R/V Endeavor Cruise #484 'Georges Bank Krill'

Cruise Report

September 22 – October 1 2010

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"*Biological and Physical Determinants of Euphausiid Aggregation, Behavior, and Interaction with Higher Predators at an Abrupt Topographical Feature in the Gulf of Maine*"

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1. Acknowledgements

The success of this cruise would not have been possible without the efforts of the Endeavor's captain, officers, and crew and we are very appreciative of their hard work. The extremely capable assistance of URI Marine Technician Dave Nelson was likewise much appreciated. We are also grateful for the efforts of the University of Rhode Island's ship support group prior to the cruise with respect to planning and installing all equipment. This cruise was supported by NSF grant OCE-0928801.

2. Background

The physical and biological forces leading to variability, or patchiness, in the distribution of zooplankton represent a long-standing problem in biological oceanography. The interaction of active vertical movements with the flow fields typical of regions of abrupt topography is thought to be an important mechanism for the generation of zooplankton aggregations, and this project addresses gaps in our understanding of the formation and maintenance of euphausiid aggregations in such regions. Euphausiids (krill) are an important group of crustacean zooplankton in North Atlantic pelagic ecosystems, and represent an interesting model species for the study of zooplankton patchiness due to their strong swimming capabilities and active aggregative behaviors.

The goal of this project is to examine the biological and physical processes leading to the aggregation of zooplankton, particularly krill, on the northern side of Georges Bank and southern Gulf of Maine, as well as the interaction of these aggregations with higher predators, including fish, marine mammals, and seabirds. The project consisted of two cruises, EN484 in late September when herring in the area, which we hypothesized to be the main predator, were expected not to be feeding on the krill due to their being pre-spawning; and then EN487 in late October at which time we anticipated that the herring would have spawned and would be feeding on the krill. This thus provided a 'natural experiment' varying the levels of predation pressure. This is an NSF-funded project with WHOI scientists Gareth Lawson, Peter Wiebe, and Andone Lavery as PIs.

Each cruise involved an ambitious set of science objectives, including the completion of two planned 'mapping' surveys of a regular transect grid to identify zooplankton aggregations, with each mapping survey followed by a 'tracking' survey along adaptively-chosen transects examining individual aggregations. Underway instruments deployed included a deep-towed broadband acoustic towed body, a surface-towed multi-frequency acoustic sled, and the ship's hull-mounted ADCP for currents. During daylight hours, visual observers were to survey surface-associated top predators and test an automated panoramic camera system. At periodic stations, underway activities were interrupted for CTD casts (for hydrography), Video Plankton Recorder (VPR) profiles, and/or MOCNESS net tows (to ground-truth the acoustic data). Each of these latter three instruments was deployed (separately) via the stern A-frame, with the intent of keeping the two acoustic bodies in the water at the surface. A calibration of the deep-towed acoustic system relative to depth and tests of a new LED-based strobe light system on the MOCNESS were also planned. Our survey work was coordinated via email and radio contact with the concurrent herring survey on the FRV Delaware II led by our collaborator Dr. J. Michael Jech of the Northeast Fisheries Science Center (NEFSC), such that we will later be able to draw upon the results of his pelagic trawls to determine the size and kinds of fish present, as well as whether or not euphausiids were present in their stomachs.

3. Cruise Objectives

The central goal of this cruise was to quantify the distribution, abundance, aggregation structure, and interaction with higher predators, of euphausiid aggregations at a study site along the northwestern flank of Georges Bank. The specific objectives included:

1. To survey hydrographic conditions via underway sampling systems and CTD deployments at a series of stations along both the mapping and tracking survey lines.
2. To characterize the flow field via ADCP data collection.
3. To conduct VPR casts to quantify the vertical and horizontal distribution and abundance of euphausiids and other zooplankton.
4. To conduct tows with a Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS) at a subset of stations to quantify the vertical and horizontal distribution and abundance of euphausiids and other zooplankton.
5. To test the efficacy of an LED-based strobe light system mounted on the MOCNESS for mitigating krill avoidance behaviors.
6. To preserve net samples of euphausiids and other zooplankton for later analyses of taxonomic composition.
7. To collect multi-frequency acoustics continuously along-track and at stations from the surface using a towed body to characterize the distribution of zooplankton, especially euphausiids, across spatial scales.
8. To collect broadband acoustic data via a towyoed package 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, size, and distribution of euphausiids.
9. To conduct visual surveys for macrofauna including seabirds, marine mammals, and surface-associated fishes.
10. To test the utility of a panoramic camera system for quantifying top predator abundance.

4. Survey Design

A tentative study region north of Cultivator Shoals, just beyond the Great South Channel, had been selected at the time of proposal submission based on acoustic and net samples made during previous years by our collaborator Dr. Jech in the course of the NEFSC fall acoustic and pelagic trawl surveys for herring. Based on observations made by Dr. Jech during Leg I (Sept 7-17) of the 2010 herring survey of this region on the FRV Delaware II, the exact study site ultimately examined was shifted slightly towards the northeast to a region centered at 42°N 67°30’W, extending from approximately the 50-m depth contour to depths >200 m in the southern Gulf of Maine (Figure 4.1).

The planned design was to conduct an initial 2-day mapping survey to map out the distribution of krill, followed by a 2-day tracking survey where the vessel would remain with a particular aggregation. This would be followed by a second mapping-tracking pair for the remaining 4 cruise days. Logistic constraints including weather and slow survey speeds required the scope of the survey effort to be reduced.

The ultimate survey design therefore involved an initial mapping survey along 7 transects running across isobaths from the ca. 50m contour towards the northwest into the Gulf of Maine (Figure 4.1). Upon completion of this survey, a tracking survey of a 6nm x 6nm region was repeatedly surveyed via a ‘bowtie’ pattern. Following the tracking survey, the remaining time was used for a short second mapping survey along those transect lines bracketing the bowtie.

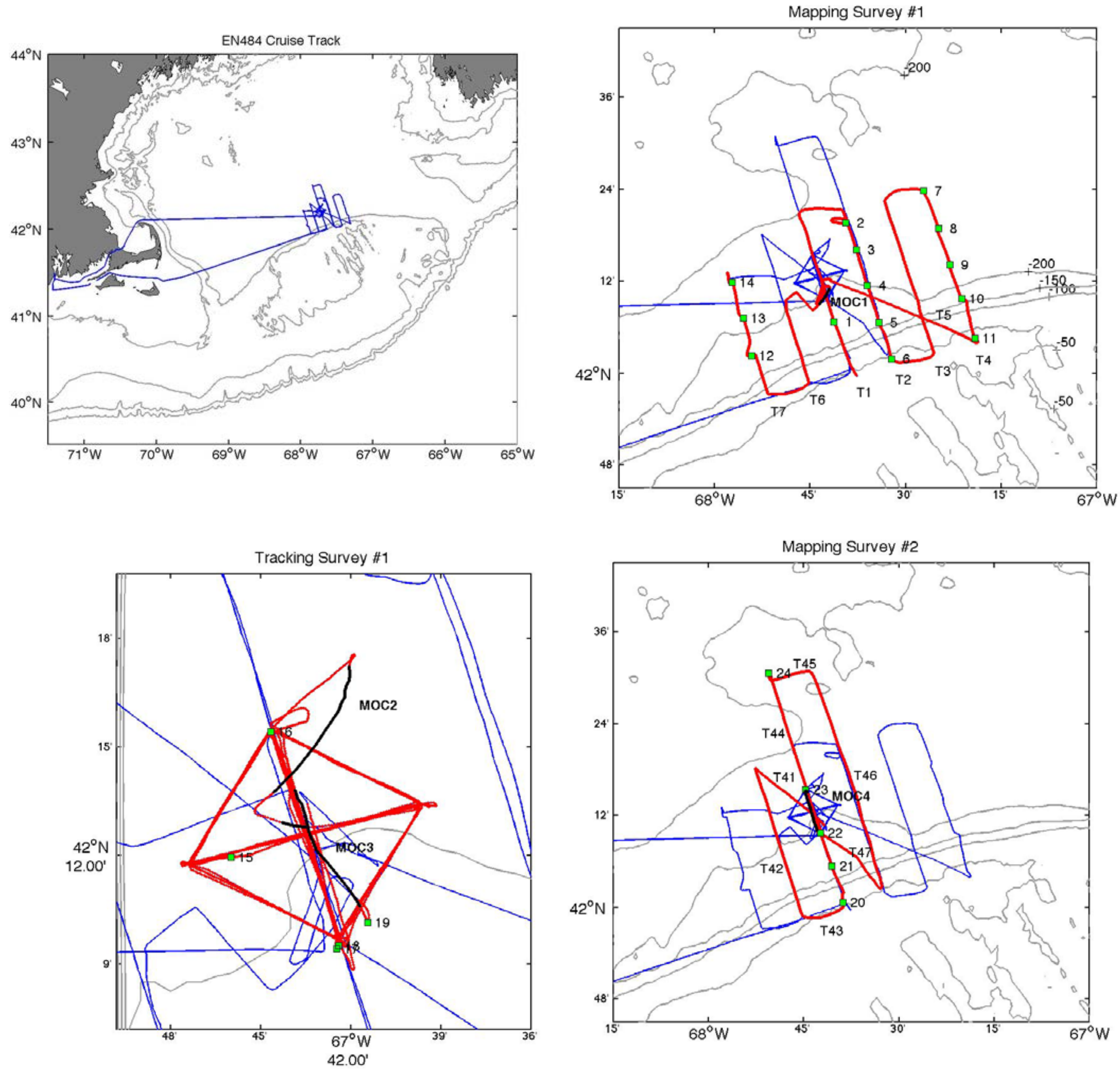


Figure 4.1. Clockwise from top left: EN484 cruise track, mapping survey #1, mapping survey #2, and tracking survey #1. Blue lines show ship's track. Red lines show survey locations with transects labeled by number. Black lines show MOCNESS tow locations. Green boxes indicate stations.

5. Cruise Narrative

The cruise began on schedule the morning of Wednesday September 22, 2010. After a series of test deployments in Long Island Sound south of Beaver Tail Point in Narragansett Day, we headed for Georges Bank, arriving on the morning of Thursday September 23. Work began with an initial mapping survey along a regular series of transects running across the slope of Georges Bank and into the Gulf of Maine, each 20 nm in extent and spaced every 5 nm along-slope (Figure 4.1). The first transect was positioned where we expected to see the maximum amount of krill, based on Dr. Jech's survey results. We then ran transects increasingly farther to the northeast until we reached the Hague Line, after which we returned to our starting line to conduct a net tow to confirm the presence of krill. On every second transect, underway surveying was interrupted at 5 regularly-spaced stations for profiles with a Video Plankton Recorder (VPR) to just above the bottom (Figure 4.1). The original intent was to conduct both CTD and VPR casts, but after the first station we decided that this approach was too time-consuming, due to the time associated with moving the instruments about over the deck and swapping the cable termination. Nonetheless, we were very pleased that at the VPR stations and MOCNESS tow locations we were often able to deploy three instruments at a time (port-side, stern, starboard-side) as intended, in order to collect co-located data. After the first net tow, two additional transects were surveyed towards the southwest, shortened slightly relative to earlier transects in order to save time.

During surveying, underway data were collected at vessel speeds of ca. 4 knots. The surface-towed multi-frequency echosounder housed in a V-fin towed body (aka the Greene Bomber) was towed over the portside with a tow boom provided by the science party. This boom was not designed for this purpose and was borrowed from the WHOI Deep Submergence Lab, but it performed reasonably well in all but the roughest sea states. The broadband echosounder was housed in a custom towed body and towyo'ed between the surface and depths in excess of 150 m. Unfortunately, this deep-towed acoustic system often could not be deployed because even at the maximum outboard extent of the J-frame, unfavorable currents relative to the vessel's course would push the body and tow cable up against the ship. The data from these acoustic sensors indicated the presence of a persistent layer of krill throughout much of the surveyed region, along with fish-like scattering (likely herring) in certain regions, particularly next to the Bank. Underway data collection with the ship's ADCP also went very smoothly. Due to the excellent support of Jules Hummon at the University of Hawaii (UH) and the user-friendly UH Data Acquisition Program, we were able to synchronize transmission from the ADCP with our own scientific echosounders; this was necessary because the three instruments overlapped in frequency. During daylight hours, visual surveying for seabirds was very successful. Due to rough conditions, visual surveying for marine mammals was often not possible or observations were compromised by sea surface state.

Examination of data collected during the mapping survey led to the identification of a box 6 nm in across- and along-track extent to be targeted by a 48-hour tracking survey, situated in a region of high krill- and fish-like acoustic scattering along the first transect surveyed. The original plan was to conduct an adaptive survey remaining with the krill aggregation, but the mapping survey had indicated that the krill layer was highly persistent and extensive, such that the tracking survey wouldn't be able to reach the layer's edges. We therefore decided to track diel changes in layer composition and position by surveying a smaller region that could be covered in 6-hours, thereby allowing the box to be surveyed repeatedly over a tidal cycle. A 'bow-tie' pattern covering the tracking survey box was thus repeatedly transited with the acoustic systems, punctuated by occasional adaptive VPR casts based on real-time examination of the acoustic data. Two MOCNESS net tows were also conducted, the second of which sampled repeatedly within the krill layer. The strobe light system was tested during the latter tow by having it turned on or off for randomly selected nets. As possible given the sea states, top predator surveying continued during the tracking survey. Successful coordination with our NEFSC collaborator was also achieved: mid-way through the tracking survey Mike Jech's herring survey on the Delaware II conducted a survey transect directly through our survey box, and conducted four midwater trawls in the vicinity.

Upon completing the tracking survey a second, abbreviated, mapping survey was conducted along two of the transects surveyed in the first mapping survey; these transects were extended by ca. 10 nm to sample the distribution of krill farther towards the northwest into the Gulf of Maine. Due to oncoming bad weather the ship departed the study site a day early. We hoped to conduct a calibration of the deep-towed broadband acoustic system in Cape Cod Bay where conditions were calmer, but due to the forecast of bad weather at the ship's home port we returned to port a day early, arriving on Thursday September 30, without managing the calibration.

The 11 member science party was divided into an eight-person zooplankton team, who handled the various acoustic/optical/environmental instruments and conducted operations around-the-clock, and the three top predator observers, who only worked during daylight hours and only when the vessel was underway (i.e., not on station). The zooplankton team was divided into two 12-hour watches of four with Lawson and Wiebe as watch leaders for the day (0530-1730) and night (1730-0530), respectively. One science party member (Liu) was bed-ridden with seasickness for the first 5 days of the cruise and still not 100% for the remainder of the cruise. This led to the night-watch being short one person. Many of the science party were students and some were first time cruise participants. Nonetheless, the science party was able to complete all of the necessary tasks towards achieving the cruise's scientific objectives. The URI ship's operator kindly provided an extra A/B (for a total of 4) and by their pulling extra shifts we had two A/Bs on watch at all times. This allowed one of them to be in the doghouse running the winch during towing operations, which often went on for many hours at a time when towing the broadband deep tow system. Dave Nelson the marine technician kept irregular hours and so was on-hand for all of the MOCNESS tows and as needed for other operations, including emergency instrument repairs.

Instrumentation, Methodologies, and Preliminary Results

6. Equipment Configuration

The Hammarhead towed body housing the Edgetech broadband system was deployed from the starboard side J-frame (Figure 6.1) via the Endeavor's oceanographic winch #1. Due to the wire getting oily during an earlier cruise to the Gulf of Mexico the EM 3-conductor cable on this winch had recently been shortened to 1477m. Tests conducted immediately prior to the cruise had confirmed that this short length of wire would provide the necessary bandwidth for the Edgetech system (tests done at WHOI previously had found that by ca. 2000m the bandwidth of standard UNOLS EM cable is compromised). Both the VPR and MOCNESS were deployed via the stern A-frame using winch #2. The VPR is autonomous and did not require conducting cable. The MOCNESS communicated with the deck unit fine with the ca. 10,000m of wire on winch #2. Only one of these two winches can be operational at any given time and swapping between them requires an engineer, making it a somewhat time consuming process (ca. 15 minutes).

Figure 6.1. Main deck layout showing the deployment locations of the HammarHead (left) and MOCNESS/VPR/CTD (right). Photos: P. Wiebe.

The Greene Bomber was deployed over the port side using a portable Hyab knuckle crane and towed from the USBL pole mount borrowed from Matt Heintz the WHOI Deep Submergence Lab (Figure 6.2). Typically this pole is oriented vertically and is used to lower a positioning transducer over the side. In our application the pole was oriented horizontally over the side. Calculations by the pole's designer at DSL, Casey Machado, had suggested it would tolerate the loads imposed by towing the Bomber. During rough sea states the pole flexed substantially however, despite our best efforts to strengthen it via a complicated arrangement of stays and lines providing topping lift. Deployment was a labor-intensive process, with all four A/B's, multiple science party, and the bosun required. For deployment, the crane lifted the Bomber over the rail via a strap kept in place with a pin. Once in the water, tension was taken up on the towline and the pin was removed.

Figure 6.2 Greene Bomber tow assembly and deployment. Photos: P. Wiebe.

The main lab housed, in order of increasing distance from the stern on the athwartship benches (Figure 6.3):

- Against the aft wall a 'surgery' table for electronic repairs
- On the first bench a series of work stations occupied by the top predator observers and Nick Woods (ADCP processing), with the VPR processing computers opposite

- On the second bench, Gareth and Peter's work stations with the acoustic data collection computers opposite
- On the third bench, the event logger computer and Wu-Jung/Cindy's personal computers used for broadband data processing, with the MOCNESS data collection computer opposite.

Figure 6.3. Main lab layout. Photos: P. Wiebe.

The wet lab and its fume hood were used for MOCNESS sample processing. The small science lab forward of the wet lab was mostly unused, other than occasionally for personal computers. For the most part, personnel off-watch set up their laptops in the main lab.

7. Physical Oceanography

7.1. *Underway Sampling*

Along-track measurements were made continuously during the course of the cruise, to provide information on environmental conditions. Sea surface temperature, salinity, fluorescence and a variety of other data were collected upon leaving port. These data were saved on the ship's data server in several different file formats on a daily basis at 1-second, 1-minute, and 1-hour resolutions.

7.2. *CTD*

A CTD package was provided by the ship's operator with a variety of sensors, including light sensors, a transmissometer, etc. The initial plan was to deploy this CTD successive to VPR casts at the regular stations. After the first such series of deployments we realized that the time spent moving the instruments and swapping the terminations was excessive and would impede completion of the surveys in a timely fashion. We therefore decided that the fast CTD that is part of the VPR package would provide sufficient hydrographic data for our purposes. For the remainder of the cruise we therefore only deployed the VPR.

7.3. *ADCP*

Nicholas Woods

Although krill are relatively strong swimmers, ocean currents may play a role in determining the size, location, and density of krill patches. In order to understand the impact of ocean physics on these organisms, two Acoustic Doppler Current Profiler (ADCP) systems were used on this cruise: Shipboard 75 kHz ADCP and a Nortek 1MHz Aquadopp ADCP.

7.3.1. Shipboard 75 kHz ADCP

The Endeavor is equipped with a 75 kHz RDI Ocean Surveyor ADCP that was in use during the majority of the cruise. This instrument directly measured ocean velocity relative to the ship and acoustic backscatter at 75 kHz. Data were acquired using the UHDAS software, a suite of software designed at the University of Hawai'i. Preliminary processing on the raw data is also performed by UHDAS, and the processed data were stored in MATLAB files available on the shipboard data server. This preliminary processing includes rotating the velocities to Earth coordinates, ensemble averaging, and removal of the ship's velocity using GPS. The final product includes water velocity, ship velocity, backscatter amplitude, velocity error, and other diagnostic variables in 8-meter vertical bins and 5-minute ensemble averages. During the cruise, an external trigger controlled the ADCP's ping emissions, so as not to interfere with other acoustic instruments; to be externally trigger the Ocean Surveyor simply takes a 5V logic signal of minimum duration 1ms (with the user specifying whether the increasing or falling edge of the pulse is used) via a BNC connector. The Endeavor is also equipped with a 153 kHz RDI Workhorse ADCP. Synchronizing the Workhorse is more difficult and requires specialized connectors from the manufacturer.

Two types of sampling schemes were utilized: cross-bathymetry sections ("transects"), and small-scale krill-patch surveys ("bowties"). Ship-track, velocity, and backscatter amplitude for an example transect are plotted in Figure 7.1. The most predominant characteristic of the ADCP sections is the semidiurnal tidal flow (M2). The tidal velocities, in general, are strongest in the shallower water on Georges Bank, and weaker off the bank to the north. The sub-tidal flow may be particularly important in determining spatial characteristics of krill patches; however, due to the spatial variability of the tidal flow in this region, a simple method of removing the tidal velocity from the data is not readily available. Upon return to shore, a suitable tidal model will be used to de-tide the shipboard ADCP data.

Problems: On occasion, the external trigger would fail, causing the ADCP to stop logging. During these times, there is no shipboard ADCP. In shallow water, the ADCP does not perform well; the bottom mask provided by UHDAS does not recognize the bottom. The processing steps taken by UHDAS have not been verified on the ship; it may be wise to check these steps to be sure that they do not alias the data in any preventable way.

