31 Dec 2013

CRUISE RESULTS

NOAA ship *HENRY B. BIGELOW*
Cruise No. HB13-03

Cetacean and Turtle Abundance Survey
(Atlantic Marine Assessment Program for Protected Species = AMAPPS)

CRUISE PERIOD AND AREA

The cruise period was divided into two legs: 1 – 23 July and 29 July – 19 August 2013.

The study area included waters south of Cape Cod (about 42° N latitude), north of North Carolina (about 36° N latitude), east of the southern tip of Nova Scotia (about 65° W longitude), and west of the US coast (about 74° 30' W longitude). This is waters shallower than about 4500 m which includes international waters and waters within the US and Canadian economic exclusive zones (EEZ).

This study area was divided into four spatial strata that represent different habitats (Figure 1):

- *Shelf Break*: a stratum ranging from Virginia to the southern tip of Nova Scotia (about 38˚N – 42˚N latitude) and in waters that are between the 100 m and 2000 m depth contours;

- *Offshore*: a stratum ranging from North Carolina to the southern tip of Nova Scotia (about 36˚N – 42˚N latitude) and in waters that are offshore of the 2000 m depth contour to beyond the U.S. EEZ and the Gulf Steam's northern wall;

- *BOEM-MA*: a stratum south of Massachusetts on the continental shelf in waters that are about 30 – 60 m deep (around 41˚N latitude); and

- *BOEM-MidAtl*: a couple small areas of water off the coasts of New Jersey, Delaware and Virginia that are on the continental shelf in waters that are about 20 – 30 m deep (between 38˚N – 40˚N latitude).

OBJECTIVES

The objectives of the survey were: 1) determine the distribution and abundance of cetaceans, sea turtles and sea birds within the study area; 2) collect vocalizations of cetaceans using passive acoustic arrays; 3) track groups of cetaceans and record multiple locations of surfacings of the group to assist in more accurately determining if the group was detected by both the visual and passive acoustic teams and to investigate availability bias in the visual line transect data; 4) determine the distribution and relative abundance of plankton and other trophic levels, 5) collect hydrographic and meteorological data, and 6) when possible, collect biopsy samples and photo-identification pictures of cetaceans.

METHODS

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

A line transect survey was conducted during daylight hours (approximately 0600-1800 with a 1 hour break at lunchtime) using the two independent team procedure. Surveying was conducted during good weather conditions (Beaufort five and below) while traveling at about 10 knots, as measured over the ground.

Scientific personnel formed two visual marine mammal-sea turtle sighting teams. The teams were on the flying bridge (15.1 m above the sea surface) and anti-roll tank (11.8 m above the sea surface). To detect animal groups, both teams were composed of two on-effort observers who searched using 25x150 powered binoculars, one on-effort observer who searched using naked eye and recorded the sightings data detected by all team members, and one off-effort observer who could rest. Every 30 minutes observers on each team rotated positions within the team. Observers did not rotate between teams. The composition of the teams changed every leg.

Position, date, time, ship's speed and course, water depth, surface temperature, salinity, and conductivity, along with other variables (Table 1) were obtained from the ship's Science Computer System (SCS). These data were routinely collected and recorded every second at least while during visual survey operations. Sightings and visual team effort data were entered by the scientists onto hand held data entry computerized systems called VisSurv-NE (version 3) which was initially developed by L. Garrison and customized by D. Palka.

At times when it was not possible to positively identify a species or when training the observers on species identifications, survey effort was discontinued (termed went off-effort) and the ship headed in a manner to intercept the animals in question. When the species identification and group size information were obtained, the ship proceeded back to the point on the track line where effort ended (or close to this point).

Both teams searched waters from 90˚ starboard to 90˚ port, where 0˚ is the track line that the ship was traveling on. For either team, when an animal group (porpoise, dolphin, whale, seal, turtle or a few large fish species) was detected the following data were recorded with VisSurv-NE:

1) Time sighting was initially detected, recorded to the nearest second,
2) Species composition of the group,
3) Radial distance between the team's platform and the location of the sighting, estimated either visually when not using the binoculars or by reticles when using binoculars,
4) Bearing between the line of sight to the group and the ship's track line; measured by a polarus mounted near the observer or a polarus at the base of the binoculars,
5) Best estimate of group size,
6) Direction of swim,
7) Number of calves,
8) Initial sighting cue,
9) Initial behavior of the group, and
10) Any comments on unusual markings or behavior.

At the same time, the location (latitude and longitude) of the ship when this information was entered was recorded by the ship's GPS via the SCS system which was connected to the data entry computers.

The following effort data were recorded every time one of the factors changed (at least every 30 minutes when the observers rotate):

1) Time of recording,
2) Position of each observer, and
3) Weather conditions: swell direction relative to the ship's travel direction and height (in meters), apparent Beaufort sea state in front of the ship, presence of light or thick haze, rain or fog, amount of cloud coverage, visibility (i.e., approximate maximum distance that can be seen), and glare location and strength of glare within the glare swath (none, slight, moderate, severe).

VISUAL SEABIRD SIGHTING TEAM

From an observation station on the flying bridge, about 15.1 m above the sea surface, one (sometimes two) observers conducted a visual daylight survey for marine birds, approximately 0600 – 1800 hours with a one hour break at lunchtime. Seabird observation effort employed a modified 300 m strip and line-transect methodology. Data on seabird distribution and abundance were collected by identifying and enumerating all birds seen within a 300 m arc on one side of the bow while the ship was underway. Seabird observers maintained a visual unaided eye watch of the 300 m survey strip, with frequent scans of the perimeter using hand-held binoculars for cryptic and/or hard to detect species. Binoculars were used for distant scanning and to confirm identification. Ship-following species were counted once and subsequently carefully monitored to prevent re-counts. All birds, including non-marine species, such as herons, doves, and Passerines, were recorded.

Operational limits are higher for seabird surveys compared to marine mammal and sea turtle surveys. As a result, seabird survey effort was possible in sea states up to and including Beaufort 7. Standardized seabird data collection effort continued during “repositioning transits” — transits between waypoints that could span a few hours to all day — even though there was no corresponding visual marine mammal survey effort. The seabird observer rotation generally adhered to a two hours on, two hours off format.

All data were entered in real time into a Panasonic Toughbook laptop running *SeeBird (vers 4.3.6),* a data collection program developed at the Southwest Fisheries Science Center. The ease of use for entry-level users was a valuable asset in maintaining data consistency when facing frequent observer turnover. The software was linked to the ship’s navigation system via a serial/RJ-45 cable. *SeeBird* incorporates a time synchronization feature to ensure the computer clock matches the GPS clock to assist with post-processing of the seabird data with the ship’s SCS data. Data on species identification, number of birds within a group, distance between the observer and the group, angle between the track line and the line of sight to the group, behavior, flight direction, flight height, age, sex and, if possible, molt condition, were collected for each sighting. The sighting record received a corresponding time and GPS fix once the observer accepted the record and the software wrote it to disk. *SeeBird* also added a time and location fix every 5 minutes. All data underwent a quality assurance and data integrity check each evening and saved to disk and to an external backup dataset.

PASSIVE ACOUSTIC DETECTION TEAM

The passive acoustic team consisted of three people who operated the system in two-hour shifts, from 0545 – 1800 or later. The hydrophone array was deployed at 0545 each morning, and was typically retrieved from 1130 – 1230 for the midday bongo/CTD casts. Daytime data collection ended at 1800, at the end of the visual survey day. The acoustic team collected data during all hours when the visual team was on-effort, except along inshore tracklines, where shallow bottom depths (50 m and less) prohibited safe deployment of the array.

The acoustic team also collected data on some occasions when weather conditions prevented the visual team from operating, as well as during several long transits between tracklines. In addition night recordings were collected opportunistically, as determined by oceanographic sampling priorities. When possible, the array was re-deployed at or near dusk prior to oceanographic transects that were on targeted canyons and along the shelf break. Night deployments generally lasted 2 – 3 hrs, with some exceptions.

The hydrophone array used in this survey was constructed in 2012/2013, and was comprised of two modular, oil-filled sections, separated by 30 m of cable. The end-array consisted of 3 “mid-frequency” elements (APC International, 42-1021), 2 “high-frequency” elements (Reson, TC 4013), and a depth sensor (Keller America, PA7FLE). The in-line array consisted of 3 “mid-frequency” elements (APC International, 42-1021). The array was towed 300 m behind the ship. Array depth typically varied between 8 – 12 m when deployed at the typical survey speed of 10 kts. Sound speed data at the tow depth of the array were extracted from morning and midday CTD casts.

Acoustic data were routed to a custom-built Acoustic Recording System that encompassed all signal conditioning, including A/D conversion, filtering, and gain. Data were filtered at 1000 Hz, and variable gain between 20 – 40 dB was added depending on the relative levels of signal and noise. The recording system incorporated two National Instruments soundcards (NI USB-6356). One soundcard sampled the six mid-frequency channels at 192 kHz, the other sampled the two high-frequency channels at 500 kHz, both at a resolution of 16 bits. Digitized acoustic data were recorded directly onto laptop and desktop computer hard drives using the software program Pamguard (http://www.pamguard.org/home.shtml), which also recorded simultaneous GPS data, continuous depth data, and allowed manual entry of corresponding notes. Two channels of analog data were also routed to an external RME Fireface 400 soundcard and a separate desktop computer, specifically for the purpose of real-time detection and tracking of vocal animals using the software packages WhalTrak and Ishmael. Whenever possible, vocally-active groups that were acoustically tracked were matched with visual detections in real-time, for assignment of unambiguous species classification. Communication was established between the acoustic team and the visual team situated on the flying bridge to facilitate this process.

Passive acoustic recordings were also opportunistically collected using the ship's centerboard-mounted hydrophone, in situations when animals of interest were particularly close to the ship.

In addition to collecting towed array data, the passive acoustic team also directed the ship in the recovery of five bottom-mounted marine autonomous recording units (MARUs) that had been previously deployed along survey tracklines. Recovery of recorders was planned when the ship was surveying in the area of the deployment site. Details for recovery methodology can be found in the HB 13-03 cruise announcement.

The passive acoustic team also rotated through visual observations at the "tracker" station; see description in the next section below.

TRACKER TEAM

On the flying bridge, behind the visual marine mammal and sea birds teams, was the "tracker" team, an additional team of two on-effort and one off-effort observers that search for marine mammals using a pair of 25x150 powered binoculars. One of the on-effort observers searched with the binoculars and the other was the recorder. The objectives for this team was to track some of the marine mammal sightings 1) to record additional locations of groups seen by the visual marine mammal team to assist determining which groups of animals were seen by the visual team and heard by the acoustic team; and 2) to record the amount of time small groups of animals were at the surface, which can be used to improve the abundance estimates by accounting for availability bias. The tracker team used the same procedures and data entry program as the visual marine mammal teams.

HYDROGRAPHIC AND PLANKTON CHARACTERISTICS

Daytime Sampling

In addition to the ship's SCS logger system that continuously recorded oceanographic data from the ship's sensors, a SEACAT 19+ Conductivity, Temperature, and Depth Profiler (CTD) was used to measure water column conductivity, temperature and depth. The CTD was mounted on a 322 conducting core cable allowing the operator to see a real time display of the instrument depth and water column temperature, salinity, density and sound speed on a computer monitor in the ship's Dry Lab. Once a day, a vertical profile was conducted with the CTD, where a Niskin bottle was attached to the wire above the CTD. The Niskin bottle was used to collect a water sample which will be used to calibrate the conductivity sensor of the CTD. The calculated sound speeds from the vertical profiles were used for the daily calibration of the acoustic sensors. Additional vertical profiles to delimitate sound speed were conducted as needed for further acoustic calibrations.

A 61 cm bongo plankton net equipped with two 333 µm nets and a CTD mounted on the wire 1 m above the nets was deployed approximately three times a day: once before the day's surveying started (about 0500 – 0530), at lunch time (about 1200 when the ship stopped surveying), and again after surveying was completed for the day (approximately 1800, depending on weather and the time of sunset). The bongo was towed in a double oblique profile using standard ECOMON protocols. The ship's speed through the water was approximately 1.5 kts. Wire-out speed was 50 m/min and wire-in speed was 20 m/min. Tows were to within 5 m of the bottom or to 200 m depth, if the bottom depth exceeded 205 m. Upon retrieval, samples were rinsed from the nets using seawater and preserved in 5% formaldehyde and seawater. Samples were transported to the Narragansett, RI National Marine Fisheries Science (NMFS) lab for future identification.

Nighttime Sampling

During night when the marine mammal/turtle and seabird visual sighting teams were off-effort, physical and biological sampling of the water column was conducted employing a combination of underway and station-based sampling. The goal was to sample on successive nights four site types: shelfbreak canyons, shelfbreak regions away from canyons, slope waters, and shelf regions, with the top priority being canyons. The amount of time available each night for sampling, the target site, and the gear to be deployed was determined by the vessel's position at the end of each day's visual surveying, the desired start location on the following day, the distance to the targeted sampling area, and the bottom depth.

Sampling equipment included:

- EK60 multi-frequency echosounder for plankton, micronekton, and fish distribution
- ADCP (Acoustic Doppler Current Profiler) for currents, synchronized to the EK60 to minimize interference
- CTDs for hydrography (max depth 3000 m)
- 1 m MOCNESS (Multiple Opening Closing Net Environmental Sensing System) with color VPR (Video Plankton Recorder) and strobes attached to collect zooplankton and ground-truth EK60 acoustic data (max depth 1000 m)
- IKMT (Isaacs Kidd Midwater Trawl) to collect zooplankton and micronekton and ground-truth EK60 data (max depth 600 m)
- V-fin black and white VPR to collect images of zooplankton and ground-truth EK60 acoustic data (max depth 600 m)

Canyons (aka Z-type surveys)

Repeat passes of cross-canyon transects were conducted of transects positioned half-way up the canyon and near the canyon head. Which instruments were deployed and the order of operations varied between nights depending on prevailing conditions. Typically though, both transects were run for ADCP and EK60 data collection in a Z- or C-shape. A series of 5 CTD casts (Seabird 19+) were made along the mid-canyon line to near-bottom (targeting one cast on the rim on each side, one about half way down each side to the max depth axis, and one in the axis). Pending available remaining time, MOCNESS, IKMT, and/or VPR tows were conducted targeting acoustic features of high scattering and interesting frequency response (e.g., characteristic of krill, small zooplankton, and mesopelagic fishes) in order to ground-truth the acoustic data.

Shelfbreak (Non-canyon)

Two passes were conducted along a transect running across the shelfbreak from about the 500 – 1000 m to 90 – 100 m isobaths. ADCP, EK60, and towed hydrophone data were conducted continuously during one pass and regularly spaced CTD casts made along the other pass. The target was roughly 3 nmi distances between CTD stations. Pending available time, net sampling with the MOCNESS or IKMT, or VPR tows, were conducted targeting acoustic features of interest.

Slope

Starting at the end-point of that day's visual survey, two passes were conducted on a transect running along-isobath. If warm-core rings were present, then the plan was to cross the ring edge. ADCP, EK60, and towed hydrophone data were conducted continuously during the outgoing pass and then regularly spaced CTD casts made along the return pass. If there was available time, then net sampling with the IKMT and VPR tows were conducted targeting acoustic features of interest.

Shelf

The HB13-03 planned cruise track included sampling transects in shelf regions off MD/VA/NC (BOEM-MidAtl stratum) and along Nantucket Shoals (BOEM-MA stratum). Due to shallow bottom depths deploying the larger net samplers was not possible so transects were conducted with the v-fin VPR. VPR transects were conducted at single depths targeting specific layers seem on the EK60 to determine plankton patchiness or in a tow-yo fashion to classify the water column structure. In the transects south of Hudson Canyon in the mid Atlantic bight ECOMON bongo/CTD stations were picked up as these southern areas could not be covered during the fall ECOMON cruise.

Active Acoustic Sampling

Active acoustic data were collected during the survey to characterize spatial distributions of potential prey and investigate relationships among predator (marine mammals), prey, and oceanography. Active acoustic data were collected with the HB Bigelow's multifrequency (18, 38, 70, 120, and 200 kHz) scientific EK60 echo sounders and split-beam transducers mounted downward-looking on the retractable keel. Data were collected to 3000 m, regardless of bottom depth. The ping interval was set to 2 pings per second, but actual ping rate will be slower due to two-way travel time and signal processing requirements of the EK60. The EK60 was synchronized to the ES60 on the bridge, the Acoustic Doppler Current Profiler (ADCP), and Simrad ME70 multibeam to alleviate acoustic interference among acoustic instruments. At daily intervals throughout the survey EK60 data were recorded in passive mode to assist with noise removal post-processing procedures. Survey speeds for underway acoustic data collection were 10 kts or less.

Active acoustic data were collected continuously but with the EK60 in passive mode on every other day during daytime operations. Active acoustic data were only collected every other day during daylight so that impacts of active acoustics on marine mammal sightings by observers can be investigated. Acoustic data in active mode were collected continuously during nighttime operations.

RESULTS

Scientists involved in this survey are detailed in Table 2.

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

The visual marine mammal and turtle team surveyed about 5021 km while on effort during 38 of the 42 possible sea-days; the weather conditions were too poor to survey on the other 4 sea-days. Some track lines initially surveyed while on effort in poor sighting conditions were re-surveyed at a later time in better conditions. Thus resulting in 4333 km of track lines surveyed in the best possible sighting conditions which will be used in the abundance estimation analyses (Figure 1; Table 3). About 70% of the survey track lines were conducted in good weather conditions, Beaufort sea state 3 or less (Table 3).

During the on-effort better condition track lines, 28 cetacean species or species groups, 3 turtle species or species groups, 3 seal species or species groups, and 5 fish species or species groups were recorded (Tables 4 and 5). For cetaceans, the upper team detected 787 groups (9,907 individuals) and the lower team detected 633 groups (5,855 individuals). For turtles, the upper team detected 38 groups (39 individuals) and the lower team detected 26 groups (27 individuals). Note some, but not all, groups of cetaceans and turtles detected by one team were also detected by the other team. Seven seal was detected. In addition, 5 (12) basking sharks and 31 (12) ocean sunfish was detected by the upper (and lower) teams.

Distribution maps of sighting locations of the cetaceans, turtles, seals and fish are displayed in Figures 2 – 11. Note these are locations of sightings seen by only the upper team. The most abundance species (Figure 4) were striped dolphins (*Stenella coeruleoalba)* and common dolphins (*Delphinus delphis*), where the striped dolphins were found in deeper waters (mostly 1000 m or deeper) than the common dolphins (mostly 1000 m or shallower). Of interest, over 140 Cuvier's beaked whales (*Ziphius cavirostris*) were positively identified, where most of them were west of 68° W in waters that were 2000 – 3000 m deep (Figure 6). In contrast, the positively identified Sowerby's beaked whales (*Mesoplodon bidens*) were in shallower waters 1000 – 2000 m deep. In contrast to previous summer surveys in the same waters, there were many humpback whales (*Megaptera novaeangliae*) just south of Massachusetts in the BOEM-MA stratum (Figure

8). Also in contrast to previous summer surveys, 4 right whales (*Eubalaena glacialis*), 3 blue whales (*Balaenoptera musculus*), and 4 minke whales (*Balaenoptera acutorostrata*) were detected (Figure 9).

Biopsy samples were collected from six animals, 4 bottlenose dolphins in 2 groups (2 individuals per group), 1 Atlantic spotted dolphin and 1 striped dolphin (Figure 12).

VISUAL SEABIRD SIGHTING TEAM

Seabird survey effort was conducted on all 42 sea-days. The NOAA ship *Henry B. Bigelow's* flying bridge provided a stable platform and afforded good visibility for the seabird team. Seabird survey data were collected on every sea-day; however, data collection effort was truncated on three days on Leg 1 due to rain and/or fog (Figure 13). Nomenclature of species identifications followed that reported in The Clements Checklist of Birds of the World. 6th edition, Cornell University Press 2007, with electronic updates to 2011.

A summary of all 5353 birds seen while on effort broken down by species is presented in Table 6 most of the species are mapped in Figures 14 – 24. This survey recorded 44 species of birds and nine unidentified species groups (e.g., unidentified shearwater or unidentified storm-petrel). Five species comprised 90% of the total birds seen. In declining order of abundance these were: Wilson's Storm-Petrel *(Oceanites oceanicus)*, Cory's Shearwater *(Calonectris diomedea),* Leach's Storm-Petrel *(Oceanodroma leucorhoa)*, Great Shearwater *(Puffinus gravis)*, and Audubon's Shearwater *(Puffinus lherminieri)*. These widespread species were occasionally found in small scale clusters, particularly storm-petrels, which would often concentrate in upwelling areas seaward of the shelf break. Meanwhile others, such as Bridled Tern *(Onychoprion anaethetus),* and Black-capped Petrel *(Pterodroma hasitata),* are tropical and sub-tropical species closely linked to their preferred habitat; in this case, warm Gulf Stream water. Extensive warm surface waters may have had an influence on the abundance and distribution of Audubon's Shearwater. This species was unusually abundant and widespread with several being seen as far north as Nova Scotia. Similarly, the large number of White-faced Storm-Petrels *(Pelagodroma marina)* seen this year, another warm water species, may be due to the same factors. Notably, one White-faced Storm-Petrel was seen off Nova Scotia which is extremely unusual.

This year's survey provided valuable additional distributional data on Barolo Shearwater *(Puffinus baroli)*. Its status in North American waters, inferred from only a handful of sightings in the last 100 years, is poorly known. It is very rare anywhere in the northwest Atlantic. The normal breeding range includes islands off northwest Africa (Canary Islands, Azores, Desertas and Salvage), but the species at-sea distribution is less clear. The seven we saw on this survey, combined with several sightings detected in the last few years from other sources, strongly support the current hypothesis that Barolo Shearwater is in fact a regular but rare late-summer to early-fall visitor to deep waters far off New England and Nova Scotia.

All other seabirds were regularly occurring northwest Atlantic Ocean species. The most obvious exception was an adult Red-billed Tropicbird *(Phaethon aethereus).* This species is exceedingly rare this far north in the Atlantic Ocean—yet another tropical species likely responding to the widespread warm surface water present this year. The sighting of an immature Yellow-headed Blackbird *(Xanthocephalus xanthocephalus)* was exceptional because the eastern edge of its range is in the US Great Plains (Illinois and Indiana), not the Atlantic Ocean. It is interesting to note that this bird was seen not far from where we saw one during the 2011 AMAPPS cruise.

PASSIVE ACOUSTIC DETECTION TEAM

Over the course of the survey, acoustic monitoring effort was conducted on 35 of 42 sea-days, with a total of 273.2 hr of daytime recording on survey tracklines. In addition, evening/nighttime recordings were made opportunistically on 14 occasions, for a total of 49.9 hr (Figure 25, Table 7), primarily in canyons and across the shelf break. Evening recordings were not monitored in real-time for acoustic events, but will be included in post-processing analyses. The hydrophone array was not deployed on days during which shallow, coastal lines were surveyed, nor during transits to and from port.

Real-time monitoring resulted in the detection of 263 groups of vocally-active odontocetes (Figure 25). Of these, approximately 22% corresponded to simultaneous visual detection of groups, allowing for species assignment (Table 8). Seven species of delphinids were represented in the data, along with sperm whales and beaked whales. In some cases, large schools of dolphins that covered a broad spatial range were difficult to localize accurately in real-time, making a direct comparison with visual sighting locations impossible. Additionally, in many cases it was impossible in real time to acoustically differentiate between subgroups of animals that were visually distinguished and counted as separate sightings, resulting in an underestimate of acoustic detections as compared to visual detections. Both of these issues will be addressed in post-processing analyses.

