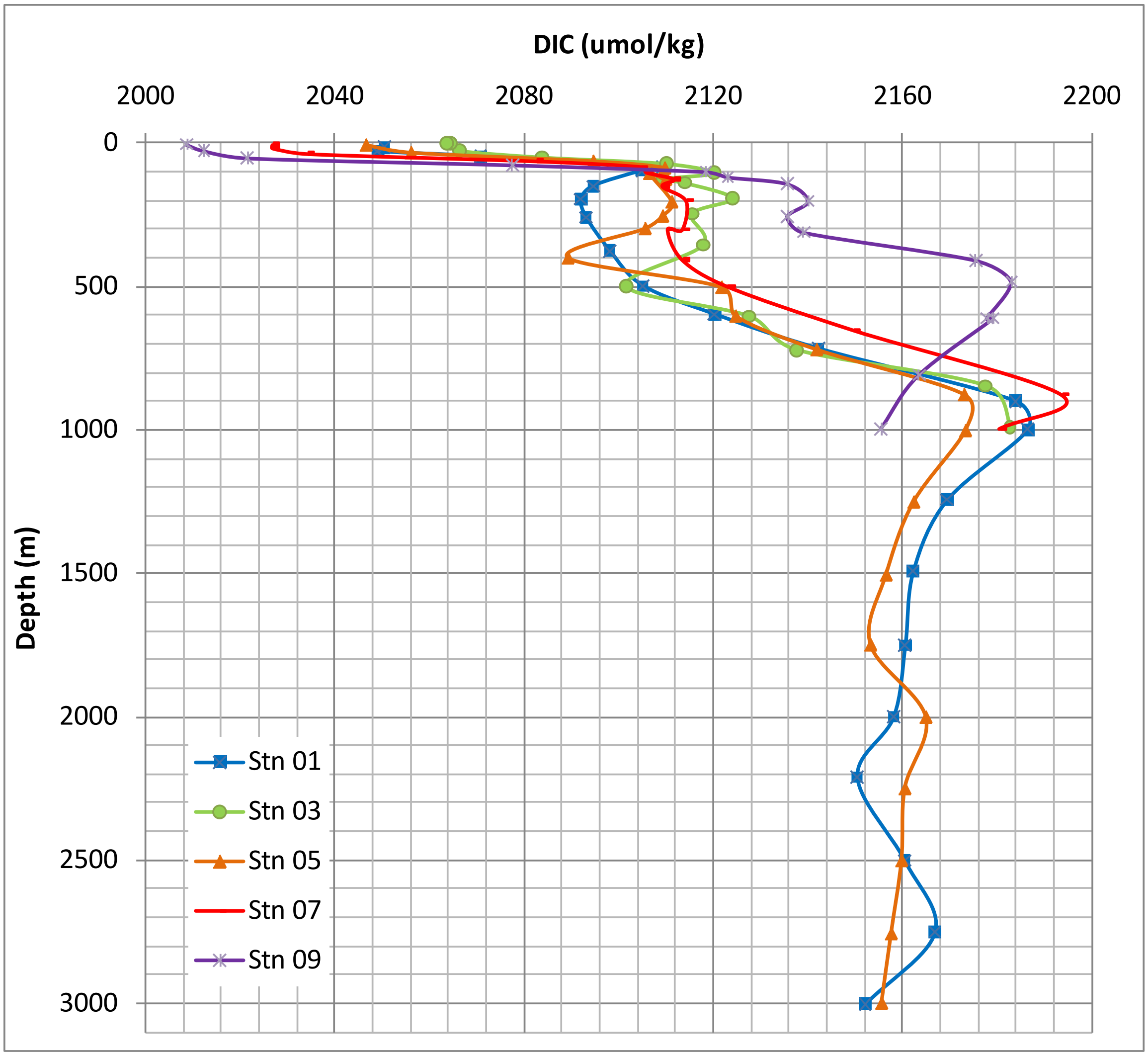

Fig. 8.3. DIC versus depth for selected stations.

8.3.4. Total Alkalinity

Total Alkalinity (TA) is vigorously defined by Dickson (1981) as the number of moles of hydrogen ion equivalent to the excess of proton acceptors (bases formed from weak acids with a dissociation constant *K* ≤ 10–4.5 at 25°C and zero ionic strength) over proton donors (acids with *K* > 10–4.5) in 1 kilogram of sample:

$$TA = [HCO_3^-] + 2[CO_3^{2-}] + [B(OH)^{4-}] + [OH^-] + [HPO_4^{2-}] + 2[PO_4^{3-}] + [Si(OH)_3O^-] + [NH_3] + [HS^-] + \ldots - [H^+]_F - [HSO_4^-] - [HF] - [H_3PO_4] - \ldots$$

where the brackets represents the total concentrations, $[H^+]_F$ is the free concentration of hydrogen ion, and the dots represent other minor acids and bases (Dickson et al., 2007).

TA measurements were made with an Apollo SciTech alkalinity auto-titrator, a Ross combination pH electrode, and a pH meter (ORION 3 Star) based on a modified Gran titration method (Wang and Cai, 2004). Input salinity values were used to approximate how much acid would need to lower sample pH to ~3.7. Thereafter, any additional amount of acid added would be a dilution process. A linear relationship could be determined by the amount of acid added and the Gran Factor. This linear relationship could then be used to calculate the amount of acid that would be needed to lower the sample pH to the CO_2 equivalence point (pH = 4.5). The amount of acid needed and its concentration were then used to calculate total alkalinity.

The pH electrode was calibrated using three NBS buffer solutions (pH = 4.01, 7.00, and 10.01) to derive the electrode response's slope used for Gran Factor calculation. This calibration was conducted every 12 hours. CRM was used to calibrate the concentration of hydrochloric acid used (0.9% HCl in 0.7 sodium chloride media solution) for titration every 24 hours.

Each sample was measured at least twice to obtain two parallel readings, the difference which was within 0.1% of each other. Also, for quality control, the CRM was run as a sample at least every 12 hours to check if there was a change between the CRM assigned and measured TA value. A linear interpolation was applied to correct measurements when such a change occured.

8.3.5. Alkalinity Preliminary Results

Figure 8.4 displays TA data from selected stations during the cruise.

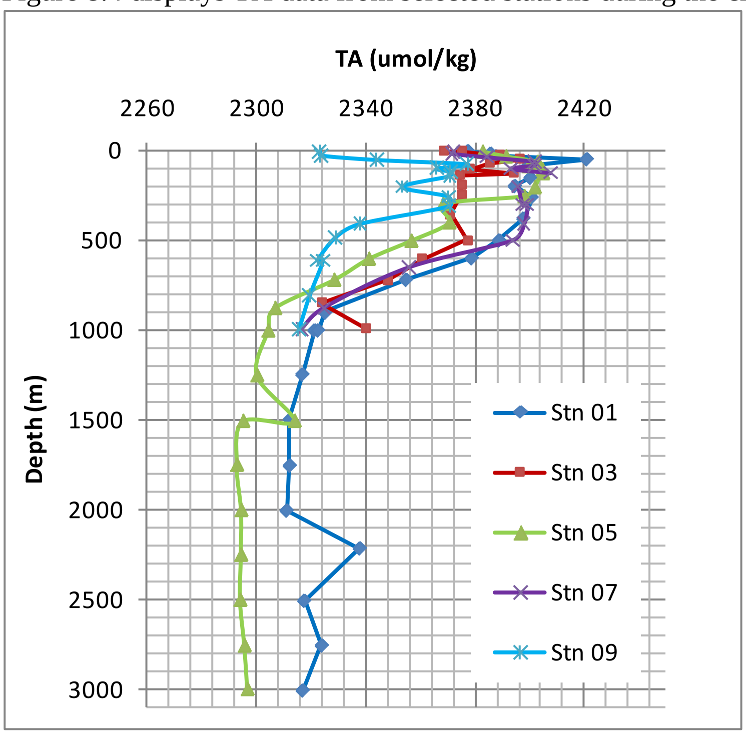

Fig. 8.4. TA versus depth for selected stations

8.3.6. References

Dickson, A. G. 1981. An Exact Definition of Total Alkalinity and a Procedure for the Estimation of Alkalinity and Total Inorganic Carbon from Titration Data. Deep-Sea Res **28:** 609-623.

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8.4. *Discrete Salinity Measurements*

8.4.1. Methods

Discrete salinity samples were collected from selected depths at each of the hydrographic stations in order to calibrate CTD salinity measurements. The salinity samples were directly collected from CTD Niskin bottles into 500 ml square borosilicate glass bottles, which were rinsed three times with the sample prior to filling.

A single Guildline Autosal Model 8410A salinometer (S/N 65735) was used for all salinity measurements at room temperature (20 - 25°C). The salinity analyses were performed after samples had equilibrated to laboratory temperature, usually within 48 hours after collection. The salinometers were standardized for each group of analyses (usually 3-4 casts, up to ~30 samples) using one fresh vial of standard seawater per group. Salinometer measurements were made manually. PSS-78 salinity (UNESCO, 1981) was calculated for each sample from the measured conductivity ratios. IAPSO Standard Seawater Batch P-152 was used to standardize all measurements.

8.4.2. Problem and Solutions

The salinometer stopped sucking in sample near the end of the cruise due to a plumbing issue inside the measurement chamber. The problem was not solved, and there were ~20 samples that were not analyzed during the cruise. They will be measured right after the cruise.

8.4.3. Preliminary Results

Fig. 8.5 shows the comparison between measured discrete salinity samples and CTD salinity. The tight relationship suggests that the CTD sensor behaved well and both measurements are consistent during the cruise.

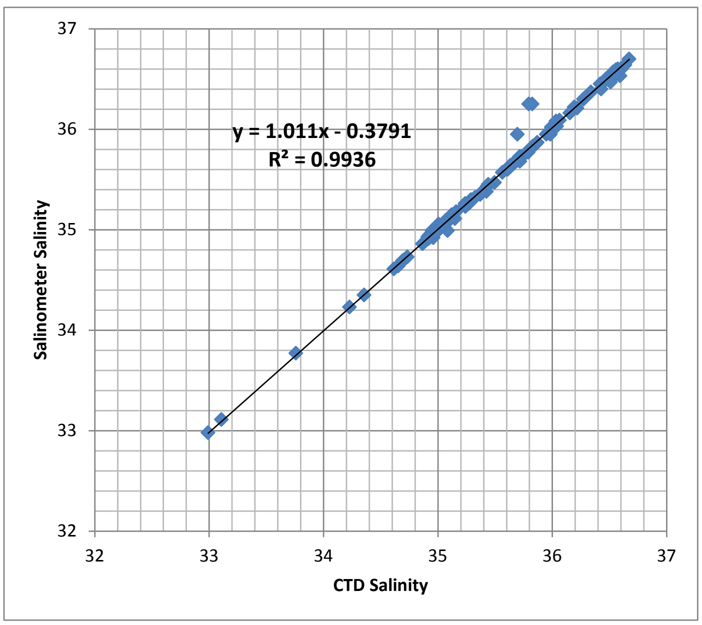

Fig. 8.5. Comparison between salinometer salinity and CTD salinity

8.5. *Discrete Nutrient Measurements*

8.5.1. Methods

Nutrient samples were collected in acid cleaned Kimble 20mL plastic bottles. Before the cruise, the bottles were soaked in 10% hydrochloric acid for four hours, rinsed three times with deionized water, and then dried in the oven at 50°C for 48 hours. During collection, the sample was filtered with a 0.22um Pall capsule filter. The bottle was rinsed three times with the sample and then filled. Collected samples were frozen onboard the ship and will be shipped on ice to the WHOI Nutrient Analytical Facility for analyses. Concentrations of ammonium, nitrate plus nitrite, nitrite, orthophosphate, and silicate will be determined by a Lachat Instruments QuickChem 8000 four-channel continuous flow injection system, using standard colorimetric methods approved by U.S. Environmental Protection Agency.

8.6. *Underway Measurements of pCO_2, DIC, and pH using Multi-parameter Inorganic Carbon Analyzer (MICA)*

8.6.1. Methods

Equipment and Analytical Techniques

The automated Multi-parameter Inorganic Carbon Analyzer (MICA) was used to simultaneously measure underway surface sea water fCO_2, DIC, pH, and air pCO_2.

The technical details and performance evaluation of the MICA can be referred to in Wang et al. (2007). The system has been recently updated to MICA II, which consists of three chambers and a total of four channels: two CO_2 channels (surface sea water fCO_2 and atmospheric pCO_2), DIC channel, and pH channel. All measurements are based on the similar spectrophotometric principle. The system can operate continuously with a sampling frequency of ~7 measurements per hour. The four channels operate and record data independently.

Spectrophotometric pH measurements are based on the method described in Clayton and Byrne (1993), but use thymol blue as the pH indicator (Zhang and Byrne, 1996; Wang et al., 2007). Indicator thymol blue are directly injected into a stream of underway sea water and absorbances at acid (435 nm), base (596 nm), and a reference wavelength (730 nm) are monitored by a spectrophotometer.

For sea water/air pCO_2 and sea water DIC measurements, Teflon AF 2400 (DuPont) is used as both a CO_2 permeable membrane and a long liquid-core waveguide (LCW) (Wang et al., 2007). For the sea water/air pCO_2 measurements, phenol red is used as the indicator, while bromocresol purple is used as the indicator in DIC measurements. During each CO_2 measurement, the indicator solution in each of two CO_2 channels is motionless inside the LCW. The sea water or air samples are directed to flow outside the LCW. After CO_2 molecules equilibrate with the LCW's internal solution through diffusion, its equilibrium pH is measured by absorbance ratios. pCO_2 is then derived from this equilibrium pH. For DIC measurements, sea water samples are first acidified to convert all carbonate species of sample water to CO_2 before measurements.

For each of the three indicators used, three wavelengths were chosen for measurement of absorbances. Two wavelengths assess the absorbance peaks of acid and base forms of the indicator, while a third wavelength serves as a reference wavelength. Absorbances vary at the acid and base wavelengths in response to pH changes, but not at the reference wavelength. Absorbance ratios between acid and base wavelengths are calculated, and used to evaluate CO_2 system parameters. The wavelengths chosen for the four channels are listed in Table 8.1.

Table 8.1. Wavelengths used for spectrophotometric determination of inorganic carbon species.				
Channel	**Indicator**	**Acid Wavelength**	**Base Wavelength**	**Reference Wavelength**
Sea water fCO_2 and air pCO_2	Phenol red	434 nm	558 nm	730 nm
DIC	Bromocresol purple	432 nm	589 nm	730 nm
pH	Thymol blue	435 nm	596 nm	730 nm

Four Ocean Optic USB4000 spectrophotometers are used to detect the light signals of the four channels. The light assemblies, spectrophotometers, and optical cells are connected through optic fibers. The light assembly of each channel consists of a high-temperature tungsten lamp with blue and short-pass filters in order to achieve an improved balance of spectral intensity between 430 and 730 nm.

The optical cells of the two CO_2 and the DIC channels are custom-machined from PEEK rods. The center piece of the optical cell has a length of 15 cm. The Teflon AF 2400 LCW is held inside this center piece. The center piece has a sample inlet and outlet, and two optical fibers that connect the optical cell with the light source and spectrophotometer are inserted into the ends of the LCW through two custom-made PEEK connectors. The ends of the LCW are sealed by two O-rings housed inside the connectors. The PEEK connectors allow both reagent and light to pass through the LCW. The pH optical cell is also machined from a PEEK rod, but does not require special connectors since no LCW is used.

The indicator solution for pCO_2 measurements consists of 2 µM phenol red in 225 µmol kg^{-1} total alkalinity (Na_2CO_3) and 0.2 µM sodium lauryl sulfate solutions. For DIC measurements, the indicator solution is made of 2 µM bromocresol purple in 1000 µmol kg^{-1} total alkalinity (Na_2CO_3) and 0.2 µM sodium lauryl sulfate solutions. The reference solutions of the pCO_2 and DIC measurements are made similarly without indicator. For pH measurements, thymol blue solution is made in Milli-Q water with a concentration of 1.5 mM. The R ratio of thymol blue solution is adjusted (R~0.77) to minimize the magnitude of indicator-induced pH perturbations. All indicator and reference solutions are stored in gas-impermeable laminated bags.

Indicator and reference solutions are pumped through separate lines into their respective channels by digital peristaltic pumps. Surface sea water is pumped on board by a shipboard pumping system. It first flows through a SBE 49 CTD that records salinity and temperature. Sea water samples are then pumped through three channels for measurements of fCO_2, DIC, and pH. For DIC, sea water samples are acidified with ~2.5 N HCl. The mixing ratio between HCl and seawater is approximately ~1:700. An in-line mixing coil is used to facilitate mixing. Thymol blue is mixed with sea water samples for pH measurement with a mixing ratio of ~1:700 (sea water to thymol blue), and the final thymol blue concentration in sample water is ~ 2 µM. Such a low indicator concentration results in insignificant pH perturbation (< 0.001 pH units) due to indicator addition. Air samples are drawn from the front of the ship through an air sample line. The air flow rate is controlled at 35 ml/min using a gas flow controller. Atmospheric pressure is recorded by a barometer.

All channels are thermostated using Peltier devices that are set to 25 ± 0.1°C. All samples, reference and indicator solutions are also temperature pre-equilibrated through the gold-plated metal plates. All measurements, as well as calibrations, are taken at this temperature.

All units of the system are connected to a custom-made electronic motherboard and controlled by a PC. The interface program runs cycles to operate the MICA continuously. The time required for each measurement cycle depends on the equilibration time (7 minutes for the fCO_2/pCO_2 and DIC channels) and flushing time for the indicator/reference solution and samples (~2 minutes). Chemical reaction for pH measurements is instantaneous. The following sequence is taken during a measurement cycle:

1. Flush pH reference (sea water samples without indicator solution).
2. Flush reference for sea water fCO_2, air pCO_2, and DIC.
3. Read and store reference readings.
4. Flush indicator solutions for sea water fCO_2, air pCO_2, and DIC; mix thymol blue with sea water samples (pH measurements); acidify DIC samples.
5. fCO_2, pCO_2 and DIC equilibration (7 minutes).
6. Read and store measurements.
7. Repeat Step 4-6 six times.
8. End of one measurement cycle and repeat from the beginning.

During measurements, the sea water and air samples are continuously flowing through the channels.

Standards

The CO_2 channels (seawater fCO_2 and air pCO_2) was calibrated before the cruise against five standard CO_2 gases ranging from 150 to 1001.6 ppm (XCO_2). DIC was also calibrated before the cruise using Certified Reference Material (CRM). Thymol blue has been previously calibrated for sea water pH measurements (Zhang and Byrne, 1996). During the cruise, CO_2 gas standards and CRM were used periodically to check the pre-cruise calibration consistency for CO_2 and DIC measurements, and re-calibration was performed if necessary.

Data Processing

The absorbance ratio R for each measurement (all four parameters) is given as:

$$R = (A_2 - A_{ref})/(A_1 - A_{ref})$$

where A_1 and A_2 are the peak absorbance at acid and base wavelengths, respectively; and A_{ref} is the absorbance at the reference wavelength. For all four parameters measured, R is used to calculate pH via the following equation:

$$pH = \log\left(\frac{R - \varepsilon_{2(HA)}/\varepsilon_{1(HA)}}{\varepsilon_{2(A)}/\varepsilon_{1(HA)} - R \cdot \varepsilon_{1(A)}/\varepsilon_{1(HA)}}\right) - pK_{a2}$$

where $\varepsilon_{1(HA)}$ and $\varepsilon_{2(HA)}$ are the molar absorptivities of the acid form (HA^-) of indicator at two peak-absorbance wavelengths; $\varepsilon_{1(A)}$ and $\varepsilon_{2(A)}$ are the molar absorptivities of the A^{2-} (fully unprotonated) form of indicator at two peak-absorbance wavelengths; and K_{a2} is the second dissociation constant of the indicator used. Molar absorptivities and K_{a2} for all indicators are determined in the laboratory at 25°C before the cruise. They are treated as constants since we only measure samples at 25°C.

From the above equations, pH can be directly calculated from absorbance ratios. Sea water fCO_2/air pCO_2 and DIC are calculated by referencing R to their respective standards.

The sea water fCO_2 and air pCO_2 measurements reflect the values at 25°C with 100% water vapor content. Our results can be corrected for temperature, water vapor and pressure to compare with other underway measurement.

The precisions of all parameters measured, estimated by replicate measurements, are given as follows:

pH	± 0.001
Seawater *f*CO_2 or air *p*CO_2	± 1 µatm
DIC	± 1-3 µmol/kg

Details on the mathematical treatment and calculation procedure can be found in Wang et al. (2007).

8.6.2. Problems and Solutions

During the cruise, the DIC acid pump and pH indicator pump occasionally stopped delivering fluids. The issue was resolved for the pH indicator pump. However, we had to frequently check with DIC acid pump and adjust it throughout the trip. The air pump was leaking for half of the cruise but we managed to get clean air sample from the General Oceanics *p*CO_2 underway system by using its air venting line.

8.6.3. Preliminary Results

Figure 8.6 shows part of preliminary data from MICA pH underway measurements during the cruise. The high resolution pH measurements captured several cross-frontal events when salinity and temperature underwent significant changes.

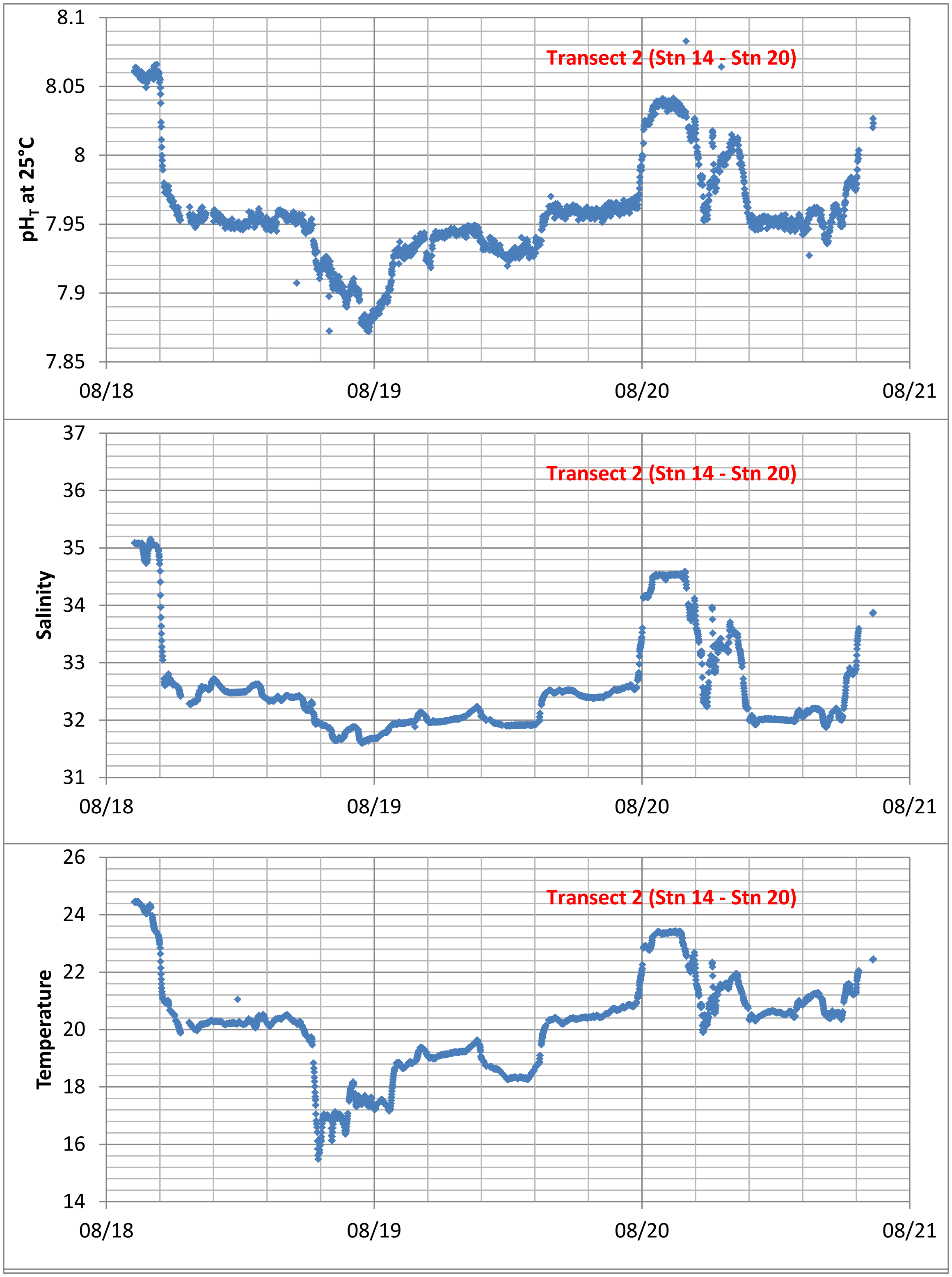

Fig. 8.6. Underway measurements of pH_T (25°C), salinity, and temperature by MICA during part of the cruise.

8.6.4. References

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Zhang, H.; Byrne, R. H. 1996. Spectrophotometric pH measurements of surface seawater at in-situ conditions: absorbance and protonation behavior of thymol blue. Mar. Chem., 52, 17-25.

8.7. *Underway Measurements of pCO_2 by the General Oceanic System*

8.7.1. Methods

Equipment and Analytical Technique

The fully automated underway *p*CO_2 system (model #8050) from General Oceanic's, Inc. (GO system) was used to measure seawater *f*CO_2 and air *p*CO_2 for the duration of the cruise. Seawater was pumped directly from the ships underway line at ~1.5 L min^{-1} to a sprinkler-type water-gas equilibrator, where a parcel of head-space air establishes CO_2 equilibrium with the flowing-through seawater. The CO_2 equilibrated air was then passed through a Peltier cooling block and a drying tube to remove the water vapor, and then measured by a LI-COR 6262 Infrared analyzer. Underway water temperature was measured with a Fluke Hart 1523 Reference Thermometer and this temperature will be used in temperature correction.

Air sample was pumped from the foremast of the ship at a rate of 60 mL/min, passed through the chiller and drying tube and air XCO_2 was then measured by the LI-COR. Air samples were measured five times and seawater was measured 45 times every hour. The following measurement sequence was used:

Sequence Setup

1. STD1Z (ZERO) Once
2. STD3S (SPAN) Once
3. STD3 Two times
4. ATM Five times
5. EQU 45 times
6. Repeat Step 4 and 5
7. Repeat the entire sequence

The precision for the GO system is better than ±1 µmol kg^{-1}.

Standards

The system was calibrated every 2 hours by two air-balanced CO_2 gas standards with XCO_2 (mole fraction of CO_2) of 0 ppm and 1001.6 ppm. These gas standards are traceable to World Meteorological Organization CO_2 standards obtained from NOAA/ESRL in Boulder, Colorado. The gas flow rates were set at the beginning of the cruise to 60mL/min.

Data Processing

The GO system measures XCO_2 (mole fraction of CO_2) in seawater and air. XCO_2 will be first converted to pCO_2 using atmospheric pressure. Final values will be corrected for in-situ temperature and water vapor, and will be reported as the fugacity of CO_2 (fCO_2).

8.7.2. Problems and Solutions

On Sunday August 21 the instrument abruptly stopped recording data and the program would not initialize. After troubleshooting the problem with a GO technician, it was determined that the name of the configuration file had been changed. The issue was resolved on Wednesday August 24 and the instrument ran until the end of the cruise on 1 September.

8.7.3. Preliminary Results

Figure 8.7 displays seawater pCO_2 during part of the cruise. Large changes in pCO_2, circled in red, indicate the ship crossed two major hydrographic fronts where different water masses meet.

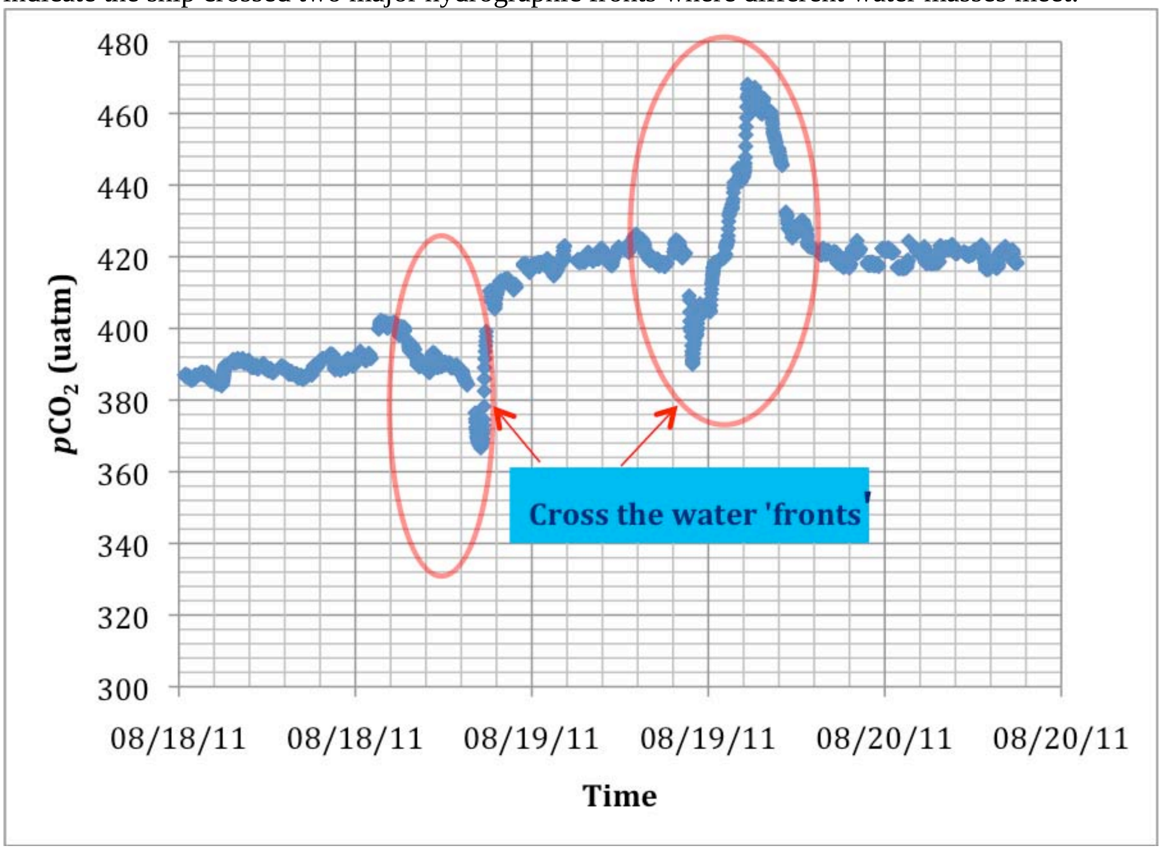


Fig. 8.7. Seawater pCO_2 during part of the cruise.

9. Zooplankton Sampling

9.1. *MOCNESS*

Peter Wiebe, Gareth Lawson

9.1.1. Introduction

A standard 1-m^2 Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS; Wiebe et al., 1985) was used to collect zooplankton to determine the taxonomic composition of the zooplankton in the study site with a specific focus on the shell bearing thecosomatous pteropods. It was also used to ground truth acoustic data collected with the HTI multi-frequency system and the Edgetech broadband system.

9.1.2. Methods

The MOCNESS was equipped with eight 150-um mesh nets (nets 1-8; borrowed from URI) and one 333-um mesh net (net 0). The underwater unit used was #169. In addition to the standard temperature and conductivity probes the system also had a beta-type strobe-light unit for reducing avoidance of the nets by some zooplankton and possibly small fish. The strobe system has two units each with 12 LED sets (LUXEON Rebel LED) with peak output between 490-520 nm. Seven of the 24 LED sets were no longer working at the start of the sampling. The LEDs are powered by the MOCNESS battery and their pulse width, amplitude, flash rate period, and on/off are controlled by the MOCNESS software. For this cruise the pulse width was 2 ms, the relative amplitude was 99%, and the flash interval was 100 ms.

Like the CTD, the MOCNESS was deployed from the starboard side hydroboom, but using the COM-15 oceanographic winch. Between casts it was laid down on its back on a galvanized steel stanchion installed for this purpose and tied down with ratchet straps. Having it lie on its back made cocking it very straightforward. For deployment, we used two slip-lines, one tied down to the same forward eye bolt/cleat used for the CTD and strung through the port side bottom I-beam U-bolt, and the other tied to the rail and strung through the starboard side bottom I-beam U-bolt. The system was first stood up then maneuvered such that it stood half-way out the gate; the nets were then thrown over the side in order (0 through 8), making sure to walk the forward end around the aft end of the gate to prevent the net from being snagged and torn. For recovery we use the forward air-tugger and a snap hook through the port side U-bolt and a snap hook on a line to the rail for the starboard side U-bolt. Like with the CTD, two people tended the sliplines while a third tended the conducting cable for the other oceanographic winch (attached to the CTD). In the course of recovery the system was again positioned half-way out the gate, allowing each net to be hauled on board, again making sure to avoid snagging any net on the edge of the gate. The nets were all hosed down with seawater with the system standing in this position. As each net was rinsed down the cod-ends were sequentially removed, placed in numbered buckets with two frozen cooler-packs, and transferred to the wet lab. Following this process, the system was then laid back down into the stanchion.

Samples were brought into the wet lab where sample splitting took place. One-half of a sample was preserved in 95% ethanol, ¼ was preserved in 5% buffered formalin, and ¼ was used for live viewing and picking, and then preserved in 70% ethanol. Sometimes, especially at night, the entire sample was very carefully viewed in a large white tray to find live pteropods for use in respiration experiments, for genetics studies, and for examination of the shell structure with an electron microscope. In addition, other species of copepods, salps, and euphausiids were also sorted live for flash freezing for genetics studies or for alcohol preservation for genetic barcoding for species identification. On occasion large fish (7) had their livers removed and preserved in RNAlater (one was flash frozen).

Oblique casts with the MOCNESS were made to 1000m with a ship speed nominally of 2 kts. Generally sampling was from 1000-800, 800-600, 600-400, 400-200, 200-100, 100-50, 50-25, 25-0m, except at test station 1 where sampling with four nets at 25 m intervals took place in the upper 100 m. The downcast started with the winch paying out at 10 m/min then at ca. 50 m the rate was increased to 20 m/min, and at ca. 100m to 30-35 m/min. Between 1500 and 2100 m were paid out to get the MOCNESS to 1000 m depending on ship speed and currents. The up-cast haul-in rate was variable, depending on the vertical velocity and how much wire was out, but was generally ca. 20 m/min below 100m and then 10 m/min in the upper 100m to ensure enough water was filtered in the shallow nets.

The MOCNESS tows were done only at the day-night stations, where one daytime and one nighttime tow were performed (Figure 9.1.1). The definitions of day and night used for both the MOCNESS and the VPR (described below in section 9.2) were:

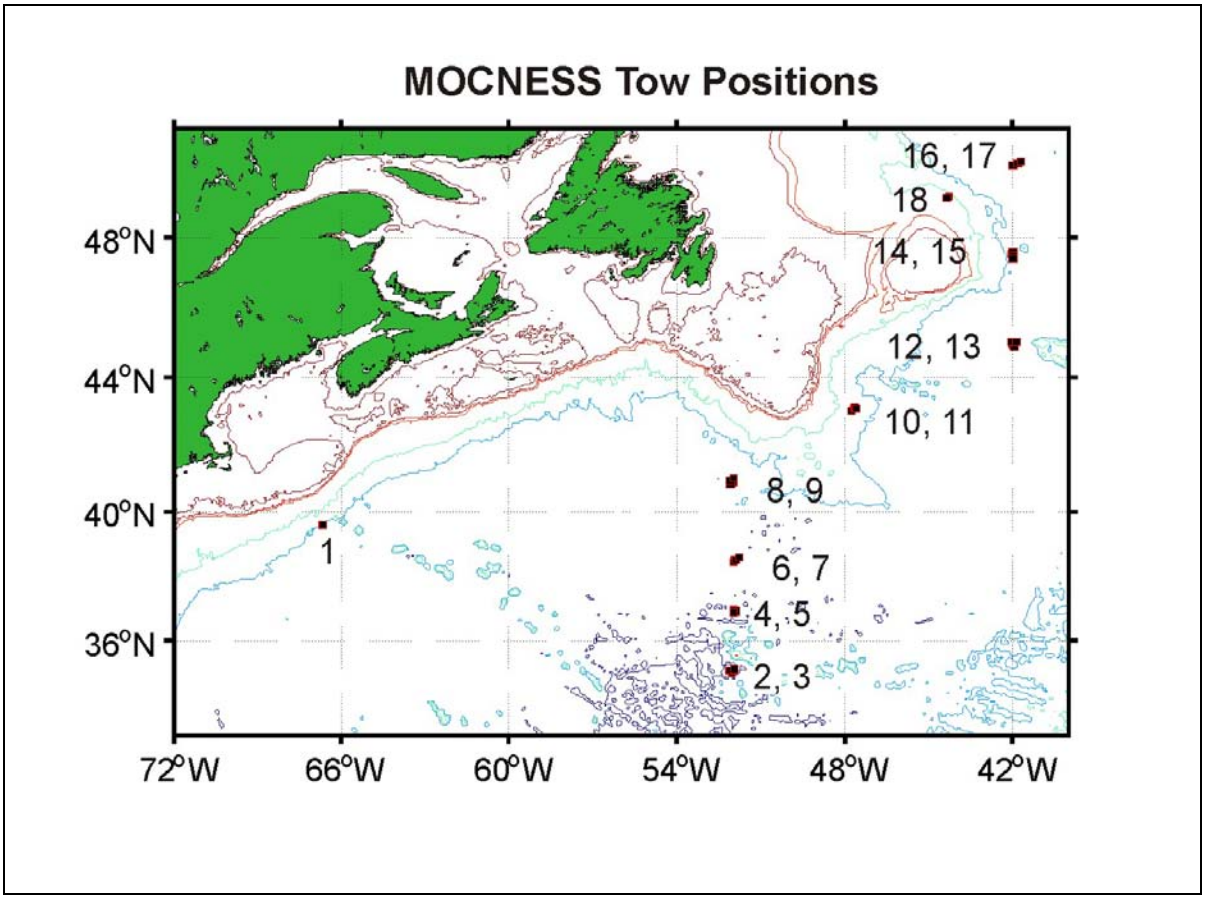
DAY
Start: The MOCNESS needed to be at depth ready to start sampling or the VPR starting its down-cast no earlier than 1 hour after sunrise.
End: The MOCNESS needed to be at depth starting sampling or the VPR finished its downcast sampling by 2 hours before sunset.

NIGHT
Start: The MOCNESS needed to be at depth starting its upcast sampling or the VPR starting its downcast no earlier than 1 hour after sunset.
End: The MOCNESS needed to be at the surface finished sampling or the VPR at depth finished with its downcast sampling by an hour before sunrise.

9.1.3. Preliminary Results

Eighteen tows were taken on the cruise, all successfully. As noted above, the first one was at Test Station 1. Sixteen were taken at strategic locations along the 3 primary sampling transect lines (Figure 9.1.1). Appendix 1 gives the positions, depths, and other information for each cast. One additional tow was taken at station # 32 to the west of transect 3 in Labrador Sea water.

Figure 9.1.1 Positions of MOCNESS tows taken on Oceanus 473 (7 August to 1 September 2011).



Mostly tropical/subtropical zooplankton species were caught along Transect 1. A mix of subtropical and temperate to Arctic/boreal species were caught along Transects 2 and 3 depending upon the water mass sampled. A pure assemblage of temperate and Arctic/boreal species were present in the MOCNESS samples taken at the single station on Transect 4.

9.2. *Video Plankton Recorder*

Nancy Copley, Alexander Bergan

9.2.1. Introduction

The Video Plankton Recorder is an underwater video microscope system designed to record images of plankton ranging in size from less than one half millimeter up to a few centimeters. A strobe light flashing at 20 times per second captures images at this rate. A program called AutoDeck reviews the images at about 15 frames per second and extracts Regions of Interest (ROIs) that may be plankton based on certain parameters such as brightness and sharpness (see Settings for ROI Extraction below).

We used the Video Plankton Recorder (VPR) in order to describe the abundance and vertical distribution of plankton taxa along our cruise path, which involved 32 stations. We sampled every station by deploying the VPR attached to a CTD rosette frame generally to 1000 m depth with a total of 44 casts.

9.2.2. Methods

The VPR was mounted in a specially designed cage attached via hose clamps below the CTD rosette frame (Figures 9.2.1 - 9.2.3). Four (nylon/plastic) boots clamped to the VPR frame allowed the unit to be bolted to the cage. The VPR remained in its usual frame, which could be slid in and out on rails positioned in such a way that the camera and strobe were unimpeded from below and thus could sample undisturbed water on the downcast. The hard-drive was removed following each cast and the data downloaded. Since the casts were deep, we only managed one cast per battery charge and therefore also found that we needed to swap battery cases on each cast. The VPR was removed from the CTD cage prior to casts greater than 3000 m.

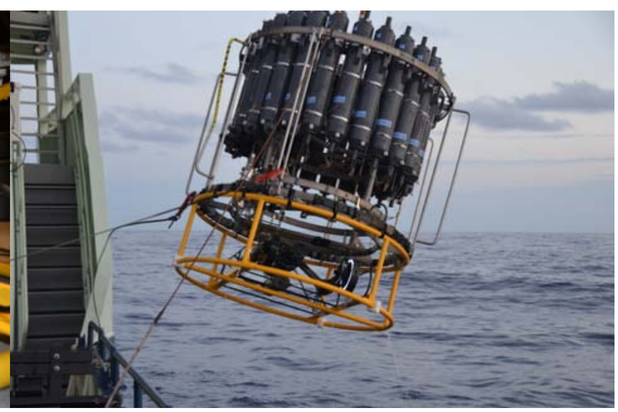



Fig. 9.2.1 The VPR installed beneath the CTD rosette. [Photo: P. Wiebe]
Fig. 9.2.2 Retrieval of the CTD rosette and VPR. Note the circular strobe light on the VPR's rightmost arm. [Photo: P. Wiebe]

Fig. 9.2.3. Side view of the VPR in its cage under the CTD rosette. [Photo: N. Copley]

The initial magnification was set at S1 with an image area of 14 x 14 mm (Table 9.2.1). At station 5, cast 9 (transect 1), a test using S0 with an image area of 7 x 7 was made in order to discover if we were missing some smaller pteropods. Upon careful examination of the images, no pteropods were positively identified and it was reset to S1. At station 13, cast 20 (transect 1), the system was set to S2 (24 x 24 mm) to explore a larger volume and hopefully see more pteropods. The larger pteropod species, such as *Clio pyramidata* and *Cuverina columnella* collected in the Reeve and MOCNESS nets were often 4 to 20 mm so it seemed likely we were missing more by using a smaller volume than the larger one.

For the end of transect 1 and much of transect 2, we switched to S2, a frame size of 24 mm X 24 mm. When using S2, AutoDeck selected two to three times the number of ROIs during extraction. When we started finding smaller *Limacina retroversa*, we returned to the S1 setting. While using S2 we saw better images of large jellies and chaetognaths, but some of the smaller ROIs were harder to identify. Using S1 gave us better resolution when viewing small organisms, but would miss or give partial images of some larger organisms.

Fig. 9.2.4. VPR images of pteropods, S2 magnification: A. possible *Styliola* or *Creseis,* B. and C. *Limacina retroversa*.

The VPR is an excellent source of imagery of plankton in their natural environment and attitude. A small selection of color images is shown in Figures 9.2.4 and 9.2.5.

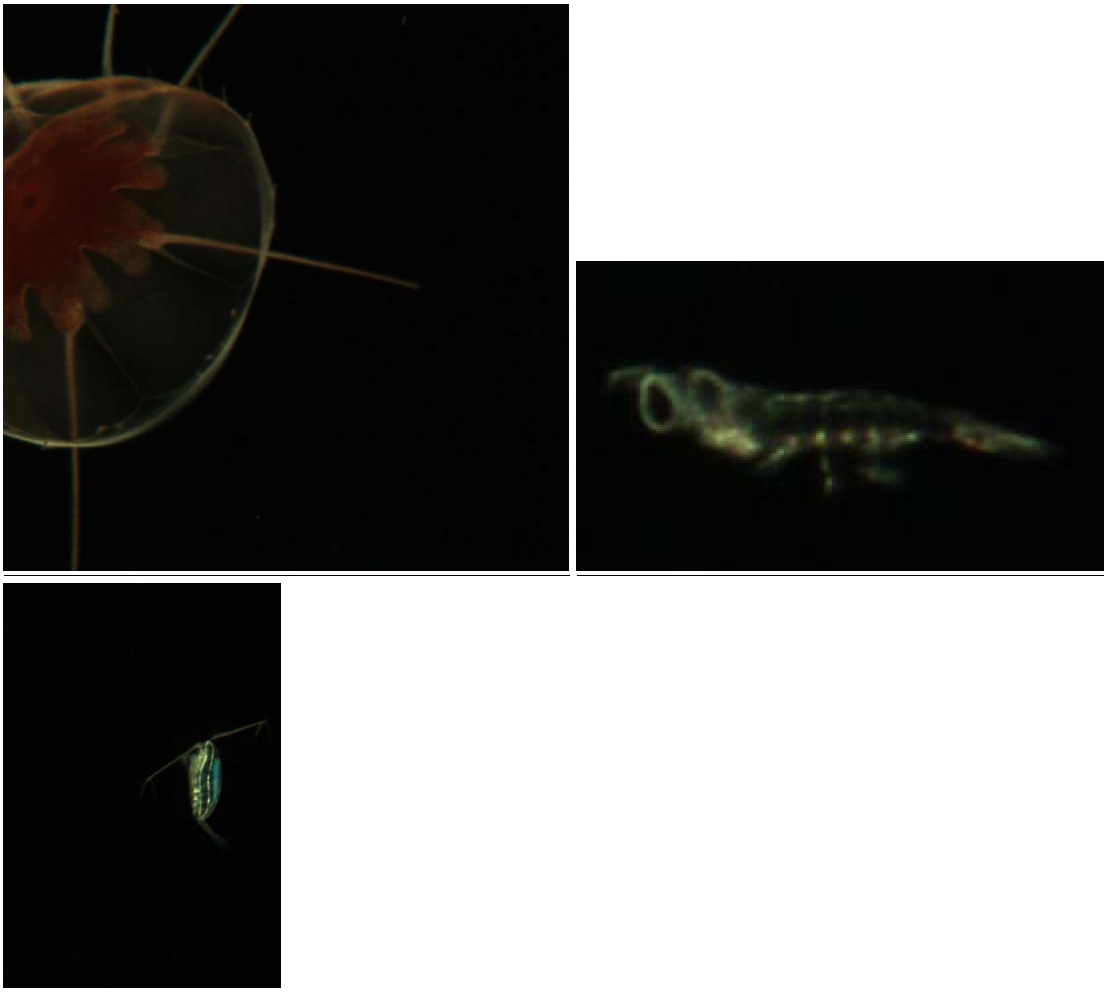


Fig. 9.2.5. VPR images using S1 magnification: A. hydromedusa, B. euphausiid, *Nematoscelis*, C. copepod *Calanus*.

During ROI extraction in AutoDeck, we identified the continuous downcast, which omitted the period of time from when the CTD frame entered the water, descended to about 10 m to boot and returned to the surface before it started down again. We also did not extract images from the upcast. With these frames selected, we watched AutoDeck run through those frames and pull out ROIs, which were saved to the hard drive, while noting any observations. ROIs that were identifiable as pteropods and euphausiids were placed into folders for later training of the auto-ID software, VisualPlankton.

To train the program Visual Plankton to classify into groups pteropods, euphausids, copepods, and other, you need at least 100 examples of each group. Three or four groups is recommended, one of which must be 'other'. Then Visual Plankton should be able to isolate pictures that belong to these groups.

<u>Settings for ROI Extraction:</u>
Segmentation threshold **0; 133** (brightness)
Focus: Sobel: **40**; Standard deviation: **0** (edge detection)
Growth Scale: **300** (extra area around object)
Minimum blob size: **10** (object size)
Minimum join distance: **1** (distance between objects)

9.2.3. Problems and Solutions

Maintaining focus of the VPR camera is important in order to obtain the best possible images. The focus of the camera is set at a certain distance for each magnification but tended to drift over time. The extraction program will only accept a certain level of blurriness before rejecting a ROI, depending on the settings chosen by the user prior to extraction. It is important that the focal distance is consistent and we noticed the focus diminishing during certain casts of transect 1. To correct this, we started refocusing the camera by changing the magnification setting and then returning to the original setting (S1 or S2). At the end of a cast (because the process uses up more battery) we would turn off the VPR as usual, and then turn it on to some other setting, which took about 3 minutes for the camera to start running while the camera moved slowly into position. Once positioned, the strobe would begin to flash. After letting the strobe run for at least 30 seconds, it was turned off, and then switched back to the setting we would use on the next cast, which took another 3 minutes to start strobing. Once we started the next cast, if the last setting was maintained for the new cast, startup took approximately 40 seconds.

The VPR position at the bottom of the CTD rosette made removing the battery slightly difficult. A 1/2" ratchet and wrench were needed to loosen the clamps, which involved getting under the Niskin bottles and between struts of the frame. The rubber padding between the clamps and the clamp braces tended to shift off center, probably as a result of slipping the battery in and out. For the top clamps, we removed and glued the rubber back on with 3M 5200 Marine Adhesive to align better, but the adhesive took longer to dry than the time available between casts and didn't seem to work particularly well. A battery was good for only one 1000 m cast. Even when the battery was at 26.2 V before a cast, it died before it returned to the surface. A low battery resulted in a reboot of the system and missed anywhere from 30 to 80 m of the cast, and wrote smaller files that caught only 5-30 m of depth. In an extreme case (cast 42) more than 600 m of the 1030 m cast were lost to rebooting time. The batteries only died if they were used for multiple casts, and a fully charged battery was usually above 27 V. Charging took between 2 and 3 hours.

A test was performed using a range of segmentation threshold maximums and sobel settings to see what the most appropriate combination would be. ROI's were extracted from 400 frames of VPR-17 with the following settings:

STmax	Sobel	blob	#rois	
130	20	10	125	most fuzzy images
130	20	20	106	excludes smaller blobs
130	30	10	42	
130	40	10	26	
133	**40**	**10**	**20**	settings used in this analysis
150	20	10	16	
150	40	10	7	most faint images

From these results, it became clear that the 150 STmax excluded too many rois that were not bright enough. The lower STmax of 130 with a Sobel 20 found an excessive number of junk rois but was also the only setting to pick up a nice chaetognath whose body was rather transparent but well focused. Pteropods have a fairly transparent shell that may be excluded from too rigorous settings.

Because pteropod shapes are so variable, it seemed a good idea to manually examine all the extracted rois and put them into subdirectories by VPR cast number. To train the Visual Plankton program requires a minimum of 100 identified rois for each category of plankton. Pteropods were not so abundant to be able to attain such numbers. Also, pteropods with different orientations will look very different and are likely not to be registered by Visual Plankton.