7.3.2. Nortek 1 MHz Aquadopp Current Profiler

A Nortek 1 MHz ADCP was affixed to the top of the HammarHead Towfish looking up in order to measure current velocity and acoustic backscatter. The transmit frequency of this instrument is higher than that of the broadband acoustics on the Towfish, and it is a self-contained unit, requiring no communication while deployed. The ADCP was set to create a velocity profile every 10 seconds during deployment. Each profile consisted of an average of 5 seconds of single-ping data. This resulted in an estimate of the single-profile velocity error of 5 cm/s. There were twenty vertical bins, each 1-meter in height, with a 0.41 m blanking distance between the instrument and the first bin. For each deployment the setup file was saved with a ".dep" extension. There was concern before deployment that the Nortek's internal compass would be unreliable due to the strong magnetic field caused by the Towfish. Thus, the instrument logged data in "XYZ" coordinates, meaning that velocity is recorded relative to the instrument. The instrument's coordinate system is depicted in Figure 7.2. The raw data will have to be rotated into Earth coordinates using a reliable compass heading (Towfish or shipboard compass).

The HammarHead was deployed and recovered several times during the cruise. During longer periods on deck, Nortek data was downloaded using Aquapro software and backed up. This resulted in 4 different Nortek files (en484101.prf, en484201.prf, en484301.prf, and en484401.prf). Each of these files was converted into ASCII data files (.a1, .a2, .a3, .v1, .v2, .v3, .hdr, and .sen), which are then read into MATLAB for later processing.

During one Nortek period of being turned on (#2), weather conditions prevented the use of the HammarHead, and so the Nortek did not make it in the water. During the other three deployments, the instrument was kept mostly near the surface, meaning that most of the bins were out of the water. However, during deployments 1, 3, and 4, the HammarHead was “towyo’d”, allowing the Towfish to fly to depth and back to the surface. At these times, more of the Nortek’s bins were underwater and there be more useable data. For example, Figure 7.3 shows time series of pressure, velocity, and acoustic backscatter as a function of depth from Nortek deployment 4. For most of the deployment the fish was near the surface. The ADCP profiles were mostly out of the water, and strong backscatter amplitude is evident due to the surface (perhaps from bubbles). The movement of the Towfish through the water dominated the along-instrument velocity channel; this velocity was positive because the instrument is mounted facing backward (thus the water appears to be moving in the positive direction). The across-instrument velocity appeared to be negative for most of the time the fish was at the surface, which may be a result of the way the Towfish was flying through the water.

Problems: The data were recorded in instrument coordinates because of interference between the Nortek compass and the innards of the Towfish. The velocity data need to be rotated to Earth coordinates using a reliable compass heading. Care must be taken to consider the fact that the Nortek was mounted facing backward on the fish. The velocity data are still contaminated with the Towfish’s velocity. This must be removed by some means (removing the ship’s velocity would be a good start). During this cruise, the Towfish spent most of the time in the water at the surface, meaning that the Nortek was not collecting useful data. In the future, new mounting locations may be considered, or more towyoing may be implemented in order to get more useful Nortek data.

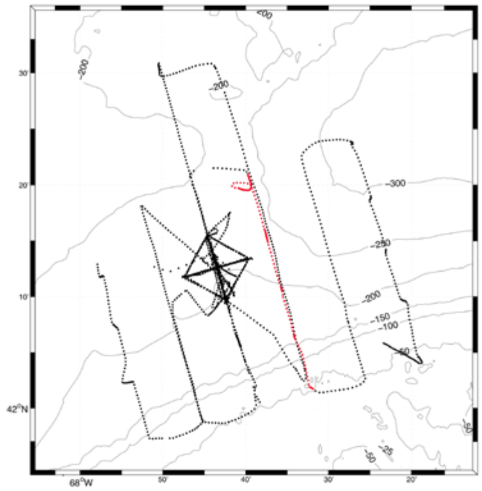
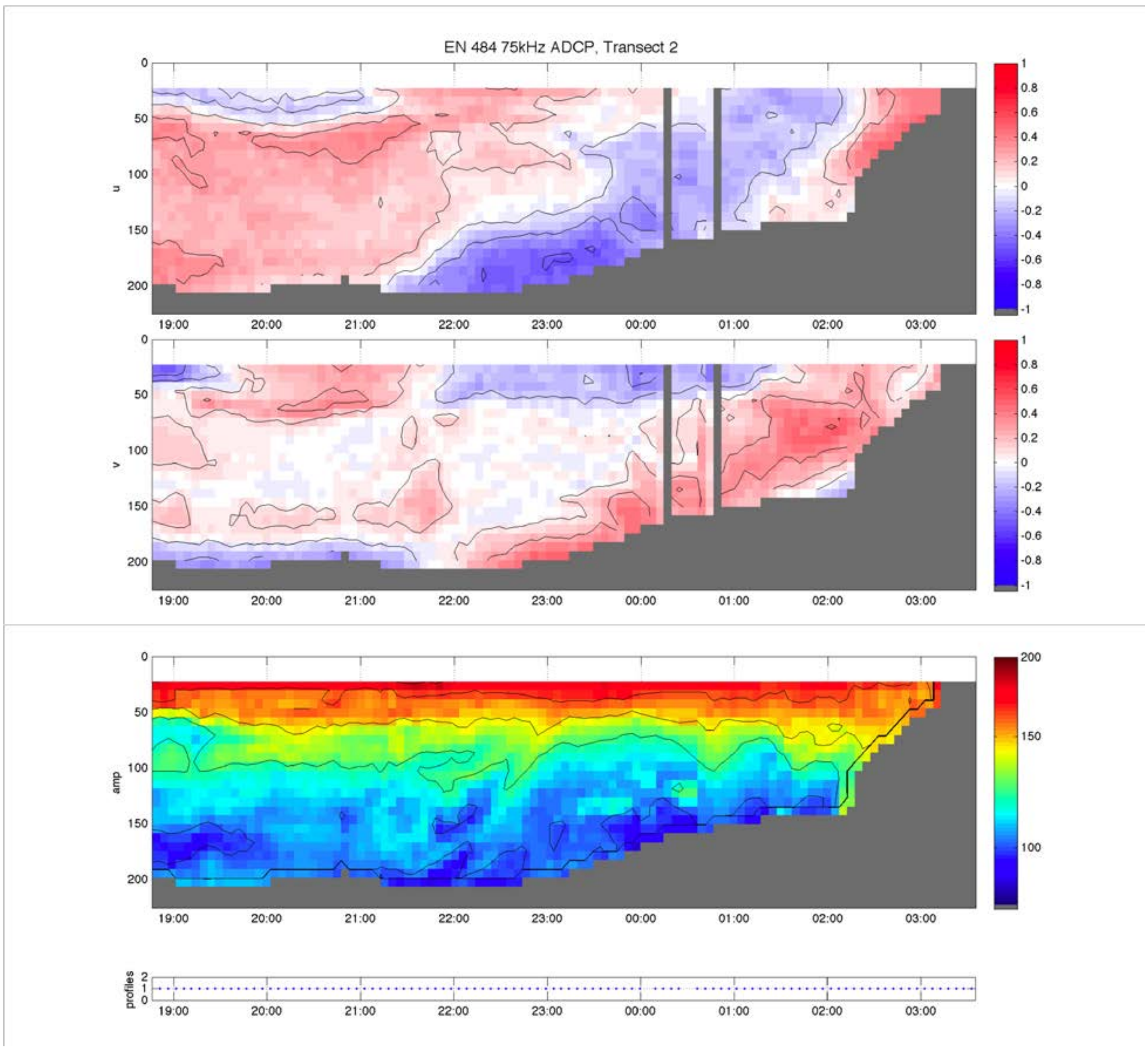


Figure 7.1. Shipboard ADCP transect 2 map (*top*), eastward velocity (*upper contour*), northward velocity (*middle contour*), and acoustic backscatter amplitude (*bottom contour*). Transect took approximately 8 hours to complete (times are in GMT).



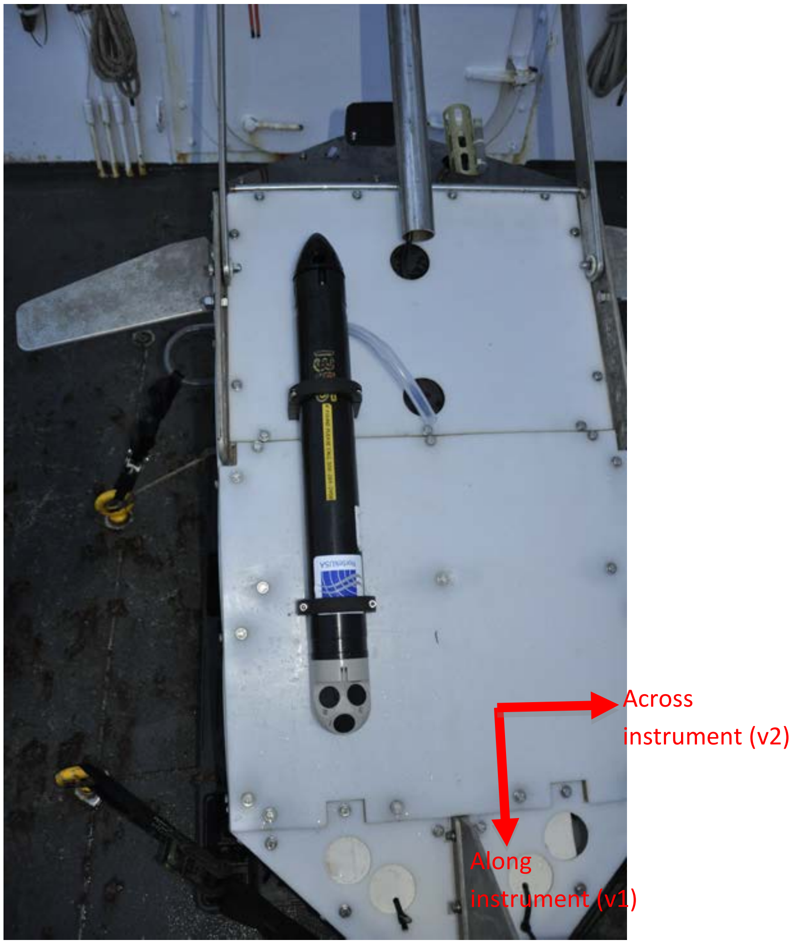


Figure 7.2. Nortek mounted on the HammarHead. Arrows indicate instrument coordinated system. The z-coordinate (v3) is straight up (out of the page). Photo: N. Woods

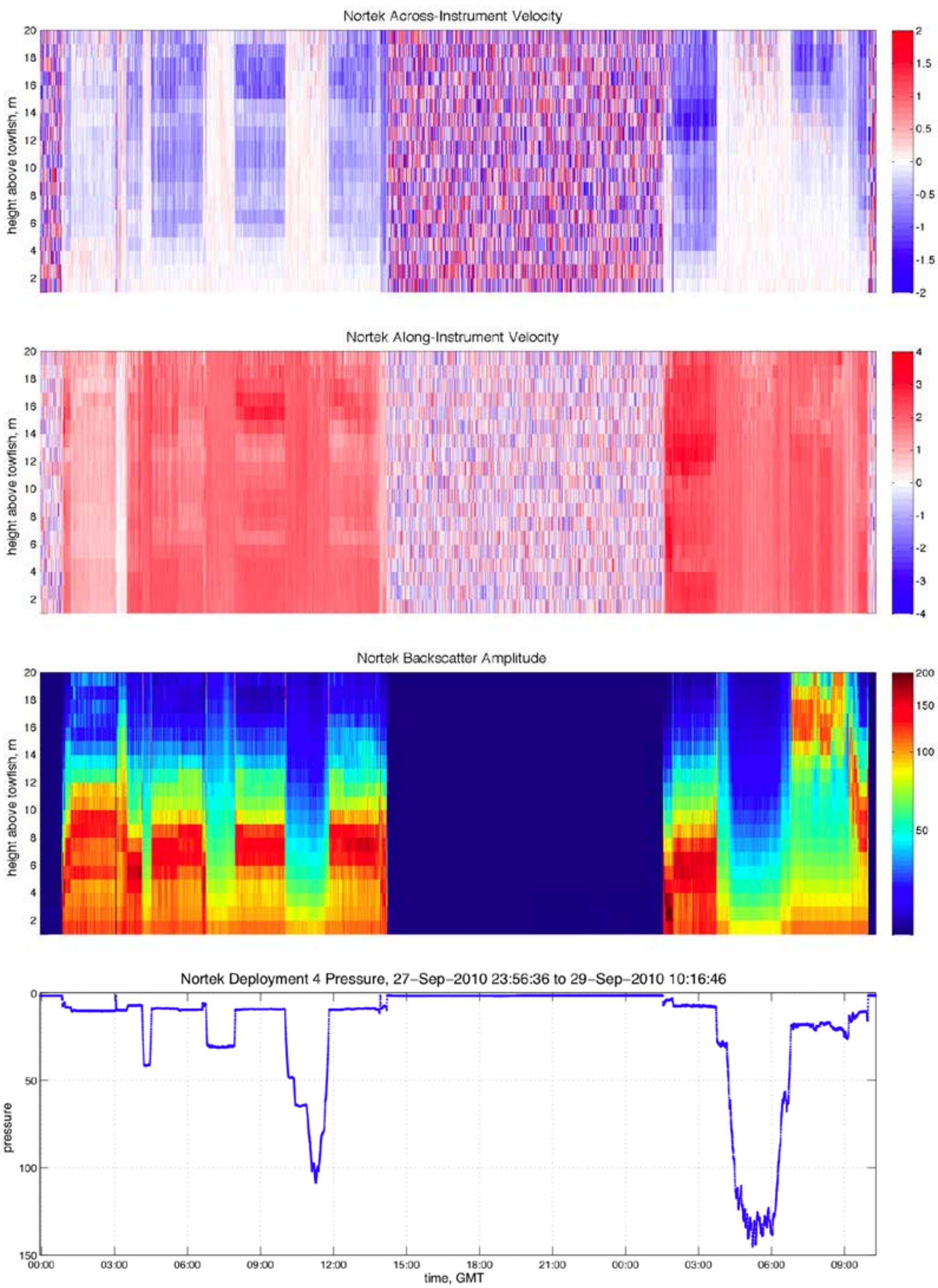


Figure 7.3. Nortek ADCP across-instrument velocity (*top*), along-instrument velocity (*top-mid*), acoustic backscatter amplitude (*bottom-mid*), and pressure (*bottom*) from September 27 to September 29. Instrument was on-deck from about 15:00 on 9/27 to 02:00 on 9/28 due to weather conditions.

8. Zooplankton Sampling

8.1. *Multi-frequency acoustics*

Gareth Lawson

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 during MOCNESS and VPR deployments. The goals were to collect acoustic data concurrent to sampling with other instruments in order to conduct cross-correlations; to characterize the distribution of scattering from biological sources, especially krill and fish, in relation to environmental conditions; to characterize patch structures as well as rates and amplitudes of diel vertical migrations; to provide indices of pelagic animal abundance to be correlated with other datasets, including observations of macrofauna.

8.1.1. 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 6.3). 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 Greene Bomber a 5’ V-fin towed body, which was towed at a roughly constant tow depth of ca. 2-3m.

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 nearly continuously over the course of the cruise during both transit and while on station, other than on two occasions after transects 4 and 7 when the Greene Bomber was recovered to shore up the tow boom arrangement (and move quickly to a new survey location), 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 mostly 4 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 300, 300, 150, and 100m, respectively, with corresponding interval durations to achieve these ranges of 650, 650, 350, and 250 ms. 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 ca. 1000 ms (the exact duration was experimented with over the course of the cruise) was used to provide the Edgetech sufficient time to complete its ping cycle.

The .INT and .BOT files were further post-processed by Gareth Lawson 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 groups of transects or bow-tie passes.

8.1.2. Problems and Solutions

Noise
The transducers operated very well with respect to noise. Initial noise tests were done at the mouth of Narragansett Bay during a series of test deployments. The HTI deck unit was plugged into the main lab’s clean power supply, which resulted in good performance – during a previous Endeavor cruise the system had been plugged into the van’s power strip which was receiving unclean deck power. That arrangement had led to strong noise at 120 kHz. The 420 kHz channel, like on the previous Endeavor cruise, was quite noisy but the other channels performed well, quieter than on the R/V Connecticut cruise conducted earlier this year. At the recommendation of the marine techs we did not use the UPS that we often use during dock tests because apparently the filters on the UPS interfere with the filters they use to clean up the power supply. Noise tests were done both with and without the HammarHead also pinging (synchronized). The noise profiles were pretty much indistinguishable, suggesting that the synchronization was working.

During surveying the acoustic data, especially at 43 kHz, were often subject to noise, especially as weather worsened, sea states increased, and tow body motion increased. Although the ship’s speed was therefore often kept low the data quality was always useable.

Interference
A number of ship’s acoustic systems interfered with the HTI frequencies, including the bridge sounder (ca. 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). The bridge and marine tech were very accommodating in allowing us to run with these systems all kept off.

Computer Issues
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 multiple times to get the M242 and M244 communicating and the samples data logging. 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. For much of the cruise we also were only associated the GPS data with one of the MUX channels, rather than with all of them. This is set in software. Historically we would associate the GPS data with all MUX ports, such that the matlab processing code could expect to find GPS data for any MUX channel in the sequence. By mistakenly setting the GPS to only log with one of the MUX channels (MUX#1), the matlab code stopped getting GPS data. This setting was fixed towards the end of the cruise and Tobias Work modified the matlab code to deal with the GPS data being assigned to only one port.

8.1.3. Preliminary Results

Multi-frequency acoustic data were collected for most of the cruise and over a reasonable geographical area. As had been the original proposed goal, by examining the frequency response of different scattering layers, coupled with strategic VPR deployments, we were able rapidly at the start of the cruise to identify krill layers (e.g., Figure 8.1.1). Following the initial mapping survey, particular regions were selected for tracking, where again on the basis of frequency response we were able to confirm that we were remaining with the krill aggregations. Qualitative examination of the data suggest that these krill aggregations are very large, extending farther both off- and along-bank than we were able to survey. Fish-like scattering was also clearly evident in the multi-frequency data, with aggregations of fish found immediately at the edge of Georges Bank and often a bit farther off-bank as the bottom dropped off further (e.g., Figure 8.1.1). Another notable scattering feature was weaker scattering consistent with smaller plankton in shallow waters, perhaps associated with large numbers of salps sampled in the MOCNESS (and in the ship's filters).

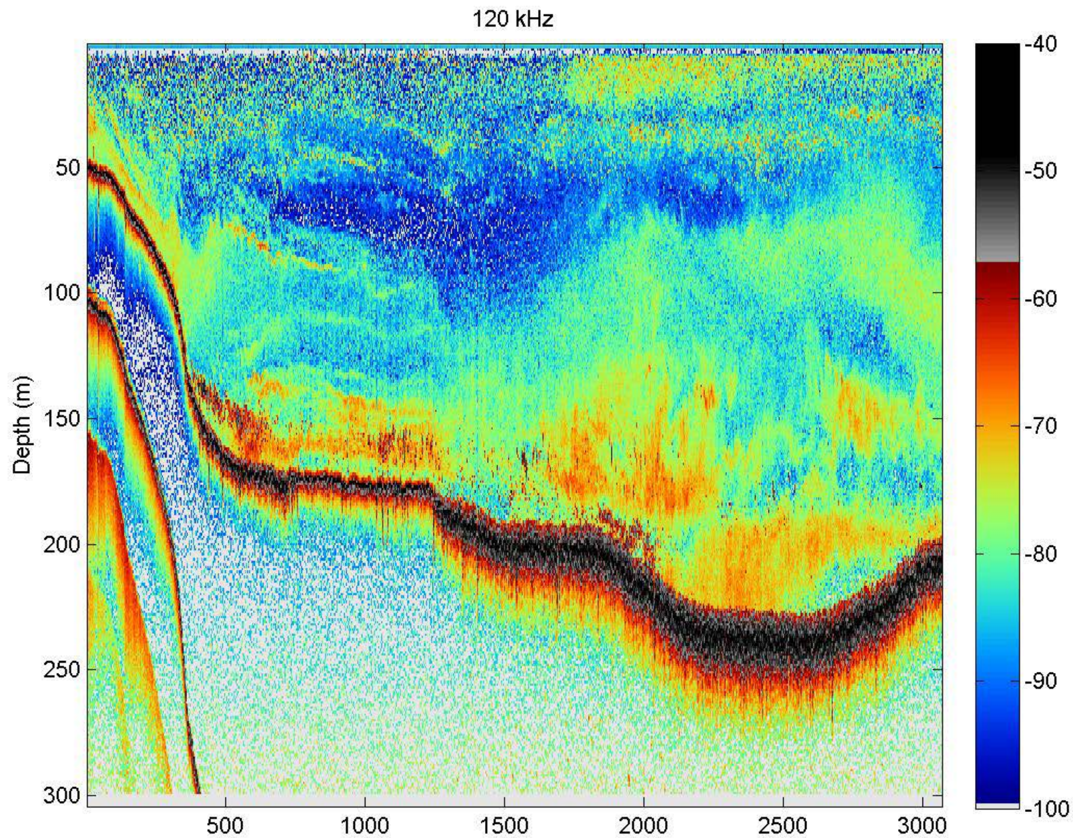


Figure 8.1.1. Acoustic data collected with the HTI system at 120 kHz along transect 1 of the first mapping survey. Intense scattering likely associated with fish is evident near pings 500 and 2000. Weaker scattering likely associated with krill is pervasive along the transect beyond the ca. 150m isobath.