Sperm whales were detected on at least 25 survey days (15 days in Leg 1 and 10 in Leg 2), for a total of 65 vocally-active groups (Figure 26, Table 8). In most cases, these acoustic events represent multiple individuals. Total number of individual sperm whales will be calculated through localization and tracking in post-processing analyses.

During the survey, on several occasions the vessel passed through areas with high levels of beaked whale density. Designated effort allowed for the recording of echolocation click trains from several groups of animals, likely representing at least three species. Further detail will be available upon pending analyses.

Four of five marine autonomous recording units (MARUs) were successfully recovered during the survey (Figure 27). The unrecovered unit (number 4 in Figure 27) did not respond to attempts to communicate with it acoustically, nor did it surface at its pre-programmed date and time. This unit is considered lost. Data from the other units will be extracted and included in post-processing analyses.

On 9 August 2013, one of the modular sections of the towed passive acoustic hydrophone array was lost, presumably due to failure of the attachment mechanism. Subsequent acoustic recordings were collected only with the “in-line” section of the array. Reconstruction of the array section, with modifications to prevent similar failure from re-occurring, is expected to take place in fall 2013.

Post-processing of passive acoustic data will be conducted to extract all acoustic events, localize individual groups and compare visual and acoustic detection rates, and evaluate performance of species-specific classifiers.

TRACKER TEAM

The tracker team (surveying with one set of 25x150 powered big eye binoculars) was on effort during the same times that the upper and lower marine mammal and turtle teams were on effort. Since they were located behind the upper team they did not have as good a viewing area as the upper team. Despite this disadvantage, they were still able to detect 114 groups of cetaceans, 497 individuals (Tables 4 – 5), where the goal was to record mostly only small sized groups (less than 5 individuals per group).

During both legs, the tracker team was able to record multiple surfacings of 35 groups of animals. Of which about half of these groups had 10 or more surfacings recorded. This information will be useful in determining which groups of animals were seen by the visual team and heard by the passive acoustic hydrophone. In addition the surfacing patterns may be able to define the availability bias of the visual teams.

HYDROGRAPHIC/BONGO/PLANKTON SAMPLES

During both legs, in the day and night over 250 sampling stations were conducted. This included 116 casts of the CTD, 89 bongo deployments, 30 video plankton recorder, VPR, deployments, 12 Isaac Kid mid-water trawl, IKMT, deployments, and 9 MOCNESS deployments (Table 9; Figure 28). At night after the visual teams were off-effort, oceanographic sampling was successfully conducted at 9 canyon sites, 4 shelfbreak non-canyon sites, 5 slope water sites, and 2 shelf sites (Table 10; Figures 29-33). More details from these sampling stations and gear types are below.

Acoustic Sampling

Large and dense acoustic scattering layers, consistent with small-bodied organisms, were frequently observed in canyons (Figure 34) and across the shelfbreak (Figure 35a). Net tows in these layers with the MOCNESS and IKMT typically sampled large numbers of euphausiids (Figure 36), copepods, hyperiid amphipods (Figure 36), mesopelagic fish, especially pearlsides (Figure 37a) and myctophids (Figure 37b), and/or salps. Of particular interest are pervasive scattering layers often observed where scattering was highest at the lower frequencies (18 and 38 kHz; Figure WWa,b). This kind of pattern is typical of scatterers bearing a small gas inclusion, such as myctophids with small or partially-filled swimbladders.

Future analysis will involve post-processing of the raw data to remove unwanted signal (e.g., from the seafloor) and noise (e.g., Figure 35a). Differences in scattering levels at the different frequencies (e.g., Figure 35b) will be used to identify features attributable to different kinds of scatters and the net and VPR data will be used to ground-truth the taxonomic composition of these features. The distribution of different kinds of scatters will then be examined in light of bathymetry, hydrography, and the distribution of marine mammal predators.

MOCNESS Sampling

Where possible, a $1m^2$ MOCNESS was deployed in conjunction with the acoustic surveys to provide depth-integrated samples of plankton and larger organisms such as mesopelagic fish and euphausiids. A total of 9 $1m^2$ MOCNESS hauls were conducted (Table 9; Figure 28). The MOCNESS was towed at 1-1.5 knots speed and was equipped with 9, 333µm mesh nets, conductivity and temperature sensors, a color VPR, and two banks of strobes. The $1m^2$ MOCNESS is designed to sample plankton under 1.5cm in size and the strobes were included to increase capture efficiency of larger plankton by disorienting euphausiids and mesopelagic fishes. Sampling locations, depth, and net open/close depths were determined by observations made during the acoustic transects, ocean conditions, and weather.

While use of the MOCNESS was often limited by the large quantities of salps in the sampling areas, the gear was successful in depicting the invertebrate composition of layers seen on the EK60. Though the MOCNESS may not have been as successful capturing mesopelagic fish, those that were captured were in very good condition (Figure 37).

Late in Leg 1 a calibration of the MOCNESS flow meter was conducted, resulting in a conversion factor of 5.5 rotations/m rather than the default used in the MOCNESS software of 4.7. Data from hauls done previous to this calibration were rerun to correct volume filtered estimates.

The self contained color VPR (Davpr 07) was used on its largest camera setting representing a water volume of 395ml per frame. The VPR imaged gelatinous zooplankton and phytoplankton destroyed by the nets as well as the euphausiids and salps captured by the nets. The VPR did not work on two hauls due to battery issues.

IKMT Sampling

The IKMT was also deployed, when possible, with the site surveys to target depth-specific layers that were observed at the lower frequencies of the EK60 and consistent with mesopelagic fish and euphausiids. A total of 11 hauls were conducted (Table 9; Figure 28) The IKMT had a 1mm mesh cod end and was mounted below a CTD. To maximize the sampling depth, the IKMT was lowered to below its target depth with the ship maintaining minimal speed without sacrificing steerage. The ship then increased its speed to 2 – 3 kts (speed over the ground, SOG). As the IKMT rose through the water with the increased SOG, the IKMT trawl depth was maintained by adjusting the amount of wire out. Oftentimes, the wire angle became too steep, causing the wire to rub on the aft block. As a result, tow speed was limited. The IKMT deployments were also limited by the large numbers of salps present, as well as wind and currents. A deployment targeting a layer thought to be mesopelagic fish yielded over 15 gallons of salps and a limited numbers of fish.

V-fin VPR Sampling

When bottom depths were shallow, large volumes of plankton, especially salps, were present, or we were not near any of the survey areas the self contained black and white V-fin VPR (Davpr 05) was deployed. A total of 30 hauls were conducted (Table 9; Figure 28). The V-fin was towed at speeds of 2 – 4 kts for 1 – 1.5 hrs and was equipped with a Seabird SBE49 Fastcat CTD and a Wet Labs combination fluorometer and turbidity sensor. The camera imaging area was set based on location, previous VPR hauls, or the types of plankton collected with the bongo nets. Two types of tows were conducted. The first type was a single depth tows targeted distinct layers on the EK60 to provide temporally fine scale plankton data to assist in the ground truthing of the EK60 data and to examine plankton patchiness. The second type was a tow-yo haul which was used to describe water column structure and plankton depth distributions. Tow-yo hauls were conducted if there were no distinct layers on the EK60 or the oceanography looked interesting. Tow-yo hauls were also used to quantify plankton, especially salps, before deciding whether to deploy the larger nets samplers.

Habitat Descriptions

The mid Atlantic bight shelf break and slope areas (BOEM-MidAtl stratum) were distinguished by very warm, salty water (Figure 38) and were dominated by gelatinous zooplankton (Figure 39). *Salpa aspera* (Figure 40) was present in large numbers from mid shelf break out into slope waters. *S. aspera* ranged from 2 – 5 cm in size and was an active dial migrator residing below 1000 m during the day and rising at dusk to 50 – 500 m. Moderate numbers of siphonophores, hydromedusa and dolids were also noted. Deeper layers contained the euphausiids: *Euphausia sp* and *Thysanoessa longicaudata*. These were both smaller euphausiid species and were also diel migrators.

The southern New England shelf break and slope areas had more complex oceanography characterized by strong thermoclines, variable salinities, and chlorophyll layers associated with the bottom of the thermocline (Figure 41). The plankton was more diverse but the biomass continued to be dominated by *S.aspera*. *Thalia democratica* was present in moderate numbers on the outer shelf and the shallow areas of the shelf break. *T.democratica* ranged in size from 5 – 15 mm in size and was not a dial migrator. The zooplankton contained large numbers of crustaceans including the copepod *Calanus finmarchicus*, the Euphausiids, *Euphasia sp* and *T. longicaudata*; and the hyperid amphipod *Thermisto gaudichaudii*. A significant number of phoronids were also present.

The Georges Bank shelf break and slope areas had highly variable oceanography with generally strong thermoclines of varying depths. Oceanography was affected by proximity to canyons or channels (Figure 42). Plankton varied with depth and locations. Slope stations continued to have high numbers of *S. aspera* with increased numbers of the copepod *C. finmarchicus* and the euphasiids *Euphasia sp* and *T. longicaudata.* In areas with colder temperatures the larger euphausiid *Meganyctiphanes norvegica* was present. The salp *T.democratica* was present in moderate numbers along the southern flank of Georges Bank.

The Nantucket shoals area (BOEM-MA stratum) was characterized by highly variable bottom depth, strong currents, moderate thermoclines, variable salinities (Figure 43), and very diverse, locally patchy plankton. The western side had high numbers of larval fish and the VPR images captured a gastropoda spawning event. The eastern side was dominated by the epibenthic amphipod, *Gammarus annulatus*, ctenophores and siphonophores (Figure 44).

Special Sampling

There were three researchers that requested special samples to be collected during this cruise. The research these samples will be used for are described below.

1) Martha Hauff, Postdoctoral Investigator, University of Connecticut, Avery Point, CT

Seventy-five (75) individual *Salpa aspera* were placed in foil packs and frozen in the -80º C freezer for the Bucklin Laboratory at University of Connecticut, Avery Point. These samples will contribute to M. Hauff's postdoctoral research investigating the role of gelatinous prey items in the diets of mesopelagic fishes. Individuals collected on this cruise will provide tissue needed for the development of DNA extraction techniques that are compatible with salps, and will also allow for the design of salp-specific primers to be used in molecular fish gut content analysis. Moreover, the organisms collected may contribute to the Bucklin lab's ongoing efforts to characterize the zooplankton assemblages of the North Atlantic Ocean, and investigate patterns of genetic connectivity therein.

2) William Orsi, Assistant Research Scientist, University of Maryland Center for Environmental Science, Cambridge, MD

Seventeen (17) tinfoil packs of 4 – 7 *Salpa aspera* were frozen in the -80º C freezer. Fecal pellets from frozen Salp specimens will be subjected to bulk DNA and RNA extractions for analysis of the microbial composition of Salp fecal material. This work will use conventional molecular biological approaches including PCR, RT-PCR, metagenomics, and metatranscriptomics. DNA and cDNA sequencing will be performed using Illumina technology and the resulting data will be analyzed and visualized using standard bioinformatic tools. The work will seek to address the following two research questions: 1) What are the dominant microbial species grazed upon by Salps? 2) What are the active microbial metabolisms occurring inside of Salp fecal pellets (e.g., do some microbes get a 'free lunch' by passing through Salps)? This work is relevant to biogeochemical studies of zooplankton mediated carbon flux and seeks to address important, yet understudied, interactions between Salps and populations of marine microbes.

3) Grace Saba, Rutgers Institute of Marine and Coastal Sciences, New Brunswick, NJ

Twenty-four (24) *Meganyctiphanes norvegica* were kept alive in 5 gallon buckets utilizing ice packs and airstones. These were shipped to Rutgers where 75% arrived alive. The krill will be used to test out a new Loligo Systems respirometry system in preparation for the upcoming field season in Antarctica funded by NSF Office of Polar Programs (#1246293; Collaborative research: Synergistic effects of elevated CO_2 and temperature on the physiology, growth, and reproduction of Antarctic krill *Euphausia superba*; co-PI Brad Seibel at URI). The collection of the Atlantic krill also allows the comparison of respiration rates of the smaller Atlantic krill to those of the much larger Antarctic krill.

Active Acoustic Data Collection

Active acoustic data were collected on a portable hard drive, which was sent to the NEFSC and the data were archived at the NEFSC at the completion of each leg. The start and end times of the EK60 data collection are specified in Table 11.

Problems were encountered with ADCP data collection. Attempts were made between the cruise legs to address these issues, from which it was determined that the ping rate was very slow, even slower than expected given that the system was slaved to the EK60. Further analysis after the cruise will be necessary to determine whether the slow ping rate led to the poor data quality.

DISPOSITION OF THE DATA

All visual and passive acoustic data collected will be maintained by the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. Visual sightings data will be archived in the NEFSC's Oracle database and later will be submitted to SEAMAP OBIS.

All hydrographic data collected will be maintained by the Fishery Oceanography Branch at the NEFSC in Woods Hole, MA. Hydrographic data can be accessed through the Oceanography web site http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html or the NEFSC's Oracle database.

All plankton samples collected will be maintained by the Fishery Oceanography Branch at the NEFSC in Narragansett RI. Plankton samples will be sent to Poland for identification. Plankton data can be accessed through the NEFSC's Oracle database after about March 2014.

All VPR data will be processed and maintained Fishery Oceanography Branch at the NEFSC in Woods Hole, MA. VPR oceanographic data and images are currently available by request only.

Table 1. SCS data collected continuously every second during the survey and stored in a user created file.

Date (MM/DD/YYYY)	
Time (hh:mm:ss)	TSG-Conductivity (s/m)
EK60-38kHz-Depth (m)	TSG-External-Temp (ºC)
EK60-18kHz-Depth (m)	TSG-InternalTemp (ºC)
ADCP-Depth (m)	TSG-Salinity (PSU)
ME70-Depth (m)	TSG-Sound-Velocity (m/s)
ES60-50kHz-Depth (m)	MX420-Time (GMT)
Doppler-Depth (m)	MX420-COG (º)
Air-Temp (ºC)	MX420-SOG (Kts)
Barometer-2 (mbar)	MX420-Lat (DDMM.MM)
YOUNG-TWIND-Direction (º)	MX420-Lon (DDMM.MM)
YOUNG-TWIND-Speed (Kts)	Doppler-F/A-BottomSpeed (Kts)
Rel-Humidity (%)	Doppler-F/A-WaterSpeed (Kts)
Rad-Case-Temp (ºC)	Doppler-P/S-BottomSpeed (Kts)
Rad-Dome-Temp (ºC)	Doppler-P/S-WaterSpeed (Kts)
Rad-Long-Wave-Flux (W/m^2)	High-Sea Temp (ºC)
Rad-Short-Wave-Flux (W/m^2)	POSMV – Time (hhmmss)
ADCP-F/A – GroundSpeed (Kts)	POSMV – Elevation (m)
ADCP-F/A – WaterSpeed (Kts)	POSMV – Heading (º)
ADCP-P/S – GroundSpeed (Kts)	POSMV – COG (Kts)
ADCP-P/S – WaterSpeed (Kts)	POSMV – SOG (Kts)
Gyro (º)	POSMV – Latitude (DDMM.MM)
POSMV – Quality (1=std)	POSMV – Longitude (DDMM.MM)
POSMV – Sats (none)	POSMV – hdops (none)

Table 2. Scientific personnel involved in the two legs of this survey. FN = Foreign National.

Personnel	Title	Organization
Leg 1 (1 – 23 Jul)		
Gordon Waring	Chief Scientist	NMFS, NEFSC, Woods Hole, MA
Elizabeth Broughton	Oceanographer	NMFS, NEFSC, Woods Hole, MA
Danielle Cholewiak	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Michael Force (FN)	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Rachel Hardee	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Joshua Hatch	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Samara Haver	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Richard Holt	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Betty Lentell	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Nicholas Metheny	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Todd Pusser	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Kelly Slivka	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Robert Valtierra	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Suzanne Yin	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Desray Reeb	Volunteer	Bureau of Ocean Energy Management
Michael Lowe	Volunteer	Woods Hole Oceanographic Institution
Leg 2 (29 Jul – 19 Aug)		
Debra Palka	Chief Scientist	NMFS, NEFSC, Woods Hole, MA
Elizabeth Broughton	Oceanographer	NMFS, NEFSC, Woods Hole, MA
Peter Duley	Fishery Biologist	NMFS, NEFSC, Woods Hole, MA
Genevieve Davis	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Michael Force (FN)	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Gary Friedrichsen	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Rachel Hardee	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Samara Haver	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Richard Holt	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Eric Matzen	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Nicholas Metheny	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Todd Pusser	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Douglas Sigourney	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Joy Stanistreet	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Suzanne Yin	Fishery Biologist	Integrated Statistics, Woods Hole, MA

Table 3. Within each Beaufort sea state condition, total length of visual teams' track lines while on effort (in km).

	Track line length (km) within Beaufort sea state levels						
Conditions	0	1	2	3	4	5	TOTAL
Better	45.5	451.6	1427.9	1094.7	864.1	448.9	4332.7
Worst	0	9.3	52.6	94.8	409.2	122.5	688.4
TOTAL	45.5	460.9	1480.5	1189.5	1273	571.4	5021.1
% of better conditions	0.0105	0.1042	0.3296	0.2527	0.199	0.104	1
cumulative percentage	0.01	0.11	0.44	0.70	0.90	1.00	

Table 4. Number of groups and individuals of cetacean species detected by the three marine mammal - turtle visual teams, upper, lower and tracker, during on-effort good condition track lines. Note, some, but not all, groups detected by one team were also detected by the other team.

		number of groups			number of individuals		
Species		lower	upper	tracker	lower	upper	tracker
Atlantic spotted dolphin	*Stenella frontalis*	5	14	0	67	316	0
Blainville's beaked whale	*Mesoplodon densirostris*	1	0	0	2	0	0
Blue whale	*Balaenoptera musculus*	0	3	0	0	3	0
Bottlenose dolphin spp.	*Tursiops truncatus*	41	65	3	374	697	10
Clymene dolphin	*Stenella clymene*	1	1	0	28	25	0
Common dolphin	*Delphinus delphis*	40	59	1	1394	2641	2
Cuvier’s beaked whale	*Ziphius cavirostris*	28	51	2	66	139	3
Dwarf sperm whale	*Kogia simus*	0	7	0	0	18	0
Fin whale	*Balaenoptera physalus*	29	28	2	40	39	2
Fin/sei whales	*B. physalus or B. borealis*	0	10	1	0	14	1
Gervais’ beaked whale	*Mesoplodon europacus*	1	0	0	5	0	0
Harbor porpoise	*Phocoena phocoena*	0	1	0	0	1	0
Humpback whale	*Megaptera novaeangliae*	19	25	1	26	34	1
Minke whale	*B. acutorostrata*	4	3	1	4	3	1
Pilot whales spp.	*Globicephala spp.*	45	67	12	378	840	55
Pygmy sperm whale	*Kogia breviceps*	2	12	0	2	16	0
Pygmy/dwarf sperm whales	*Kogia spp.*	2	2	0	2	2	0
Right whale	*Eubalaena glacialis*	1	2	1	1	4	2
Risso’s dolphin	*Grampus griseus*	55	86	11	249	433	23
Rough-toothed dolphin	*Steno bredanensis*	1	2	1	5	11	1
Sei whale	*Balaenoptera borealis*	0	1	0	0	1	0
Sowerby’s beaked whale	*Mesoplodon bidens*	9	12	1	32	32	3
Sperm whale	*Physeter macrocephalus*	35	58	4	64	86	4
Stenella spp.	*Stenella spp.*	4	17	1	69	329	1
Striped dolphin	*Stenella coeruleoalba*	45	47	6	1408	2112	90
Unid. dolphin	*Delphinidae*	166	112	47	1469	1888	265
Unid. whale	*Mysticeti*	59	28	14	73	35	16
Unid. Mesoplodon	*Mesoplodon spp.*	40	74	5	97	188	17
TOTAL CETACEANS		633	787	114	5,855	9,907	497

Table 5. Number of groups and individuals of large fish, turtles, and seals detected by the three marine mammal - turtle visual teams, upper, lower and tracker, during on-effort good condition track lines. Note, some, but not all, groups detected by one team were also detected by the other team.

		number of groups			number of individuals		
Species		lower	upper	tracker	lower	upper	tracker
Basking shark	*Cetorhinus maximus*	12	5	0	12	5	0
Billfish spp.		3	4	0	3	4	0
Manta rays spp.	*Manta spp.*	11	18	0	22	31	0
Ocean sunfish	*Mola mola*	11	28	0	12	31	0
Shark spp.		49	70	1	58	75	1
Leatherback turtle*	*Dermochelys coriacea*	2	1	0	2	1	0
Loggerhead turtle	*Caretta caretta*	13	21	0	14	22	0
Unid hardshell turtle	*Chelonioidea*	11	16	2	11	16	2
Gray seal	*Halichoerus grypus*	1	2	0	1	2	0
Harbor seal	*Phoca vitulina*	4	4	0	4	4	0
Unid seal	*Pinniped*	2	1	0	2	1	0
TOTAL ALL SPECIES		752	957	117	5,996	10,099	500

* Off effort sightings

Table 6. Number of groups and individual birds detected within the 300 m strip during the NOAA ship *Henry B. Bigelow* abundance survey conducted during 1 Jul – 18 Aug 2013.

Species		Number of groups	Number of individuals	Relative abundance (%)
Trindade (Herald) Petrel	*Pterodroma (heraldica) arminjoniana*	1	1	0.02
Black-capped Petrel	*Pterodroma hasitata*	16	16	0.30
Cory's Shearwater	*Calonectris diomedea*	362	1177	21.99
Great Shearwater	*Puffinus gravis*	271	735	13.74
Sooty Shearwater	*Puffinus griseus*	24	34	0.64
Manx Shearwater	*Puffinus puffinus*	16	16	0.30
Barolo (Little) Shearwater	*Puffinus baroli*	7	7	0.14
Audubon's Shearwater	*Puffinus lherminieri*	184	661	12.35
unidentified shearwater	*Puffinus sp.*	16	66	1.24
Wilson's Storm-Petrel	*Oceanites oceanicus*	475	1469	27.45
White-faced Storm-Petrel	*Pelagodroma marina*	18	18	0.34
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	530	778	14.54
Band-rumped Storm-Petrel	*Oceanodroma castro*	70	90	1.69
unidentified storm-petrel	*Oceanodroma sp.*	7	12	0.23
Leach’s/Harcourt’s Storm-Petrel	*Oceanodroma leucorhoa/castro*	30	35	0.66
White-tailed Tropicbird	*Phaethon lepturus*	7	7	0.14
Red-billed Tropicbird	*Phaethon aethereus*	1	1	0.02
unidentified tropicbird	*Phaethon sp.*	1	1	0.02
Northern Gannet	*Morus bassanus*	4	4	0.08
Double-crested Cormorant	*Phalacrocorax auritus*	1	1	0.02
Great Blue Heron	*Ardea herodias*	1	1	0.02
Black-bellied Plover	*Pluvialis squatarola*	1	1	0.02
Greater Yellowlegs	*Tringa melanoleuca*	1	1	0.02
Ruddy Turnstone	*Arenaria interpres*	1	1	0.02
Semipalmated Sandpiper	*Calidris pusilla*	3	3	0.06
Least Sandpiper	*Calidris minutilla*	2	2	0.06
White-rumped Sandpiper	*Calidris fuscicollis*	2	7	0.14
unidentified dowitcher	*Limnodromus griseus/scolopaceus*	1	1	0.02
Red Phalarope	*Phalaropus fulicarius*	2	3	0.06
unidentified phalarope	*Phalaropus sp.*	1	2	0.04
unidentified shorebird	*Sp.*	16	16	0.30
Laughing Gull	*Leucophaeus atricilla*	11	14	0.27
Herring Gull	*Larus argentatus*	33	46	0.86
Great Black-backed Gull	*Larus marinus*	23	31	0.58

Table 6 (cont). Number of groups and individual birds detected within the 300 m strip during the NOAA ship *Henry B. Bigelow* abundance survey conducted during 1 Jul – 18 Aug 2013.