9.2.4. Preliminary Results

VPR cast information is provided in Table 9.2.1, with table columns as follows:

The date, time, and position is for the start of the casts.
Event : event number as listed in the event log
T: transect
Sta: station number
VPR#: cast number
date Local: local date at start of tow
time Local : local time at start of tow
day/ night: whether tow took place in the day or night, dusk or dawn
Latitude : decimal latitude at start of cast
Longitude : decimal longitude at start of cast
Seafloor : depth of seafloor
Cast Depth : nominal depth of cast; actual depth is usually within 15 meters of nominal
Mag.: magnification setting on the VPR (S0=7x7mm; S1=14x14mm; S2=28x28mm)
Filename: name of video file; suffix is .dat and also .idx
YearDay: yearday according to the Autodeck extraction software; used January 1 = yearday 0
Hour: hour of video recording according to the Autodeck extraction software
rois exam: whether each roi in the cast has been manually examined for pteropods
possible pteropods: number of possible pteropods in the cast; tends to be higher than actual number
8-bit gray: whether or not the rois have been converted to 8-bit gray scale (necessary for auto-identification process)
Total ROIs: number of rois extracted using the settings listed above
Notes: comments pertaining to the cast and roi examination

Table 9.2.1: VPR cast information

Event	T	Sta	VPR#	date local	time Local	day/ night	Latitude	Longitude	Seafloor	Cast Depth	Mag.	Filename	rois exam	possible pteropods	8-bit gray	Total ROIs	Notes
20110808.1448.002	0	Test 1	1	8/08/2011	10:48	day	39.65370	-66.95792	3785	575	S1	1312814583			√	786	
20110810.2354.002	0	Test 2	2	8/10/2011	19:54	dusk	36.34585	-56.17255	NaN	500	S1	1313020225			√	870	
20110812.0531.002	0	1	3	8/12/2011	1:30	night	35.05747	-52.09988	5465	1000	S1	1313126736			√	500	
20110812.1437.002	0	1	4	8/12/2011	11:37	day	35.11570	-51.94445	NaN	1000	S1	1313159586			√	614	
20110812.1925.001	0	2	5	8/12/2011	16:24	day	35.47460	-51.99077	1023	1000	S1	1313176932	√	9	√	943	
20110813.0257.001	1	3	6	8/12/2011	23:56	night	35.95490	-51.97347	NaN	1000	S1	1313203996	√	2	√	337	
20110813.0743.001	1	4	7	8/13/2011	4:43	night	36.50000	-51.99950	5387	1000	S1	1313221170	√	4	√	498	
20110813.1214.001	1	5	8	8/13/2011	9:13	day	36.99747	-51.99490	NaN	1000	S1	1313237342	√	0	√	591	
20110814.0438.001	1	5	9	8/14/2011	1:37	night	36.86895	-52.01547	5385	200	**S0**	1313296246	√	0	√	88	looking for smaller pteropods
20110814.0512.001	1	5	10	8/14/2011	2:10	night	36.86003	-52.01485	NaN	1000	S1	1313298407	√	5	√	601	
20110814.1613.001	1	6	11	8/14/2011	13:12	day	37.50057	-52.00282	5370	1000	S1	1313338340	√	1	√	228	
20110814.2058.003	1	7	12	8/14/2011	17:58	dusk	38.00067	-52.00028	NaN	1000	S1	1313355353	√	3	√	470	
20110815.0641.001	1	8	13	8/15/2011	3:40	night	38.44463	-51.99120	5314	1000	S1	1313390025	√	5	√	585	
20110815.1552.001	1	8	14	8/15/2011	12:51	day	38.57025	-51.74442	NaN	1000	S1	1313423348	√	4	√	490	
20110815.2036.001	1	9	15	8/15/2011	17:35	dusk	38.99767	-51.99205	NaN	1000	S1	1313440406	√	2	√	252	battery died at 587m
20110816.0255.001	1	10	16	8/15/2011	23:54	night	39.48290	-51.98522	5274	1000	S1	1313463214	√	0	√	440	
20110816.1840.002	1	10	17	8/16/2011	15:40	day	39.44017	-51.97122	NaN	500	S1	1313519891	√	2	√	1052	yoyo: 0-130-27-120-40-500-0-500-0-500-0
20110817.1059.002	1	11	18	8/17/2011	7:59	day	39.99670	-52.00670	NaN	1000	S1	1313578713	√	4	√	773	
20110817.1603.001	1	12	19	8/17/2011	13:02	day	40.47877	-52.00852	NaN	1000	S1	1313596752	√	9	√	1595	
20110818.0623.001	1	13	20	8/18/2011	3:22	night	40.81603	-52.09275	NaN	1000	**S2**	1313648149	√	36	√	3074	surface thick with filamentous algae
20110818.1312.002	1	13	21	8/18/2011	10:11	day	41.03622	-51.89807	NaN	1000	**S2**	1313672897	√	12	√	1009	surface thick with filamentous algae
20110818.1709.001	1	14	22	8/18/2011	14:09	day	41.49718	-51.99260	NaN	1000	**S2**	1313687162	√	15	√	1310	
20110819.0256.001	2	15	23	8/19/2011	23:55	night	42.03967	-50.54362	NaN	1000	**S2**	1313722417	√	36	√	2068	
20110819.1037.002	2	16	24	8/19/2011	7:37	day	42.49937	-49.19945	NaN	1000	**S2**	1313750183	√	77	√	3789	
20110819.1825.002	2	17	25	8/19/2011	15:25	day	43.00340	-47.77322	3576	1000	**S2**	1313778278	√	68	√	3398	
20110820.0417.001	2	17	26	8/20/2011	1:15	night	43.10958	-47.67235	3502	1000	**S2**	1313813981			√	2162	
												1313816598			√	-	
												1313816964			√	-	

Event	T	Sta	VPR#	date local	time Local	day/ night	Latitude	Longitude	Seafloor	Cast Depth	Mag.	Filename	rois exam	possible pteropods	8-bit gray	Total ROIs	Notes
20110820.1751.001	2	18	27	8/20/2011	14:50	day	43.49727	-46.35400	NaN	1000	S1	1313862592	√	18	√	648	many tiny Limacina in MOC tow
20110821.0324.001	2	19	28	8/21/2011	0:23	night	43.94778	-44.90418	4558	1000	**S2**	1313896681			√	2694	
20110821.1133.001	2	20	29	8/21/2011	8:33	day	44.50587	-43.46345	4762	1000	S1	1313926347			√	715	
20110821.1905.001	3	21	30	8/21/2011	16:04	day	44.99830	-42.00163	NaN	1000	S1	1313986692			√	716	MOC caught lots of *Limacina retroversa*
20110822.0423.001	3	21	31	8/22/2011	1:22	night	44.84568	-41.91448	NaN	1000	S1	1313986692			√	864	
20110822.1608.001	3	22	32	8/22/2011	13:08	day	45.50022	-41.99645	4462	1000	S1	1314029294			√	685	
20110822.2035.001	3	23	33	8/22/2011	17:34	day	45.99795	-42.00047	4639	1000	S1	1314045140			√	944	
20110823.0200.001	3	24	34	8/22/2011	23:00	night	46.50238	-41.96785	4170	1000	S1	1314064686			√	1094	reran #34 with same settings as rest of cruiise
20110823.0650.001	3	25	35	8/23/2011	3:49	dawn	47.00207	-42.00080	4222	1000	S1	1314081909			√	699	
20110823.1117.001	3	26	36	8/23/2011	8:16	day	47.50047	-42.00113	NaN	1000	S1	1314098091			√	855	
20110824.0246.001	3	26	37	8/23/2011	23:45	night	47.37980	-41.97285	NaN	1000	S1	1314152421			√	743	
20110824.0827.001	3	27	38	8/24/2011	5:26	day	47.99758	-42.00435	NaN	1000	S1	1314174353			√	941	
20110824.1346.001	3	28	39	8/24/2011	10:46	day	48.50635	-42.00162	NaN	1000	S1	1314193442			√	816	
20110824.1753.002	3	29	40	8/24/2011	14:53	day	49.00008	-42.00150	4269	1000	S1	1314208318			√	810	
20110824.2134.001	3	30	41	8/24/2011	18:35	night	49.50433	-41.99498	4485	1000	S1	1314221648			√	1056	
20110825.0630.001	3	31	42	8/25/2011	3:29	night	50.06572	-41.76740	4356	1000	S1	13142534763 to 1314256019			√	411	battery low: 15 files for downcast, losing about 600 meters due to rebooting.
20110825.1540.001	3	31	43	8/25/2011	12:39	day	50.08977	-41.71417	NaN	1000	S1	1314286690			√	712	
20110826.0721.001	4	32	44	8/26/2011	4:20	night	49.07877	-44.36317	2536	1000	S1	1314343116			√	1237	

9.3. *Multi-frequency acousticsg*

Gareth Lawson, Katie Wurtzell

9.3.1. Introduction

Quantifying the distribution of any marine organism requires sampling tools able to resolve adequately the scales of variability, which has led biological oceanographers in recent decades to employ a variety of increasingly sophisticated technologies. In particular, high-frequency active acoustic scattering techniques are uniquely suited to the study of zooplankton and fish distributions, as they provide remote and non-intrusive samples at high resolution and to large ranges, allowing patch structure to be quantified in fine detail: a task that is difficult to achieve using traditional net or optical sampling systems alone. Single frequency systems, while useful in this regard, are much less capable of providing insight into the composition of scatterer types present than is a system with multiple frequencies. Multi-frequency systems capitalize on the fact that different kinds of organisms scatter sound differently as the frequency changes, such that measurements of backscattering at multiple frequencies can be used to make inferences about the taxonomic composition of animals present.

On the current cruise, multi-frequency measurements were made near-continuously along-track and while on station. The goals were to characterize the distribution of scattering in relation to changing environmental quantities along the latitudinal gradient of our survey transect; to characterize rates and amplitudes of diel vertical migrations; to provide indices of pelagic animal abundance to be correlated with other datasets, including observations of macrofauna; and to assess the feasibility of using acoustics to characterize pteropod distribution and abundance.

9.3.2. Methods

High-frequency acoustic measurements were made using a Hydroacoustic Technology Inc (HTI) multi-frequency echosounder operating at frequencies of 43, 120, 200, and 420 kHz (Fig 9.3.1). One complement of four split-beam transducers at 43 (7 degree full-beamwidth), 120, 200, and 420 (all 3 degree beamwidths) kHz was installed in the hull via transducer wells. Installation was a complicated operation: three transducers (120 and 420 in one large well, 200 in a small well) were installed during a long in-port period in July, while the last (43) was installed immediately prior to the cruise into a well normally occupied, now vacated, by the RDI Ocean Surveyor ADCP. The multiplexor bottle was strapped to an overhead pipe. The 250' underwater cable from the MUX bottle to the deck unit goes through a couple of cable passes from the main lab ultimately into the shaft down to the transducer wells. The original plan was to run the cable through watertight passes rather than the shaft, since having the cable in the shaft required keeping the hatch open throughout the cruise; in the event of an emergency where the hatch needed to be closed the cable would have to be cut. This wasn't possible, however, due to time constraints immediately prior to the cruise.

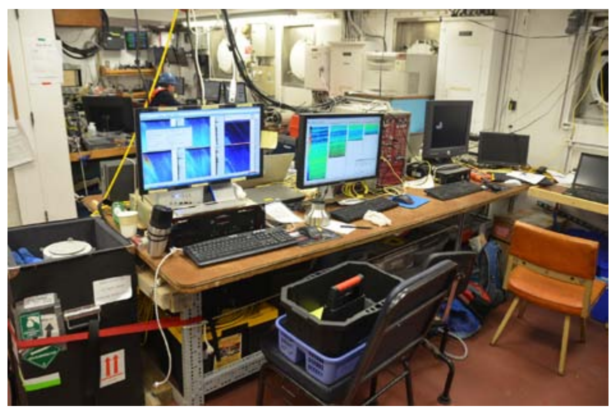


Figure 9.3.1 - Acoustic control area. HTI deck unit (red) on right with control computer immediately to the left. Edgetech deck unit and control computer to far left. [Photo: P. Wiebe]

A second complement of four transducers was installed in the Greene Bomber a 5' V-fin towed body, which was available as a backup to the hull-mounts. Thankfully we did not have to use the Greene Bomber at any point in the cruise as deployment/recovery would have been a labor- and time-intensive operation. If we were to have deployed it, the Bomber would have been picked up and lowered into the water via the main crane, attended by two air tuggers on the main deck. It would then have been towed via a third, larger, air tugger bearing a weak line of appropriate breaking strength and a block attached to the end of the tow boom (aka the Cannon) developed by Terry Hammar.

The HTI Model 244 Digital Echo Sounder (DES) deck unit (aka the big red box) was installed in the main lab, along with a Model 242 DES deck unit (aka the little red box) and the control laptop. The latter was used with a 24" flat-screen monitor to allow easy visualization of the real-time data. A GPS DB-9 feed connected to the laptop via a serial-to-USB converter provides GPS to the HTI Sounder.exe software. The M244 contained the transmit/receive cards and processed the raw data into integrated and target strength data streams, transferred to the control laptop over a local area network (LAN) and using Lantastic networking software. These are displayed and recorded by the HTI software and saved as hourly .INT (integrated data), .RAW (target strength), and .BOT (time and position) files. The raw data are also transferred from the M244 to M242 via a microphone cable, where they are processed and transferred via the LAN to the laptop to be saved as .SMP files. These 'sample' data allow us to later re-process the raw data using alternative noise profiles, depth strata, etc relative to what was used at-sea for the collection of integrated data, and can be used to look at the data on a ping-by-ping basis.

Acoustic data were collected continuously over the course of the cruise during both transit and while on station, other than during periods of data transfer (mostly timed to occur during station activities), when the system needed to be shut down to avoid interference with the Edgetech broadband acoustic system, or when trouble-shooting some issue with the multi-frequency echosounder. Data were collected at vessel speeds of up to 12 kn. Due to differences in absorption of acoustic energy by seawater, the range limits of the transducers are different. After testing various range settings and associated noise levels, the final configuration involved the 43, 120, 200, and 420 kHz channels looking to 500, 300, 150, and 100m, respectively, with corresponding interval durations to achieve these ranges of 1000, 650, 350, and 250 ms. This resulted in an overall ping rate of 1.78 pings per second. Integration intervals were set to 0.1 min and depth strata at all frequencies were set to 1m. When using the HTI system to trigger the Edgetech broadband echosounder (see next section), a fifth 'empty' period with an interval duration of 1200 ms was used to provide the Edgetech sufficient time to complete its ping cycle.

The .INT and .BOT files were further post-processed by Katie Wurtzell to convert the text files to Matlab format and concatenate the hourly files into daily sections. Echograms for these sections were generated and printed for each cruise day. The daily echograms were combined to provide an image of the backscattering for each transect. Analyses were also made based on visual scrutiny of the rate, timing, and amplitude of diel vertical migrations evident in the data.

9.3.3. Problems and Solutions

Noise

The transducers operated very well with respect to noise. Initially while in transit to the study transect we operated with no noise threshold. A series of noise tests were conducted early in the cruise, varying the vessel speed and whether or not the echosounder was plugged into various UPS and power filters or not (the Oceanus does not have a clean power supply). These tests suggested that the 43 kHz channel was marginally quieter using the UPS than without; the other channels were unchanged. The 43, 120, and 200 kHz channels were 1-1.5 dB or less noisier at a vessel speed of 10 kn relative to 8 or 2 kn. The 420 kHz was unchanged. Based on these tests we transited between stations at a speed of 10+ kn, in the interest of getting all of the stations done on time, using noise thresholds derived from collecting passive data at a speed of 10 kn. Relative to previous noise tests on other vessels, the Oceanus was noisier than the Connecticut, which was itself noisier than the Endeavor, except for the 420 kHz where the Oceanus was the quietest of the three vessels. The Oceanus was particularly noisy at 120 kHz. Efforts were made to minimize this noise, including moving the 250' data cable away from other cables in the stairwell and using various power filters and inverters. None of these improved the signal. It may have been some kind of harmonic of the power supply. We were thus somewhat range-limited at 120 kHz. Overall, however, we were extremely happy with how the hull-mounted transducers performed, particularly that we were able to collect reasonable-quality data while steaming. We also did not need to resort to using the Greene Bomber; the fact that noise tests at 10 and 2 kn were negligibly different suggests that the noise relates to some aspect of the power supply, rather than to the hull-mount configuration. It thus seems likely that the Bomber transducers would be equally affected by noise.

Interference
A number of ship's acoustic systems interfered with the HTI frequencies, including the bridge sounder (50 kHz, interfering with the 43 kHz), ADCP (153 kHz, interfering with the 120 kHz), the Knudsen depth sounder (3.5 and 12 kHz, interfering with the 43 and 120 kHz), and the Doppler speed log (440 kHz, interfering with the 420 kHz). As is the ship's custom, the 50 kHz sounder was secured once the ship left the continental shelf. After a couple of days of exploring sources of interference, we also secured the workhorse ADCP. For the Knudsen, the protocol we settled on was to turn on both the 3.5 and 12 kHz systems at the start of each station to check the water depth and make sure the CTD didn't hit the bottom. Similarly, the bridge preferred to have the speed log on at stations to facilitate deployments/recoveries, and so the speed log was only secured while in transit.

Computer Issues
Occasional problems occurred with the control laptop used for HTI data collection. Once or twice a day the M244 would reboot itself for no apparent reason. This would manifest itself via a Lantastic error message saying that the server 1017533 was shutting down, the Sounder.exe software would cease the connection to the M244 along with data processing and recording. After the M244 rebooted, the software would automatically reconnect and resume data collection to a new file. Less frequently, also without explanation, the laptop encountered the blue screen of death and the system needed to be restarted. On such occasions, and other instances where the laptop needed to be rebooted, getting the full system communicating was often problematic. The boot-up sequence involves having the laptop on, turning on the M242, then turning on the M244, then restarting the M242. In some instances this process had to be repeated as many as six times to get the M242 and M244 communicating and the samples data logging. Mid-way through the cruise we realized that after going through the boot up process if the samples data weren't coming through, only the M242 needed to be re-booted, rather than having to go through the entire boot up sequence. On a couple of occasions the system was rebooted but without checking the samples data stream, and so there are stretches of time where only the processed data were logged. The final computer issue involved the GPS. Often when creating a new configuration the GPS feed was inexplicably lost and the GPS had to be plugged into a different port on the serial to USB converter.

9.3.4. Preliminary Results

Multi-frequency acoustic data were collected on all 26 days of the cruise, and thus covered a very broad geographical area. A total of more than 40 GB of processed data and well over 100 GB of raw samples data were collected. In this report, analysis of the multi-frequency acoustic data collected during the cruise is limited to qualitative descriptions of overall patterns. Future post-processing and analyses will include data clean-up, examinations of the frequency response of different scattering features, and ground-truthing relative to net and video samples.

Table 9.3.1 – Diel vertical migration timing, amplitude, and rate based on analysis of 43 kHz acoustic data

Direction (0=Down,1 =Up)	YD_Start	YD_End	Duration	Depth_Start	Depth_End	Depth_Change	Rate (m/h)	latdeg	latdec	longdeg	longdec	Sunrise	Sunset	Moon	Time Start	Time End
0	220.334	220.3888	1.3205	26.4085	227.1127	200.7042	151.991064	40	5.189	67	59.5486	9:36	23:38	72%	8:01	9:19
0	221.341	221.3936	1.2632	26.4085	237.6761	211.2676	167.2479417	38	46.482	63	54.313	9:24	23:18	81%	8:11	9:26
0	222.409	222.4278	0.4524	63.7097	242.7419	179.0323	395.7389478	37	14.8255	59	0.2	9:08	22:54	89%	9:48	10:16
0	223.368	223.3891	0.5026	66.9355	239.5161	172.5806	343.3756466	35	55.6623	54	52.8848	8:55	22:34	95%	8:49	9:10
0	224.246	224.2697	0.578	62.0968	245.9677	183.871	318.115917	35	3.4982	52	6.0574	8:46	22:21	98%	5:54	6:28
0	225.346	225.3715	0.6217	73.3871	244.3548	170.9677	275.0003217	36	30.193	52	0.0137	8:44	22:22	100%	8:18	8:55
0	226.407	226.4251	0.4254	65.3226	181.4516	116.129	272.9877762	36	44.4404	51	59.5986	8:44	22:21	99%	9:46	10:12
0	227.335	227.3587	0.578	63.7097	244.3548	180.6452	312.5349481	38	26.8163	51	58.787	8:42	22:22	97%	8:02	8:36
0	228.338	228.3796	1.0052	47.5806	242.7419	195.1613	194.1517111	39	28.666	51	58.497	8:41	22:23	93%	8:06	9:06
0	229.354	229.3791	0.6043	50.8065	231.4516	180.6452	298.9329803	39	37.7896	52	2.481	8:42	22:22	87%	8:30	9:05
0	230.318	230.3567	0.919	49.1935	244.3548	195.1613	212.3626768	40	48.8915	52	6.783	8:41	22:23	80%	7:38	8:33
0	231.34	231.3734	0.8042	18.3871	95.8065	77.4194	96.2688386	42	19.326	49	42.836	8:30	22:14	72%	8:09	5:57
0	232.329	232.3597	0.7288	41.129	202.4194	161.2903	221.3094127	43	4.017	47	37.6284	8:21	22:06	63%	7:53	8:37
0	233.292	233.3315	0.955	29.3269	144.7115	115.3846	120.8215707	44	7.8634	44	32.3494	8:08	21:54	50%	7:01	7:57
0	234.282	234.344	1.4827	45.9677	241.129	195.1613	131.6256154	44	53.359	41	55.446	7:57	21:43	44%	6:46	8:15
0	235.29	235.3618	1.7341	37.9032	239.5161	201.6129	116.2637103	47	0.1497	42	0.0923	7:55	21:45	35%	6:57	8:40
0	236.247	236.3326	2.0607	41.129	244.3548	203.2258	98.61978939	47	34.861	42	0.301	7:55	21:45	25%	5:55	7:58
0	238.271	238.3137	1.0303	27.4038	146.6346	119.2308	115.7243521	49	4.6865	44	19.9585	8:05	21:53	9%	6:30	7:31
0	239.301	239.3629	1.4827	34.6774	239.5161	204.8387	138.1524921	45	24.0213	44	41.5887	8:14	21:46	4%	7:23	8:42
1	221.829	221.8601	0.7465	237.6761	47.5352	190.1408	254.709712	38	2.354	61	30.938	9:16	23:07	81%	19:53	20:38
1	222.962	222.9797	0.4272	244.3548	63.7097	180.6452	422.8586142	36	22.608	56	15.637	8:59	22:42	89%	23:05	23:31
1	223.947	223.965	0.4272	242.7419	58.871	183.871	430.4096442	35	5.999	52	18.7465	8:46	22:23	95%	22:44	23:09
1	224.934	224.9587	0.6031	244.3548	70.1613	174.1935	288.8302106	35	33.664	52	0	8:45	22:21	98%	22:24	23:01
1	225.943	225.9652	0.5222	245.9677	70.1613	175.8065	336.6650709	36	58.1857	51	59.7145	8:43	22:22	100%	22:37	23:09
1	226.929	226.9641	0.8509	245.9677	60.4839	185.4839	217.9855447	37	59.1857	51	59.365	8:41	22:24	99%	22:17	23:08
1	227.913	227.9598	1.1309	239.5161	36.2903	203.2258	179.7027147	38	59.1523	51	56.238	8:41	22:23	97%	21:54	23:02
1	228.915	228.9639	1.1811	241.129	41.129	200	169.333672	39	26.005	52	0.079	8:41	22:23	93%	21:57	23:08
1	229.509	229.5367	0.6715	94.5161	15.1613	79.3548	118.1754281	40	59.293	51	59.749	8:39	22:24	87%	12:13	12:52

Direction (0=Down,1 =Up)	YD_Start	YD_End	Duration	Depth_Start	Depth_End	Depth_Change	Rate (m/h)	latdeg	latdec	longdeg	longdec	Sunrise	Sunset	Moon	Time Start	Time End
1	230.792	230.9079	2.7811	72.5806	24.1935	48.3871	17.39854734	41	28.9135	51	54.2183	8:39	22:23	80%	19:01	21:47
1	231.9	231.9472	1.1309	200.8065	44.3548	156.4516	138.342559	42	58.4942	47	47.2738	8:21	22:08	72%	21:36	22:43
1	232.865	232.943	1.8597	241.129	47.5806	193.5484	104.0750659	43	36.542	46	2.609	8:14	22:00	63%	20:45	22:37
1	234.908	234.9378	0.7037	143.75	35.0962	108.6538	154.4035811	46	0.0883	42	0.174	7:56	21:45	44%	21:47	22:30
1	235.893	235.9231	0.7288	147.5962	21.6346	125.9615	172.8341109	47	28.2255	41	59.7055	7:54	21:46	35%	21:25	22:09
1	236.879	236.964	2.0355	242.7419	52.4194	190.3226	93.50164579	49	25.0415	41	59.738	7:48	21:44	25%	21:05	23:08
1	237.875	237.9461	1.7089	228.2258	29.8387	198.3871	116.0905261	49	45.5163	42	36.3617	7:55	21:49	17%	21:00	22:43
1	238.855	238.9346	1.9099	137.0192	65.8654	71.1538	37.25524897	47	11.5307	44	34.517	8:09	21:50	9%	20:31	22:25
1	239.89	239.9325	1.0304	236.2903	41.129	195.1613	189.4034356	43	5.5706	44	49.312	8:18	21:43	4%	21:21	22:22

The most pervasive acoustic phenomenon observed was a regular diel vertical migration (DVM) evident along all survey transects. The DVM signal was most clear and with the largest measurable amplitude at 43 kHz, but was evident at all frequencies. Preliminary analyses were made of the timing, amplitude, and rate of migration based on visual scrutiny of the 43 kHz echograms; results are shown in Table 9.3.1.

Scattering along Transect 0 during transit from WHOI, in the Sargasso Sea and as we crossed the Gulf Stream was characterized by pervasive fish-like but little zooplankton-like scattering (Figure 9.3.2). A strong layer of fish-like scattering was usually present at shallow depths (<100m). This scattering was strongest at night, associated with the DVM, but some scattering was typically present during daytime as well. A second layer was evident at 200m during both day and night on the 43 kHz, but not visible on the 120 kHz due to noise limitations. A deep and mostly non-migratory layer was also evident >400m at 43 kHz.

Along much of its length from the Sargasso into the transition zone north of the Gulf Stream, Transect 1 showed many of the same scattering features as Transect 0, until year day 228 when the scattering during daytime became very low at 43 kHz, with no shallow daytime layer, but rather just the deep >400m layer. Some weaker scattering consistent with zooplankton, however, was evident at the higher frequencies even during day at ca. 50m. This persisted until day 230 when the vessel returned into waters with scattering more similar to Transect 0.

By Transects 2 and 3 when the ship had mostly returned to colder waters in the transition area north of the Gulf Stream, the pattern of very low scattering at 43 kHz during day was the norm. The nighttime layer in the upper 100m of fish-like scattering was also much reduced relative to earlier in the survey. The deep (>400m) scattering layer at 43 kHz became particularly strong, however, at the northern end of the transect. Zooplankton-like scattering at depths of ca. 50m became much more common, often during daytime as well as night. Some of this scattering had a frequency response showing strongest scattering at 120 kHz, some at 200 kHz, and some at 420 kHz; often these patches were extremely dense.

Based on qualitative examination of net catches, our initial impression is that some of these regions where scattering was high at all frequencies and highest at 420 kHz may be associated with high abundances of pteropods, particularly Limacina retroversa. Such features were not evident along Transect 0 or the Sargasso-like portions of Transect 1, at least based on initial impressions. Overall, we are hopeful that in some times and places we will be able to demonstrate that pteropods dominated the scattering, and will be able to gain insight into their patch structure.

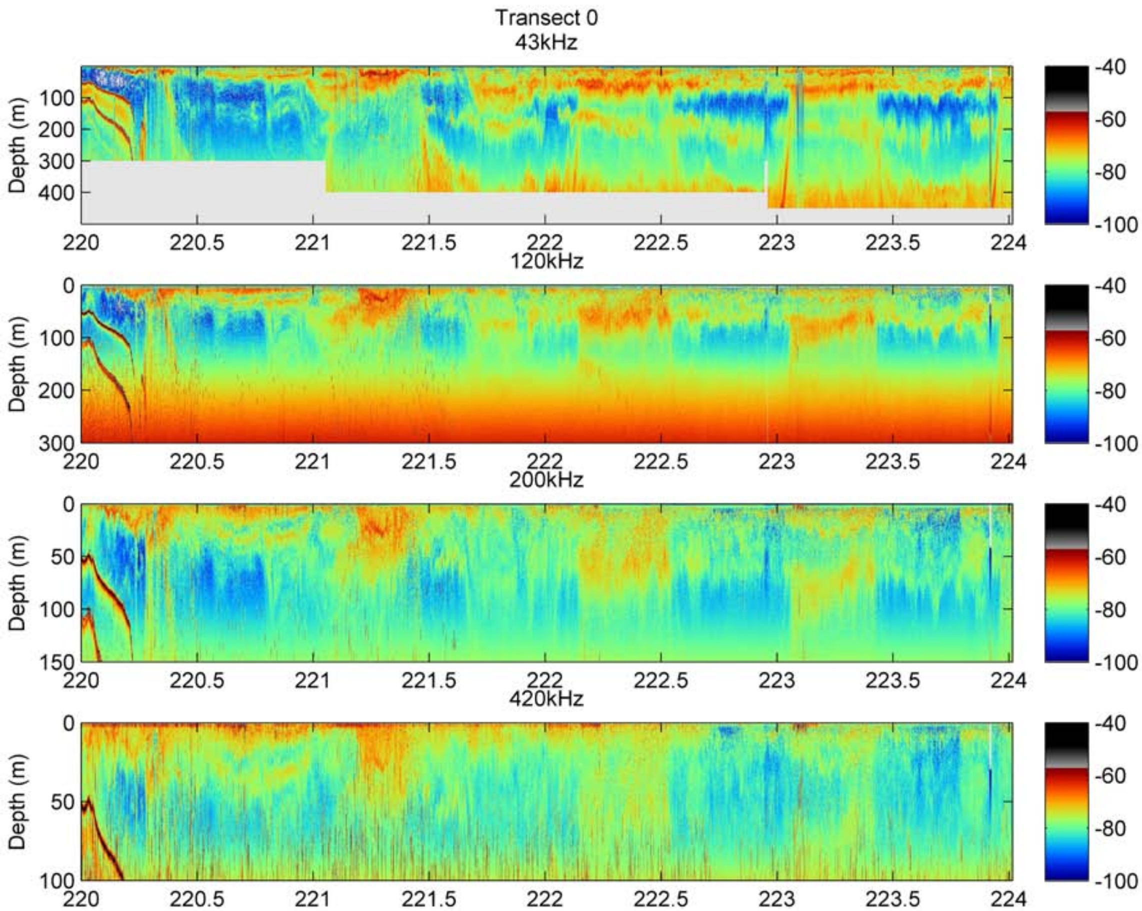


Figure 9.3.2 – Transect 0 echogram showing volume backscattering strength (dB) on the color scale relative to depth (m) and time (yearday).

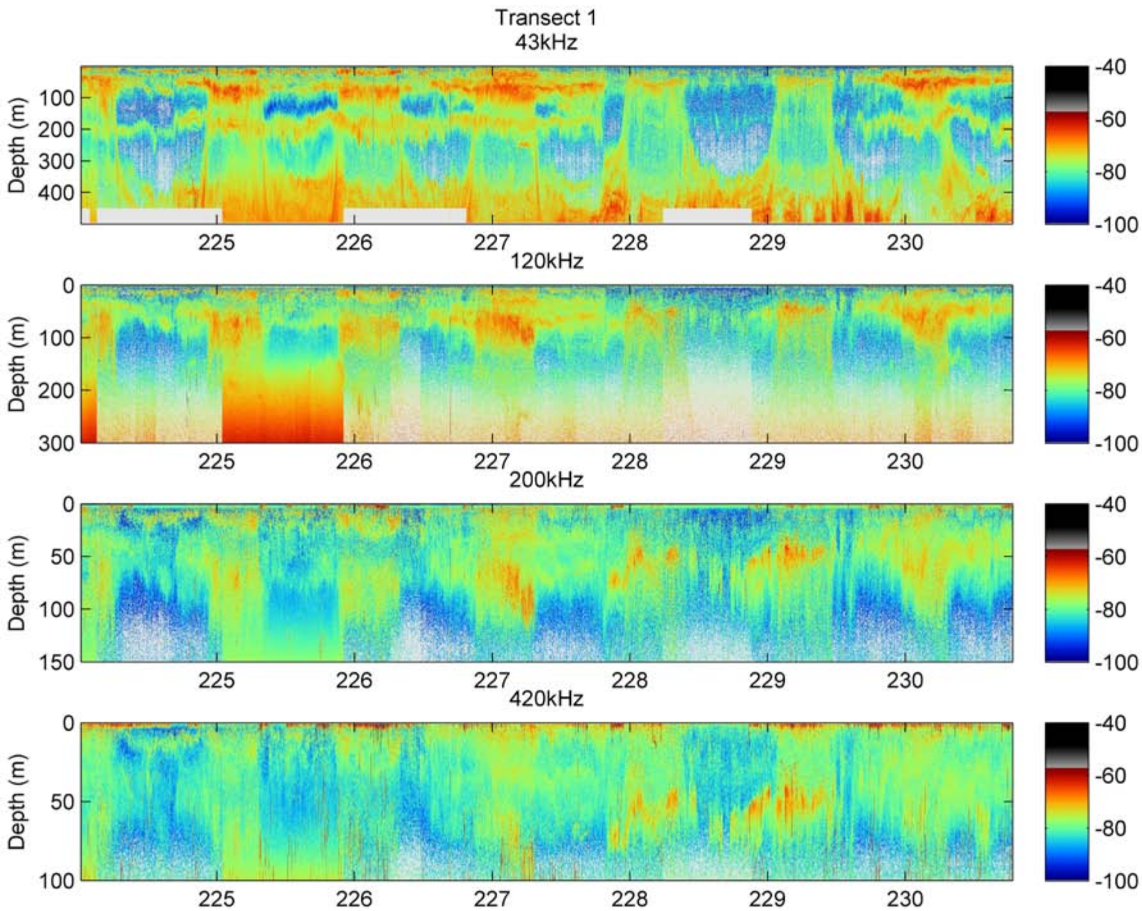


Figure 9.3.2 continued – Transect 1 echogram

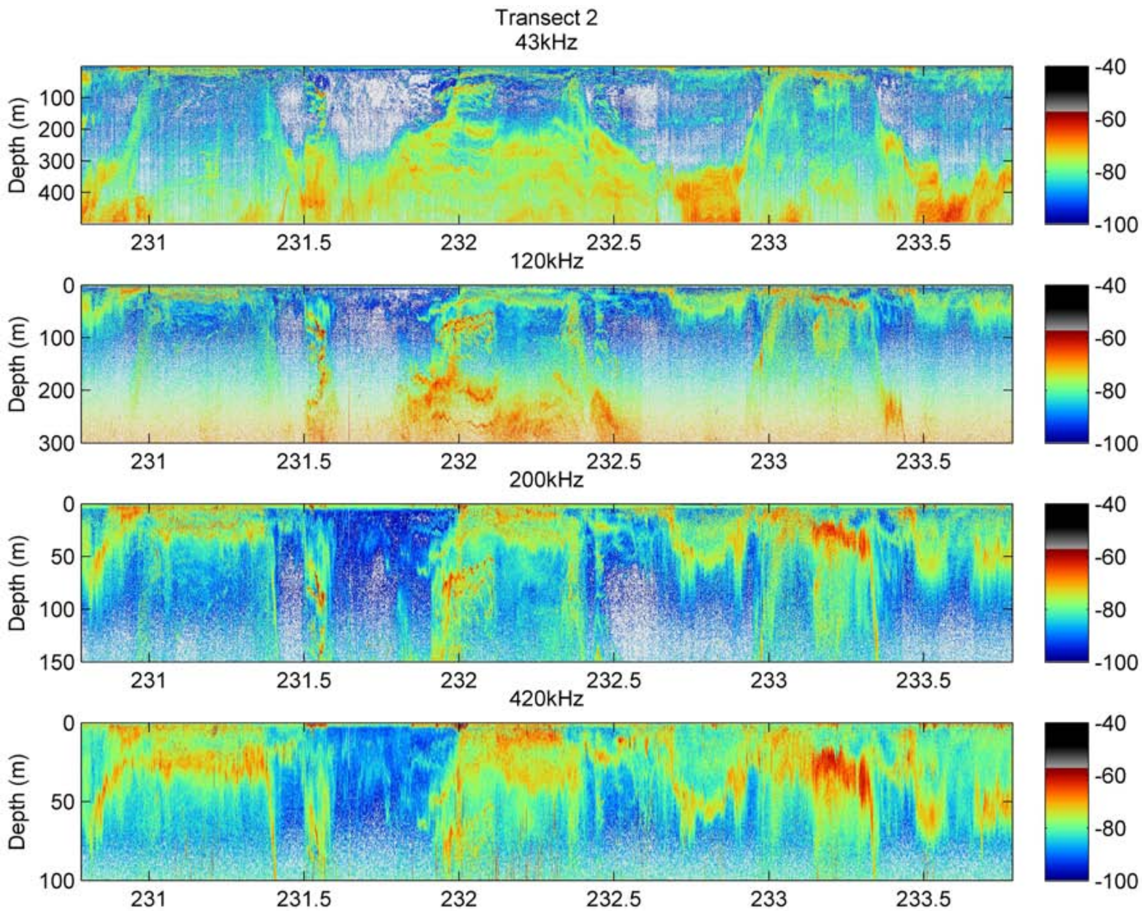


Figure 9.3.2 continued – Transect 2 echogram

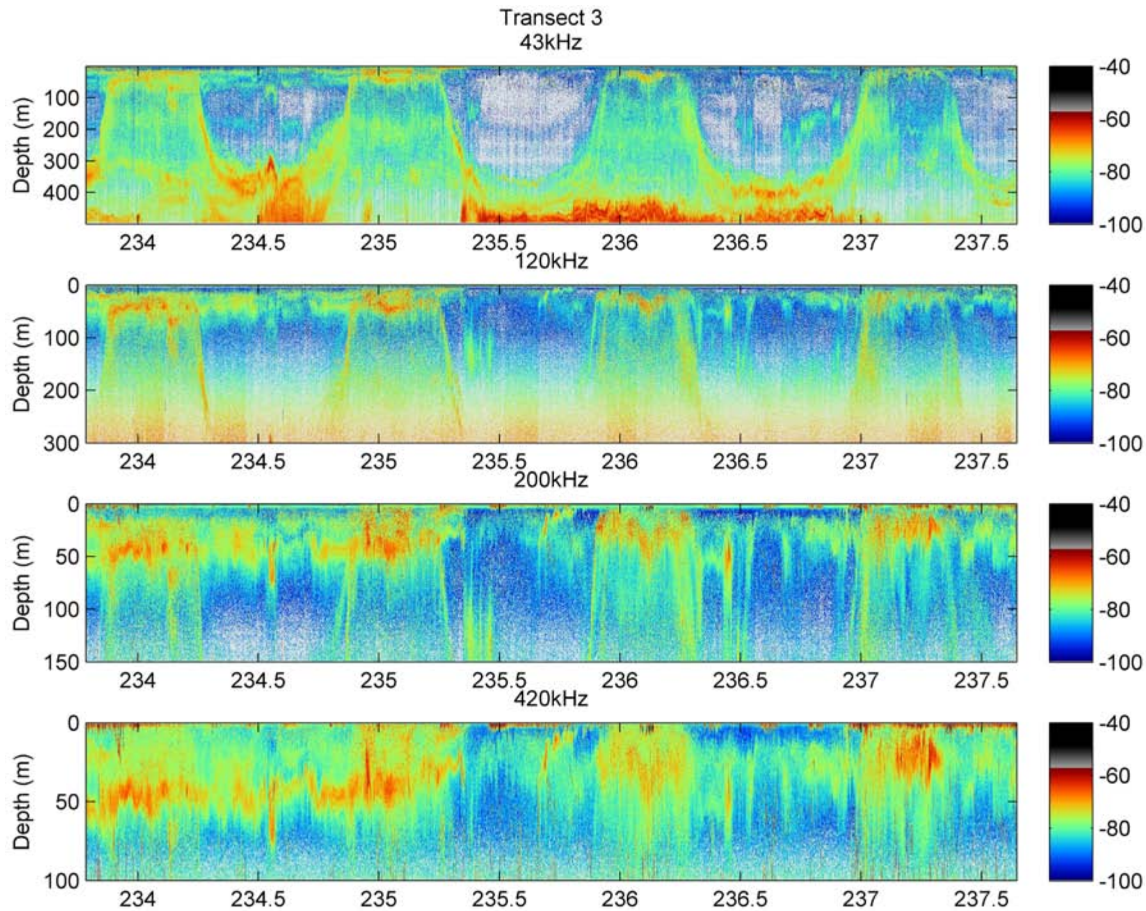


Figure 9.3.2 Continued – Transect 3 echogram

9.4. *Broadband acoustics*

Jonathan Fincke, Andone Lavery, Gareth Lawson

9.4.1. Introduction

A chronic difficultly in the use of acoustics to quantify animal distributions lies in discriminating among the various animals likely to be present and contributing to acoustic scattering measurements. With only one or a limited number of frequencies, the problem of solving for quantities like the abundance of each animal type present is strongly complicated by differences in the scattering characteristics of the different types: at a single frequency, a given level of observed scattering could be accounted for by a large abundance of small and weakly-scattering organisms like copepods, or an orders-of-magnitude smaller number of strong scatterers like gas-bearing siphonophores. Broadband acoustic scattering techniques, of the sort under development by the co-PI A. Lavery for the past few years, offer the potential for substantial improvements in species discrimination due to the ability to measure scattering relative to frequency (i.e, the scattering spectrum, or acoustic signature) over a broad frequency range. In cases where a single taxon dominates scattering or in mixed assemblages where the scattering spectra of the different animals are sufficiently distinct, the sources of scattering can then be characterized and quantitative estimates of animal abundance and size made.

In recent tests, a newly-developed system has been used to identify and quantify thecosome pteropod abundance and size off the New Jersey continental shelf and verified relative to net samples; similar tests have been conducted for quantification of krill distributions. On the present cruise, broadband data were collected at select stations, with the objective of continuing to develop these broadband techniques for remote identification and characterization of thecosome pteropods and other zooplankton. The intention was also for the broadband system to provide improved species identification capabilities, to supplement the multi-frequency system's underway measurements.

9.4.2. Methods

A heavily-customized downwards-looking broadband acoustic scattering system manufactured by EdgeTech Marine and spanning a near-continuous frequency band of 40-600 kHz was used. This broadband system was limited to a maximum range of 50-150 m (varying with frequency) and so to achieve sampling over a greater depth range was either profiled vertically towed obliquely up and down through the water column (during occasional small-scale acoustic surveys). The system operates at six channels, and the frequency bands and subsystem sharing for the six channels and associated transducers employed during this cruise are shown in Figure 9.4.1. These channel assignments reflect the channel assignments in the data acquisition software (JSTAR), however, the channel assignments in the data files are as follows:

4. Processing Channels

The table below shows which processing channels are used for different applications.

WHEN RUNNING MULTI-PING, THE CHANNELS ARE:

	Item	JStar MF Channel	JStar Raw Channel	Sonar Subsystem	Sonar MF Channel	Sonar Raw Channel
A1	1. 80-120	0	2	0	0	2
LOW	2. 160-250	5	7	0	5	7
MID	3. 220-230	8	10	20	0	2
A2	4. 35-70	13	15	20	5	7
HL	5. 300-450	16	18	21	0	2
HH	6. 420-620	21	23	21	5	7

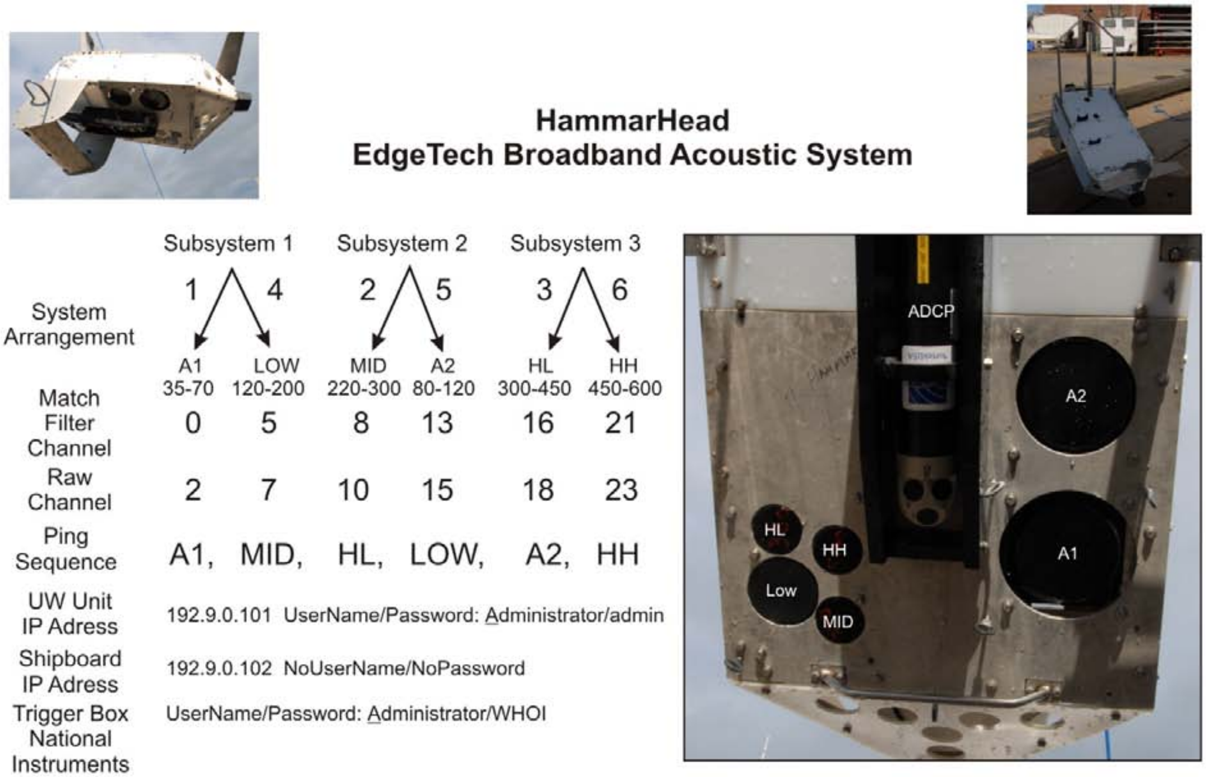


Figure 9.4.1 – Edgetech channel assignments and other settings [Photos: P. Wiebe]

The HammarHead was deployed via the stern A-frame and a portable Dynacon cantilevered winch. This winch, which came from the University of Alaska, had never been used. It was designed for use with an unusual gauge wire and had to be adapted for use with 0.322" wire for our purposes. The level wind mechanism is quite simplistic, but was not working perfectly with the 0.322" wire; the level wind corrector had to be used quite frequently.

Deployment required one person on the winch, one on the A-frame, two on slip-lines, and a deck boss. In most instances the bosun served as deck boss, with science party and/or ABs covering the other tasks. Recovery additionally required someone, usually the bosun, to use a fend-off pole; the block provided by SSSG didn't have a swivel so one was added in between the block and the A-frame by the Oceanus crew, along with a series of shackles to get the block attached properly. This led to the block hanging very low, so the clearance of the fish when launching/recovering over the stern was small, requiring the fend-off pole during recovery.

The HammarHead was deployed at all day-night stations, in almost all cases with deployments during both daytime and nighttime, sometimes spanning the dusk or dawn transitions. Deployments were also made at a subset of the regular stations.

Data collection at the "surface" involved holding the towed body at ca. 10m depth, which seemed a comfortable depth in terms of flight characteristics. During most deployments we were just profiling, sending the body down at 10 m/min for shallow depths and 20 m/min after ca. 100 mwo. Upcasts were likewise at ca. 20 m/min. The HTI data were used to identify layers of interest and the HammarHead sent to 10-20m above those layers, then held at constant depth for 5 minutes to collect a good number of pings.

On a few occasions where we had time, we did ‘bowtie’ surveys similar to on Endeavor cruises 484 and 497, running a bowtie-shaped survey with the central lines ca. 6 nm in length and running N-S and E-W.

HammarHead casts usually lasted ca. one hour with the vessel moving at 2-5 kn. During night when the animals were mostly shallow in distribution, data collection was usually done at the “surface” with the towed body held at a constant depth, ca. 10-20m, in order to obtain high resolution data of particular scattering layers. During daytime when the scattering usually involved layering at a series of depths, the HTI data were used to identify layers of interest and the HammarHead profiled to 10-20m above those layers, then held at constant depth for 5 minutes to collect a reasonable number of pings. Layers as deep as 500 m were targeted. On several occasions, mostly while waiting for tropical storms to move past the ship, “bowtie” surveys were conducted with the Hammarhead, similar to on Endeavor cruises 484 and 487. These consisted of steaming along two perpendicular lines of 6 nm length connected by diagonals of 4.2 nm. The towed body was lowered and raised at about 20 m/min.

9.4.3. Problems and Solutions

Deployment Strategy

The original plan had been for HammarHead deployments at all of the stations. Due to the relatively high noise floor of the system, however, we found early in the cruise that some deployments were resulting in few interesting, super-threshold, measurements. Given the time constraints we faced to complete the survey on time, we chose to focus on HammarHead deployments in regions where the scattering was likely to be high and easily accessible (i.e., when shallow during night) and on the day-night stations where ground-truthing information would be available from other instruments. Overall, the hope was that this would result in fewer, but higher-quality, data.

Synchronization

Interference between the broadband and multi-frequency systems can be avoided by synchronizing transmissions between the two systems using a National Instruments system and Labview program written by Wu-Jung Lee (a system overall referred to as Wu-Jung’s box). The initial plan for the cruise was to use the trigger box during small-scale acoustic surveys when broadband and multi-frequency data would be collected simultaneously. Because running the systems in this way results in lower ping rates on both, in the interest of collecting high quality broadband data, during regular HammarHead casts the multi-frequency system was mostly kept off. Early in the cruise we made some attempts to run the Edgetech system with the external trigger, but found that we were getting overflows (i.e., missed pings topside) and that some channels, mostly the High-High and High-Low were not updating on every ping cycle. We were unable to diagnose the source of this problem, and decided not to use the trigger for the remainder of the cruise. During the small-scale surveys both systems were used without synchronization; based on visual scrutiny, the interference was not too severe, and was worst for the A1 and A2 channels on the broadband system.

Data Transmission

The Dynacon portable winch provided to us by Jamie Haley and the NSF regional winch pool came with 1498m of standard UNOLS 0.322” EM 3-wire conducting cable. We requested this length of wire as previous experience with 0.322” suggested we could achieve the necessary bandwidth for the Edgetech system while still having enough wire to target deep depths. Dockside tests and pre-cruise tests with the winch installed indicated we were getting the full bandwidth needed for the ~ 4 MBps data transfer rates between the underwater and deck units. This allowed us to configure the system for RAW data collection to ranges of 70, 70, and 50m for the A1/LOW, A2/MID, and HL/HH subchannels, respectively. For most of the cruise we were able to collect data with these settings with no overflows. Late in the cruise, however, we started to get regular overflows. Changing the ranges to 50m at all sub-channels remedied this problem. The reason behind this change in bandwidth was not clear. On a previous cruise on the R/V

Connecticut, a similar phenomenon of a sudden increase in the frequency of overflows was observed. In that case, however, changing the ranges of data collection and not collecting RAW data did not remedy the problem, which ultimately proved to be fraying in the wires at the wet-end termination. Rather than that kind of intermittency, the present problem appeared to be more of a decrease in bandwidth. Examination of all of the connections between underwater and deck units (i.e., bulkhead on the U/W unit, connector cable to the cable termination, winch j-box, dry-end connector to the deck unit) did not reveal any obvious problems. The wire itself did have a kink at ca. 5m from the termination, where the C-clamp used to attach the Reeve net (see below) was clamped to the wire; this may be the source of the reduced bandwidth.

9.4.4. Preliminary Results

After each cast scattering patches of interest were selected and spectra were produced for the patches. If there were no particularly interesting features in a cast due to low scattering levels overall no spectra were generated for that cast. Below is a summary of the scattering we saw organized by transect, with plots of characteristic spectra; Appendix 2 also provides spectra for each cast at each station.

Transect One: Measurements from the Hammerhead along transect one generally produced low scattering in the Sargasso Sea regions. There were very few scattering patches in the Sargasso Sea region and only a few spectra were generated for the region (e.g., Figures 9.4.1-9.4.2). An example of the spectra associated with Sargasso Sea regions can be seen below in Figure 9.4.2; these spectra were generally consistent with the presence of fish.

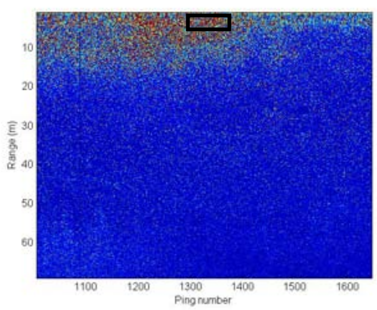


Figure 9.4.1: Scattering the spectrum was taken from. Note the black box indicates the region of data analyzed

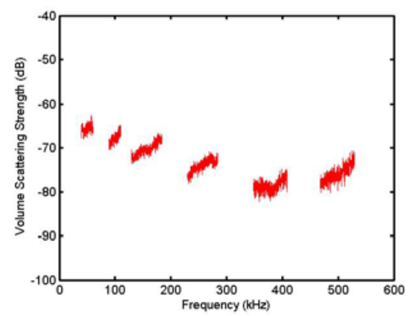


Figure 9.4.2: Typical spectrum shape associated with the Sargasso Sea regions along transect 1. This spectrum is from station five cast seven.

At station ten which was about half way through transect one identifiable patches were first observed. These patches yielded higher scattering levels at the higher frequencies with spectra that were either flat or rolled over around 200 kHz as seen in Figures 9.4.3 through 9.4.4. The spectrum at station ten was similar to spectra seen at all the following stations (Figures 9.4.5-9.4.6).

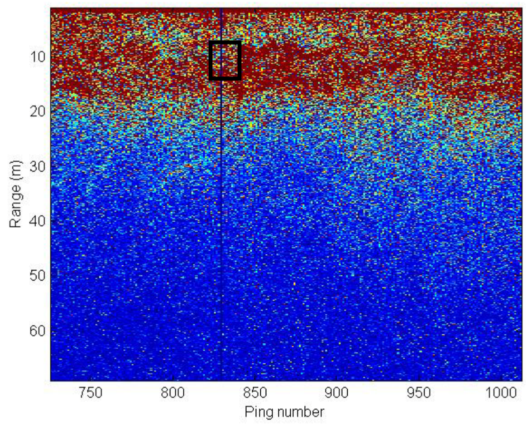


Figure 9.4.3: Scattering the spectrum was taken from. Note the black box indicates the region of data analyzed

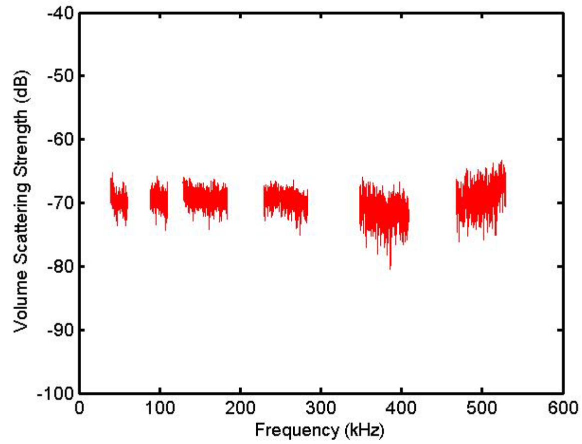


Figure 9.4.4: Flat spectrum observed at station ten. This spectra shape was observed often at all stations after station ten

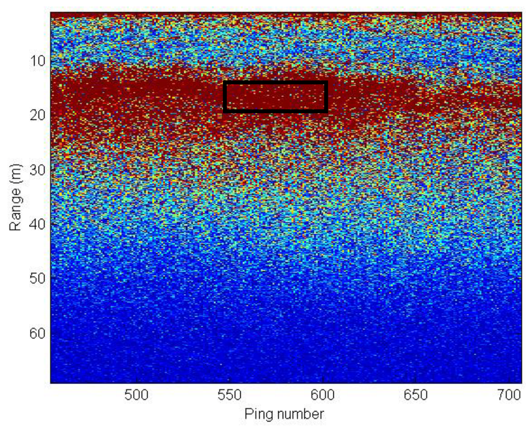


Figure 9.4.5: Scattering the spectrum was taken from. Note the black box indicates the region of data analyzed

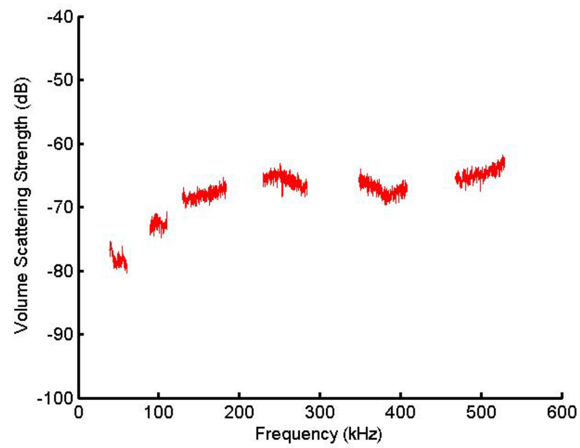


Figure 9.4.6: Spectrum rolling over at ca. 200 kHz observed at station ten. This spectra shape was observed often at all stations after station ten

Transect Two: The HammarHead was only deployed at station seventeen along transect two. The scattering was similar to station ten and the stations to the north of it but overall produced some of the most interesting echograms. The data from station seventeen should be further explored beyond what is presented in Appendix 2. One of the most notable patches from station seventeen was observed on cast fifteen. The patch displayed linearly increasing volume backscattering with respect to frequency as seen in figures 9.4.7 and 9.4.8.

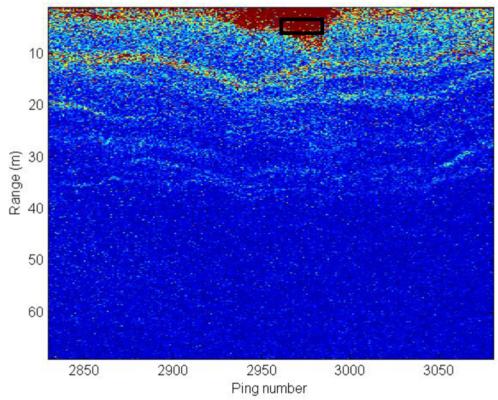
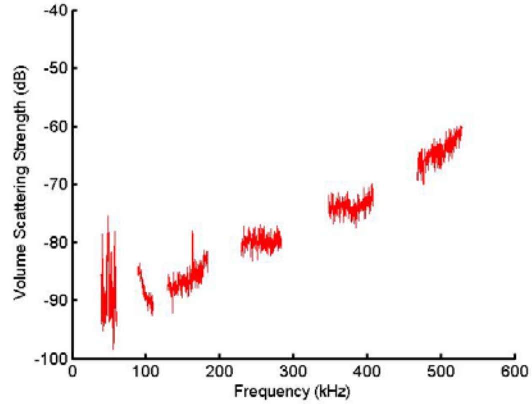
	

Figure 9.4.7: Scattering the spectrum was taken from. Note the black box indicates the region of data analyzed	**Figure 9.4.8:** Nearly linearly increasing volume backscatter with respect to frequency.