8.2. *Broadband acoustics*

Cindy Sellers, Wu-Jung Lee, Gareth Lawson

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 earlier applications, a broadband system (ca. 150-600 kHz) has been used to identify and quantify thecosome pteropod abundance and size off the New Jersey continental shelf and verified relative to net samples. More recently, this system has been modified to include lower frequency channels (down to 40 kHz) in order to be able to quantify the Rayleigh to geometric transition for larger elongated scatterers like krill and used in krill applications such as the present project. One goal of this project is therefore a feasibility demonstration of the use of this modified system for remote identification of krill and other zooplankton, and for quantification of animal size and abundance. The broadband system is more range-limited than the multi-frequency system, and so the intention was also for the broadband system to provide improved species identification capabilities along its saw-tooth tow-yo trajectory, to supplement the multi-frequency system's more continuous measurements of water column scattering.

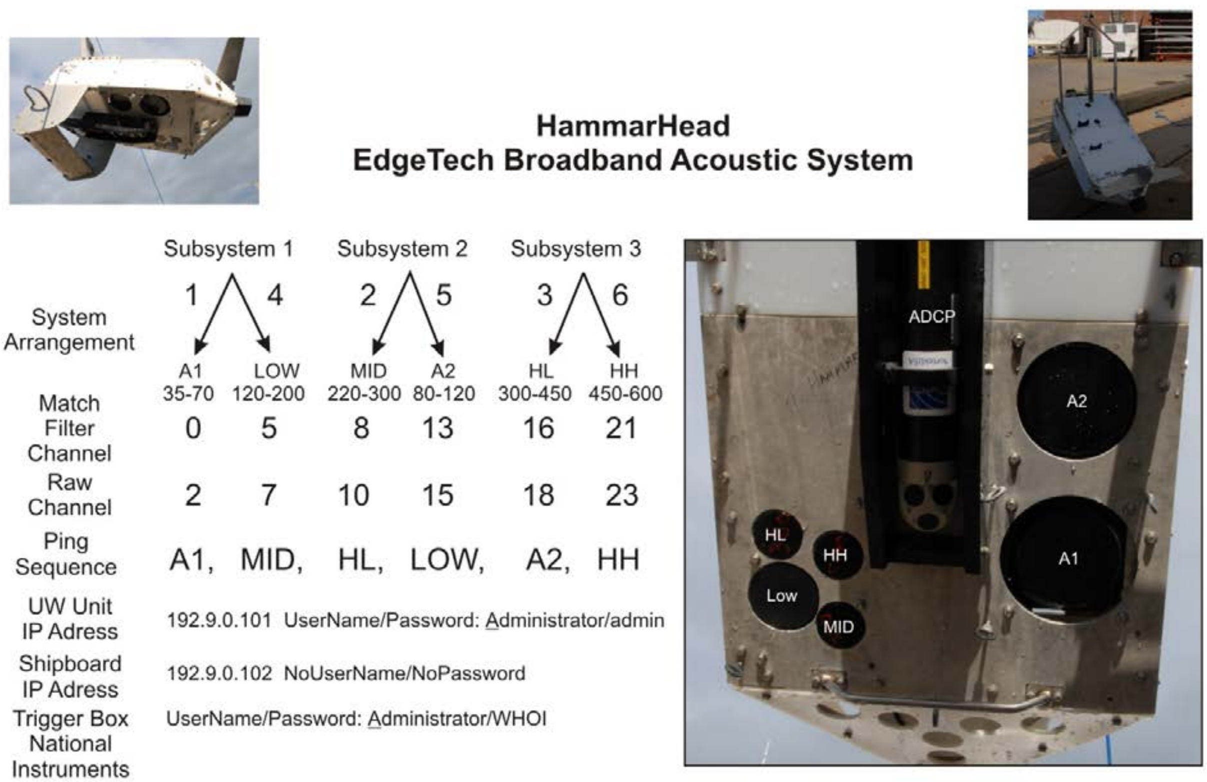


Figure 8.2.1 – Edgetech channel assignments and other settings [Photos: P. Wiebe]

8.2.1. 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 towed obliquely up and down through the water column. 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 8.2.1. These channel assignments reflect the channel assignments in the data acquisition software (JSTAR), however, the channel assignments in the data files are as follows:

These waveforms were used for the entire cruise:
A1L_10005_11005_5ms_00.spf
MA2_20005_12005_5ms_00.spf
H_30005_31005_5ms_00.spf

The broadband system was housed in a towed body nicknamed the HammarHead after its designer, Terry Hammar. Along with the broadband system and its 6 transducers were a transponder, CTD, fluorometer, and pump (to provide sufficient water flow to the fluorometer). The top panel of the towed body is lined with corprene to baffle the transducers and prevent energy leaking out the back.

The HammarHead was deployed via the starboard J-frame using oceanographic winch #1. Two slip-lines were used in deployment. Snap hooks were used for recovery. One goal was to keep the HammarHead at the surface during MOCNESS/VPR deployments, to collect co-located data. This required tying off the tail of the towed body in order to prevent it from spinning around and/or hitting the side of the ship. To do so we brought the fish up to just above the surface, allowing a happy hooker to be used to put a line around one of the large U-bolts on the HammarHead's forward stabilizing foot. This line was then led aft and tied off. Once MOCNESS/VPR operations were complete and the ship underway the line was released and the HammarHead sent back to depth. Much of the time for maneuverability the HammarHead was kept at the surface. The exact depth of 'surface' tows varied over the course of the cruise but was generally ca. 10m. During tow-yos the rate of payout and haul-in as well as target depth were also varied adaptively, based on where the scattering features of interest were located and where the ship was located relative to turns. The winch had troubles maintaining a speed of less than ca. 15 m/min, however, and so this was generally our minimum speed. Because the towed body is quite light, getting it to large depths was time consuming.

The HammarHead topside electronics and data collection computer (named remote) were set up in the main lab running JSTAR. The yellow data cable (aka the deck cable) connected the deck unit (via an amphenol connector) to a screw-panel coming off the slip rings located behind the main lab's forward computer rack, via a short connector cable with spades on one end and a BNC on the other.

In general data were collected to 75m on the two lower frequency channels (A1/Low and Mid/A2) and to 50m on HL/HH channel. However when bottom depth was less than 75m below the HammarHead towbody, the depth range was reduced to 50m on all channels as JSTAR normalizes the received signals to the highest level in the received signal.

Originally (prior to 20100926) the delays between successive channels were:
A1/Low master
Mid/A2 delay 167
HL/HH delay 333

Issues associated with synchronizing the systems led to the final (20100926 and beyond) arrangement being:
A1/Low master
Mid/A2 delay 333
HL/HH delay 667

8.2.2. Synchronization of Acoustic Systems

Interference between the broadband and multi-frequency systems and the ADCP was 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 hope had been to send a trigger to each of the instruments in succession and the original Labview program implemented this plan. Problems in getting the HTI system to accept a trigger led to an alternate arrangement and a second program where the HTI sent out a sync pulse and then was set to wait for some amount of time. Wu-Jung's box received this pulse, then sent out pulses to the Edgetech and ADCP. The timing of the triggering in the first program is based on an internal computer clock in that system, while in the second program, the triggering timing was determined by the pulse sent out by the HTI system. See block diagram in Figure 8.2.2.

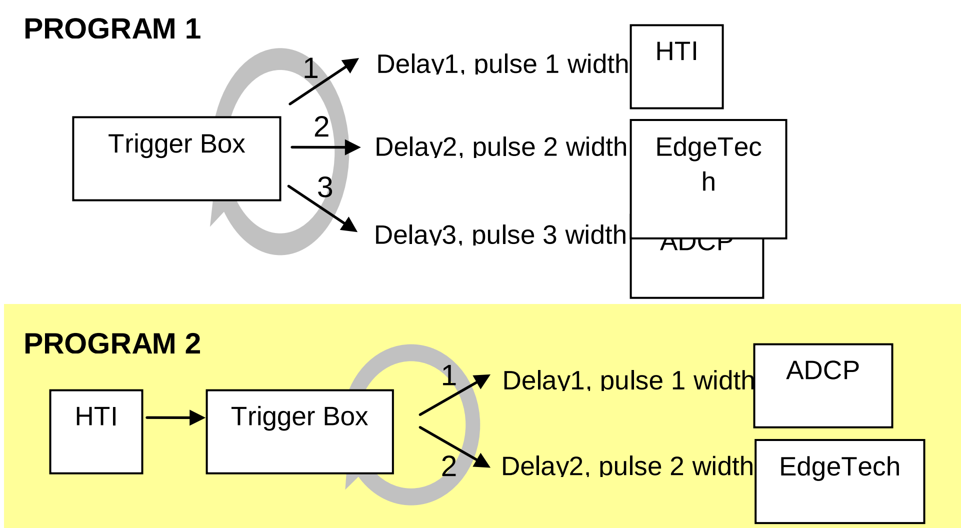


Figure 8.2.2. Trigger box program schematics.

Both of the two programs can be set up to handle more than three instruments. The number of instruments is physically limited by the hardware on the 6115 board (8 digital input/output lines).

Program 2 was used throughout the whole cruise. This was written after the failure of the first program during the test phase of this cruise. The first program did not work because the HTI system does not maintain the same delay between each set of the four pings in each cycle, therefore having HTI as the master trigger solved the problem.

8.2.3. Problems and Solutions

CTD

During tests conducted while still in port the CTD data were not appearing in the data files. After checking all the hardware and using a test cable allowing the CTD to be run directly from a laptop, it was determined that the CTD was functioning properly but data were not being seen by JSTAR (Com3 was not getting any data). A call to EdgeTech was made and we found that "Raw (Sonar Data Stream)" must be selected on the 'Disk' tab in JSTAR to include the CTD data in the data stream.

Deployment Strategy

The original plan had been for HammarHead deployments concurrent to all multi-frequency acoustic surveying. Because the J-frame can only extend a limited distance over the side, however, along many of our intended survey courses, due to wind direction the wire would tend towards the side of the ship. This made everyone nervous and also affected data quality. Deploying the HammarHead during MOCNESS operations was particularly tricky. HammarHead deployments were therefore much fewer than planned.

Synchronization

Wu-Jung spent a great deal of time over the course of the cruise trying to sort out the performance of the triggering arrangement because a number of problems emerged in getting the Edgetech system to behave as we wanted it to – it seemed often to miss pulses and change the order of channels in unexpected ways. These issues were not resolved during the cruise, but nonetheless, interference between the three acoustic systems did appear to be minimized.

Interference on A1 and A2 channels

When the HammarHead was shallow, we noticed short noise spikes on A1 and A2 channels. When the instrument was deeper, this noise disappeared. The source of the noise was not resolved. One speculation was that it was sidelobes from the hull.

Mechanical Issues

A series of issues arose over the course of the cruise with the HammarHead. Early in the cruise (during the night of Sept 23) we lost depth (and other CTD) data. We postponed recovery of the body until the morning of Sept 24 to keep collecting good data. Upon recovery we found that the cable connecting the CTD to the main housing had come off the CTD's bulkhead connector and one of the cable's pins had dissolved away because we were sending 12V into seawater. Luckily we had a spare pigtail, which Dave Nelson spliced on for us. Later in the cruise the system stopped collecting data entirely, first becoming erratic and then connection to the instrument was lost completely (i.e., 'net off'). Satellite phone conversations with Edgetech suggested that it was likely a problem with the modem (which apparently tend to die) and that whatever the problem was, they thought we would almost certainly not be able to fix it. Nontheless we opened the can up and shortly after the underwater electronics was pulled from the underwater case, Dave Nelson identified the problem - a broken solder joint in a component associated with the incoming high voltage to power the system (Figure 8.2.3). Within about 30 minutes the problem was fixed. After the cruise the system was given a thorough once-over by technicians in AOPE to make sure no other similar loose connectors or minor problems were evident. Finally, on its last deployment of the cruise we started to think we were knocking the side of the ship (from noises on the hull and patterns of interference in the acoustic data). Upon recovery the HammarHead had indeed lost its port-side wing. This presumably happened during the long run off-bank (file names 20100928_long_run*) during which pitch and roll had been somewhat erratic.

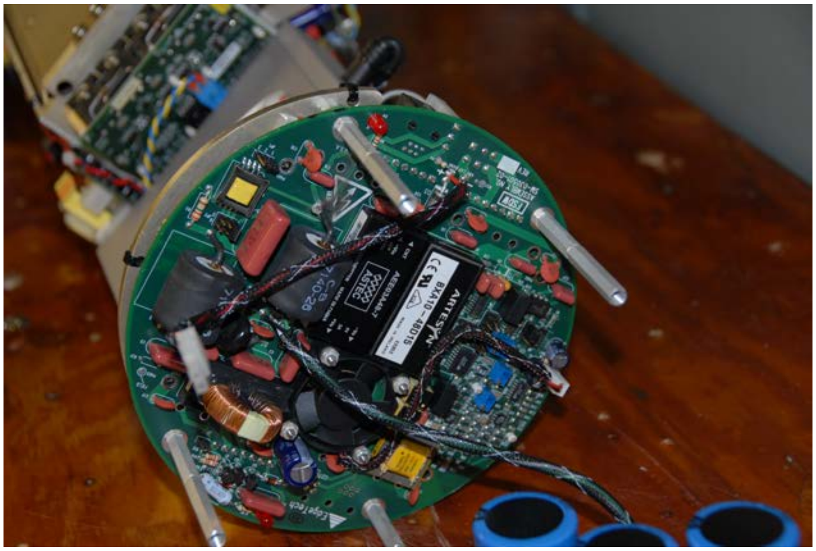


Figure 8.2.3 Damaged transformer (note scorching) on the Edgetech underwater electronics. Photo: P. Wiebe.

8.2.4. Preliminary Data

Files and folders were named according to date and survey type, and are as follows:

Folder 20100923:
Files en484_20100923_map1_000 - 343 20100923 07:07L - 20100924 13:55L

Folder 20100926:
Files en484_20100926_track1_000 - 114 20100926 07:02L - 20100926 18:59L

Folder 20100927:
Files en484_20100927_track1_000 - 015 20100927 12:20L - 20100927 13:17L
Files en484_20100927_deep_noise_000
Files en484_20100927_towyo_noise_000
Files en484_20100927_towyo_noise_fast000 - 001
Files en484_20100927_track1_017 - 024 20100927 13:51L - 20100927 14:36L
Files en484_20100927_track2_000 - 048 20100927 20:55L - 20100928 10:04L

Folder 20100928:
Files en484_20100928_long_run_000 - 076 20100928 21:40L - 20100929 05:50L

Data Processing:
Raw data files (.jsf) were unpacked in Matlab via EdgeTechMicrostructure_smallGUI_2010_6ch_v1, which was altered at sea so that Lat/Lon information was extracted into the files properly. The altered routine was read_jsf_file_fun.m. *.mat files and *.png images were made for each channel for each data file, using the same file naming convention. Files from each data run were plotted together, one image for each channel, accounting for the depth of the towed body.

Overall the data appear very encouraging (e.g., Figure 8.2.4). Visual scrutiny of the data during real-time collection and post-processing suggested multiple scattering features consistent with fish- and krill-like scatterers, similar to observations made with the multi-frequency system. A number of deep profiles positioned the towed body immediately above deep layers of putative different composition and it will be very interesting to examine these data in more detail.

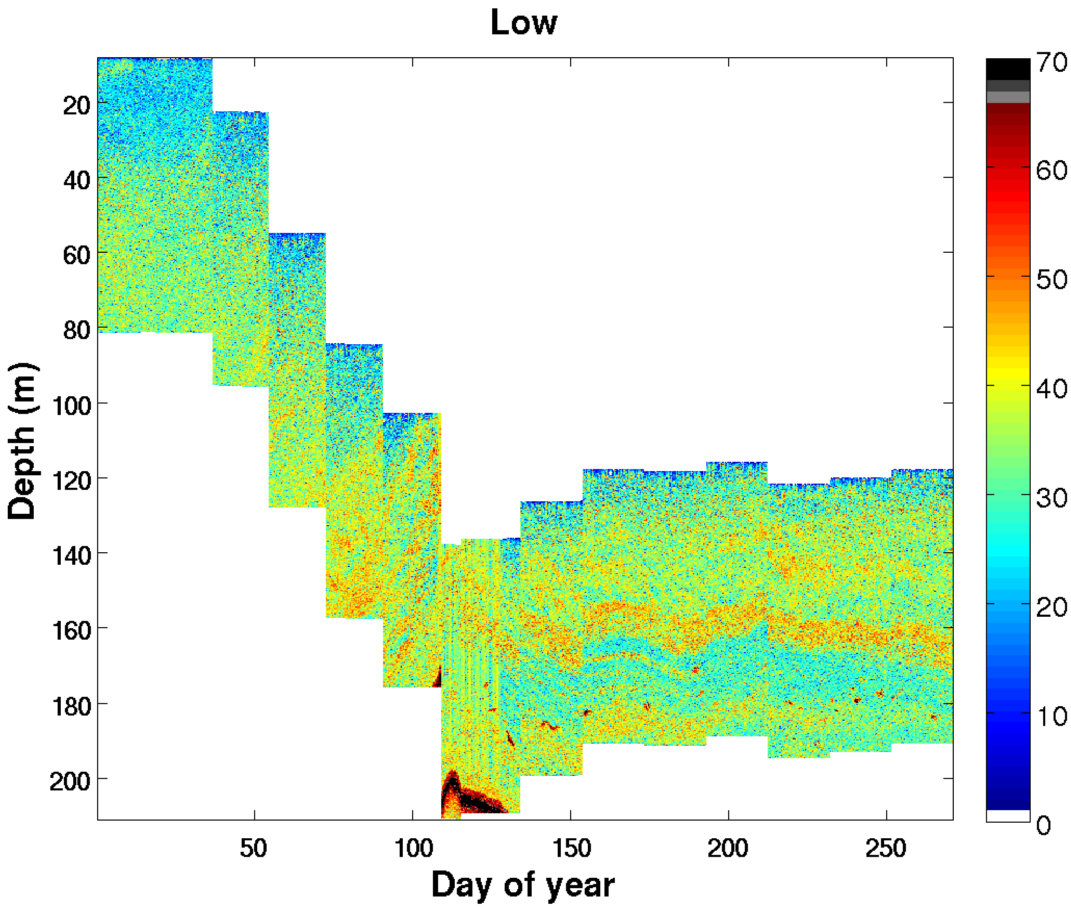


Figure 8.2.4. Broadband data collected on the LOW channel during a deep cast of the tracking survey.

8.3. *MOCNESS*

Kaylyn Becker, Peter Wiebe, Gareth Lawson

8.3.1. Methods

A standard 1m^2 Multiple Opening/Closing Net and Environmental Sensing System (MOCNESS) was used to collect zooplankton in order to determine the taxonomic composition of the zooplankton in the study region and also to ground truth acoustic data collected with the HTI multi-frequency and Edgetech broadband systems. The MOCNESS has 9 nets with a 335 µm mesh size that can sample different regions of the water column. 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, notably krill, 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. Two of the 24 LED sets were working inconsistently 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.

The MOCNESS was launched and recovered from the stern A-frame. Samples were brought into the wet lab for processing. Nets 1-8 were preserved in buffered formalin. Often the net 0 samples were so large that they would have taken multiple jars so either the entirety or a large fraction was frozen in the -80C freezer, in the hopes that they might be useful. It would have been useful to have brought along some alcohol for preserving animals for molecular analyses.

8.3.2. Preliminary Results

Four tows were conducted over the course of the cruise, two during the day and two at night (Table 8.3.1). All of the tows were conducted in the center of the study region, near the location of the tracking survey (Figure 8.3.1). The first two tows were oblique tows to depths of ca. 200m. As predicted from examinations of the frequency response evident in acoustic data and from VPR observations, large numbers of krill were present, including abundant large *Meganyctiphanes norvegica*. In the shallowest nets salps were also abundant.