Species		Number of groups	Number of individuals	Relative abundance (%)
Bridled Tern	*Onychoprion anaethetus*	5	5	0.10
Least Tern	*Sternula antillarum*	1	2	0.04
Common Tern	*Sterna hirundo*	11	23	0.43
Arctic Tern	*Sterna paradisaea*	1	1	0.02
unidentified tern	*Sp.*	2	9	0.17
Royal Tern	*Thalasseus maximus*	2	2	0.04
South Polar Skua	*Stercorarius maccormicki*	3	3	0.06
Pomarine Jaeger	*Stercorarius pomarinus*	9	10	0.19
Parasitic Jaeger	*Stercorarius parasiticus*	11	14	0.27
Long-tailed Jaeger	*Stercorarius longicaudus*	2	3	0.06
unidentified jaeger	*Stercorarius sp.*	2	2	0.04
Mourning Dove	*Zenaida macroura*	1	1	0.02
Tree Swallow	*Tachycineta bicolor*	1	1	0.02
Barn Swallow	*Hirundo rustica*	6	8	0.15
Cape May Warbler	*Setophaga tigrina*	1	1	0.02
Yellow Warbler	*Dendroica petechia*	1	1	0.02
Red-winged Blackbird	*Agelaius phoeniceus*	2	2	0.04
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	1	1	0.02
Brown-headed Cowbird	*Molothrus ater*	5	5	0.10
TOTAL		2211	5353	

Table 7. Summary of passive acoustic recording effort.

	Leg 1	Leg 2	TOTAL
Days with acoustic effort	19	16	35
Daytime recording time (hh:mm)	149:18	123:50	273:09
Nights with acoustic effort	11	3	14
Evening/night recording time (hh:mm)	33:06	16:45	49:51

Table 8. Summary of acoustic events detected in real-time during the survey. Species were assigned to acoustic detections when acoustic localization and tracking resulted in direct correspondence with visual sightings. Groups without species assignment include both those that were not visually detected, as well as groups that could not be definitively linked to visual sightings in real-time. Note that in many cases, acoustic detections include multiple individuals (in the case of sperm whales) or multiple subgroups (in the case of delphinids).

	Leg 1	Leg 2	TOTAL
Bottlenose dolphin	5	7	12
Common dolphin	9	2	11
Atlantic spotted dolphin	5	3	8
Striped dolphin	11	6	17
Risso's dolphin	15	5	20
Pilot whales	0	7	7
Clymene's dolphin	1	0	1
Mixed species groups	5	2	7
Sperm whales	50	15	65
Beaked whales	1	1	2
Stenella spp.	0	2	2
Groups without species assignment	65	46	111
TOTAL	167	96	263

Table 9. The number of hydrographic and oceanographic sampling stations.

Sampling type	Leg 1	Leg 2	TOTAL
CTD only	74	42	116
Bongo + CTD	39	50	89
VPR + CTD	13	17	30
IKMT + CTD	11	1	12
MOCNESS	6	3	9
TOTAL	143	113	256

Table 10. Nighttime shelfbreak and canyon surveys summary.

Canyon	Transect Type	Date	Time (GMT)	Leg	CTD (Vertical)	CTD (Attached)	EK60	MOC	IKMT
NA	Shelf	7/3/13		I		X	X		
NA	Shelf	7/4/13		I		X	X		X
Wilmington	Z-type	7/5/13	0003-0400	I	X	X	X		X
NA	Slope	7/6/13	2212-2355	I		X	X	X	
NA	Slope	7/7/13	0050-0629	I		X	X		X
Hudson	Z-type	7/8/13	2130-0630	I	X	X	X	X	
Block	Z-type	7/9/13	2340-0530	I	X	X	X		X
Atlantis	Z-type	7/10/13	2208-0350	I	X	X	X		X
Atlantis	Z-type	7/12/13	0230-0350	I		X	X	X	
Veatch	Z-type	7/12/13	2230-2352	I	X	X	X		
NA	Slope	7/14/13	0030-0215	I		X	X	X	
NA	Slope	7/15/13	0050-0247	I		X	X	X	
NA	Slope	7/16/13	0050-0230	I		X	X		X
West of Powell	Shelfbreak	7/18/13	0050-0255	I	X	X	X		
Lydonia	Z-type	7/19/13	0208-0627	I	X	X	X	X	
East of Hydrogrpher	Shelfbreak	7/19/13	2338-0820	I	X	X	X		X
Hydrographer	Z-type	7/21/13	0004-0210	I	X	X	X		
East of Welker	Shelfbreak	7/22/13	0200-0500	I	X	X	X		X
Munson	Z-type	8/3/13		II	X	X	X	X	
NA	Shelfbreak	8/4/13	0041-0225	II	X	X	X	X	
Oceanographer	Z-type	8/17/13	2054-2231	II	X	X	X	X	

Table 11. Start and end times of EK60 data collection.

Start Date/Time	End Date/Time	Start Date/Time	End Date/Time
Leg 1		Leg 2	
07/02/2013-16:16:22	07/04/2013-07:11:59	07/30/2013-20:43:12	08/01/2013-13:10:32
07/04/2013-07:26:00	07/05/2013-08:16:03	08/01/2013-18:18:43	08/03/2013-10:11:57
07/05/2013-08:28:59	07/05/2013-09:47:56	08/03/2013-15:52:33	08/05/2013-09:58:29
07/05/2013-15:48:02	07/05/2013-16:21:21	08/05/2013-15:42:18	08/05/2013-16:39:51
07/05/2013-21:30:49	07/07/2013-10:09:32	08/05/2013-22:31:40	08/06/2013-22:50:06
07/07/2013-15:47:12	07/07/2013-16:15:45	08/06/2013-23:35:48	08/07/2013-10:00:37
07/07/2013-22:28:21	07/09/2013-10:11:25	08/07/2013-23:20:13	08/09/2013-09:58:10
07/09/2013-15:41:34	07/09/2013-16:44:08	08/09/2013-21:46:07	08/11/2013-09:59:03
07/09/2013-22:23:19	07/11/2013-09:37:10	08/11/2013-16:12:06	08/11/2013-16:12:12
07/11/2013-22:31:05	07/13/2013-09:49:17	08/11/2013-22:04:40	08/13/2013-10:09:19
07/13/2013-14:12:51	07/13/2013-15:00:48	08/14/2013-12:48:38	08/15/2013-10:32:35
07/13/2013-16:22:49	07/13/2013-16:23:41	08/15/2013-16:50:52	08/15/2013-16:51:01
07/13/2013-22:20:47	07/15/2013-10:53:19	08/15/2013-22:10:33	08/17/2013-10:04:36
07/15/2013-15:37:05	07/15/2013-16:30:54	08/17/2013-14:41:03	08/17/2013-15:30:16
07/15/2013-22:19:30	07/17/2013-10:56:02		
07/17/2013-16:39:15	07/17/2013-16:39:20		
07/17/2013-20:56:38	07/17/2013-20:56:52		
07/17/2013-22:39:14	07/19/2013-11:25:23		
07/19/2013-15:45:32	07/19/2013-16:49:31		
07/19/2013-22:04:16	07/21/2013-10:13:45		
07/21/2013-15:52:17	07/21/2013-16:22:26		
07/21/2013-22:33:33	07/23/2013-11:31:12		

Figure 1. Strata locations (colored regions) and Beaufort sea states that the tracklines (colored lines) were surveyed under. Strata include: offshore (purple), shelfbreak (blue), BOEM-MA wind energy area (green), and BOEM-MidAtl wind energy areas (red). The US exclusive economic zone (EEZ) and the 100 m, 2000 m, and 4000 m depth contours are also displayed.

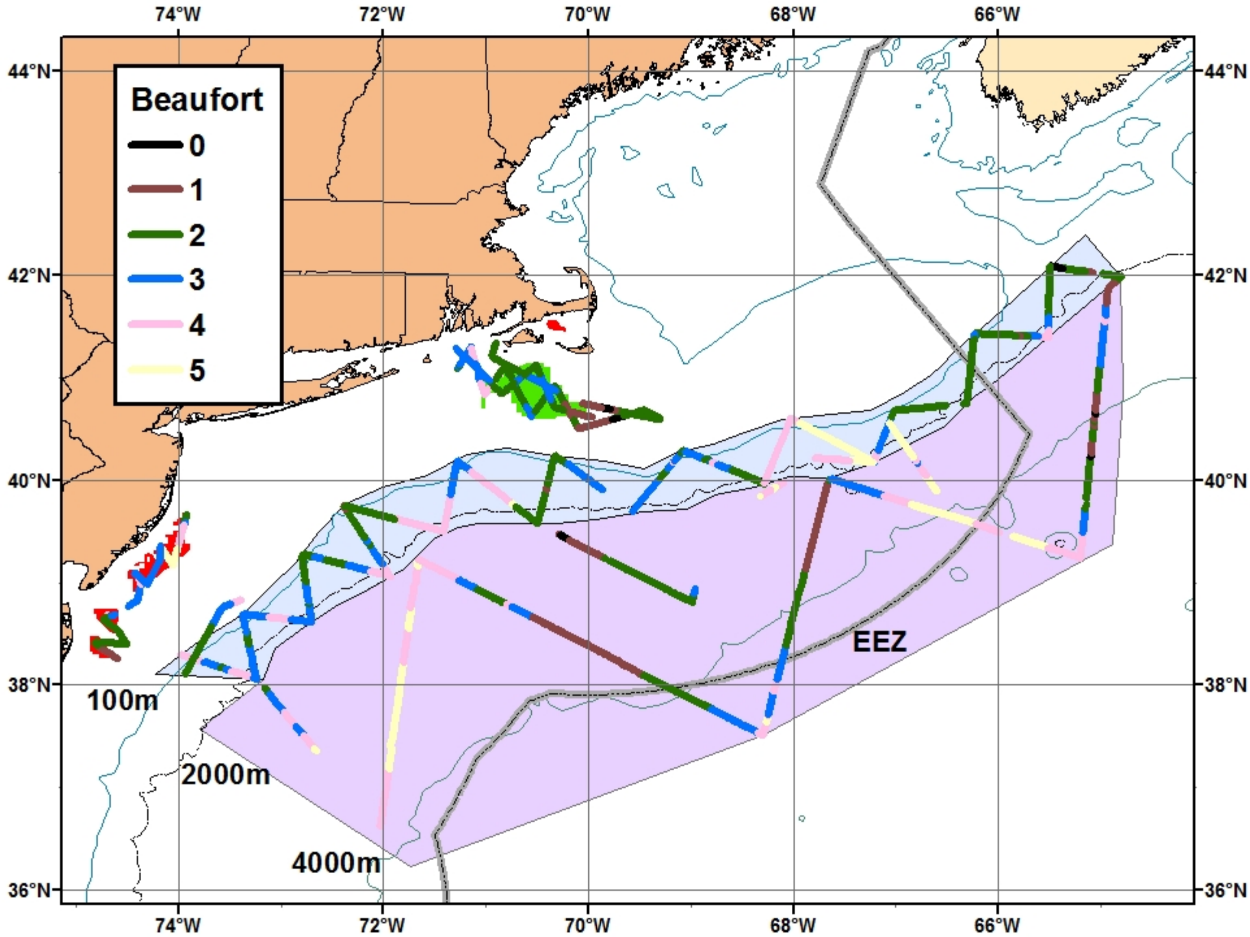


Figure 2. Location of Atlantic spotted dolphin (*Stenella frontalis*; top) and bottlenose spp. dolphin (*Tursiops truncatus*; bottom) sightings detected by the upper team during on-effort better conditions.

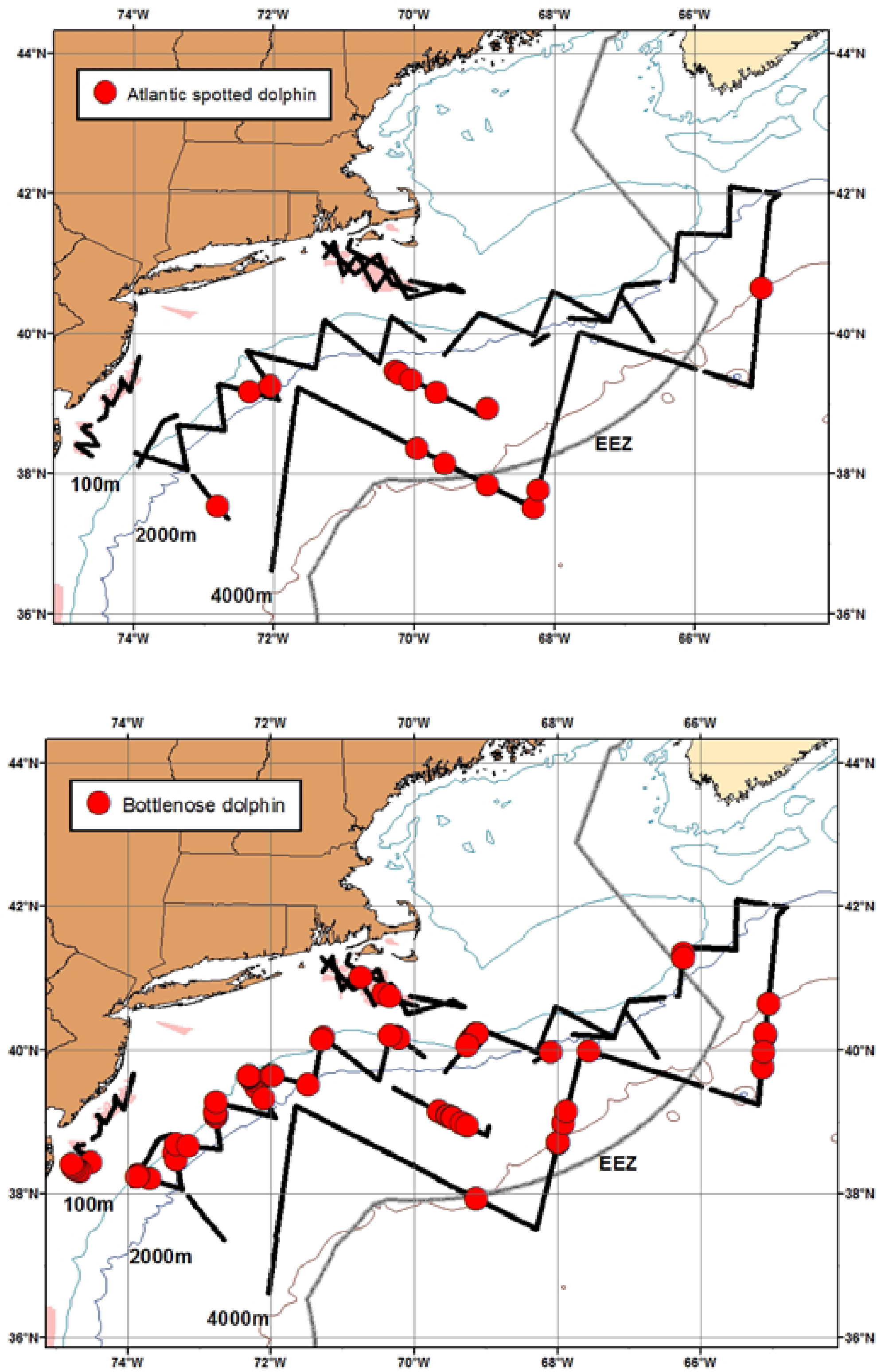


Figure 3. Location of pilot whale spp. (Globicephala spp.; top) and Risso's dolphin (*Grampus griseus*; bottom) sightings detected by the upper team during on-effort better conditions.

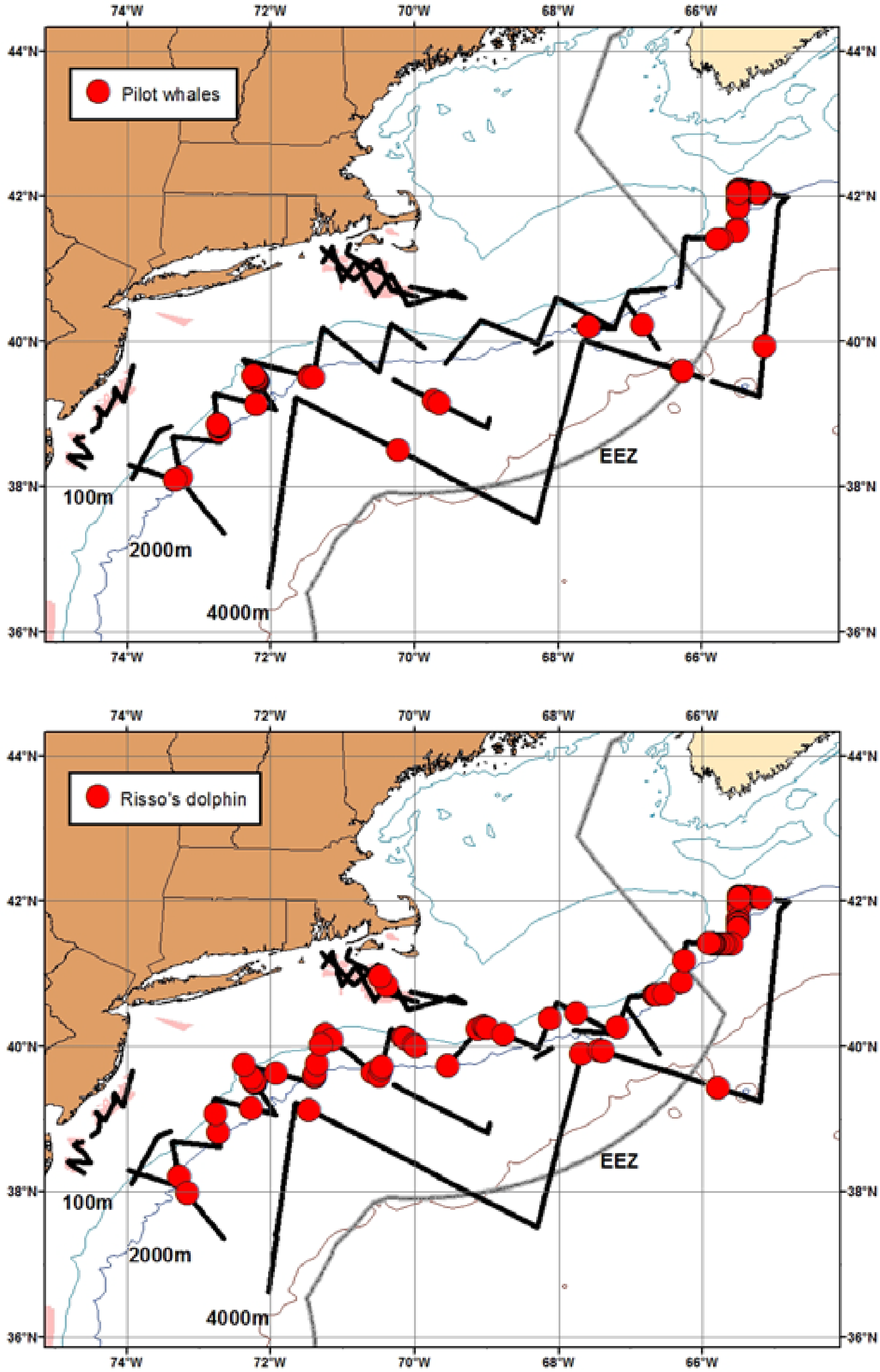


Figure 4. Location of common dolphin (*Delphinus delphis*; top) and striped dolphin (*Stenella coeruleoalba*; bottom) sightings detected by the upper team during on-effort better conditions.

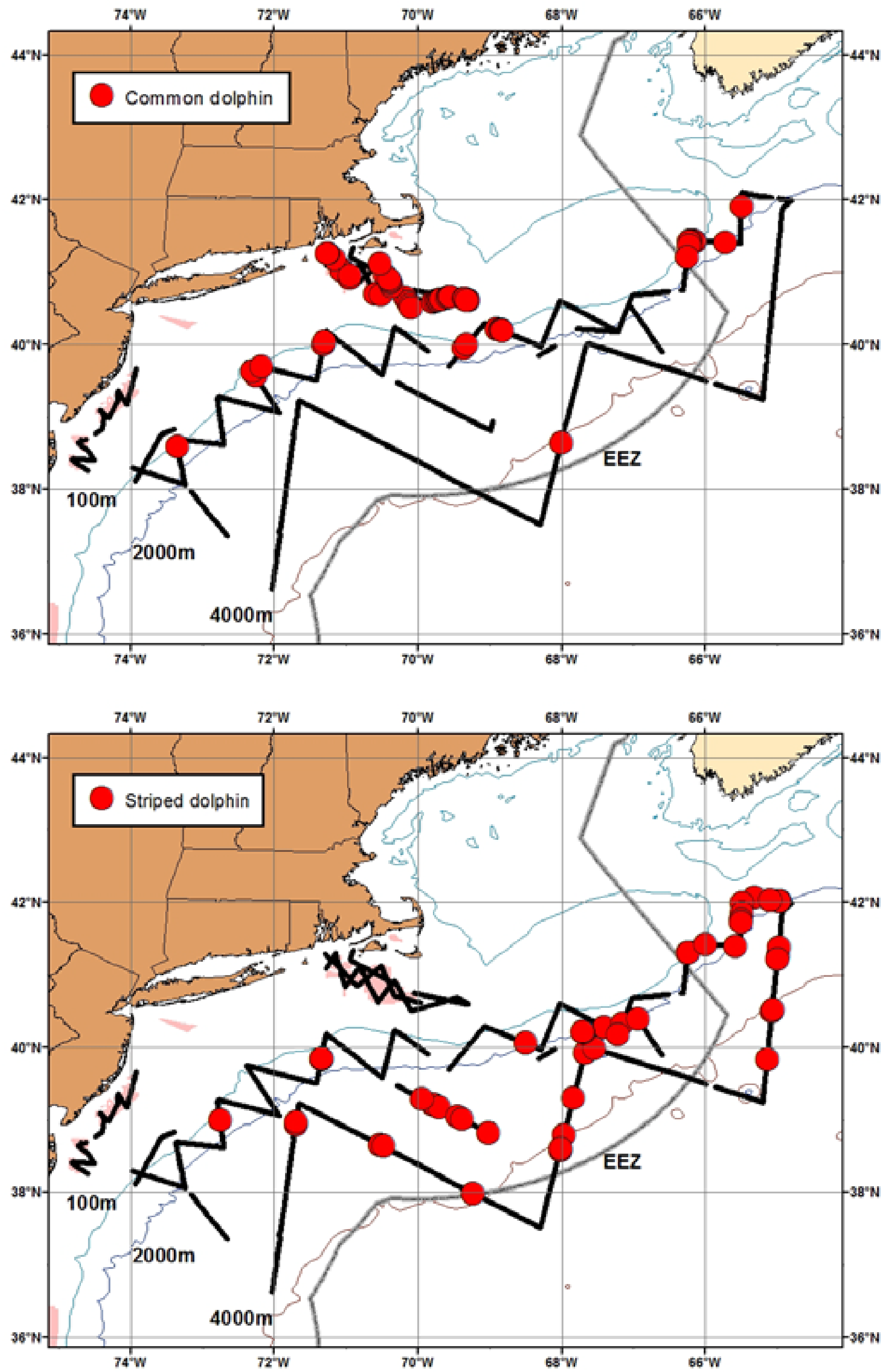
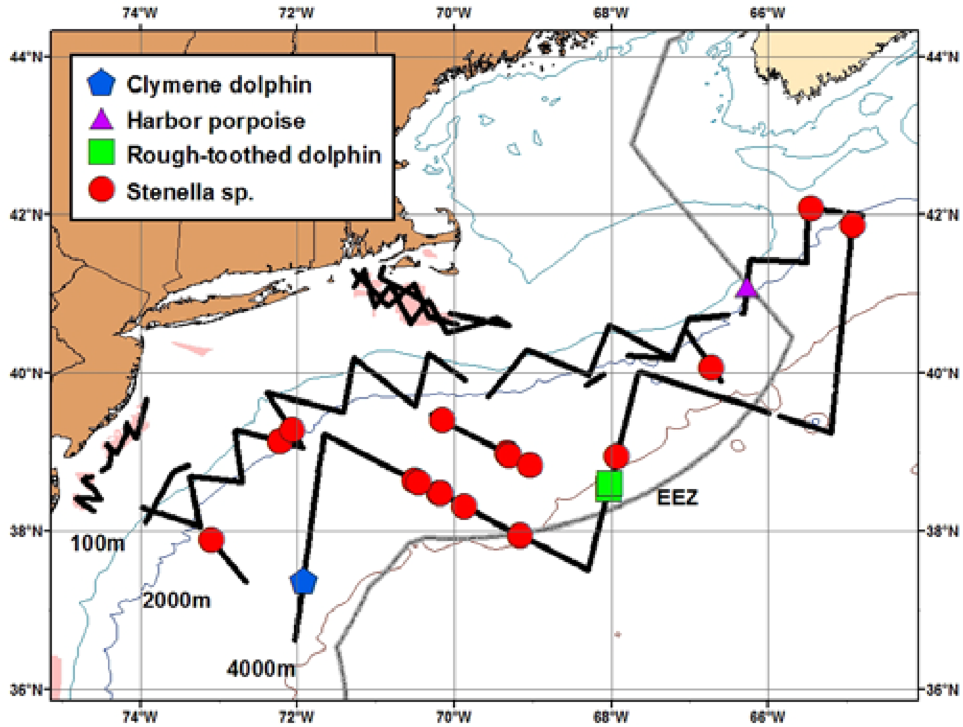


Figure 5. Location of Clymene dolphins (*Stenella clymene*), harbor porpoises (*Phocoena phocoena*), rough-toothed dolphins (*Steno bredanensis*), Stenella spp. (top) and unidentified dolphin (bottom) sightings detected by the upper team during on-effort better conditions.