Transect Three: The data analyzed from transect three revealed that most of the patches rolled over at 200kHz as seen in figures 9.4.9-9.4.10. The echograms from transect three have many patches and layers that could have different scattering characteristics but were not analyzed due to time constraints.

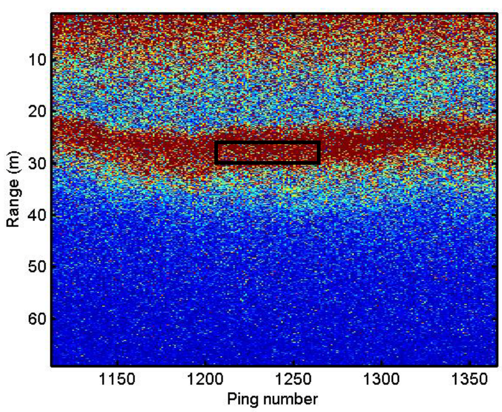
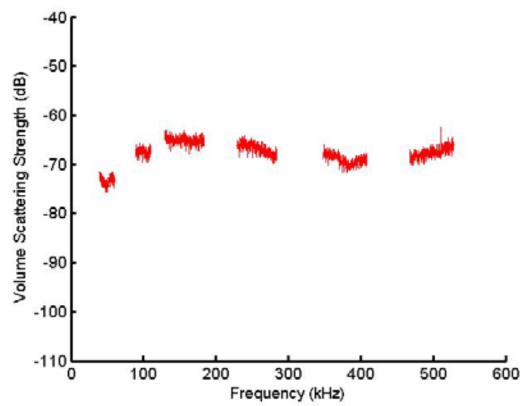
	

Figure 9.4.9: Scattering the spectrum was taken from. Note the black box indicates the region of data analyzed	**Figure 9.4.10: S**pectrum that rolls over at 200 kHz which was common in the data analyzed from stations along transect three.

9.5. *Reeve Net*

Amy Maas

9.5.1. Introduction

The e objective of Reeve net sampling was the gentle collection of live specimens to be sampled for physiological and genetic analyses. These trawls were short in duration to minimize handling time, usually lasting for no more than an hour. To maximize collection of diel vertically migrating species, trawls occurred at the first station after sunset each evening (Table 9.5.1).

Table 9.5.1: Reeve net deployments

Tow	Station	Date	Local Time	Wire out (m)	Downcast (m/min)	Upcast (m/min)	5 min stops (m wire out)	Latitude (N)	Longitude (W)
1	Transit	8/9/2011	20:45	150	15	5	-	37.743	60.628
2	Transit	8/10/2011	21:05	200	20	7	75	36.346	56.179
3	1	8/11/2011	20:30	150	20	5	-	35.001	52.003
4	3	8/12/2011	22:32	200	10	5	200, 50	35.976	51.987
5	5	8/13/2011	20:42	200	20	5	100, 50	36.990	52.002
6	8	8/14/2011	22:52	200	20	5	100, 50	38.499	51.995
7	10	8/15/2011	22:44	200	20	5	100, 50	39.998	51.999
8	10	8/16/2011	21:29	200	10	5	100, 50	39.416	51.969
9	13	8/17/2011	22:30	200	20	5	100, 50	40.878	51.976
10	15	8/18/2011	22:29	250	20	5	180, 30	42.003	50.604
11	17	8/19/2011	20:32	200	20	5	120, 50	42.985	47.773
12	19	8/20/2011	23:05	200	20	5	110, 40	43.997	44.917
13	21	8/21/2011	21:16	200	20	5	70	44.941	41.997
14	24	8/22/2011	21:53	200	20	5	60	46.502	41.997
15	26	8/23/2011	19:02	200	10	5	35	47.490	41.992
16	31	8/24/2011	20:05	200	20	5	60	49.552	41.942
17	32	8/26/2011	00:03	200	20	10	-	49.130	44.250

9.5.2. Methods and Approach

A 1-m diameter Reeve net with a new 150-um mesh net was deployed via the A-frame and portable winch. Deploying the Reeve net required disconnecting the termination from the HammarHead; of the three winches and their terminations this was the easiest to break off, hence our decision to use this winch for the Reeve net. A large (~75 lb) weight was attached to the cable termination via a short length of hydrowire. This weight was sent down to 5m and a clamp was then attached to the wire, from which the Reeve net was towed. The lines supporting the cod-end attached to the ring were initially too short and on the first tow, the net got twisted. After adjustment, the subsequent Reeve net casts were straightforward. During the last tow (#17), a substantial tear occurred near the mouth of the net, which will have to be repaired on shore.

Reeve net deployments were conducted once per day, at the first station after sunset each day, and generally lasted ca. 1 hour. Ship speed during tows was ~1-1.5 knots. The downcast was done at ca. 20 m/min and the upcast at 5 m/min; typically the net was held at some depth(s) chosen either for either scattering on the HTI or high chl-a in the CTD data for ca. 5 minutes; typically these depths were ca. 75m and 40m. Most often a maximum 150-200m of wire was put out, depending on wire angle and desired sampling depth. Upon recovery of the net on deck and the code-end detached, the net was then washed down over the side, since only live animals were sought from these tows. The cod-end was immediately taken to the wet lab and the catch carefully examined.

In the wet lab, the cod end was promptly divided among a number of buckets and diluted with fresh filtered seawater. These buckets were individually poured into a white plastic tray for sorting. Since pteropods tend to sink, the bottom buckets were examined first. Individuals were transferred to plastic beakers at low densities (>20 individuals) for experimentation. Species identification was done using a compound microscope while individuals were still alive (Figure 9.5.1).

9.5.3. Preliminary Findings

Pteropods were found in every Reeve net tow, although their diversity and densities varied widely between stations (Table 9.5.2). There were two distinct patterns of diversity which appear to have been related to the temperature and salinity profiles of the water masses sampled. When the top 100 m of the water column were above 15 °C there was a greater likelihood of high pteropod diversity. Colder (<10 °C), fresher (<33 psu) water frequently resulted in catches that were dominated by the subpolar species *Limacina retroversa.* Using the PRIMER 6 statistical package (PRIMER-E, Luton UK) we found that average temperature and the maximum salinity of the top 100 m of the water column best explained the species distributions between stations (BESTENV analysis, Cor. = 0.76). Principle Components Analysis of the top 100 m temperature and salinity as described by CTD casts (Figure 9.5.2), Multidimensional Scaling plot of pteropod diversity according to station (Figure 9.5.3), and a dendrogram showing the similarity in pteropod diversity between species (Figure 9.5.4) were plotted using the PRIMER 6 package.

Table 9.5.2: Presence of pteropod species in Reeve nets.

	Station #															
	t1	t2	1	3	5	8	10	13	15	17	19	21	24	26	31	32
Cavolinia gibbosa				x								x				
Cavolinia inflexa				x		x	x	x			x	x	x			
Cavolinia longirostris			x	x	x	x	x	x								
Cavolinia uncinata						x										
Clio cuspidata			x	x	x		x					x	x			
Clio pyramidata	x	x	x	x	x	x	x	x				x	x	x	x	
Creseis acicula					x		x									
Creseis virgula		x			x			x			x	x	x			
Cuvierina columnella	x	x		x		x	x					x	x	x	x	
Diacria quadridentata	x			x		x		x								
Diacria trispinosa	x	x	x	x			x	x				x	x		x	
Hyalocylis striata				x	x	x	x	x				x				
Limacina bulimoides				x	x	x	x	x					x			
Limacina inflata		x		x	x	x	x	x				x	x			
Limacina retroversa									x	x	x	x	x			x
Limacina lesueurii						x										
Peracle reticulata		x		x		x		x				x	x			
Peracle triacantha					x	x										
Styliola subula			x	x		x	x	x	x			x	x			

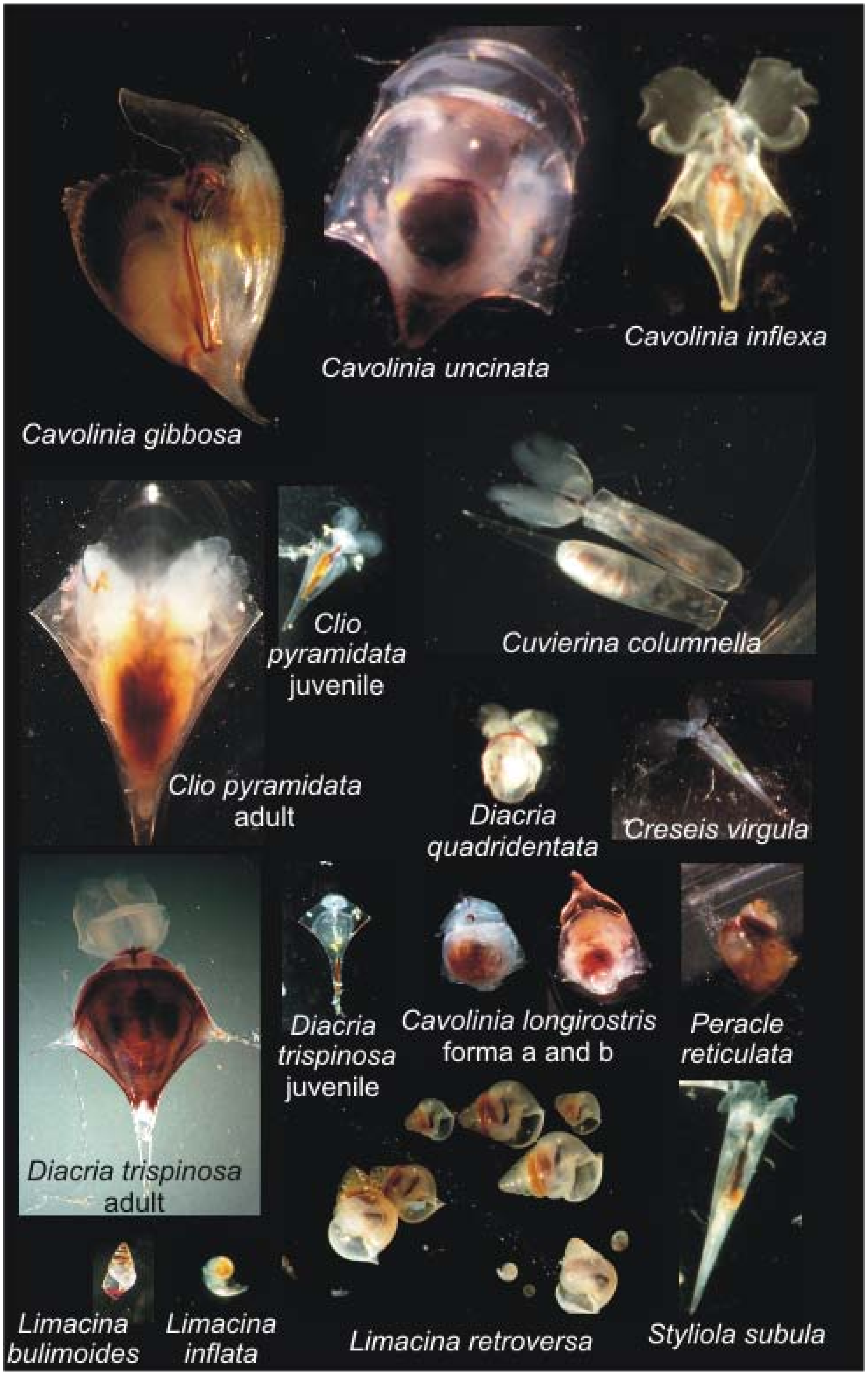


Figure 9.5.1: Pteropod species sampled with the Reeve net.

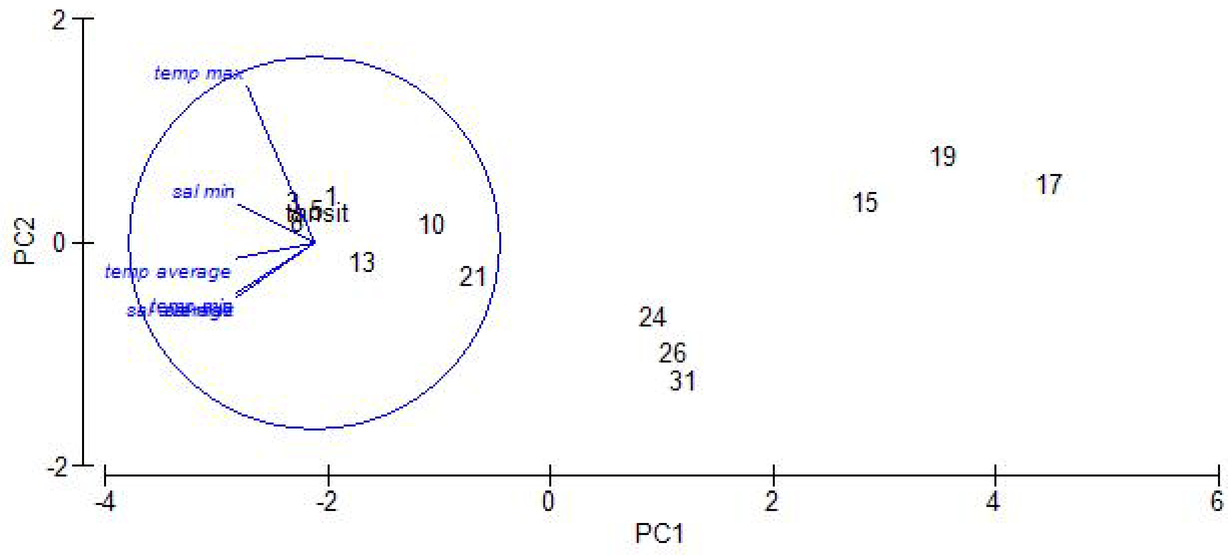


Figure 9.5.2: Principal Components Analysis (PCA) of the environmental variables sampled by CTD at each station where a Reeve net was deployed. The hydrographic data is an average, minimum and maximum temperature and salinity for the top 100 meters of the water column.

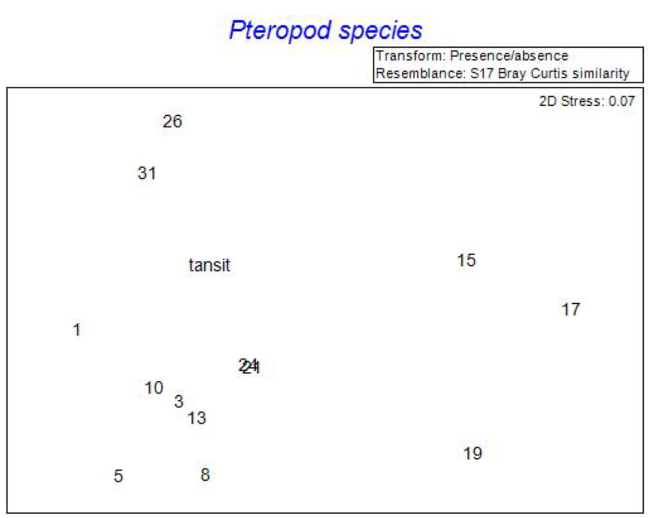


Figure 9.5.3: Multidimensional Scaling (MDS) plot of pteropod species sampled by the Reeve net by station.

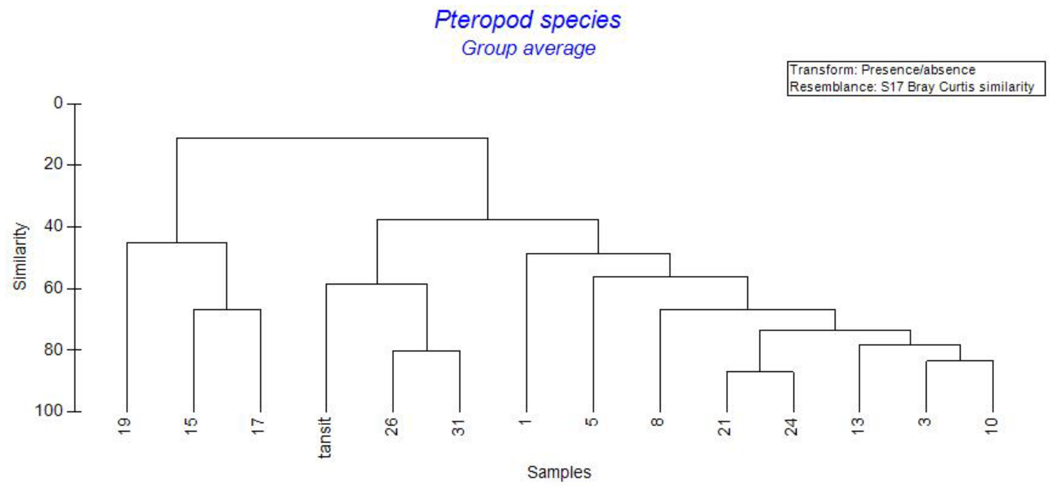


Figure 9.5.4: Dendrogram depicting the similiarity in species diversity at stations where Reeve net sampling occurred.

10. Zooplankton Physiology

Amy Maas

10.1. *Introduction*

To predict the effects of ocean acidification on pteropods, we must understand the physiological mechanisms through which pteropods respond to high CO2. Our first objective was to expose multiple species of pteropods from the North Atlantic to conditions mimicking predicted CO2 levels at the end of the century and to measure their physiological response (oxygen consumption, ammonia excretion). Our long-term research goal is to compare the response of pteropods collected from the Atlantic and Pacific Oceans to hypercapnia (high CO2); this made it necessary for us to expose Atlantic species to CO2 and O2 conditions mimicking conditions which naturally occur at depth in the Pacific Ocean. In the Pacific, diel migratory species such as Clio pyramidata and Cuvierina columnella may experience conditions of low O2 in concert with elevated CO2 during the daytime. To disentangle the physiological response of pteropods to low O2 (10%), high CO2 (800 ppm), we were obliged to expose pteropods to both stressors independently and in combination. Using closed-chamber end-point respiration experiments aboard ship, and with the intention of employing molecular techniques in the lab, we will determine how exposure to elevated CO2 differentially affects acid-base balance and metabolism of thecosomatous pteropods.

10.2. *Methods and Approach*

At sea, animals were captured for physiological experiments using a 1 m diameter, 335 µm mesh Reeve net trawl, or a 1 m2 MOCNESS tow (see above sections). Pteropods were placed in filtered seawater at densities of < 30 individuals liter-1 and acclimated for at least 8 hours at 20° C, 15°C or 10°C in temperature controlled waterbaths. After acclimation, individuals that were in good condition were put into glass syringe respiration chambers with a known volume of 0.2 micron filtered seawater for at least four hours. The water contained 25mg each of Streptomycin and Ampicillin liter-1, to prevent bacterial growth, and was bubbled with certified gas mixes to achieve normal air saturated (21% O2, 380 ppm CO2), high CO2 (21% O2, 800 ppm CO2), low O2 (10% O2, 380 ppm CO2) or low O2 – high CO2 (10% O2, 800 ppm CO2) conditions. Bubbling of 10% O2 achieved a mean initial O¬2 concentration of 133.8 ± 5.4 µmoles kg-1 in low O2 treatments. To calculate the variation in the experimentally bubbled 800 ppm CO2 Total alkalinity was taken of each batch of 0.2 – micron water and DIC was taken of control water (Appendix 3.1). There was some difficulty analyzing the actual ppm CO2 of the water as the DIC instrument was calibrated for 25° whereas experiments were conducted from 10-25° C. If samples were allowed to warm to room temperature, gas bubbles evolved which occasionally interfered with chemical analysis.

During each experiment, we simultaneously ran a control syringe to monitor background respiration of microbes. At the conclusion of the experiments, we measured the O2 level by withdrawing a sample of water from the chamber using a 500 µL airtight Hamilton syringe and injecting it past a Clarke type O2 electrode (Strathkelvin Instruments, North Lanarkshire, United Kingdom) in a water-jacketed injection port. Our resulting O2 consumption rates are reported in µmoles g-1 h-1 (wet mass). A second aliquot of water was drawn from both the experimental and control chambers and frozen (labled as OC473.11.# NH3 and OC473.11.# control). Upon return to land these samples will be thawed and analyzed for NH3 excretion (µmoles g-1 h-1 wet mass) using the indophenol blue colorimetric assay (Ivancic and Degobbis 1984). After taking water samples, individual pteropods were blotted dry and frozen in liquid nitrogen so that they can be weighed upon return to land (labeled as OC73.11.# or OC473.11.# Species).

In the lab cryogenically preserved *Clio pyramidata* and *Syliola subula* samples will be further analyzed for transcriptome expression during exposure to hypercapnia (high CO_2) using the complimentary approaches of quantitative RT-PCR (qPCR) and high-throughput transcriptional profiling (RNAseq). We will use qPCR, to quantify the expression of 8-12 genes that regulate acid-base balance (e.g., Na+/K+-ATPase, carbonic anhydrase), protein synthesis (e.g., aminoacyl-tRNA synthetases), protein degradation (e.g., S-adenosylmethionine), metabolic rate (e.g., phosphofructokinase, citrate synthase , protein inhibitor IF1) and oxidative stress (e.g., superoxide dismutase, pyruvate dehydrogenase kinase). Briefly, we will use degenerate primers to amplify, clone and sequence genes of interest. We will extract RNA from individual pteropods, prepare complementary DNA, and measure gene expression by qPCR. We will use RNA-seq to generate a complete and quantitative snapshot of gene expression (transcriptional profile) and identify novel genes and pathways affected by hypercapnia. We will sequence replicate samples of pteropods exposed to two treatment conditions (380 or 800 ppm) using multiplexed 100 bp paired-end reads on an Illumina HiSeq instrument (Hudson Alpha). Reads will initially be pooled and assembled into a *de novo* transcriptome using the Trinity software package; assembly will be aided by currently available pteropod genomic and transcriptomic data (Hoffman, personal communication). Sequences within each library will then be clustered and used to identify differentially-expressed genes.

10.3. *Preliminary Results*

At the end of the cruise we had completed 221 respiration experiments on 6 species of pteropod (Table 10.1, Appendix 3.2). Species appeared to be sensitive to temperatures above 20° C and some, *Clio pyramidata* in particular, seemed quite sensitive to conditions of low oxygen.

Table 10.1: Summary of respiration experiments

Species	Treatment			
	380 ppm, 21%	800 ppm, 21%	380 ppm, 10%	800 ppm, 10%
Cavolinia inflexa	6	4		
Clio pyramidata	14	10	9	8
Cuvierina columnella	18	10	10	10
Diacria trispinosa	16	17		
Limacina retroversa	12	13	9	9
Styliola subula	10	8		

11. Zooplankton Molecular Ecology

Lecadio Blanco Bercial

11.1. *Pteropod DNA Barcoding and Phylogeography of Selected Species*

11.1.1. Introduction

DNA Barcoding (the derivation of short DNA sequences that enables species identification, recognition, and discovery in a particular domain of life) provides a mean to identify known species, and to detect potentially unknown ones, as well as possible misidentifications. In addition, Barcoding may allow studying the possible relationships between the different shell shapes (forma) of pteropods with distinctive genetic lineages. Furthermore, the development of molecular markers like the Barcoding region of the cytochrome *c* oxydase subunit I (COI) allows phylogeographic studies based on these markers and can yield improved understanding in the marine environment. This approach facilitates the investigation of the presence and effect of barriers to population connectivity and gene flow of marine holoplanktonic species from different ocean basins (Atlantic and Pacific) but also within the ocean basin, between water masses.

11.1.2. Methods

Individuals were identified and picked by eye on white trays from both Reeve and MOCNESS samples when alive. Some small individuals were identified under the stereomicroscope. Afterward they were preserved in 95 % undenatured ethanol and kept at -20 °C. The ethanol was changed after 24 h. In some cases, due to turbidity or coloration on the sample, more ethanol changes were needed, until the ethanol in the vial remained clear, indicating a proper preservation. For some selected species, high numbers were collected when possible in order to carry out phylogeographic studies based on DNA sequences. Additionally, high numbers of each species were preserved in 70 % undenatured ethanol. This preservation would be useful for the correct preservation of the pteropod shells for electronic microscopy, as well as the tissue for molecular approaches, allowing the joint study of the potentially shell shape changes (forma) and genetic lineages. In this case, more than one changes of the ethanol were done to ensure the complete removal of the excess of water from the tissues, since this ethanol concentration (70 %) is the minimum required for correct preservation. For each sample designated for molecular studies, a unique code corresponding to the Census of Marine Zooplankton (www.CMarZ.org) database was assigned, and both the individuals and the extracted DNA will be kept (available by request) at the CMarZ archives located at the Department of Marine Sciences of the University of Connecticut.

11.1.3. Sampling results and future work.

The detailed sampling is shown in Appendix 4. In total, 30 taxa were identified, for a total number of 194 samples (31 of them in 70 % ethanol) including approximately 1400 individuals. Of those, ~ 900 corresponded to the species designated for the phylogeographic analysis, which included the six species in which physiology experiments were performed, and *Limacina inflata* (Table 11.1; Appendix 4). For Barcoding, the corresponding 660 bp fragment of the COI gene will be amplified using the universal primers LCO-1490 and HCO-2198, and compared to the available data on GenBank (http://www.ncbi.nlm.nih.gov/genbank/) and other local data available from CMarZ. For the phylogeographic approach, the same COI region, together with other target genes (like the mitochondrial Cytochrome *b* and the nuclear ribosomal ITS regions) will be studied.

Table 11.1. Number of individuals preserved at each station for phylogeography from either the Reeve net or the MOCNESS. Horizontal lines indicate boundaries between transects.

St.	*C. inflexa*	*C. pyramidata*	*C. columnella*	*D. trispinosa*	*L. inflata*	*L. retroversa*	*S. subula*
3	1	2	4	4	5		3
5		12			10		5
8	3	14	5		5		29
10	21	32	4	16	55		47
13	2	4		6	10		3
15						30	
17						30	
19	1					50	
21	5	28	1	12	26	7	13
24	1	14	13	8	30	30	7
26		50	51	6			
30		50					
31					9	78	1
32		3	2			30	

11.2. *Genomics and Gene Expression of Calanus finmarchicus, Euphausiacea and Thaliacea*

11.2.1. Introduction

Next Generation sequencing technologies are in rapid development nowadays, increasing their presence in gene expression, community analysis, phylogenomics and molecular ecology studies. Despite their technological advantages in obtaining enormous amounts of data in a fast and relatively cheap way, the sample preservation requires extra care than the previous methods, especially if the aim of the study involves mRNA (transcriptomics). Thus, the available stock of suitable samples for these analyses is reduced. During the OC473 cruise, key species from the North Atlantic Ocean ecosystems were targeted in order to obtain samples whose quality would allow posterior analysis on Next-Gen platforms.

11.2.2. Methods

Flash freezing of live individuals in liquid nitrogen was the preservation and storage method. The species targeted were the calanoid copepod *Calanus finmarchicus*, different species of Euphausiacea and Salpidae (Thaliacea). For salps, large individuals required dissecting muscle tissue, meanwhile smaller individuals were preserved after dissecting the gut and cutting the tunic for easing the posterior sample processing. Single Euphausiids were included in each cryovial, meanwhile for *C. finmarchicus*, 12 to 16 individuals (adult females or CV) were pooled per cryovial. The selection and preservation of the individuals was carried out immediately after the capture, and only on alive individuals with active behavior.

11.2.3. Preliminary Results

High densities of Salpidae were detected throughout the cruise, meanwhile *C. finmarchicus* was only found in the last station. Five species of Euphausiids were identified and preserved (Table 11.2). As a opportunistic catch, a single female of *Calanus hyperboreus* was found and preserved from the last station. In total, 94 samples were preserved, including 3 from *C. finmarchicus* that were made of 12 females, and 15 and 16 CV respectively. Additional samples of both salps and euphausiids were preserved in 70 % and 95 % ethanol respectively in order to ease the posterior identification, since salps were not identified to species and because when very similar euphausiid species were found, fast sample processing was prioritized over accurate identification. In any case, Barcoding would allow the posterior identification of the species preserved in liquid nitrogen if needed. These samples will be suitable for a wide spectrum of different analysis, from transcriptomics to genomics and phylogenomics.

Table 11.2. Number of flash frozen samples in liquid nitrogen from the selected taxa per station and gear. Horizontal lines indicate boundaries between transects.

St.	Net	Salp	*Meganyctiphanes norvegica*	*Nematoscelis megalops*	*Thysanoessa gregaria*	*Euphausia krohnii*	*Euphausia brevis*	*Calanus hyperboreus*	*Calanus finmarchicus*
T2	Reeve1	4							
15	Reeve4	4							
	Reeve6	2							
17	Reeve11		3						
	MOC10-6		4						
19	Reeve12		2	2					
24	Reeve14				5	5			
26	Reeve15	5		1					
30	Reeve16	5		1		4			
31	MOC16-4			1					
	MOC16-5			3					
	MOC16-6			2		3	1		
32	Reeve17			4		1		1	3
	MOC17-5			3					
	MOC17-6		10						
	MOC17-7		4	6					
	MOC17-8			5					

12. Macrofauna

Timothy White

12.1. *Introduction*

Visual surveys for seabirds and other surface-associated macrofauna (e.g., marine mammals, large pelagic fishes) were conducted as an unfunded add-on to the project. The goal will be to relate observations of these top predators to concurrent measurements of the water column's biological and chemical environment.

12.2. *Survey Methods*

A single observer (T. White) conducted visual surveys during daylight hours for the duration of the cruise, including the main study transect but also during the long transits to the transect start and from the transect end.

Seabirds were identified to the species level, and assigned a behavioral code. When possible, individual birds were assigned to an age class, as determined by plumage characteristics. Flight direction and association type, e.g, tuna, whales, fishing vessels, were also recorded throughout the survey; as well as observation conditions, such as visibility (scale from 0-5; 0= poor and 5=best) and Beaufort sea-state. In addition to seabirds, all other marine megafauna were recorded when encountered, e.g, tuna, marine mammals, turtles; as well as fishing vessels within 2 kilometers of the Endeavor. Distinguishable features, such as fronts or mats of macroalgae, were recorded in comment fields of the database.

Observations were recorded with the software Dlog 3 (Ford, R.G. 2010), continuously during daylight hours, while the ship was underway. Dlog 3 records location (decimal degrees) every few seconds, in GMT (ZULU) time; each observation is assigned a unique geographic coordinate and time stamp. I discontinued the survey during stations and MOCNESS tows.

The strip transect method (Tasker et al. 1984) was used for the majority of the survey period. All birds were recorded in a 300 meter strip width, from bow to beam (90 degree arc), on the side of the ship with the best visibility. I switched to the distance sampling method (Thomas et al. 2010) when seabird density was low, marine mammals were encountered, or when large groups of seabirds were beyond the strip width. Seabirds and marine mammals were counted only once upon entering the survey strip, and ignored if they followed the ship.

12.3. *Preliminary Results*

7 Aug – 17 Aug-2011: Areas along the NE Seamounts and the Gulf Stream produced interesting sightings of Pteradroma petrels, shearwaters, and storm petrels. Herald petrel (Pteradroma arminjoniana) and black-capped petrel (Pterodroma hasitata) were recorded on first day of steaming. Cory's shearwater (Calonectris diomedia) and Audubon's shearwater (Puffinus Iherminieri) were also abundant in the Gulf Stream, as were band-rumped storm petrels (Oceanodroma castro; Figure 12.1).

Figure 12.1: Band-rumped storm petrel [Photo: T. White]

Densities of flying fish were high in the Sargasso Sea but seabird abundance was generally low, with an occassional sighting of Cory's shearwater (Fig. 12.2), and rare sightings of great shearwater. Band-rumped storm petrel was encountered most frequently in the Sargasso Sea. White-tailed tropicbird also became a daily encounter in the Sargasso, likely due to our proximately to Bermuda where colonies are present. Leach's storm petrel was encountered more frequently upon re-entering Gulf Stream waters on our northward steam.

Figure 12.2 Cory's Shearwater [Photo: T. White]

Groups of sperm whales (Shyster macrocephalus) were encountered in the Sargasso as well as a pod of Atlantic spotted dolphin (Stenella frontalis). The pod of dolphin was composed of mixed age classes; adults, sub-adults, and juveniles were present. An unidentified whale was encountered on 17-Aug rolling belly-up in the water. Katie and Nancy observed the blow, however, it was motionless and did not appear to be feeding. My conclusion was that the whale was likely to be sleeping.

18-aug-2011: A spike in seabird abundance marked an abrupt drop in salinity. Sperm whales were observed very close to the seabird spike, and possibly associated with the salinity front. High densities of Leach's storm-petrel, Cory's and great shearwaters were associated with the front. White-faced storm petrels (Pelagodroma marina) also marked the frontal zone. Many LESP flew aboard the ship on ship during evening casts; Peter has images and Amy collected feathers. A single LESP regurgitated its gut contents that consisted of myctophids, copepods, and krill. Samples will be stored at WHOI for future analysis.

19-aug-2011: We steamed south of the Tail of the Grand Banks and crossed another frontal zone. High densities of Leach's storm petrels and shearwaters (Cory's/great) were recorded, as well as the first occurrence of northern fulmar (Fulmaris glacialis). A group of pilot whales was sighted in this area. Striped dolphin (Stenella coeruleoalba), pomarine jaeger (Stercorarius pomarinus) and long-tailed jaeger (Stercorarius longicaudus) also recorded. After analyzing a section of the underway data, Peter discovered an inverse relationship between SST and florescence; possibly a strong thermal front and/or cold water entrainment.

20-Aug-2011: We seemed to have been steaming through transition waters over the next few days, and on the "edge" of warm Gulf Stream water and the colder Labrador current. Feeding groups of LESP were encountered during the morning hours, and groups of short-beaked common dolphin (Delphinus delphis). A very interesting sighting of a Barolo shearwater (Puffinus lherminieri baroli), Macaronesian shearwater, was encountered in warm water(~20□ Celsius) and in a high Sargassum area. I was also able to have a clear view of a LESP preying upon a small fish at the surface. Flying fish were also present in the area.
21-Aug - 22Aug- 2011—The day was characterized by warm water and tropical species. Interesting highlights of Bulwer's petrel (Bulweria bulwerii), WFSP, and BRSP--possible first records for the area. Other species recorded were GRSH, COSH, LTJA, WISP, LESP, south polar skua (Stercorarius maccormicki). Flying fish and dorado (Coryphaena hippurus) were also seen yesterday. Arctic tern (Sterna paradisaea) was spotted for the first time. Long-finned pilot whales (Globicephala melas), sperm whales, short-beaked common dolphin and a loggerhead turtle (Caretta caretta) were observed.

24-AUG -30 Aug -2011 —High abundances were observed of LTJA and ARTE (Fig. 12.3). Productive waters held short-beaked common dolphin, long-finned pilot whale and ocean sunfish (Mola mola).

Figure 12.3: Arctic tern east of the Flemish Cap [Photo: T. White]

During a night station we observed shearwaters and fulmars feeding on fish (myctophids) within the light of the ship. Some fish seemed to be very large and as long as the bill of a great shearwater. We obtained surface samples using the Reeve net and Peter captured feeding behavior with his camera. WFSP were encountered on 29-Aug-2011.

High abundance and diversity was observed along the frontal zone south of the Tail of the Grand Banks, including large groups of Cory's and great shearwater. Striped Dolphin was also abundant in the area, and a group of sperm whales were spotted. An Atlantic Ridley turtle (Lepidochelys kempi) was recorded in an area of high Sargassum. Band-rumped storm petrels, LESP, an unidentified turtle, striped dolphins, a parasitic jaeger, and Audubon's shearwater (30-Aug). Peter had mentioned that we were in and out of eddies (warm core) throughout the day.

31-Aug-2011— With the ship en route for WHOI and nearing Georges Bank, band-rumped storm petrels and fin whales (Balaenoptera physalus) were obdserved as we approached the shelf-break. Across Georges Bank itself, blue shark (Prionace glauca) and shortfin mako shark (Isurus oxyrhinchus) were abundant at the surface. Short-beaked common dolphin and minke whale (Balaenoptera acutorostrata) were the cetaceans species recorded on Georges east of the "Hague" line. COSH, GRSH, LESP, WISP were the dominant seabirds recorded. A minke whale with GRSH feeding interaction was observed, perhaps suggestive of commensalism? MIWH were observed "chasing" baitfish (herring?) out of water, while shearwaters would mill over, and feed upon fish.

12.4. *Other Seabird Sampling*

Two species of storm petrel, Leach's Storm-Petrel (*Oceanodroma leucorhoa*) and the Band-rumped Storm-Petrel (*Oceanodroma castro*), were often found "wrecked" onboard the Oceanus during nighttime operations, likely due to the disorienting effect of the ship's lights on the flying birds. These birds were opportunistically retrieved and photographs were taken of the wing, the dorsal rump, the ventral rump and the beak as diagnostic identification features of individuals (Fig. 12.4). A feather was taken from the ventral region of the bird and immediately frozen in liquid nitrogen and when available, regurgitates were collected for stomach content analysis (Table 12.1).

Ultimately, the aim will be to determine the feeding patterns of these populations using isotopic analysis of feathers and by analyzing collected gut samples. Feathers will also be genetically barcoded using the cytochrome c oxydase subunit I (COI) region of the genome (Section 11) to analyze the population diversity.

Figure 12.4: Leach's storm petrel captured at station 5 [Photo: N. Copley]

Table 12.1 Storm petrel sampling

Date	Station	ID #	Species ID	Gut Contents	Storage Location	Latitude (N)	Longitude (W)
8/18/2011	15		Feather	CT	42.003	50.604	8/18/2011
8/18/2011	15	1	Gut Contents	WHOI	42.003	50.604	8/18/2011
8/19/2011	17		Feather	CT	42.985	47.773	8/19/2011
8/20/2011	19	4	Gut Contents	WHOI	43.997	44.917	8/20/2011
8/21/2011	21	1	Gut Contents	WHOI	44.941	41.997	8/21/2011
8/21/2011	21	None	Gut Contents	WHOI	44.941	41.997	8/21/2011
8/22/2011	24		Feather	CT	46.502	41.997	8/22/2011

12.5. *References*

Tasker, M.L., Hope-Jones, P., Dixon, T and Blake, B.F. 1984. Counting seabirds at sea fom ships: a review of methods employed and suggestion for a standardized approach. Auk 101: 567-577.

Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47: 5-14. DOI: 10.1111/j.1365-2664.2009.01737.x

13. Opportunistic Sampling

A number of other samples were collected for various collaborators interested in our geographical area of operation and/ore in using our cruise as a ship of opportunity.

13.1. *NBOSI Test CTD*

Nancy Copley

A new prototype high-precision CTD developed by Neil Brown Ocean Sensors, Inc. (NBOSI) was mounted on the CTD rosette frame for the duration of the cruise for the purpose of testing it. It employed a combination of hardware and software in an electronics board that was potted in polyurethane and could be subjected to full ocean depth pressures (Fig. 13.1, green-cabled square on left). Normally this would cause significant errors in analog to digital conversions but the circuitry and code automatically corrects for these errors. Data were logged to a memory stick with a separate battery pack and data logger (Fig. 13.1, right). Figure 13.2 shows a comparison of temperatures from NCTD file 40 with SeaBird cast 36 (oc4732136) to 3000 db. These preliminary results are very encouraging. The slight differences between the test NBOSI CTD and the Seabird CTD likely stem from the former not having yet been fully calibrated.

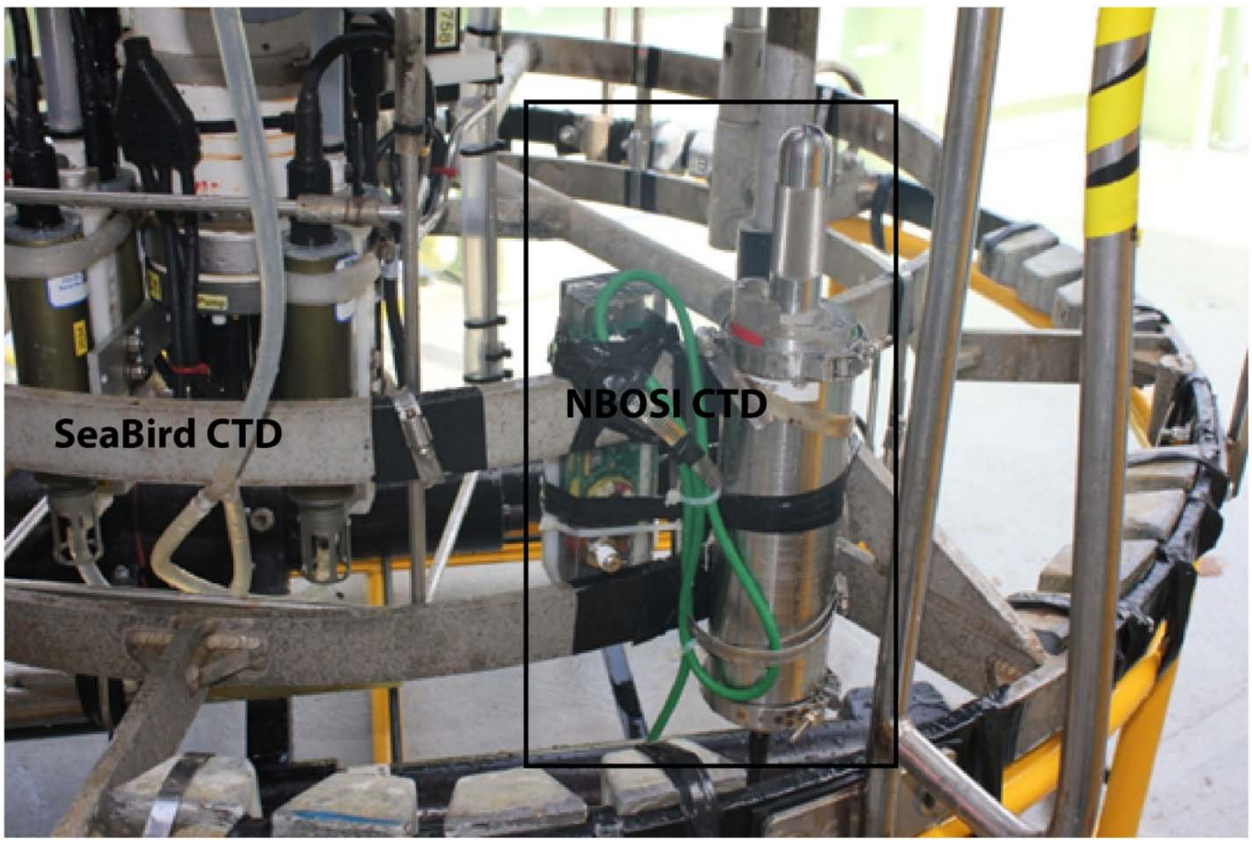


Fig. 13.1. NBOSI CTD mounted on rosette frame. [Photo: N. Copley]

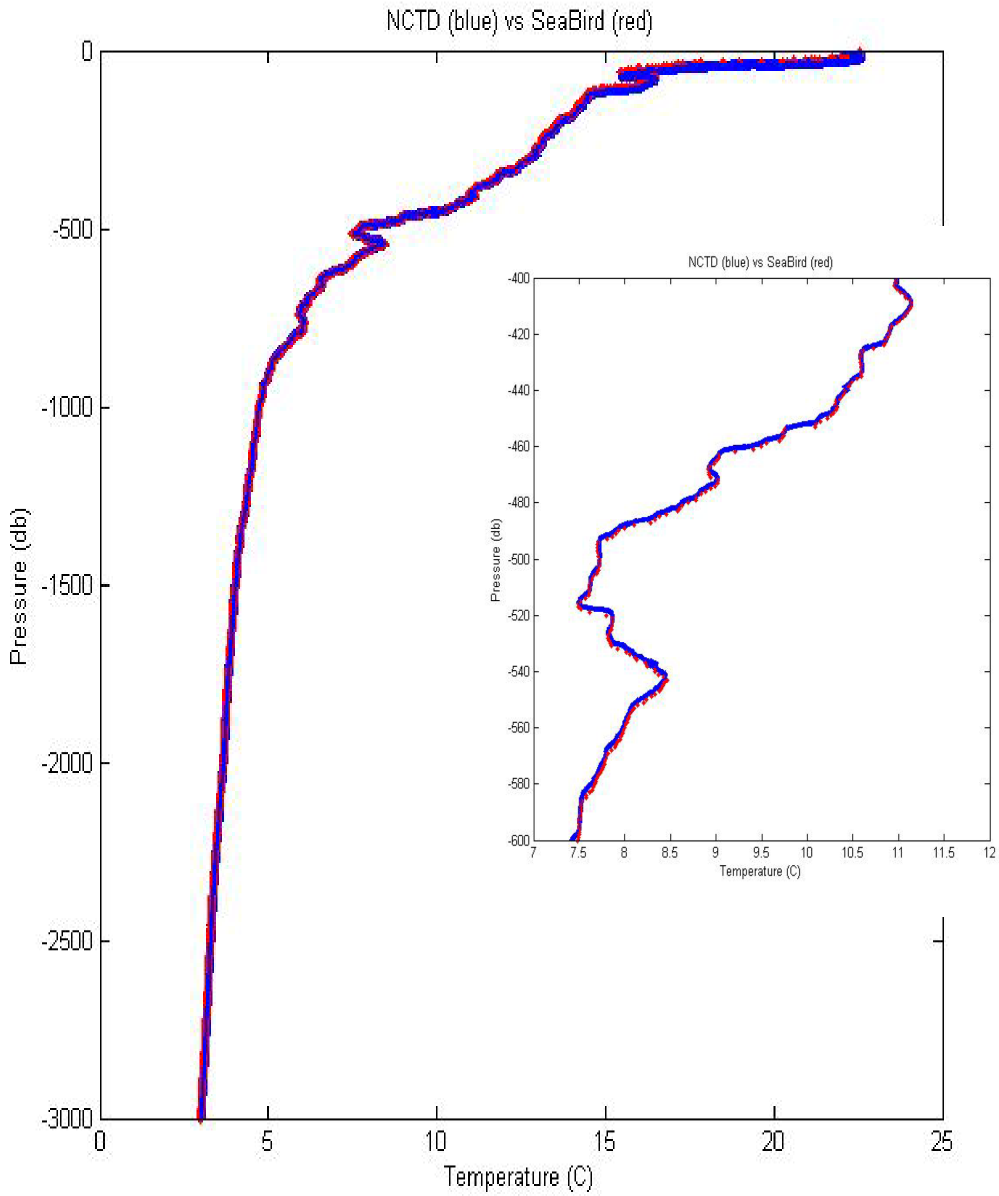


Fig. 13.2. Temperature trace for both the SeaBird and the NBOSI CTD's from cast 36, station 21.

13.2. *Seawater Isotopic Composition*

Lecadio Blanco Bercial

Dr. Craig Tobias (University of Connecticut) asked for water samples (20 L) from subsurface water from the most southern and the most northern stations. The objective was to characterize the isotopic composition of the Sargasso Sea Waters and (ideally) the Greenland Waters, since these are the most extreme water masses that may influence the New England Shelf. The first sample (Sargasso Sea Water) was taken at Station 1 (35° 3.45' N 52° 6' W). For the most northern station, the sample was initially taken at Station 31 (end of transect 3 and most septentrional station) but, since the water mass still belonged to a meander from the Gulf Stream, a second chance was taken at Station 32 (49° 4.69 N 44° 21.8 W) where colder waters were found (maybe Labrador Shelf Water).

13.3. *Tintinnida*

Lecadio Blanco Bercial

Attempts were made to sample Tintinnida (Ciliophora, Spirotrichea) during this cruise for Dr. Luciana Santoferrara (University of Buenos Aires – University of Connecticut). The original idea included two sampling strategies: 1) Lugol samples: short vertical tows (o-ring net of 30 cm diameter, 20 µm mesh), from 50 m depth to the surface. Tows were programmed at 5 m per minute winch speed. The concentrated seawater would be poured in tubes with Lugol (up to 50 mL, 2 % final concentration) and stored in the refrigerator. 2) DNA samples: 2-3 L of seawater from the rosete (depth above 30 m) should be filtered through a 0.2 µm filter. The filter would be kept in a microcentrifuge tube containing lysis buffer, and stored in the refrigerator.

Initially, the refrigerator was not working properly, with the temperature below freezing, and consequently the sampling was delayed until the refrigerator was working well enough. Then, in the first net tow, the mesh was broken, likely due to the bad condition (age) of the net. As a second option, a filter was made with a piece of the net, but the time spent in filtering water enough from the rosete (at least 50-60 L were needed) made this sampling unviable to fit into the already scheduled activities.

Since DNA samples were not useful without the Lugol samples, the whole sampling of tintinnida was abandonned.

13.4. *Photochemistry of Dissolved Organic Matter*

Aleck Wang

At Stations 1 and 31, seawater samples for analysis of photochemistry of dissolved organic matter were collected for Drs. O. Zafiriou (WHOI) and H. Xie (University of Quebec Rimouski) from the CTD Niskin Bottles in the mixing layer (~10 m). The sample water was filtered through a 0.8/0.2 µm inline filter and collected into four 4-liter brown glass jars after rinse of the filter and the connecting tubing. The glass jars were pre-cleaned before the cruise.

13.5. *Meso-pelagic Fish Liver Sampling*

Lecadio Blanco Bercial

13.5.1. Introduction and Methods

Fish liver samples were taken at the request of Dr. John Stegeman (WHOI). The protocol involved excising liver from freshly killed (live) or very recently dead fish. 1 to 3 cubic pieces less than 0.5 cm in any dimension were to be cut and placed into 15 mL Falcon tubes containing 5 mL RNAlater. These samples were stored refrigerated. The balance of the liver, as possible, was to be frozen in the coldest archive available.

13.5.2. Results

In total, seven fish livers were preserved. Since only six RNAlater tubes were provided, the last one was flash frozen in liquid nitrogen (Table 13.1).

The first issue was the establishment of “recently dead fish”. In general, MOCNESS tows took around 3 h and the fish sampled were dead upon recovery of the net system. As a consequence, the time of death of each fish would depend on in which net it was caught. The lower the net number is, the more time the fish spent in the net and the longer it had likely been dead. For nets 1 and 2 (i.e., the deeper nets), the time spent in the cod-end by the fish would be around 1.5 h to 2 h.

The second issue with the protocol concerned the "balance" of the fish liver. The fishes caught in the net were in general small (always < 30 cm), and therefore the full liver was preserved in the RNAlater due to its reduced size. Instead of preserving the remaining liver, the entire remainder of the fish were preserved in a separated jar after the liver extraction, in 70 % or 95 % ethanol to ease any posterior identification and availability for the researcher. Since no fish taxonomist was involved in the cruise, no species identification was carried out.

Table 13.1. Number of fish liver samples obtained during the cruise, and preservation procedure. Station and gear data are also indicated.

St.	Gear	Net (depth)	N	Preservation
13	MOC-01-09	2 (600 - 800 m)	2	RNAlater
17	MOC-01-10	1 (800 -1000 m)	2	RNAlater
26	MOC-01-15	2 (600 - 800 m)	1	RNAlater
26	MOC-01-15	3 (400 - 600 m)	1	RNAlater
32	MOC-01-18	0 (0 - 1000 m)	1	Liquid N_2

14. R2R Event Logger

Nancy Copley

A detailed event log is an important part of every oceanographic cruise. Not only can it be used during the cruise to keep track of casts, equipment and to diagnose problems, but it also aids in data management after the cruise has ended. In preparation for the cruise we also discussed best practices for data collection with staff from the WHOI-based Biological and Chemical Oceanography Data Management Office (BCO-DMO), in anticipation of our archiving cruise data with that office and in accordance with NSF's policies on data management. BCO-DMO best practices include the use of an event log to record all scientific sampling events occurring during a cruise.

Traditionally, event logs begin in hand-written form and are transcribed to electronic form (such as an Excel spreadsheet). Instead, these steps were bypassed with a beta version of Elog, an open source browser-based event logger from the NSF program "Rolling Deck to Repository" [http://www.whoi.edu/page.do?pid=35716]. Events could be entered to Elog from any computer that was connected to the ship's intranet. After some research the IP address was discovered so that this was true for wired and wirelessly connected computers. This made it possible for bird observation starts and stops to be entered from the flying bridge (03 deck) as well as from the main lab (e.g., Fig. 14.1).

Fig. 14.1. Tim White enters bird and marine mammal sightings from the flying bridge. [Photo: N. Copley]

Prior to the cruise, the headings were custom assigned such as the addition of transect and local time. The list of instruments and names of cruise participants was created and edited in the configuration file. Another feature of the event logger is the ability to select a single instrument to for viewing as well as subselecting an action (start, stop, etc.) which made it easy to determine the next cast number for each instrument (Figures 14.2, 14.3).

At first, the event entries were often missed or delayed but this improved quickly once routines were established. An event could be queued up with all the information except for the local time prior to the event. Once it occurred, the local time would be added and the event submitted. At that moment, the position and UTC time were automatically updated. This was fine as long as the event was entered promptly. If it was added later, the UTC time and event number were off and had to be manually edited. Position data for late entries were also updated to the moment of submission and will need to be corrected post-cruise as this information was not readily available.

The echosounder interfered with the other science acoustics and was therefore only turned on briefly prior to CTD casts. It was thought that a script unsuccessfully looking for seafloor depth resulted in a significant delay for 'new' and 'duplicate' events. When the script was edited so that depth wasn't included, it did not seem to speed things up. It took about 10 seconds for a new or duplicate page to appear. This was found to be uncomfortably long and should be examined further by the R2R team.

A total of 649 events were logged over the course of the cruise. One person (Copley) was in charge of checking the log to make corrections in locked fields (event number, UTC time, etc) and to check for consistency such as end events following start events.