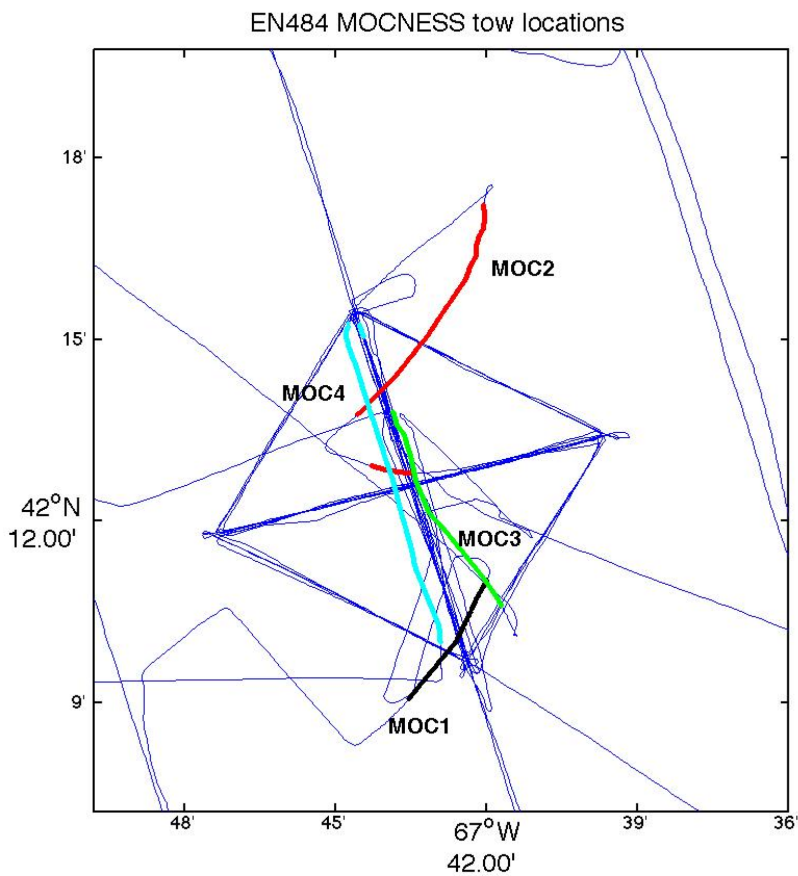


Figure 8.3.1 Positions of MOCNESS tows taken on EN484.

Table 8.3.1. MOCNESS tow information

Station	Tow	Month local	Day local	Time local	Time start/end (Yearday. time)	Lat. (N) start/end	Long.(W) start/end	Net: depth_open-depth_closed	Volume filtered (m^3)
1	1	9	24	23:30	267.97925	42.18302	-67.70047	net 0: 3-183	494
				00:28	268.01968	42.14590	-67.73170	net 1: 152-180	256
								net 2: 126-155	527
								net 3: 96-125	431
								net 4: 74-93	267
								net 5: 45-73	299
								net 6: 25-47	353
								net 7: 0-24	450
								net 8: not used	Nd
2	2	9	26	15:09	269.63156	42.22902	-67.74330	net 0: 3-216	1634
				16:25	269.68465	42.28733	-67.70092	net 1: 166-213	697
								net 2: 151-164	350
								net 3: 124-150	708
								net 4: 100-127	454
								net 5: 75-102	295
								net 6: 50-75	244
								net 7: 24-50	218
								net 8: -1-23	213
3	3	9	27	21:24	270.88146	42.22475	-67.72800	net 0: 0-66	404
				22:46	270.94885	42.17015	-67.69117	net 1: 60-75	463
								net 2: 60-75	500
								net 3: 59-76	611
								net 4: 60-76	545
								net 5: 60-75	561
								net 6: 60-76	651
								net 7: 60-75	665
								net 8: 60-75	582
4	4	9	29	0928	272.39331	42.21465	-67.73240	net 0: 0-161	1478
				11:18	272.47089	42.12570	-69.33947	net 1: 162-187	576
								net 2: 161-189	693
								net 3: 160-190	741
								net 4: 161-190	681
								net 5: 160-189	627
								net 6: 160-190	620
								net 7: 160-190	667
								net 8: 159-191	547

The third and fourth tows were both conducted along the center line of the bowtie survey and were targeted at particular scattering layers thought to be composed of krill to test the efficacy of the strobe light in reducing net avoidance. Each tow consisted of a sequential series of down and up oblique casts through a set depth interval (60 to 75 m at night; 160 to 190 m during daylight). The strobe light was set to either "on" or 'off" with four of the eight nets (335 µm mesh) sampling with the strobe flashing and four sampling with the strobe off, in a random sequence. For both tows, volumes filtered by each net ranged from 463 to 741 m^3. Results for the night (MOC 3) tow showed a positive relationship between the strobe light and the amount of krill caught. Results for the day tow (MOC 4) were even more striking, with the strobe light multiplying the catch by an order of magnitude or more (Figure 8.3.2).

Figure 8.3.2: Results of the Day Strobe Experiment tow. Jars lined up left to right with catches from nets 8 to 1. Nets 8, 6, 4 and 1 did not have the strobe light on, while jars 7, 5, 2, and 3 had the strobe light on. Multiple jars were used when the catch could not fit into one jar.

8.4. *Video Plankton Recorder*

Gareth Lawson

A Digital Automatic Video Plankton Recorder (DAVPR) was employed to optically scan the water column for plankton and particles, providing information on the small-scale vertical distribution of smaller zooplankton and verifying acoustic inferences. The Video Plankton Recorder (VPR) is a system comprised of an underwater video camera(s), strobe, and environmental sensors designed by WHOI and Seascan, Inc. Several versions of the basic unit have been designed to sample from different platforms, in different manners. The DAVPR is a self-contained, digitally recording video microscope utilizing a Seabird Conductivity/Temperature/Depth sensor and a Wetlabs Fluorometer. The unit used on EN484 was borrowed from Jon Hare and Betsy Broughton in the Oceanography Branch at NEFSC. It is housed in a yellow v-fin towed body together with a cabled CTD and altimeter (not used on this cruise). The system collects images at a rate of 20 Hz, synchronized to a strobe light. Using 1 of 4 magnifications (named S0-S3), the video microscope can record plankton and particles, yielding information on the type and abundance of various sized particles in the water column. Targets for this cruise included krill, copepods, and salps. As such, the DAVPR was employed using its lowest magnification (i.e., S3 with a nominal view 4.2 cm x 4.2 cm).

The VPR v-fin was deployed via the stern A-frame and oceanographic winch #2, although because the system was used in internally-logging mode, no electrical termination was required. Deployment involved slip-lines. Recovery required snap-hooks and a fend-off pole to keep the system from hitting the stern. Pat Quigley the bosun attached some extremely handy bails made out of thick polypropylene line to give us purchase points for snap-hooks. During deployments the ship kept a small amount of way on to keep the v-fin tending forward. After each cast, the detachable hard drive containing the cast video and CTD file was removed, downloaded to a computer, and scanned. Specialized software (Autodeck) allows extraction of in-focus images from the downloaded video file. This software was used between casts for initial extraction of data. A dedicated user monitored the data extraction for both the down- and up-cast, noting the depths at which particular animals of interest (mostly krill and copepods) were observed. This information was used to guide the acoustic surveying and inform the choice of tracking survey location. Later analysis by Phil Alatalo in the lab will allow automatic identification, followed by manual confirmation, and abundance plots for each station.

8.4.1. Preliminary Results

In addition to a test deployment in Long Island Sound, the VPR-CTD package was deployed at 22 of the 24 survey stations (Figure 8.4.1; Table 8.4.1). The system performed admirably throughout the cruise. The only occasional problem was in profiling to near-bottom, given the lack of real-time data on the unit's depth. On one occasion, due to the winch's payout meter not being re-zeroed at the start of the deployment, the system briefly hit bottom. A variety of animals were imaged with the VPR, notably krill, copepods, and salps (Figure 8.4.2). Diatom chains were also common. Initial scrutiny of the cast data confirmed the presence of krill in the distinct scattering layers observed acoustically and the approach of doing 'quick' ground-truthing with the VPR so as not to interrupt the acoustic surveying was quite successful.

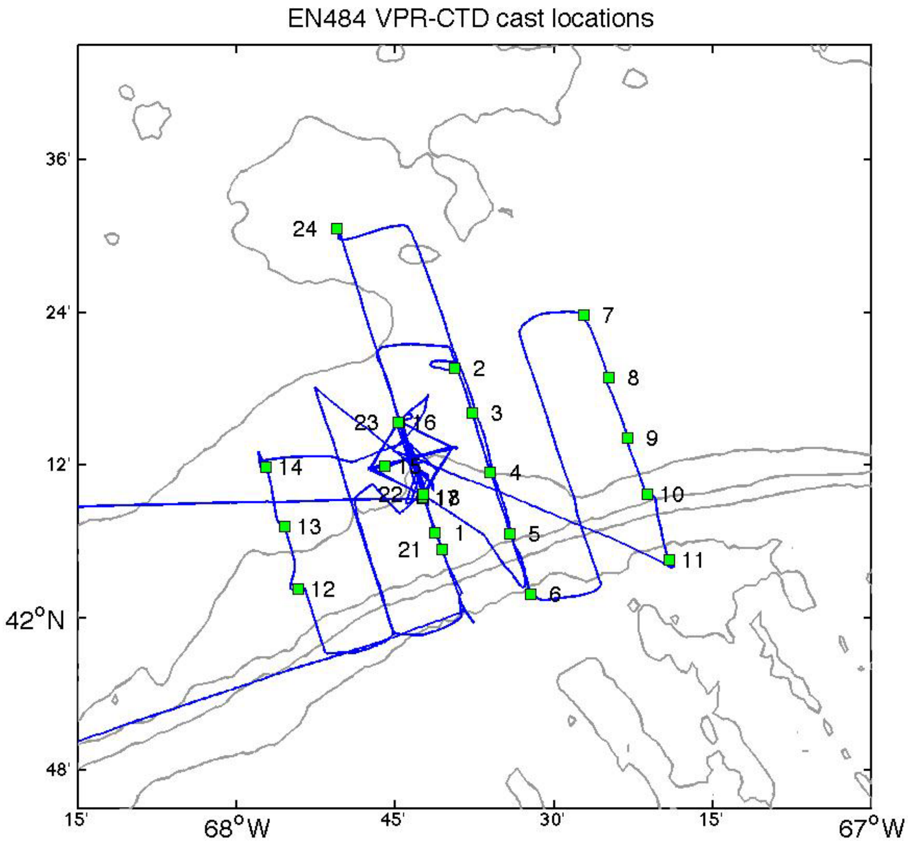


Figure 8.4.1. Location of VPR-CTD casts.

Table 8.4.1. VPR deployment data. Note that the YearDay convention used in VPR processing defines January 1 as YD 0, so the VPR year day is one day behind the year day convention used elsewhere for this cruise (e.g. in the HTI file naming, in the acoustic log). Note also that 'VPR number' is the number used in Phil Alatalo's later analyses and starts at 1 for the first survey deployment. This number is thus one less than the VPR cast number found in the event log, since there was an initial test cast (#1 in the event log) conducted in Long Island Sound. The local hour gives the folder name for VPR analysis; this appears to be 1 hour different from the local time recorded for the cast, perhaps due to computer issues with daylight savings.

Station	Date	Local Time	Phil VPR #	VPR Year Day	Local Hour
1	9/23/10	8:58	1	265	7,8
2	9/23/10	15:00	2	265	13,14
3	9/23/10	18:33	3	265	17
4	9/23/10	20:11	4	265	19
5	9/23/10	21:43	5	265	20
6	9/23/10	23:15	6	265	22
7	9/24/10	7:08	7	266	6
8	9/24/10	8:55	8	266	7,8
9	9/24/10	10:23	9	266	9
10	9/24/10	12:16	10	266	11
11	9/24/10	14:07	11	266	13

Station	Date	Local Time	Phil VPR #	VPR Year Day	Local Hour
12	9/25/10	9:01	12	267	8
13	9/25/10	10:48	13	267	9,10
14	9/25/10	12:29	14	267	11
15	9/26/10	21:12	15	268	20
16	9/27/10	7:34	16	269	6
17	9/27/10	9:26	17	269	8
18	9/27/10	10:26	18	269	9
19	Handlining only		19		
20	Aborted VPR cast		20		
21	9/28/10	11:20	21	270	10
22	9/28/10	no record	22	270	11,12
23	9/28/10	14:33	23	270	13
24	9/28/10	17:31	24	270	18

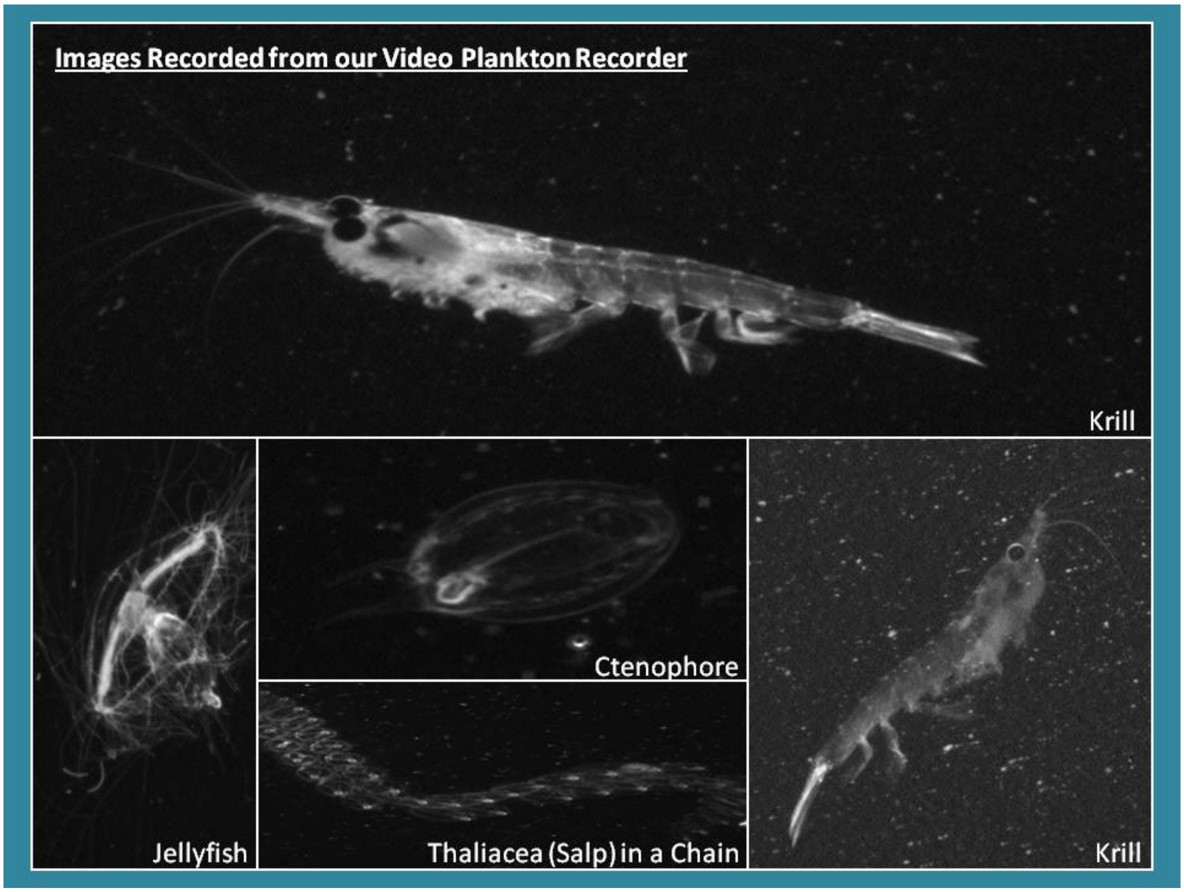


Figure 8.4.2. Some representative images collected with the VPR.

9. Higher Predators

9.1. *Fish Sampling*

Gareth Lawson

The survey design for this project involves two cruises timed to occur before and after the herring spawn at which times they should be first not feeding and then feeding on their krill prey. Sampling herring to confirm their presence and determine whether or not krill were in their stomaches is difficult to achieve from a UNOLS vessel. At the recommendation of Mike Jech we purchased some handlines along with a series of hooked flies made to resemble krill. On one occasion, immediately after MOC 3, we attempted some hook and line fishing for herring, using these hand lines and some fishing rods Dave Nelson had along. A half hour of fishing in this way was completely unsuccessful. That same night though, a small (probably juvenile) herring came up onto the back deck where Peter Wiebe caught it. Dissection of its stomach found two krill, presumably recently eaten as they were readily identifiable.

To provide additional information on the abundance and stomach contents of herring in the region, our cruise was done in coordination with Leg II of Mike Jech's 2010 herring survey. We therefore remained in contact via email and radio with Mike for the duration of our cruise. Aside from shifting our study region to the NE from its originally planned location, based on data from Leg I of Mike's survey, we did not change the location of our survey efforts based on information from the Delaware II, which was making its way from regions to the NE of us towards and ultimately past our location. On September 26, however, the Delaware conducted four pelagic trawls in our general area, along one of their survey lines that seemingly ran almost exactly along the N-W axis of our tracking survey. We will retrieve the results of those tows from Mike once they are available.

9.2. *Seabird Observations*

Timothy White

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 predators to concurrent measurements of the water column's biological environment.

9.2.1. 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 transits to the survey start and from the survey end. The seabird survey was initiated on 22-Sept-2010, and concluded 29-Sept-2010. The seabird

Figure 9.2.2 Flying bridge macrofauna observation setup.

observer, as well as the two marine mammal observers, were positioned on the flying bridge. The Endeavor's flying bridge had been outfitted for a previous marine mammal-focused cruise with a 'bimini top' as well as Bernoulli deflectors, making it overall a quite comfortable observing platform (Figure 9.2.1). Power and internet were supplied via a stuffing hole from the bridge.

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, the observer recorded all other marine megafauna 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 was assigned a unique geographic coordinate and time stamp. The survey was discontinued 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. The observer 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.

9.2.2. Preliminary Results

Greater shearwater (*Calonectris diomedea)* was the dominant seabird species encountered on George Bank. This species is found on Georges Bank during the nonbreeding season, and returns to south Atlantic breeding colonies from September onward (Harrison, 1984). Highest aggregations of greater shearwaters, not associated with fishing vessels, were found over the slopes of Georges Bank. Groups of feeding shearwaters were observed in close association with bluefin tuna schools, likely due to forage fish driven to the surface by predatory tuna.

Leach's storm petrel (*Oceanodrama leucorhoa)* and Wilson's storm petrel (*Oceanites oceanicus*) were in low abundance on Georges Bank, as expected. Leach's storm petrel, a northern hemisphere breeder, migrates out of the area during August and Wilson's storm petrel return to Antarctic breeding colonies during this period.

Red-necked Phalaropes (*Phalaropus lobatus)* were observed on Georges Bank in moderate number. Large groups were observed feeding on aggregated mats of rockweed, likely because of the high abundance of crustacean and other prey associated with the macroalgae. Feeding phalaropes were organized along lines of rockweed, within "slicks" of water; possibly oceanic fronts. Phalaropes are known to feed on Sargassum mats concentrated along frontal thermal fronts (Haney 1986).
Arctic breeding pomarine jaegers (*Stercorarius pomarinus)* were migrating through in high abundance over Georges Bank. Great skuas (*Stercoraruis skua)*, North Sea breeding seabirds, were observed during the survey, and are occasionally found in the NW Atlantic during winter. Small numbers of Antarctic breeding south polar skuas were also over Georges Bank.

Humpback whales (*Megaptera novaeangliae*) and long-finned pilot whales (*Globicephala melas)* were found over the slopes of the bank; however, fin whales (*Balaenoptera physalus*) were noticeably absent.

Two leatherback turtles (*Dermochelys coriacea)* were recorded, an unusual sight on Georges Bank (personal observation). Two Audubon's shearwaters were also found on Georges Bank; both birds were observed feeding on rockweed. This species is primarily found in Gulf Stream water and is a rarity on Georges Bank. The presence of Audubon's shearwater is interesting, and may indicate an incursion of warm water into the region.

<u>Migrant landbirds recorded over Georges Bank</u>:
Purple Finch (female)—(*Carpodacus purpureus*)
American Goldfinch (male)-- (*Carduelis tristis*)
White-throated Sparrow (*Zonotrichia albicollis*)
Baltimore Oriole (female)—(*Icterus galbula*)

<u>Unusual/Rarities</u>:
Audubon's Shearwater (*Puffinus Ihermminieri*)

<u>Encountered Occasionally</u>:
Sooty Shearwater (*Puffinus griseus*)

<u>Migrants</u>:
Pomarine Jaeger (*Stercorarius pomarinus*)
Parasitic Jaeger (*Stercorarius parasiticus*)
Manx Shearwater (*Puffinus puffinus*)
Common Tern (*Sterna hirundo*)
Unidentified Tern (*Sterna* Spp.)
Phalaropes --mostly red-necked (*Phalaropus lobatus*)

<u>Wintering Birds (migrating in to the area)</u>:
Great Skua (*Stercoraruis skua*)
Northern Gannet (*Morus bassanus*)

<u>Common decreasing</u>:
Greater shearwater (*Puffinus gravis*)
Cory's Shearwater (*Calonectris diomedea*)
Wilson's Storm Petrel (*Oceanites oceanicus*)
Leach's Storm Petrel (*Oceanodrama leucorhoa*)

<u>Common</u> :
Herring Gull (*Larus argentatus*)
Greater Black-backed Gull (*Larus marinus*)

9.2.3. References

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9.3. *Marine Mammal Observations*

Reny Tyson, Julie van der Hoop

Visual surveys for marine mammals 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 environment.

9.3.1. Methods

Marine mammal observations were conducted concurrently with acoustic surveys from 23 September to 29 September 2010. Two trained observers (R. Tyson, J. van der Hoop) stationed on the flying bridge of the *R/V Endeavour* (observer height: 11.8 m) scanned for marine mammals using the naked eye and 7x 50 Fuginon binoculars with reticle marks in the oculars. Observers searched from directly ahead (0 degrees) to 90 degrees abeam of the ship. Observations occurred when the ship was underway traveling at a speed of 3-5 knots during reasonable sighting conditions (Beaufort sea state ≤ 4). Survey effort was often hindered by large swell or high Beaufort sea states and thus did not occur during all acoustic surveys or at night. Observers switched observation sides every 30 minutes and took breaks when needed.