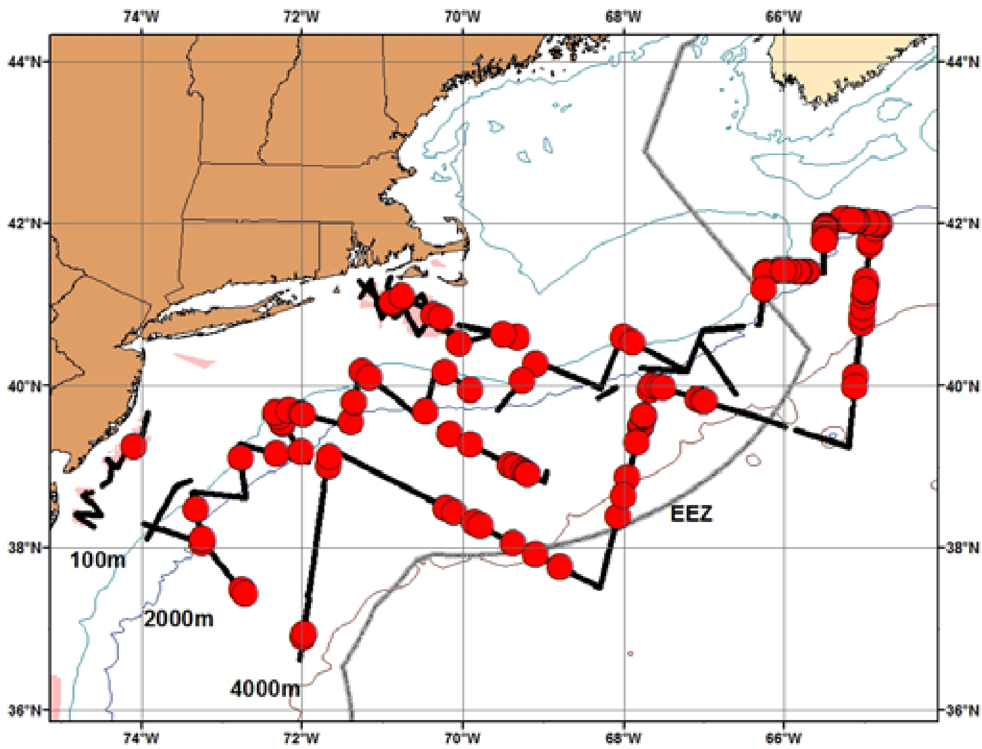


Figure 6. Location of Cuvier's beaked whale (*Ziphius cavirostris*; top) and Sowerby's beaked whale (*Mesoplodon bidens*; bottom) sightings detected by the upper team during on-effort better conditions.

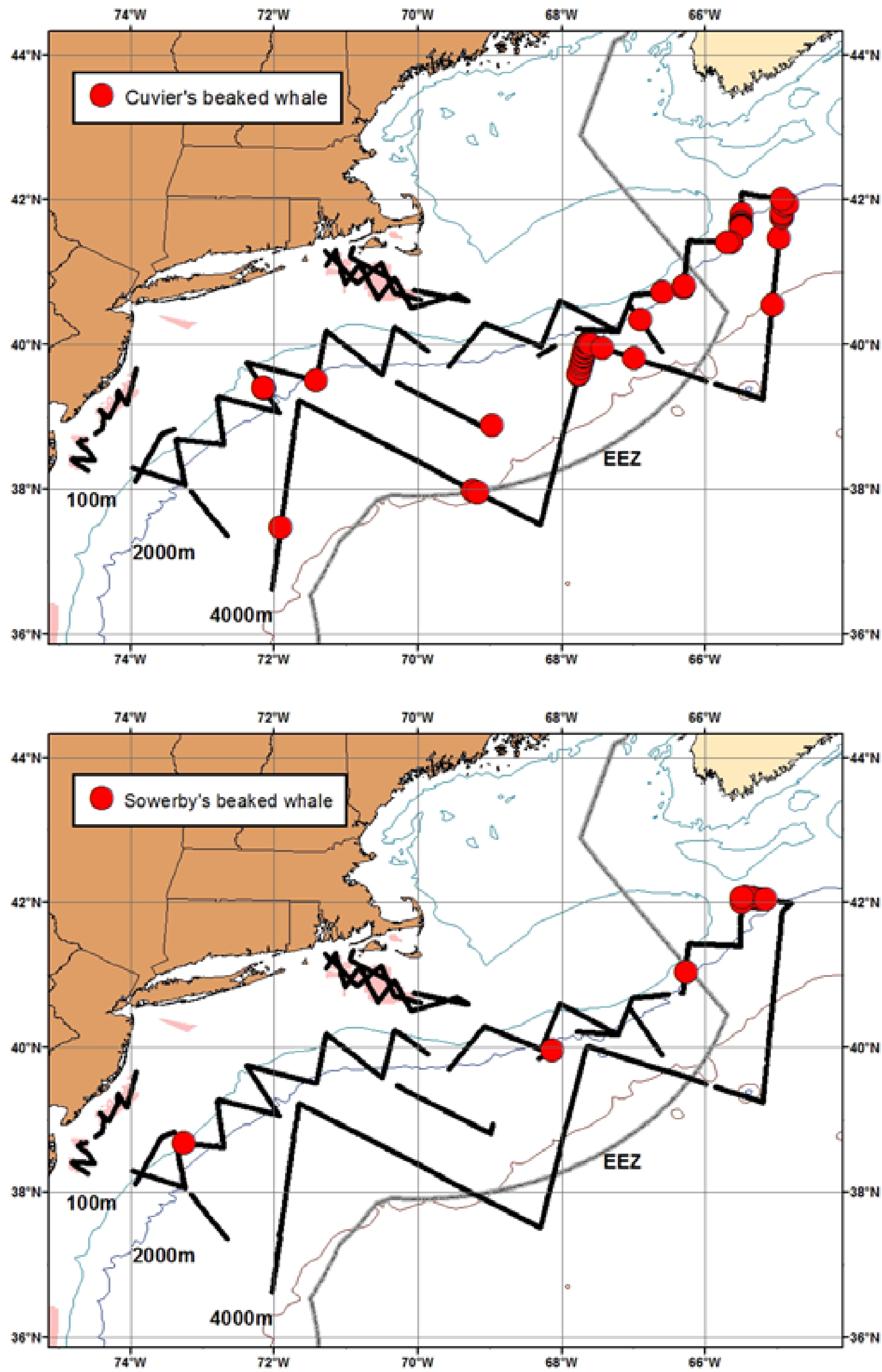


Figure 7. Location of unidentified beaked whales (Mesoplodon spp.; top) and dwarf sperm whales (*Kogia simus*), pygmy sperm whale (*Kogia breviceps*; bottom) sightings detected by the upper team during on-effort better conditions.

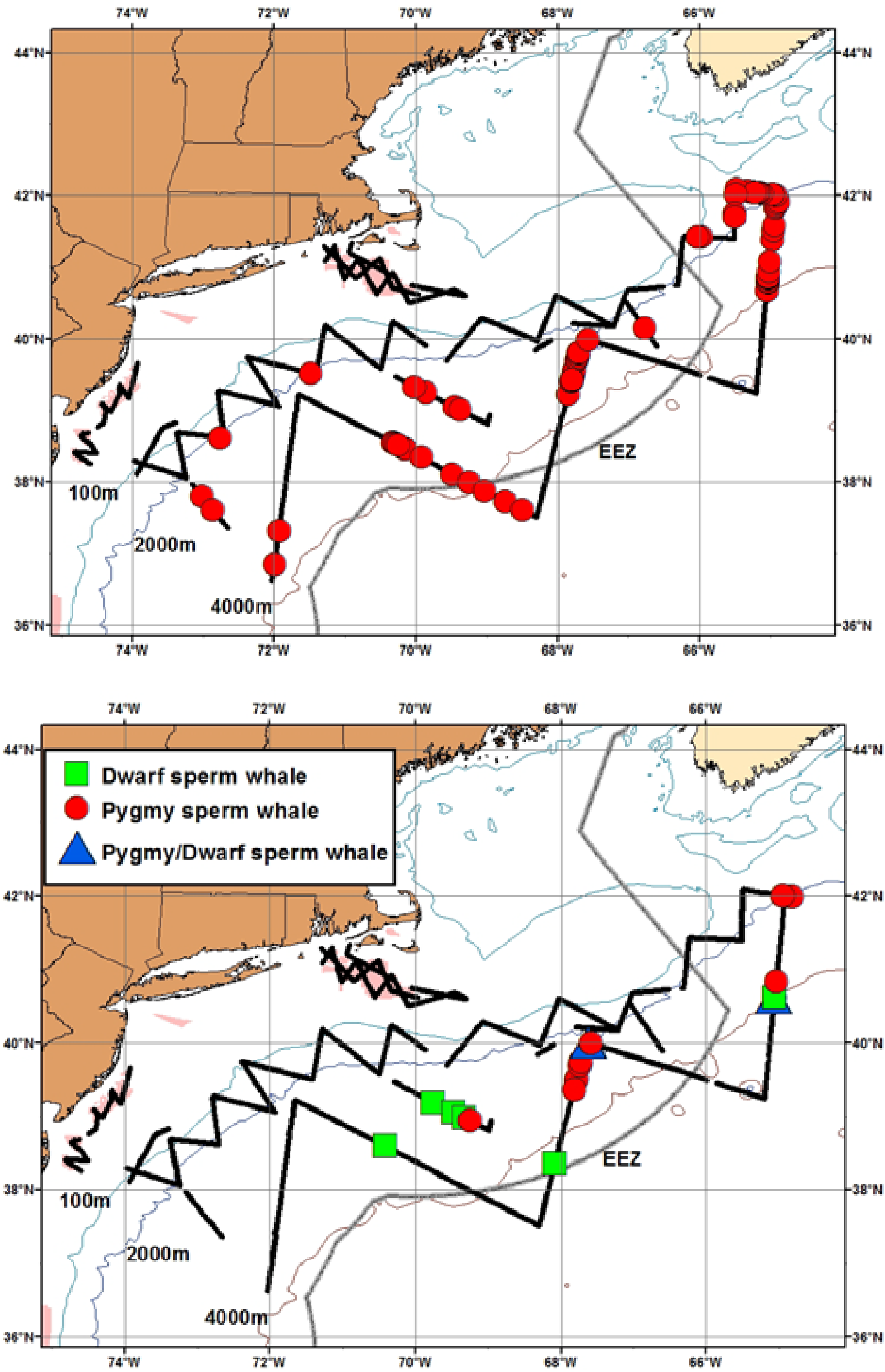
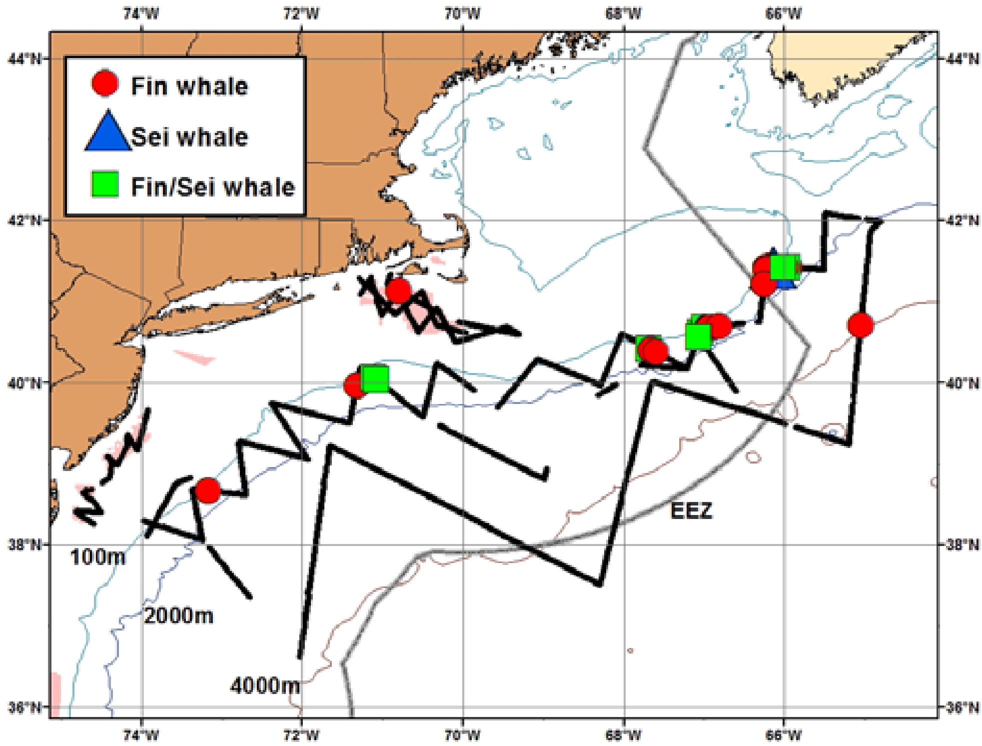


Figure 8. Location of fin whales (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*; top) and humpback whale (*Megaptera novaeangliae*; bottom) sightings detected by the upper team during on-effort better conditions.



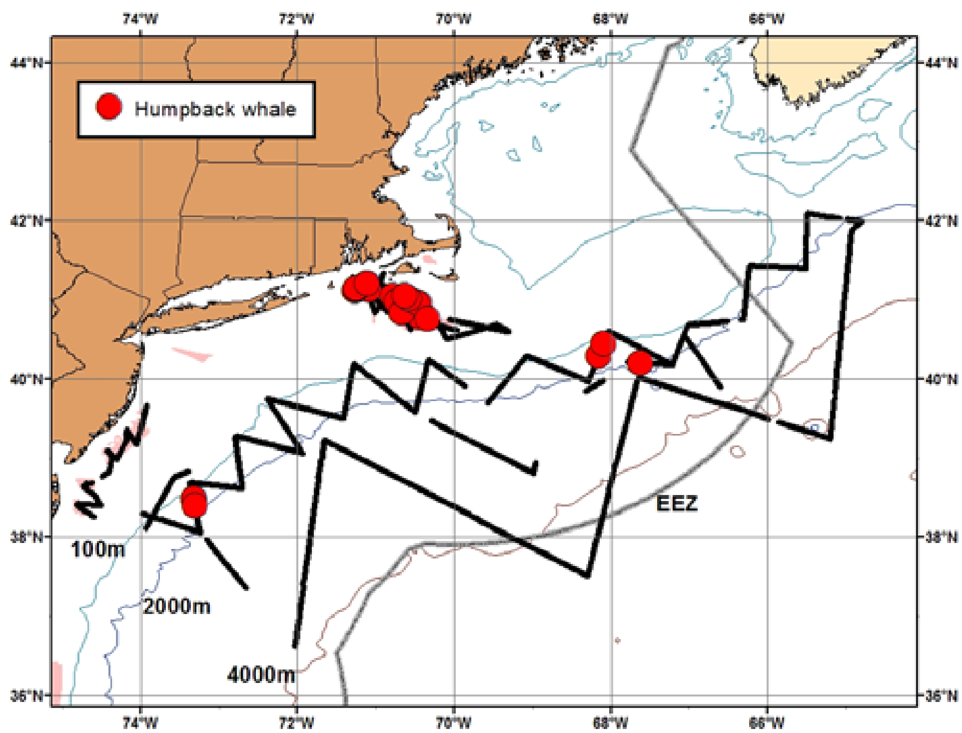
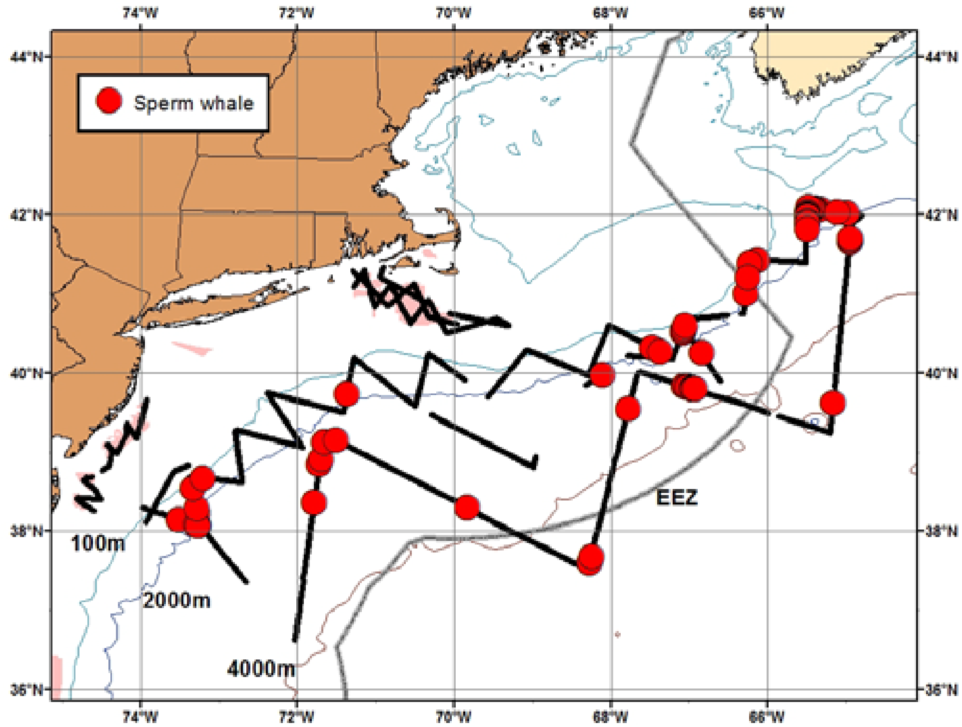


Figure 9. Location of sperm whale (*Physeter macrocephalus*; top), blue whale (*Balaenoptera musculus*), minke whale (*Balaenoptera acutorostrata*) and right whale (*Eubalaena glacialis*; bottom) sightings detected by the upper team during on-effort better conditions.



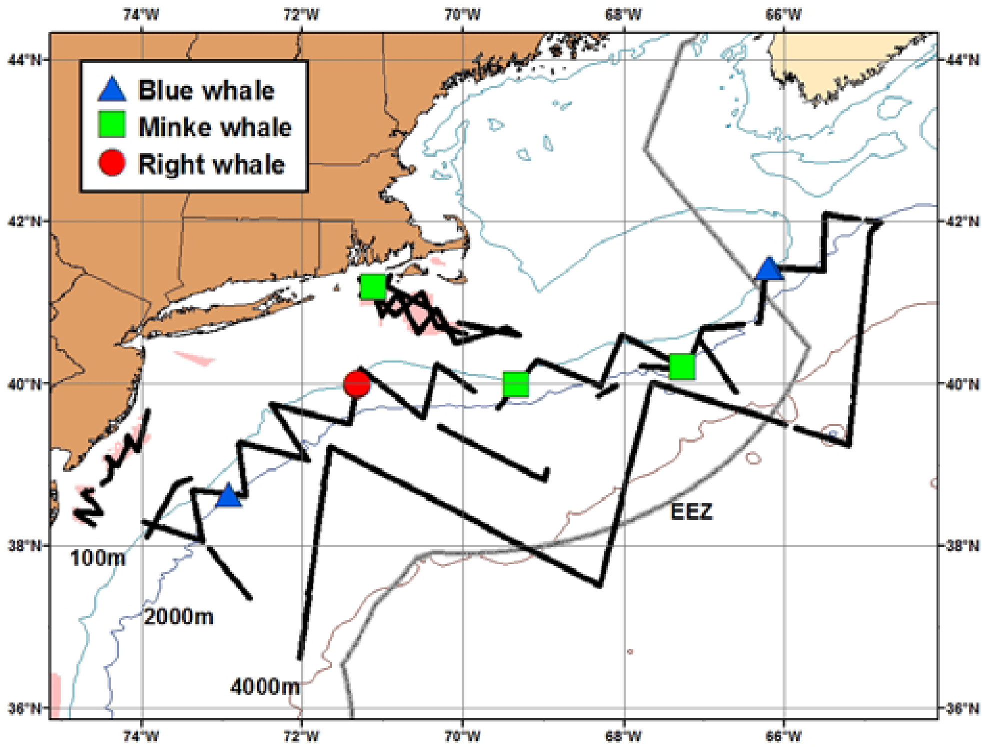


Figure 10. Location of unidentified whales (top), loggerhead turtle (*Caretta caretta*), and unidentified hardshell turtle (bottom) sightings detected by the upper team during on-effort better conditions.