Cruise
OC473-SE

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New | Find | Select | Import | Config | Last day | Help

Summary | Threaded — -- Author -- | -- Instrument -- | -- Action -- | 637 Entries

Goto page Previous 1, 2, 3 ... 30, 31, 32 Next

Event	Instrument	Action	Transect	Station	Cast	timeLocal	Latitude	Longitude	Seafloor	CastDepth	Author	PI_name	timeZone	Comment	Revision
20110825.0749.002	HTI-Hull	end	3	31	21	04:49	50.069783	-41.735650	NaN		gLawson	gLawson	-3		
20110825.0805.001	HTI-Hull	start	3	31	22	05:05	50.069133	-41.738200	NaN		gLawson	gLawson	-3		
20110825.0853.001	Hammarhead	end	3	31	20	05:53	50.059717	-41.749033	NaN		gLawson	aLavery	-3		
20110825.0901.001	CTD911	start	3	31	50	06:00	50.059233	-41.746983	4356	3000	aWang	aWang	-3		
20110825.0907.001	HTI-Hull	end	3	31	22	06:07	50.059083	-41.743717	NaN		gLawson	gLawson	-3		
20110825.1020.001	HTI-Hull	start	3	31	23	07:19	50.068833	-41.734600	NaN		gLawson	gLawson	-3		
20110825.1129.001	CTD911	end	3	31	50	08:29	50.083900	-41.730100	4356	3000	kHoering	aWang	-3		
20110825.1157.001	MOCNESS	start	3	31	17	08:57	50.091250	-41.731267	NaN		gLawson	pWiebe	-3		
20110825.1456.001	MOCNESS	end	3	31	17	11:56	50.071383	-41.730433	NaN	1000	gLawson	pWiebe	-3		& 27 Aug 2011 13:31
20110825.1540.001	VPR	start	3	31	43	12:39	50.089767	-41.714167	NaN	1000	kHoering	gLawson	-3		
20110825.1541.001	CTD911	start	3	31	51	12:40	50.089767	-41.714100	NaN	1000	kHoering	aWang	-3		& 27 Aug 2011 12:02
20110825.1613.001	HTI-Hull	end	3	31	23	13:13	50.097700	-41.703783	NaN		gLawson	gLawson	-3		
20110825.1634.001	CTD911	end	3	31	51	13:33	50.102350	-41.697700	NaN	1000	kHoering	aWang	-3		& 27 Aug 2011 12:36
20110825.1634.002	VPR	end	3	31	43	13:34	50.102433	-41.697383	NaN	1000	kHoering	gLawson	-3		
20110825.1643.001	Ship	endStation	3	31	NaN	13:43	50.103433	-41.697400	NaN		kHoering	NaN	-3	ENTERED ONE MIN. LATE	
20110825.1643.002	Ship	startTransect	4	NaN	NaN	19:07	50.103433	-41.697400	NaN	NaN	nCopley	NaN	-3	chgd evt# from 20110825.2208.001 to 20110825.1643.002	& 25 Aug 2011 22:10
20110825.1706.001	ObserverMacroFauna	start	4	NaN	NaN	14:06	50.084383	-41.757600	NaN		twhite	tWhite	-3		& 25 Aug 2011 22:11
20110825.1916.001	HTI-Hull	start	4	31	24	16:16	49.922017	-42.207317	NaN		gLawson	gLawson	-3		
20110825.2104.001	ObserverMacroFauna	end	4	NaN	NaN	18:03	49.749833	-42.631183	NaN		twhite	tWhite	-3		& 25 Aug 2011 22:07
20110826.0334.001	Ship	startStation	4	32	NaN	00:33	49.130367	-44.249200	NaN		pWiebe	NaN	-3		

Goto page Previous 1, 2, 3 ... 30, 31, 32 Next

Fig. 14.2 The Elog browser window:

Event	Instrument	Action	Transect	Station	Cast	timeLocal	Latitude	Longitude	Seafloor	CastDepth
20110823.0648.001	CTD911	start	3	25	41	03:47	47.001833	-42.000733	4222	1000
20110823.1117.002	CTD911	start	3	26	42	08:17	47.500567	-42.001267	NaN	1000m
20110823.1613.001	CTD911	start	3	26	43	13:13	47.574333	-41.978083	NaN	3000
20110824.0225.001	CTD911	start	3	26	44	23:24	47.384683	-41.971033	4196	1000
20110824.0826.001	CTD911	start	3	27	45	05:25	47.997867	-42.004183	4375	1000
20110824.1347.001	CTD911	start	3	28	46	10:47	48.506100	-42.001683	NaN	1000
20110824.1753.001	CTD911	start	3	29	47	14:53	49.000050	-42.001450	4269	1000
20110824.2135.001	CTD911	start	3	30	48	18:35	49.504400	-41.994967	4485	1000
20110825.0629.001	CTD911	start	3	31	49	03:27	50.065583	-41.768283	4356	1000
20110825.0901.001	CTD911	start	3	31	50	06:00	50.059233	-41.746983	4356	3000
20110825.1541.001	CTD911	start	3	31	51	12:40	50.089767	-41.714100	NaN	1000
20110826.0720.001	CTD911	start	4	32	52	04:15	49.079117	-44.362817	2563	1000

Fig. 14.3. The user can select by instrument and action:

15. Blog

Katie Wurtzell

15.1. *Introduction*

The Lawson Lab fieldwork blog, formerly entitled 'The Krill Blog' but renamed for the present [non-krill] cruise 'The Charismatic Microfauna Blog,' was maintained by the science team during the cruise as an outreach effort. The goal of this blog was to give real-time updates from the field to describe in a conversational and engaging, but professional, tone for the public our work on pteropods, including where we were, what we were doing, and why, as well as information on life at sea and oceanographic research more generally.

15.2. *Methods*

All scientists were encouraged to participate in writing a post or two. Because of the interdisciplinary nature of the science performed, this resulted in a wide range of topics including pteropod physiology, chemistry, acoustics, and more. Other posts were written to introduce readers about life on a research vessel, these ranged from a tour of the engine room, to discussions about the food onboard, and more. A total of 23 posts were completed during this cruise. All posts contained media such as photographs, panoramas, and preliminary figures. Because of the shipboard internet, the posts could be uploaded directly from the ship.

The blog host utilized was www.blogger.com. The site has the capacity to track the number of views on the blog, what country the viewers are from, and where they found the blog link. To show where we were at any given time, the blog included a link to the WHOI website "Where is the Oceanus now?" which features a map showing our cruise track (Figure 15.1).

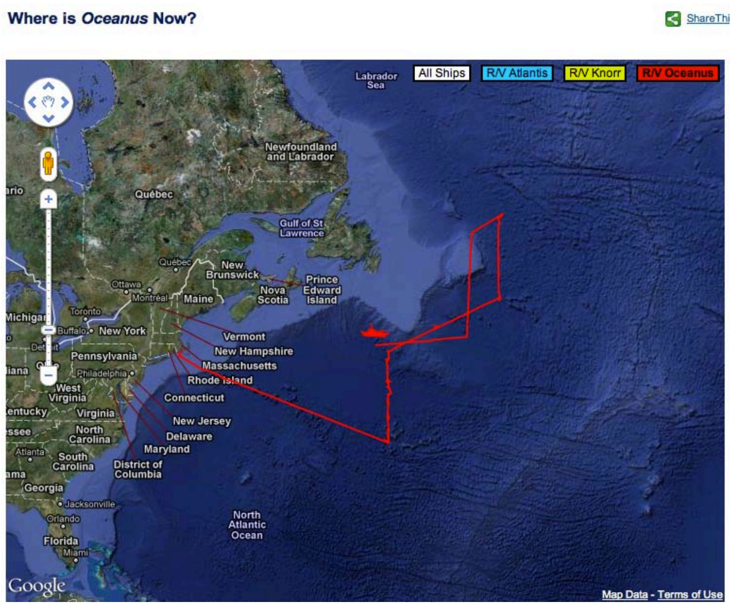


Figure 15.1 Regularly updated figure linked to the blog, allowing viewers to follow along our cruise track.

The blog link was posted on the WHOI homepage (www.whoi.edu) as well as sent out in the WHOI Headlines weekly email to all WHOI staff (Figure 15.2). It was also published by the WHOI Media Relations twitter. This publicity likely increased the number of readers.

Figure 15.2 Screenshots of the blog links from the WHOI Media Relations twitter account (above) and from the WHOI website (below).

15.3. *Problems and Solutions*

One minor issue was that the posts were quite difficult to format. Font, text size, and captions were inconsistent among posts and posters, which did not look as professional as we would have hoped. Ken Kostel, from WHOI, offered to help with formatting from shore and his help made a substantial difference. Ken also facilitated the posting of some QuickTime Virtual Reality (QTVR) movie files to the WHOI website, which were then linked to the blog, since the blogger software did not allow the QTVRs to play.

15.4. *Preliminary Results*

Thanks to tracking software on the blog site, we were able to tell how many people have been checking in. Over the 26 day cruise, there were over 3,000 views on the blog page (Figure 15.3). While the majority of the viewers were from the United States, our audience had some international representation with more than 10 views from each of Germany, Canada, the UK, Romania, Bangladesh, the Netherlands, Brazil, Japan, and more.

Figure 15.3 Blog views from July 31st to August 30th. The large peak around August 10th corresponds to when link was sent out in WHOI Headlines newsletter.

The site has the capacity to display the referring sites from the blog. The most amount of web traffic was directed from the WHOI homepage, followed by Facebook and Google (Figure 15.4). To promote the blog and increase our outreach efforts, it is important to publicize it. The WHOI homepage, newsletter, and twitter account are all effective ways to do so and will be continued next year to maintain a strong blog following.

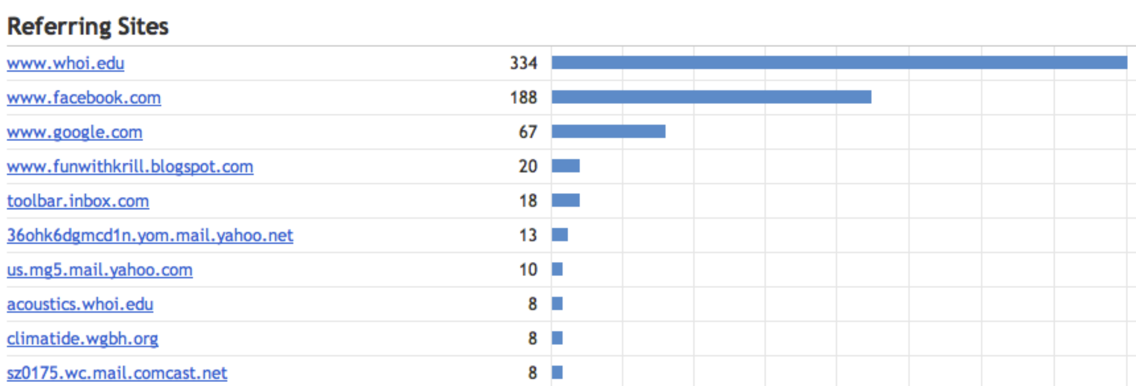


Figure 15.4 Referring Sites to the blog from July 21st to August 29th.

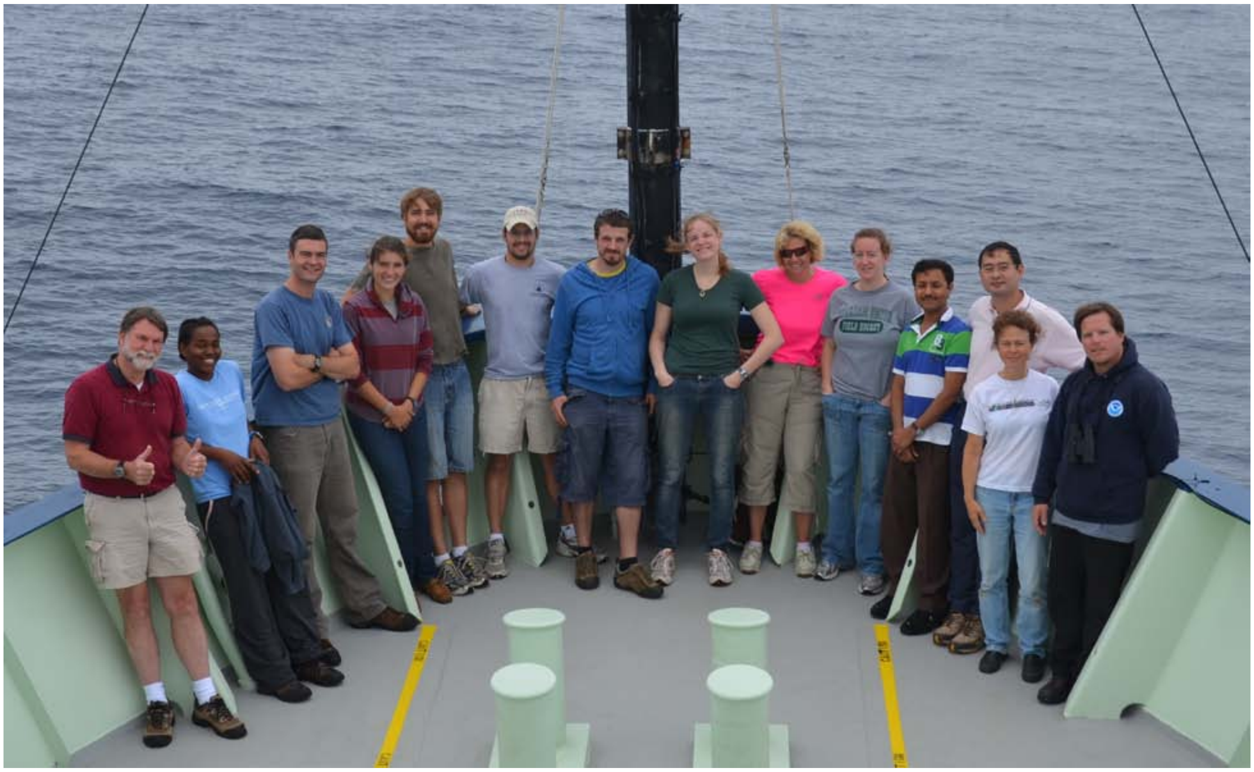
16. Cruise Participants

Science Party

1	Gareth Lawson	Chief Scientist	WHOI	Biology
2	Peter Wiebe	Scientist	WHOI	Biology
3	Zhaohui 'Aleck' Wang	Scientist	WHOI	Chemistry
4	Amy Maas	Postdoc	WHOI	Biology
5	Nancy Copley	Research Associate	WHOI	Biology
6	Katherine Hoering	Research Assistant	WHOI	Chemistry
7	Jonathan Fincke	Research Assistant	WHOI	Biology
8	Alex Bergan	JP Student (Lawson)	WHOI	Biology
9	Leocadio Blanco Bercial	Postdoc	University of Connecticut	Biology
10	Jacinta Edebeli	Summer Student Fellow	Mt Holyoke	Chemistry
11	Mohammad Muslem Uddin	Guest Student	University of New Hampshire	Chemistry
12	Katherine Wurtzell	Volunteer	Gulf of Maine Research Inst.	Biology
13	Timothy White	PhD Student (Veit)	City University of New York	Macrofauna
14	Cristin Luttazi	Guest Student	Kingston University	Chemistry
15	Robert Hagg	Marine Technician	WHOI	SSSG

Officers and Crew

1	Diego Mello	Captain
2	Gary McGrath	Chief Engineer
3	Logan Johnsen	Chief Mate
4	Emily Rizzo	Second Mate
5	Glen White	Junior Engineer
6	Paul Butler	Junior Engineer
7	Pimenio 'Clindor' Cacho	Boatswain
8	Leo Fitz	A/B
9	Mark Anderson	A/B
10	Chris Armanetti	A/B
11	Steven Sniezak	Chief Steward
12	Elisabeth Boyle	Messman



OC473 Science Party. From left to right: Peter Wiebe, Jacinta Edebeli, Gareth Lawson, Katie Wurtzell, Alex Bergan, Jon Fincke, Leo Blanco Bercial, Amy Maas, Cris Luttazi, Katherine Hoering, Mohammad Muslem Uddin, Aleck Wang, Nancy Copley, Tim White. [Photo: Capt. D. Mello]

Appendix 1. Summary of MOCNESS tow data.

Station	Tow	Month local	Day local	Time Start end (Yearday .time)	Lat. (N) start end	Long.(W) start end	Net: depth_open-depth_closed	Volume filtered
test 1	1	8	9	220.63	39.5676	-66.6620	net 0: 0 - 100	892
				220.66	39.5886	-66.6472	net 1: 105 - 75	227
							net 2: 75 - 50	219
							net 3: 50 - 25	177
							net 4: 25 - 0	324
1	2	8	11	223.89	34.9960	-52.0270	net 0: 0 - 1006	?
				224	35.0607	-52.1184	net 1: 1000 - 866	783*
							net 2: 866 - 600	1280*
							net 3: 600 - 400	1158*
							net 4: 400 - 367	171
							net 5: 367 - 150	1323
							net 6: 150 - 50	665
							net 7: 50 - 25	303
							net 8: 25 - 0	288
1	3	8	12	224.3	35.0683	-52.0773	net 0: 0 - 1010	1931
				224.42	35.1081	-51.9697	net 1: 995 - 800	573
							net 2: 800 - 602	1103
							net 3: 602 - 400	1477
							net 4: 400 - 200	1410
							net 5: 200 - 100	640
							net 6: 100 - 52	451
							net 7: 52 - 25	296
							net 8: 25 - 0	271
5	4	8	13	225.44	36.9855	-51.9741	net 0: 0 - 1015	1201
				225.54	36.9164	-51.9225	net 1: 999 - 801	568
							net 2: 801 - 601	914
							net 3: 601 - 400	1186
							net 4: 400 - 200	1048
							net 5: 200 - 100	527
							net 6: 100 - 52	523
							net 7: 52 - 26	283
							net 8: 26 - 0	277
5	5	8	13	225.93	36.9619	-52.0088	net 0: 0 - 1012	2343
				226.04	36.8761	-52.0034	net 1: 1000 - 800	1029
							net 2: 800 - 600	1057
							net 3: 600 - 400	1029

Station	Tow	Month local	Day local	Time Start end (Yearday .time)	Lat. (N) start end	Long.(W) start end	Net: depth_open-depth_closed	Volume filtered
							net 4: 400 - 200	1091
							net 5: 200 - 100	538
							net 6: 100 - 50	425
							net 7: 50 - 25	347
							net 8: 25 - 0	399
8	6	8	15	227.02	38.5111	-51.9614	net 0: 0 - 1011	2427
				227.13	38.4433	-51.9896	net 1: 1001 - 800	938
							net 2: 800 - 600	1054
							net 3: 600 - 405	1089
							net 4: 405 - 200	1241
							net 5: 200 - 100	644
							net 6: 100 - 50	324
							net 7: 50 - 23	233
							net 8: 23 - 0	243
8	7	8	15	227.38	38.5028	-51.8998	net 0: 0 - 1005	3554
				227.51	38.5747	-51.7540	net 1: 1001 - 801	1315
							net 2: 801 - 600	1076
							net 3: 600 - 405	1068
							net 4: 405 - 200	1186
							net 5: 200 - 100	590
							net 6: 100 - 50	471
							net 7: 51 - 22	495
							net 8: 22 - 0	245
13	8	8	17	229.95	40.8834	-51.9874	net 0: 0 - 1014	2919
				230.07	40.8147	-52.0794	net 1: 1000 - 898	613
							net 2: 898 - 600	1300
							net 3: 600 - 400	1358
							net 4: 405 - 200	1151
							net 5: 200 - 100	507
							net 6: 100 - 50	365
							net 7: 50 - 26	254
							net 8: 25 - 6	348
13	9	8	18	230.22	40.9291	-52.0704	net 0: 0 - 1006	3020
				230.35	41.0080	-51.9944	net 1: 995 - 800	900
							net 2: 800 - 600	1152
							net 3: 600 - 400	1264
							net 4: 405 - 200	1196
							net 5: 200 - 100	945

Station	Tow	Month local	Day local	Time Start end (Yearday .time)	Lat. (N) start end	Long.(W) start end	Net: depth_open-depth_closed	Volume filtered
							net 6: 100 - 50	381
							net 7: 50 - 26	307
							net 8: 25 - 0	293
17	10	8	19	231.87	42.9874	-47.7761	net 0: 0 - 1006	2981
				231.99	43.0925	-47.6960	net 1: 995 - 800	1099
							net 2: 800 - 599	1117
							net 3: 599 - 387	1160
							net 4: 405 - 200	1241
							net 5: 200 - 100	608
							net 6: 100 - 48	383
							net 7: 48 - 24	186
							net 8: 24 - 0	397
17	11	8	19	232.21	43.1022	-47.6382	net 0: 0 - 1011	1490
				232.33	43.0635	-47.5673	net 1: 1000 - 800	1043
							net 2: 800 - 598	924
							net 3: 598 - 400	1064
							net 4: 405 - 200	1006
							net 5: 200 - 100	602
							net 6: 100 - 50	459
							net 7: 50 - 26	373
							net 8: 25 - 0	524
21	12	8	19	233.88	44.9326	-41.9964	net 0: 0 - 1007	2111
				232.33	44.8550	-41.9220	net 1: 1000 - 798	1215
							net 2: 798 - 600	1109
							net 3: 600 - 400	1099
							net 4: 405 - 200	1330
							net 5: 200 - 102	586
							net 6: 102 - 50	391
							net 7: 50 - 24	243
							net 8: 24 - 0	287
21	13	8	22	234.21	45.0128	-42.0055	net 0: 0 - 1008	3643
				234.35	45.0020	-41.8291	net 1: 1002 - 808	1507
							net 2: 808- 600	1030
							net 3: 600 - 400	1201
							net 4: 400 - 200	1132
							net 5: 200 - 100	619
							net 6: 100 - 50	441
							net 7: 50 - 25	452

Station	Tow	Month local	Day local	Time Start end (Yearday .time)	Lat. (N) start end	Long.(W) start end	Net: depth_open-depth_closed	Volume filtered
							net 8: 25 - 0	523
26	14	8	23	235.36	47.5120	-42.0297	net 0: 0 - 1012	2354
				235.49	47.5764	-41.9996	net 1: 1000 - 800	1024
							net 2: 800 - 600	1123
							net 3: 600 - 400	1234
							net 4: 405 - 200	1138
							net 5: 200 - 100	675
							net 6: 100- 50	469
							net 7: 50 - 25	361
							net 8: 25 - 0	540
26	15	8	23	235.8	47.4902	-41.9860	net 0: 0 - 1009	2076
				235.92	47.3981	-41.9677	net 1: 1001 - 798	983
							net 2: 798 - 600	1139
							net 3: 600 - 400	1136
							net 4: 405 - 200	980
							net 5: 200 - 102	621
							net 6: 102 - 50	305
							net 7: 50 - 25	191
							net 8: 25 - 0	333
31	16	8	23	236.96	49.9928	-41.9893	net 0: 0 - 1000	920
				237.09	50.0603	-41.7954	net 1: 1000 - 800	1242
							net 2: 797 - 599	993
							net 3: 599 - 400	1511
							net 4: 405 - 202	1123
							net 5: 202 - 101	629
							net 6: 101 - 50	318
							net 7: 50 - 25	189
							net 8: 25 - 0	270
31	17	8	23	237.33	50.0912	-41.7312	net 0: 0 - 1000	1778
				237.45	50.0703	-41.7312	net 1: 1000 - 800	605
							net 2: 800 - 600	1056
							net 3: 600 - 400	1208
							net 4: 405 - 200	1596
							net 5: 200 - 100	915
							net 6: 100- 50	515
							net 7: 50 - 25	390
							net 8: 25 - 0	523

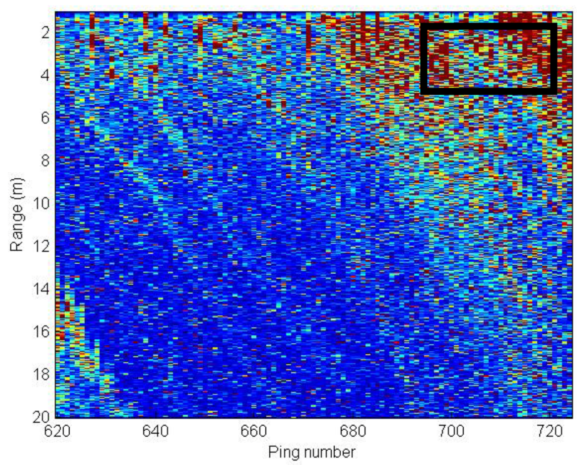
Station	Tow	Month local	Day local	Time Start end (Yearday .time)	Lat. (N) start end	Long.(W) start end	Net: depth_open-depth_closed	Volume filtered
32	18	8	23	238.02	49.1102	-44.2784	net 0: 0 - 1012	1761
				238.12	49.0807	-44.3450	net 1: 999- 797	924
							net 2: 800 - 600	678
							net 3: 600 - 400	896
							net 4: 405 - 200	1194
							net 5: 200 - 102	667
							net 6: 102 - 50	415
							net 7: 50 - 25	346
							net 8: 25 - 0	249
* Flowmeter reedswitch failed; Volume estimated based on average net angle and GPS distance.								

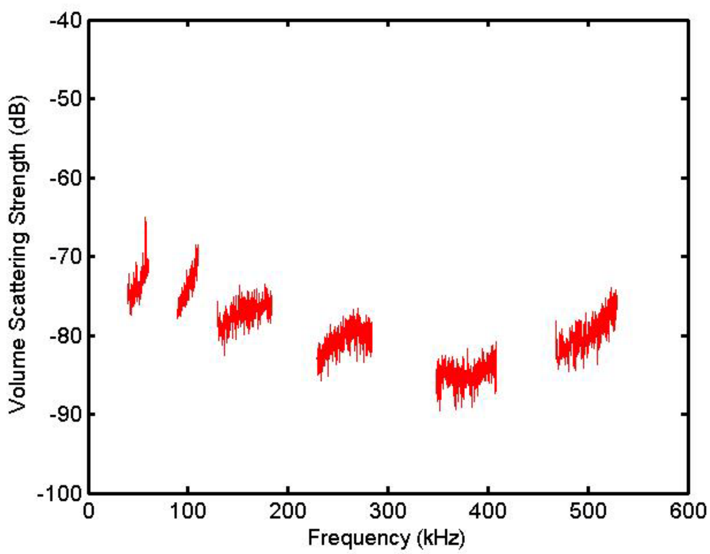
Appendix 2. Log of interesting spectra from Edgetech casts

Test Station:

There was very little scattering at the test station and this was the best piece of data from the station. The black box in the upper right hand corner of the echogram shows the data the spectra were calculated from .

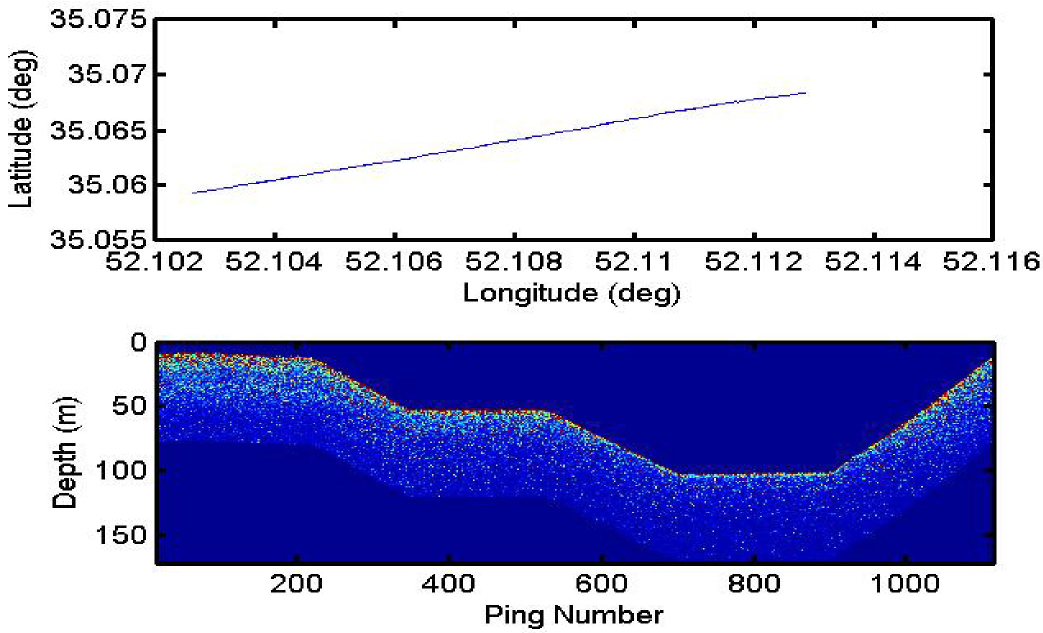
Day/Night	Day
HammarHead Depth	
Layer Depth	
Pings Processed	700-720
Range Processed	2 -7 meters
File	



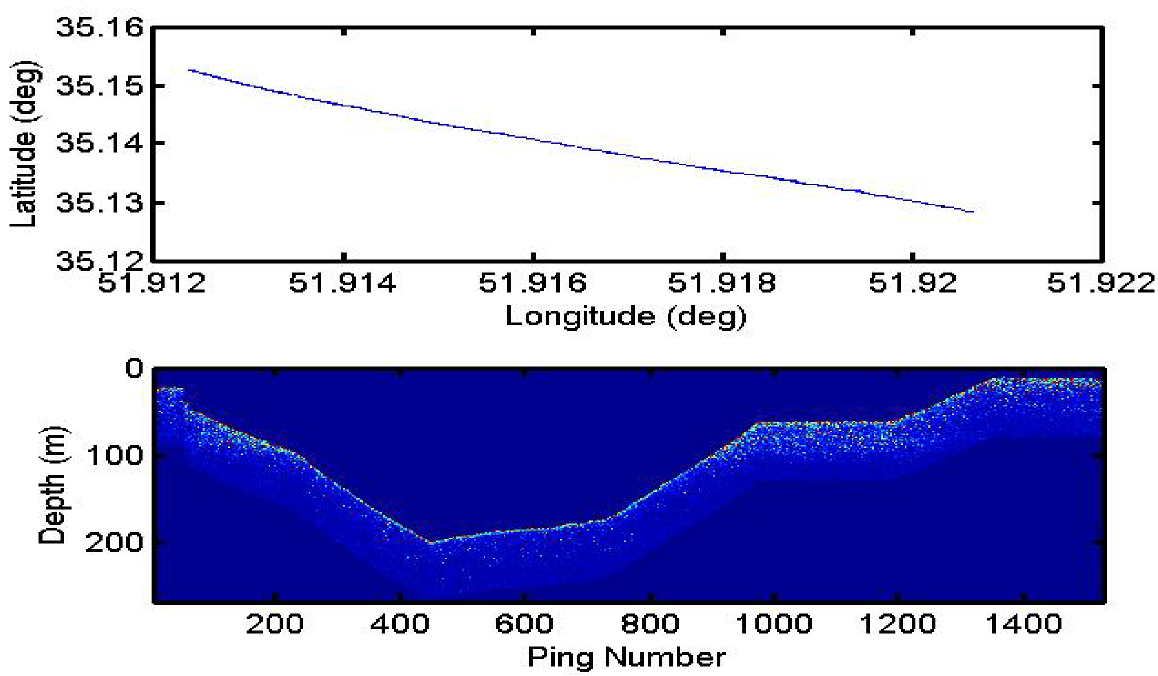


Station 1:

Cast2:

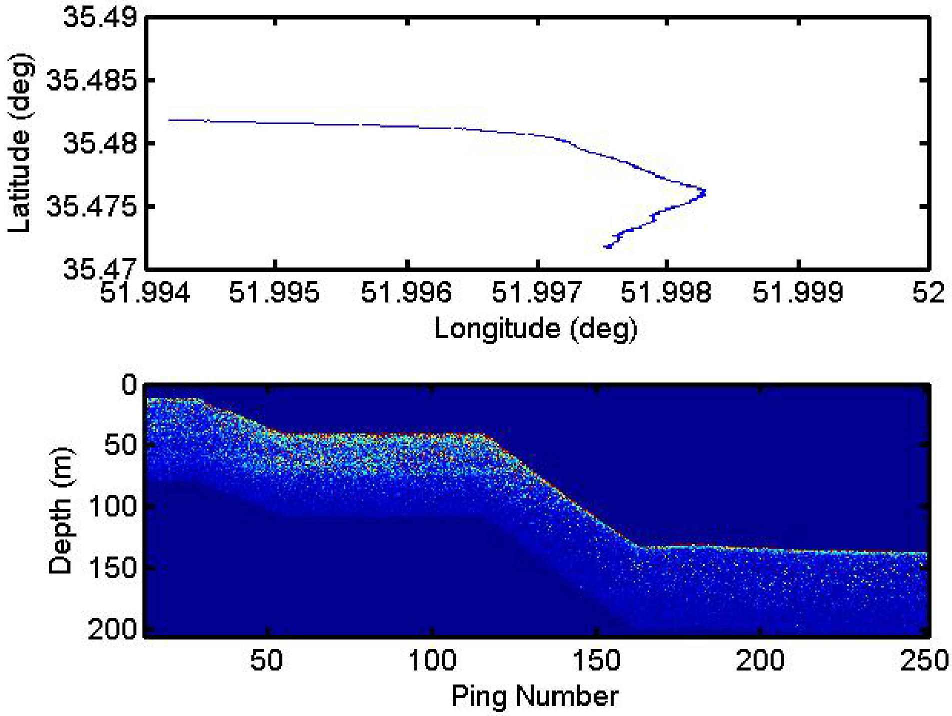


Cast3:



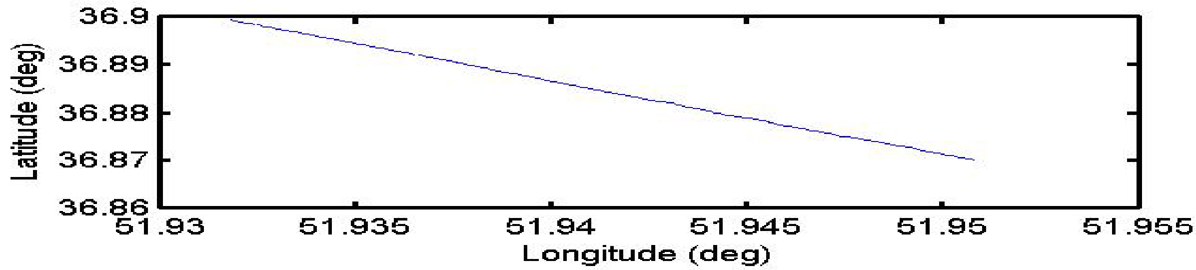
Station 2:

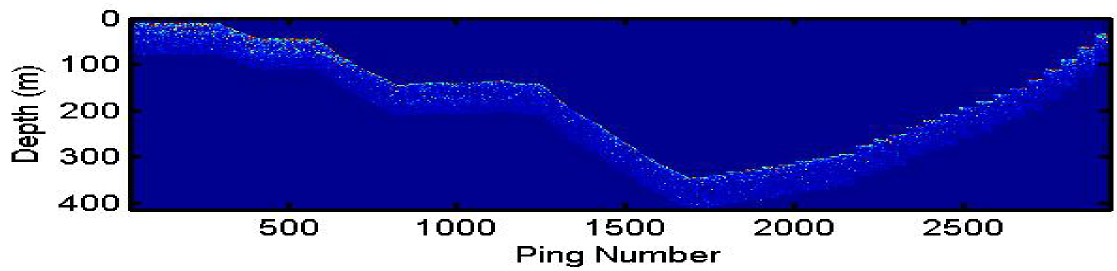
Cast4:



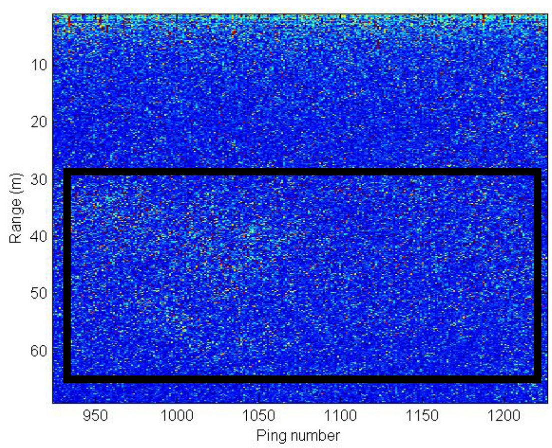
Station 5:

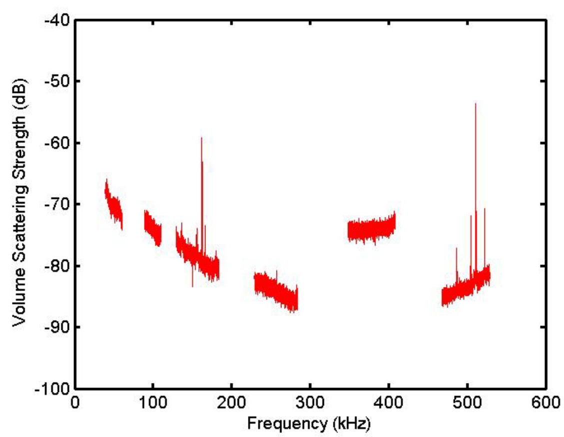
Cast 6:





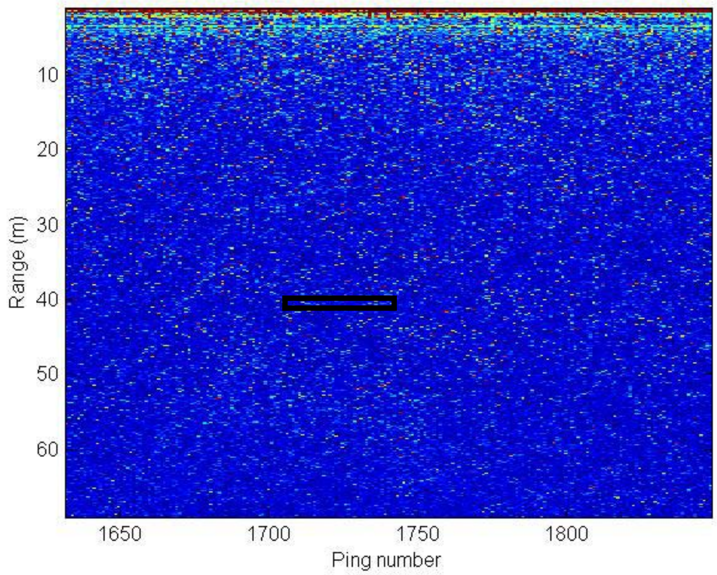
Day/Night	Day
HammarHead Depth	130 meters
Layer Depth	160 meters
Pings Processed	924-973
Range Processed	30 -49 meters
File	station_5_cast_6_021.jsf

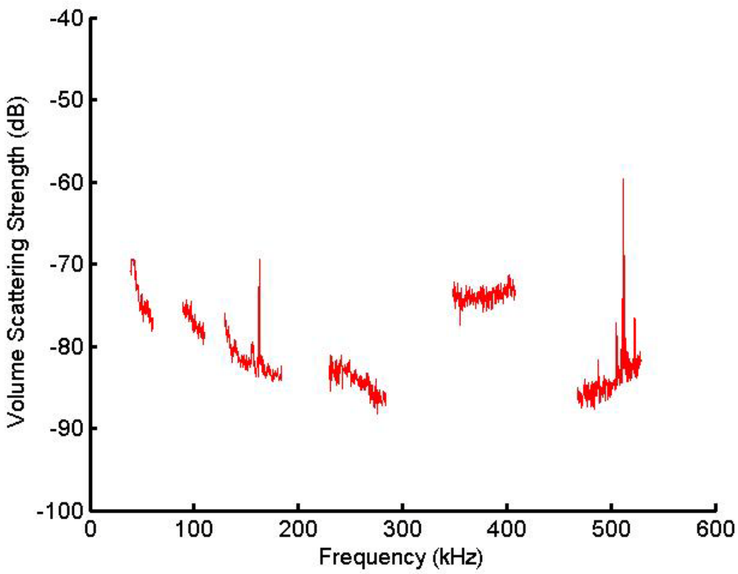




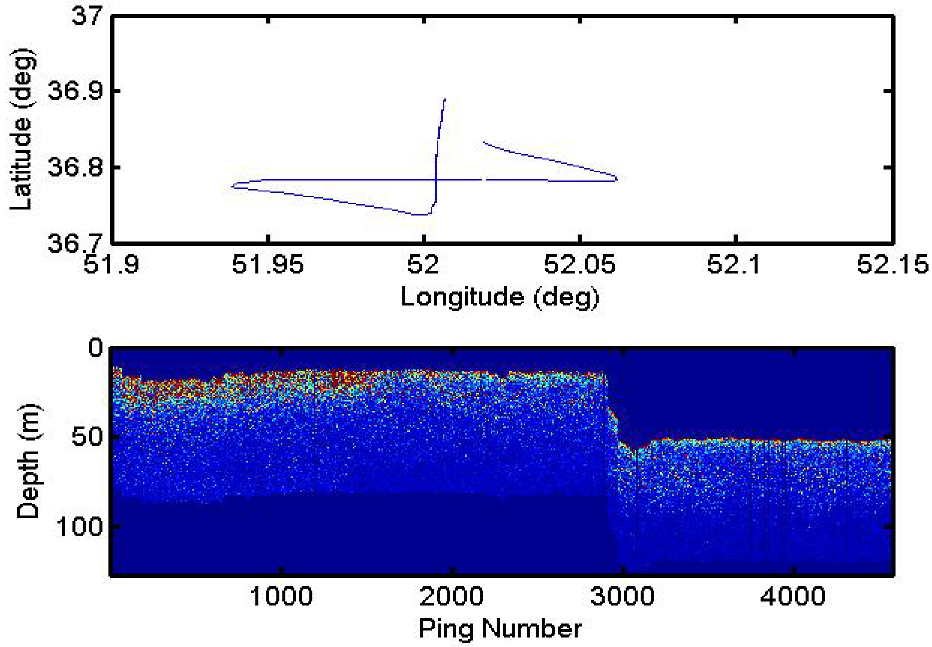
Cast 6:

Day/Night	Day
HammarHead Depth	331 meters
Layer Depth	370 meters
Pings Processed	1700-1740
Range Processed	40 -41.5 meters
File	station_5_cast_6_037.jsf

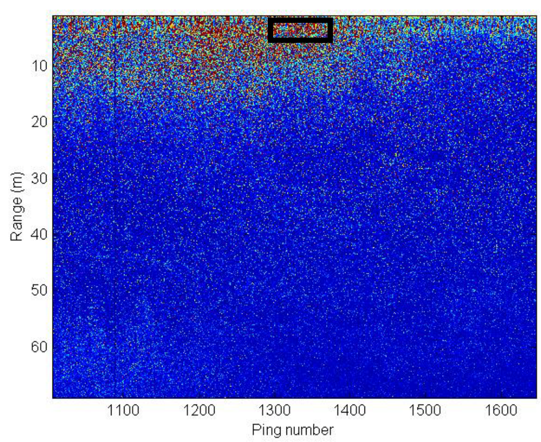


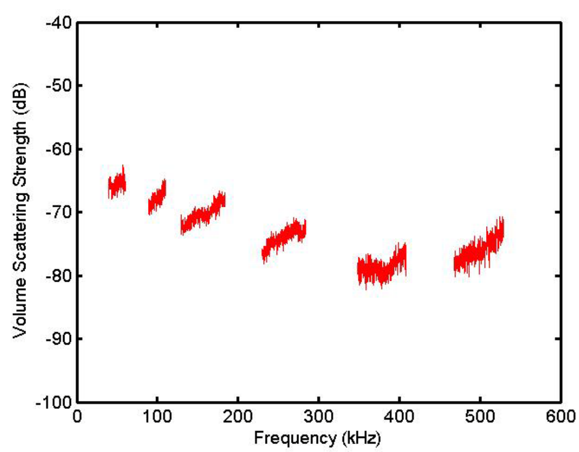


Cast 7:



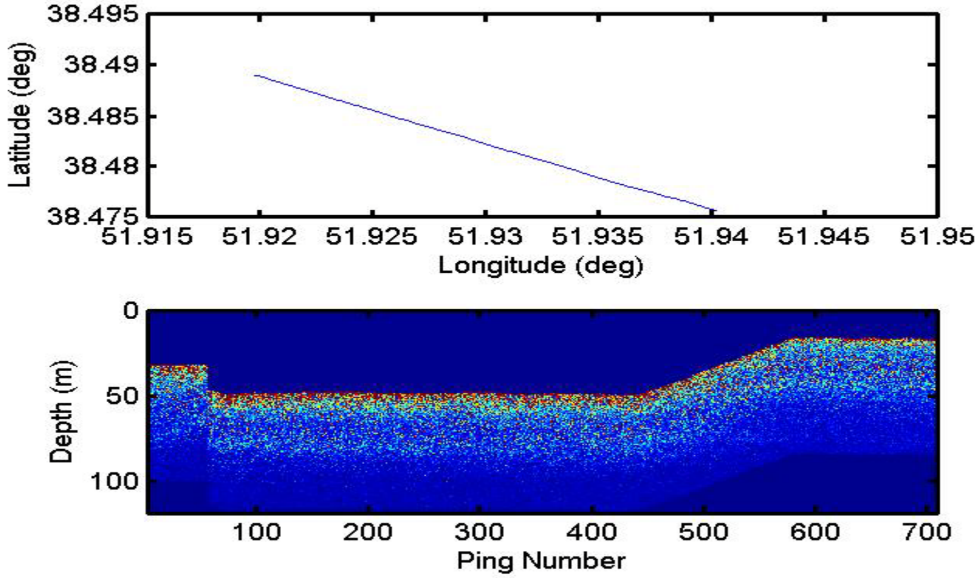
Day/Night	Day
HammarHead Depth	30 meters
Layer Depth	32 meters
Pings Processed	1305-1345
Range Processed	2 -7 meters
File	station_5_cast_7_023.jsf



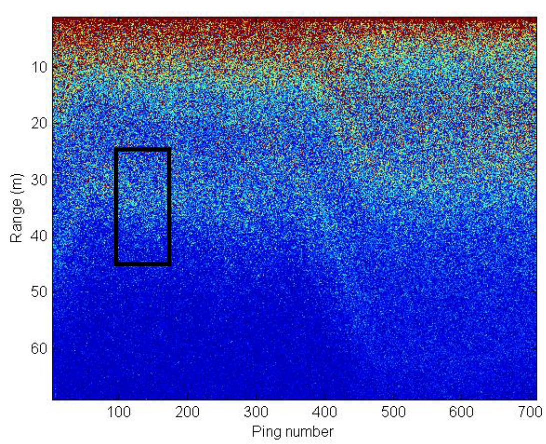


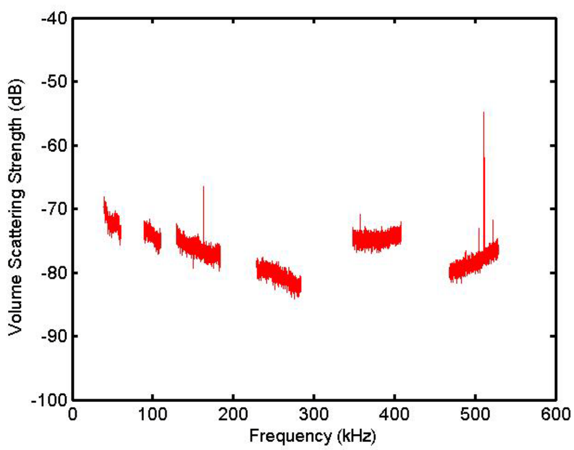
Station 8:

Cast 8:



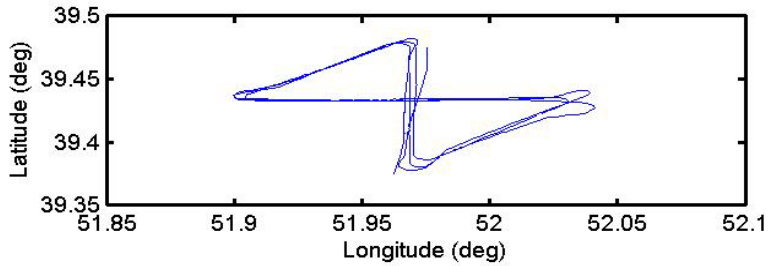
Day/Night	Day
HammarHead Depth	50 meters
Layer Depth	80meters
Pings Processed	106-155
Range Processed	25 -45 meters
File	station_8_cast_8_004.jsf

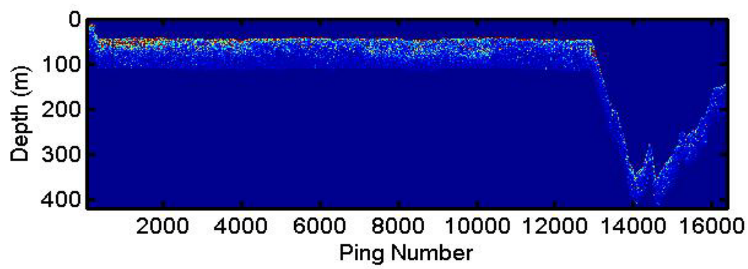




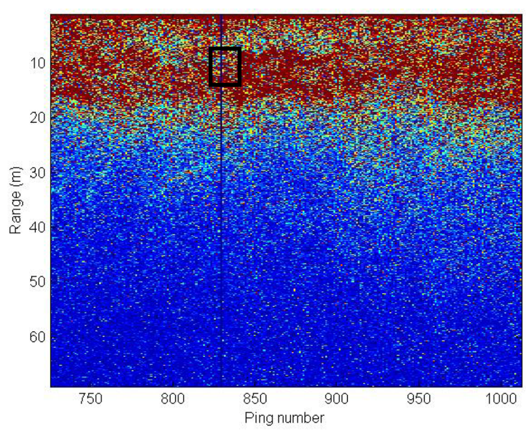
Station 10:

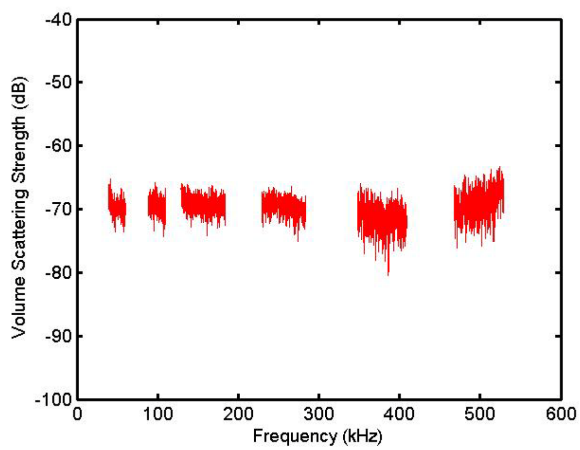
Cast 9:





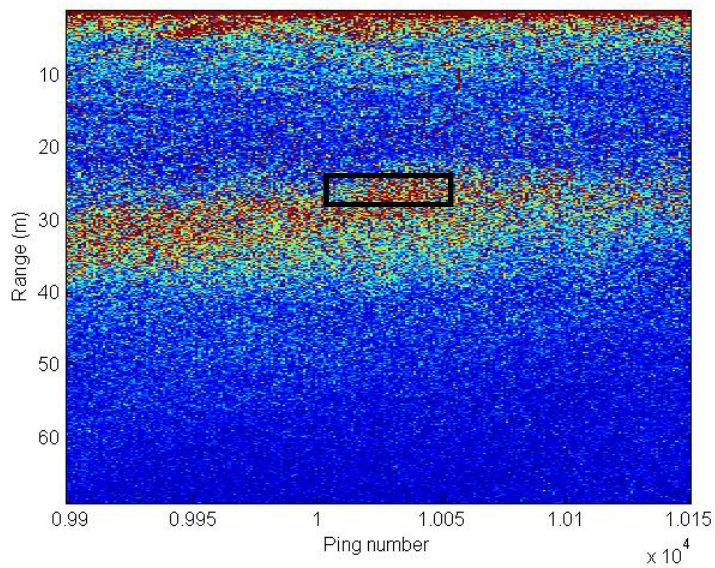
Day/Night	Night
HammarHead Depth	40 meters
Layer Depth	40meters
Pings Processed	845-860
Range Processed	8 -15 meters
File	station_10_cast_9_014.jsf

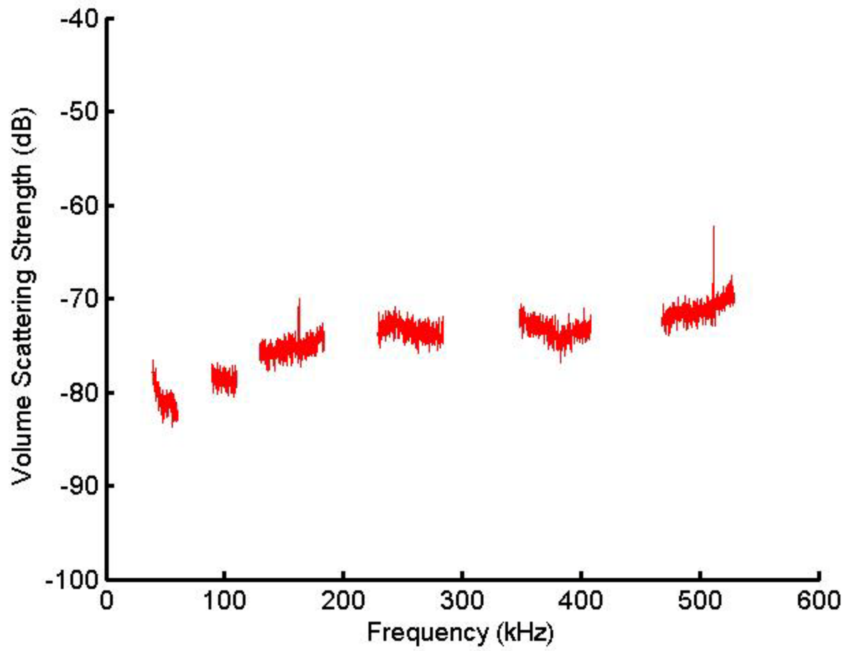




Cast9:

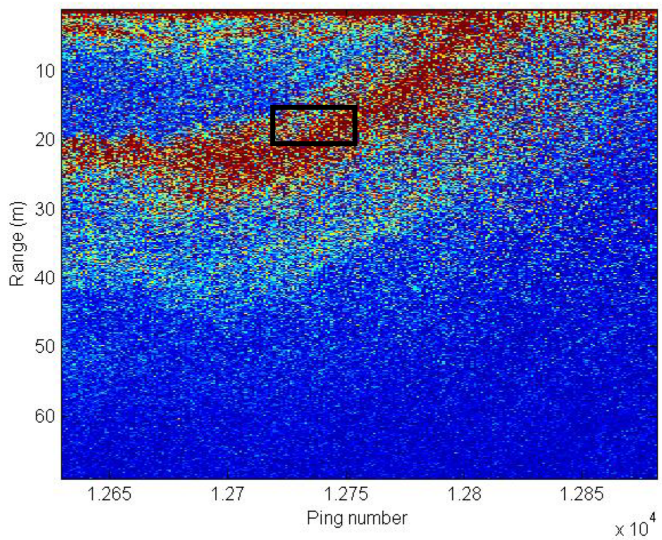
Day/Night	Day
HammarHead Depth	40.5 meters
Layer Depth	65 meters
Pings Processed	10010-10060
Range Processed	25 -29 meters
File	station_10_cast_9_211.jsf

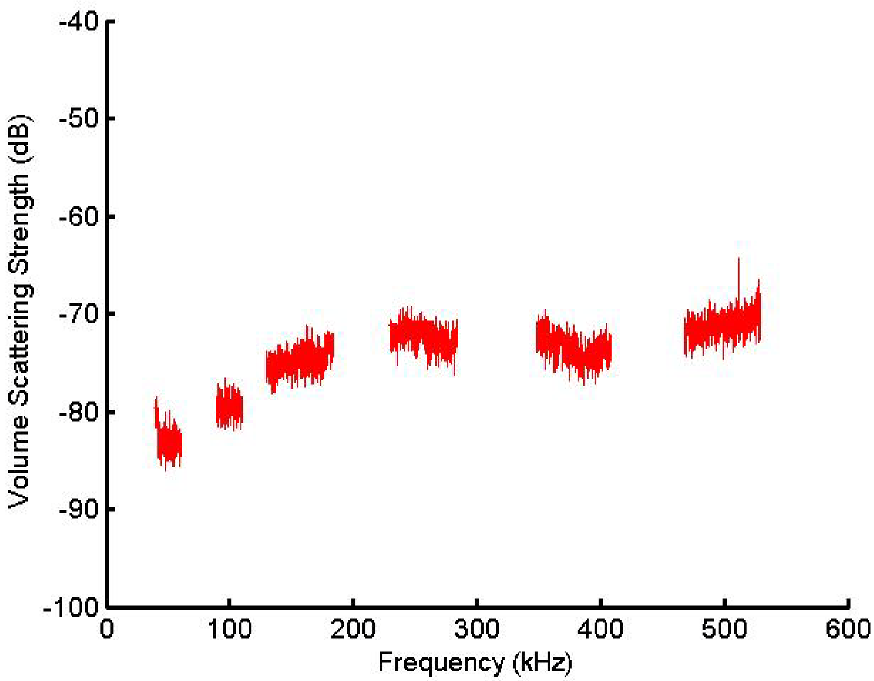




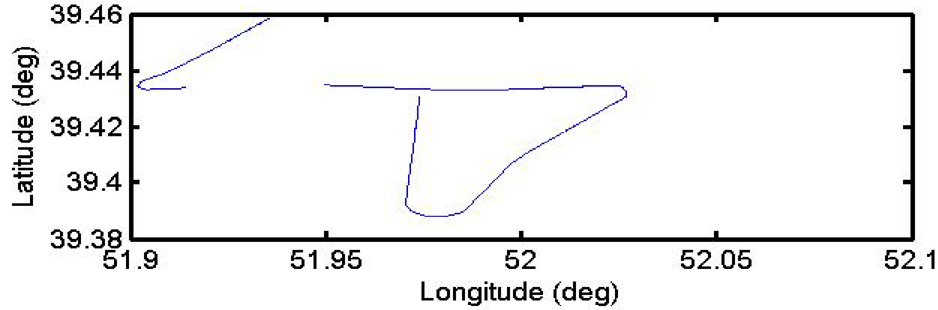
Cast 9:

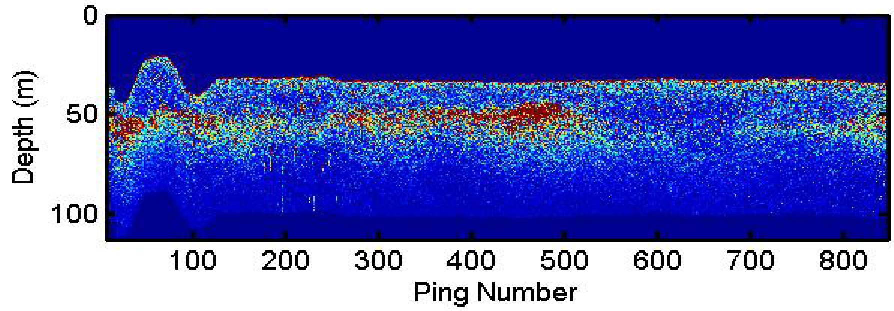
Day/Night	Day
HammarHead Depth	60 meters
Layer Depth	80 meters
Pings Processed	12731-12750
Range Processed	17.5 - 22 meters
File	station_10_cast_10_265.jsf



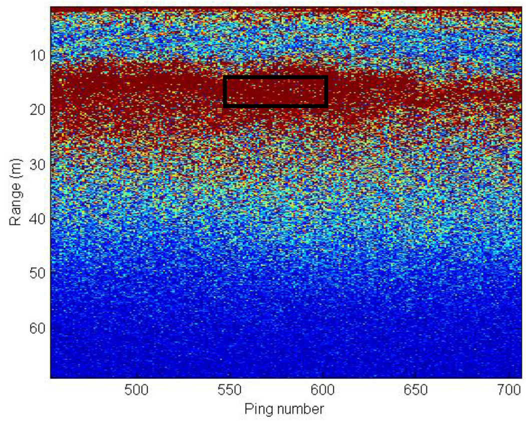


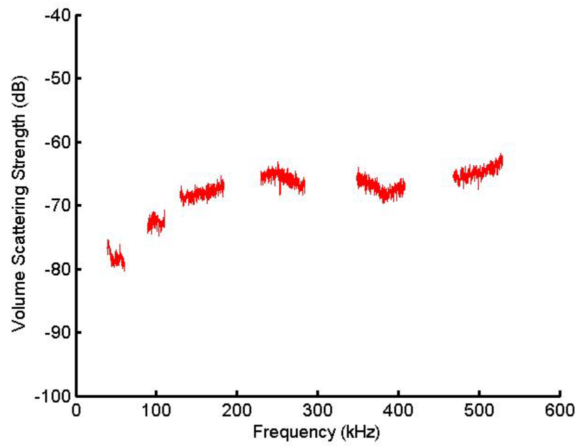
Cast 10:





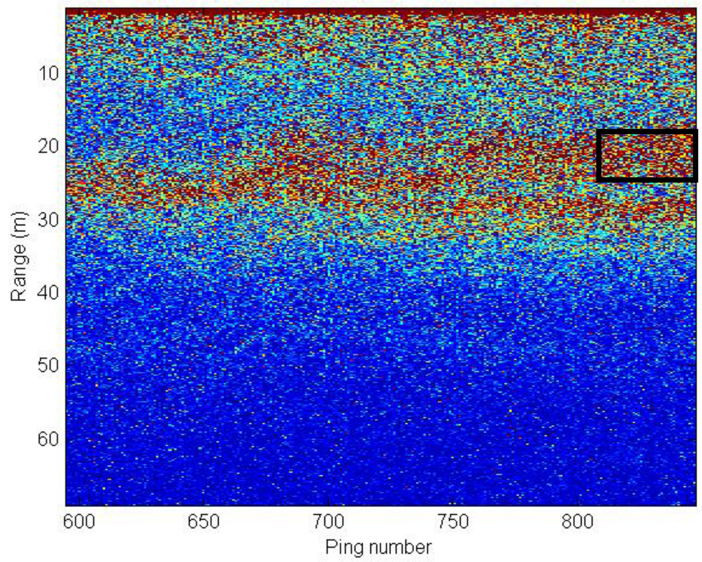
Day/Night	Day
HammarHead Depth	32 meters
Layer Depth	45 meters
Pings Processed	550-615
Range Processed	16.5-19.5 meters
File	station_10_cast_10_044.jsf

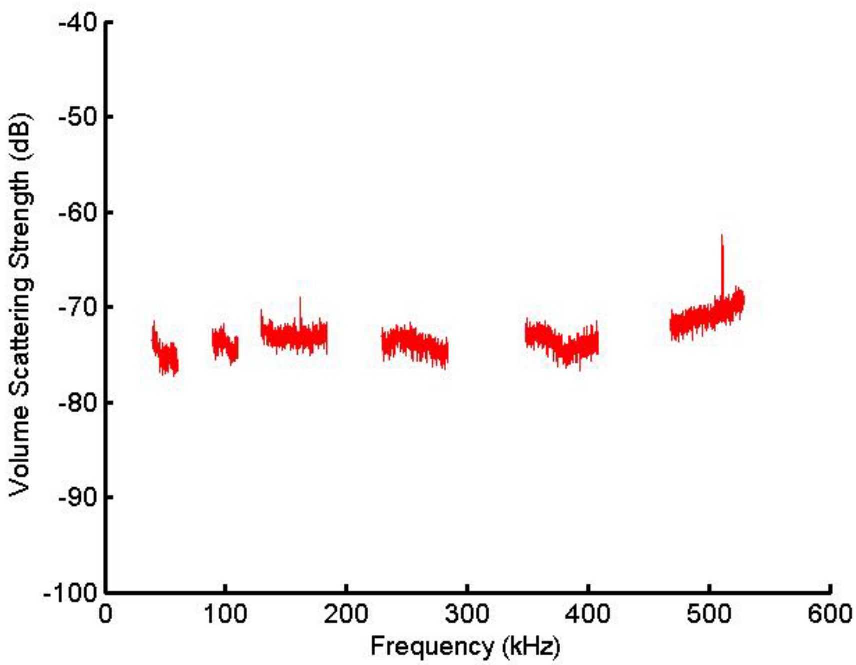




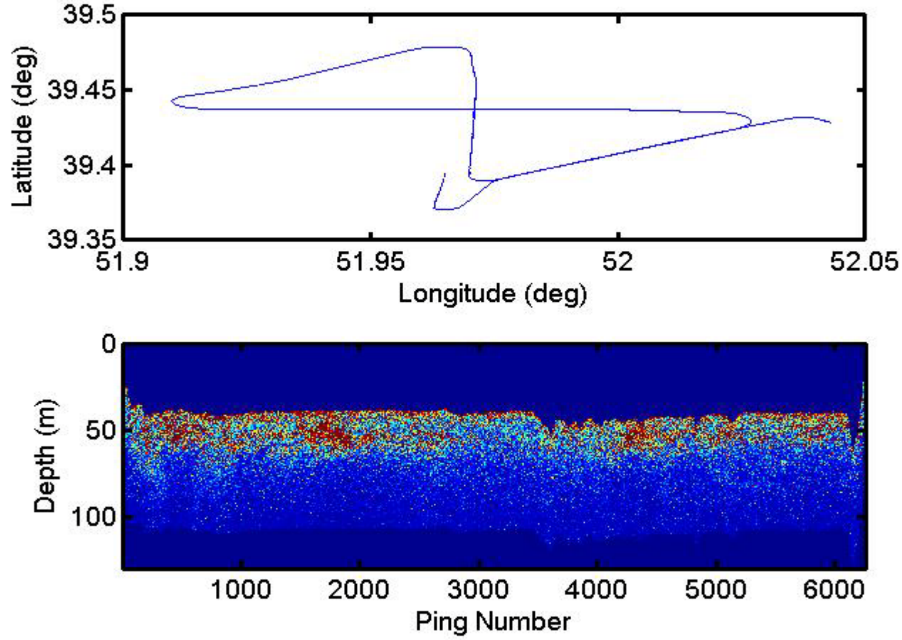
Cast 10:

Day/Night	Night
HammarHead Depth	32.9 meters
Layer Depth	50 meters
Pings Processed	790-845
Range Processed	20.0 - 25.5 meters
File	station_10_cast_10_081.jsf

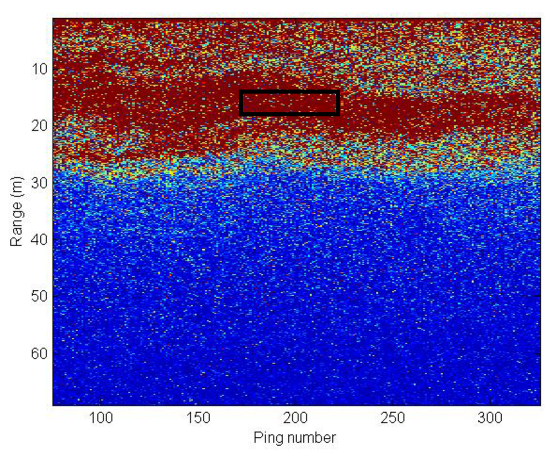


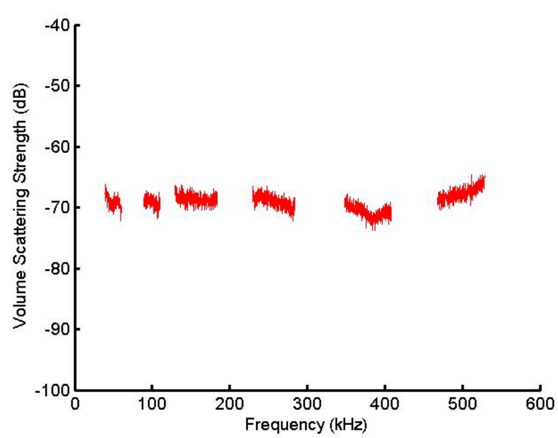


Cast 11:



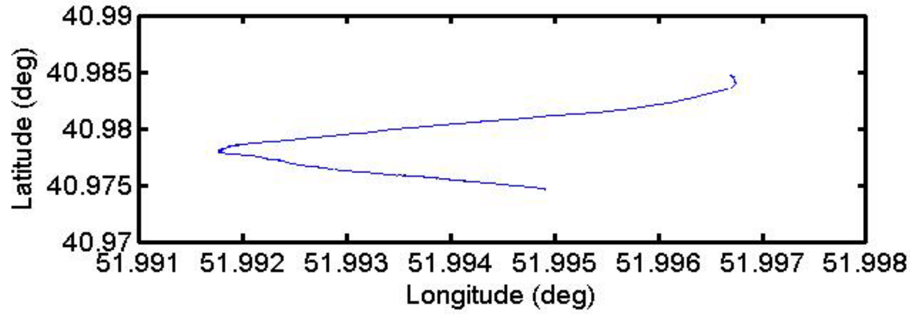
Day/Night	Night
HammarHead Depth	38.0 meters
Layer Depth	48 meters
Pings Processed	176 -224
Range Processed	16 - 18 meters
File	station_10_cast_11_049.jsf

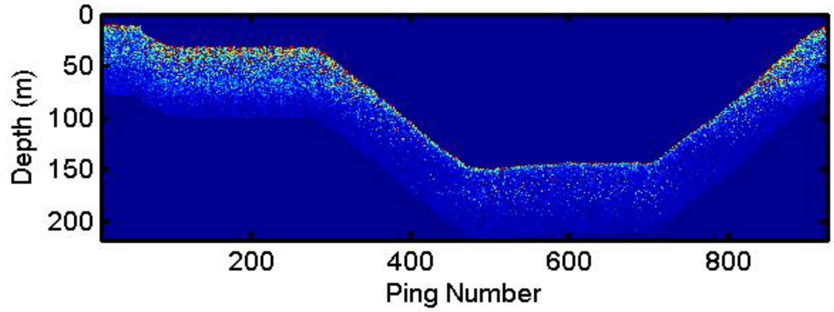




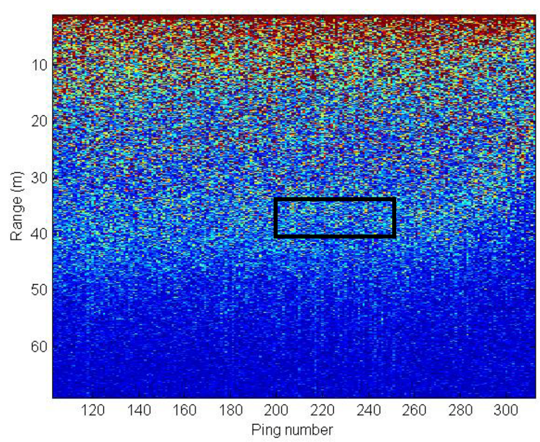
Station 13:

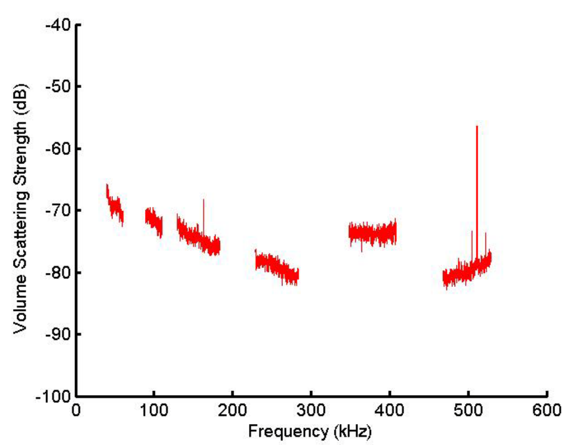
Cast 12



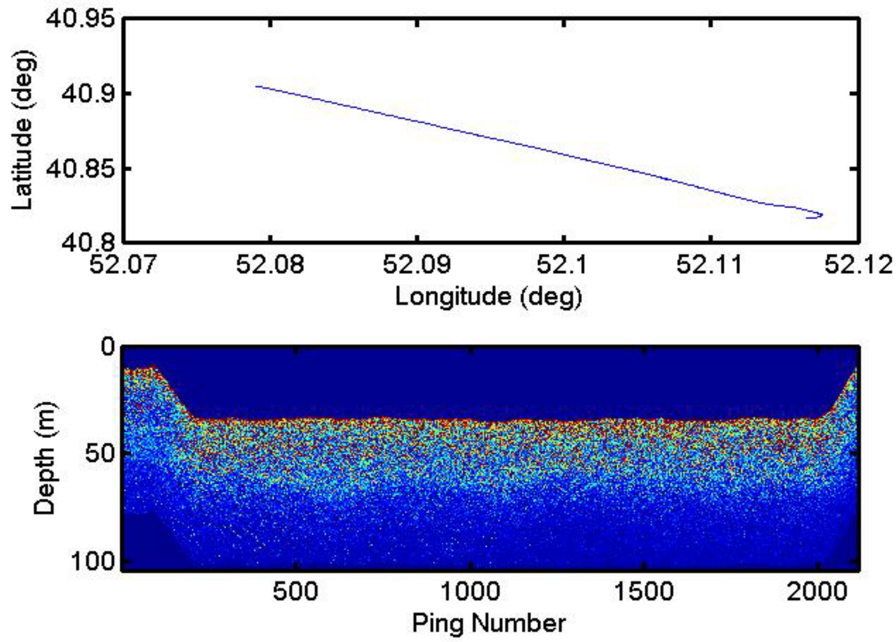


Day/Night	Night
HammarHead Depth	60.0 meters
Layer Depth	95 meters
Pings Processed	200 - 250
Range Processed	35 - 40 meters
File	station_13_cast_12_004.jsf

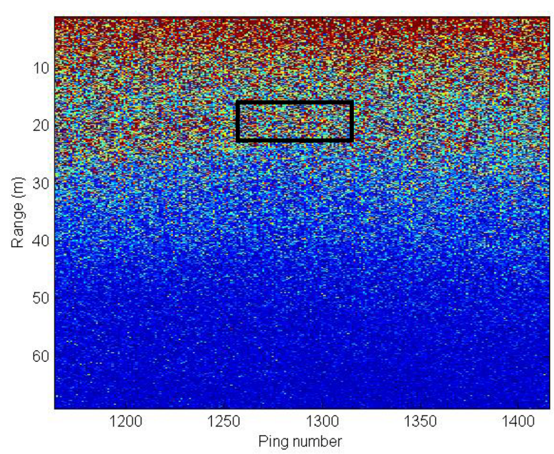


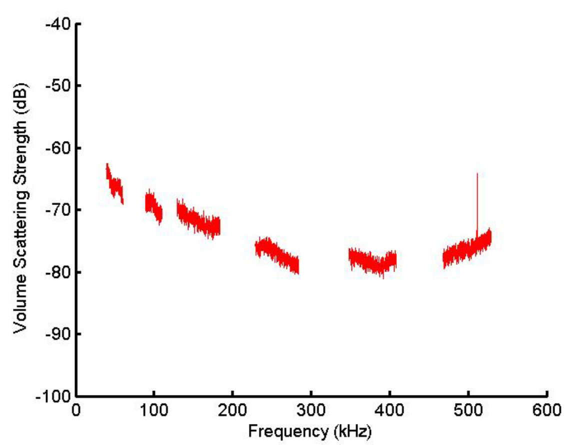


Cast13:



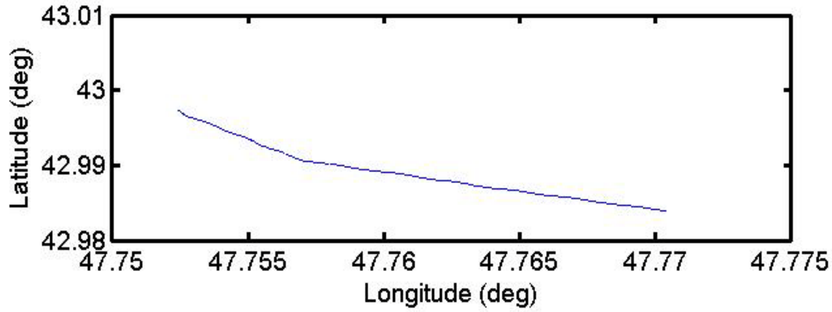
Day/Night	Night
HammarHead Depth	33.4 meters
Layer Depth	50 meters
Pings Processed	1265 -1315
Range Processed	16.5 - 24 meters
File	station_13_cast_13_025.jsf

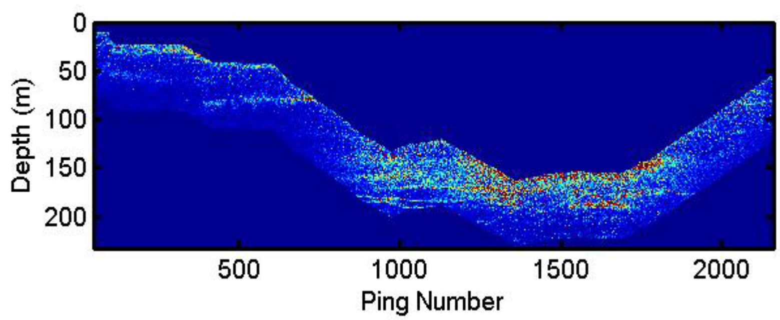




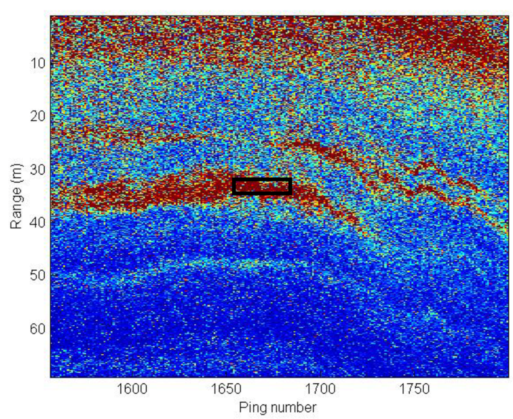
Station 17:

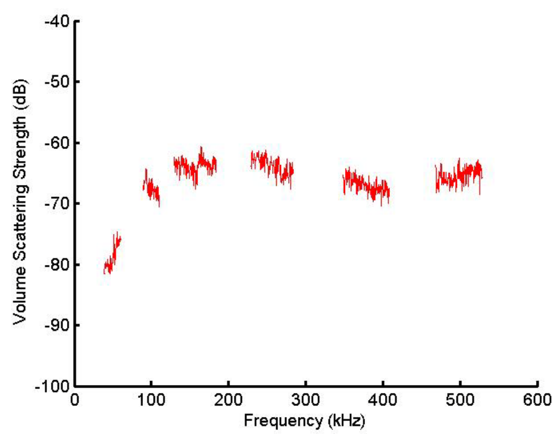
Cast14:



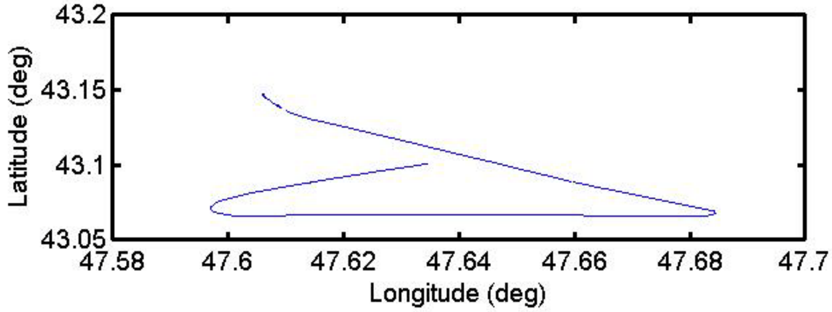


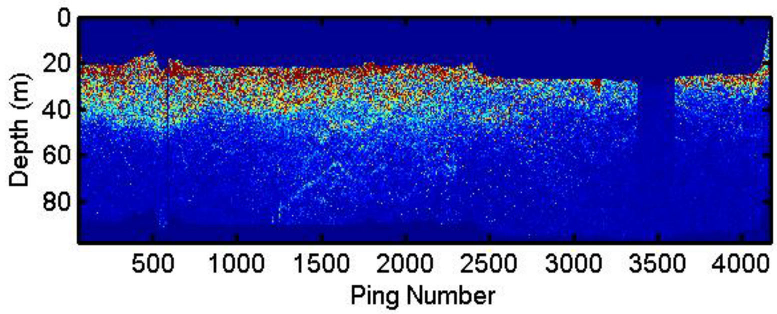
Day/Night	Day
HammarHead Depth	150.3 meters
Layer Depth	34 meters
Pings Processed	1664 -1684
Range Processed	34-35 meters
File	station_17_cast_14_035.jsf



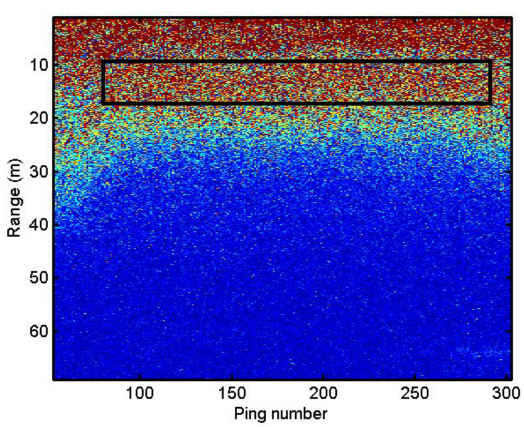


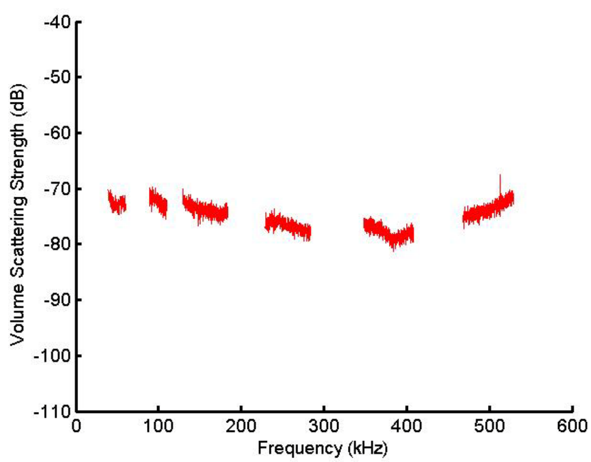
Cast15:



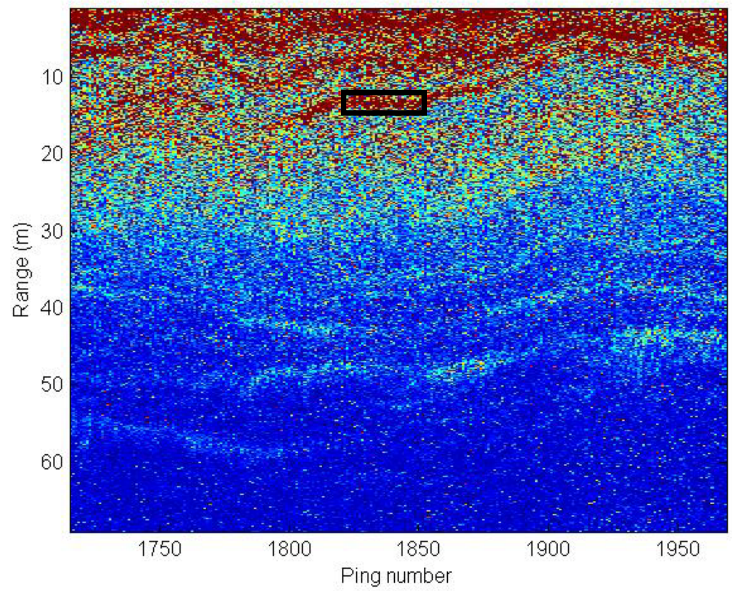


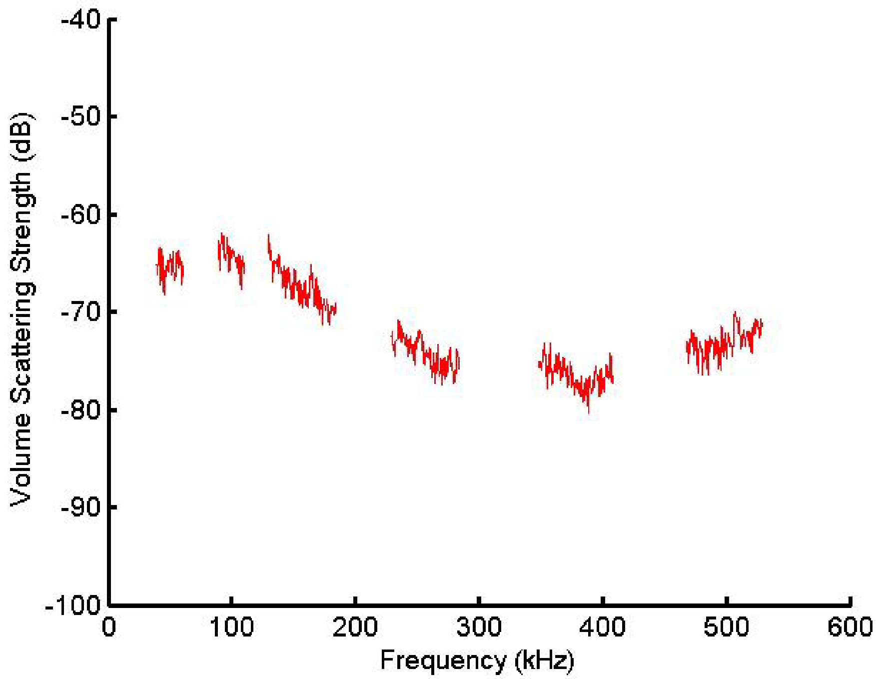
Day/Night	Night
HammarHead Depth	19.7 meters
Layer Depth	34 meters
Pings Processed	103-153
Range Processed	10-16 meters
File	station_17_cast_15_002.jsf





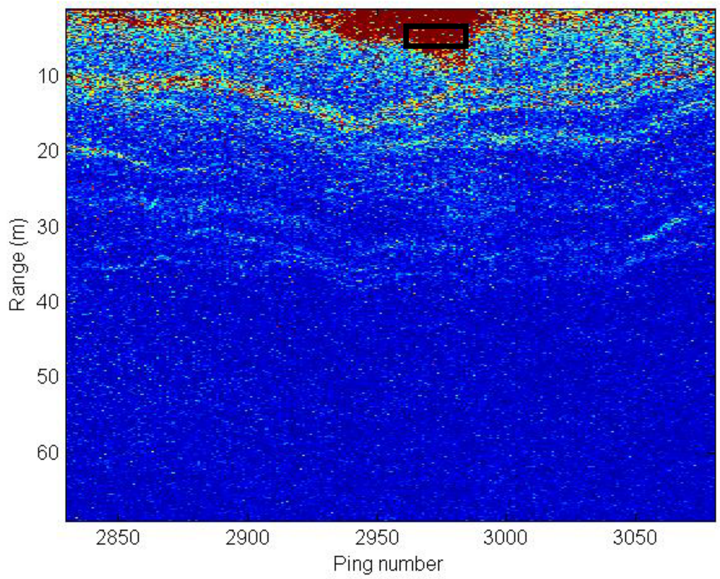
Day/Night	Night
HammarHead Depth	21.2 meters
Layer Depth	34 meters
Pings Processed	1828 -1848
Range Processed	13.13-14 meters
File	station_17_cast_15_049.jsf

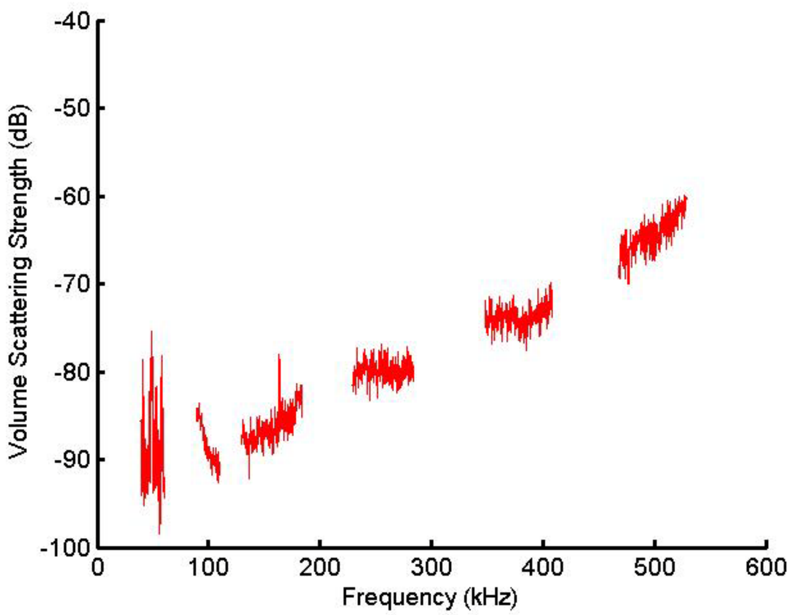




Cast15:

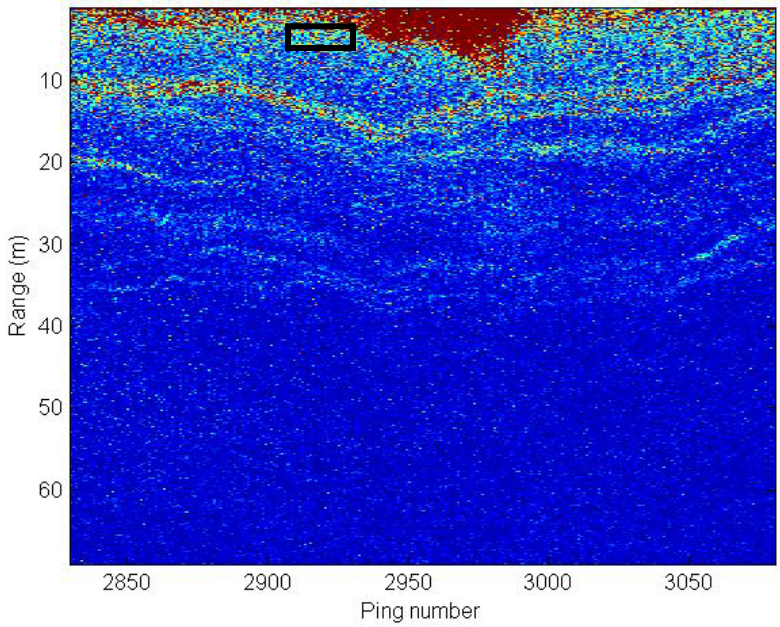
Day/Night	Night
HammarHead Depth	27.7 meters
Layer Depth	32 meters
Pings Processed	2961 -2978
Range Processed	4-6 meters
File	station_17_cast_15_071.jsf

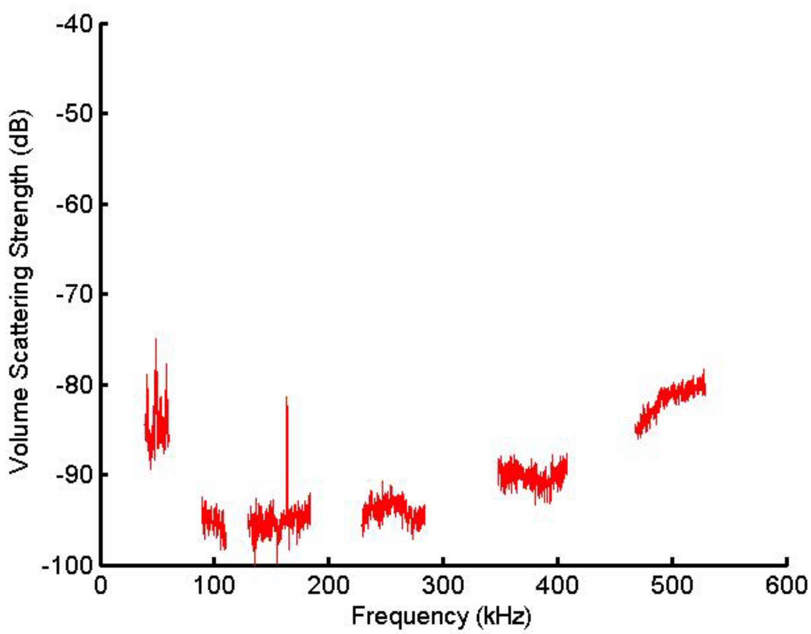




Cast15:

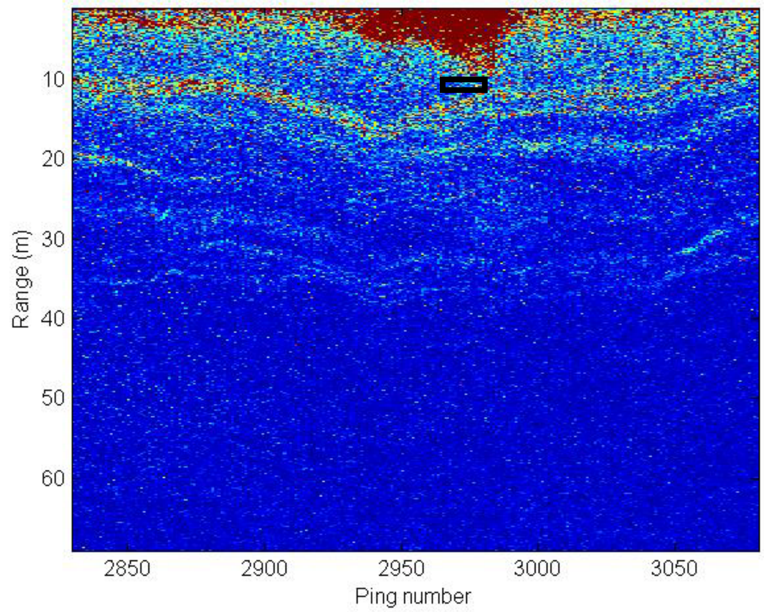
Day/Night	Night
HammarHead Depth	27.7 meters
Layer Depth	32 meters
Pings Processed	2900 -2920
Range Processed	4-6 meters
File	station_17_cast_15_070.jsf

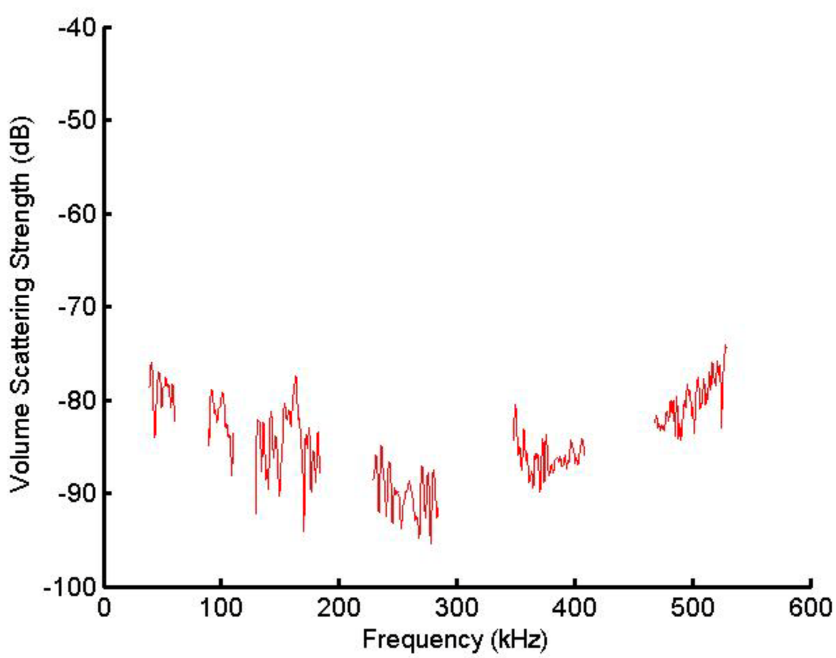




Cast15:

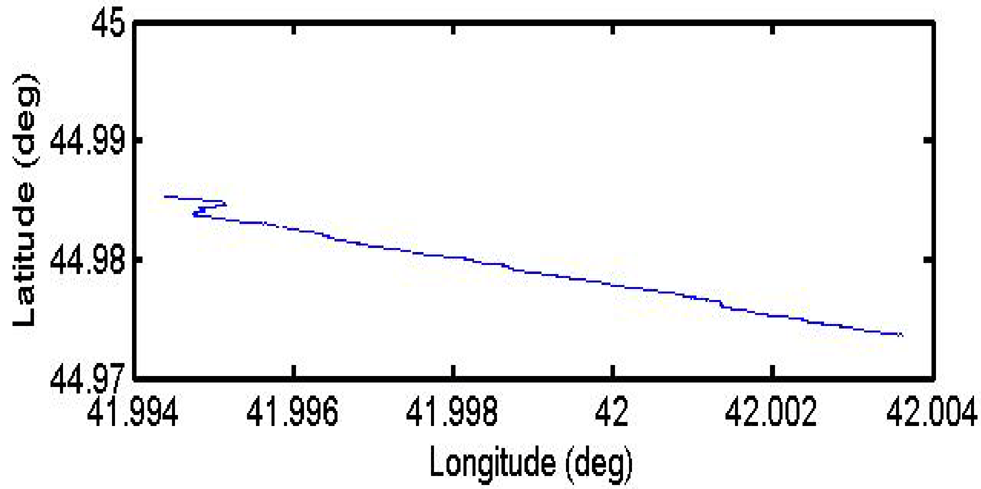
Day/Night	Night
HammarHead Depth	27.7 meters
Layer Depth	38 meters
Pings Processed	2961 -2978
Range Processed	11.4-11.8 meters
File	station_17_cast_15_071.jsf

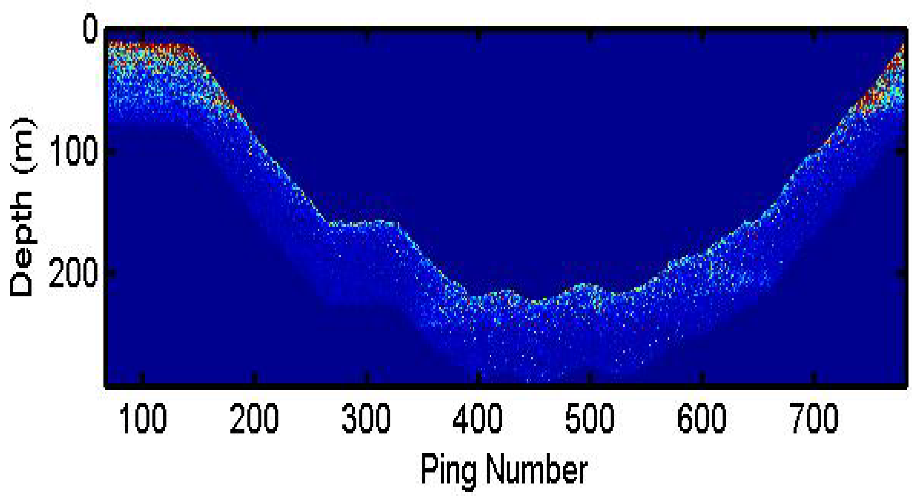




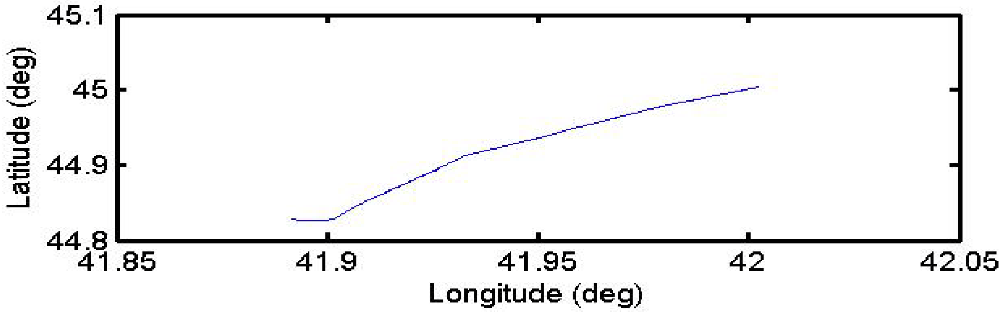
Station 21:

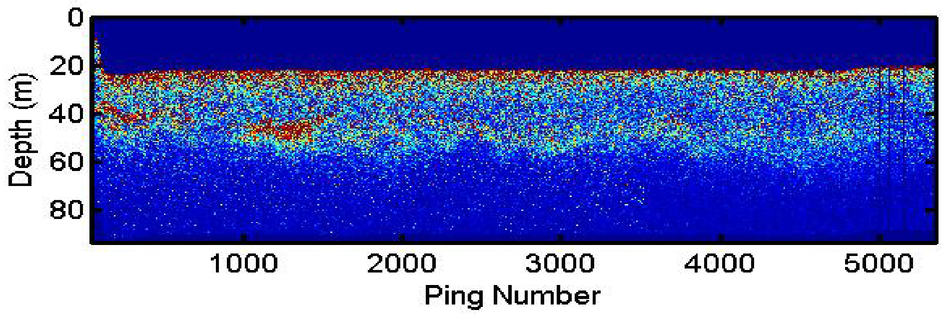
Cast16:



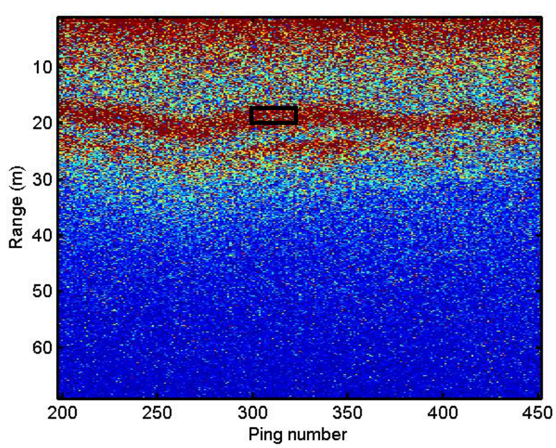


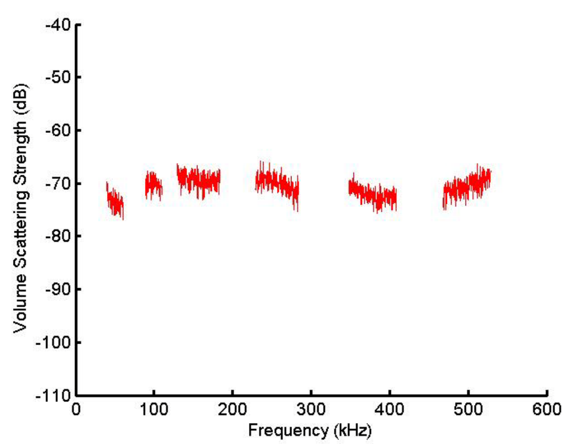
Cast17:



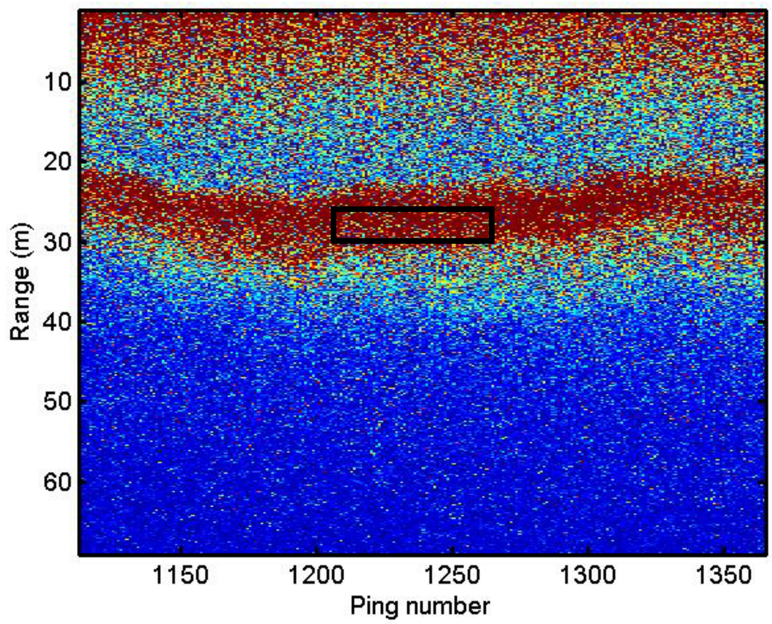


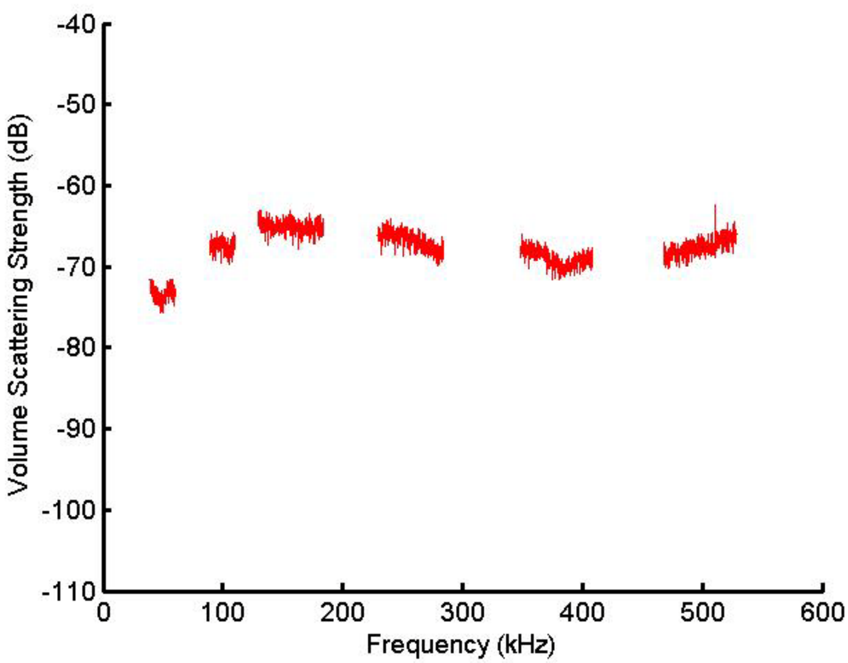
Day/Night	Night
HammarHead Depth	22.2 meters
Layer Depth	40 meters
Pings Processed	299 -314
Range Processed	17.5-19.5 meters
File	station_21_cast_17_006.jsf





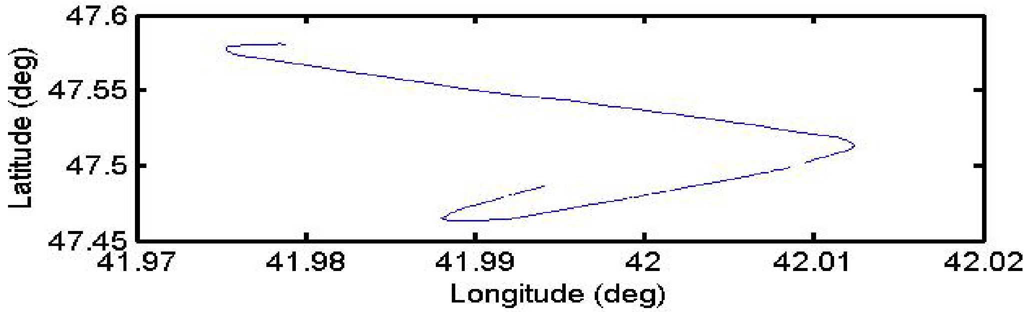
Day/Night	Night
HammarHead Depth	21.4 meters
Layer Depth	47 meters
Pings Processed	1220 -1260
Range Processed	25.5-29 meters
File	station_21_cast_17_024.jsf

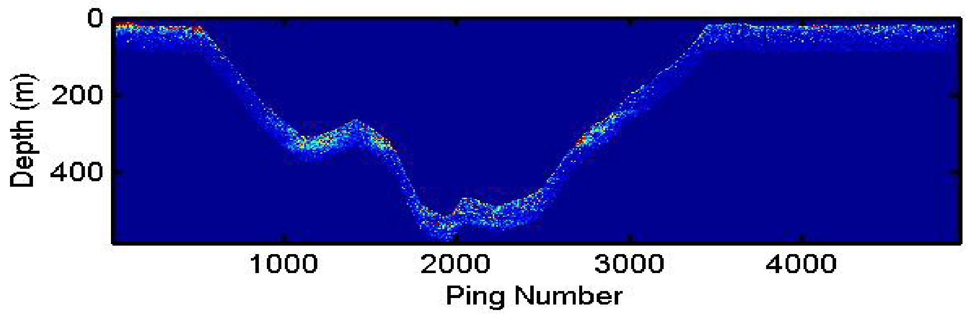




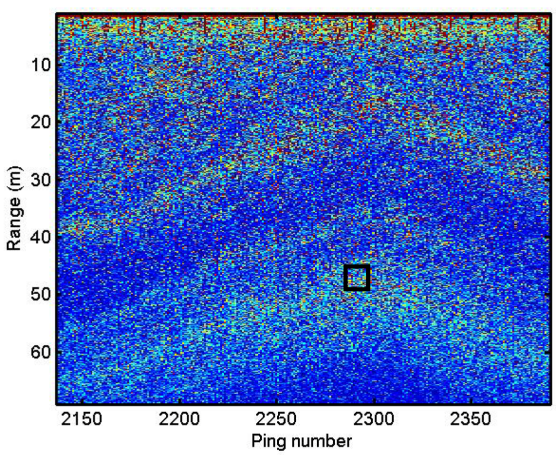
Station 26:

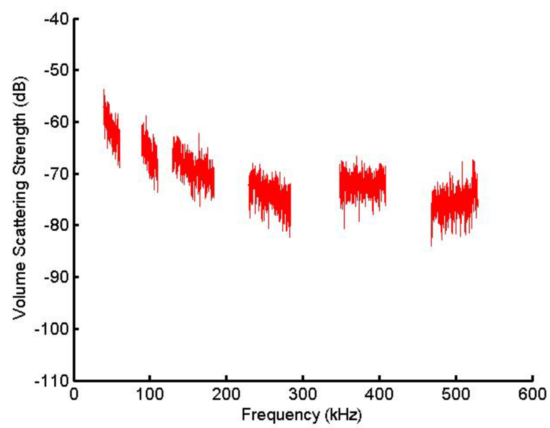
Cast18:



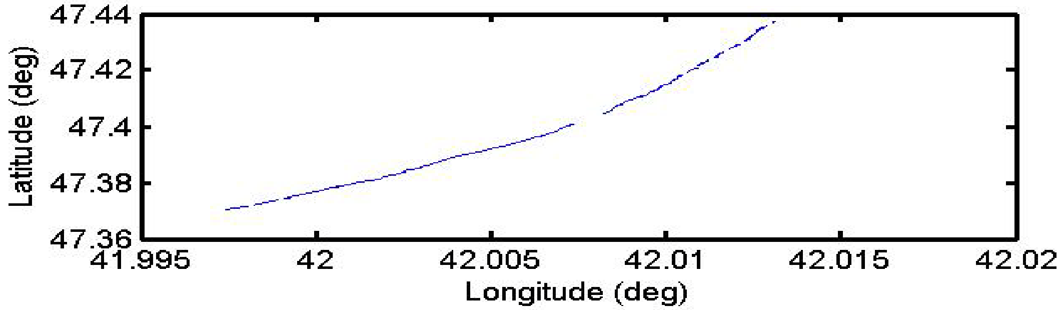


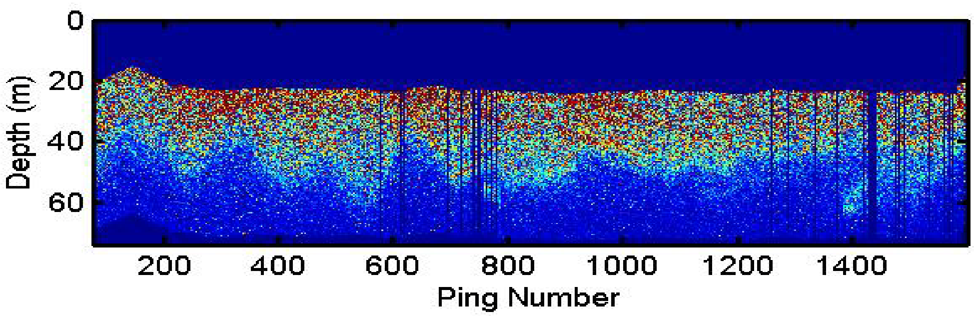
Day/Night	day
HammarHead Depth	473.2 meters
Layer Depth	520 meters
Pings Processed	2283-2288
Range Processed	45-49.5 meters
File	station_26_cast_18_047.jsf



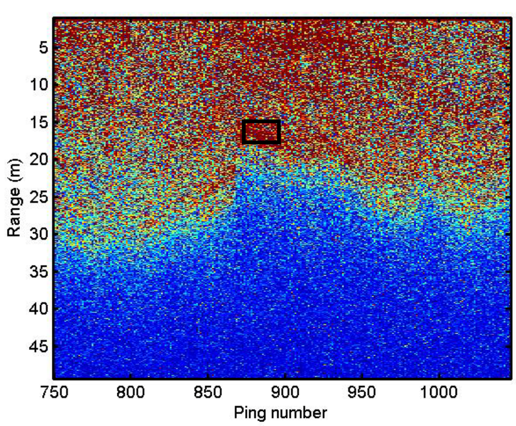


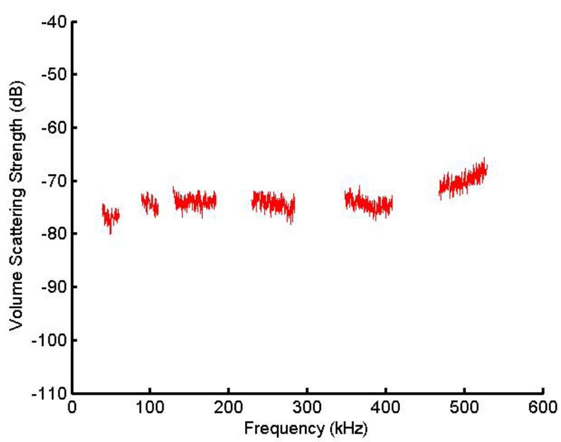
Cast19:





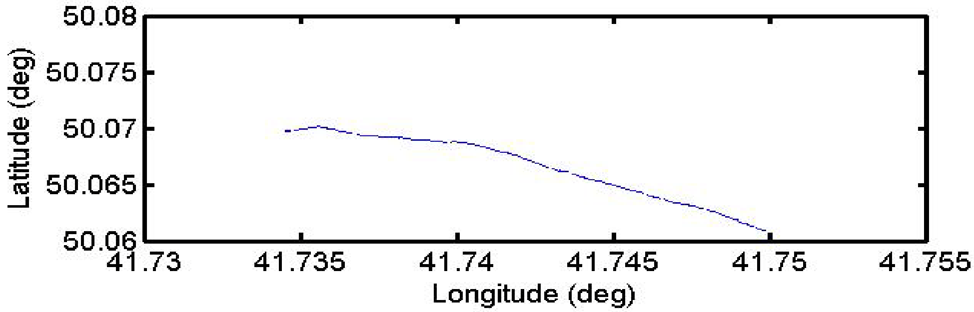
Day/Night	Night
HammarHead Depth	22.6 meters
Layer Depth	40 meters
Pings Processed	874-895
Range Processed	15.5-17.2 meters
File	station_26_cast_19_015.jsf

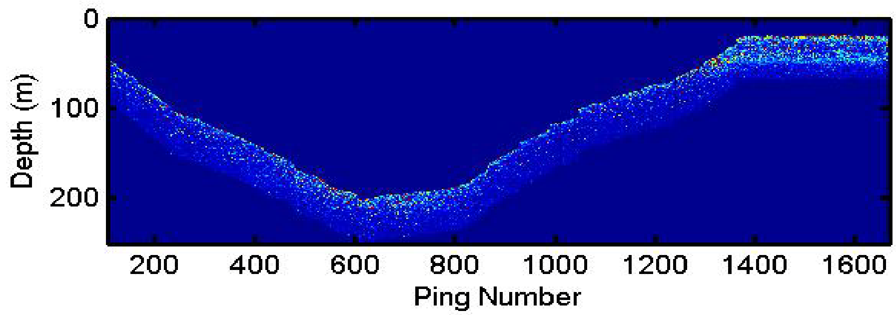




Station 31:

Cast20:

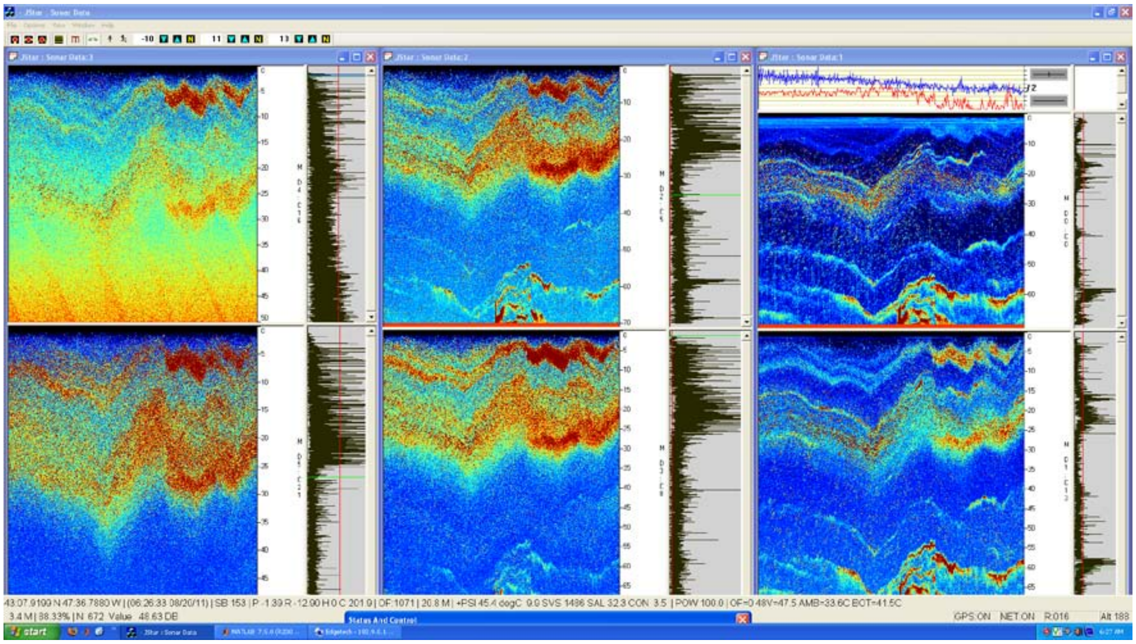




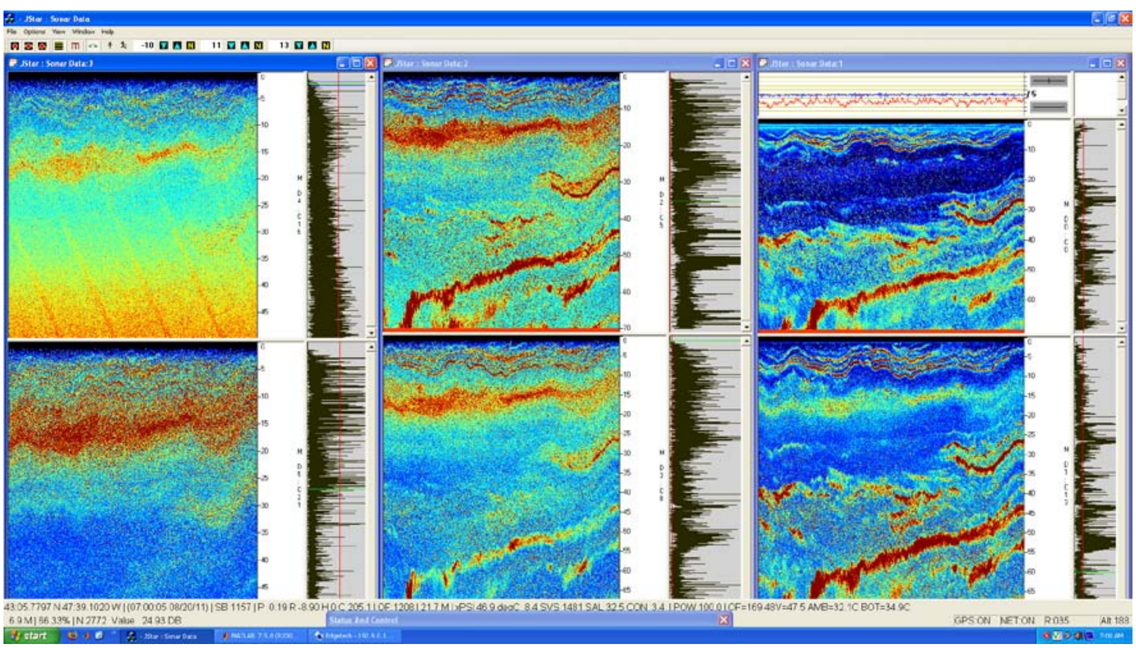
SCREEEN SHOTS From Cast 15

Note: HammarHead was at 20 meters depth being towed at 5knots as we moved back onto station. Seas were calm.