Environmental conditions were recorded during each survey and updated every 30 minutes or more frequently when conditions changed. Swell height, swell direction, wind speed, wind direction, glare, Beaufort sea state, and weather conditions (% cloud cover, fog, rain, overcast) were recorded. When a sighting of a predator was made (marine mammal, large fish, sea turtle, shark) , the number of reticle marks from the horizon (used to estimate distance from the ship), bearing of the animal (estimated with a protractor), latitude, longitude, group size, cue (blow, splash, body) and species (when species could be determined) were recorded in the program *Logger* (IFAW). There were many instances when species could not be determined because the animal was seen too far from the ship, the environmental conditions were unfavorable, and/or we were unable to break transect to approach for better group size estimates or species identification. Overall environmental conditions were coded base on their suitability for effective observing (Table 9.3.1).

9.3.2. Results

We actively surveyed for marine mammal predators for approximately 24 hours over September 23 through September 29th and traveled approximately 150.3 km (some areas were surveyed more than once; Table 9.3.2; Fig 9.3.1). Environmental conditions were variable (Table 9.3.1, Table 9.3.3) and often our ability to observe marine predators was hindered due to increasing winds, increasing sea states, and increasing swell. Because of this many of our sightings can only be deemed as 'opportunistic' sightings; Sightings should be thought of as being present at the time of their sighting (presence) and not as being present at the time of their sighting and not being present when no sightings were made (presence/absence; except during favorable and okay surveying conditions).

We had a total of 51 sightings including humpback whales (*Megaptera novaengliae*), common dolphins (*Delphinus delphis*), pilot whales (*Globicephala melas*), ocean sunfish (*Mola mola*), leatherback turtles (*Dermochelys coriacea)*, unidentified tuna, and a shark (possibly mako; *Isurus oxyrinchus*) (Table 9.3.1, Fig 9.3.2). The majority of sightings occurred during favorable and okay surveying conditions (Table 9.3.1, Table 9.3.4), however sightings per unit effort were different depending on different transects (Table 9.3.4). Throughout the "bow tie" surveys sightings per unit effort were lower than they were in other locations we surveyed. This may suggest that animals were not foraging on the prey patch we were measuring, animals were foraging on the patch and we did not record their presence, animals were actively avoiding the area (or vessel), animals were not in the area, and/or animals were not seen in the area.

Table 9.3.1: Codes for survey conditions based on overall environmental conditions

Environmental conditions favorable for surveying
Environmental conditions okay for surveying
Environmental conditions marginal for surveying
Environmental conditions not good for surveying
Environmental conditions not appropriate for surveying

Table 9.3.2. Summary of effort status for marine mammal observing

Date	GMT Time	Local Time	Latitude	Longitude	Ship Speed (knots)	Transect ID	Search Status
23-Sep-10	11:22:59	7:22:59	42.0227	-67.64697	3.6	1	On Effort
23-Sep-10	12:35:11	8:35:11	42.0894	-67.67597	3.3	1	Off Effort
23-Sep-10	13:45:15	9:45:15	42.114	-67.68856	3.6	1	On Effort
23-Sep-10	16:12:20	12:12:20	42.2709	-67.74856	3.8	1	Off Effort
23-Sep-10	21:18:45	17:18:45	42.3274	-67.65334	3.9	2	On Effort
23-Sep-10	22:12:40	18:12:40	42.2683	-67.62926	2.3	2	Off Effort
24-Sep-10	11:43:44	7:43:44	42.3867	-67.44894	4	4	On Effort
24-Sep-10	12:46:51	8:46:51	42.3168	-67.41503	2.2	4	Off Effort
24-Sep-10	13:34:03	9:34:03	42.2943	-67.40968	4.2	4	On Effort
24-Sep-10	14:27:13	10:27:13	42.2373	-67.38443	2.7	4	Off Effort
24-Sep-10	14:58:15	10:58:15	42.2277	-67.3837	4.1	4	On Effort
24-Sep-10	16:00:50	12:00:50	42.164	-67.35551	2.1	4	Off Effort
24-Sep-10	16:38:08	12:38:08	42.158	-67.34245	2.5	4	On Effort
24-Sep-10	17:55:43	13:55:43	42.079	-67.3213	2.8	4	Off Effort
24-Sep-10	21:32:00	17:32:00				4	On Effort
24-Sep-10	21:31:17	17:31:17	42.1405	-67.51466	9.8	4	Off Effort
26-Sep-10	10:45:07	6:45:07	42.1934	-67.7188	4.4	16	On Effort
26-Sep-10	11:13:25	7:13:25	42.1619	-67.70674	4	16	Off Effort
26-Sep-10	14:59:03	10:59:03	42.2301	-67.76486	3.7	16	On Effort
26-Sep-10	15:25:42	11:25:42	42.2552	-67.74566	3.8	16	Off Effort
26-Sep-10	15:44:05	11:44:05	42.2363	-67.73457	4	20	On Effort

Date	GMT Time	Local Time	Latitude	Longitude	Ship Speed (knots)	Transect ID	Search Status
26-Sep-10	16:39:07	12:39:07	42.1748	-67.7109	4	20	Off Effort
26-Sep-10	18:01:49	14:01:49	42.2233	-67.66943	4.3	20	On Effort
26-Sep-10	18:51:35	14:51:35	42.2187	-67.75088	3.8	20	Off Effort
26-Sep-10	21:33:54	17:33:54	42.2531	-67.74197	3.4	22	On Effort
26-Sep-10	22:19:03	18:19:03	42.2117	-67.72585	3.3	22	Off Effort
27-Sep-10	12:27:02	8:27:02	42.2587	-67.74393	3.6	32	On Effort
27-Sep-10	13:11:53	9:11:53	42.2106	-67.72355	2.6	32	Off Effort
27-Sep-10	13:50:44	9:50:44	42.1973	-67.7166	4	32	On Effort
27-Sep-10	14:23:55	10:23:55	42.164	-67.70829	1.1	32	Off Effort
27-Sep-10	16:24:26	12:24:26	42.2028	-67.76009	4	32	On Effort
27-Sep-10	17:44:40	13:44:40	42.2228	-67.66386	2.9	32	Off Effort
27-Sep-10	20:36:55	16:36:55	42.1644	-67.71277	4	37	On Effort
27-Sep-10	21:38:36	17:38:36	42.1968	-67.79253	3.7	37	Off Effort
27-Sep-10	21:46:15	17:46:15	42.197	-67.78616	3.8	38	On Effort
27-Sep-10	22:11:27	18:11:27	42.2047	-67.74978	4.2	38	Off Effort
28-Sep-10	10:29:31	6:29:31	42.0913	-67.79652	3.8	42	On Effort
28-Sep-10	12:16:34	8:16:34	41.9848	-67.75505	3.2	42	Off Effort
28-Sep-10	14:26:26	10:26:26	42.0432	-67.65114	3.5	43	On Effort
28-Sep-10	15:13:29	11:13:29	42.0865	-67.67486	4	43	Off Effort
28-Sep-10	16:37:00	12:37:00				43	On Effort
28-Sep-10	18:22:52	14:22:52	42.2535	-67.74207	3.8	43	Off Effort
28-Sep-10	20:17:39	16:17:39	42.3349	-67.77279	3.9	43	On Effort

28-Sep-10	21:20:09	17:20:09	42.3999	-67.79826	3.9	43	Off Effort
29-Sep-10	10:35:04	6:35:04	42.0953	-67.59905	4.5	46	On Effort
29-Sep-10	11:35:32	7:35:32	42.1434	-67.67188	4.4	46	Off Effort
29-Sep-10	11:45:53	7:45:53	42.1508	-67.68564	4.3	46	On Effort
29-Sep-10	12:39:13	8:39:13	42.2131	-67.7251	4.6	46	Off Effort
29-Sep-10	12:45:07	8:45:07	42.2203	-67.72794	4.5	46	On Effort
29-Sep-10	13:16:44	9:16:44	42.2578	-67.74363	3.4	46	Off Effort

Table 9.4.3. Summary of environmental conditions while on effort

Date	GMT Time	Local Time	Latitude	Longitude	Wind Speed (knots)	Sea State	Wave Height (m)	Visibility
23-Sep-10	11:18:33	7:18:33	42.01901	-67.64525	11 - 15	2	0.5 - 1	Good 5 - 10 km
23-Sep-10	11:19:13	7:19:13	42.0196	-67.64556	11 - 15	2	0.5 - 1	Good 5 - 10 km
23-Sep-10	11:49:04	7:49:04	42.04882	-67.65854	11 - 15	2	0.5 - 1	Good 5 - 10 km
23-Sep-10	12:22:42	8:22:42	42.07839	-67.67138	11 - 15	3	0.5 - 1	Good 5 - 10 km
23-Sep-10	12:23:25	8:23:25	42.07903	-67.6717	11 - 15	3	0.5 - 1	Good 5 - 10 km
23-Sep-10	13:44:27	9:44:27	42.11324	-67.68828	11 - 15	2	1 - 1.5	Good 5 - 10 km
23-Sep-10	14:21:14	10:21:14	42.15263	-67.70286	11 - 15	2	1 - 1.5	Good 5 - 10 km
23-Sep-10	14:46:46	10:46:46	42.17947	-67.71183	11 - 15	2	1 - 1.5	Good 5 - 10 km
23-Sep-10	14:47:59	10:47:59	42.18072	-67.71228	11 - 15	2	0.5 - 1	Good 5 - 10 km
23-Sep-10	15:09:09	11:09:09	42.2035	-67.72	11 - 15	1	0.5 - 1	Good 5 - 10 km
23-Sep-10	15:13:59	11:13:59	42.20863	-67.72234	11 - 15	1	0.5 - 1	Good 5 - 10 km
23-Sep-10	15:26:08	11:26:08	42.22205	-67.72834	11 - 15	2	0.5 - 1	Good 5 - 10 km
23-Sep-10	15:45:30	11:45:30	42.24311	-67.73754	11 - 15	2	0.5 - 1	Good 5 - 10 km
23-Sep-10	20:48:28	16:48:28	42.33617	-67.68977	1 - 5	1	0 - 0.5	Good 5 - 10 km
23-Sep-10	21:19:59	17:19:59	42.32613	-67.65271	1 - 5	1	0 - 0.5	Good 5 - 10 km
23-Sep-10	21:20:17	17:20:17	42.32581	-67.65254	1 - 5	1	0 - 0.5	Good 5 - 10 km
23-Sep-10	21:28:49	17:28:49	42.31662	-67.64857	1 - 5	1	0 - 0.5	Excellent >10 km
23-Sep-10	21:48:55	17:48:55	42.2939	-67.63894	1 - 5	1	0 - 0.5	Excellent >10 km
24-Sep-10	11:43:44	7:43:44	42.38668	-67.44894	11 - 15	1	0 - 0.5	Excellent >10 km
24-Sep-10	11:52:09	7:52:09	42.37832	-67.44284	11 - 15	2	0 - 0.5	Excellent >10 km
24-Sep-10	12:04:19	8:04:19	42.3648	-67.4359	11 - 15	2	0 - 0.5	Excellent >10 km
24-Sep-10	12:22:40	8:22:40	42.34373	-67.42634	16 - 20	3	0 - 0.5	Excellent >10 km
24-Sep-10	12:29:47	8:29:47	42.33557	-67.4229	16 - 20	3	0.5 - 1	Good 5 - 10 km

Date	GMT Time	Local Time	Latitude	Longitude	Wind Speed (knots)	Sea State	Wave Height (m)	Visibility
24-Sep-10	12:44:20	8:44:20	42.31903	-67.41584	16 - 20	3	0.5 - 1	Good 5 - 10 km
24-Sep-10	13:35:13	9:35:13	42.29305	-67.40908	16 - 20	3	1 - 1.5	Good 5 - 10 km
24-Sep-10	13:39:46	9:39:46	42.28822	-67.40672	16 - 20	4	1 - 1.5	Good 5 - 10 km
24-Sep-10	13:52:22	9:52:22	42.27538	-67.4007	16 - 20	3	1 - 1.5	Good 5 - 10 km
24-Sep-10	14:18:45	10:18:45	42.24676	-67.38808	16 - 20	4	1 - 1.5	Good 5 - 10 km
24-Sep-10	14:59:38	10:59:38	42.22611	-67.38309	16 - 20	4	1 - 1.5	Excellent >10 km
24-Sep-10	15:28:17	11:28:17	42.1953	-67.36924	16 - 20	4	1 - 1.5	Excellent >10 km
24-Sep-10	15:58:20	11:58:20	42.16621	-67.35666	16 - 20	4	1 - 1.5	Excellent >10 km
24-Sep-10	16:39:21	12:39:21	42.15729	-67.34171	11 - 15	4	1 - 1.5	Excellent >10 km
24-Sep-10	16:58:22	12:58:22	42.13784	-67.33823	11 - 15	4	1 - 1.5	Excellent >10 km
24-Sep-10	17:14:19	13:14:19	42.12046	-67.33301	11 - 15	3	1 - 1.5	Excellent >10 km
24-Sep-10	17:30:07	13:30:07	42.10504	-67.32959	11 - 15	3	1 - 1.5	Excellent >10 km
24-Sep-10	17:54:53	13:54:53	42.07959	-67.32169	11 - 15	4	1 - 1.5	Excellent >10 km
24-Sep-10	21:08:28	17:08:28	42.11452	-67.43938	16 - 20	3	1 - 1.5	Moderate 2 -5 km
26-Sep-10	10:29:15	6:29:15	42.20675	-67.72366	6 - 10	1	0 - 0.5	Excellent >10 km
26-Sep-10	10:45:53	6:45:53	42.19246	-67.71853	6 - 10	1	0 - 0.5	Excellent >10 km
26-Sep-10	15:00:52	11:00:52	42.23174	-67.76352	16 - 20	4	1 - 1.5	Moderate 2 -5 km
26-Sep-10	15:45:44	11:45:44	42.23451	-67.73391	16 - 20	4	1 - 1.5	Good 5 - 10 km
26-Sep-10	16:14:21	12:14:21	42.20207	-67.72395	16 - 20	5	1 - 1.5	Good 5 - 10 km
26-Sep-10	18:03:19	14:03:19	42.22274	-67.67175	21+	5	1 - 1.5	Good 5 - 10 km
26-Sep-10	18:37:40	14:37:40	42.21346	-67.7279	21+	5	1.5 - 2	Good 5 - 10 km
26-Sep-10	21:34:55	17:34:55	42.2522	-67.74165	21+	4	1 - 1.5	Good 5 - 10 km

Date	GMT Time	Local Time	Latitude	Longitude	Wind Speed (knots)	Sea State	Wave Height (m)	Visibility
26-Sep-10	21:59:05	17:59:05	42.22981	-67.73284	21+	4	1 - 1.5	Good 5 - 10 km
26-Sep-10	22:01:05	18:01:05	42.22794	-67.73219	21+	5	1.5 - 2	Good 5 - 10 km
27-Sep-10	12:02:50	8:02:50	42.26699	-67.72414	16 - 20	2	1 - 1.5	Moderate 2 -5 km
27-Sep-10	12:28:08	8:28:08	42.25761	-67.74352	16 - 20	2	1 - 1.5	Moderate 2 -5 km
27-Sep-10	12:45:50	8:45:50	42.23897	-67.73536	16 - 20	3	1.5 - 2	Moderate 2 -5 km
27-Sep-10	12:57:32	8:57:32	42.22617	-67.73022	16 - 20	3	1.5 - 2	Moderate 2 -5 km
27-Sep-10	13:50:44	9:50:44	42.19731	-67.7166	16 - 20	4	1.5 - 2	Moderate 2 -5 km
27-Sep-10	14:17:45	10:17:45	42.16889	-67.71022	16 - 20	4	1.5 - 2	Moderate 2 -5 km
27-Sep-10	16:24:18	12:24:18	42.20277	-67.76028	16 - 20	4	1.5 - 2	Moderate 2 -5 km
27-Sep-10	16:51:28	12:51:28	42.20979	-67.7225	16 - 20	4	1.5 - 2	Moderate 2 -5 km
27-Sep-10	17:20:05	13:20:05	42.21667	-67.6909	16 - 20	1	1.5 - 2	Moderate 2 -5 km
27-Sep-10	20:38:15	16:38:15	42.16505	-67.71455	6 - 10	1	0 - 0.5	Moderate 2 -5 km
27-Sep-10	21:06:42	17:06:42	42.18044	-67.75172	6 - 10	1	0 - 0.5	Moderate 2 -5 km
27-Sep-10	21:32:33	17:32:33	42.1939	-67.78484	6 - 10	1	0 - 0.5	Moderate 2 -5 km
27-Sep-10	21:46:57	17:46:57	42.19714	-67.78518	6 - 10	1	0 - 0.5	Moderate 2 -5 km
28-Sep-10	10:33:00	6:33:00	42.0877	-67.79501	16 - 20	1	0.5 - 1	Good 5 - 10 km

Date	GMT Time	Local Time	Latitude	Longitude	Wind Speed (knots)	Sea State	Wave Height (m)	Visibility
28-Sep-10	10:46:31	6:46:31	42.07384	-67.78926	16 - 20	1	0.5 - 1	Good 5 - 10 km
28-Sep-10	10:51:12	6:51:12	42.06892	-67.78751	16 - 20	2	0.5 - 1	Good 5 - 10 km
28-Sep-10	11:00:51	7:00:51	42.05847	-67.78345	16 - 20	2	0.5 - 1	Good 5 - 10 km
28-Sep-10	11:18:33	7:18:33	42.03998	-67.77637	16 - 20	2	0.5 - 1	Good 5 - 10 km
28-Sep-10	11:29:59	7:29:59	42.0296	-67.77242	16 - 20	3	0.5 - 1	Good 5 - 10 km
28-Sep-10	12:01:12	8:01:12	41.99866	-67.76109	16 - 20	3	0.5 - 1	Good 5 - 10 km
28-Sep-10	14:26:26	10:26:26	42.04316	-67.65114	16 - 20	4	1 - 1.5	Good 5 - 10 km
28-Sep-10	14:52:09	10:52:09	42.06544	-67.66464	16 - 20	4	1 - 1.5	Good 5 - 10 km
28-Sep-10	14:59:15	10:59:15	42.07124	-67.66812	21+	4	1.5 - 2	Good 5 - 10 km
28-Sep-10	17:48:52	13:48:52	42.21834	-67.72793	6 - 10	4	1.5 - 2	Good 5 - 10 km
28-Sep-10	18:16:04	14:16:04	42.24657	-67.73919	16 - 20	4	1.5 - 2	Good 5 - 10 km
28-Sep-10	18:21:41	14:21:41	42.2523	-67.74155	16 - 20	4	1.5 - 2	Good 5 - 10 km
28-Sep-10	20:17:32	16:17:32	42.33476	-67.77274	6 - 10	4	1.5 - 2	Good 5 - 10 km
28-Sep-10	20:45:53	16:45:53	42.3649	-67.78471	6 - 10	4	1.5 - 2	Good 5 - 10 km
29-Sep-10	10:36:54	6:36:54	42.09731	-67.60066	16 - 20	2	1.5 - 2	Good 5 - 10 km
29-Sep-10	11:05:15	7:05:15	42.12143	-67.63216	16 - 20	2	1.5 - 2	Good 5 - 10 km
29-Sep-10	11:35:32	7:35:32	42.14339	-67.67188	16 - 20	3	1.5 - 2	Good 5 - 10 km
29-Sep-10	11:46:35	7:46:35	42.15125	-67.6866	16 - 20	3	1.5 - 2	Good 5 - 10 km
29-Sep-10	11:47:36	7:47:36	42.15191	-67.68795	16 - 20	3	1.5 - 2	Good 5 - 10 km
29-Sep-10	11:56:04	7:56:04	42.1578	-67.6993	16 - 20	3	1.5 - 2	Good 5 - 10 km
29-Sep-10	12:11:05	8:11:05	42.17668	-67.70979	16 - 20	3	1.5 - 2	Good 5 - 10 km
29-Sep-10	12:29:13	8:29:13	42.20096	-67.72009	16 - 20	2	1.5 - 2	Good 5 - 10 km
29-Sep-10	12:36:57	8:36:57	42.21032	-67.72401	16 - 20	3	1.5 - 2	Good 5 - 10 km
29-Sep-10	12:45:57	8:45:57	42.22127	-67.72839	16 - 20	2	1.5 - 2	Good 5 - 10 km

Date	GMT Time	Local Time	Latitude	Longitude	Wind Speed (knots)	Sea State	Wave Height (m)	Visibility
29-Sep-10	13:17:23	9:17:23	42.25806	-67.74406	16 - 20	2	1.5 - 2	Good 5 - 10 km

Table 9.4.4. Summary of predator sightings from 23 September to 29 September 2010. *Off effort sighting