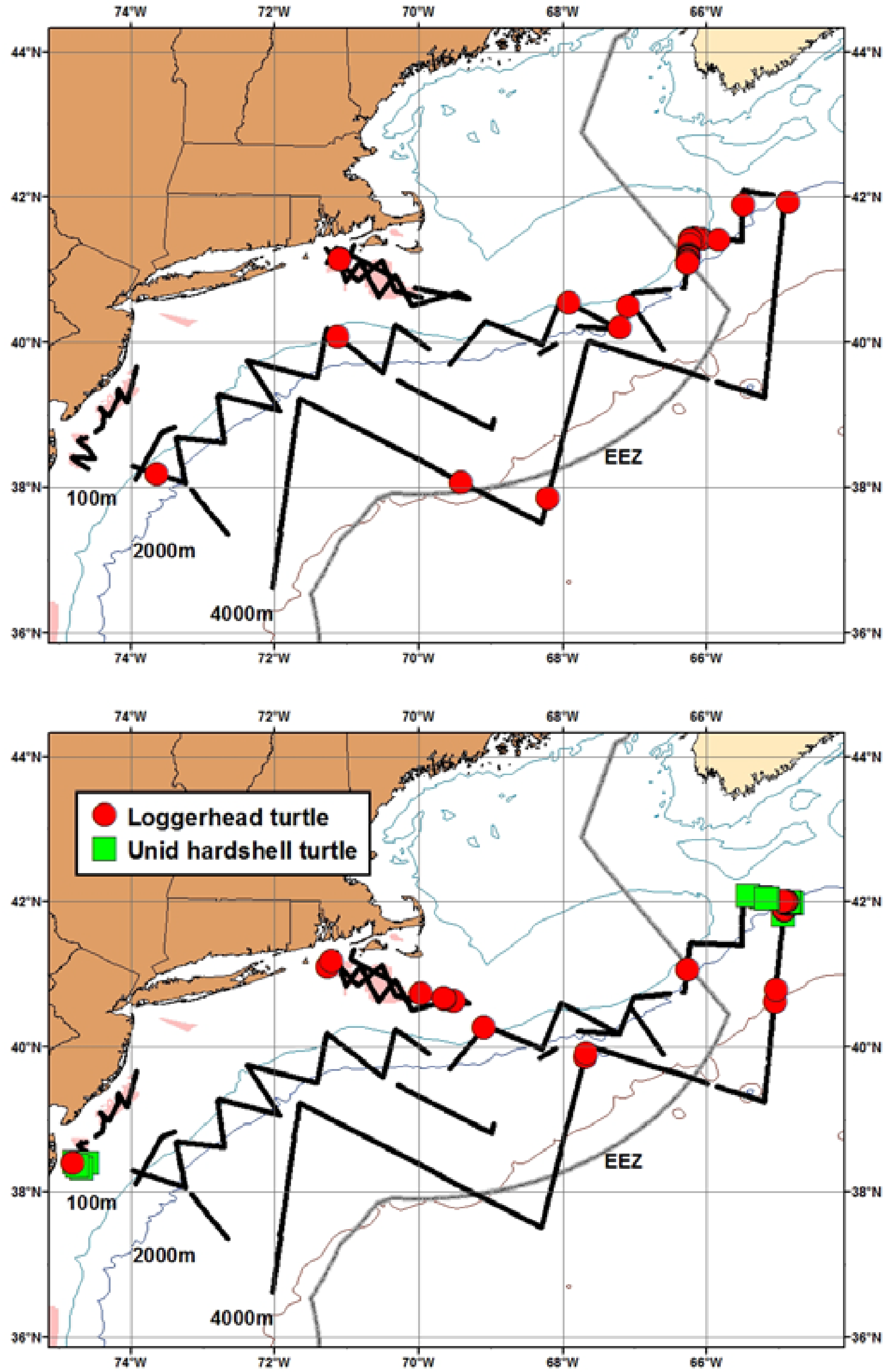


Figure 11. Location of basking sharks (*Cetorhinus maximus*), billfish spp., manta rays (Manta spp.), marlin, tuna (top), gray seals, harbor seals (*Phoca vitulina*) and unidentified seal (Pinniped; bottom) sightings detected by the upper team during on-effort better conditions.

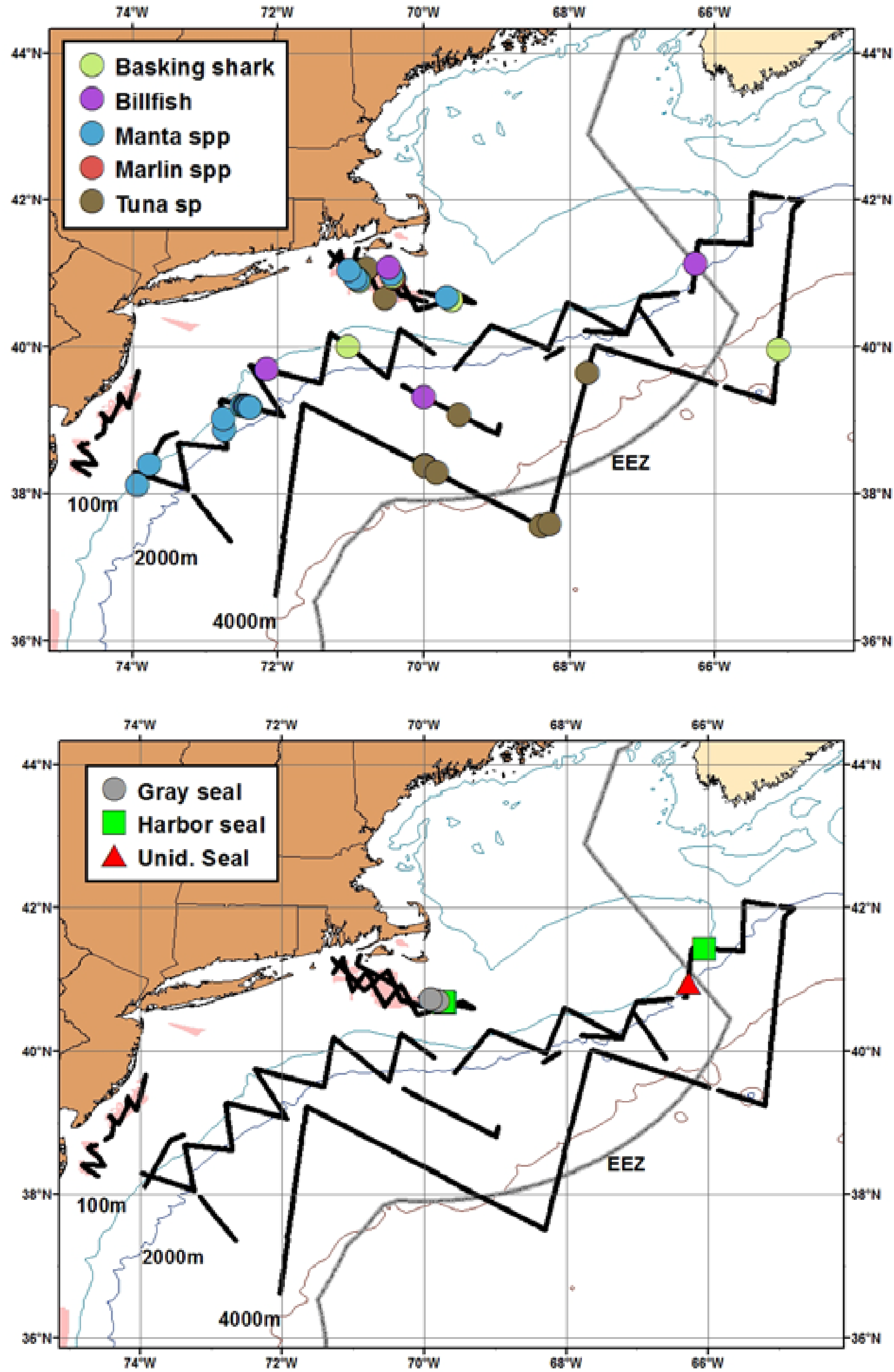


Figure 12. Locations of biopsied dolphins.

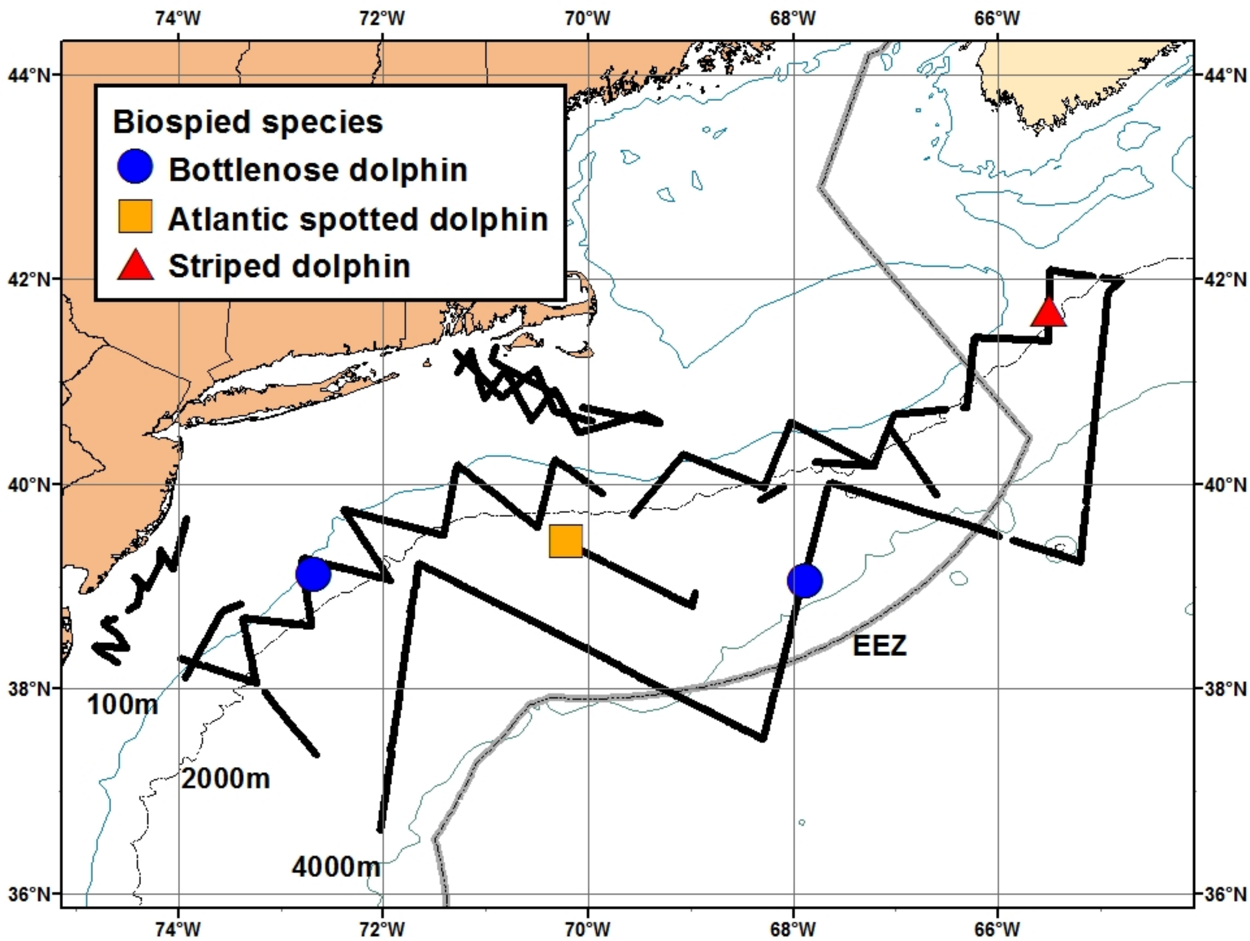


Figure 13. Black tracklines surveyed by both seabird and marine mammal/turtle observer teams. Red tracklines surveyed only by the seabird team.

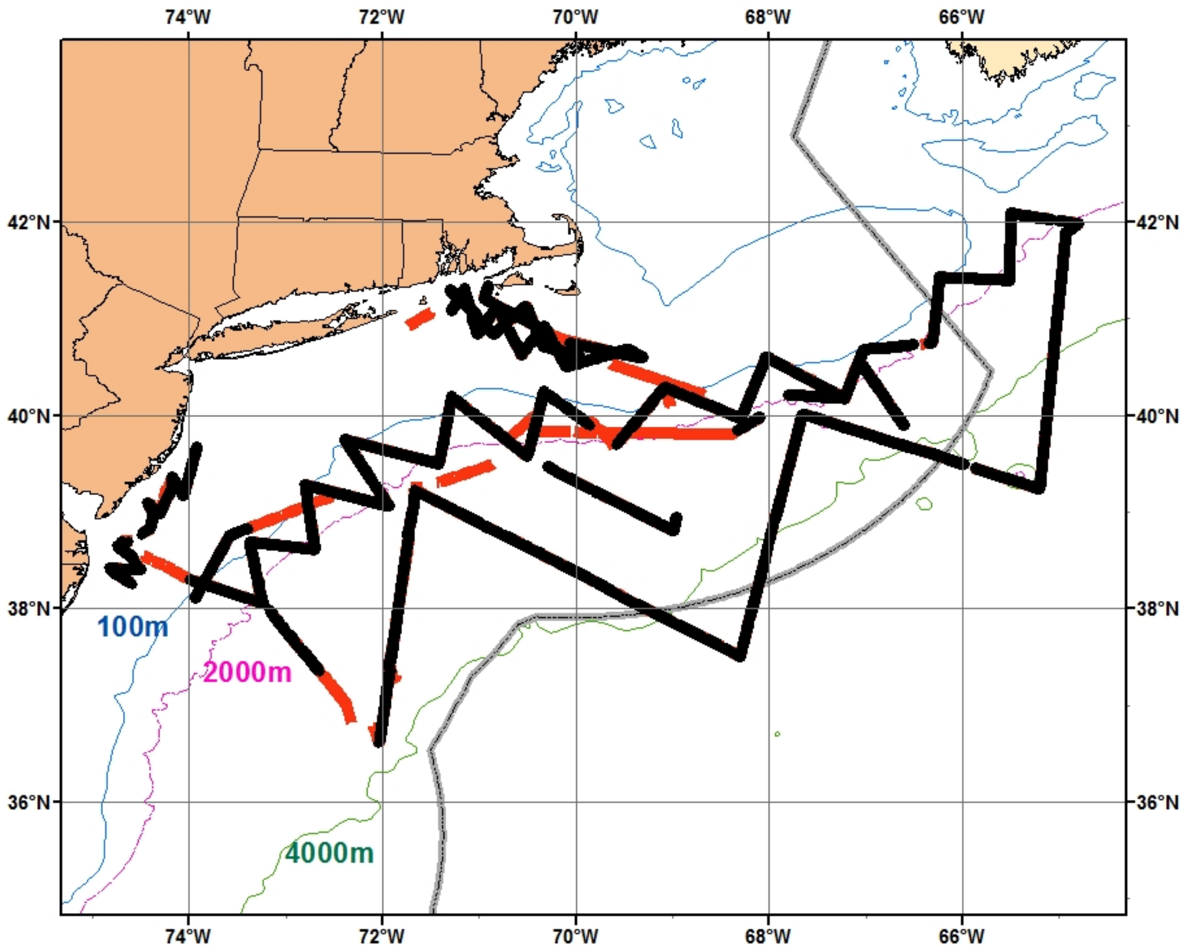


Figure 14. Location of Audubon shearwaters (*Puffinus lherminieri*; top), and Barolo (Little) shearwater (*Puffinus baroli*; bottom) sightings detected by the seabird team.

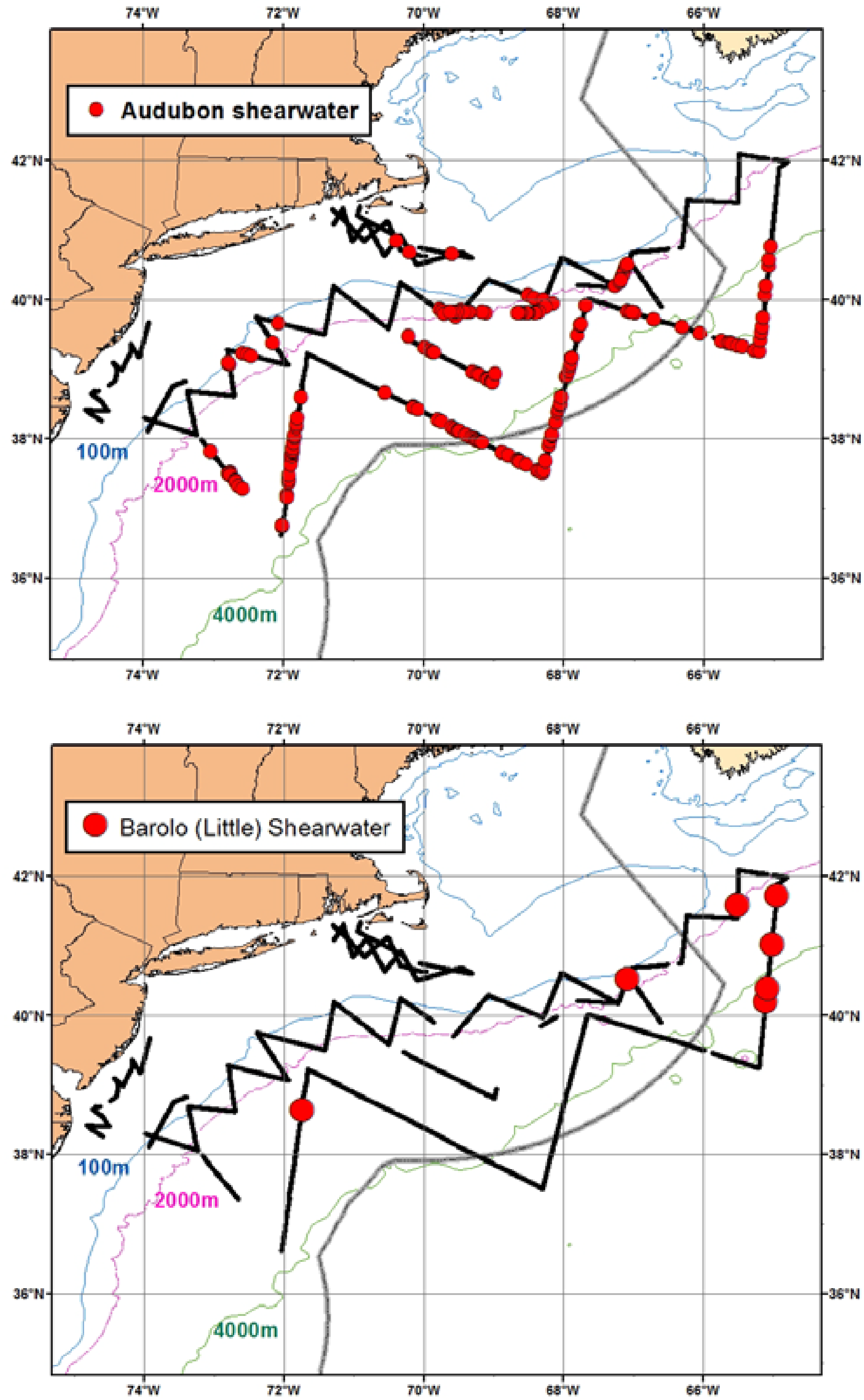
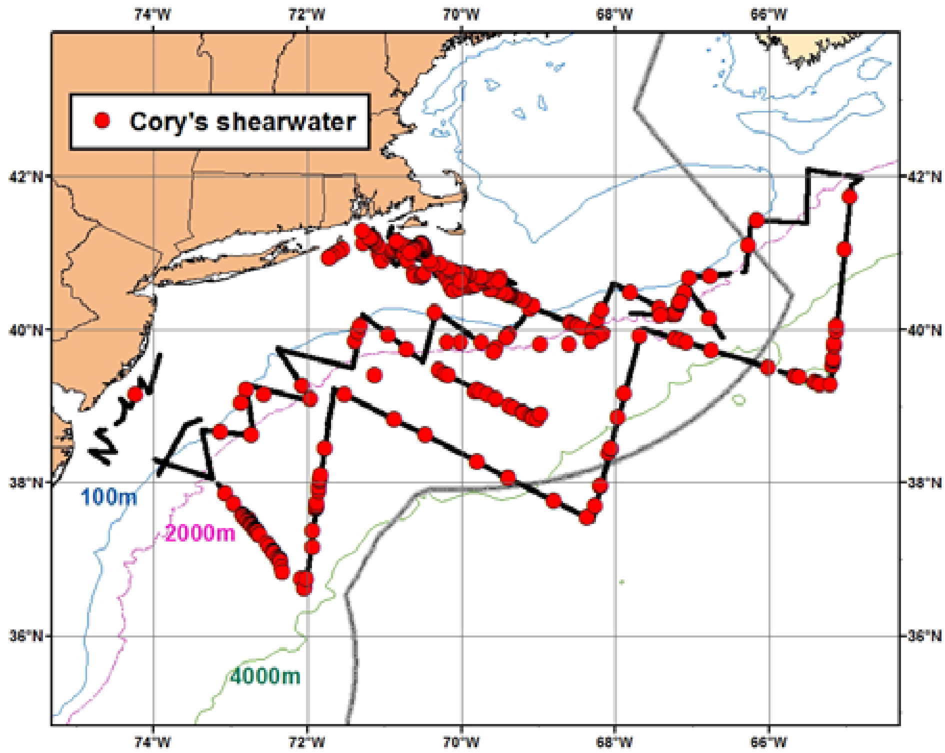


Figure 15. Location of Cory's shearwaters (*Calonectris diomedea*; top), and Great shearwater (*Puffinus gravis*; bottom) sightings detected by the seabird team.



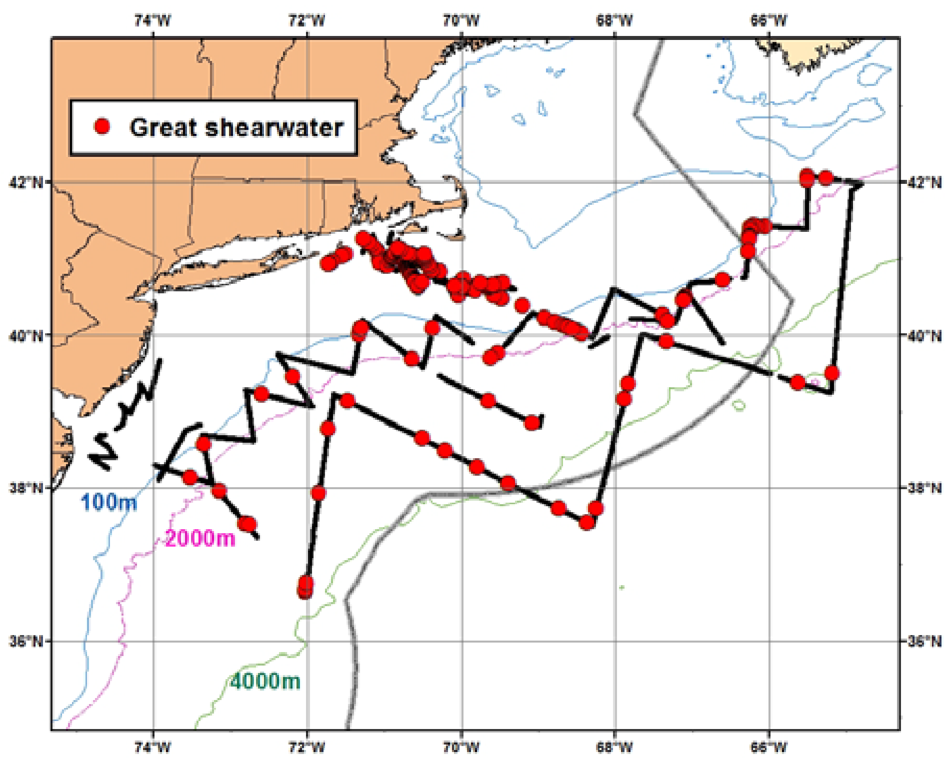
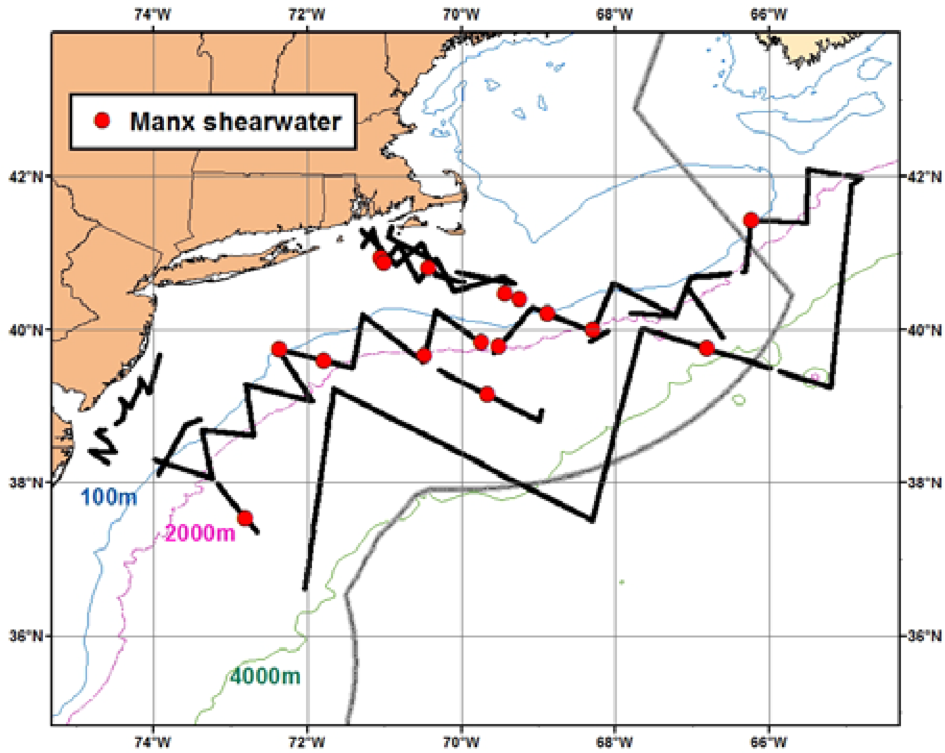


Figure 16. Location of Manx shearwaters (*Puffinus puffinus*; top), and Sooty shearwater (*Puffinus griseus*; bottom) sightings detected by the seabird team.