Shot1: Interesting scattering. Much different from anything we have seen thus far.



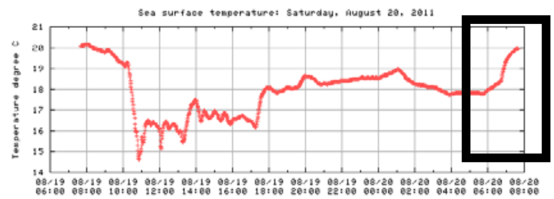
Shot2: more interesting scattering. Look particularly at 10 meters range for all channels at the right of the echogram. There is a layer from 10-15 meters range that is not detected by the A1 and only slightly by the A2 but shows up well on all the others.



Shot3: Acoustics going through a front here. This is a picture of the surface salinity, temperature and fluorometer. The boxed areas show the front we passed through. The screenshot is below. Note this data has not been unpacked yet so I did not use the temperature, Salinity and Fluorometer from the HammarHead.

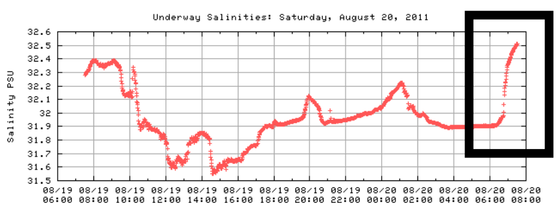
R/V Oceanus, WHOI, 07:39:25 gmt, 43.06683 N, -47.65555 E

Last Sea surface temperature: 19.94 ° C, 67.89 ° F



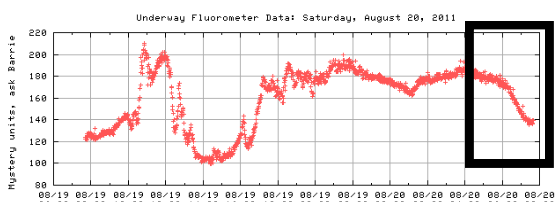
R/V Oceanus, WHOI, 07:31:25 gmt, 43.06572 N, -47.67528 E

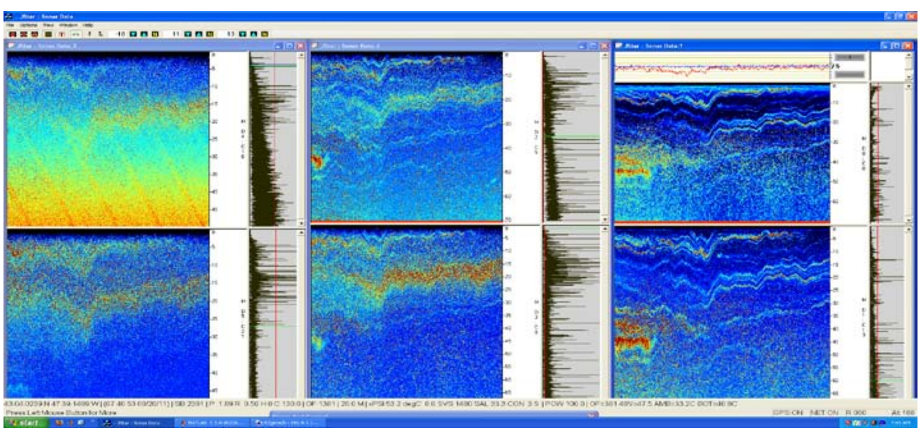
Last Sea Surface Salinity: 32.51 PSU



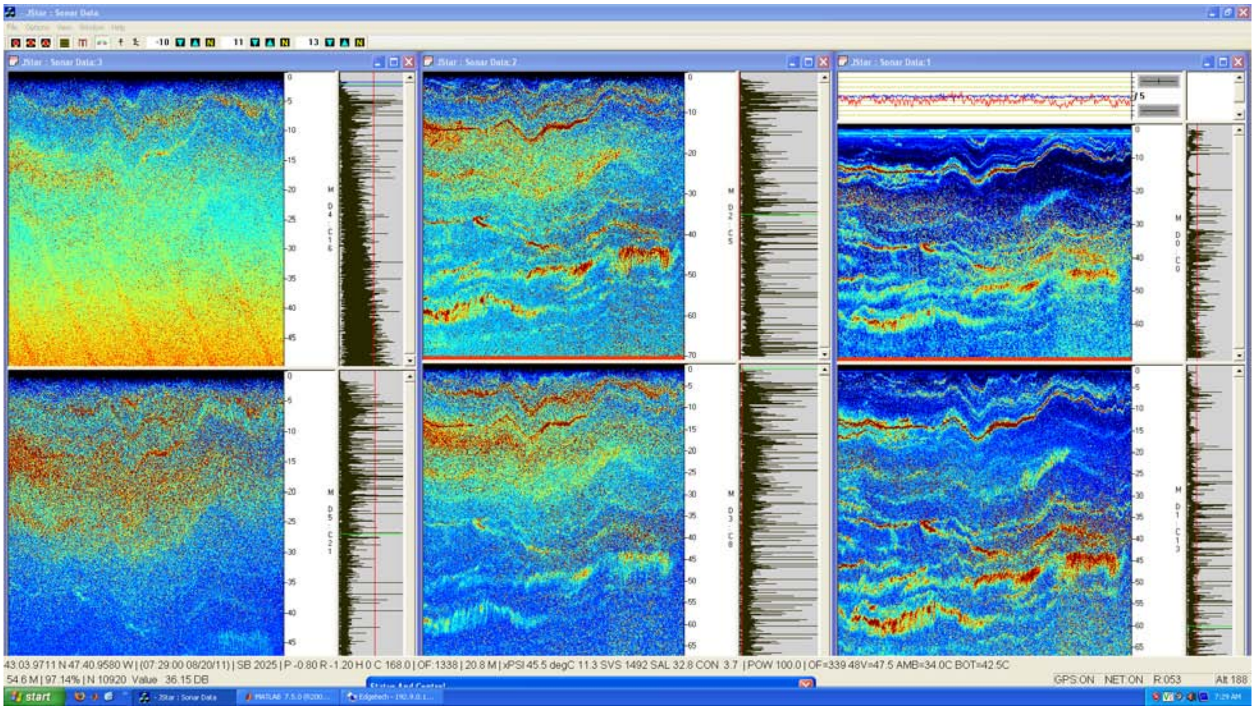
R/V Oceanus, WHOI, 07:39:25 gmt, 43.06683 N, -47.65555 E

Fluorometer





Shot4: Looks like there could be contributions from microstructure here in the thinner layers at closer ranges (Peter also suggested this as a possibility)



Appendix 3.1. Table of Carbonate Chemistry for Respiration Experiments.

DIC and TA measurements were conducted aboard ship following the procedures listed in Section X, and X. Temperature dependent (based on the temp of the experiment) and independent (based on 25° C) values of control chamber ppm CO_2 were calculated.

Date	Time	Sample ID	DIC (umol/kg)	DIC Stdev	TA (umol/kg)	TA Stdev	Temp. dependent ppm CO_2	Temp. independent ppm CO_2	Gas	Temp (° C)
8/9/2011	18:44	Bio-001C	2011.8	0.0200	2345.8	1.556	288.3	353.2	Ambient Air	20
8/9/2011	19:36	Bio-003C	2020.7	0.1002	2345.8	1.556	300.3	367.9	Ambient Air	20
8/11/2011	3:38	Bio-005C	2173.5	0.0200	2345.8	1.556	664.8	808.4	Ambient Air	20
8/11/2011	4:18	Bio-007C	2053.3	5.7119	2345.8	1.556	350.4	428.8	Ambient Air	20
8/13/2011	2:26	Bio-007bC	2076.8	0.3011	2345.8	1.556	480.8	480.8	Ambient Air	25
8/13/2011	3:12	Bio-009C	2079.8	1.9872	2345.8	1.556	487.9	487.9	Ambient Air	25
8/14/2011	8:54	Bio-011C	2173.5	0.1801	2345.8	1.556	664.9	808.4	800 ppm	20
8/14/2011	9:50	Bio-014C	2183.9	0.4403	2345.8	1.556	707.7	859.7	800 ppm	20
8/15/2011	22:34	Bio-018C	2056.4	4.7836	2367.2	1.626	327.2	400.7	380 ppm	20
8/15/2011	22:50	Bio-020C	2168.2	25.1389	2367.2	1.626	579.1	705.5	800 ppm	20
8/15/2011	23:12	Bio-022C	2171.2	1.1409	2367.2	1.626	589.1	717.5	800 ppm	20
8/15/2011	23:33	Bio-024C	2086.0	6.3848	2367.2	1.626	377.1	461.2	380 ppm	20
8/16/2011	21:47	Bio-038C	2077.5	1.6199	2367.2	1.626	361.8	442.7	380 ppm	20
8/16/2011	22:07	Bio-043C	2082.9	1.1599	2367.2	1.626	371.5	454.5	380 ppm	20
8/16/2011	22:21	Bio-044C	2153.6	4.3797	2367.2	1.626	534.2	651.4	800 ppm	20

Date	Time	Sample ID	DIC (umol/kg)	DIC Stdev	TA (umol/kg)	TA Stdev	Temp. dependent ppm CO_2	Temp. independent ppm CO_2	Gas	Temp (° C)
8/16/2011	20:56	Bio-053C	2075.1	3.2197	2367.2	1.626	357.7	437.7	380 ppm	20
8/16/2011	21:13	Bio-055C	2080.7	1.1399	2367.2	1.626	367.4	449.5	380 ppm	20
8/16/2011	21:30	Bio-057C	2216.8	1.6199	2367.2	1.626	771.2	935.7	800 ppm	20
8/18/2011	7:22	Bio-071C	2243.1	0.4814	2367.2	1.626	911.7	1103.0	380 ppm	20
8/18/2011	8:25	Bio-073C	6331.7	249.1281	2367.2	1.626			380 ppm	20
8/18/2011	8:52	Bio-076C	2245.2	0.5817	2367.2	1.626	924.2	1117.8	800 ppm	20
8/18/2011	7:57	Bio-079C	1755.8	3.1690	2367.2	1.626	91.9	113.5	380 ppm	20
8/18/2011	7:14	Bio-083C	2260.6	4.7334	2367.2	1.626	1024.3	1236.3	800 ppm	20
8/18/2011	20:56	Bio-086C	2098.9	3.9651	2367.2	1.626	401.8	491.3	380 ppm	20
8/18/2011	21:47	Bio-088C	2082.4	19.0246	2367.2	1.626	370.5	453.3	380 ppm	20
8/18/2011	6:42	Bio-08SC	2253.6	3.2904	2367.2	1.626	977.5	1180.9		20
8/18/2011	21:11	Bio-090C	2238.3	0.6008	2367.2	1.626	884.0	1070.1	380 ppm	20
8/18/2011	20:25	Bio-094C	2232.2	0.2603	2367.2	1.626	849.7	1029.3	800 ppm	20
8/18/2011	20:37	Bio-098C	2058.0	3.2041	2367.2	1.626	329.7	403.7	380 ppm	20
8/21/2011	5:04	Bio-0116C	2192.4	3.5039	2307.3	0.000	622.2	1126.7	800 ppm	10
8/21/2011	5:22	Bio-0114C	2104	4.6853	2307.3	0.000	355.2	657.8	380 ppm	10
8/21/2011	5:37	Bio-0127C	2211	1.4817	2307.3	0.000	710.9	1277.6	380 ppm	10
8/21/2011	6:00	Bio-0123C	2209.5	0.901	2307.3	0.000	703.1	1264.5	800 ppm	10

Date	Time	Sample ID	DIC (umol/kg)	DIC Stdev	TA (umol/kg)	TA Stdev	Temp. dependent ppm CO_2	Temp. independent ppm CO_2	Gas	Temp (° C)
8/21/2011	6:12	Bio-0125C	2225	0.1802	2307.3	0.000	788.7	1408.2	800 ppm	10
8/21/2011	16:46	Bio-141C	1046.2	117.8727	2307.3	0.000			380 ppm	10
8/22/2011	17:09	Bio-127C	2108.2	0.4405	2307.3	0.000	363.9	673.5	380 ppm	10
8/22/2011	17:30	Bio-131C	2235.9	0.3804	2307.3	0.000	856.8	1521.2	800 ppm	10
8/22/2011	17:47	Bio-144C	1919.7	3.584	2307.3	0.000	142.1	268.0	380 ppm	10
8/22/2011	19:06	Bio-136C	2244.6	0.7408	2307.3	0.000	916.4	1619.2	800 ppm	10
8/22/2011	19:51	Bio-0145C	2071.1	3.5101	2307.3	0.000	295.8	550.5	380 ppm	10
8/22/2011	20:11	Bio-0156C	2059.3	18.1604	2307.3	0.000	344.4	517.7	380 ppm	15
8/22/2011	20:30	Bio-015C	2192.5	4.9255	2307.3	0.000	765.5	1127.5		15
8/22/2011	20:48	Bio-0154C	2208	0.9411	2307.3	0.000	853.5	1251.6	800 ppm	15
8/22/2011	21:01	Bio-0162C	2079.1	7.1881	2307.3	0.000	382.8	574.3	380 ppm	15
8/24/2011	0:53	Bio-0170C	1729.4	0.1806	2307.3	0.000	78.9	120.8	380 ppm	15
8/24/2011	1:12	Bio-0178C	2157.2	0.3411	2307.3	0.000	605.6	899.0	380 ppm	15
8/24/2011	1:24	Bio-0186C	1818.3	1.1638	2307.3	0.000	114.3	174.2	380 ppm	15
8/24/2011	1:38	Bio-0172C	1721.6	64.7932	2307.3	0.000	76.4	117.0	380 ppm	15
8/24/2011	1:51	Bio-0182C	1829.8	2.9096	2307.3	0.000	120.0	182.7	380 ppm	15
8/24/2011	20:26	Bio-0190C	1970.4	21.5509	2307.3	0.000	222.4	336.4	380 ppm	15
8/24/2011	20:50	Bio-0192C	2165.6	5.0767	2307.3	0.000	639.3	947.4	800 ppm	15

Date	Time	Sample ID	DIC (umol/kg)	DIC Stdev	TA (umol/kg)	TA Stdev	Temp. dependent ppm CO_2	Temp. independent ppm CO_2	Gas	Temp (° C)
8/24/2011	21:05	Bio-0194C	2206.7	3.6921	2307.3	0.000	845.6	1240.5	800 ppm	15
8/24/2011	21:21	Bio-0208C	2199.2	1.2441	2354.5	0.071	606.0	900.2	800 ppm	15
8/25/2011	3:03	Bio-0211C	2191.7	2.0467	2354.5	0.071	578.5	860.5	800 ppm	15
8/25/2011	3:35	Bio-0213C	2069.6	0.5217	2354.5	0.071	297.3	448.1	800 ppm	15
8/25/2011	4:06	Bio-0214C	2073.3	0.6822	2354.5	0.071	302.8	456.2	380 ppm	15
8/25/2011	4:18	Bio-0224C	2201.3	2.8092	2354.5	0.071	614.0	911.7	800 ppm	15
8/26/2011	3:41	Bio-0227C	1852.7	0.02	2354.5	0.071	114.2	174.0	380 ppm	15
8/26/2011	3:54	Bio-0232C	2126.2	2.0401	2354.5	0.071	397.4	596.2	800 ppm	15
8/26/2011	4:05	Bio-0236C	2139.5	3.2602	2354.5	0.071	427.2	640.0	800 ppm	15
8/26/2011	4:38	Bio-0244C	2059.4	1.8001	2354.5	0.071	282.9	426.7	380 ppm	15

Appendix 3.2. Table of Respiration Experiment Details.

Species were exposed to various treatments at various temperatures (°C). Type of capture was reported for most specimens. The batch of filtered, antibiotically treated water was documented for later Total Alkalinity comparison. The volume of each respiration trial (mL) and the duration of the experiment (hours) are noted. The experimental and control values are reported in μmol of O_2 kg^{-1} of water.

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (μmol kg^{-1})	Control (μmol kg^{-1})
1	*Cavolinia longirostris*	21% O_2, ~440 ppm CO_2	20	MOC 1	1	20	8.52	187.5	226.5
2	*Cavolinia longirostris*	21% O_2, ~440 ppm CO_2	20	MOC 1	1	20	8.63	161.4	226.5
3	*Cavolinia longirostris*	21% O_2, ~440 ppm CO_2	20	MOC 1	1	20	9.12	185.3	228.4
4	*Cavolinia longirostris*	21% O_2, ~440 ppm CO_2	20	MOC 1	1	20	9.30	124.5	228.4
5	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	25	Reeve 1	1	20	12.33	74.0	190.5
6	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	25	Reeve 1	1	20	12.42	127.5	190.5
7	*Diacria trispinosa*	21% O_2, ~440 ppm CO_2	25	Reeve 1	1	20	12.68	180.7	201.5
9	*Diacria trispinosa*	21% O_2, ~440 ppm CO_2	25	Reeve 1	1	20	12.25	198.6	208.9
7b	*Diacria trispinosa*	21% O_2, ~440 ppm CO_2	20	Reeve 3	1	20	7.40	163.2	226.9
8b	*Diacria trispinosa*	21% O_2, ~440 ppm CO_2	20	Reeve 3	1	20	7.57	209.7	226.9
9b	*Diacria trispinosa*	21% O_2, ~440 ppm CO_2	20	Reeve 3	1	20	7.63	160.6	230.5
11	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 4	1	20	8.83	194.2	217.1
12	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 4	1	20	8.98	197.5	217.1
14	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 4	1	20	19.08	197.8	223.1

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
15	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 4	1	20	9.23	215.8	229.8
16	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 4	1	20	9.53	208.1	229.8
17	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 4	1	20	11.52	199.9	228.4
18	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 6	2	20	12.72	174.8	219.5
20	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	MOC 6.7	2	20	12.82	60.8	226.4
21	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	MOC 6.7	2	20	12.95	69.4	226.4
22	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 6	2	20	13.00	179.4	220.0
23	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 6	2	20	13.12	179.6	220.0
24	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 6	2	20	13.40	191.9	223.1
25	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 6	2	20	13.55	125.1	223.1
26	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	MOC 6	1	20	11.12	177.3	214.6
27	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	MOC 6	1	20	11.17	176.0	220.0
31	*Styliola subula*	21% O_2, 380 ppm CO_2	20	MOC 6	2	20	15.12	212.5	222.9
32	*Styliola subula*	21% O_2, 380 ppm CO_2	20	MOC 6	2	18.5	15.30	197.5	228.4
33	*Styliola subula*	21% O_2, 380 ppm CO_2	20	MOC 6	2	20	15.52	207.0	228.4
36	*Styliola subula*	21% O_2, **800 ppm CO_2**	20	MOC 6	2	20	15.50	204.5	235.0
38	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	48	12.62	175.9	230.5

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
39	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	12.78	211.3	225.1
40	*Styliola subula*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	18	16.57	192.4	225.8
41	*Styliola subula*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	16.72	188.6	225.8
43	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	12.77	207.0	223.8
44	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	13.30	178.1	224.1
45	*Cuvierina columnella*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	13.43	207.4	224.1
46	*Styliola subula*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	16.57	213.9	230.5
47	*Styliola subula*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	16.63	181.6	230.5
48	*Styliola subula*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	16.68	187.5	221.8
49	*Styliola subula*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	17.43	157.8	223.5
50	*Styliola subula*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	17.62	165.5	223.5
51	*Styliola subula*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	17.63	175.8	219.2
53	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	10.57	177.2	221.5
54	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	10.78	211.8	221.5
55	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	10.98	214.4	220.6
56	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 7	2	20	11.13	88.0	220.6
57	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	11.07	197.3	223.0

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
58	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	11.20	214.9	223.0
59	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	11.30	121.3	220.7
60	*Styliola subula*	21% O_2, **800 ppm CO_2**	20	Reeve 7	2	20	17.40	179.8	206.3
61	*Styliola subula*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	17.92	146.7	219.3
63	*Styliola subula*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	17.97	155.2	227.6
64	*Styliola subula*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	18.08	156.9	227.6
66	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	50	13.20	175.7	225.7
68	*Styliola subula*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	20	17.98	202.2	230.5
71	*Cavolinia inflexa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	12.90	186.4	222.9
72	*Cavolinia inflexa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	13.23	187.5	222.9
73	*Cavolinia inflexa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	13.28	174.5	221.0
74	*Cavolinia inflexa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	13.47	171.6	221.0
75	*Cavolinia inflexa*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	20	13.48	169.7	224.7
76	*Cavolinia inflexa*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	20	13.65	192.9	224.7
77	*Cavolinia inflexa*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	20	13.72	170.0	229.0
78	*Cavolinia inflexa*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	20	13.85	178.4	229.0
79	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	50	11.83	144.9	211.4

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
80	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	11.70	166.0	211.4
81	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	12.17	192.7	216.2
82	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20	Reeve 8	2	20	12.37	185.4	216.2
83	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	20	12.37	208.9	219.0
84	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	20	12.50	202.9	219.0
85	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20	Reeve 8	2	50	11.98	193.6	217.1
86	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 9	2	50	10.58	137.0	205.0
87	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	Reeve 9	2	50	10.75	197.0	205.0
88	*Clio pyramidata*	21% O_2, 380 ppm CO_2	20	Reeve 9	2	20	10.77	202.5	216.1
90	*Clio pyramidata*	21% O_2, 380 ppm CO_2	20	Reeve 9	2	20	11.63	142.7	218.5
91	*Clio pyramidata*	21% O_2, 380 ppm CO_2	20	Reeve 9	2	20	1.83	188.4	218.5
94	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	20	Reeve 9	2	20	12.02	195.8	227.7
96	*Styliola subula*	21% O_2, **800 ppm CO_2**	20		2	20	12.40	209.3	233.7
98	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20		2	20	10.53	203.7	216.9
99	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	20		2	50	10.67	180.8	216.0
100	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20		2	50	11.05	160.5	218.6
101	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	20		2	20	11.20	210.8	218.6

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
102	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	20		2	20	12.27	206.2	229.1
103	*Cavolinia inflexa*	21% O_2, 380 ppm CO_2	20	MOC 9.5	2	15	3.90	208.7	232.2
104	*Cavolinia inflexa*	21% O_2, 380 ppm CO_2	20	MOC 9.5	2	15	4.03	202.1	232.2
105	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	20	MOC 9.5	2	20	4.20	214.8	238.2
106	*Clio pyramidata*	21% O_2, 380 ppm CO_2	20		2	20	4.35	181.3	238.2
107	*Styliola subula*	21% O_2, 380 ppm CO_2	20	MOC 9.4	2	15	4.42	220.0	235.4
108	*Styliola subula*	21% O_2, 380 ppm CO_2	20	MOC 9.4	2	15	4.58	222.3	235.4
109	*Clio pyramidata*	21% O_2, 380 ppm CO_2	20		2	15	4.60	218.8	235.6
110	*Clio pyramidata*	21% O_2, 380 ppm CO_2	20		2	15	4.77	220.4	235.6
111	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	12.43	220.1	235.4
112	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	12.60	236.3	253.3
113	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	12.75	225.1	256.6
114	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	13.22	236.5	256.6
115	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	MOC 10.8	3	14.5	12.70	230.8	250.9
116	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	MOC 10.8	3	15	12.88	237.3	250.9
117	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	18.52	202.6	250.8
118	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	18.65	220.7	250.8

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
119	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	18.82	230.6	250.7
120	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	MOC 10.8	3	15	18.98	230.8	250.7
122	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	MOC 10.8	3	15	19.00	240.7	257.6
123	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	MOC 10.8	3	15	19.03	240.9	259.9
125	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	MOC 10.8	3	15	19.20	238.3	280.1
127	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	Reeve 12	3	15	14.13	225.6	256.6
128	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	Reeve 12	3	15	14.25	215.6	256.6
129	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	Reeve 12	3	15	14.28	244.4	255.2
130	*Limacina retroversa*	21% O_2, 380 ppm CO_2	10	Reeve 12	3	15	14.47	223.0	255.2
131	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	20	14.93	238.4	270.2
132	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	15	15.00	231.1	270.2
133	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	15	15.10	236.8	272.6
134	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	20	15.17	238.6	272.6
135	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	15	15.25	246.6	273.6
136	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	15	15.32	247.1	273.6
137	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	15	15.38	258.5	280.1
138	*Limacina retroversa*	21% O_2, **800 ppm CO_2**	10	Reeve 12	3	20	15.40	248.2	280.1

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (μmol kg^{-1})	Control (μmol kg^{-1})
139	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	6.90	117.5	130.0
140	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	7.00	120.4	130.0
141	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	9.42	122.3	132.4
142	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	9.57	126.2	132.4
143	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	9.70	119.3	133.6
144	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	12.78	115.1	128.4
145	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	12.92	110.2	128.4
146	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	12.90	119.1	128.5
147	*Limacina retroversa*	**10% O_2,** 380 ppm CO_2	10	Reeve 12	3	20	13.07	119.5	128.5
148	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	50	9.62	195.2	231.7
149	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	50	9.47	188.8	231.7
150	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	20	9.65	199.0	235.7
151	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	20	9.80	209.7	235.7
152	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	20	0.18	174.1	238.1
153	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	20	9.98	228.7	238.1
154	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	20	10.02	226.1	246.3
155	*Clio pyramidata*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	20	10.13	209.4	246.3

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
156	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	50	10.17	166.5	224.1
157	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	50	10.28	180.7	224.1
158	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	20	10.30	191.9	225.6
159	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	20	10.43	171.7	225.6
160	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	20	10.48	172.4	228.9
161	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	20	10.62	204.2	228.9
162	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	20	10.63	132.9	228.0
163	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	20	10.77	192.0	228.0
165	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	50	10.83	204.5	236.7
166	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 13	3	50	10.90	206.6	236.7
167	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	50	11.02	223.8	253.5
168	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	50	11.10	209.0	253.5
169	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	Reeve 13	3	50	11.18	241.3	253.5
170	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	4.92	116.1	135.3
171	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	5.05	129.7	135.3
172	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	5.03	111.9	137.6
173	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	5.17	122.6	137.6

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
174	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	20	5.22	119.2	132.5
175	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	20	5.35	115.7	132.5
176	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	20	5.17	111.7	134.7
177	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	20	5.32	119.4	134.7
178	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 14	3	20	4.95	135.0	243.7
179	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 14	3	20	5.10	191.6	243.7
180	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 14	3	20	5.62	162.3	253.5
181	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 14	3	20	5.75	125.7	253.5
182	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	5.83	120.5	133.4
183	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	5.95	122.2	133.4
184	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	5.98	114.6	136.0
185	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	6.13	106.4	136.0
186	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	6.18	115.6	131.7
187	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 14	3	50	6.30	115.8	131.7
189	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	MOC 14.8	3	20	4.55	207.2	249.3
190	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	MOC 14.8	3	50	3.77	232.3	248.8
191	*Clio pyramidata*	21% O_2, 380 ppm CO_2	15	MOC 14.8	3	50	3.90	219.2	248.8

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
192	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	3.93	92.6	134.6
193	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	4.07	116.2	134.6
194	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	4.05	113.3	134.7
195	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	4.12	100.1	134.7
196	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	4.17	117.5	130.8
197	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	4.25	110.6	130.8
198	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	4.05	111.0	132.3
199	*Clio pyramidata*	**10% O_2, 800 ppm CO_2**	15	MOC 14.8	3	50	4.18	119.6	132.3
208	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	2.77	122.7	139.5
209	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	2.95	127.1	139.5
210	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	3.02	125.8	139.5
211	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	6.02	111.4	132.2
212	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	6.13	110.4	132.2
213	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	6.20	111.6	132.2
214	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.07	184.0	253.5
215	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.18	163.1	253.5
216	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.20	184.6	253.0

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
217	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.32	148.8	253.0
218	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.33	214.3	242.0
219	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.45	180.6	242.0
220	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.53	192.9	252.1
221	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.53	178.6	249.6
222	*Cuvierina columnella*	21% O_2, 380 ppm CO_2	15	Reeve 15	4	20	5.65	230.6	249.6
223	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	7.10	107.8	130.2
224	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	7.22	103.8	130.2
225	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 15	4	50	7.27	94.2	130.2
226	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 16	4	50	5.17	117.6	129.4
227	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 16	4	50	5.27	116.2	129.4
228	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 16	4	50	5.33	106.2	129.4
230	*Cuvierina columnella*	**10% O_2,** 380 ppm CO_2	15	Reeve 16	4	50	6.93	103.7	128.0
232	*Cuvierina columnella*	**10% O_2, 800 ppm CO_2**	15	Reeve 16	4	50	7.07	87.1	130.0
234	*Clio pyramidata*	**10% O_2,** 380 ppm CO_2	15	Reeve 16	4	50	7.10	88.9	125.9
236	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	MOC 16	4	20	4.63	181.6	247.6
237	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	MOC 16	4	20	4.75	207.7	247.6

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
238	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	Reeve 16	4	20	4.82	191.3	237.2
239	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	MOC 16	4	20	4.95	233.3	237.2
240	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	Reeve 16	4	20	4.98	200.7	253.5
241	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	Reeve 16	4	20	5.12	219.4	253.5
242	*Diacria trispinosa*	21% O_2, **800 ppm CO_2**	15	Reeve 16	4	20	5.50	192.8	242.6
243	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 16	4	20	5.62	160.5	242.6
244	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 16	4	20	5.60	192.9	232.3
245	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 16	4	20	5.75	223.0	232.3
246	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 16	4	20	6.43	203.5	245.4
247	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 16	4	20	6.53	173.8	245.4
248	*Diacria trispinosa*	21% O_2, 380 ppm CO_2	15	Reeve 16	4	20	6.60	144.0	245.4
249	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	5.05	142.7	147.2
250	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	5.18	141.0	147.2
251	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	5.23	138.6	147.2
252	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	11.33	137.4	119.2
253	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	11.38	123.3	137.4
254	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	11.45	129.3	137.4

ID #	Species	Treatment	Temp (°C)	Capture	Water Batch	Volume (mL)	Time (hr)	Experimental (µmol kg^{-1})	Control (µmol kg^{-1})
255	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	11.43	139.5	143.1
256	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	11.57	133.6	143.1
257	*Limacina retroversa*	**10% O_2, 800 ppm CO_2**	10	Reeve 17	4	15	11.62	134.4	143.1

Appendix 4. Table of Sampling for Pteropod DNA Barcoding and Phylogeography

Planktonic gastropods identified and individually collected during the cruise. Species, code assigned and number of individuals per vial, as well as station data and sampling method are indicated. Preservation was carried out in 95 % ethanol unless indicated.

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
Atlanta sp.	Ga109	2	1	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Cavolinia gibbosa	Ga05	6	1	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Cavolinia gibbosa	Ga05	7	1	05	8/13/11	36.962	-52.009	MOC-01-005	6	50-100	70 % EtOH
Cavolinia gibbosa	Ga05	8	1	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Cavolinia gibbosa	Ga05	11	1	26	8/23/11	47.490	-41.992	MOC-01-015	6	50-100	
Cavolinia gibbosa	Ga05	10	1	26	8/23/11	47.512	-42.030	MOC-01-014	7	25-50	
Cavolinia gibbosa	Ga05	9	2	26	8/23/11	47.512	-42.030	MOC-01-014	0	0-1000	
Cavolinia inflexa	Ga37	2	1	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Cavolinia inflexa	Ga37	3	1	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Cavolinia inflexa	Ga37	4	2	08	8/15/11	38.510	-51.960	MOC-01-006	8	0-23	
Cavolinia inflexa	Ga37	5	13	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Cavolinia inflexa	Ga37	6	7	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Cavolinia inflexa	Ga37	7	1	10	8/16/11	39.416	-51.969	Reeve	8	0-100	70 % EtOH
Cavolinia inflexa	Ga37	8	2	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Cavolinia inflexa	Ga37	9	1	19	8/19/11	43.997	-44.917	Reeve	12	0-100	
Cavolinia inflexa	Ga37	10	5	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Cavolinia inflexa	Ga37	11	1	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Cavolinia longirostris	Ga32	4	2	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Cavolinia longirostris	Ga32	5	1	05	8/13/11	36.962	-52.009	MOC-01-005	7	25-50	70 % EtOH
Cavolinia longirostris	Ga32	6	7	05	8/13/11	36.962	-52.009	MOC-01-005	8	0-25	70 % EtOH
Cavolinia longirostris	Ga32	7	8	05	8/13/11	36.962	-52.009	MOC-01-005	0	0-1000	70 % EtOH
Cavolinia longirostris	Ga32	8	2	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Cavolinia longirostris	Ga32	9	51	08	8/14/11	38.499	-51.995	Reeve	6	0-100	

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
Cavolinia longirostris	Ga32	10	2	08	8/15/11	38.510	-51.960	MOC-01-006	7	23-50	
Cavolinia longirostris	Ga32	11	14	08	8/15/11	38.510	-51.960	MOC-01-006	8	0-23	
Cavolinia longirostris	Ga32	12	4	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Cavolinia longirostris	Ga32	14	1	13	8/17/11	40.929	-52.071	MOC-01-009	7	25-50	
Cavolinia longirostris	Ga32	15	12	13	8/17/11	40.929	-52.071	MOC-01-009	8	0-25	
Cavolinia longirostris	Ga32	13	1	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Cavolinia uncinata	Ga29	11	1	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Clio cuspidata	Ga59	4	1	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Clio cuspidata	Ga59	5	2	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Clio cuspidata	Ga59	6	1	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Clio cuspidata	Ga59	7	1	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Clio cuspidata	Ga59	8	2	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Clio cuspidata	Ga59	9	2	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Clio polita	Ga112	1	1	08	8/15/11	38.510	-51.960	MOC-01-006	1	800-1000	
Clio pyramidata	Ga01	10	2	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Clio pyramidata	Ga01	6	1	05	8/13/11	36.962	-52.009	MOC-01-005	0	0-1000	70 % EtOH
Clio pyramidata	Ga01	7	3	05	8/13/11	36.962	-52.009	MOC-01-005	8	0-25	70 % EtOH
Clio pyramidata	Ga01	8	1	05	8/13/11	36.962	-52.009	MOC-01-005	7	25-50	70 % EtOH
Clio pyramidata	Ga01	9	7	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Clio pyramidata	Ga01	11	4	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Clio pyramidata	Ga01	12	5	08	8/15/11	38.510	-51.960	MOC-01-006	7	23-50	
Clio pyramidata	Ga01	13	5	08	8/15/11	38.510	-51.960	MOC-01-006	8	0-23	
Clio pyramidata	Ga01	14	10	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Clio pyramidata	Ga01	15	17	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Clio pyramidata	Ga01	16	5	10	8/16/11	39.416	-51.969	Reeve	8	0-100	70 % EtOH
Clio pyramidata	Ga01	17	4	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Clio pyramidata	Ga01	18	24	21	8/22/11	44.942	-	Reeve	13	0-100	

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
							41.998				
Clio pyramidata	Ga01	19	4	21	8/22/11	44.942	-41.998	Reeve	13	0-100	70 % EtOH
Clio pyramidata	Ga01	20	14	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Clio pyramidata	Ga01	21	50	26	8/23/11	47.490	-41.992	Reeve	15	0-100	
Clio pyramidata	Ga01	22	50	30	8/24/11	49.552	-41.942	Reeve	16	0-100	
Clio pyramidata	Ga01	23	2	32	8/26/11	49.110	-44.278	MOC-01-018	5	100-200	
Clio pyramidata	Ga01	24	1	32	8/26/11	49.110	-44.278	MOC-01-018	6	50-100	
Clione limacina	Ga04	10	12	19	8/19/11	43.997	-44.917	Reeve	12	0-100	
Clione limacina	Ga04	11	5	19	8/19/11	43.997	-44.917	Reeve	12	0-100	
Clione limacina	Ga04	12	5	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Clione limacina	Ga04	16	1	32	8/26/11	49.110	-44.278	MOC-01-018	6	50-100	
Clione limacina	Ga04	13	1	31	8/24/11	49.993	-41.990	MOC-01-016	3	400-600	
Clione limacina	Ga04	14	1	31	8/24/11	49.993	-41.990	MOC-01-016	4	200-400	
Clione limacina	Ga04	15	1	31	8/24/11	49.993	-41.990	MOC-01-016	0	0-1000	
Creseis acicula	Ga19	6	1	05	8/13/11	36.967	-52.006	Reeve		0-100	
Creseis acicula	Ga19	7	3	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Creseis acicula	Ga19	8	1	13	8/17/11	40.929	-52.071	MOC-01-009	8	0-25	
Creseis sp	Ga22	6	34	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Creseis sp	Ga22	2	3	13	8/17/11	40.929	-52.071	MOC-01-009	7	25-50	
Creseis sp	Ga22	4	33	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Creseis sp	Ga22	5	20	21	8/22/11	44.942	-41.998	Reeve	13	0-100	70 % EtOH
Creseis sp	Ga22	7	1	31	8/24/11	49.993	-41.990	MOC-01-016	8	0-25	
Creseis sp. (spp.)	Ga22	3	12	13	8/17/11	40.929	-52.071	MOC-01-009	8	0-25	
Creseis virgula	Ga14	6	2	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Creseis virgula	Ga14	7	1	08	8/15/11	38.510	-51.960	MOC-01-006	8	0-23	
Creseis virgula	Ga14	9	1	13	8/17/11	40.929	-52.071	MOC-01-009	5	100-200	
Creseis virgula	Ga14	8	20	13	8/18/11	40.878	-51.976	Reeve	9	0-100	

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
Creseis virgula	Ga14	10	11	19	8/19/11	43.997	-44.917	Reeve	12	0-100	
Creseis virgula	Ga14	5	2	Test	8/8/11	39.548	-66.454	MOC-01-000	2	600-800	
Cuvierina columnella	Ga06	8	4	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Cuvierina columnella	Ga06	9	4	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Cuvierina columnella	Ga06	10	1	08	8/15/11	38.510	-51.960	MOC-01-006	8	0-23	
Cuvierina columnella	Ga06	11	4	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Cuvierina columnella	Ga06	12	1	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Cuvierina columnella	Ga06	13	13	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Cuvierina columnella	Ga06	15	50	26	8/23/11	47.490	-41.992	Reeve	15	0-100	
Cuvierina columnella	Ga06	14	1	26	8/23/11	47.512	-42.030	MOC-01-014	1	800-1000	
Cuvierina columnella	Ga06	16	2	32	8/26/11	49.110	-44.278	MOC-01-018	5	100-200	
Diacria quatridentata	Ga07	5	1	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Diacria quatridentata	Ga07	6	4	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Diacria quatridentata	Ga07	7	2	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Diacria quatridentata	Ga07	10	3	13	8/17/11	40.929	-52.071	MOC-01-009	7	25-50	
Diacria quatridentata	Ga07	9	1	13	8/17/11	40.929	-52.071	MOC-01-009	5	100-200	
Diacria quatridentata	Ga07	8	1	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Diacria quatridentata	Ga07	11	1	21	8/22/11	44.933	-41.996	MOC-01-012	7	25-50	
Diacria trispinosa	Ga02	14	4	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Diacria trispinosa	Ga02	15	7	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Diacria trispinosa	Ga02	16	3	10	8/16/11	39.416	-51.969	Reeve	8	0-100	70 % EtOH
Diacria trispinosa	Ga02	17	6	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Diacria trispinosa	Ga02	19	1	13	8/17/11	40.929	-52.071	MOC-01-009	5	100-200	
Diacria trispinosa	Ga02	18	5	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Diacria trispinosa	Ga02	20	12	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Diacria trispinosa	Ga02	21	8	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Diacria trispinosa	Ga02	22	6	26	8/23/11	47.490	-	Reeve	15	0-100	

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
							41.992				
Gastropoda	Ga110	1	1	05	8/13/11	36.962	-52.009	MOC-01-005	1	800-1000	
Gymnosome	Ga35	2	9	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Hyalocylis striata	Ga09	8	2	Test	8/8/11	39.548	-66.454	MOC-01-000	2	600-800	
Hyalocylis striata	Ga09	9	2	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Hyalocylis striata	Ga09	10	2	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Hyalocylis striata	Ga09	11	4	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Hyalocylis striata	Ga09	12	1	08	8/15/11	38.510	-51.960	MOC-01-006	8	0-23	
Hyalocylis striata	Ga09	13	28	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Hyalocylis striata	Ga09	13	5	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Hyalocylis striata	Ga09	14	3	10	8/16/11	39.416	-51.969	Reeve	8	0-100	70 % EtOH
Hyalocylis striata	Ga09	15	3	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Hyalocylis striata	Ga09	16	2	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Limacina bulimoides	Ga12	5	5	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Limacina bulimoides	Ga12	6	7	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Limacina bulimoides	Ga12	7	4	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Limacina bulimoides	Ga12	8	5	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Limacina bulimoides	Ga12	9	1	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Limacina bulimoides	Ga12	10	6	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Limacina bulimoides	Ga12	11	3	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Limacina helicoides	Ga62	3	1	13	8/17/11	40.529	-51.592	MOC-01-008	1	898-1000	
Limacina helicoides	Ga62	4	1	13	8/17/11	40.929	-52.071	MOC-01-009	1	800-1000	
Limacina helicoides	Ga62	5	2	13	8/17/11	40.929	-52.071	MOC-01-009	2	600-8000	
Limacina helicoides	Ga62	6	1	17	8/19/11	42.987	-47.776	MOC-1-010	2	600-800	
Limacina helicoides	Ga62	7	1	21	8/22/11	44.933	-41.996	MOC-01-012	3	400-600	
Limacina helicoides	Ga62	10	1	26	8/23/11	47.490	-41.992	MOC-01-015	2	600-800	70 % EtOH
Limacina helicoides	Ga62	8	1	26	8/23/11	47.512	-42.030	MOC-01-014	2	600-800	

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
Limacina helicoides	Ga62	9	1	26	8/23/11	47.512	-42.030	MOC-01-014	2	600-800	70 % EtOH
Limacina helicoides	Ga62	11	2	31	8/24/11	49.993	-41.990	MOC-01-016	2	800-600	
Limacina helicoides	Ga62	12	2	32	8/26/11	49.110	-44.278	MOC-01-018	3	400-600	
Limacina inflata	Ga11	5	5	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Limacina inflata	Ga11	6	10	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Limacina inflata	Ga11	7	5	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Limacina inflata	Ga11	8	13	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Limacina inflata	Ga11	10	8	10	8/16/11	39.416	-51.969	Reeve	8	0-100	70 % EtOH
Limacina inflata	Ga11	9	34	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Limacina inflata	Ga11	11	10	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Limacina inflata	Ga11	12	26	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Limacina inflata	Ga11	13	30	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Limacina inflata	Ga11	14	5	31	8/24/11	49.993	-41.990	MOC-01-016	8	0-25	
Limacina inflata	Ga11	15	4	31	8/24/11	49.993	-41.990	MOC-01-016	7	25-50	
Limacina lesueurii	Ga08	5	1	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Limacina retroversa	Ga100	3	30	15	8/18/11	42.003	-50.694	Reeve	10	0-100	
Limacina retroversa	Ga100	4	30	17	8/19/11	42.985	-47.773	Reeve	11	0-100	
Limacina retroversa	Ga100	5	40	19	8/19/11	43.997	-44.917	Reeve	12	0-100	
Limacina retroversa	Ga100	6	10	19	8/19/11	43.997	-44.917	Reeve	12	0-100	70 % EtOH
Limacina retroversa	Ga100	7	7	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Limacina retroversa	Ga100	8	30	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Limacina retroversa	Ga100	10	66	31	8/24/11	49.993	-41.990	MOC-01-016	7	25-50	
Limacina retroversa	Ga100	9	12	31	8/24/11	49.993	-41.990	MOC-01-016	8	0-25	
Limacina retroversa	Ga100	11	30	32	8/26/11	49.130	-44.250	Reeve	17	0-100	
Peracle bispinosa	Ga31	8	3	21	8/22/11	44.933	-41.996	MOC-01-012	1	800-1000	
Peracle bispinosa	Ga31	9	4	21	8/22/11	44.933	-41.996	MOC-01-012	0	0-1000	
Peracle bispinosa	Ga31	12	3	26	8/23/11	47.490	-	MOC-01-	4	200-400	

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
							41.992	015			
Peracle bispinosa	Ga31	10	1	26	8/23/11	47.512	-42.030	MOC-01-014	1	800-1000	70 % EtOH
Peracle bispinosa	Ga31	11	1	26	8/23/11	47.512	-42.030	MOC-01-014	1	800-1000	
Peracle bispinosa	Ga31	13	2	31	8/24/11	49.993	-41.990	MOC-01-016	2	600-800	
Peracle bispinosa	Ga31	14	1	31	8/24/11	49.993	-41.990	MOC-01-016	1	800-1000	70 % EtOH
Peracle bispinosa	Ga31	15	2	32	8/26/11	49.110	-44.278	MOC-01-018	2	600-800	
Peracle bispinosa	Ga31	7	3	17	8/19/11	42.087	-47.776	MOC-1-010	0	0-1000	
Peracle reticulata	Ga47	5	1	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Peracle reticulata	Ga47	6	1	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Peracle reticulata	Ga47	8	7	13	8/17/11	40.929	-52.071	MOC-01-009	5	100-200	
Peracle reticulata	Ga47	7	10	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Peracle reticulata	Ga47	9	6	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Peracle reticulata	Ga47	10	1	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Peracle triacantha	Ga39	4	2	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Peracle triacantha	Ga39	5	1	08	8/14/11	38.499	-51.995	Reeve	6	0-100	
Peracle triacantha	Ga39	6	1	13	8/17/11	40.529	-51.592	MOC-01-008	0	0-1000	
Peracle triacantha	Ga39	7	1	13	8/17/11	40.929	-52.071	MOC-01-009	3	400-600	
Pneumoderma sp.	Ga113	2	14	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Pneumoderma sp.	Ga113	3	14	26	8/23/11	47.490	-41.992	Reeve	15	0-100	
Pneumoderma sp.	Ga113	4	3	30	8/24/11	49.552	-41.942	Reeve	16	0-100	
Pneumoderma sp.	Ga113	5	1	31	8/24/11	49.993	-41.990	MOC-01-016	7	25-50	
Pneumoderma? Sp.	Ga113	1	2	Test 2	8/10/11	36.346	-56.179	Reeve		0-100	
Pterotracheidae	Ga111	1	1	05	8/13/11	36.967	-52.006	Reeve		0-100	70 % EtOH
Styliola subula	Ga13	5	3	03	8/12/11	35.976	-51.987	Reeve	4	0-100	
Styliola subula	Ga13	6	3	05	8/13/11	36.962	-52.009	MOC-01-005	7	25-50	70 % EtOH
Styliola subula	Ga13	7	2	05	8/13/11	36.962	-52.009	MOC-01-005	6	50-100	70 % EtOH
Styliola subula	Ga13	8	25	08	8/14/11	38.499	-51.995	Reeve	6	0-100	

Species	Code	Vial	N	St.	Date	Lat.	Long.	Gear Type	Net	Depth	Notes
Styliola subula	Ga13	9	4	08	8/15/11	38.510	-51.960	MOC-01-006	7	50-23	
Styliola subula	Ga13	10	32	10	8/15/11	38.998	-51.999	Reeve	7	0-100	
Styliola subula	Ga13	11	12	10	8/16/11	39.416	-51.969	Reeve	8	0-100	
Styliola subula	Ga13	12	3	10	8/16/11	39.416	-51.969	Reeve	8	0-100	70 % EtOH
Styliola subula	Ga13	14	1	13	8/17/11	40.929	-52.071	MOC-01-009	2	600-8000	
Styliola subula	Ga13	13	2	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Styliola subula	Ga13	15	13	21	8/22/11	44.942	-41.998	Reeve	13	0-100	
Styliola subula	Ga13	16	7	24	8/22/11	46.502	-41.997	Reeve	14	0-100	
Styliola subula	Ga13	17	1	31	8/24/11	49.993	-41.990	MOC-01-016	7	25-50	
Thliptodon diaphanus	Ga28	4	1	05	8/13/11	36.967	-52.006	Reeve		0-100	
Thliptodon diaphanus	Ga28	5	1	13	8/18/11	40.878	-51.976	Reeve	9	0-100	
Thliptodon diaphanus	Ga28	6	2	21	8/22/11	44.942	-41.998	Reeve	13	0-100	

Appendix 5. OC473 Science Party Watch Schedule

Day Watch 0800 – 2000

BIOLOGY
Watch Leader: Lawson
Copley
White
Bergan
Wurtzell

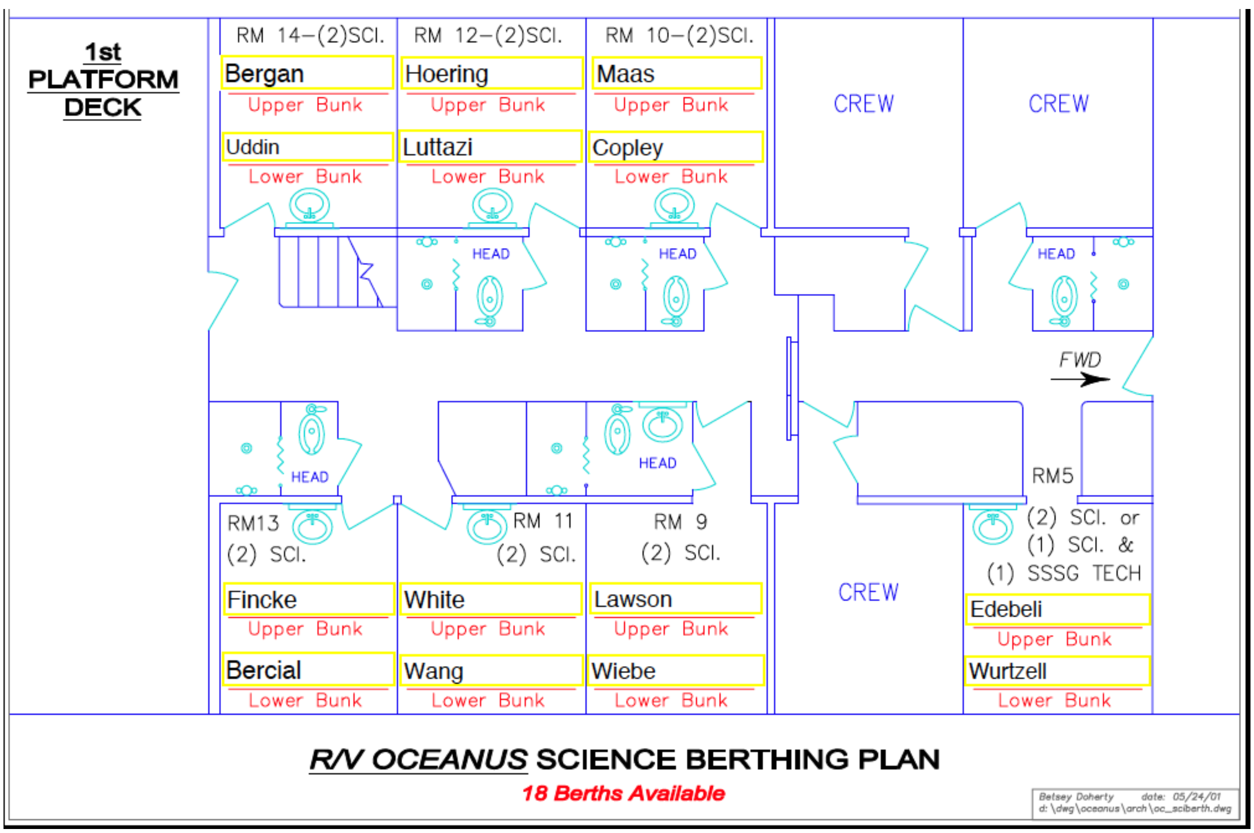
CHEMISTRY
Watch Leader: Hoering
Luttazi

Night Watch 2000 – 0800

BIOLOGY
Watch Leader: Wiebe
Maas
Bercial
Fincke

CHEMISTRY
Watch Leader: Wang
Edebeli
Uddin

Appendix 6. Science Party Berthing Plan



Appendix 7. Over-the-side Insurance Policy

OTS REPORT #11-34
American Home Insurance: 49136
Underwriter: Michael Coyle
OTS/Coastal Mixing Policy: Effective 1/1/11
Effective Date of Endorsement: August 7, 2011
Coverage bound for:
Project Number 84106800/84106802
Additional Premium Amount
$9,231
Deductible $5,000
Project Period
August 7, 2011 to September 1, 2011
Equipment Valuation $946,773
Vessel(s)
Contact: Gareth Lawson
Email: glawson@whoi.edu
Extension: 3713
Project Name: Horizontal and Vertical Distribution of Thecosome Pteropods in Relation to Carbonate Chemistry in the Northwest Atlantic and Northeast Pacific Purpose: To conduct acoustic, net, and optical surveys of zooplankton abundance and distribution in relation to concurrent measurements of carbonate chemistry in the NW Atlantic
Project Number: 84106800 (68%), 84106802 (32%)
Investigators: Gareth Lawson (glawson@whoi.edu) Andone Lavery (alavery@whoi.edu) Peter Wiebe (pwiebe@whoi.edu)
Equipment: Equipment 1. EdgeTech Inc. deep towed broadband acoustic scattering system, including deck unit, underwater unit (combined $152,850), Seabird Fastcat 49 CTD ($8,300), 6 custom Airmar transducers ($5,708), Wetlabs fluorometer ($3,874), Seabird 5t pump ($1,751), OIS transponder ($2,000), and custom WHOI-built towed body ($10,000). Total system valuation $184,483. 2. One full 1-m2 MOCNESS (Multiple Opening and Closing Net and Environmental Sensing System) with 9 nets and deck unit ($65,000) and one 1/4-m2 MOCNESS ($69,250), and a custom strobe light system ($15,000). Manufacturer is BESS (Biological Environmental Sampling Systems). Total system valuation $149,250. 3. Multi-frequency acoustic system with surface-towed and hull-mounted transducers including deck units (models 244 and 242), cables, underwater multiplexing unit, and transducers, all from Hydroacoustic Technology Inc ($239,900). System also includes an OIS transponder ($2,000), custom modified Endeco towed body ($20,000), and custom tow boom ($10,000). Total system valuation $278,040. 4. Microscopes. Three at $10,000 each. Total valuation $30,000. Multiparameter Inorganic Carbon Analyzer: $130,000. Dissolved Inorganic Carbon Auto-analyzer: $62,000. Alkalinity analyzer: $36,000. General Oceanics underway pCO2 system: $65,000. Sea-bird SBE 49 CTD $12,000.
GRAND TOTAL: $946,773.