Date	GMT Time	Local Time	Lat	Long	Head	Sp (kn)	Species	Est Grp Size	Distance (m)	Bearing
9/23/2010	13:56:17	9:56:17	42.1254	-67.69253	344.7	4	Fish, Possibly Tuna	1	1272	-45
9/23/2010	14:07:18	10:07:18	42.1375	-67.69717	345.1	4.1	Unidentified Whale	1	1746	40
9/23/2010	14:30:18	10:30:18	42.1623	-67.70621	347.5	3.9	Tuna	1	826	20
9/23/2010	14:59:06	10:59:06	42.1926	-67.71592	347.1	4	Fish, Possibly Tuna	1	704	-40
9/23/2010	15:28:50	11:28:50	42.225	-67.72965	342	4	Fish	1	1002	-30
9/23/2010	16:08:31	12:08:31	42.267	-67.7472	346.2	3.8	Unidentified Dolphin	1	2817	-55
9/23/2010	18:03:30	14:03:30	42.3586	-67.72669	89.9	4.6	*Common Dolphin	7	10	220
9/23/2010	19:32:06	15:32:06	42.3286	-67.65629	200.2	1.8	*Unidentified Whale	1	1746	-25
9/23/2010	21:32:46	17:32:46	42.3122	-67.64659	160.6	4.3	Unidentified Dolphin	1	6075	30
9/23/2010	21:33:59	17:33:59	42.3108	-67.64591	160.4	4.3	Unidentified Whale	1	613	15
9/23/2010	21:38:16	17:38:16	42.3061	-67.64349	160.4	4.2	Humpback Whale	2	1002	15
9/23/2010	21:47:18	17:47:18	42.2958	-67.63956	166	4.4	Leatherback Sea Turtle	1	440	240
9/23/2010	21:52:00	17:52:00	42.2904	-67.63763	164.3	4	Leatherback Sea Turtle	1	70	-90
9/23/2010	21:58:00	17:58:00	42.2839	-67.63516	162.7	4.3	Fish	1	2817	-30
9/23/2010	22:04:16	18:04:16	42.2765	-67.63247	166	4.4	Fish	1	4149	25
9/23/2010	22:08:17	18:08:17	42.2719	-67.63081	164.9	4.1	Tuna	1	1130	-15
9/24/2010	11:48:57	7:48:57	42.3817	-67.44496	155	4.2	Fish	1	1002	-90
9/24/2010	12:04:19	8:04:19	42.3648	-67.4359	160.2	4.3	Unidentified Dolphin	2	826	-45
9/24/2010	12:08:50	8:08:50	42.3596	-67.43345	160.9	4.3	Common Dolphin	25	1272	5
9/24/2010	13:42:26	9:42:26	42.2855	-67.40545	161.1	3.9	Unidentified Whale	1	1746	0
9/24/2010	14:08:43	10:08:43	42.2582	-67.39266	163.4	4.3	Unidentified Whale	1	4149	-25
9/24/2010	15:00:04	11:00:04	42.2256	-67.3829	163.6	4.2	Humpback Whale	1	1746	-35

Date	GMT Time	Local Time	Lat	Long	Head	Sp (kn)	Species	Est Grp Size	Distance (m)	Bearing
9/24/2010	15:25:17	11:25:17	42.1982	-67.37064	157.8	3.7	Unidentified Whale	1	1272	50
9/24/2010	15:34:25	11:34:25	42.1894	-67.36671	162.2	3.4	Humpback Whale	2	2817	10
9/24/2010	15:50:48	11:50:48	42.1739	-67.36031	162.2	3.6	Pilot Whale	3	300	0
9/24/2010	16:35:17	12:35:17	42.1595	-67.34398	142.6	2	*Unidentified Dolphin	3	826	120
9/24/2010	16:39:58	12:39:58	42.1569	-67.34135	145.1	2.6	Pilot Whale	5	5278	80
9/24/2010	16:42:20	12:42:20	42.155	-67.3405	169.3	3.6	Pilot Whale	6	250	75
9/24/2010	16:51:41	12:51:41	42.1452	-67.33936	175.8	3.9	Pilot Whale	7	826	-45
9/24/2010	16:59:21	12:59:21	42.1367	-67.33801	171.9	4.2	Unidentified Dolphin	5	6075	-40
9/24/2010	17:00:19	13:00:19	42.1356	-67.33779	172.1	4.3	Humpback Whale	2	6075	-45
9/24/2010	17:18:12	13:18:12	42.1168	-67.33181	174.2	3.6	Unidentified Whale	1	2817	-30
9/24/2010	17:25:11	13:25:11	42.1102	-67.33088	175.4	3.5	Unidentified Dolphin	2	1746	60
9/24/2010	19:52:52	15:52:52	42.0857	-67.36053	294.4	1.9	Unidentified Whale	1	1200	35
9/26/2010	10:57:08	6:57:08	42.1795	-67.71353	163.7	3.9	Tuna	1	1746	40
9/26/2010	15:11:22	11:11:22	42.2413	-67.75587	28.9	3.7	Humpback Whale	1	1272	-45
9/26/2010	16:33:26	12:33:26	42.181	-67.71388	163.1	4.2	Unidentified Whale	1	1272	0
9/26/2010	18:50:10	14:50:10	42.2183	-67.74886	285.2	4	Mola Mola	1	100	90
9/27/2010	17:43:20	13:43:20	42.2225	-67.6653	74.9	3.1	Shark, Possibly Mako	1	200	-90
9/27/2010	20:19:11	16:19:11	42.1675	-67.70879	162.8	3.9	*Common Dolphin	11	200	160
9/27/2010	22:02:24	18:02:24	42.2019	-67.76328	74	4.1	Tuna	1	1002	50
9/28/2010	10:35:12	6:35:12	42.0854	-67.79415	163.9	3.8	Pilot Whale	1	200	45
9/28/2010	11:05:53	7:05:53	42.053	-67.78144	164	3.9	Tuna	1	1272	45
9/28/2010	11:12:23	7:12:23	42.0459	-67.77866	164.1	3.9	Pilot Whale	12	826	-20
9/29/2010	10:36:14	6:36:14	42.0966	-67.60008	329.6	4.5	Humpback Whale	1	2817	-50
9/29/2010	10:39:24	6:39:24	42.1	-67.60277	332.9	4.5	Humpback Whale	2	2817	-10
9/29/2010	10:51:44	6:51:44	42.112	-67.61459	308.6	4.1	Humpback Whale	4	1272	-45

Date	GMT Time	Local Time	Lat	Long	Head	Sp (kn)	Species	Est Grp Size	Distance (m)	Bearing
9/29/2010	10:56:03	6:56:03	42.115	-67.62006	302.9	4.3	Humpback Whale	4	543	-60
9/29/2010	11:13:25	7:13:25	42.1274	-67.64291	307.1	4.3	Common Dolphin	3	613	45
9/29/2010	11:16:12	7:16:12	42.1294	-67.64656	306.6	4.4	Pilot Whale	3	704	70
9/29/2010	11:50:46	7:50:46	42.154	-67.69224	305.3	4.4	Pilot Whale	3	400	5

Table 9.4.4. Summary of effort, sightings, sightings per unit effort and transect ID

Date (2010)	Distance Traveled On Effort (km)	Time On Effort (hrs)	Number of Marine Mammal Sightings	Sightings per unit effort (Sightings/km)	Transect ID's surveyed
September 23	25.5	3:36:21	7	0.275	1, 2
September 24	27.8	3:49:56	17	0.612	4
September 25	--	--	--	--	--
September 26	21.0	2:39:42	2	0.095	16, 20, 22
September 27	17.6	2:38:13	1	0.057	33, 37, 38
September 28	37.9	5:43:27	2	0.053	42, 43
September 29	20.5	2:25:34	7	0.341	46
	150.3	23:53:13	36		

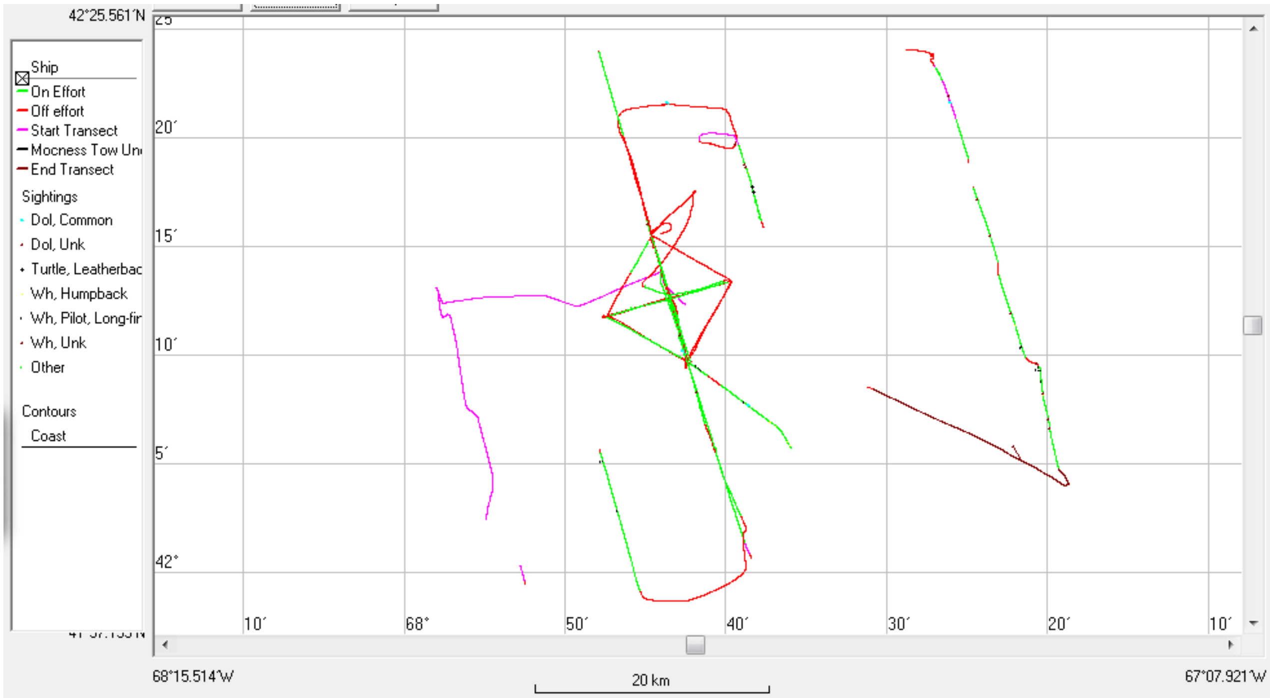


Figure 9.4.1. Map of effort and sightings created in the IFAW program *Logger*. Green lines represent on effort surveying and dots represent the ship location when marine predators were sighted.

Figure 9.4.2. Marine mammal species identified during the surveys. (A) Common dolphin (*Delphinus delphis*); (B) long-finned pilot whale (*Globicephala melas*); (C1, C2) humpback whale (*Megaptera novaengliae*).

9.4. *GigaPan Panoramic Camera System*

Julie van der Hoop

The GigaPan Epic Pro system is a rotating camera mounting platform that allows a scene to be captured in multiple images. The user is able to set the corner bounds of the scene, and the system automatically determines the number of frames the system requires to photograph the panorama. The system then operates the mounted camera automatically to capture the scene. Using GigaPan Stitch software, the individual photographs are aligned and blended to create a composite image of a single panorama. Importantly, the user must manually initiate the process of capturing images.

We employed the use of the GigaPan Epic Pro system and Stitching software to investigate whether a rotating camera system can adequately capture the presence and abundance of seabirds and marine mammals. Such a system also collects time and GPS information, similar to the data collected by human seabird or marine mammal observers.

The GigaPan Epic Pro platform was mounted to the front of the RV Endeavor and operated during dry weather conditions and under various sea states and wind speeds. Different scene sizes were selected based on glare, the area of interest, and the presence of animals of interest. Panoramas were preferentially captured when marine mammals or seabirds were visible to marine mammal and seabird observers to allow success rates to be determined.

9.4.1. Preliminary Results

The GigaPan Epic Pro system was able to capture wide areas of ocean in a relatively short period of time; 25 frames take roughly over a minute and can capture a field of view of >100 degrees with 75% overlap between frames.

Single images from panorama sets were analyzed to count the number of sightings per panorama (Figure 9.4.1). This was then compared to stitched images to determine if blending the individual frames together resulted in the deletion of bodies present in individual but not overlapping frames. The GigaPan was deployed during a sighting of a group of approximately 13 pilot whales, but was unable to pick up the group in any frame. Trials were only successful in capturing seabirds. Five trials captured the one or more seabirds in individual frames.

Figure 9.4.1. Individual frame indicating the presence of two seabirds (marked with red circles).

Stitching these images together becomes difficult due to the pitch and roll of the vessel, creating an uneven horizon (Figure 9.4.2). Furthermore, the dynamic wave surface complicates stitching algorithms and produces a much larger result with minimal overlap of the original photos. While the GigaPan Epic Pro was set to take photographs that overlapped by 75%, the stitching algorithms overlapped photographs by as little as 7.1% to as much as 93.3% (Figure 9.4.3). The inability of blending algorithms to compensate for deviations in the position of the horizon results in the apparent field of view of the composite image greatly exaggerating the true field of view of the intended panorama.

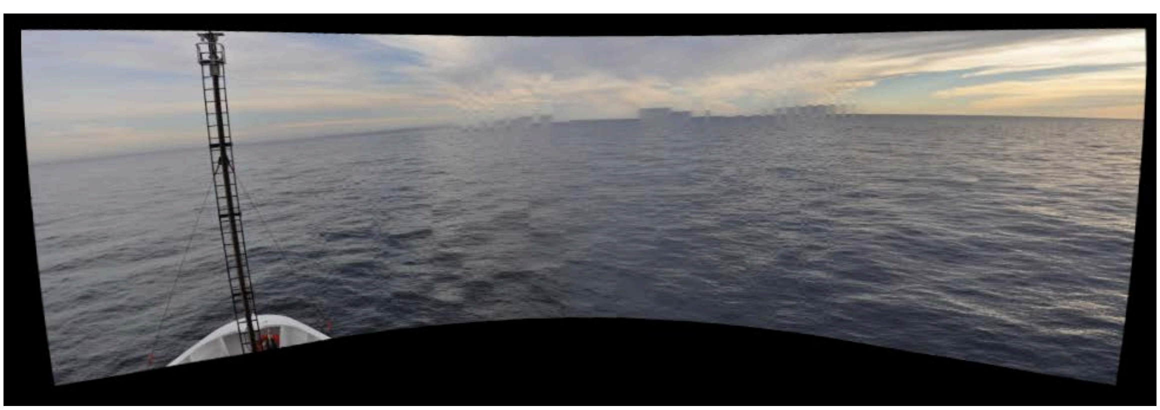


Figure 9.4.2. GigaPan stitched composite image from the front of the RV Endeavor. The unmatched horizon results from the pitch and roll of the vessel relative to the fixed position of the camera.

The success rate of incorporating sightings from individual frames into composite images was on average 71.9%, ranging from 9.5-100%. Figure 9.4.3 contains the individual frame in Figure 9.4.1, showing 2 seabirds. Note the absence of seabirds in the composite image (Figure 9.4.3) despite the poor overlap in the blending procedure.

Figure 9.4.3. GigaPan stitched composite image with 7.1-9.3% overlap of individual frames due to uneven horizon lines from the pitch and roll of the vessel relative to the fixed position of the camera.

The GigaPan Epic Pro camera mounting system was tested to determine the feasibility of using an automatic, oscillating camera system to resolve the presence and abundance of seabirds and marine mammals similar to the effort made by human observers. The system was not successful in capturing the presence of a large group of pilot whales in its single trial to capture marine mammals. The system's success in capturing seabirds was variable; as seabirds travel quickly (average 11 m/s for herring gulls; Deardoff 1976) and the camera can be set to take photographs as quickly as every 14s, birds can quickly travel through the observing area without being captured by the camera. Furthermore, the stitching of individual frames into a composite image can result in the deletion of bodies, capturing as low as 9.5% of the number of sightings in individual frames. The GigaPan Epic Pro system may be thus better suited for times when seabirds or marine mammals are more stationary relative to the camera system, such as when birds are floating on water, or when seals are hauled out on land.

9.4.2. References

Deardoff, J.W. 1976. Discussion of 'Thermals over the sea and gull flight behavior' by A.H. Woodcock. Boundary-Layer Meteorology 10:241-246.

10. R2R Event Logger

Tobias Work

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.

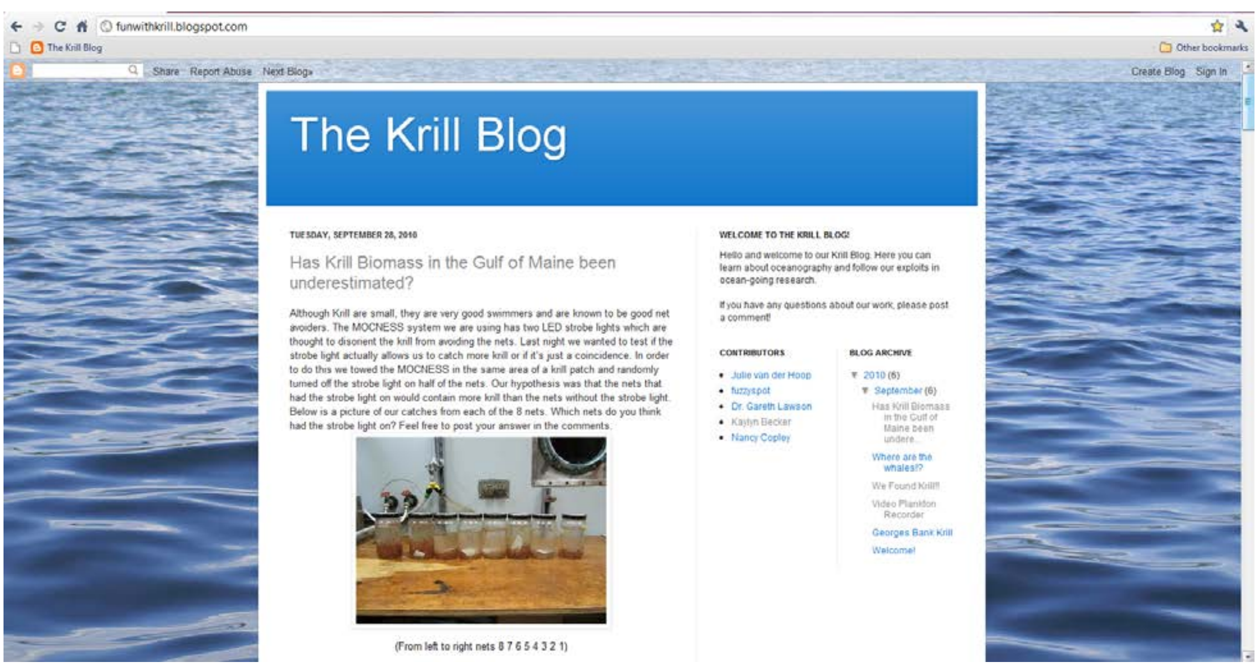
Traditionally, event logs begin in hand-written form and are transcribed to electronic form (such as an Excel spreadsheet). On this cruise, we tested a system that is electronic to begin with, so the hand-writing and transcription step is not necessary. This not only saves time, but increases accuracy as it eliminates several chances for human error. The software that was used on this cruise is known as “Elog”, which is an open source event logging package that was configured to work with the Endeavor’s data streams. A dedicated netbook acted as a server that allowed any computer on the ship’s network to log events, including computers used by the macrofauna observers on the flying bridge (connected via a long Ethernet cable from the bridge).

One science party member (T. Work) had the ability to modify the Elog parameters and was also tasked with cleaning up erroneous entries each night. Overall, the electronic event log approach proved extremely useful and the Elog software enabled everyone on board to produce a detailed, accurate event log.

11. Outreach

Kaylyn Becker

A blog entitled ‘The Krill Blog’ was established using the free Blogger host site and associated tools. 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 krill, including where we were, what we were doing, and why, as well as information on life at sea and oceanographic research more generally. Different science party personnel contributed to the blog over the course of the cruise and a variety of photographs were posted (mostly small in size due to bandwidth issues). As Chief Scientist Gareth Lawson checked over each post prior to its being uploaded.



12. Cruise Participants

Science Party

	NAME	TITLE	AFFILIATION	TEAM
1	Gareth Lawson	Chief Scientist	WHOI	Zooplankton - Day
2	Peter Wiebe	Scientist	WHOI	Zooplankton - Night
3	Cynthia Sellers	Technician	WHOI	Zooplankton - Night
4	Tobias Work	Technician	WHOI	Zooplankton - Night
5	Wu-Jung Lee	Grad student	WHOI	Zooplankton - Day
6	Nicholas Woods	Grad student	WHOI	Zooplankton - Day
7	Kaylyn Becker	Volunteer	GMRI	Zooplankton - Day
8	Qianqian Liu	Grad student	URI	Zooplankton - Night
9	Reny Tyson	Grad student	Duke	Top Predators
10	Julie van der Hoop	Volunteer	WHOI	Top Predators
11	Timothy White	Grad student	CUNY	Top Predators
12	David Nelson	Marine Technician	URI	

EN484 Science Party. Back row, left to right: Tim White, Gareth Lawson, Tobias Work, Reny Tyson, Cindy Sellers, Julie van der Hoop, Kaylyn Becker, Peter Wiebe, Qianqian Liu. Fron row, left to right: Nick Woods, Wu-Jung Lee.