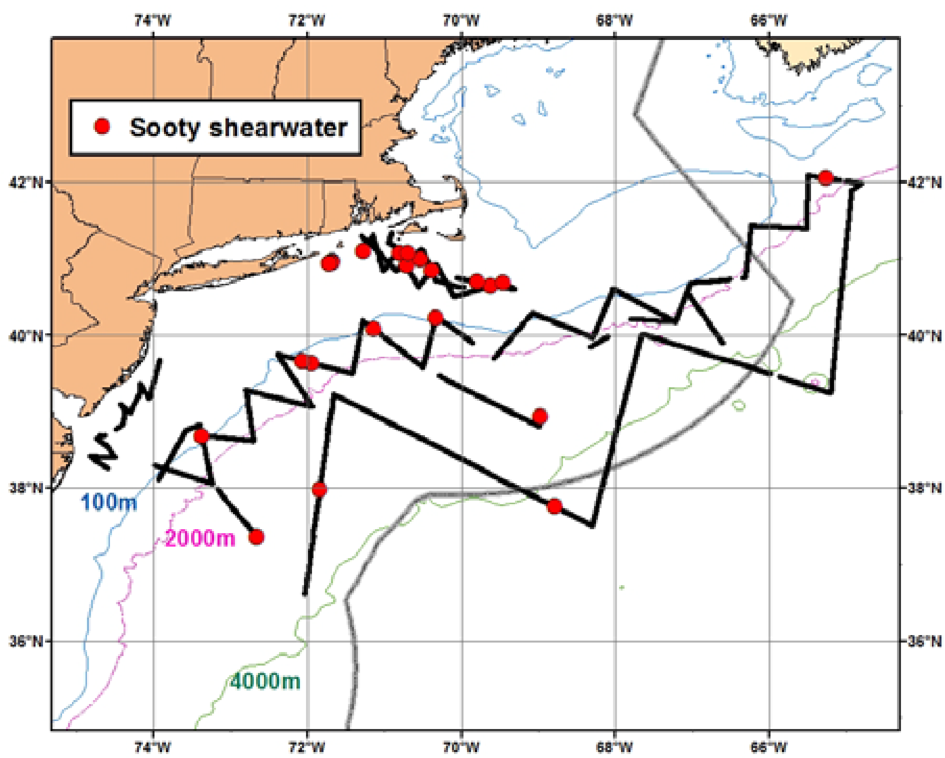
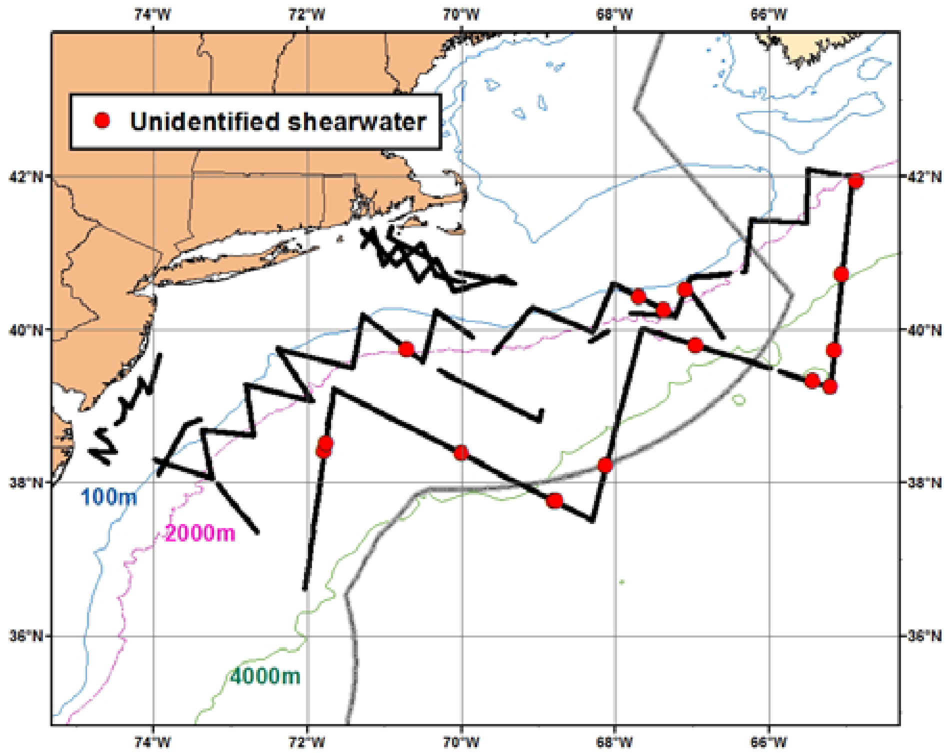


Figure 17. Location of unidentified shearwaters (*Puffinus sp.*; top), and Band-rumped storm-petrel (*Oceanodroma castro*; bottom) sightings detected by the seabird team.



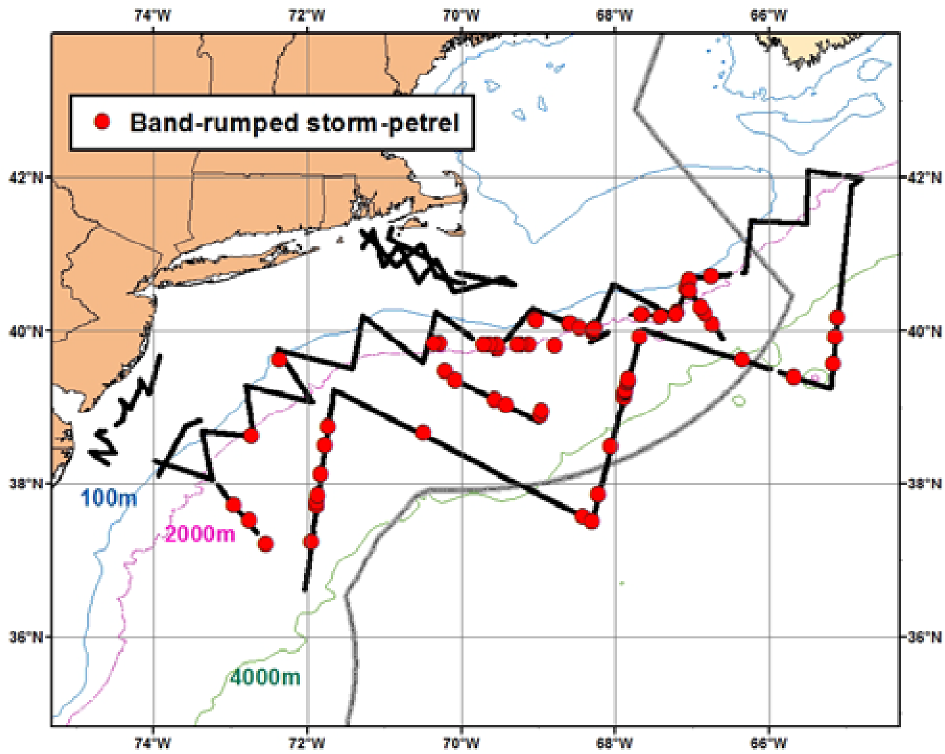
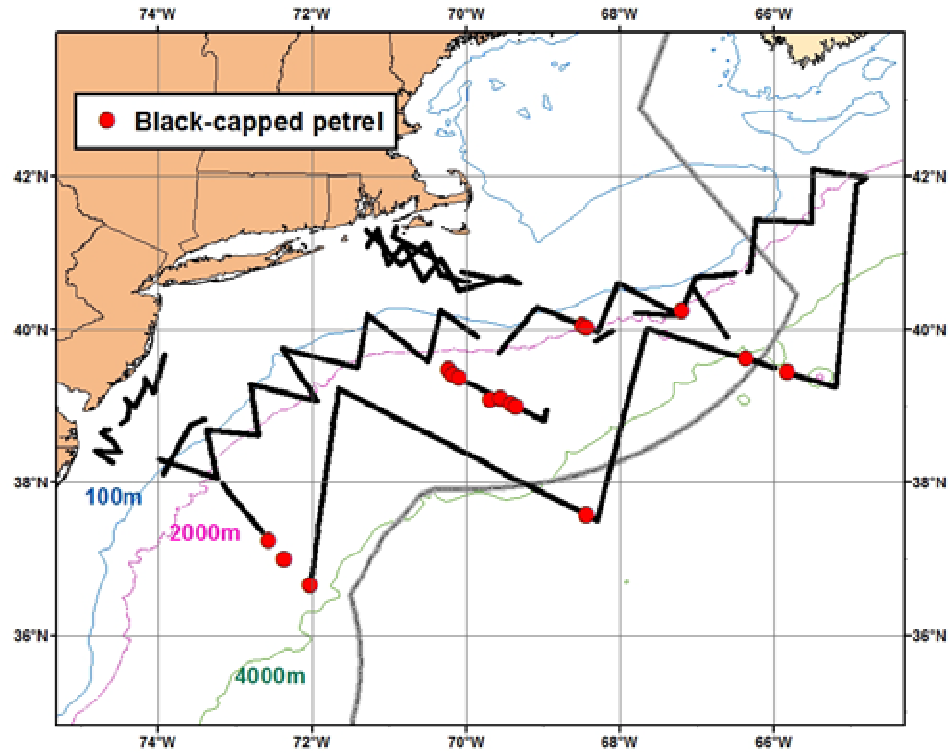


Figure 18. Location of Black-caped petrels (*Pterodroma hasitata*; top), and Leach's/Harcourt's storm-petrel (*Oceanodroma leucorhoa/castro*; bottom) sightings detected by the seabird team.



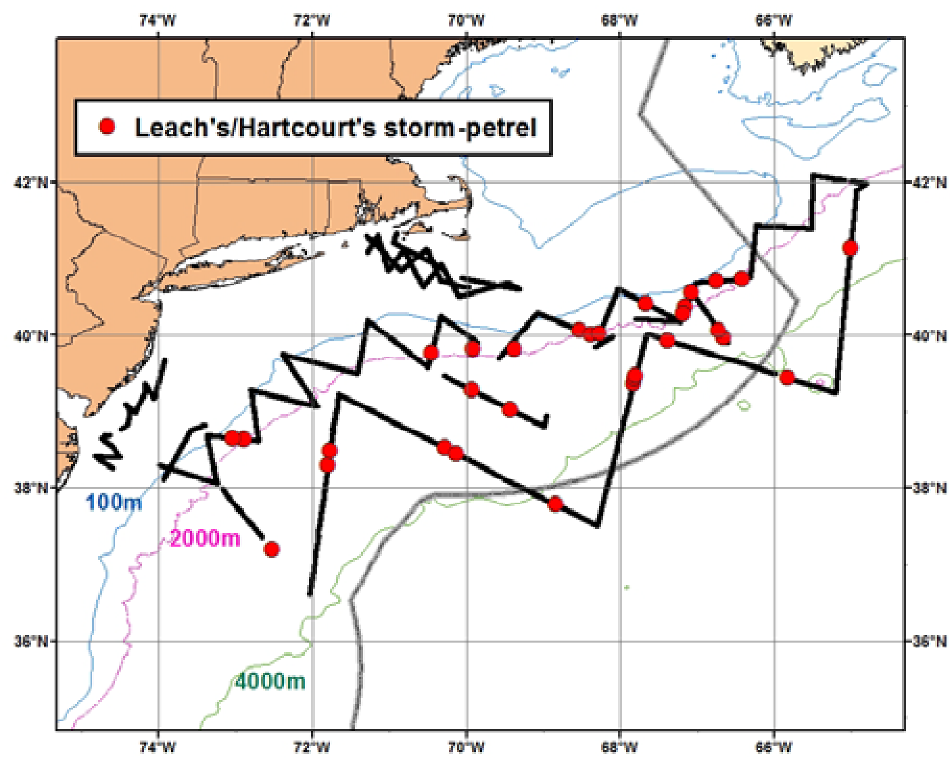


Figure 19. Location of Leach's storm-petrels (*Oceanodroma leucorhoa*; top), and Trindade petrel (*Pterodroma (heraldica) arminjoniana*; bottom) sightings detected by the seabird team.

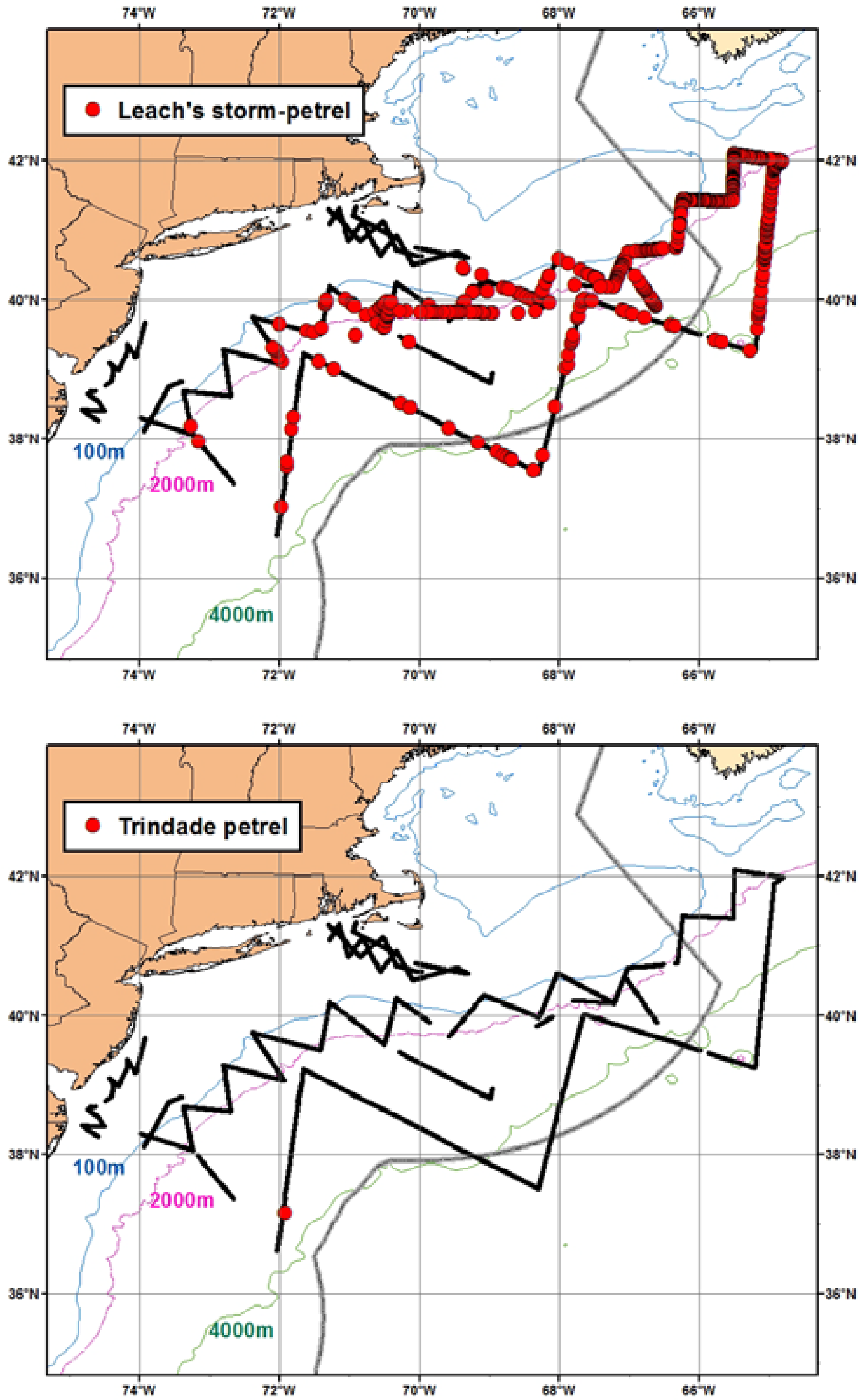
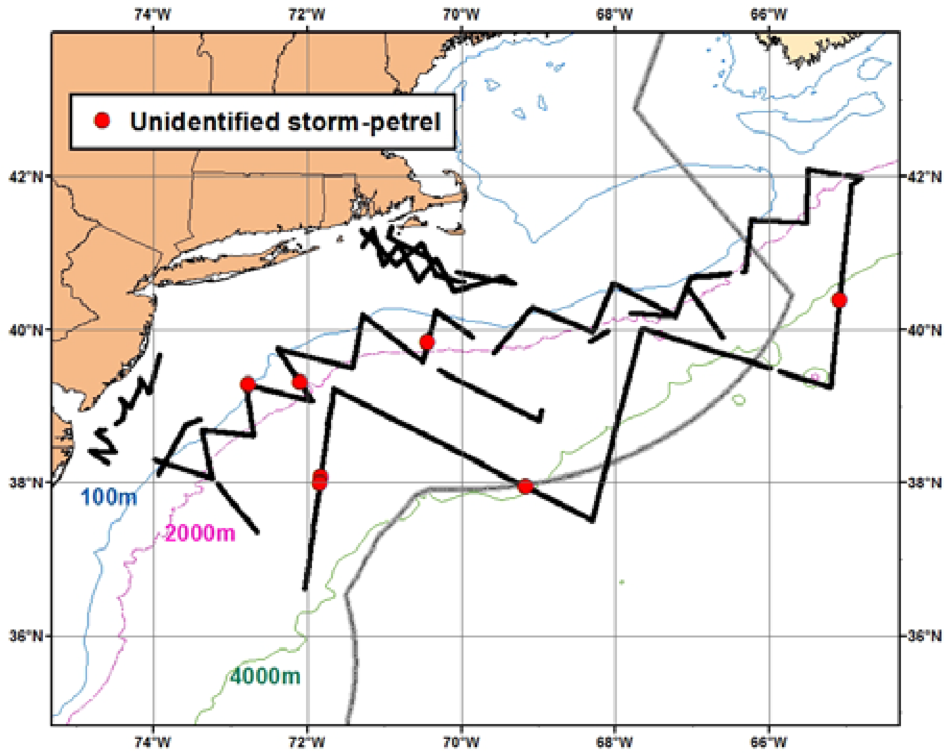


Figure 20. Location of unidentified storm-petrels (Oceanodroma sp.; top), and white-faced storm-petrel (*Pelagodroma marina*; bottom) sightings detected by the seabird team.



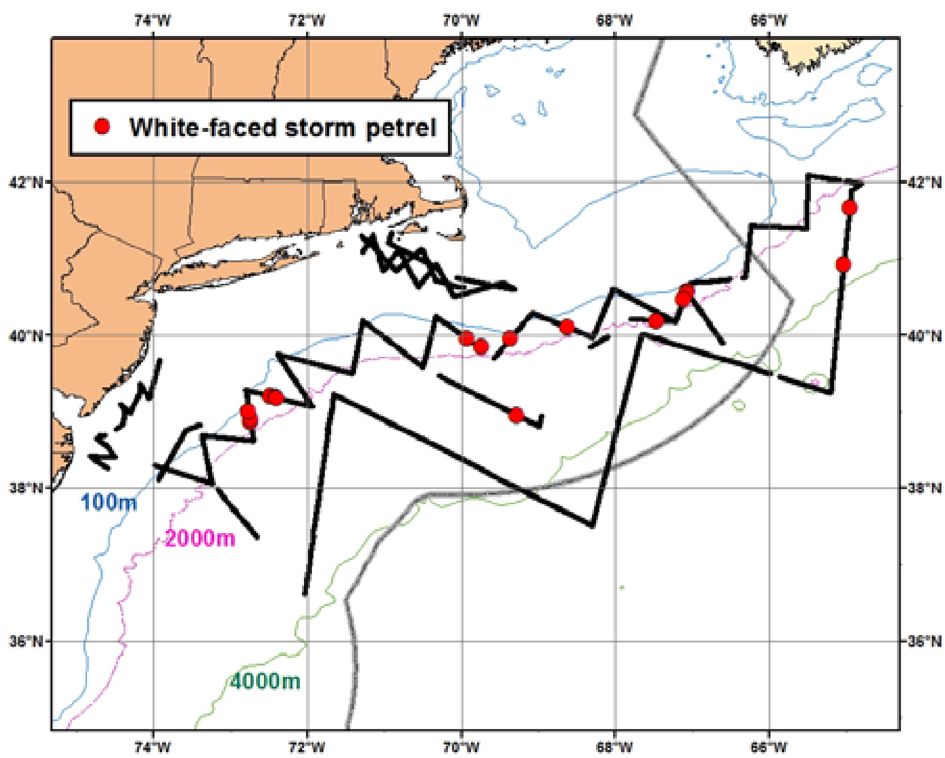


Figure 21. Location of Bridled terns (*Onychoprion anaethetus*; top), and Common tern (*Sterna hirundo*; bottom) sightings detected by the seabird team.