Description of Project: Start date: Sunday, August 7, 2011 End date: Thursday, September 1, 2011 Vessel: R/V Oceanus Area of operations: New England continental shelf, Scotian Shelf, Grand Banks, and offshore waters, including a transect from 35N/52W to 50N/42W. Water depths of 20 to 6000m. 1. The Edgetech deep towed system will be profiled or towed with the vessel underway between the surface and 500m using a portable oceanographic winch with .322 cable. This cable has a breaking strength of 10,000lbs. The system has a transponder attached. 2. The MOCNESS will be towed with the vessel underway to depths of 1000m using the vessel's oceanographic winch with .322 cable. 3. The multi-frequency acoustic system will be towed alongside the vessel at the surface from a tow boom with the vessel underway, with a safety line attached. The system has a transponder atttached. A second complement of transducers will be mounted in wells in the vessel's hull. 4. The microscopes will be installed and used in the main lab.

Appendix 8 Event Log

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110807.1437.001	Ship	startCruise	0	NaN	NaN	10:31	8/7/11 14:37	41.523267	-70.671983	NaN		NaN	
20110807.1741.001	MICA	start	0	NaN	NaN	13:41	8/7/11 17:41	41.197583	-70.873383	20		aWang	
20110807.2152.001	HTI-Hull	start	0	NaN	1	17:51	8/7/11 21:52	40.829750	-70.062033	4		gLawson	
20110808.0014.001	underwayPCO2	start	0	NaN	NaN	16:20	8/8/11 0:14	40.605200	-69.580317	4		aWang	
20110808.0344.001	Echosounder	end	0	NaN	NaN	22:00	8/8/11 3:44	40.295000	-68.888250	NaN		NaN	12KHz secured on Knudsen at 01:50Z to test possible interference
20110808.1312.001	ADCP150	end	0	NaN	NaN	8:00	8/8/11 13:12	39.668070	-66.946930	3716		gLawson	Approx 0800 local secured ADCP150 to test for Noise; position added from alongtrack
20110808.1327.001	Hammarhead	start	0	Test 1	1	9:25	8/8/11 13:27	39.692400	-66.920683	NaN		aLavery	
20110808.1405.001	ADCP150	end	0	NaN	NaN	10:03	8/8/11 14:05	39.668317	-66.946750	NaN		gLawson	ADCP150 remains off due to interferemce with other instruments
20110808.1406.001	Hammarhead	end	0	Test 1	1	10:06	8/8/11 14:06	39.667550	-66.947517	3784		aLavery	
20110808.1448.001	CTD911	start	0	0	1	10:48	8/8/11 14:48	39.653700	-66.957917	3785	575	aWang	Test Station 1; ~550 m cast
20110808.1448.002	VPR	start	0	Test 1	1	10:48	8/8/11 14:48	39.653700	-66.957917	3785	575	gLawson	chg. from 20110808.1658.001 to 20110808.1448.002 to match ctd-00-01 start
20110808.1552.001	CTD911	end	0	0	1	11:52	8/8/11 15:52	39.649850	-66.976417	3782	575	aWang	Test Station 1
20110808.1552.002	VPR	end	0	Test 1	1	11:52	8/8/11 15:52	39.649850	-66.976417	3782	575	gLawson	chg from 20110808.1701.001 to 20110808.1552.002 to match ctd-00-01 end
20110808.1815.001	MacroFaunaObs	start	0	NaN	NaN	14:15:22	8/8/11 18:15	39.584857	-66.739840	NaN		tWhite	chg from 20110809.0007.001 to 20110808.1815.001; coordinate edit 14-aug-2011 07:30
20110808.1824.001	MacroFaunaObs	end	0	NaN	NaN	14:24:26	8/8/11 18:24	39.577965	-66.707352	NaN		tWhite	chg from 20110809.0011.001 to 20110808.1824.001 ; coordinate edit 14-aug-2011 07:30
20110808.1831.001	MacroFaunaObs	start	0	NaN	NaN	14:31:54	8/8/11 18:31	39.572630	-66.680450	NaN		tWhite	chg. from 20110809.0029.001 to 20110808.1831.001; corrected position
20110808.1831.001	MacroFaunaObs	start	0	NaN	NaN	14:31:54	8/8/11 18:31	39.657220	-66.955980	NaN		NaN	transit whoi to station 1; please change date to 08-aug-2011 (tw); chgd evt from 20110814.1056.001 to 20110808.1831.001 (njc); corrected position with alongtrack data
20110808.1844.001	MacroFaunaObs	end	0	NaN	NaN	14:44:14	8/8/11 18:44	39.559718	-66.658293	NaN		tWhite	chg from 20110809.0040.001 to 20110808.1844.001 ; coordinate change 14-aug-2011 07:30
20110808.1911.001	MOCNESS	start	0	Test 1	1	15:12	8/8/11 19:12	39.567583	-66.662050	4037		pWiebe	
20110808.2056.001	MacroFaunaObs	start	0	NaN	NaN	16:56:43	8/8/11 20:56	39.572605	-66.615137	NaN		tWhite	chg from 20110809.0043.001 to 20110808.2056.001 ; coordinate change 14-aug-2011
20110808.2128.001	MOCNESS	end	0	Test 1	1	15:51	8/8/11 21:28	39.588880	-66.646500	4037	105	pWiebe	
20110808.2158.001	MacroFaunaObs	end	0	NaN	NaN	17:58:20	8/8/11 21:58	39.536045	-66.365310	NaN		tWhite	chg from 20110809.0045.001 to 20110808.2158.001 ; coordiante change 14-aug-2011

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110808.2222.001	MacroFaunaObs	start	0	NaN	NaN	18:22:25	8/8/11 22:22	39.507830	-66.269550	NaN		tWhite	chg from 20110809.0046.001 to 20110809.2222.001; chgd from 20110809.2222.001 to 20110808.2222.001; corrected position
20110808.2339.001	MacroFaunaObs	end	0	NaN	NaN	19:39:11	8/8/11 23:39	39.408420	-65.955850	NaN		tWhite	chg from 20110809.0048.001 to 20110808.2339.001; corrected position
20110808.2354.001	Other	edit config	0	NaN	NaN	17:37	8/8/11 23:54	39.387650	-65.892000	NaN		NaN	changed config to make lat/lon editable
20110809.0948.001	MacroFaunaObs	start	0	NaN	NaN	5:47	8/9/11 9:48	38.668667	-63.582800	NaN		tWhite	
20110809.1101.001	MacroFaunaObs	end	0	NaN	NaN	6:58	8/9/11 11:01	38.599233	-63.337050	NaN		tWhite	
20110809.1121.001	MacroFaunaObs	start	0	NaN	NaN	7:21	8/9/11 11:21	38.579850	-63.268350	NaN		tWhite	
20110809.1130.001	Echosounder	start	0	NaN	NaN	7:30	8/9/11 11:30	38.571680	-63.240400	NaN		NaN	12KHz on Knudsen restarted; chgd evt from 20110809.0142.001 to 20110809.1130.001: lat/lon added later
20110809.1159.001	Echosounder	end	0	NaN	NaN	7:57	8/9/11 11:59	38.540367	-63.146233	2809		NaN	Securing echosounder d.t. possible noise interferrence
20110809.1200.001	Echosounder	end	0	NaN	NaN	7:59	8/9/11 12:00	38.539267	-63.142817	2755		NaN	securing echosounder d.t. possible acoustic interferrence
20110809.1355.001	MacroFaunaObs	end	0	NaN	NaN	9:54	8/9/11 13:55	38.439417	-62.763200	NaN		tWhite	
20110809.1438.001	MacroFaunaObs	start	0	NaN	NaN	10:37	8/9/11 14:38	38.405000	-62.623300	NaN		tWhite	
20110809.1608.001	MacroFaunaObs	end	0	NaN	NaN	12:07	8/9/11 16:08	38.303567	-62.337133	NaN		tWhite	
20110809.1631.001	MacroFaunaObs	start	0	NaN	NaN	12:30	8/9/11 16:31	38.274333	-62.263850	NaN		tWhite	
20110809.1725.001	MacroFaunaObs	end	0	NaN	NaN	13:25	8/9/11 17:25	38.211500	-62.082133	NaN		tWhite	
20110809.1751.001	MacroFaunaObs	start	0	NaN	NaN	13:50	8/9/11 17:51	38.182700	-61.986317	NaN		tWhite	
20110809.2046.001	MacroFaunaObs	end	0	NaN	NaN	16:45	8/9/11 20:46	37.978633	-61.323267	NaN		tWhite	
20110809.2101.001	MacroFaunaObs	start	0	NaN	NaN	17:00	8/9/11 21:01	37.960733	-61.269150	NaN		tWhite	
20110809.2159.001	MacroFaunaObs	end	0	NaN	NaN	17:59	8/9/11 22:00	37.901317	-61.067650	NaN		tWhite	
20110809.2225.001	MacroFaunaObs	start	0	NaN	NaN	18:24	8/9/11 22:25	37.871717	-60.976850	NaN		tWhite	
20110809.2311.001	MacroFaunaObs	end	0	NaN	NaN	19:10	8/9/11 23:11	37.811633	-60.813700	NaN		tWhite	
20110810.0046.001	ReeveNet	start	0	NaN	1	20:45	8/10/11 0:46	37.743050	-60.628200	NaN	150 mwo	gLawson	100m : 150m wire out
20110810.0122.001	ReeveNet	end	0	NaN	1	21:22	8/10/11 1:22	37.741600	-60.649600	NaN	150 mwo	gLawson	
20110810.0941.001	MacroFaunaObs	start	0	NaN	NaN	5:40	8/10/11 9:41	37.256250	-59.026583	NaN		tWhite	
20110810.1305.001	MacroFaunaObs	end	0	NaN	NaN	9:05	8/10/11 13:06	37.027800	-58.294267	NaN		tWhite	
20110810.1321.001	MacroFaunaObs	start	0	NaN	NaN	9:05	8/10/11 13:21	37.012350	-58.241600	NaN		tWhite	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110810.1322.001	MacroFaunaObs	start	0	NaN	NaN	9:21	8/10/11 13:22	37.011300	-58.237733	NaN		tWhite	
20110810.1533.001	MacroFaunaObs	end	0	NaN	NaN	11:32	8/10/11 15:33	36.862033	-57.794533	NaN		tWhite	
20110810.1612.001	MacroFaunaObs	start	0	NaN	NaN	12:11	8/10/11 16:12	36.836833	-57.670850	NaN		tWhite	
20110810.1755.001	MacroFaunaObs	end	0	NaN	NaN	13:54	8/10/11 17:55	36.713100	-57.332783	NaN		tWhite	
20110810.1906.001	MacroFaunaObs	start	0	NaN	NaN	15:06	8/10/11 19:06	36.638250	-57.085317	NaN		tWhite	
20110810.2030.001	HTI-Hull	end	0	NaN	1	14:30	8/10/11 20:30	36.543270	-56.798030	NaN		gLawson	this entry moved to before HTI-Hull/start; evnt# 20110810.2037.001; loctime ~ 16:30; evt#, date, timeUTC, GPS_time chg from 20110811.1249.001 to 20110810.2030.001; pos added from alongtrack
20110810.2037.001	HTI-Hull	start	0	NaN	2	16:36	8/10/11 20:37	36.536433	-56.772250	NaN		gLawson	
20110810.2206.001	MacroFaunaObs	end	0	NaN	NaN	18:05	8/10/11 22:06	36.441700	-56.458233	NaN		tWhite	
20110810.2233.001	MacroFaunaObs	start	0	NaN	NaN	18:32	8/10/11 22:33	36.412633	-56.368633	NaN		tWhite	
20110810.2256.001	MacroFaunaObs	end	0	NaN	NaN	18:55	8/10/11 22:56	36.386117	-56.288633	NaN		tWhite	
20110810.2354.001	CTD911	start	0	0	2	19:54	8/10/11 23:54	36.345850	-56.172550	NaN	500	aWang	Test Station 2; ~500m cast
20110810.2354.002	VPR	start	0	Test 2	2	19:54	8/10/11 23:54	36.345850	-56.172550	NaN	500	gLawson	changed evt#, R2R_Event, dateTimeUTC, GPS_Time from 20110811.1253.001 to 20110810.2354.002 to match ctd
20110811.0016.001	Echosounder	start	0	Test 2	2	19:54	8/11/11 0:16	36.345933	-56.173067	5380		NaN	
20110811.0040.001	Echosounder	end	0	Test 2	2	20:39	8/11/11 0:40	36.345917	-56.175350	NaN		NaN	Rob turned the 3.5/12 sounders off ~15 mins ago
20110811.0050.001	CTD911	end	0	0	2	20:49	8/11/11 0:50	36.346167	-56.175700	NaN	500	aWang	Test Station 2
20110811.0050.002	VPR	end	0	Test 2	2	20:49	8/11/11 0:50	36.346167	-56.175700	NaN	500	gLawson	changed evt#, date, timeUTC, GPS_time from 20110811.1258.001 to 20110811.0050.002 to match ctd
20110811.0105.001	ReeveNet	start	0	Test 2	2	21:05	8/11/11 1:05	36.346217	-56.179083	NaN	200 mwo	gLawson	
20110811.0150.001	ReeveNet	end	0	Test 2	2	21:49	8/11/11 1:50	36.346183	-56.190933	NaN	200 mwo	gLawson	
20110811.0921.001	MacroFaunaObs	start	0	NaN	NaN	5:20	8/11/11 9:21	35.893117	-54.777767	NaN		tWhite	
20110811.0921.002	MacroFaunaObs	start	0	NaN	NaN	5:20	8/11/11 9:21	35.893017	-54.777450	NaN		tWhite	
20110811.1159.001	HTI-Hull	end	0	NaN	2	7:59	8/11/11 11:59	35.734767	-54.273283	NaN		gLawson	Rebooting machine
20110811.1239.001	HTI-Hull	start	0	NaN	3	8:39	8/11/11 12:39	35.695500	-54.143817	NaN		gLawson	
20110811.1533.001	MacroFaunaObs	end	0	NaN	NaN	11:33	8/11/11 15:34	35.511150	-53.572667	NaN		tWhite	
20110811.1557.001	MacroFaunaObs	start	0	NaN	NaN	11:56	8/11/11 15:57	35.486667	-53.498433	NaN		tWhite	
20110811.1806.001	MacroFaunaObs	end	0	NaN	NaN	14:05	8/11/11 18:06	35.352733	-53.078817	NaN		tWhite	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110811.1906.001	MacroFaunaObs	start	0	NaN	NaN	14:54	8/11/11 19:06	35.316050	-52.968083	NaN		tWhite	
20110811.1916.001	MacroFaunaObs	end	0	NaN	NaN	15:14	8/11/11 19:16	35.305367	-52.945267	NaN		tWhite	
20110811.1921.001	MacroFaunaObs	start	0	NaN	NaN	15:20	8/11/11 19:21	35.301217	-52.934583	NaN		tWhite	
20110811.2023.001	HTI-Hull	end	0	NaN	3	16:23	8/11/11 20:23	35.240717	-52.730300	NaN		gLawson	
20110811.2132.001	MacroFaunaObs	end	0	NaN	NaN	17:32	8/11/11 21:32	35.168100	-52.512783			tWhite	
20110811.2201.001	MacroFaunaObs	start	0	NaN	NaN	18:01	8/11/11 22:02	35.143133	-52.441167			tWhite	
20110811.2209.001	HTI-Hull	start	0	NaN	4	18:09	8/11/11 22:10	35.134667	-52.417150			gLawson	
20110811.2229.001	MacroFaunaObs	end	0	NaN	NaN	18:29	8/11/11 22:29	35.113017	-52.354050			tWhite	
20110812.0021.001	Ship	startTransect	1	1	NaN	20:21	8/12/11 0:21	35.003183	-51.997817			NaN	
20110812.0022.001	Ship	startStation	1	1	NaN	20:21	8/12/11 0:22	35.002450	-51.998750			NaN	
20110812.0030.001	ReeveNet	start	1	1	3	20:30	8/12/11 0:30	35.001017	-52.003867		150 mwo	gLawson	
20110812.0057.001	Echosounder	start	1	1	NaN	20:56	8/12/11 0:57	34.998067	-52.015717			NaN	
20110812.0102.001	ReeveNet	end	1	1	3	21:02	8/12/11 1:02	34.997600	-52.017917	5467	150 mwo	gLawson	nominal 100m : 150m wire out
20110812.0121.001	MOCNESS	start	1	1	2	21:22	8/12/11 1:21	34.996083	-52.026767	5467		pWiebe	
20110812.0127.001	HTI-Hull	end	1	1	4	21:26	8/12/11 1:27	34.996400	-52.030217	NaN		gLawson	
20110812.0135.001	HTI-Hull	start	1	1	5	21:35	8/12/11 1:35	34.999650	-52.035083	5467		gLawson	
20110812.0138.001	Echosounder	end	1	1	NaN	21:38	8/12/11 1:38	35.000667	-52.036700	NaN		NaN	
20110812.0200.001	HTI-Hull	end	1	1	5	21:59	8/12/11 2:00	35.008133	-52.048517	NaN		gLawson	
20110812.0257.001	HTI-Hull	start	1	1	6	22:56	8/12/11 2:57	35.029850	-52.079800	NaN		gLawson	
20110812.0401.001	MOCNESS	end	1	1	2	0:01	8/12/11 4:02	35.061700	-52.118450	NaN	1005.8	pWiebe	
20110812.0404.001	HTI-Hull	end	1	1	6	0:04	8/12/11 4:04	35.062917	-52.118867	NaN		gLawson	
20110812.0415.001	Echosounder	start	1	1	NaN	0:15	8/12/11 4:15	35.066370	-52.121300	NaN		NaN	This start was entered AFTER the end so the event number is wrong. The local time is approximate. chged evnt# from 20110812.0503.001 to 20110812.0415.001; chgd lat/lon
20110812.0419.001	Echosounder	end	1	1	NaN	0:18	8/12/11 4:19	35.069850	-52.120633	NaN		NaN	
20110812.0419.002	HTI-Hull	start	1	1	7	0:17	8/12/11 4:19	35.070233	-52.120333	5464		gLawson	
20110812.0429.001	Hammarhead	start	1	1	2	0:28	8/12/11 4:29	35.070533	-52.115633	NaN		aLavery	
20110812.0436.001	HTI-Hull	end	1	NaN	7	0:36	8/12/11 4:36	35.067450	-52.111500	NaN		gLawson	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110812.0510.001	Hammarhead	end	1	1	2	1:10	8/12/11 5:10	35.059000	-52.102117	NaN	100	aLavery	
20110812.0514.001	Echosounder	start	1	1	3	1:14	8/12/11 5:15	35.057733	-52.100333	NaN		NaN	
20110812.0531.001	CTD911	start	1	1	3	1:30	8/12/11 5:31	35.057467	-52.099883	5465	1000	aWang	1000m cast
20110812.0531.002	VPR	start	1	1	3	1:30	8/12/11 5:31	35.057467	-52.099883	5465	1000	gLawson	Time, lat, and long chgd to match CTD 0103; chg from 20110812.1546.001 to 20110812.0531.002
20110812.0539.001	HTI-Hull	start	1	1	8	1:38	8/12/11 5:39	35.057767	-52.100317	NaN		gLawson	
20110812.0540.001	Echosounder	end	1	1	3	1:39	8/12/11 5:40	35.057817	-52.100417	5464		NaN	
20110812.0600.001	Ship	changeTi mezone	1	1	NaN	2:00	8/12/11 6:00	35.059000	-52.101130	NaN		NaN	chgd from 20110812.1118.001 to 20110812.0600.001; pos added from alongtrack
20110812.0643.001	CTD911	end	1	1	3	3:42	8/12/11 6:43	35.062317	-52.101050		1000	aWang	chgd tzone from -4 to -3; added 1 hour to timeLocal
20110812.0643.002	VPR	end	1	1	3	3:42	8/12/11 6:43	35.062317	-52.101050	NaN	1000	gLawson	Time, lat, and long chgd to match CTD 0103; chgd evt from 20110812.1547.001 to 20110812.0643.002
20110812.0736.001	Echosounder	start	1	1	4	4:35	8/12/11 7:36	35.052767	-52.081900	5467		NaN	chgd tzone from -4 to -3; added 1 hour to timeLocal
20110812.0737.001	Echosounder	end	1	1	4	4:36	8/12/11 7:37	35.052783	-52.081933	5467		NaN	chgd tzone from -4 to -3; added 1 hour to timeLocal
20110812.0738.001	CTD911	start	1	1	4	4:37	8/12/11 7:38	35.052850	-52.082100	5467	3000	aWang	3000m cast; chgd tzone from -4 to -3; added 1 hour to timeLocal
20110812.1112.001	CTD911	end	1	1	4	7:45	8/12/11 11:12	35.068250	-52.077317	5467	3000	aWang	chg tzone from -4 to -3 (njc)
20110812.1113.001	MOCNESS	start	1	1	3	8:12	8/12/11 11:13	35.068617	-52.076917	5467		pWiebe	chgd tzone from -4 to -3; added 1 hour to timeLocal (njc)
20110812.1344.001	MacroFaunaObs	start	1	1	3	10:43	8/12/11 13:44	35.103917	-51.981517	NaN		tWhite	mocness count station1 cast 3
20110812.1406.001	MacroFaunaObs	end	1	1	3	11:05	8/12/11 14:06	35.109233	-51.966567	NaN		tWhite	mocness count station1 cast 3
20110812.1418.001	MOCNESS	end	1	1	3	10:45	8/12/11 14:18	35.111883	-51.957133	NaN	1010	pWiebe	
20110812.1420.001	Echosounder	start	1	1	5	11:19	8/12/11 14:20	35.112183	-51.955717	5465		NaN	
20110812.1437.001	CTD911	start	1	1	5	11:36	8/12/11 14:37	35.115583	-51.944683	5465	1000	aWang	
20110812.1437.002	VPR	start	1	1	4	11:37	8/12/11 14:37	35.115700	-51.944450	NaN	1000	gLawson	
20110812.1450.001	Echosounder	end	1	1	5	11:50	8/12/11 14:51	35.118117	-51.939250	5470		NaN	
20110812.1534.001	CTD911	end	1	1	5	12:34	8/12/11 15:34	35.121833	-51.927300	NaN	1000	aWang	
20110812.1535.001	VPR	end	1	1	4	12:35	8/12/11 15:35	35.121900	-51.926967	NaN	1000	gLawson	
20110812.1547.002	HTI-Hull	end	1	1	8	12:47	8/12/11 15:47	35.126117	-51.921117	NaN		gLawson	
20110812.1550.001	Hammarhead	start	1	1	3	12:50	8/12/11 15:50	35.128300	-51.920617	NaN		aLavery	
20110812.1644.001	HTI-Hull	start	1	1	9	13:44	8/12/11 16:44	35.153517	-51.912150	NaN		gLawson	
20110812.1645.001	Hammarhead	end	1	1	3	13:44	8/12/11 16:45	35.153767	-51.912067	NaN	195	aLavery	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110812.1646.001	Ship	endStation	1	1	NaN	13:46	8/12/11 16:47	35.154667	-51.911867	NaN		NaN	
20110812.1701.001	MacroFaunaObs	end	1	NaN	NaN	14:00	8/12/11 17:01	35.188400	-51.917433	NaN		tWhite	transit to station 2
20110812.1856.001	Echosounder	start	1	2	6	15:55	8/12/11 18:56	35.496933	-52.000267	997.9		NaN	
20110812.1924.001	CTD911	start	1	2	6	16:24	8/12/11 19:24	35.474550	-51.990717	1021	1000	aWang	
20110812.1925.001	VPR	start	1	2	5	16:24	8/12/11 19:25	35.474600	-51.990767	1023	1000	gLawson	
20110812.2046.001	CTD911	end	1	2	6	17:45	8/12/11 20:46	35.464950	-51.998050	NaN	1000.8	aWang	
20110812.2047.001	VPR	end	1	2	5	17:47	8/12/11 20:47	35.464967	-51.998050	NaN	1000.8	gLawson	
20110812.2053.001	Echosounder	end	1	2	6	17:53	8/12/11 20:53	35.465133	-51.997983	NaN		NaN	
20110812.2102.001	Hammarhead	start	1	2	4	18:02	8/12/11 21:02	35.468250	-51.997100	NaN		aLavery	
20110812.2106.001	HTI-Hull	end	1	2	9	18:06	8/12/11 21:07	35.470517	-51.997333	NaN		gLawson	
20110812.2145.001	Hammarhead	end	1	2	4	18:46	8/12/11 21:46	35.482967	-51.989767	NaN	125	aLavery	
20110812.2153.001	Ship	endStation	1	2	NaN	18:52	8/12/11 21:53	35.484317	-51.986167	NaN		NaN	
20110812.2153.002	HTI-Hull	start	1	2	10	18:53	8/12/11 21:53	35.484717	-51.986050	NaN		gLawson	
20110812.2158.001	MacroFaunaObs	start	1	NaN	NaN	18:57	8/12/11 21:58	35.492867	-51.989817	NaN		tWhite	transit to station 3
20110812.2236.001	MacroFaunaObs	end	1	NaN	NaN	19:36	8/12/11 22:36	35.600983	-51.999550	NaN		tWhite	
20110813.0005.001	HTI-Hull	end	1	2	10	21:05	8/13/11 0:05	36.816230	-51.955900	NaN		gLawson	added late; chgd event # from 20110814.1651.001 to 20110813.0005.001; position added from alongtrack
20110813.0042.001	Ship	startStation	1	3	NaN	21:43	8/13/11 0:42	35.996267	-51.999683	NaN		NaN	
20110813.0055.001	Hammarhead	start	1	3	5	21:55	8/13/11 0:55	35.997730	-51.994650	NaN	100	aLavery	chgd evt from 20110813.1403.001 to 20110813.0055.001; corrected position
20110813.0125.001	Hammarhead	end	1	3	5	22:24	8/13/11 1:25	35.982783	-51.989250	NaN	100	aLavery	
20110813.0138.001	ReeveNet	start	1	3	4	22:32	8/13/11 1:38	35.976483	-51.987033	NaN	200 mwo	gLawson	
20110813.0140.001	HTI-Hull	start	1	3	11	22:39	8/13/11 1:40	35.975667	-51.986683	NaN		gLawson	
20110813.0239.001	ReeveNet	end	1	3	4	23:40	8/13/11 2:39	35.959733	-51.977467	NaN	200 mwo	gLawson	13 pteropod species found!
20110813.0245.001	Echosounder	start	1	3	7	23:44	8/13/11 2:45	35.957700	-51.976483	4857	1000	NaN	
20110813.0247.001	Echosounder	end	1	3	7	23:47	8/13/11 2:48	35.956933	-51.976050	NaN	1000	NaN	
20110813.0256.001	CTD911	start	1	3	7	23:55	8/13/11 2:56	35.954900	-51.973783	4857	1000	aWang	
20110813.0257.001	VPR	start	1	3	6	23:56	8/13/11 2:57	35.954900	-51.973467	NaN	1000	gLawson	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110813.0419.001	VPR	end	1	3	6	1:18	8/13/11 4:19	35.958283	-51.956400	NaN	1000	gLawson	vpr not flashing at surface
20110813.0420.001	CTD911	end	1	3	7	1:19	8/13/11 4:20	35.958083	-51.956083	4857	1000	aWang	
20110813.0431.001	Ship	endStation	1	3	NaN	1:30	8/13/11 4:31	35.971483	-51.952283	NaN		NaN	a little slow marking this event.
20110813.0732.001	Ship	startStation	1	4	NaN	4:31	8/13/11 7:32	36.497450	-52.000100	NaN		NaN	
20110813.0737.001	Echosounder	start	1	4	8	4:35	8/13/11 7:37	36.499117	-51.998533	5387	1000	NaN	
20110813.0739.001	Echosounder	end	1	4	8	4:39	8/13/11 7:39	36.499267	-51.998650	5387	1000	NaN	
20110813.0743.001	VPR	start	1	4	7	4:43	8/13/11 7:44	36.500000	-51.999500	5387	1000	gLawson	
20110813.0745.001	CTD911	start	1	4	8	4:44	8/13/11 7:45	36.500233	-51.999567	5387	1000	aWang	
20110813.0903.001	VPR	end	1	4	7	6:04	8/13/11 9:04	36.506167	-52.007183	NaN	1000	gLawson	
20110813.0904.001	CTD911	end	1	4	8	6:04	8/13/11 9:04	36.506100	-52.007517	NaN	1000	aWang	
20110813.0907.001	Ship	endStation	1	4	NaN	6:07	8/13/11 9:07	36.506417	-52.008383	NaN		NaN	
20110813.1200.001	Echosounder	start	1	5	9	9:00	8/13/11 12:00	36.996650	-51.999417	NaN		NaN	
20110813.1204.001	Ship	startStation	1	5	NaN	9:03	8/13/11 12:04	36.999033	-51.997600	NaN		NaN	
20110813.1213.001	CTD911	start	1	5	9	9:12	8/13/11 12:13	36.997517	-51.995033	NaN	1000	aWang	
20110813.1214.001	VPR	start	1	5	8	9:13	8/13/11 12:14	36.997467	-51.994900	NaN	1000	gLawson	
20110813.1226.001	Echosounder	end	1	5	9	9:26	8/13/11 12:26	36.996117	-51.991717	NaN	1000	NaN	
20110813.1311.001	VPR	end	1	5	8	10:10	8/13/11 13:11	36.989967	-51.980083	NaN	1000	gLawson	
20110813.1312.001	CTD911	end	1	5	9	10:11	8/13/11 13:12	36.989883	-51.979917	NaN	1000	aWang	
20110813.1337.001	MOCNESS	start	1	5	4	10:36	8/13/11 13:38	36.985317	-51.973750	NaN	1000	pWiebe	
20110813.1627.001	MOCNESS	end	1	5	4	13:27	8/13/11 16:27	36.909133	-51.925150	NaN	1000	pWiebe	
20110813.1647.001	Hammarhead	start	1	5	6	13:46	8/13/11 16:47	36.900883	-51.930833	NaN	100	aLavery	
20110813.1648.001	HTI-Hull	end	1	5	11	13:48	8/13/11 16:48	36.900250	-51.931317	NaN		gLawson	
20110813.1827.001	Hammarhead	end	1	5	6	15:26	8/13/11 18:27	36.851017	-51.962783	NaN	100	aLavery	
20110813.1835.001	HTI-Hull	start	1	5	12	15:34	8/13/11 18:35	36.846950	-51.965333	NaN		gLawson	
20110813.1846.001	CTD911	start	1	5	10	15:45	8/13/11 18:46	36.843683	-51.964017	NaN	3000	aWang	
20110813.1855.001	Echosounder	start	1	5	10	15:54	8/13/11 18:55	36.841500	-51.962017	NaN		NaN	
20110813.1857.001	Echosounder	end	1	5	10	15:57	8/13/11 18:57	36.840933	-51.961550	NaN		NaN	
20110813.2123.001	CTD911	end	1	5	10	18:23	8/13/11 21:23	36.811100	-51.955583	NaN	3000	aWang	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110813.2313.001	Tintinid net tow	start	1	5	2	20:13	8/13/11 23:13	36.998783	-51.998500	NaN	60 nominal	NaN	85m wire out; 30 cm diameter net w/ 53 micron mesh
20110813.2336.001	Tintinid net tow	end	1	5	2	20:36	8/13/11 23:36	36.991767	-52.002233	NaN	60 nominal	NaN	down at 10 m/min; up at 5 m/min
20110813.2340.001	ReeveNet	start	1	5	5	20:42	8/13/11 23:40	36.990283	-52.002583	NaN	200 mwo	gLawson	
20110814.0052.001	ReeveNet	end	1	5	5	21:52	8/14/11 0:52	36.967100	-52.006150	NaN	200 mwo	gLawson	
20110814.0113.001	MOCNESS	start	1	5	5	22:13	8/14/11 1:13	36.961800	-52.008833	NaN		pWiebe	
20110814.0403.001	MOCNESS	end	1	5	5	1:02	8/14/11 4:03	36.875767	-52.003983	NaN	1012	pWiebe	
20110814.0415.001	Echosounder	start	1	5	11	1:14	8/14/11 4:15	36.875583	-52.010633	5385		NaN	
20110814.0436.001	CTD911	start	1	5	11	1:35	8/14/11 4:37	36.869683	-52.015367	5385	200	aWang	200
20110814.0438.001	VPR	start	1	5	9	1:37	8/14/11 4:38	36.868950	-52.015467	5385	200	gLawson	S0
20110814.0446.001	Echosounder	end	1	5	11	1:45	8/14/11 4:46	36.865950	-52.015783	NaN	200	NaN	
20110814.0500.001	CTD911	end	1	5	11	2:00	8/14/11 5:00	36.863170	-52.015180	5387	200	aWang	Deployment ended at 5:00utc (+3hrs); changed evt#, etc. frm 20110814.0524.001 to 20110814.0500.001 -occured at 0500 utc; pos added from alongtrack data later
20110814.0500.002	VPR	end	1	5	9	2:00	8/14/11 5:00	36.863170	-52.015180	5385	200	gLawson	Deployment ended at 5:00 utc; changed evt# from 20110814.0526.001 to 20110814.0500.002 (njc); pos added from alongtrack data later
20110814.0510.001	CTD911	start	1	5	12	2:09	8/14/11 5:10	36.860333	-52.014883	NaN	1000	aWang	
20110814.0512.001	VPR	start	1	5	10	2:10	8/14/11 5:12	36.860033	-52.014850	NaN	1000	gLawson	
20110814.0630.001	CTD911	end	1	5	12	3:30	8/14/11 6:30	36.839130	-52.011370	NaN	1000	aWang	local time approximate; chgd evt# from 20110814.1026.001 to 20110814.0630.001 (njc); corrected position
20110814.0630.002	VPR	end	1	5	10	3:30	8/14/11 6:30	36.839130	-52.011370	NaN	1000	gLawson	chgd evt# from 20110814.1356.001 to 20110814.0630.002 (njc); corrected position
20110814.0643.001	Hammarhead	start	1	5	7	3:43	8/14/11 6:43	36.835767	-52.017067	NaN		aLavery	Acoustic bowtie survey
20110814.1159.001	Hammarhead	end	1	5	7	8:58	8/14/11 11:59	36.909233	-52.018650	NaN		aLavery	
20110814.1207.001	Ship	endStation	1	5	NaN	9:06	8/14/11 12:07	36.911483	-52.023767	NaN		NaN	
20110814.1218.001	MacroFaunaObs	start	1	NaN	NaN	9:17	8/14/11 12:19	36.923717	-52.028650	NaN		tWhite	transit to station 6
20110814.1605.001	Ship	startStation	1	6	NaN	13:05	8/14/11 16:05	37.498200	-52.000133	NaN		NaN	
20110814.1608.001	MacroFaunaObs	end	1	6	NaN	13:06	8/14/11 16:08	37.499617	-52.001533	NaN		tWhite	transit to station 6

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110814.1609.001	Echosounder	start	1	6	12	13:08	8/14/11 16:09	37.499967	-52.001933	NaN		NaN	
20110814.1613.001	VPR	start	1	6	11	13:12	8/14/11 16:14	37.500567	-52.002817	5370	1000	gLawson	
20110814.1614.001	CTD911	start	1	6	13	13:14	8/14/11 16:14	37.500583	-52.002833	5370	1000	aWang	
20110814.1617.001	HTI-Hull	end	1	6	12	13:17	8/14/11 16:18	37.501067	-52.003267	NaN		gLawson	
20110814.1618.001	Echosounder	end	1	6	12	13:17	8/14/11 16:18	37.501100	-52.003267	NaN		NaN	
20110814.1717.001	Hammarhead	other	1	6	NaN	14:16	8/14/11 17:17	37.513683	-51.996117	NaN		aLavery	changed HH computer time to +1 day advanced; previous file dates off by -1 day
20110814.1743.001	CTD911	end	1	6	13	14:44	8/14/11 17:44	37.519967	-51.990150	NaN	1000	aWang	
20110814.1744.001	VPR	end	1	6	11	14:44	8/14/11 17:44	37.520067	-51.990117	NaN	1000	gLawson	
20110814.1845.001	Ship	endStation	1	6	NaN	14:55	8/14/11 18:46	37.651000	-51.985120	NaN		NaN	time approximate; lat/lon added later from alongtrack data
20110814.1808.001	MacroFaunaObs	start	1	NaN	NaN	15:07	8/14/11 18:08	37.550050	-51.981983	NaN		tWhite	transit to station 7
20110814.1855.001	HTI-Hull	start	1	NaN	13	15:54	8/14/11 18:55	37.678233	-51.986300	NaN		gLawson	
20110814.2048.001	Ship	startStation	1	7	NaN	17:48	8/14/11 20:48	37.995683	-52.002700	NaN		NaN	
20110814.2048.002	Echosounder	start	1	7	13	17:48	8/14/11 20:49	37.996250	-52.002733	5338		NaN	
20110814.2050.001	MacroFaunaObs	end	1	7	NaN	17:49	8/14/11 20:50	37.998250	-52.002533	5339		tWhite	
20110814.2050.002	Ship	startStation	1	7	NaN	17:50	8/14/11 20:51	37.998667	-52.002183	NaN		NaN	
20110814.2053.001	Echosounder	end	1	7	13	17:52	8/14/11 20:53	37.999800	-52.001317	NaN		NaN	
20110814.2058.001	Echosounder	start	1	7	14	17:57	8/14/11 20:58	38.000600	-52.000367	NaN		NaN	
20110814.2058.002	CTD911	start	1	7	14	17:58	8/14/11 20:58	38.000667	-52.000283	NaN	1000	aWang	
20110814.2058.003	VPR	start	1	7	12	17:58	8/14/11 20:58	38.000667	-52.000283	NaN	996.1	gLawson	chg. evt. from 20110814.2254.001 to match ctd#14; new# = 20110814.2058.003
20110814.2122.001	HTI-Hull	end	1	7	13	18:21	8/14/11 21:22	37.999633	-51.996300	NaN		gLawson	
20110814.2142.001	HTI-Hull	start	1	7	14	18:37	8/14/11 21:42	37.994167	-51.994133	NaN		gLawson	
20110814.2227.001	CTD911	end	1	7	14	19:26	8/14/11 22:27	37.983967	-51.987617	NaN	996.1	aWang	
20110814.2229.001	VPR	end	1	7	12	19:28	8/14/11 22:29	37.983417	-51.986783	NaN	996.1	gLawson	
20110814.2232.001	Ship	endStation	1	7	NaN	19:31	8/14/11 22:32	37.983283	-51.984617	NaN		NaN	
20110815.0152.001	Ship	startStation	1	8	NaN	22:50	8/15/11 1:52	38.499730	-51.996280	NaN		NaN	logged late - after Reeve start; chgd evnt@ from 20110815.0158.001 to 20110815.0152.001; ; corrected position
20110815.0153.001	ReeveNet	start	1	8	6	22:52	8/15/11 1:54	38.499750	-51.995667	NaN	200 mwo	gLawson	100 nominal ; 200 mwo