Officers and Crew

	NAME	TITLE
1	Richard Chase III	Captain
2	Tom Dornhofer	Chief Engineer
3	John Wilder	Chief Mate
4	Shanna Post-Maher	Second Mate
5	George Maltby	QMED
6	Bruce Bannick	QMED
7	Patrick Quigley	Boatswain
8	Paul Rousell	A/B
9	Kevin Walsh	A/B
10	S. Oscar Sisson	A/B
11	Jim Montminy	A/B
12	Jeff Avery	Chief Steward
13	Kim Heine	Messman

Appendix 1. Event Log.

Event number = local date (year, month, day).local time; T = transect number; Seafloor = depth of water in meters

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100922.0901	0901	41.49222	-71.41870	Cruise	start	NaN	NaN	NaN	NaN	NaN	nd
20100922.1046	1046	41.42265	-71.40903	GreeneBomber	start	NaN	NaN	1	NaN	glawson	test deployment
20100922.1122	1122	41.41108	-71.41975	Hammarhead	start	NaN	NaN	1	NaN	aLavery	test deployment
20100922.1249	1249	41.32265	-71.43360	Station	start	NaN	0	NaN	NaN	NaN	station 0
20100922.1308	1308	41.31557	-71.43043	VPR	start	NaN	0	1	NaN	glawson	test deployment
20100922.1316	1316	41.31278	-71.43042	VPR	end	NaN	0	1	NaN	glawson	test recovery
20100922.1330	1330	41.30827	-71.43108	Hammarhead	end	NaN	NaN	1	NaN	aLavery	test recovery
20100922.1358	1358	41.30295	-71.43343	GreeneBomber	end	NaN	NaN	1	NaN	glawson	test recovery
20100922.1415	1415	41.30080	-71.42310	SafetyDrill	start	NaN	NaN	NaN	25.31	NaN	meeting in the galley
20100922.1525	1525	41.33328	-71.12270	SafetyDrill	end	NaN	NaN	NaN	28.54	NaN	nd
20100922.1534	1934	41.33763	-71.08700	ObserverMammals	start	NaN	NaN	NaN	28.11	rtyson	Test Observer Protocol
20100922.1613	2013	41.36343	-70.93063	ObserverMammals	end	NaN	NaN	NaN	33.55	rtyson	Test Observer Protocol
20100923.0640	0640	41.99695	-67.63018	GreeneBomber	start	NaN	NaN	2	NaN	glawson	
20100923.0655	0655	42.00107	-67.63275	Hammarhead	start	NaN	NaN	2	NaN	aLavery	
20100923.0703	0703	42.00740	-67.63740	ADCP75	start	NaN	NaN	NaN	NaN	glawson	starting it with external trigger; lat/lon 42 00.444 N 67 38.244 W
20100923.0722	0722	42.02262	-67.64695	ObserverMammals	start	1	NaN	NaN	NaN	rtyson	nd
20100923.0723	0723	42.02262	-67.64695	ObserverBirds	start	1	NaN	NaN	NaN	twhite	nd
20100923.0836	0835	42.09035	-67.67648	ObserverMammals	end	1	NaN	NaN	NaN	rtyson	VPR station?
20100923.0837	0836	42.09035	-67.67648	ObserverBirds	end	1	NaN	NaN	NaN	twhite	VPR station?
20100923.0858	0858	42.09705	-67.67982	VPR	start	1	1	2	NaN	glawson	down at 10m per min; up at 20m per min
20100923.0933	0933	42.10785	-67.68528	VPR	end	1	1	2	NaN	glawson	nd
20100923.0942	0942	42.11188	-67.68767	Transect	start	1	NaN	NaN	NaN	NaN	nd
20100923.0943	0943	42.11188	-67.68767	Station	start	1	1	NaN	NaN	NaN	nd
20100923.0944	0837	42.11283	-67.68813	Station	end	1	1	NaN	NaN	NaN	station end