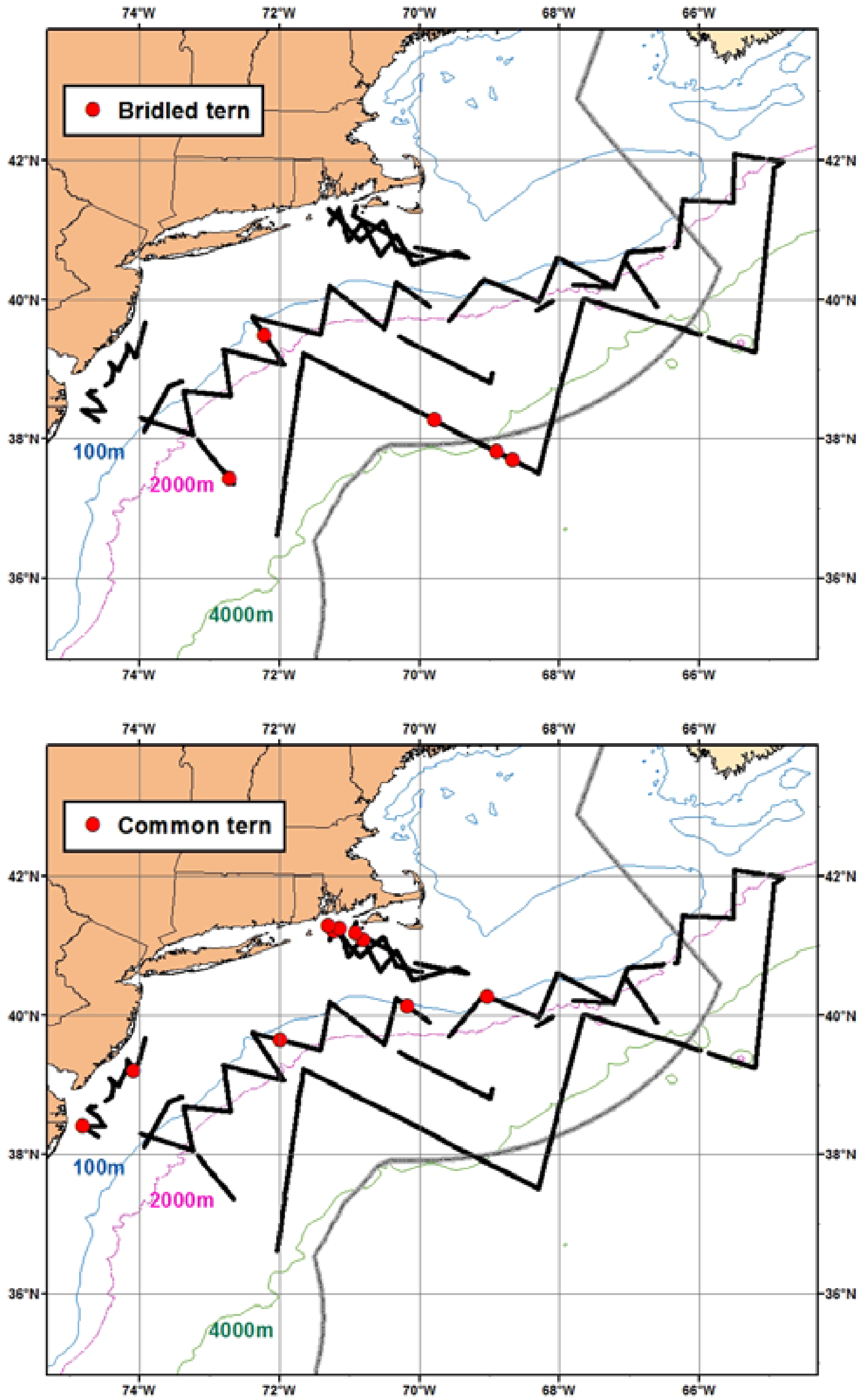
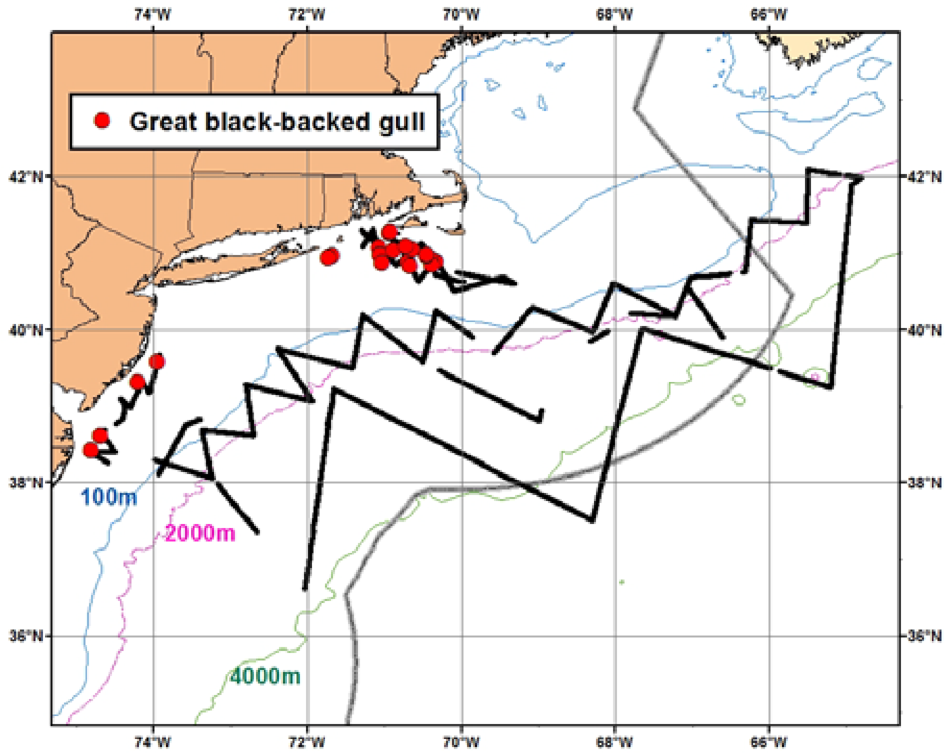


Figure 22. Location of Great black-backed gulls (*Larus marinus*; top), and Herring gull (*Larus argentatus*; bottom) sightings detected by the seabird team.



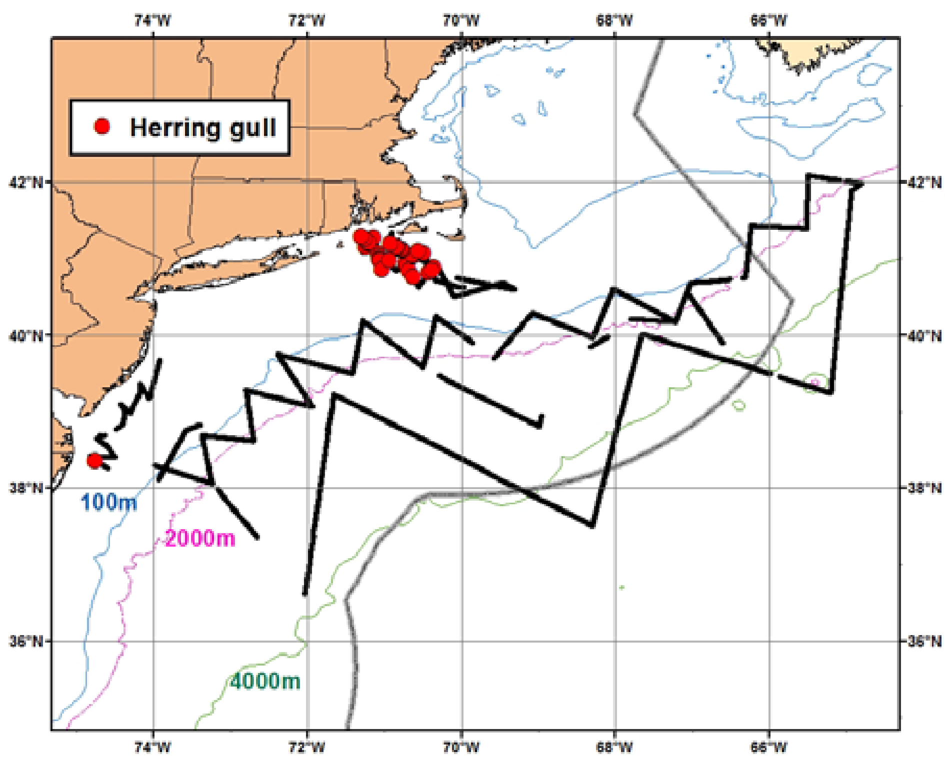
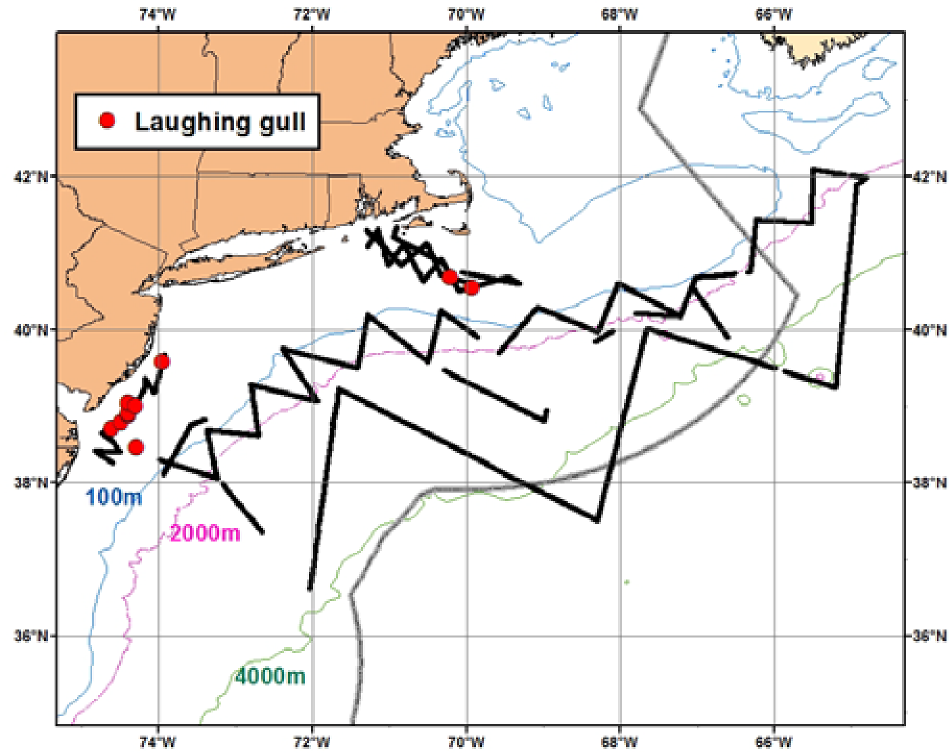


Figure 23. Location of Laughing gulls (*Leucophaeus atricilla*; top), and Parasitic jaeger (*Stercorarius parasiticus*; bottom) sightings detected by the seabird team.



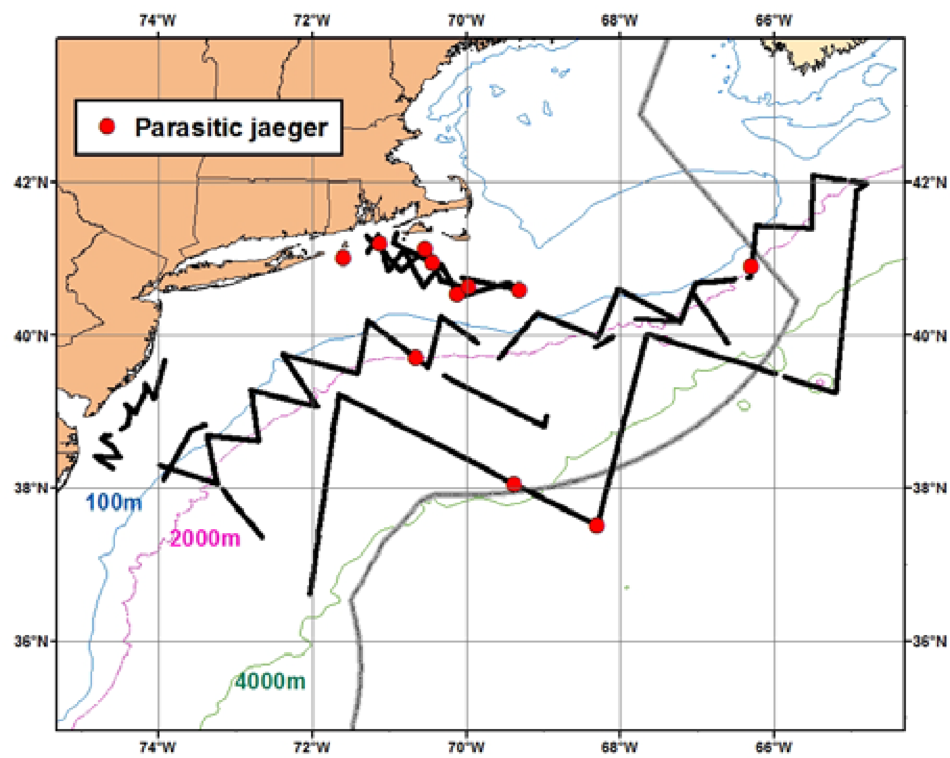
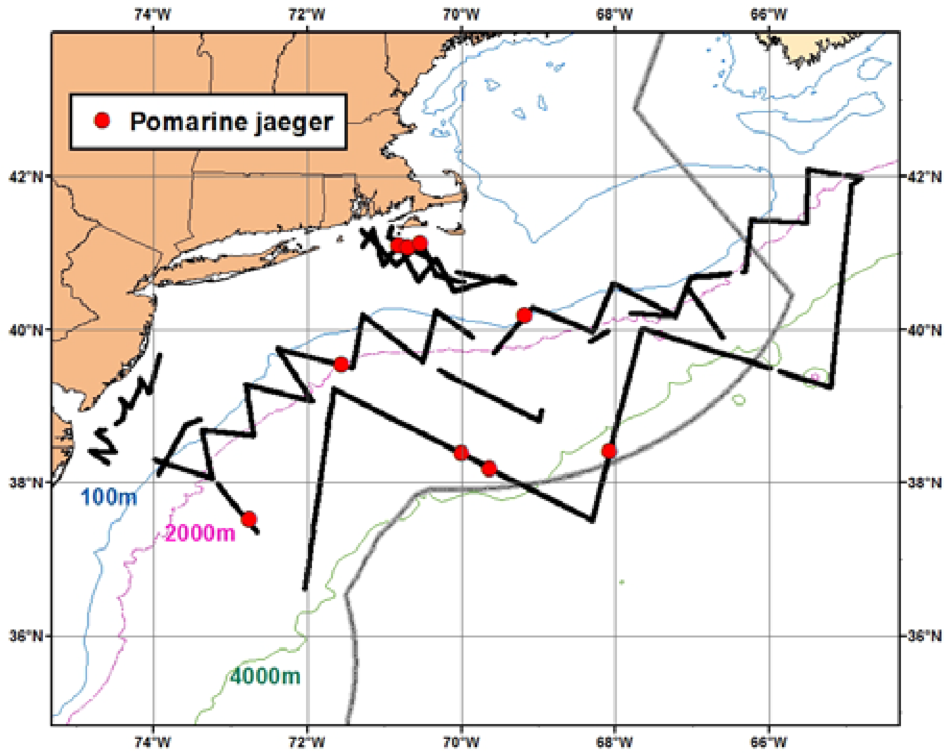


Figure 24. Location of Pomarine jaeger (*Stercorarius pomarinus*; top), and White-tailed tropicbirds (*Phaethon lepturus*; bottom) sightings detected by the seabird team.



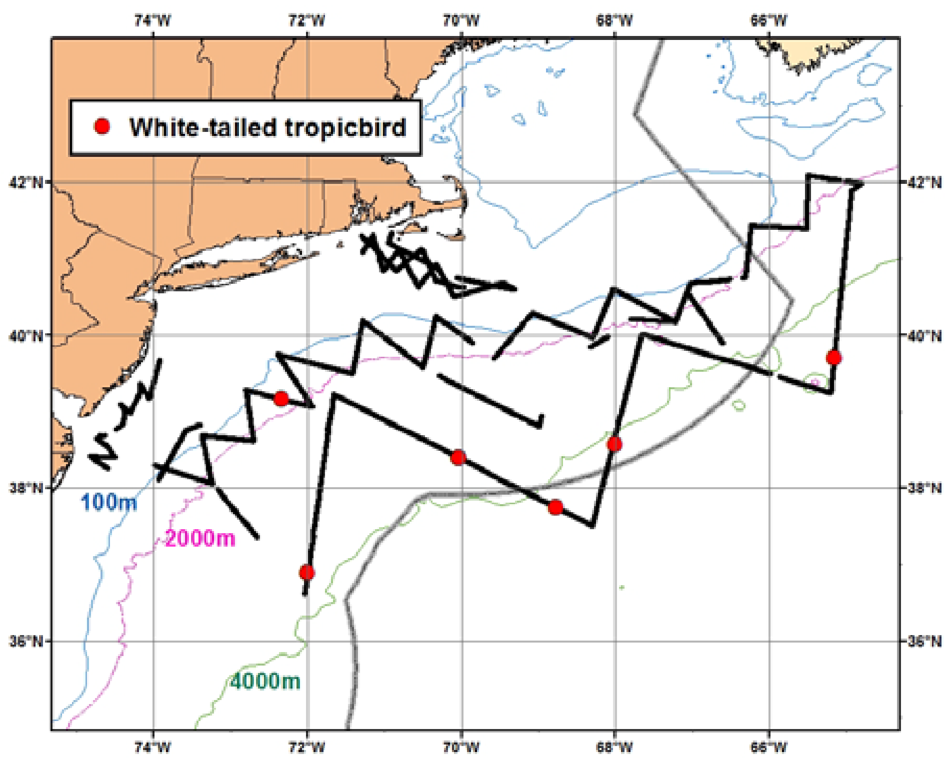


Figure 25. Acoustic recording effort and location of the *NOAA ship Henry B. Bigelow* during acoustic detections of vocally-active cetacean groups. Purple lines indicate daytime recording effort, during which time all data were reviewed in real-time. Blue lines indicate evening recording effort. Black dots indicate ship's location during acoustic events. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

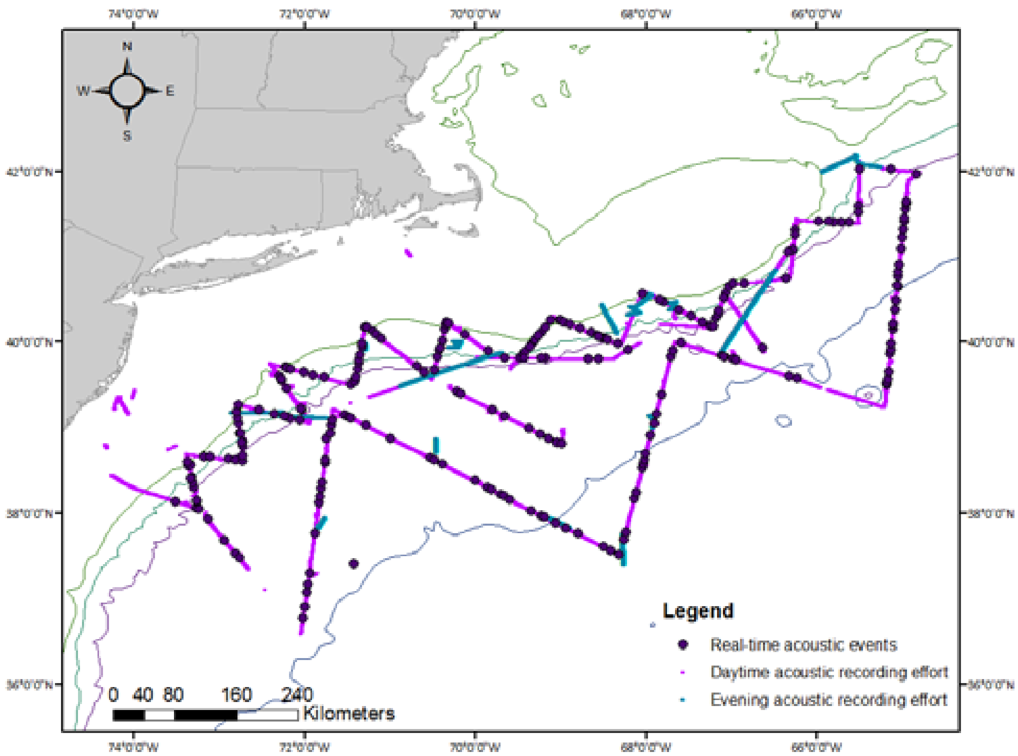


Figure 26. Acoustic detection of sperm whales. Purple lines indicate daytime recording effort; orange squares indicate the location of the *NOAA ship Henry B. Bigelow* during detections of sperm whales.

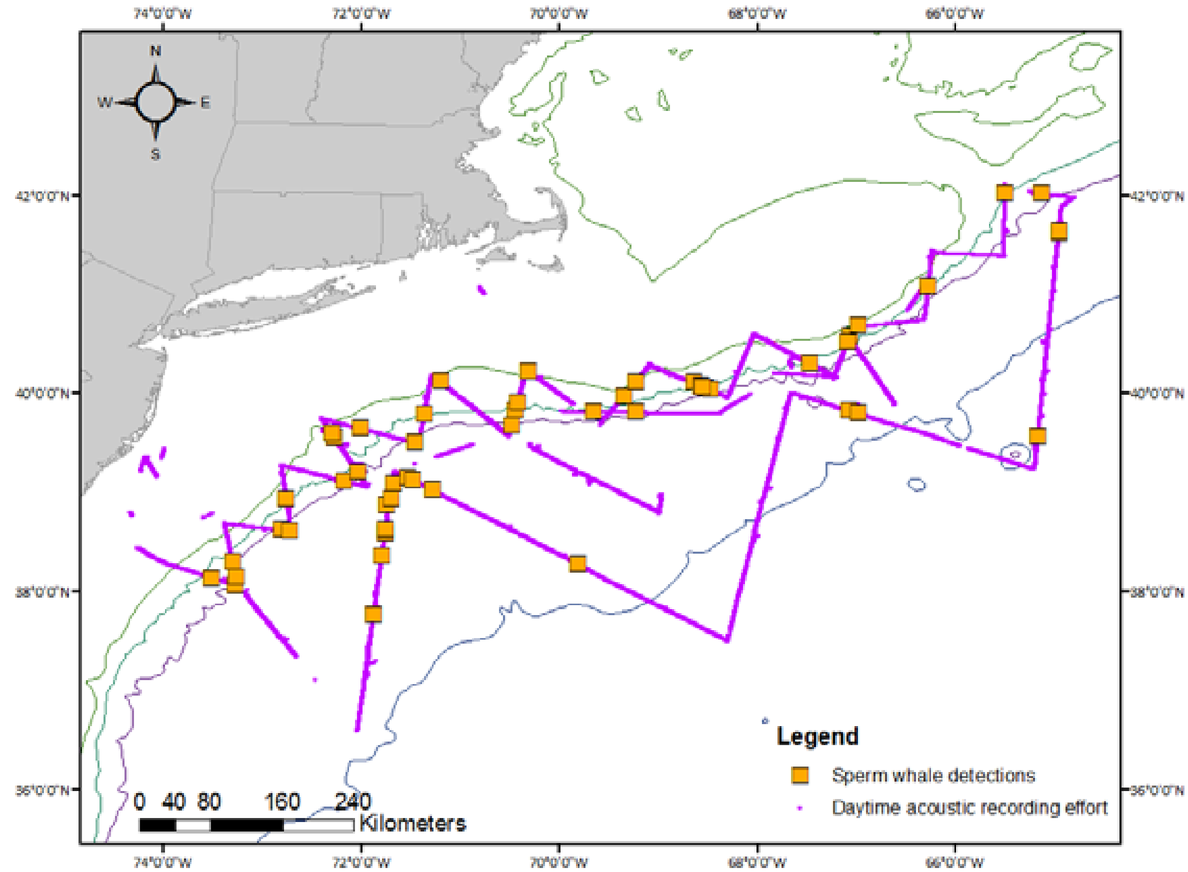


Figure 27. (Left) Photo of a marine autonomous recording unit (MARU). The yellow harness lines and white float are good points for grappling with the boat hook. The black power lines and the white burn connector (on the right side of the picture) should be avoided when attempting to retrieve it.

(Right) Map showing the tracklines for the AMAPPS survey (orange) and the locations of the five MARUs (purple dots).