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110815.0252.001	ReeveNet	end	1	8	6	23:52	8/15/11 2:52	38.516650	-51.983267	NaN	200 mwo	gLawson	100 nominal ; 200 mwo
20110815.0324.001	MOCNESS	start	1	8	6	0:23	8/15/11 3:24	38.510783	-51.960383	NaN		pWiebe	
20110815.0605.001	MOCNESS	end	1	8	6	3:05	8/15/11 6:05	38.443700	-51.990367	NaN	1000	pWiebe	
20110815.0633.001	Echosounder	start	1	8	15	3:32	8/15/11 6:33	38.445033	-51.991167	5314		NaN	
20110815.0634.001	Echosounder	end	1	8	15	3:34	8/15/11 6:34	38.444967	-51.991217	5314		NaN	
20110815.0639.001	CTD911	start	1	8	15	3:38	8/15/11 6:40	38.444683	-51.991200	5314	1000	aWang	
20110815.0641.001	VPR	start	1	8	13	3:40	8/15/11 6:41	38.444633	-51.991200	5314	1000	gLawson	
20110815.0740.001	CTD911	end	1	8	15	4:40	8/15/11 7:40	38.446317	-51.981583	5314	1000	aWang	
20110815.0741.001	VPR	end	1	8	13	4:40	8/15/11 7:41	38.446333	-51.981467	5314	1000	gLawson	
20110815.0813.001	CTD911	start	1	8	16	5:12	8/15/11 8:14	38.447267	-51.978833	5314	3000	aWang	
20110815.1056.001	CTD911	end	1	8	16	7:56	8/15/11 10:56	38.469600	-51.948467	5314	3000	aWang	
20110815.1110.001	Hammarhead	start	1	8	8	8:10	8/15/11 11:10	38.473067	-51.944383	NaN		aLavery	
20110815.1113.001	HTI-Hull	end	1	8	14	8:12	8/15/11 11:13	38.474317	-51.942517	NaN		gLawson	
20110815.1151.001	Hammarhead	end	1	8	8	8:50	8/15/11 11:51	38.494083	-51.912417	NaN	50	aLavery	
20110815.1211.001	MOCNESS	start	1	8	7	9:10	8/15/11 12:11	38.502867	-51.899733	NaN	1000	pWiebe	
20110815.1215.001	HTI-Hull	start	1	8	15	9:15	8/15/11 12:15	38.504250	-51.897783	NaN		gLawson	
20110815.1303.001	Other	dip net	1	8	1	10:02	8/15/11 13:03	38.526700	-51.862667	NaN	surfac e	NaN	sample for Sargassum weed community
20110815.1520.001	MOCNESS	end	1	8	7	12:20	8/15/11 15:20	38.574467	-51.753867	NaN	1005	pWiebe	
20110815.1552.001	VPR	start	1	8	14	12:51	8/15/11 15:52	38.570250	-51.744417	NaN	1000	gLawson	
20110815.1552.002	CTD911	start	1	8	17	12:52	8/15/11 15:53	38.570450	-51.744067	NaN	1000	aWang	
20110815.1656.001	VPR	end	1	8	14	13:56	8/15/11 16:56	38.576633	-51.710533	NaN	1000	gLawson	
20110815.1657.001	CTD911	end	1	8	17	13:57	8/15/11 16:57	38.576500	-51.710200	NaN	1000	aWang	
20110815.1708.001	Ship	endStatio n	1	8	NaN	14:08	8/15/11 17:08	38.574333	-51.702000	NaN		NaN	
20110815.1720.001	MacroFaunaObs	start	1	NaN	NaN	14:19	8/15/11 17:20	38.591367	-51.702550	NaN		tWhite	transit to station 9
20110815.2025.001	Echosounder	start	1	9	16	17:24	8/15/11 20:25	38.997317	-51.995017	NaN		NaN	
20110815.2026.001	MacroFaunaObs	end	1	9	NaN	17:25	8/15/11 20:26	38.998683	-51.995950	NaN		tWhite	
20110815.2030.001	Ship	startStatio n	1	9	NaN	17:29	8/15/11 20:30	38.998933	-51.996883	NaN		NaN	
20110815.2036.001	VPR	start	1	9	15	17:35	8/15/11 20:36	38.997667	-51.992050	NaN	1000	gLawson	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110815.2037.001	CTD911	start	1	9	18	17:30	8/15/11 20:37	38.997717	-51.991200	5300	1000	aWang	
20110815.2038.001	Echosounder	end	1	9	16	17:37	8/15/11 20:38	38.997717	-51.990517	NaN		NaN	
20110815.2213.001	CTD911	end	1	9	18	19:13	8/15/11 22:14	38.981850	-51.920900	NaN	996.3	aWang	
20110815.2214.001	VPR	end	1	9	15	19:14	8/15/11 22:14	38.981733	-51.920183	NaN	996.3	gLawson	
20110815.2228.001	Ship	endStation	1	9	NaN	19:27	8/15/11 22:28	38.983300	-51.910650	NaN		NaN	
20110816.0136.001	Ship	startStation	1	10	NaN	22:35	8/16/11 1:36	39.498350	-52.000233	NaN		NaN	
20110816.0143.001	ReeveNet	start	1	10	7	22:44	8/16/11 1:43	39.497767	-51.998850	NaN	200 mwo	gLawson	
20110816.0249.001	ReeveNet	end	1	10	7	23:49	8/16/11 2:50	39.483083	-51.985917	NaN	200 mwo	gLawson	
20110816.0253.001	Echosounder	start	1	10	17	23:50	8/16/11 2:53	39.483017	-51.985583	NaN		NaN	
20110816.0254.001	CTD911	start	1	10	19	23:53	8/16/11 2:54	39.482967	-51.985367	5274	1000	aWang	
20110816.0255.001	VPR	start	1	10	16	23:54	8/16/11 2:55	39.482900	-51.985217	5274	1000	gLawson	
20110816.0257.001	Echosounder	end	1	10	17	23:57	8/16/11 2:57	39.482767	-51.985033	5274		NaN	
20110816.0418.001	CTD911	end	1	10	19	1:16	8/16/11 4:18	39.481967	-51.975783	5274	1000	aWang	
20110816.0419.001	VPR	end	1	10	16	1:18	8/16/11 4:19	39.481950	-51.975667	5274	1000	gLawson	
20110816.0434.001	Hammarhead	start	1	10	9	1:33	8/16/11 4:34	39.479133	-51.974667	NaN		aLavery	
20110816.1411.001	MacroFaunaObs	start	1	NaN	NaN	11:10	8/16/11 14:11	39.432950	-51.942450	NaN		tWhite	bow tie
20110816.1540.001	MacroFaunaObs	end	1	NaN	NaN	12:39	8/16/11 15:40	39.439750	-51.967033	NaN		tWhite	bow tie
20110816.1755.001	Hammarhead	end	1	10	9	14:54	8/16/11 17:55	39.367383	-51.959667	NaN		aLavery	
20110816.1840.001	CTD911	start	1	10	20	15:40	8/16/11 18:40	39.440133	-51.971217	NaN	500	aWang	surface to 100m to 50m to 100m, etc. yoyo
20110816.1840.002	VPR	start	1	10	17	15:40	8/16/11 18:40	39.440167	-51.971217	NaN	500	gLawson	
20110816.2016.001	VPR	end	1	10	17	17:16	8/16/11 20:16	39.434183	-51.969867	NaN	500	gLawson	
20110816.2016.002	CTD911	end	1	10	20	17:16	8/16/11 20:16	39.434200	-51.969850	NaN	500	aWang	
20110816.2037.001	Hammarhead	start	1	10	10	17:37	8/16/11 0:20	39.430080	-51.973830	NaN		aLavery	chgd evnt# from 20110817.0021.001 to 20110816.2037.001; position added later from alongtrack
20110816.2121.001	MacroFaunaObs	start	1	NaN	NaN	18:20	8/16/11 21:21	39.408417	-51.999400	NaN		tWhite	bowtie
20110816.2216.001	MacroFaunaObs	end	1	NaN	NaN	19:15	8/16/11 22:16	39.433850	-51.963967	NaN		tWhite	bowtie
20110816.2241.001	MacroFaunaObs	other	1	10	NaN	19:40	8/16/11 22:41	39.433883	-51.916283	NaN		tWhite	unidentified whale spouted going west - probably sperm whale
20110817.0017.001	Hammarhead	end	1	10	10	21:17	8/17/11 0:17	39.420733	-51.969517	NaN		aLavery	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110817.0029.001	ReeveNet	start	1	10	8	21:29	8/17/11 0:29	39.416983	-51.969917	NaN	200 mwo	gLawson	
20110817.0147.001	ReeveNet	end	1	10	8	22:46	8/17/11 1:47	39.399750	-51.966467	NaN	200 mwo	gLawson	100 nominal; 200 mwo
20110817.0153.001	Hammarhead	start	1	10	11	22:54	8/17/11 1:53	39.397833	-51.965617	NaN		aLavery	
20110817.0643.001	Hammarhead	end	1	10	11	3:43	8/17/11 6:43	39.428133	-52.043450	NaN		aLavery	
20110817.0650.001	Ship	endStation	1	10	NaN	3:49	8/17/11 6:50	39.424083	-52.048000	NaN		NaN	
20110817.0837.001	MacroFaunaObs	start	1	NaN	NaN	5:36	8/17/11 8:37	39.650567	-52.039800	NaN		tWhite	
20110817.1051.001	Ship	startStation	1	11	NaN	7:51	8/17/11 10:51	39.996217	-52.002400	NaN		NaN	
20110817.1051.002	MacroFaunaObs	end	1	NaN	NaN	7:51	8/17/11 10:51	39.996900	-52.002317	NaN		tWhite	
20110817.1055.001	Echosounder	start	1	11	18	7:54	8/17/11 10:55	39.999500	-52.004717	4926		NaN	
20110817.1059.001	Echosounder	end	1	11	18	7:58	8/17/11 10:59	39.997183	-52.006367	NaN		NaN	
20110817.1059.002	VPR	start	1	11	18	7:59	8/17/11 11:00	39.996700	-52.006700	NaN	1000	gLawson	
20110817.1100.001	CTD911	start	1	11	21	8:00	8/17/11 11:00	39.996300	-52.007050	NaN	1000	aWang	
20110817.1106.001	HTI-Hull	end	1	11	15	8:06	8/17/11 11:06	39.993050	-52.009230	NaN		gLawson	Entered this a little late so event number was off. Local time is accurate; chgd evt# frm 20110817.1224.001 to 20110817.1106.001; corrected position
20110817.1231.001	VPR	end	1	11	18	9:30	8/17/11 12:31	39.974250	-52.065650	NaN	1000	gLawson	
20110817.1231.002	CTD911	end	1	11	21	9:31	8/17/11 12:31	39.974200	-52.065967	NaN	1000	aWang	
20110817.1235.001	HTI-Hull	start	1	11	16	9:34	8/17/11 12:35	39.977300	-52.068400	NaN		gLawson	
20110817.1235.001	Ship	endStation	1	11	NaN	9:35	8/17/11 12:35	39.977480	-52.068400	NaN		NaN	entered late; chgd evt# from 20110817.1246.001 to 20110817.1235.001; corrected position
20110817.1241.001	MacroFaunaObs	start	1	NaN	NaN	9:40	8/17/11 12:41	39.990800	-52.067200	NaN		tWhite	transit to station 12
20110817.1345.001	MacroFaunaObs	end	1	NaN	NaN	10:44	8/17/11 13:45	40.166800	-52.047017	NaN		tWhite	transit to station 12
20110817.1352.001	MacroFaunaObs	start	1	NaN	NaN	10:52	8/17/11 13:53	40.187750	-52.042933	NaN		tWhite	transit to station 12
20110817.1542.001	MacroFaunaObs	end	1	NaN	NaN	12:42	8/17/11 15:42	40.485950	-52.012233	NaN		tWhite	transit to station 12
20110817.1544.001	Ship	startStation	1	12	NaN	12:44	8/17/11 15:44	40.489667	-52.008050	NaN		NaN	
20110817.1545.001	Echosounder	start	1	12	19	12:44	8/17/11 15:45	40.490100	-52.006417	NaN		NaN	
20110817.1551.001	Echosounder	end	1	12	19	12:50	8/17/11 15:51	40.485467	-52.002767	NaN		NaN	
20110817.1603.001	VPR	start	1	12	19	13:02	8/17/11 16:03	40.478767	-52.008517	NaN	1000	gLawson	
20110817.1603.002	CTD911	start	1	12	22	13:03	8/17/11 16:03	40.478550	-52.008733	NaN	1000	aWang	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110817.1725.001	CTD911	end	1	12	22	14:24	8/17/11 17:25	40.473317	-52.017117	NaN	1000	aWang	
20110817.1726.001	VPR	end	1	12	19	14:26	8/17/11 17:26	40.472917	-52.017517	NaN	1000	gLawson	
20110817.1734.001	Ship	endStation	1	12	NaN	14:33	8/17/11 17:34	40.471317	-52.025317	NaN		NaN	
20110817.1813.001	MacroFaunaObs	start	1	NaN	NaN	15:12	8/17/11 18:13	40.547517	-52.070883	NaN		tWhite	steaming to NL
20110817.2000.001	MacroFaunaObs	end	1	NaN	NaN	16:59	8/17/11 20:00	40.840033	-52.101467	NaN		tWhite	steaming to NL
20110817.2011.001	MacroFaunaObs	start	1	NaN	NaN	17:11	8/17/11 20:11	40.872200	-52.103100	NaN		tWhite	steaming to NL
20110817.2105.001	Echosounder	start	1	13	20	18:04	8/17/11 21:05	40.995033	-52.005683	NaN		NaN	
20110817.2106.001	Ship	startStation	1	13	NaN	18:06	8/17/11 21:06	40.996983	-52.000917	NaN		NaN	
20110817.2109.001	MacroFaunaObs	end	1	NaN	NaN	18:08	8/17/11 21:09	40.997333	-51.996783	NaN		tWhite	
20110817.2117.001	Echosounder	end	1	13	20	18:17	8/17/11 21:17	40.991683	-51.995200	NaN		NaN	this is correct time, position
20110817.2118.001	Hammarhead	start	1	13	12	18:17	8/17/11 21:18	40.990917	-51.995417	NaN		aLavery	
20110817.2124.001	HTI-Hull	end	1	13	16	18:22	8/17/11 21:24	40.985800	-51.996350	NaN		gLawson	
20110817.2200.001	Hammarhead	end	1	13	12	19:00	8/17/11 22:00	40.973500	-51.999283	NaN		aLavery	
20110817.2203.001	CTD911	start	1	13	23	19:05	8/17/11 22:03	40.972933	-52.001300	NaN	3000	aWang	
20110818.0054.001	HTI-Hull	start	1	16	17	10:44	8/18/11 0:54	40.892780	-51.973970	NaN		gLawson	This should have been entered at 0054UTC on Aug 18; chgd evt# from 20110819.1345.001 to 20110818.0054.001; corrected position
20110818.0110.001	CTD911	end	1	13	23	22:09	8/18/11 1:10	40.882483	-51.975267	NaN		aWang	
20110818.0132.001	ReeveNet	start	1	13	9	22:33	8/18/11 1:32	40.878817	-51.976883	NaN	200 mwo	gLawson	
20110818.0239.001	ReeveNet	end	1	13	9	23:30	8/18/11 2:39	40.885030	-51.982950	NaN	200 mwo	gLawson	100 m nominal; 200 mwotime entered after the fact; position fixed
20110818.0252.001	MOCNESS	start	1	13	8	23:39	8/18/11 2:52	40.883283	-51.987700	NaN		pWiebe	
20110818.0549.001	MOCNESS	end	1	13	8	2:49	8/18/11 5:49	40.816517	-52.083017	NaN	1014	pWiebe	
20110818.0620.001	CTD911	start	1	13	24	3:18	8/18/11 6:20	40.816567	-52.092117	NaN	1000	aWang	PAR sensor absent
20110818.0623.001	VPR	start	1	13	20	3:22	NaN	40.816033	-52.092750	NaN	1000	gLawson	
20110818.0625.001	Echosounder	start	1	13	21	3:23	8/18/11 6:25	40.815867	-52.093050	59.53	1000	NaN	
20110818.0631.001	Echosounder	end	1	13	21	3:30	8/18/11 6:31	40.815200	-52.094400	3399	1000	NaN	
20110818.0717.001	CTD911	end	1	13	24	4:16	8/18/11 7:17	40.809250	-52.103417	NaN	1000	aWang	
20110818.0718.001	VPR	end	1	13	20	4:17	8/18/11 7:19	40.809483	-52.103817	NaN	1000	gLawson	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110818.0737.001	Hammarhead	start	1	13	13	4:36	8/18/11 7:37	40.815117	-52.113617	NaN		aLavery	
20110818.0859.001	Hammarhead	end	1	13	13	5:59	8/18/11 8:59	40.913267	-52.074917	NaN		aLavery	
20110818.0915.001	MOCNESS	start	1	13	9	6:15	8/18/11 9:16	40.929400	-52.070733	NaN		pWiebe	
20110818.1239.001	MOCNESS	end	1	13	9	9:28	8/18/11 12:39	41.017267	-51.969133	NaN	1006	pWiebe	
20110818.1312.001	CTD911	start	1	13	25	10:12	8/18/11 13:12	41.036233	-51.898067	NaN	1000	aWang	
20110818.1312.002	VPR	start	1	13	21	10:11	8/18/11 13:13	41.036217	-51.898067	NaN	1000	gLawson	
20110818.1405.001	VPR	end	1	13	21	11:04	8/18/11 14:05	41.033900	-51.896250	NaN	1000	gLawson	
20110818.1405.002	CTD911	end	1	13	25	11:05	8/18/11 14:05	41.033900	-51.896267	NaN	1000	aWang	
20110818.1411.001	Ship	startStation	1	13	NaN	11:11	8/18/11 14:12	41.034150	-51.895717	NaN		NaN	
20110818.1424.001	MacroFaunaObs	start	1	NaN	NaN	11:23	8/18/11 14:24	41.058133	-51.899800	NaN		tWhite	transit to station 14
20110818.1555.001	MacroFaunaObs	end	1	NaN	NaN	12:54	8/18/11 15:55	41.315000	-51.947750	NaN		tWhite	transit to station 14
20110818.1603.001	MacroFaunaObs	start	1	NaN	NaN	13:02	8/18/11 16:03	41.338600	-51.951283	NaN		tWhite	transit to station 14
20110818.1700.001	Echosounder	start	1	14	22	14:00	8/18/11 17:00	41.497633	-51.998133	NaN		NaN	
20110818.1701.001	MacroFaunaObs	end	1	14	NaN	14:00	8/18/11 17:01	41.498050	-51.997900	NaN		tWhite	
20110818.1701.002	Ship	startStation	1	14	NaN	14:01	8/18/11 17:01	41.498150	-51.997717	4650		NaN	
20110818.1704.001	Echosounder	end	1	14	22	14:04	8/18/11 17:04	41.497933	-51.995567	NaN		NaN	
20110818.1709.001	VPR	start	1	14	22	14:09	8/18/11 17:09	41.497183	-51.992600	NaN	1000	gLawson	
20110818.1710.001	CTD911	start	1	14	26	14:09	8/18/11 17:10	41.497050	-51.992167	NaN	1000	aWang	
20110818.1831.001	CTD911	end	1	14	26	15:30	8/18/11 18:31	41.465600	-51.959483	NaN	1002	aWang	
20110818.1831.002	VPR	end	1	14	22	15:31	8/18/11 18:31	41.465367	-51.959317	NaN	1002	gLawson	
20110818.1837.001	Ship	endStation	1	14	NaN	15:35	8/18/11 18:37	41.464250	-51.962617	NaN		NaN	
20110818.1844.001	MacroFaunaObs	start	2	NaN	NaN	15:43	8/18/11 18:44	41.469733	-51.949700	NaN		tWhite	transit to station 15
20110818.1844.002	Ship	endTransect	1	14	NaN	15:43	8/18/11 18:44	41.469850	-51.949300	NaN		NaN	
20110818.1844.003	Ship	startTransect	2	NaN	NaN	15:44	8/18/11 18:44	41.470200	-51.947967	NaN		NaN	
20110818.2230.001	MacroFaunaObs	end	2	NaN	NaN	19:24	8/18/11 22:30	41.777200	-51.232067	NaN		tWhite	
20110819.0119.001	Ship	startStation	2	15	NaN	22:19	8/19/11 1:19	41.999300	-50.609783	NaN		NaN	
20110819.0124.001	ReeveNet	start	2	15	10	22:24	8/19/11 1:24	42.003133	-50.604317	NaN	250 mwo	gLawson	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110819.0245.001	ReeveNet	end	2	15	10	23:46	8/19/11 2:46	42.035400	-50.549050	NaN	250 mwo	gLawson	
20110819.0255.001	CTD911	start	2	15	27	23:55	8/19/11 2:56	42.039517	-50.543833	NaN	1000	aWang	
20110819.0256.001	VPR	start	2	15	23	23:55	8/19/11 2:56	42.039667	-50.543617	NaN	1000	gLawson	
20110819.0304.001	Echosounder	start	2	15	23	0:03	8/19/11 3:04	42.042133	-50.541183	3378	1000	NaN	
20110819.0306.001	Echosounder	end	2	15	23	0:06	8/19/11 3:06	42.042850	-50.540517	3378	1000	NaN	
20110819.0422.001	CTD911	end	2	15	27	1:21	8/19/11 4:22	42.066867	-50.513733	3378	1000	aWang	
20110819.0423.001	VPR	end	2	15	23	1:22	8/19/11 4:23	42.067767	-50.511417	3378	1000	gLawson	
20110819.0500.001	Ship	endStation	2	15	NaN	1:25	8/19/11 5:01	42.084683	-50.373967	NaN		NaN	Entered very late at 02:00 local time
20110819.0904.001	MacroFaunaObs	start	2	NaN	NaN	6:04	8/19/11 9:04	42.393000	-49.513067	NaN		tWhite	transit to station 17
20110819.1032.001	Echosounder	start	2	16	24	7:31	8/19/11 10:32	42.499750	-49.202200	2699		NaN	
20110819.1033.001	Ship	startStation	2	16	NaN	7:32	8/19/11 10:33	42.499883	-49.201333	NaN		NaN	
20110819.1034.001	MacroFaunaObs	end	2	NaN	NaN	7:34	8/19/11 10:34	42.499717	-49.200200	NaN		tWhite	
20110819.1037.001	CTD911	start	2	16	28	7:37	8/19/11 10:37	42.499367	-49.199467	NaN	1000	aWang	
20110819.1037.002	VPR	start	2	16	24	7:37	8/19/11 10:37	42.499367	-49.199450	NaN	1000	gLawson	
20110819.1051.001	Echosounder	end	2	16	24	7:50	8/19/11 10:51	42.497300	-49.196883	NaN		NaN	
20110819.1150.001	CTD911	end	2	16	28	8:50	8/19/11 11:50	42.499833	-49.178650	NaN	1000	aWang	
20110819.1151.001	VPR	end	2	16	24	8:51	8/19/11 11:51	42.499950	-49.178483	NaN	1000	gLawson	
20110819.1201.001	Ship	endStation	2	16	NaN	9:01	8/19/11 12:02	42.503583	-49.170483	NaN		NaN	2 minutes late
20110819.1222.001	MacroFaunaObs	start	2	NaN	NaN	9:22	8/19/11 12:22	42.536533	-49.102133	NaN		tWhite	transit to station 18
20110819.1328.001	MacroFaunaObs	end	2	NaN	NaN	10:27	8/19/11 13:28	42.623183	-48.860767	NaN		tWhite	
20110819.1340.001	MacroFaunaObs	start	2	NaN	NaN	10:39	8/19/11 13:40	42.638483	-48.815067	NaN		tWhite	transit to station 18
20110819.1345.002	HTI-Hull	end	2	16	17	10:45	8/19/11 13:46	42.645467	-48.793633	NaN		gLawson	
20110819.1352.001	HTI-Hull	start	2	17	18	10:52	8/19/11 13:52	42.995550	-47.753617	NaN		gLawson	This should have been entered at 1352UTC on Aug 19; chgd local time and evt# from 20110819.1943.001 t o 20110819.1352.001
20110819.1511.001	MacroFaunaObs	end	2	NaN	NaN	12:10	8/19/11 15:11	42.750933	-48.482167	NaN		tWhite	
20110819.1516.001	MacroFaunaObs	start	2	NaN	NaN	12:15	8/19/11 15:16	42.757367	-48.464417	NaN		tWhite	
20110819.1643.001	MacroFaunaObs	end	2	NaN	NaN	13:43	8/19/11 16:43	42.877017	-48.152667	NaN		tWhite	
20110819.1752.001	MacroFaunaObs	start	2	NaN	NaN	14:51	8/19/11 17:52	42.971383	-47.882133	NaN		tWhite	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110819.1806.001	MacroFaunaObs	end	2	NaN	NaN	15:06	8/19/11 18:06	42.989233	-47.818817	NaN		tWhite	
20110819.1815.001	Ship	startStation	2	17	NaN	15:15	8/19/11 18:15	43.001150	-47.780900	NaN		NaN	
20110819.1817.001	Echosounder	start	2	17	25	15:16	8/19/11 18:17	43.001267	-47.778667	NaN		NaN	
20110819.1819.001	Echosounder	end	2	17	25	15:19	8/19/11 18:19	43.002133	-47.777000	NaN		NaN	
20110819.1825.001	CTD911	start	2	17	29	15:25	8/19/11 18:25	43.003417	-47.773283	3576	1000	aWang	
20110819.1825.002	VPR	start	2	17	25	15:25	8/19/11 18:25	43.003400	-47.773217	3576	1000	gLawson	
20110819.1924.001	CTD911	end	2	17	29	16:22	8/19/11 19:24	43.002033	-47.751533	3576	1000	aWang	
20110819.1925.001	VPR	end	2	17	25	16:24	8/19/11 19:25	43.001867	-47.751183	NaN	1000	gLawson	
20110819.1939.001	Hammarhead	start	2	17	14	16:38	8/19/11 19:39	42.997783	-47.752033	NaN		aLavery	
20110819.1944.001	HTI-Hull	end	2	17	18	16:44	8/19/11 19:44	42.995250	-47.753800	NaN		gLawson	
20110819.2045.001	HTI-Hull	start	2	17	19	17:45	8/19/11 20:45	42.974283	-47.791983	NaN		gLawson	
20110819.2053.001	Hammarhead	end	2	17	14	17:53	8/19/11 20:53	42.972067	-47.797800	NaN		aLavery	
20110819.2056.001	Echosounder	start	2	17	26	17:56	8/19/11 20:56	42.971667	-47.799067	0		NaN	
20110819.2100.001	Echosounder	end	2	17	26	18:00	8/19/11 21:01	42.971300	-47.799617	NaN		NaN	
20110819.2101.001	CTD911	start	2	17	30	18:02	8/19/11 21:02	42.971283	-47.799400	3627	3000	aWang	
20110819.2319.001	CTD911	end	2	17	30	20:19	8/19/11 23:19	42.976520	-47.781530	3627	3000	aWang	chg evnt# from 20110820.0145.001 to 20110819.2319.001; corrected position
20110819.2332.001	ReeveNet	start	2	17	11	20:32	8/19/11 23:32	42.985167	-47.773200	NaN	200 mwo	gLawson	
20110820.0028.001	ReeveNet	end	2	17	11	21:28	8/20/11 0:28	42.987780	-47.779580	NaN	200 mwo	gLawson	a little slow logging event: chg evt# from 20110820.0038.001 to 20110820.0028.001; corrected position
20110820.0054.001	MOCNESS	start	2	17	10	21:54	8/20/11 0:54	42.987450	-47.776167	NaN		pWiebe	
20110820.0348.001	MOCNESS	end	2	17	10	0:48	8/20/11 3:48	43.093000	-47.695083	NaN	1005	pWiebe	
20110820.0417.001	VPR	start	2	17	26	1:15	8/20/11 4:17	43.109583	-47.672350	3502	1000	gLawson	
20110820.0422.001	CTD911	start	2	17	31	1:21	8/20/11 4:22	43.112417	-47.668667	3502	1000	aWang	
20110820.0426.001	Echosounder	start	2	17	27	1:24	8/20/11 4:26	43.114433	-47.665483	3502	1000	NaN	
20110820.0444.001	Echosounder	end	2	17	27	1:44	8/20/11 4:44	43.123333	-47.651733	3502	1000	NaN	
20110820.0543.001	CTD911	end	2	17	31	2:42	8/20/11 5:43	43.149067	-47.610400	3502	1000	aWang	
20110820.0544.001	VPR	end	2	17	26	2:44	8/20/11 5:44	43.149600	-47.609167	3502	1000	gLawson	
20110820.0556.001	Hammarhead	start	2	17	15	2:57	8/20/11 5:56	43.148783	-47.605617	NaN		aLavery	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110820.0840.001	Hammarhead	end	2	17	15	5:39	8/20/11 8:40	43.100550	-47.634067	NaN		aLavery	
20110820.0850.001	Hammarhead	end	2	17	15	5:49	8/20/11 8:50	43.105067	-47.638517	NaN		aLavery	
20110820.0903.001	MOCNESS	start	2	17	11	6:03	8/20/11 9:03	43.102217	-47.638150	NaN		pWiebe	
20110820.1155.001	MOCNESS	end	2	17	11	8:54	8/20/11 11:55	43.063817	-47.567500	NaN	1011	pWiebe	
20110820.1219.001	Ship	endStatio n	2	17	NaN	9:19	8/20/11 12:19	43.071033	-47.568317	NaN		NaN	
20110820.1233.001	MacroFaunaObs	start	2	NaN	NaN	9:33:44	8/20/11 12:33	43.090593	-47.517775	NaN		tWhite	corrected GPS time to agree with local time
20110820.1433.001	MacroFaunaObs	end	2	NaN	NaN	11:33:17	8/20/11 14:33	43.258062	-47.044318	NaN		tWhite	corrected GPS time to agree with local time
20110820.1734.001	Echosounder	start	2	17	28	14:33	8/20/11 17:34	43.492867	-46.376533	NaN		NaN	
20110820.1741.001	Ship	startStatio n	2	18	NaN	14:40	8/20/11 17:41	43.498833	-46.356383	NaN		NaN	
20110820.1742.001	Echosounder	end	2	17	28	14:41	8/20/11 17:42	43.498700	-46.356217	NaN		NaN	
20110820.1751.001	VPR	start	2	18	27	14:50	8/20/11 17:51	43.497267	-46.354000	NaN	1000	gLawson	
20110820.1751.002	CTD911	start	2	18	32	14:51	8/20/11 17:52	43.497067	-46.353883	NaN	1000	aWang	
20110820.1911.001	CTD911	end	2	18	32	16:11	8/20/11 19:11	43.487033	-46.341483	NaN	1001.4	aWang	
20110820.1912.001	VPR	end	2	18	27	16:12	8/20/11 19:12	43.486867	-46.341450	NaN	1001.4	gLawson	
20110820.1916.001	Ship	endStatio n	2	18	NaN	16:15	8/20/11 19:16	43.485883	-46.341000	NaN		NaN	
20110820.1926.001	MacroFaunaObs	start	2	NaN	NaN	16:25	8/20/11 19:26	43.498150	-46.316083	NaN		tWhite	
20110820.2208.001	MacroFaunaObs	end	2	NaN	NaN	19:08:54	8/20/11 22:08	43.720045	-45.722838	NaN		tWhite	corrected GPS time to agree with local time
20110821.0157.001	Ship	startStatio n	2	19		22:51	8/21/11 1:57	43.998467	-44.922350	NaN		NaN	
20110821.0204.001	ReeveNet	start	2	19	12	23:05	8/21/11 2:05	43.997550	-44.917300	NaN	200 mwo	gLawson	
20110821.0248.001	Echosounder	start	2	19	29	23:47	8/21/11 2:48	43.968100	-44.909350	4558	1000	NaN	
20110821.0258.001	Echosounder	end	2	19	29	23:57	8/21/11 2:58	43.961917	-44.907717	4558	1000	NaN	
20110821.0310.001	ReeveNet	end	2	19	12	0:05	8/21/11 3:10	43.954050	-44.905817	NaN	200 mwo	gLawson	200m wire out
20110821.0320.001	CTD911	start	2	19	33	0:19	8/21/11 3:21	43.949517	-44.904650	4558	1000	aWang	
20110821.0324.001	VPR	start	2	19	28	0:23	8/21/11 3:24	43.947783	-44.904183	4558	1000	gLawson	
20110821.0448.001	CTD911	end	2	19	33	1:48	8/21/11 4:48	43.930583	-44.917533	4558	1000	aWang	
20110821.0449.001	VPR	end	2	19	28	1:48	8/21/11 4:49	43.930533	-44.917183	4558	1000	gLawson	
20110821.0450.001	Ship	endStatio	2	19		1:50	8/21/11 4:50	43.930733	-44.916183	4558		NaN	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
		n											
20110821.0831.001	MacroFaunaObs	start	2	NaN	NaN	5:30	8/21/11 8:31	44.260867	-44.180250	NaN		tWhite	transit to station 20
20110821.1117.001	Echosounder	start	2	20	30	8:17	8/21/11 11:17	44.492267	-43.488133	NaN		NaN	
20110821.1120.001	Echosounder	end	2	20	30	8:20	8/21/11 11:20	44.495717	-43.479733	NaN		NaN	
20110821.1121.001	MacroFaunaObs	end	2	NaN	NaN	8:21	8/21/11 11:21	44.497317	-43.476017	NaN		tWhite	
20110821.1125.001	Ship	startStation	2	20	NaN	8:25	8/21/11 11:25	44.501817	-43.465733	NaN		NaN	
20110821.1133.001	VPR	start	2	20	29	8:33	8/21/11 11:33	44.505867	-43.463450	4762	1000	gLawson	
20110821.1133.002	CTD911	start	2	20	34	8:33	8/21/11 11:33	44.505933	-43.463417	4762	1000	aWang	
20110821.1243.001	CTD911	end	2	20	34	9:43	8/21/11 12:43	44.535067	-43.437750	NaN	999.6	aWang	
20110821.1244.001	VPR	end	2	20	29	9:44	8/21/11 12:44	44.535383	-43.437717	NaN	1000	gLawson	
20110821.1248.001	Ship	endStation	2	20	NaN	9:47	8/21/11 12:48	44.535983	-43.437350	NaN		NaN	
20110821.1248.002	Ship	endTransect	2	20	NaN	12:48	8/21/11 12:48	44.535930	-43.437320	4558	NaN	NaN	entered late: chgd evt# from 20110821.2132.001 to 20110821.1248.002, position
20110821.1314.001	MacroFaunaObs	start	2	NaN	NaN	10:13	8/21/11 13:14	44.568783	-43.340317	NaN		tWhite	
20110821.1852.001	Ship	startTransect	3	20	NaN	15:52	8/21/11 18:52	44.968000	-41.998367	NaN	NaN	NaN	entered late: chgd evt# from 20110821.2142.001 to 20110821.1856.001
20110821.1852.002	Ship	startStation	3	21	NaN	15:52	8/21/11 18:52	44.993200	-42.015867	NaN		NaN	
20110821.1852.003	Echosounder	start	3	21	31	15:52	8/21/11 18:52	44.993200	-42.015867	NaN		NaN	
20110821.1856.002	MacroFaunaObs	end	3	NaN	NaN	15:56	8/21/11 18:57	44.997150	-42.004183	4693		tWhite	
20110821.1857.001	Echosounder	end	3	21	31	15:56	8/21/11 18:57	44.997183	-42.004000	NaN		NaN	chgd cast from 35 to 31
20110821.1904.001	CTD911	start	3	21	35	16:04	8/21/11 19:04	44.998317	-42.001883	NaN	1000	aWang	
20110821.1905.001	VPR	start	3	21	30	16:04	8/21/11 19:05	44.998300	-42.001633	NaN	1000	gLawson	
20110821.2002.001	CTD911	end	3	21	35	17:01	8/21/11 20:02	44.988333	-41.989383	NaN	1000	aWang	
20110821.2003.001	VPR	end	3	21	30	17:03	8/21/11 20:03	44.988300	-41.989167	NaN	1000	gLawson	
20110821.2012.001	HTI-Hull	end	3	21	19	17:12	8/21/11 20:12	44.986667	-41.991633	NaN		gLawson	
20110821.2013.001	Hammarhead	start	3	21	16	17:11	8/21/11 20:13	44.986417	-41.992067			aLavery	
20110821.2117.001	Hammarhead	end	3	21	16	18:16	8/21/11 21:17	44.971333	-42.004783	NaN		aLavery	
20110821.2124.001	CTD911	start	3	21	36	18:24	8/21/11 21:24	44.970333	-42.001533	NaN	3000	aWang	
20110821.2132.002	HTI-Hull	start	3	21	20	18:32	8/21/11 21:32	44.969617	-42.000017	NaN		gLawson	
20110821.2343.001	CTD911	end	3	21	36	20:43	8/21/11 23:43	44.945600	-41.992783	NaN	3000	aWang	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110821.2356.001	ReeveNet	start	3	21	13	20:56	8/21/11 23:56	44.944650	-41.992783	NaN	200 mwo	gLawson	
20110822.0049.001	ReeveNet	end	3	21	13	21:40	8/22/11 0:49	44.937600	-42.002567	NaN	200 mwo	gLawson	
20110822.0102.001	MOCNESS	start	3	21	12	22:03	8/22/11 1:02	44.932020	-41.995550	NaN		pWiebe	Time entered was wrong orginally; corrected position
20110822.0358.001	MOCNESS	end	3	21	12	0:58	8/22/11 3:58	44.854500	-41.921767	NaN	1007	pWiebe	
20110822.0405.001	Echosounder	start	3	21	32	1:04	8/22/11 4:06	44.850533	-41.919867	4692	1000	NaN	chgd cast from 36 to 32
20110822.0407.001	Echosounder	end	3	21	32	1:06	8/22/11 4:07	44.849800	-41.919550	4692	1000	NaN	chgd cast from 36 to 32
20110822.0419.001	CTD911	start	3	21	37	1:16	8/22/11 4:19	44.846267	-41.915800	NaN	1000	aWang	
20110822.0423.001	VPR	start	3	21	31	1:22	8/22/11 4:23	44.845683	-41.914483	NaN	1000	gLawson	
20110822.0526.001	CTD911	end	3	21	37	2:26	8/22/11 5:26	44.837067	-41.893300	4692	1000	aWang	
20110822.0527.001	VPR	end	3	21	31	2:27	8/22/11 5:27	44.836650	-41.893050	4692	1000	gLawson	
20110822.0536.001	Hammarhead	start	3	21	17	2:36	8/22/11 5:37	44.831583	-41.891817	NaN		aLavery	
20110822.0849.001	Hammarhead	end	3	21	17	5:49	8/22/11 8:49	45.011433	-42.008750	NaN		aLavery	
20110822.0907.001	MOCNESS	start	3	21	13	6:03	8/22/11 9:07	45.014617	-42.006000	NaN		pWiebe	
20110822.1219.001	MOCNESS	end	3	21	13	9:19	8/22/11 12:19	45.001567	-41.828350	NaN	1008	pWiebe	
20110822.1301.001	Ship	endStation	3	21	NaN	10:00	8/22/11 13:01	45.026750	-41.823917	NaN		NaN	
20110822.1554.001	Echosounder	start	3	22	33	12:53	8/22/11 15:54	45.487117	-41.999917	NaN		NaN	chgd cast from 37 to 33
20110822.1559.001	Ship	startStation	3	22	NaN	12:58	8/22/11 15:59	45.499167	-41.999167	4660		NaN	
20110822.1559.003	Echosounder	end	3	22	33	12:59	8/22/11 16:00	45.499550	-41.998817	NaN		NaN	chgd cast from 37 to 33
20110822.1608.001	VPR	start	3	22	32	13:08	8/22/11 16:08	45.500217	-41.996450	4462	1000	gLawson	
20110822.1608.002	CTD911	start	3	22	38	13:08	8/22/11 16:08	45.500217	-41.996433	4462	1000	aWang	
20110822.1719.001	CTD911	end	3	22	38	14:18	8/22/11 17:19	45.496600	-41.984400	NaN	1000	aWang	
20110822.1720.001	VPR	end	3	22	32	14:19	8/22/11 17:20	45.496483	-41.984383	NaN	1000	gLawson	
20110822.1730.001	Ship	endStation	3	22	NaN	14:30	8/22/11 17:30	45.502480	-41.986580	NaN		NaN	entered late;corrected position; chgd evt# from 20110822.1951.001 to 20110822.1730.001
20110822.1735.001	MacroFaunaObs	start	3	NaN	NaN	14:35	8/22/11 17:36	45.515833	-41.987517	NaN		tWhite	
20110822.2021.001	Echosounder	start	3	23	34	17:21	8/22/11 20:22	45.983850	-42.000250	NaN		NaN	chgd cast from 38 to 34
20110822.2028.001	Ship	startStation	3	23	NaN	17:28	8/22/11 20:29	45.998633	-41.999433	NaN		NaN	
20110822.2029.001	Echosounder	end	3	23	34	17:29	8/22/11 20:29	45.998583	-41.999350	NaN		NaN	chgd cast from 38 to 34

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110822.2035.001	VPR	start	3	23	33	17:34	8/22/11 20:35	45.997950	-42.000467	4639	1000m	gLawson	
20110822.2035.002	CTD911	start	3	23	39	17:35	8/22/11 20:35	45.997800	-42.000567	4639	1000	aWang	
20110822.2145.001	CTD911	end	3	23	39	18:44	8/22/11 21:45	46.001350	-42.002817	NaN	1000	aWang	
20110822.2146.001	VPR	end	3	23	33	18:45	8/22/11 21:46	46.001483	-42.002900	NaN	1000m	gLawson	
20110822.2148.001	Ship	endStation	3	23	NaN	18:48	8/22/11 21:48	46.001983	-42.003233	NaN		NaN	
20110823.0047.001	Ship	startStation	3	24	NaN	21:49	8/23/11 0:48	46.501067	-41.997917	NaN		NaN	
20110823.0052.001	ReeveNet	start	3	24	14	21:53	8/23/11 0:52	46.502017	-41.997167	NaN	200 mwo	gLawson	
20110823.0147.001	ReeveNet	end	3	24	14	22:37	8/23/11 1:47	46.499800	-41.970867	NaN	200 mwo	gLawson	
20110823.0153.001	Echosounder	start	3	24	35	22:51	8/23/11 1:53	46.501317	-41.969883	4170		NaN	chgd cast from 39 to 35
20110823.0200.001	VPR	start	3	24	34	23:00	8/23/11 2:00	46.502383	-41.967850	4170	1000	gLawson	
20110823.0202.001	CTD911	start	3	24	40	23:01	8/23/11 2:02	46.502433	-41.967233	4170	1000	aWang	
20110823.0204.001	Echosounder	end	3	24	35	23:03	8/23/11 2:04	46.502650	-41.966467	4170	1000	NaN	chgd cast from 39 to 35
20110823.0330.001	CTD911	end	3	24	40	0:30	8/23/11 3:30	46.512150	-41.936700	4170	1000	aWang	
20110823.0331.001	VPR	end	3	24	34	0:31	8/23/11 3:31	46.512183	-41.936383	4170	1000	gLawson	
20110823.0333.001	Ship	endStation	3	24	NaN	0:32	8/23/11 3:33	46.511550	-41.934233	4170		NaN	
20110823.0641.001	Ship	startStation	3	25	NaN	3:39	8/23/11 6:41	47.000117	-42.000517	NaN		NaN	
20110823.0642.001	Echosounder	start	3	25	36	3:41	8/23/11 6:42	47.000617	-42.000250	4222		NaN	chgd cast from 40 to 36
20110823.0648.001	CTD911	start	3	25	41	3:47	8/23/11 6:48	47.001833	-42.000733	4222	1000	aWang	
20110823.0650.001	VPR	start	3	25	35	3:49	8/23/11 6:50	47.002067	-42.000800	4222	1000	gLawson	
20110823.0654.001	Echosounder	end	3	25	36	3:53	8/23/11 6:54	47.002383	-42.001483	4222		NaN	chgd cast from 40 to 36
20110823.0813.001	CTD911	end	3	25	41	5:13	8/23/11 8:13	47.019983	-42.013100	4222	1000	aWang	
20110823.0814.001	VPR	end	3	25	35	5:14	8/23/11 8:14	47.020567	-42.013217	4222	1000	gLawson	
20110823.0815.001	Ship	endStation	3	25	NaN	5:15	8/23/11 8:15	47.022333	-42.013017	4222		NaN	
20110823.1104.001	Echosounder	start	3	26	37	8:02	8/23/11 11:04	47.488567	-42.001367	NaN		NaN	chgd cast from 41 to 37
20110823.1108.001	Ship	startStation	3	26	NaN	8:07	8/23/11 11:08	47.497950	-42.000333	NaN		NaN	
20110823.1109.001	Echosounder	end	3	26	37	8:08	8/23/11 11:09	47.498450	-42.000050	NaN		NaN	chgd cast from 41 to 37

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110823.1117.001	VPR	start	3	26	36	8:16	8/23/11 11:17	47.500467	-42.001133	NaN	1000	gLawson	
20110823.1117.002	CTD911	start	3	26	42	8:17	8/23/11 11:17	47.500567	-42.001267	NaN	1000m	aWang	
20110823.1214.001	CTD911	end	3	26	42	9:14	8/23/11 12:14	47.508250	-42.023017	NaN	1000m	aWang	
20110823.1215.001	VPR	end	3	26	36	9:14	8/23/11 12:15	47.508367	-42.023233	NaN	1000	gLawson	
20110823.1236.001	MOCNESS	start	3	26	14	9:36	8/23/11 12:36	47.512133	-42.029817	NaN		pWiebe	
20110823.1539.001	MOCNESS	end	3	26	14	12:39	8/23/11 15:39	47.576050	-41.999000	NaN	1012	pWiebe	
20110823.1613.001	CTD911	start	3	26	43	13:13	8/23/11 16:14	47.574333	-41.978083	NaN	3000	aWang	
20110823.1623.001	Echosounder	start	3	26	38	13:22	8/23/11 16:23	47.573600	-41.978833	NaN		NaN	chgd cast from 42 to 38
20110823.1624.001	Echosounder	end	3	26	38	13:24	8/23/11 16:24	47.573633	-41.978750	NaN		NaN	chgd cast from 42 to 38
20110823.1838.001	CTD911	end	3	26	43	15:38	8/23/11 18:38	47.577667	-41.986933	4325	3003	aWang	
20110823.1848.001	HTI-Hull	end	3	26	20	15:48	8/23/11 18:49	47.579283	-41.982183	NaN		gLawson	
20110823.1850.001	Hammarhead	start	3	26	18	15:45	8/23/11 18:50	47.579417	-41.981600	NaN	500	aLavery	entered ~5 minutes late so position not exact
20110823.2010.001	HTI-Hull	start	3	26	21	17:10	8/23/11 20:10	47.537000	-41.999850	NaN		gLawson	
20110823.2157.001	Hammarhead	end	3	26	18	18:57	8/23/11 21:57	47.490783	-41.992417	NaN	500	aLavery	entered a couple of minutes late
20110823.2202.001	ReeveNet	start	3	26	15	19:02	8/23/11 22:02	47.490433	-41.992183	NaN	200 mwo	gLawson	200m wire out
20110823.2300.001	ReeveNet	end	3	26	15	20:00	8/23/11 23:00	47.489500	-41.989030	NaN	200 mwo	gLawson	late entry, estimated time out ; chgd evt# from 20110823.2327.001 to 20110823.2300.001; position chgd to agree w/time
20110823.2311.001	MOCNESS	start	3	26	15	20:11	8/23/11 23:11	47.490067	-41.986600	NaN	1000m	pWiebe	
20110824.0200.001	MOCNESS	end	3	26	15	23:00	8/24/11 2:00	47.396983	-41.967817	NaN	1000m	pWiebe	
20110824.0225.001	CTD911	start	3	26	44	23:24	8/24/11 2:25	47.384683	-41.971033	4196	1000	aWang	There was a delay due to communication issue on the CTD; unclear on whether ctd or vpr time is correct, or neither is right (njc)
20110824.0246.001	VPR	start	3	26	37	23:45	8/24/11 2:46	47.379800	-41.972850	NaN	1000	gLawson	There was a delay due to communication issue on the CTD; corrected position
20110824.0302.001	Echosounder	start	3	26	39	0:01	8/24/11 3:02	47.375800	-41.974933	4196		NaN	chgd cast from 43 to 39
20110824.0303.001	Echosounder	end	3	26	39	0:03	8/24/11 3:03	47.375483	-41.975100	4196		NaN	chgd cast from 43 to 39
20110824.0341.001	CTD911	end	3	26	44	0:40	8/24/11 3:41	47.366550	-41.990850	4196	1000	aWang	
20110824.0342.001	VPR	end	3	26	37	0:41	8/24/11 3:42	47.366400	-41.991800	4196	1000	gLawson	
20110824.0348.001	Hammarhead	start	3	26	19	0:49	8/24/11 3:48	47.368333	-41.995850	4196		aLavery	
20110824.0504.001	Hammarhead	end	3	26	19	2:04	8/24/11 5:04	47.450217	-42.016317	NaN		aLavery	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110824.0505.001	Ship	endStation	3	26	NaN	2:04	8/24/11 5:05	47.451850	-42.016417	NaN		NaN	
20110824.0825.001	Ship	startStation	3	27	NaN	5:24	8/24/11 8:25	47.998150	-42.004000	NaN		NaN	
20110824.0826.001	CTD911	start	3	27	45	5:25	8/24/11 8:26	47.997867	-42.004183	4375	1000	aWang	
20110824.0827.001	VPR	start	3	27	38	5:26	8/24/11 8:27	47.997583	-42.004350	NaN	1000	gLawson	
20110824.0829.001	Echosounder	start	3	27	40	5:28	8/24/11 8:29	47.997117	-42.004633	4375		NaN	
20110824.0851.001	Echosounder	end	3	27	40	5:51	8/24/11 8:51	47.996117	-42.005067	4375		NaN	
20110824.0951.001	CTD911	end	3	27	45	6:51	8/24/11 9:51	47.993900	-42.006167	4375	1000	aWang	
20110824.0953.001	VPR	end	3	27	38	6:53	8/24/11 9:54	47.994133	-42.005667	4375	1000	gLawson	
20110824.0954.001	Ship	endStation	3	27	NaN	6:54	8/24/11 9:54	47.994583	-42.005400	4375		NaN	
20110824.1011.001	MacroFaunaObs	start	3	NaN	NaN	7:11	8/24/11 10:12	48.026517	-42.021317	NaN		tWhite	transit to station 28
20110824.1305.001	Echosounder	start	3	28	41	10:04	8/24/11 13:05	48.492767	-42.002033	NaN		NaN	
20110824.1313.001	Ship	startStation	3	28	NaN	10:12	8/24/11 13:13	48.499783	-42.001033	4333		NaN	
20110824.1313.002	Echosounder	end	3	28	41	10:13	8/24/11 13:14	48.500617	-42.000933	4333		NaN	
20110824.1346.001	VPR	start	3	28	39	10:46	8/24/11 13:46	48.506350	-42.001617	NaN	1000	gLawson	
20110824.1347.001	CTD911	start	3	28	46	10:47	8/24/11 13:47	48.506100	-42.001683	NaN	1000	aWang	
20110824.1456.001	CTD911	end	3	28	46	11:56	8/24/11 14:56	48.493433	-42.014200	NaN	1000	aWang	
20110824.1457.001	VPR	end	3	28	39	11:56	8/24/11 14:57	48.493400	-42.014250	NaN	1000	gLawson	
20110824.1501.001	Ship	endStation	3	28	NaN	12:01	8/24/11 15:01	48.494567	-42.017550	NaN		NaN	
20110824.1516.001	MacroFaunaObs	start	3	NaN	NaN	12:15	8/24/11 15:16	48.529950	-42.019700	NaN		tWhite	
20110824.1748.001	Echosounder	start	3	29	42	14:47	8/24/11 17:48	48.998783	-42.000900	4292		NaN	chgd cast from 46 to 42
20110824.1749.001	Echosounder	end	3	29	42	14:48	8/24/11 17:49	48.999017	-42.000583	NaN		NaN	chgd cast from 46 to 42
20110824.1749.002	MacroFaunaObs	end	3	NaN	NaN	14:48	8/24/11 17:49	48.999100	-42.000517	NaN		tWhite	
20110824.1749.003	Ship	startStation	3	29	NaN	14:49	8/24/11 17:49	48.999117	-42.000517	NaN		NaN	
20110824.1753.001	CTD911	start	3	29	47	14:53	8/24/11 17:53	49.000050	-42.001450	4269	1000	aWang	
20110824.1753.002	VPR	start	3	29	40	14:53	8/24/11 17:54	49.000083	-42.001500	4269	1000	gLawson	
20110824.1841.001	underwayPCO2	start	3	NaN	NaN	15:38	8/24/11 18:41	49.011933	-42.009950	NaN		aWang	program crashed Sunday Aug21, rapaired today and started again.
20110824.1900.001	CTD911	end	3	29	47	16:00	8/24/11 19:00	49.017967	-42.010900	NaN	1000	aWang	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110824.1902.001	VPR	end	3	29	40	16:01	8/24/11 19:02	49.018383	-42.010950	NaN	1000	gLawson	
20110824.1904.001	Ship	endStation	3	29	NaN	16:03	8/24/11 19:04	49.019050	-42.010883	NaN		NaN	
20110824.1913.001	MacroFaunaObs	start	3	NaN	NaN	16:13	8/24/11 19:13	49.038033	-42.011033	NaN		tWhite	
20110824.2126.001	MacroFaunaObs	end	3	NaN	NaN	18:26	8/24/11 21:26	49.498483	-41.997217	NaN		tWhite	
20110824.2126.002	Echosounder	start	3	30	43	18:26	8/24/11 21:26	49.499217	-41.997167	NaN		NaN	chgd cast from 47 to 43
20110824.2127.001	Ship	startStation	3	30	NaN	18:27	8/24/11 21:27	49.500317	-41.996667	NaN		NaN	
20110824.2129.001	Echosounder	end	3	30	43	18:29	8/24/11 21:29	49.501467	-41.995267	NaN		NaN	chgd cast from 47 to 43
20110824.2134.001	VPR	start	3	30	41	18:35	8/24/11 21:34	49.504333	-41.994983	4485	1000	gLawson	
20110824.2135.001	CTD911	start	3	30	48	18:35	8/24/11 21:35	49.504400	-41.994967	4485	1000	aWang	no water collected
20110824.2302.001	VPR	end	3	30	41	20:02	8/24/11 23:02	49.544733	-41.952583	NaN	1000	gLawson	
20110824.2303.001	CTD911	end	3	30	48	20:03	8/24/11 23:03	49.545150	-41.952200	4486	1000	aWang	
20110824.2317.001	ReeveNet	start	3	30	16	20:05	8/24/11 23:17	49.552400	-41.942500	NaN	200 mwo	gLawson	
20110825.0013.001	ReeveNet	end	3	30	16	21:12	8/25/11 0:13	49.572967	-41.894367	NaN	200 mwo	gLawson	
20110825.0013.002	Ship	endStation	3	30	NaN	21:12	8/25/11 0:13	49.573150	-41.893533	NaN		NaN	
20110825.0245.001	Ship	startStation	3	31	NaN	23:45	8/25/11 2:45	49.984500	-42.001317	NaN		NaN	
20110825.0246.001	Echosounder	start	3	31	44	23:45	8/25/11 2:46	49.987600	-42.001550	4356		NaN	
20110825.0247.001	Echosounder	end	3	31	44	23:47	8/25/11 2:47	49.989033	-42.001467	4356		NaN	
20110825.0302.001	MOCNESS	start	3	31	16	0:02	8/25/11 3:02	49.992733	-41.989583	NaN		pWiebe	
20110825.0606.001	MOCNESS	end	3	31	16	3:06	8/25/11 6:06	50.060483	-41.793600	NaN	1010	pWiebe	
20110825.0629.001	CTD911	start	3	31	49	3:27	8/25/11 6:29	50.065583	-41.768283	4356	1000	aWang	
20110825.0630.001	VPR	start	3	31	42	3:29	8/25/11 6:30	50.065717	-41.767400	4356	1000	gLawson	
20110825.0738.001	CTD911	end	3	31	49	4:38	8/25/11 7:38	50.069833	-41.735967	NaN	1000	aWang	chgd evt# from 20110825.0749.001 to 20110825.0738.001; corrected position
20110825.0738.002	VPR	end	3	31	42	4:38	8/25/11 7:38	50.069750	-41.735300	4356	1000	gLawson	Approximate time; chgd evt# from 20110825.0750.001 to 20110825.0738.002
20110825.0746.001	Hammarhead	start	3	31	20	4:44	8/25/11 7:46	50.070317	-41.737683	4356		aLavery	
20110825.0749.002	HTI-Hull	end	3	31	21	4:49	8/25/11 7:49	50.069783	-41.735650	NaN		gLawson	
20110825.0805.001	HTI-Hull	start	3	31	22	5:05	8/25/11 8:05	50.069133	-41.738200	NaN		gLawson	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110825.0853.001	Hammarhead	end	3	31	20	5:53	8/25/11 8:53	50.059717	-41.749033	NaN		aLavery	
20110825.0901.001	CTD911	start	3	31	50	6:00	8/25/11 9:02	50.059233	-41.746983	4356	3000	aWang	
20110825.0907.001	HTI-Hull	end	3	31	22	6:07	8/25/11 9:07	50.059083	-41.743717	NaN		gLawson	
20110825.1020.001	HTI-Hull	start	3	31	23	7:19	8/25/11 10:20	50.068833	-41.734600	NaN		gLawson	
20110825.1129.001	CTD911	end	3	31	50	8:29	8/25/11 11:30	50.083900	-41.730100	4356	3000	aWang	
20110825.1157.001	MOCNESS	start	3	31	17	8:57	8/25/11 11:57	50.091250	-41.731267	NaN		pWiebe	
20110825.1456.001	MOCNESS	end	3	31	17	11:56	8/25/11 14:56	50.071383	-41.730433	NaN	1000	pWiebe	
20110825.1540.001	VPR	start	3	31	43	12:39	8/25/11 15:40	50.089767	-41.714167	NaN	1000	gLawson	
20110825.1541.001	CTD911	start	3	31	51	12:40	8/25/11 15:41	50.089767	-41.714100	NaN	1000	aWang	
20110825.1613.001	HTI-Hull	end	3	31	23	13:13	8/25/11 16:13	50.097700	-41.703783	NaN		gLawson	
20110825.1634.001	CTD911	end	3	31	51	13:33	8/25/11 16:34	50.102350	-41.697700	NaN	1000	aWang	
20110825.1634.002	VPR	end	3	31	43	13:34	8/25/11 16:34	50.102433	-41.697383	NaN	1000	gLawson	
20110825.1643.001	Ship	endStation	3	31	NaN	13:43	8/25/11 16:43	50.103433	-41.697400	NaN		NaN	ENTERED ONE MIN. LATE
20110825.1643.002	Ship	endTransect	3	NaN	NaN	13:43	8/25/11 16:43	50.103433	-41.697400	NaN	NaN	NaN	added late; chgd evt# from 20110827.2133.001 to 20110825.1643.002
20110825.1643.003	Ship	startTransect	4	NaN	NaN	19:07	8/25/11 16:43	50.103433	-41.697400	NaN	NaN	NaN	chgd evt# from 20110825.2208.001 to 20110825.1643.003
20110825.1706.001	MacroFaunaObs	start	4	NaN	NaN	14:06	8/25/11 17:06	50.084383	-41.757600	NaN		tWhite	
20110825.1916.001	HTI-Hull	start	4	NaN	24	16:16	8/25/11 19:17	49.922017	-42.207317	NaN		gLawson	
20110825.2104.001	MacroFaunaObs	end	4	NaN	NaN	18:03	8/25/11 21:04	49.749833	-42.631183	NaN		tWhite	
20110826.0334.001	Ship	startStation	4	32	NaN	0:33	8/26/11 3:34	49.130367	-44.249200	NaN		NaN	
20110826.0335.001	ReeveNet	start	4	32	17	0:34	8/26/11 3:35	49.130033	-44.250150	NaN	200 mwo	gLawson	
20110826.0425.001	ReeveNet	end	4	32	17	1:00	8/26/11 4:25	49.111900	-44.277130	NaN	200 mwo	gLawson	Late entering time; chgd evt# from 20110826.0435.001 to 20110826.0425.001; corrected position
20110826.0428.001	MOCNESS	start	4	32	18	1:28	8/26/11 4:28	49.110450	-44.278220	NaN		pWiebe	position adjusted, njc 9/8/11
20110826.0700.001	MOCNESS	end	4	32	18	4:00	8/26/11 7:00	49.080050	-44.345430	NaN	1012	pWiebe	positions need adjustment (position almost exactly matches alongtrack so did not change - njc)
20110826.0707.001	Echosounder	start	4	32	45	4:06	8/26/11 7:07	49.079550	-44.348117	2563		NaN	
20110826.0711.001	Echosounder	end	4	32	45	4:11	8/26/11 7:11	49.079817	-44.353333	2563		NaN	
20110826.0720.001	CTD911	start	4	32	52	4:15	8/26/11 7:20	49.079117	-44.362817	2563	1000	aWang	

Event	Instrument	Action	T	Station	Cast	Time Local	GPS_Time	Latitude	Longitude	Seafloor	Cast Depth	PI_name	Comment
20110826.0721.001	VPR	start	4	32	44	4:20	8/26/11 7:21	49.078767	-44.363167	2536	1000	gLawson	
20110826.0852.001	CTD911	end	4	32	52	5:52	8/26/11 8:52	49.066717	-44.368000	NaN	1000	aWang	
20110826.0852.002	VPR	end	4	32	44	5:52	8/26/11 8:52	49.066717	-44.367933	NaN	1000	gLawson	
20110826.0853.001	Ship	endStation	4	32	NaN	5:52	8/26/11 8:53	49.066733	-44.367800	NaN		NaN	
20110826.0934.001	MacroFaunaObs	start	4	NaN	NaN	6:34	8/26/11 9:35	48.988583	-44.395983	NaN		tWhite	
20110826.1750.001	MacroFaunaObs	end	4	NaN	NaN	14:49	8/26/11 17:50	47.628500	-44.542033	NaN		tWhite	
20110826.1835.001	MacroFaunaObs	start	4	NaN	NaN	15:34	8/26/11 18:35	47.505500	-44.549233	NaN		tWhite	
20110826.2151.001	MacroFaunaObs	end	4	NaN	NaN	18:50	8/26/11 21:51	46.970550	-44.581000	NaN		tWhite	sunset on the Flemish Cap
20110827.0932.001	MacroFaunaObs	start	4	NaN	NaN	6:31	8/27/11 9:32	44.998867	-44.700083	NaN		tWhite	
20110827.2052.001	MacroFaunaObs	end	4	NaN	NaN	17:52	8/27/11 20:52	43.166850	-44.818233	NaN		tWhite	
20110828.1016.001	MacroFaunaObs	start	4	NaN	NaN	7:15	8/28/11 10:16	42.342750	-46.889867	NaN		tWhite	
20110828.2208.001	MacroFaunaObs	end	4	NaN	NaN	19:07	8/28/11 22:08	42.135633	-49.656167	NaN		tWhite	
20110829.0933.001	MacroFaunaObs	start	4	NaN	NaN	6:32	8/29/11 9:33	41.949050	-52.536567	NaN		tWhite	end event not recorded
20110829.2011.001	Echosounder	start	4	32	45	17:10	8/29/11 20:11	41.780767	-55.152900	4706		NaN	
20110829.2011.002	Echosounder	end	4	32	45	17:11	8/29/11 20:11	41.780700	-55.154900	NaN		NaN	
20110831.0000.001	Ship	other	4	NaN	NaN	0:00	8/31/11 22:12	NaN	NaN	NaN	NaN	NaN	rough weather: no deck activities
20110831.0959.001	MacroFaunaObs	start	4	NaN	NaN	6:58	8/31/11 9:59	41.472350	-64.205200	NaN		tWhite	
20110831.2212.001	MacroFaunaObs	end	4	NaN	NaN	19:12	8/31/11 22:12	41.474183	-67.396350	NaN		tWhite	
20110901.1244.001	HTI-Hull	end	4	NaN	24	8:44	9/1/11 12:44	41.523433	-70.671717	NaN		gLawson	chgd evt # to preceed end of cruise: from 20110901.1245.001 to 20110901.1243.001
20110901.1244.002	MICA	end	4	NaN	NaN	8:44	9/1/11 12:44	41.523400	-70.671783	NaN		aWang	
20110901.1244.005	underwayPCO2	end	4	NaN	NaN	8:44	9/1/11 12:44	41.523400	-70.671783	NaN		aWang	added to event log post-cruise
20110901.1244.003	Ship	endTransect	4	NaN	NaN	8:43	9/1/11 12:44	41.490033	-70.589467	NaN		NaN	entered early; chgd time/position, etc.: chgd evt# from 20110901.1203.001 to 20110901.1244.003
20110901.1244.004	Ship	endCruise	4	NaN	NaN	8:43	9/1/11 12:44	41.523417	-70.671783	NaN		NaN	