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100923.0945	0944	42.11397	-67.68860	ObserverMammals	start	1	NaN	NaN	NaN	rtyson	nd
20100923.0946	0945	42.11397	-67.68860	ObserverBirds	start	1	NaN	NaN	NaN	twhite	nd
20100923.1148	1147	42.24592	-67.73880	ObserverBirds	end	1	NaN	NaN	NaN	twhite	Mammal obs still observing
20100923.1213	1212	42.27162	-67.74885	ObserverMammals	end	1	NaN	NaN	NaN	rtyson	lunch break
20100923.1300	1258	42.31945	-67.76598	ObserverBirds	start	1	NaN	NaN	NaN	twhite	No mammal observers
20100923.1308	1308	42.32782	-67.77050	Transect	end	1	NaN	NaN	NaN	NaN	nd
20100923.1309	1308	42.32782	-67.77050	Transect	start	2	NaN	NaN	NaN	NaN	nd
20100923.1311	1310	42.33022	-67.77192	ObserverBirds	end	2	NaN	NaN	NaN	twhite	No mammal observers
20100923.1330	1330	42.35052	-67.77707	ObserverBirds	start	2	NaN	NaN	NaN	twhite	No Duke observers
20100923.1441	1440	42.35265	-67.66462	ObserverBirds	end	2	NaN	NaN	NaN	twhite	No Duke observers
20100923.1500	1500	42.34197	-67.65930	VPR	start	2	2	3	NaN	glawson	nd
20100923.1531	1531	42.32905	-67.65612	VPR	end	2	2	3	NaN	glawson	nd
20100923.1535	1441	42.32728	-67.65725	Station	start	2	2	NaN	NaN	NaN	start station
20100923.1559	1559	42.32600	-67.66965	CTD911	start	2	2	NaN	NaN	glawson	nd
20100923.1627	1627	42.32815	-67.67938	CTD911	end	2	2	NaN	NaN	glawson	nd
20100923.1641	1640	42.33032	-67.69308	ObserverBirds	start	2	2	NaN	NaN	twhite	On Effort
20100923.1719	1719	42.32643	-67.65283	ObserverMammals	start	2	2	NaN	NaN	rtyson	nd
20100923.1720	1720	42.32643	-67.65283	ObserverBirds	start	2	2	NaN	NaN	twhite	nd
20100923.1726	1640	42.31877	-67.64948	Station	end	2	2	NaN	NaN	NaN	station end
20100923.1811	1810	42.26943	-67.62975	Station	start	2	3	NaN	NaN	NaN	station 3
20100923.1815	1815	42.26677	-67.62858	Hammarhead	other	2	3	2	NaN	aLavery	put a line on it so that it doesn't spin when on station
20100923.1816	1815	42.26633	-67.62835	ObserverMammals	end	2	3	NaN	NaN	rtyson	nd
20100923.1817	1815	42.26633	-67.62835	ObserverBirds	end	2	3	NaN	NaN	twhite	nd
20100923.1833	1833	42.25970	-67.62567	VPR	start	2	3	4	NaN	glawson	nd
20100923.1900	1900	42.24938	-67.62233	VPR	end	2	3	4	NaN	glawson	nd
20100923.1905	1904	42.24790	-67.62175	Station	end	2	3	NaN	NaN	NaN	nd
20100923.1955	1955	42.19095	-67.60045	Station	start	2	4	NaN	NaN	NaN	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100923.1959	1959	42.18780	-67.59885	Hammarhead	other	2	4	2	NaN	aLavery	put line on HammarHead so it doesn't spin while on station
20100923.2011	2011	42.18100	-67.59587	VPR	start	2	4	5	NaN	glawson	station 4
20100923.2036	2034	42.16955	-67.59223	VPR	end	2	4	5	NaN	glawson	nd
20100923.2039	2037	42.16792	-67.59207	Hammarhead	other	2	4	2	NaN	aLavery	line taken off HammarHead; getting get back up to speed
20100923.2044	2044	42.16263	-67.59032	Station	end	2	4	NaN	NaN	NaN	nd
20100923.2134	2134	42.11017	-67.56952	Station	start	2	5	NaN	NaN	NaN	nd
20100923.2135	2134	42.11000	-67.56947	Hammarhead	other	2	5	2	NaN	aLavery	putting line on HammarHead to limit spin on station
20100923.2143	2143	42.10835	-67.56918	VPR	start	2	5	6	NaN	glawson	nd
20100923.2158	2158	42.10623	-67.56852	VPR	end	2	5	6	NaN	glawson	nd
20100923.2200	2200	42.10528	-67.56800	Station	end	2	5	NaN	NaN	NaN	nd
20100923.2316	2315	42.03127	-67.53667	Station	start	2	6	NaN	NaN	NaN	tied up the HammarHead so that it didn't spin while on station
20100923.2324	2324	42.03045	-67.53415	VPR	start	2	6	7	NaN	glawson	nd
20100923.2330	2330	42.02940	-67.53178	VPR	end	2	6	7	NaN	glawson	nd
20100923.2333	2332	42.02890	-67.53097	Station	end	2	6	NaN	NaN	NaN	took the line of the HammarHead
20100923.2335	2335	42.02707	-67.52888	Transect	end	2	NaN	NaN	NaN	NaN	nd
20100924.0054	0054	42.05627	-67.43118	Transect	start	3	NaN	NaN	NaN	NaN	Start transect ; Greene Bomber and HammarHead in water
20100924.0537	0536	42.37342	-67.55432	Transect	end	3	NaN	NaN	NaN	NaN	GreeneBomber and HammarHead still in the water
20100924.0706	0706	42.39677	-67.45323	Transect	start	4	NaN	NaN	NaN	NaN	nd
20100924.0707	0707	42.39673	-67.45335	Station	start	4	7	NaN	NaN	NaN	nd
20100924.0709	0708	42.39657	-67.45378	VPR	start	4	7	8	NaN	glawson	nd
20100924.0733	0732	42.39360	-67.45373	VPR	end	4	7	8	NaN	glawson	nd
20100924.0734	0734	42.39355	-67.45410	Station	end	4	7	NaN	NaN	NaN	nd
20100924.0741	0740	42.38903	-67.45098	ObserverMammals	start	4	NaN	NaN	NaN	rtyson	nd
20100924.0758	0757	42.37197	-67.43933	ObserverBirds	start	4	NaN	NaN	NaN	twhite	nd
20100924.0850	0850	42.31505	-67.41480	Station	start	4	8	NaN	NaN	NaN	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100924.0851	0851	42.31468	-67.41480	ObserverMammals	end	4	8	NaN	NaN	rtyson	nd
20100924.0852	0852	42.31450	-67.41482	ObserverBirds	end	4	8	NaN	NaN	twhite	nd
20100924.0855	0855	42.31368	-67.41490	VPR	start	4	8	9	NaN	glawson	nd
20100924.0859	0859	42.31298	-67.41522	ObserverBirds	end	4	8	NaN	NaN	twhite	nd
20100924.0916	0914	42.31038	-67.41732	VPR	end	4	8	9	NaN	glawson	nd
20100924.0917	0917	42.31025	-67.41732	Station	end	4	8	NaN	NaN	NaN	nd
20100924.0918	0918	42.31010	-67.41730	ObserverBirds	start	4	NaN	NaN	NaN	twhite	nd
20100924.0919	0919	42.30967	-67.41732	ObserverMammals	start	4	NaN	NaN	NaN	rtyson	nd
20100924.1028	1028	42.23668	-67.38428	ObserverBirds	end	4	NaN	NaN	NaN	twhite	nd
20100924.1029	1028	42.23648	-67.68430	ObserverMammals	end	4	NaN	NaN	NaN	rtyson	nd
20100924.1030	1029	42.23628	-67.38433	Station	start	4	9	NaN	NaN	NaN	nd
20100924.1033	1033	42.23575	-67.38462	VPR	start	4	9	10	NaN	glawson	nd
20100924.1050	1050	42.23193	-67.38507	VPR	end	4	9	10	NaN	glawson	nd
20100924.1053	1053	42.23132	-67.38502	Station	end	4	9	NaN	NaN	NaN	nd
20100924.1056	1056	42.22917	-67.38430	ObserverBirds	start	4	NaN	NaN	NaN	twhite	nd
20100924.1058	1057	42.22780	-67.38377	ObserverMammals	start	4	NaN	NaN	NaN	rtyson	nd
20100924.1201	1201	42.16368	-67.35518	ObserverMammals	end	4	NaN	NaN	NaN	rtyson	nd
20100924.1202	1202	42.16355	-67.35505	ObserverBirds	end	4	NaN	NaN	NaN	twhite	nd
20100924.1206	1205	42.16285	-67.35380	Station	start	4	10	NaN	NaN	NaN	the station location was revised
20100924.1216	1206	42.16138	-67.35065	VPR	start	4	10	11	NaN	glawson	nd
20100924.1233	1227	42.15998	-67.34443	VPR	end	4	10	11	NaN	glawson	nd
20100924.1234	1234	42.15988	-67.34428	Station	end	4	10	NaN	NaN	NaN	nd
20100924.1235	1235	42.15920	-67.34370	ObserverBirds	start	4	NaN	NaN	NaN	twhite	nd
20100924.1237	1236	42.15825	-67.34265	ObserverMammals	start	4	NaN	NaN	NaN	rtyson	nd
20100924.1356	1356	42.07832	-67.32073	ObserverMammals	end	4	NaN	NaN	NaN	rtyson	nd
20100924.1357	1357	42.07802	-67.32047	ObserverBirds	end	4	NaN	NaN	NaN	twhite	nd
20100924.1400	1400	42.07687	-67.31878	Station	start	4	11	NaN	NaN	NaN	nd
20100924.1401	1400	42.07690	-67.31910	Transect	end	4	11	NaN	NaN	NaN	nd
20100924.1407	1402	42.07500	-67.31653	VPR	start	NaN	11	12	NaN	glawson	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100924.1412	1412	42.07322	-67.31505	VPR	end	NaN	11	12	NaN	glawson	nd
20100924.1423	1423	42.06892	-67.31180	Hammarhead	end	NaN	11	2	NaN	aLavery	brought on deck to inspect problems on the CTD reading.
20100924.1424	1424	42.06880	-67.31170	Transect	start	5	NaN	NaN	NaN	NaN	nd
20100924.1425	1424	42.06873	-67.31158	Station	end	5	11	NaN	NaN	NaN	nd
20100924.1645	1645	42.14418	-67.52497	GreeneBomber	end	5	NaN	2	184.1	glawson	nd
20100924.1700	1659	42.10555	-67.41198	ObserverBirds	start	5	NaN	NaN	83.77	twhite	Transit to Mocness 1
20100924.1709	1709	42.11587	-67.44360	ObserverMammals	start	5	NaN	NaN	135.56	rtyson	On effort
20100924.1732	1732	42.14245	-67.52005	ObserverMammals	end	5	NaN	NaN	185.09	rtyson	Off Effort
20100924.2024	2024	42.20430	-67.71250	ObserverBirds	end	5	NaN	NaN	204.25	twhite	stop observation 22:24 GMT
20100924.2119	2118	42.19502	-67.71813	GreeneBomber	start	5	NaN	3	202.63	glawson	nd
20100924.2120	2120	42.19460	-67.71800	Transect	end	5	NaN	NaN	NaN	NaN	nd
20100924.2331	2331	42.18302	-67.70047	MOCNESS	start	NaN	NaN	1	NaN	pwiebe	nd
20100925.0040	0040	42.14590	-67.73170	MOCNESS	end	NaN	NaN	1	NaN	pwiebe	nd
20100925.0247	0246	42.14413	-67.81358	Transect	start	6	NaN	NaN	NaN	NaN	nd
20100925.0535	0535	41.98463	-67.75525	Transect	end	6	NaN	NaN	NaN	NaN	nd
20100925.0630	0630	41.95740	-67.80460	ObserverBirds	start	7	NaN	NaN	NaN	twhite	started observations at 630 first transect was t6_end
20100925.0720	0720	41.96197	-67.86305	Transect	start	7	NaN	NaN	NaN	NaN	no VPR cast on the first station
20100925.0900	0900	42.03827	-67.90327	Station	start	7	12	NaN	NaN	NaN	nd
20100925.0902	0901	42.03807	-67.90462	VPR	start	7	12	13	NaN	glawson	nd
20100925.0919	0913	42.03783	-67.91258	VPR	end	7	12	13	NaN	glawson	nd
20100925.0920	0920	42.03785	-67.91275	Station	end	7	12	NaN	NaN	NaN	nd
20100925.1045	1045	42.12012	-67.92510	Station	start	7	13	NaN	NaN	NaN	nd
20100925.1048	1046	42.12070	-67.92613	VPR	start	7	13	14	NaN	glawson	nd
20100925.1107	1105	42.12468	-67.93250	VPR	end	7	13	14	NaN	glawson	nd
20100925.1108	1107	42.12475	-67.93267	Station	end	7	13	NaN	NaN	NaN	nd
20100925.1227	1220	42.19760	-67.95438	Station	start	7	14	NaN	NaN	NaN	nd
20100925.1228	1228	42.19770	-67.95447	ObserverBirds	end	7	14	NaN	NaN	twhite	nd
20100925.1229	1229	42.19777	-67.95447	VPR	start	7	14	15	NaN	glawson	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100925.1249	1249	42.19632	-67.95765	VPR	end	7	14	15	NaN	glawson	nd
20100925.1251	1251	42.19613	-67.95803	Station	end	7	14	NaN	NaN	NaN	nd
20100925.1325	1324	42.21817	-67.96598	ObserverBirds	start	7	NaN	NaN	NaN	twhite	nd
20100925.1328	1327	42.21835	-67.96648	ObserverBirds	end	7	NaN	NaN	NaN	twhite	nd
20100925.1338	1338	42.21390	-67.96417	GreeneBomber	end	7	NaN	3	NaN	glawson	nd
20100925.1339	1339	42.21357	-67.96395	Transect	end	7	NaN	NaN	NaN	NaN	nd
20100925.1400	1359	42.20852	-67.93993	ObserverBirds	start	NaN	NaN	NaN	NaN	twhite	Transit
20100925.1507	1506	42.22880	-67.73338	ObserverBirds	end	NaN	NaN	NaN	NaN	twhite	nd
20100925.1738	1738	42.22640	-67.72610	Transect	start	8	NaN	NaN	NaN	NaN	nd
20100925.1739	1739	42.22597	-67.72560	GreeneBomber	start	8	NaN	4	220.76	glawson	nd
20100925.1900	1900	42.14770	-67.69910	Transect	end	8	NaN	NaN	NaN	NaN	nd
20100925.1901	1901	42.14820	-67.69980	Transect	start	9	NaN	NaN	NaN	NaN	nd
20100925.2033	2033	42.22152	-67.66343	Transect	end	9	NaN	NaN	NaN	NaN	nd
20100925.2034	2034	42.22120	-67.66460	Transect	start	10	NaN	NaN	NaN	NaN	nd
20100925.2227	2227	42.19783	-67.78697	Transect	end	10	NaN	NaN	NaN	NaN	nd
20100925.2228	2228	42.19870	-67.78683	Transect	start	11	NaN	NaN	NaN	NaN	nd
20100925.2352	2352	42.25712	-67.74448	Transect	end	11	NaN	NaN	NaN	NaN	nd
20100925.2353	2353	42.25702	-67.74433	Transect	start	12	NaN	NaN	NaN	NaN	nd
20100926.0141	0141	42.16192	-67.70582	Transect	end	12	NaN	NaN	192	NaN	nd
20100926.0142	0142	42.16170	-67.70570	Transect	start	13	NaN	NaN	192	NaN	nd
20100926.0249	0249	42.22275	-67.66422	Transect	end	13	NaN	NaN	210	NaN	nd
20100926.0250	0250	42.22272	-67.66447	Transect	start	14	NaN	NaN	210	NaN	nd
20100926.0432	0432	42.19740	-67.78890	Transect	end	14	NaN	NaN	224	NaN	nd
20100926.0433	0432	42.19767	-67.78897	Transect	start	15	NaN	NaN	224	NaN	nd
20100926.0542	0542	42.25807	-67.73937	Transect	end	15	NaN	NaN	227	NaN	nd
20100926.0543	0543	42.25783	-67.73912	Transect	start	16	NaN	NaN	227	NaN	nd
20100926.0638	0638	42.19918	-67.72047	Hammarhead	start	16	NaN	3	200	aLavery	nd
20100926.0644	0644	42.19417	-67.71902	ObserverMammals	start	16	NaN	NaN	NaN	rtyson	nd
20100926.0645	0644	42.19348	-67.71883	ObserverBirds	start	16	NaN	NaN	NaN	twhite	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100926.0713	0713	42.16125	-67.70645	ObserverBirds	start	16	NaN	NaN	NaN	twhite	nd
20100926.0714	0713	42.16103	-67.70637	Transect	end	16	NaN	NaN	193	NaN	nd
20100926.0715	0713	42.16125	-67.70645	ObserverMammals	end	16	NaN	NaN	NaN	rtyson	nd
20100926.0716	0715	42.15933	-67.70655	Transect	start	17	NaN	NaN	193	NaN	nd
20100926.0832	0832	42.22260	-67.66067	Transect	end	17	NaN	NaN	NaN	NaN	Tow-yo in this transect
20100926.0833	0832	42.22285	-67.66078	Transect	start	18	NaN	NaN	NaN	NaN	nd
20100926.1021	1021	42.19770	-67.78923	Transect	end	18	NaN	NaN	NaN	NaN	nd
20100926.1022	1021	42.19808	-67.78888	Transect	start	19	NaN	NaN	NaN	NaN	nd
20100926.1059	1059	42.23065	-67.76453	ObserverMammals	start	19	NaN	NaN	NaN	rtyson	nd
20100926.1126	1126	42.25497	-67.74405	ObserverMammals	end	19	NaN	NaN	NaN	rtyson	nd
20100926.1127	1127	42.25342	-67.74215	Transect	end	19	NaN	NaN	NaN	NaN	nd
20100926.1128	1128	42.25272	-67.74163	Transect	start	20	NaN	NaN	NaN	NaN	nd
20100926.1135	1134	42.24612	-67.73852	ObserverBirds	start	20	NaN	NaN	NaN	twhite	nd
20100926.1144	1143	42.23645	-67.73457	ObserverBirds	end	20	NaN	NaN	NaN	twhite	nd
20100926.1145	1144	42.23645	-67.73457	ObserverMammals	start	20	NaN	NaN	NaN	rtyson	nd
20100926.1243	1242	42.17088	-67.70933	ObserverMammals	end	20	NaN	NaN	NaN	rtyson	nd
20100926.1252	1252	42.16432	-67.70538	Transect	end	20	NaN	NaN	NaN	NaN	nd
20100926.1253	1252	42.16488	-67.70517	Transect	start	21	NaN	NaN	NaN	NaN	nd
20100926.1356	1356	42.22328	-67.66145	Transect	end	21	NaN	NaN	NaN	NaN	nd
20100926.1357	1357	42.22377	-67.66157	Transect	start	22	NaN	NaN	NaN	NaN	nd
20100926.1402	1402	42.22307	-67.67040	ObserverMammals	start	22	NaN	NaN	NaN	rtyson	nd
20100926.1406	1405	42.22152	-67.67717	ObserverBirds	start	22	NaN	NaN	NaN	twhite	nd
20100926.1446	1446	42.21670	-67.74290	Transect	end	22	NaN	NaN	NaN	NaN	changed course; full transect not completed; localTime is approx. time
20100926.1452	1452	42.21915	-67.75248	ObserverMammals	end	NaN	NaN	NaN	225.46	rtyson	nd
20100926.1453	1453	42.21915	-67.75248	ObserverBirds	end	NaN	NaN	NaN	225.46	twhite	nd
20100926.1508	1508	42.22902	-67.74332	MOCNESS	start	NaN	NaN	2	228.59	pwiebe	nd
20100926.1628	1627	42.28733	-67.70092	MOCNESS	end	NaN	NaN	2	NaN	pwiebe	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100926.1732	1732	42.25408	-67.74228	Transect	start	23	NaN	NaN	NaN	NaN	way off course to do MOCNESS tow; returning to top bowline corner
20100926.1733	1733	42.25320	-67.74200	ObserverBirds	start	23	NaN	NaN	NaN	twhite	nd
20100926.1734	1734	42.25320	-67.74200	ObserverMammals	start	23	NaN	NaN	NaN	rtyson	nd
20100926.1819	1819	42.21112	-67.72558	ObserverMammals	end	23	NaN	NaN	NaN	rtyson	nd
20100926.1820	1819	42.21072	-67.72538	ObserverBirds	end	23	NaN	NaN	NaN	twhite	nd
20100926.1904	1903	42.17558	-67.71197	Hammarhead	end	23	NaN	3	191	aLavery	not flying correctly; brought it on deck to diagnose problem
20100926.1920	1919	42.16205	-67.70647	Transect	end	23	NaN	NaN	NaN	NaN	nd
20100926.1921	1920	42.16118	-67.70612	Transect	start	24	NaN	NaN	NaN	NaN	began reverse bow-tie
20100926.2046	2046	42.19680	-67.78417	Transect	end	24	NaN	NaN	216	NaN	nd
20100926.2047	2047	42.19695	-67.78343	Transect	start	25	NaN	NaN	216	NaN	nd
20100926.2114	2112	42.19923	-67.76885	VPR	start	25	15	16	212	glawson	nd
20100926.2118	2112	42.19937	-67.76653	Station	start	25	15	NaN	212	NaN	see timeLocal for more accurate time
20100926.2134	2134	42.19992	-67.75805	VPR	end	25	15	16	212	glawson	nd
20100926.2135	2135	42.19998	-67.75768	Station	end	25	15	NaN	212	NaN	nd
20100926.2325	2325	42.22563	-67.66328	Transect	end	25	NaN	NaN	215	NaN	nd
20100926.2326	2326	42.22578	-67.66377	Transect	start	26	NaN	NaN	216	NaN	nd
20100927.0044	0044	42.25755	-67.74348	Transect	end	26	NaN	NaN	230	NaN	nd
20100927.0045	0045	42.25742	-67.74393	Transect	start	27	NaN	NaN	230	NaN	nd
20100927.0255	0255	42.16247	-67.70748	Transect	end	27	NaN	NaN	193	NaN	nd
20100927.0256	0256	42.16195	-67.70823	Transect	start	28	NaN	NaN	193	NaN	nd
20100927.0413	0413	42.19662	-67.79107	Transect	end	28	NaN	NaN	220	NaN	nd
20100927.0414	0414	42.19675	-67.79138	Transect	start	29	NaN	NaN	220	NaN	nd
20100927.0605	0605	42.22300	-67.65630	Transect	end	29	NaN	NaN	213	NaN	Missed transect start on this line; see time local for approx. time
20100927.0625	0625	42.23015	-67.67620	Transect	start	30	NaN	NaN	213	NaN	Missed transect start on this line; see time local for approx. time
20100927.0723	0723	42.25818	-67.74520	Transect	end	30	NaN	NaN	NaN	NaN	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100927.0724	0724	42.25768	-67.74547	Transect	start	31	NaN	NaN	NaN	NaN	nd
20100927.0725	0725	42.25702	-67.74463	Station	start	31	16	NaN	NaN	NaN	nd
20100927.0734	0734	42.25838	-67.73843	VPR	start	31	16	17	NaN	glawson	nd
20100927.0751	0751	42.26130	-67.72758	VPR	end	31	16	17	NaN	glawson	nd
20100927.0752	0751	42.26130	-67.72720	Station	end	31	16	NaN	NaN	NaN	nd
20100927.0800	0759	42.26537	-67.72352	ObserverBirds	start	31	NaN	NaN	NaN	twhite	nd
20100927.0825	0825	42.26020	-67.74450	Transect	end	31	NaN	NaN	NaN	NaN	nd
20100927.0826	0825	42.25870	-67.74422	Transect	start	32	NaN	NaN	NaN	NaN	Transect 32 start now; drifted off course during VPR station
20100927.0827	0827	42.25870	-67.72323	ObserverMammals	start	32	NaN	NaN	NaN	rtyson	nd
20100927.0912	0912	42.21018	-67.72323	ObserverMammals	end	32	NaN	NaN	NaN	rtyson	nd
20100927.0913	0912	42.21000	-67.72310	ObserverBirds	end	32	NaN	NaN	NaN	twhite	nd
20100927.0927	0926	42.20692	-67.72067	VPR	start	32	NaN	18	NaN	glawson	nd
20100927.0943	0941	42.20275	-67.71830	VPR	end	32	NaN	18	NaN	glawson	nd
20100927.0948	0947	42.20038	-67.71728	ObserverMammals	start	32	NaN	NaN	NaN	rtyson	On Effort
20100927.0953	0952	42.19482	-67.71610	ObserverBirds	start	32	NaN	NaN	NaN	twhite	nd
20100927.1024	1024	42.16387	-67.70827	ObserverMammals	end	32	NaN	NaN	NaN	rtyson	nd
20100927.1025	1025	42.16375	-67.70827	ObserverBirds	end	32	NaN	NaN	NaN	twhite	nd
20100927.1026	1021	42.16358	-67.70830	Transect	end	32	NaN	NaN	NaN	NaN	nd
20100927.1030	1026	42.16207	-67.70793	VPR	start	NaN	NaN	19	NaN	glawson	nd
20100927.1048	1044	42.15795	-67.70867	VPR	end	NaN	NaN	19	NaN	glawson	nd
20100927.1050	1048	42.15750	-67.70893	Transect	start	33	NaN	NaN	NaN	NaN	nd
20100927.1053	0927	42.15723	-67.70777	Station	start	33	17	NaN	NaN	NaN	forgot to add station
20100927.1054	0943	42.15778	-67.70750	Station	end	33	17	NaN	NaN	NaN	nd
20100927.1055	1026	42.15860	-67.70705	Station	start	33	18	NaN	NaN	NaN	nd
20100927.1056	1044	42.15925	-67.70712	Station	end	33	18	NaN	NaN	NaN	nd
20100927.1202	1201	42.19767	-67.78800	Transect	end	33	NaN	NaN	NaN	NaN	will deploy the Hammerhead when this transect ends
20100927.1204	1204	42.19765	-67.78548	Transect	start	34	NaN	NaN	NaN	NaN	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100927.1216	1216	42.20063	-67.77080	Hammarhead	start	34	NaN	4	NaN	aLavery	nd
20100927.1219	1219	42.20145	-67.76698	ObserverBirds	start	34	NaN	NaN	NaN	twhite	nd
20100927.1223	1222	42.20247	-67.76192	ObserverMammals	start	34	NaN	NaN	NaN	rtyson	On Effort
20100927.1345	1345	42.22305	-67.66310	ObserverMammals	end	34	NaN	NaN	NaN	rtyson	nd
20100927.1346	1345	42.22313	-67.66270	ObserverBirds	end	34	NaN	NaN	NaN	twhite	nd
20100927.1347	1346	42.22427	-67.66237	ObserverBirds	end	34	NaN	NaN	NaN	twhite	nd
20100927.1349	1349	42.22538	-67.66490	Transect	end	34	NaN	NaN	NaN	NaN	nd
20100927.1350	1350	42.22660	-67.66730	Transect	start	35	NaN	NaN	NaN	NaN	nd
20100927.1443	1443	42.25743	-67.74338	Transect	end	35	NaN	NaN	NaN	NaN	nd
20100927.1444	1444	42.25705	-67.74363	Transect	start	36	NaN	NaN	NaN	NaN	nd
20100927.1448	1449	42.25460	-67.74273	Hammarhead	end	36	NaN	4	NaN	aLavery	nd
20100927.1627	1627	42.16070	-67.70293	Transect	end	36	NaN	NaN	NaN	NaN	nd
20100927.1629	1629	42.16210	-67.70333	Transect	start	37	NaN	NaN	NaN	NaN	nd
20100927.1637	1636	42.16463	-67.71353	ObserverMammals	start	37	NaN	NaN	NaN	rtyson	nd
20100927.1715	1715	42.18557	-67.76380	ObserverBirds	start	37	NaN	NaN	NaN	twhite	nd
20100927.1737	1738	42.19687	-67.79308	Transect	end	37	NaN	NaN	214	NaN	nd
20100927.1738	1738	42.19685	-67.79325	ObserverMammals	end	37	NaN	NaN	NaN	rtyson	nd
20100927.1739	1739	42.19673	-67.79362	Transect	start	38	NaN	NaN	214	NaN	nd
20100927.1740	1739	42.19665	-67.79373	ObserverBirds	end	38	NaN	NaN	NaN	twhite	nd
20100927.1746	1745	42.19698	-67.78623	ObserverMammals	start	38	NaN	NaN	NaN	rtyson	nd
20100927.1758	1757	42.20050	-67.76953	ObserverBirds	start	38	NaN	NaN	NaN	twhite	nd
20100927.1812	1812	42.20498	-67.74827	ObserverMammals	end	38	NaN	NaN	NaN	rtyson	nd
20100927.1838	1838	42.21358	-67.70747	ObserverBirds	end	38	NaN	NaN	NaN	twhite	nd
20100927.1910	1910	42.22430	-67.65705	Transect	end	38	NaN	NaN	212	NaN	nd
20100927.1911	1911	42.22445	-67.65620	Transect	start	39	NaN	NaN	NaN	NaN	nd
20100927.2040	2039	42.25525	-67.74022	Transect	end	39	NaN	NaN	NaN	NaN	nd
20100927.2041	2040	42.25433	-67.73972	Transect	start	40	NaN	NaN	NaN	NaN	nd
20100927.2051	2051	42.24557	-67.73647	Hammarhead	start	40	NaN	5	225	aLavery	nd
20100927.2117	2116	42.22475	-67.72803	MOCNESS	start	40	NaN	3	215	pwiebe	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100927.2304	2304	42.17015	-67.69117	MOCNESS	end	40	NaN	3	189	pwiebe	nd
20100927.2306	2306	42.16908	-67.69057	Station	start	40	19	NaN	191	NaN	nd
20100927.2308	2307	42.16852	-67.69022	Handline	start	40	19	1	NaN	glawson	nd
20100927.2339	2339	42.17760	-67.69330	Handline	end	40	19	1	NaN	glawson	entry information is approximated
20100927.2340	2340	42.17830	-67.69410	Station	end	40	19	NaN	NaN	NaN	entry information is approximated
20100927.2342	2342	42.17983	-67.69625	Transect	end	40	NaN	NaN	NaN	NaN	nd
20100927.2343	2343	42.18047	-67.69708	Transect	start	41	NaN	NaN	NaN	NaN	started a little earlier than this
20100928.0240	0240	42.30267	-67.87748	Transect	end	41	NaN	NaN	NaN	NaN	nd
20100928.0241	0241	42.30243	-67.87767	Transect	start	42	NaN	NaN	NaN	NaN	nd
20100928.0627	0628	42.09248	-67.79692	ObserverMammals	start	42	NaN	NaN	NaN	rtyson	nd
20100928.0628	0628	42.09207	-67.79678	ObserverBirds	start	42	NaN	NaN	NaN	twhite	nd
20100928.0631	0631	42.08913	-67.79557	ObserverBirds	start	42	NaN	NaN	NaN	twhite	nd
20100928.0816	0816	41.98432	-67.75480	ObserverMammals	end	42	NaN	NaN	NaN	rtyson	nd
20100928.0817	0817	41.98393	-67.75463	ObserverBirds	end	42	NaN	NaN	NaN	twhite	nd
20100928.0818	0816	41.98232	-67.75355	Transect	end	42	NaN	NaN	NaN	NaN	nd
20100928.0819	0819	41.99295	-67.65968	Transect	start	43	NaN	NaN	NaN	NaN	local time needs updating; Reference TransectEnd 42 as start time
20100928.0855	0855	41.97778	-67.70788	ObserverBirds	start	43	NaN	NaN	NaN	twhite	nd
20100928.0948	0948	42.00853	-67.64632	Transect	end	43	NaN	NaN	NaN	NaN	nd
20100928.0949	0949	42.00945	-67.64650	ObserverBirds	end	NaN	NaN	NaN	NaN	twhite	nd
20100928.0950	0950	42.01013	-67.64665	Transect	start	44	NaN	NaN	NaN	NaN	nd
20100928.0951	0951	42.01132	-67.64687	Station	start	44	20	NaN	NaN	NaN	nd
20100928.1013	1012	42.03100	-67.64682	Hammarhead	end	44	NaN	5	NaN	aLavery	wire angle not good at station; therefore recovery
20100928.1022	1021	42.03955	-67.64890	Station	end	44	20	NaN	87	NaN	Aborted
20100928.1023	1023	42.04048	-67.64947	ObserverBirds	start	44	NaN	NaN	NaN	twhite	nd
20100928.1024	1023	42.04120	-67.64990	ObserverMammals	start	44	NaN	NaN	NaN	rtyson	nd
20100928.1114	1114	42.08738	-67.67528	ObserverMammals	end	44	NaN	NaN	NaN	rtyson	nd
20100928.1115	1114	42.08767	-67.67547	ObserverBirds	end	44	NaN	NaN	NaN	twhite	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100928.1117	1117	42.08993	-67.67610	Station	start	44	21	NaN	NaN	NaN	nd
20100928.1120	1120	42.09208	-67.67602	VPR	start	44	21	20	NaN	glawson	nd
20100928.1135	1135	42.10147	-67.68080	VPR	end	44	21	20	NaN	glawson	nd
20100928.1136	1136	42.10185	-67.68093	Station	end	44	21	NaN	NaN	NaN	nd
20100928.1242	1241	42.16245	-67.70695	Station	start	44	22	NaN	191	NaN	nd
20100928.1244	1244	42.16388	-67.70757	VPR	start	44	22	21	NaN	glawson	nd
20100928.1307	1307	42.17563	-67.71222	VPR	end	44	22	21	NaN	glawson	nd
20100928.1308	1307	42.17587	-67.71230	Station	end	44	22	NaN	NaN	NaN	nd
20100928.1333	1332	42.20227	-67.72255	ObserverBirds	start	44	NaN	NaN	NaN	twhite	nd
20100928.1347	1347	42.21713	-67.72750	ObserverMammals	start	44	NaN	NaN	NaN	rtyson	nd
20100928.1423	1423	42.25405	-67.74228	ObserverMammals	end	44	NaN	NaN	NaN	rtyson	nd
20100928.1426	1426	42.25717	-67.74377	ObserverBirds	end	44	NaN	NaN	NaN	twhite	nd
20100928.1429	1428	42.25632	-67.74485	Station	start	44	23	NaN	229	NaN	nd
20100928.1433	1432	42.25507	-67.74403	VPR	start	44	23	22	NaN	glawson	nd
20100928.1450	1450	42.24960	-67.74170	VPR	end	44	23	22	NaN	glawson	nd
20100928.1451	1451	42.24923	-67.74162	Station	end	44	23	NaN	NaN	NaN	nd
20100928.1506	1506	42.26163	-67.74403	ObserverBirds	start	44	NaN	NaN	NaN	twhite	nd
20100928.1616	1616	42.33363	-67.77233	ObserverMammals	start	44	NaN	NaN	NaN	rtyson	On Effort
20100928.1719	1718	42.39962	-67.79818	ObserverMammals	end	44	NaN	NaN	NaN	rtyson	nd
20100928.1720	1718	42.39962	-67.79818	ObserverBirds	end	44	NaN	NaN	NaN	twhite	nd
20100928.1930	1930	42.51060	-67.84200	Station	start	44	24	NaN	221	NaN	nd
20100928.1931	1931	42.51017	-67.84188	VPR	start	44	24	23	221	glawson	nd
20100928.1950	1949	42.50257	-67.84030	VPR	end	44	24	23	221	glawson	nd
20100928.1952	1951	42.50187	-67.84032	Station	end	44	24	NaN	NaN	NaN	nd
20100928.2016	2016	42.49603	-67.82533	Transect	end	44	NaN	NaN	NaN	NaN	nd
20100928.2017	2016	42.49612	-67.82478	Transect	start	45	NaN	NaN	226	NaN	nd
20100928.2119	2119	42.51433	-67.73932	Transect	end	45	NaN	NaN	238	NaN	nd
20100928.2120	2120	42.51440	-67.73837	Transect	start	46	NaN	NaN	238	NaN	nd
20100928.2132	2132	42.50830	-67.72835	Hammarhead	start	46	NaN	6	236	aLavery	nd

Event	Time Local	Latitude	Longitude	Instrument	Action	T	Station	Cast	Seafloor	PI_name	Comment
20100929.0536	0535	42.04213	-67.55215	Transect	end	46	NaN	NaN	55	NaN	nd
20100929.0537	0536	42.04277	-67.55298	Transect	start	47	NaN	NaN	55	NaN	55m depth
20100929.0559	0558	42.05923	-67.56630	Hammarhead	end	47	NaN	6	NaN	aLavery	nd
20100929.0629	0629	42.08990	-67.59450	ObserverBirds	start	47	NaN	NaN	NaN	twhite	start at 630
20100929.0634	0634	42.09527	-67.59907	ObserverMammals	start	47	NaN	NaN	NaN	rtyson	nd
20100929.0759	0758	42.16102	-67.70355	Transect	end	47	NaN	NaN	NaN	NaN	nd
20100929.0800	0759	42.16185	-67.70383	Transect	start	48	NaN	NaN	NaN	NaN	nd
20100929.0917	0917	42.25815	-67.74443	ObserverMammals	end	48	NaN	NaN	NaN	rtyson	nd
20100929.0918	0917	42.25805	-67.74460	ObserverBirds	end	48	NaN	NaN	NaN	twhite	nd
20100929.0919	0919	42.25775	-67.74467	Transect	end	48	NaN	NaN	NaN	NaN	transect end; start a MOCNESS tow
20100929.1025	0928	42.21465	-67.73238	MOCNESS	start	NaN	NaN	4	NaN	pwiebe	please update and use the local time
20100929.1203	1203	42.15820	-67.71490	GreeneBomber	end	NaN	NaN	4	198.54	glawson	nd
20100929.1920	1139	42.12570	-69.33947	MOCNESS	end	NaN	NaN	4	NaN	pwiebe	update loc from MOCNESS system; position was W 42 9.9912 N -67 42.919
20100930.1031	1030	41.49232	-71.41868	Cruise	end	NaN	NaN	NaN	8.55	NaN	nd