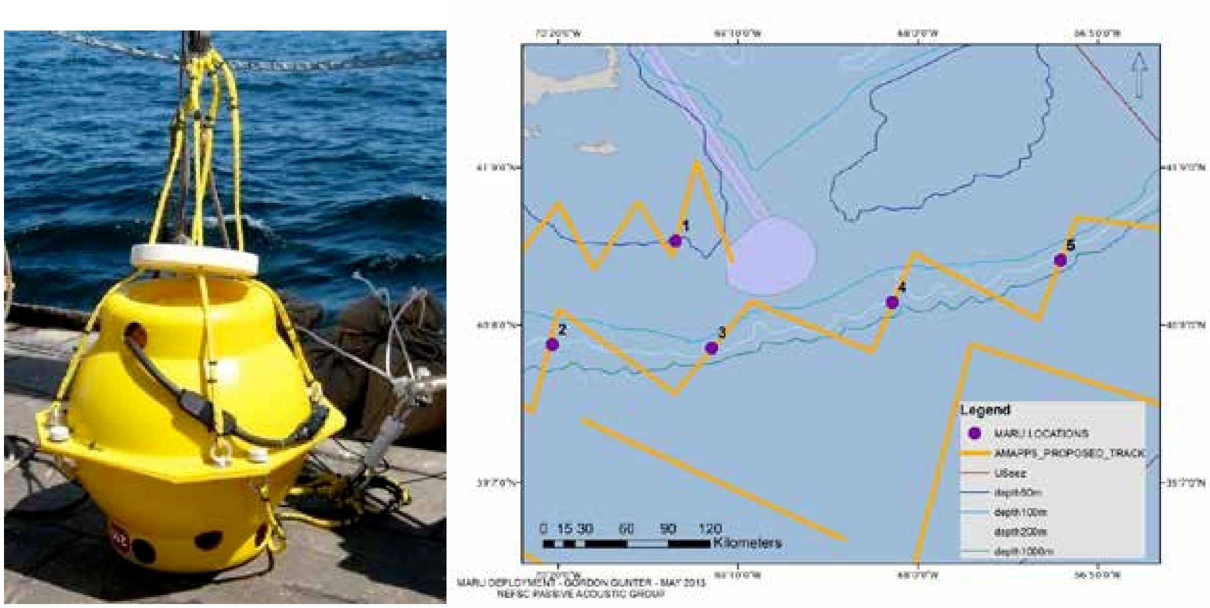


Figure 28. Overall view of the locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS.

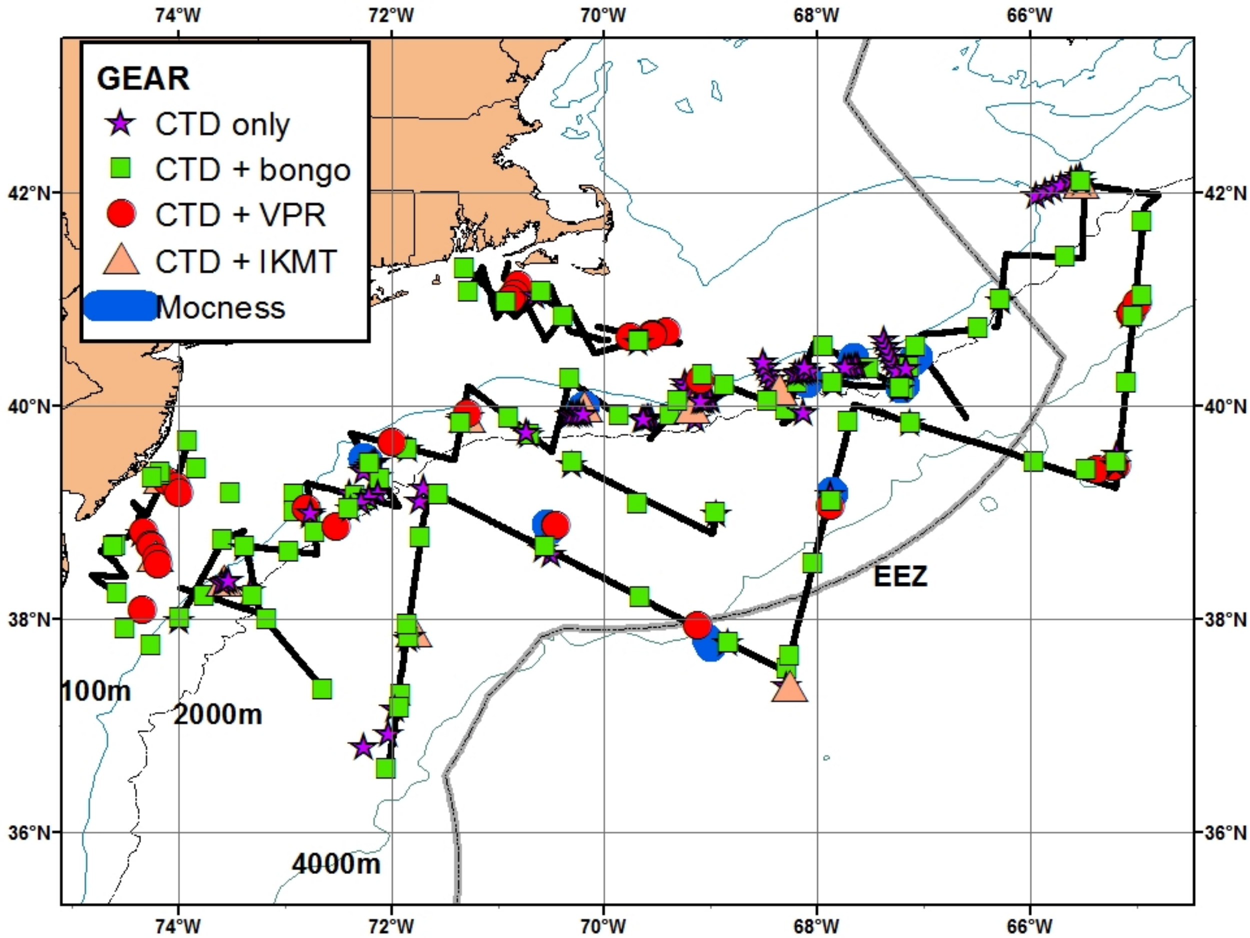
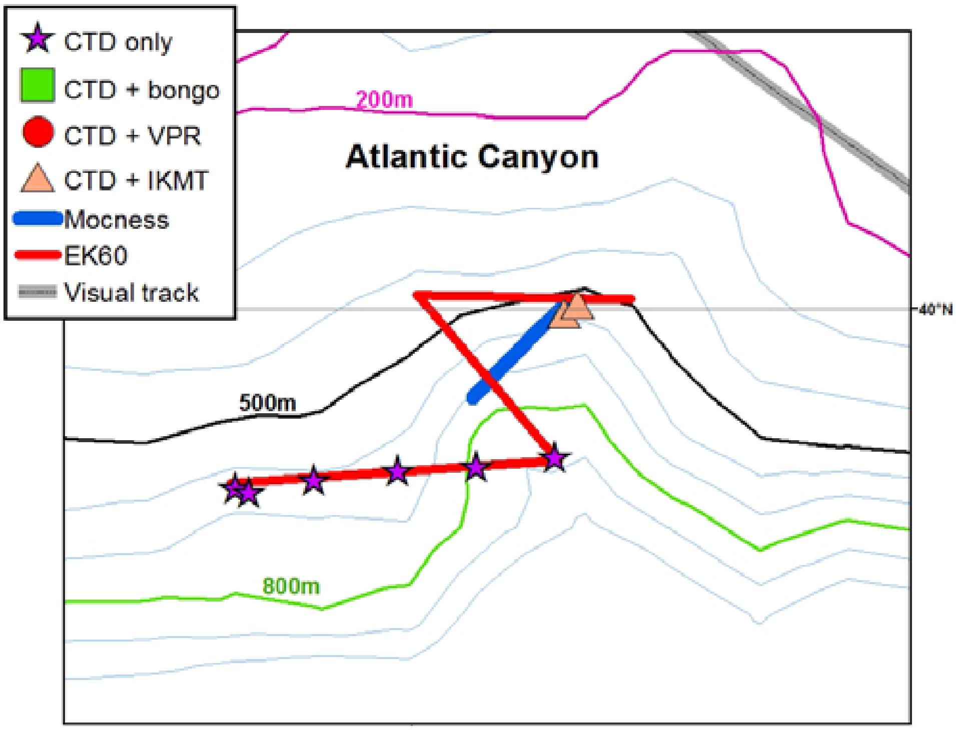


Figure 29. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near Atlantic Canyon; Bottom: near Hudson Canyon.



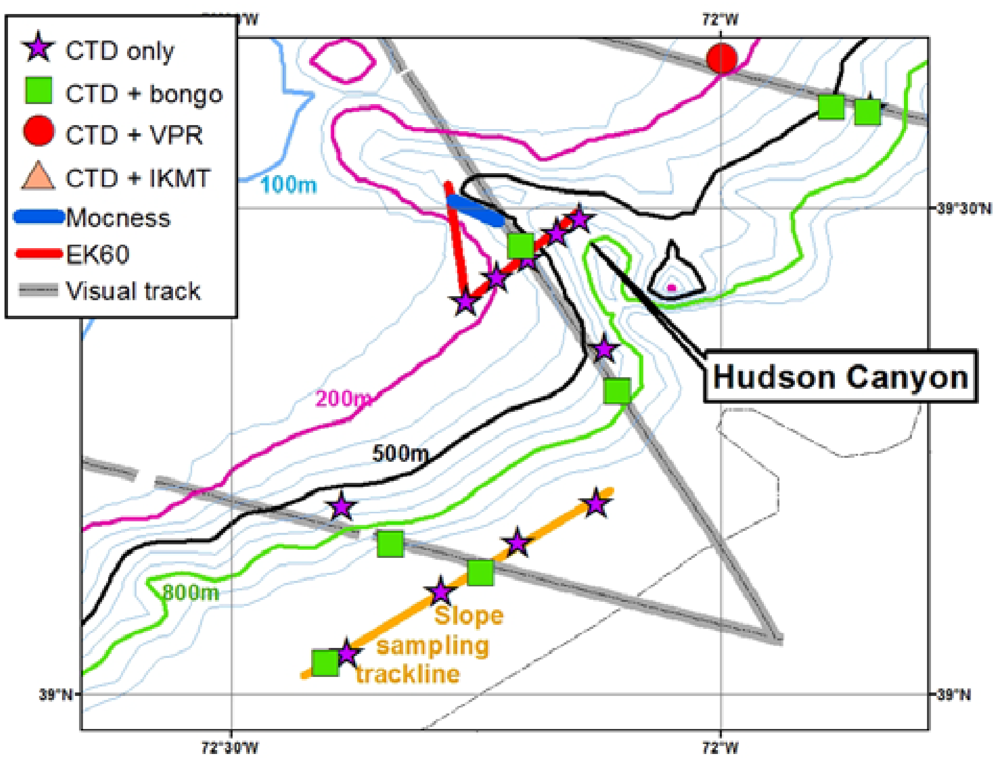


Figure 30. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near Hydrographer Canyon; Bottom: near Lydonia Canyon.

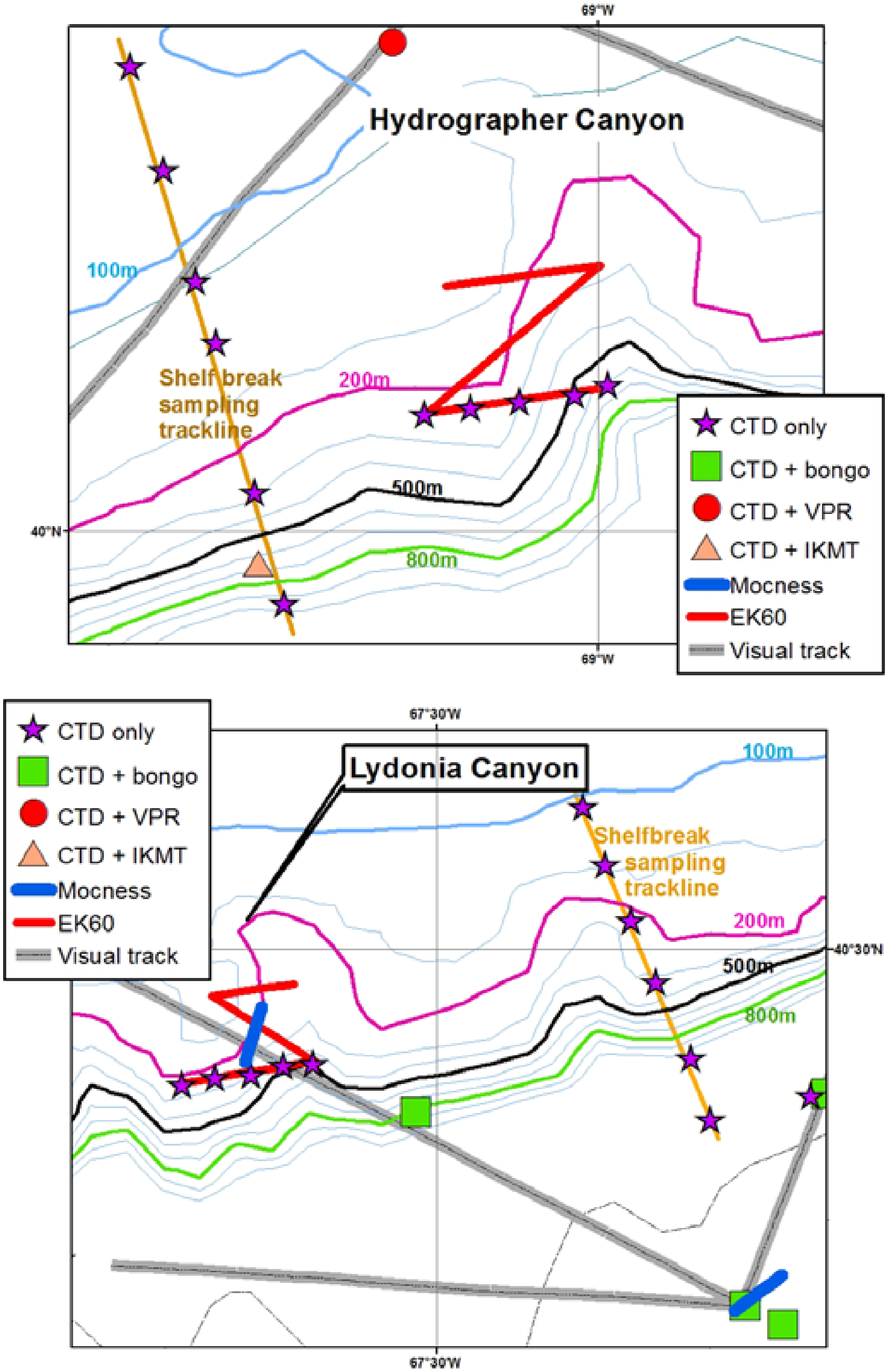
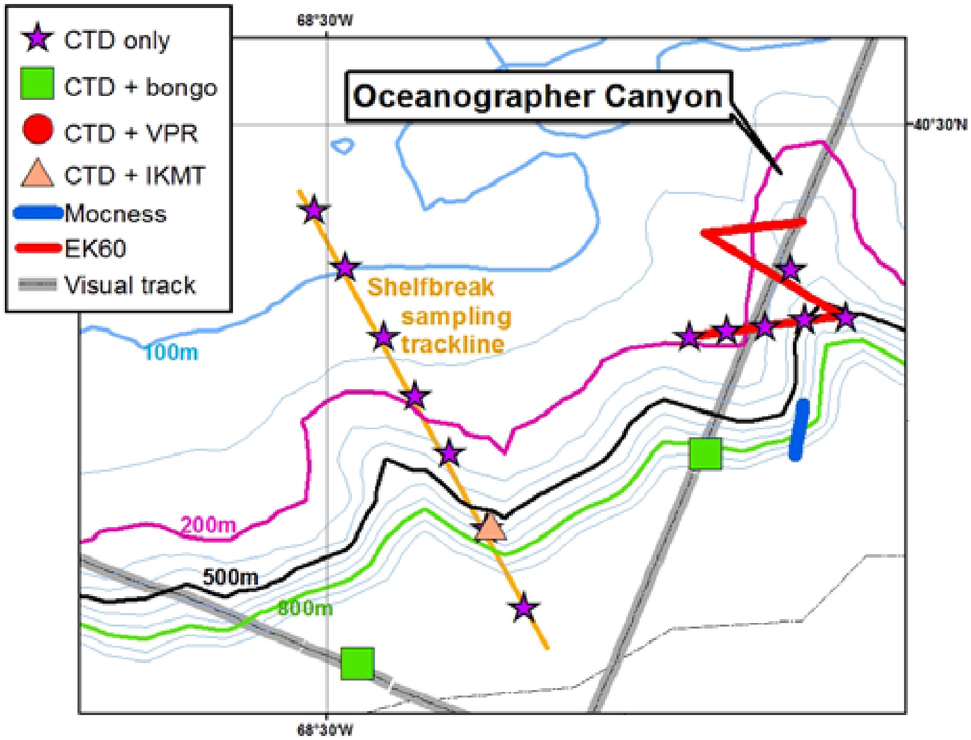


Figure 31. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near Oceanographer Canyon; Bottom: near Wilmington Canyon.



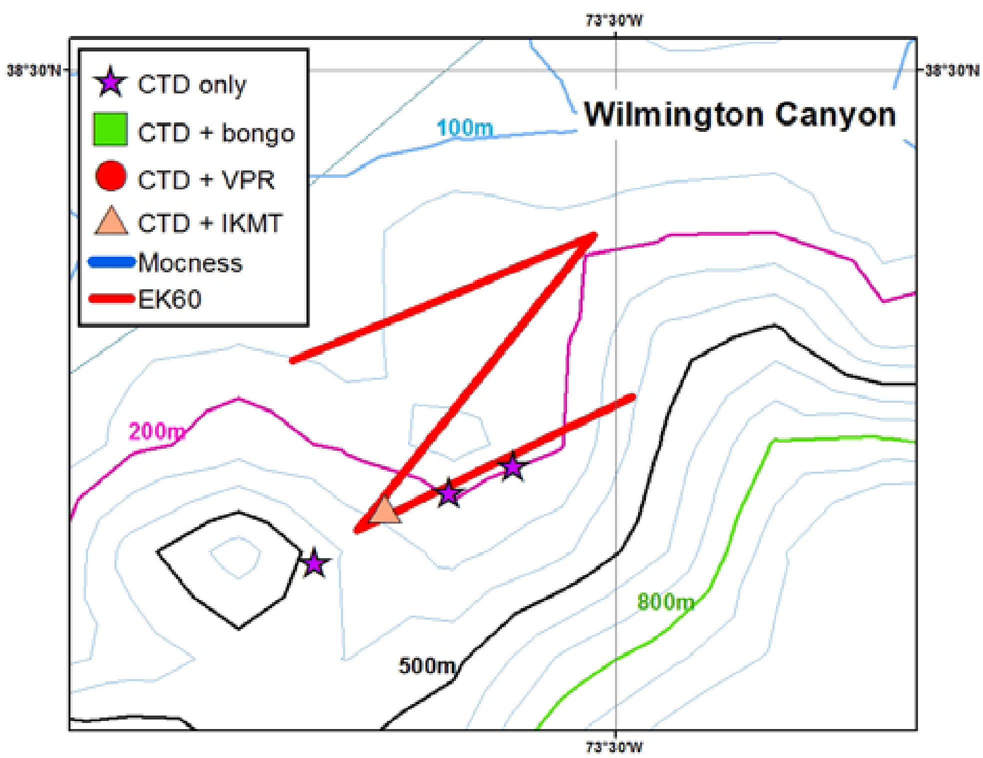


Figure 32. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near the BOEM-MA stratum; Bottom: near BOEM-MidAtl stratum.

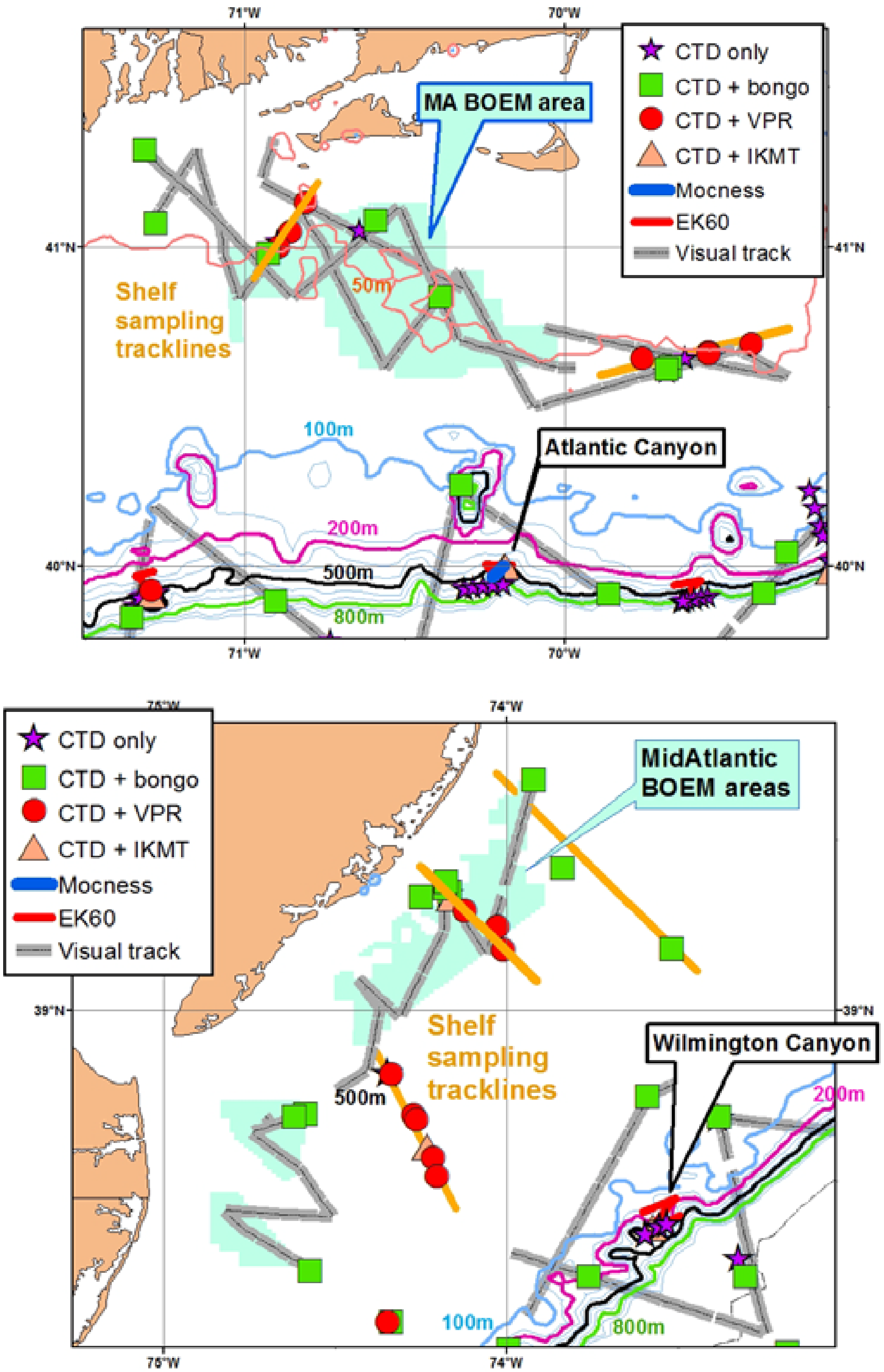


Figure 33. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT) , and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Near the Northeast Channel, east of Georges Bank.

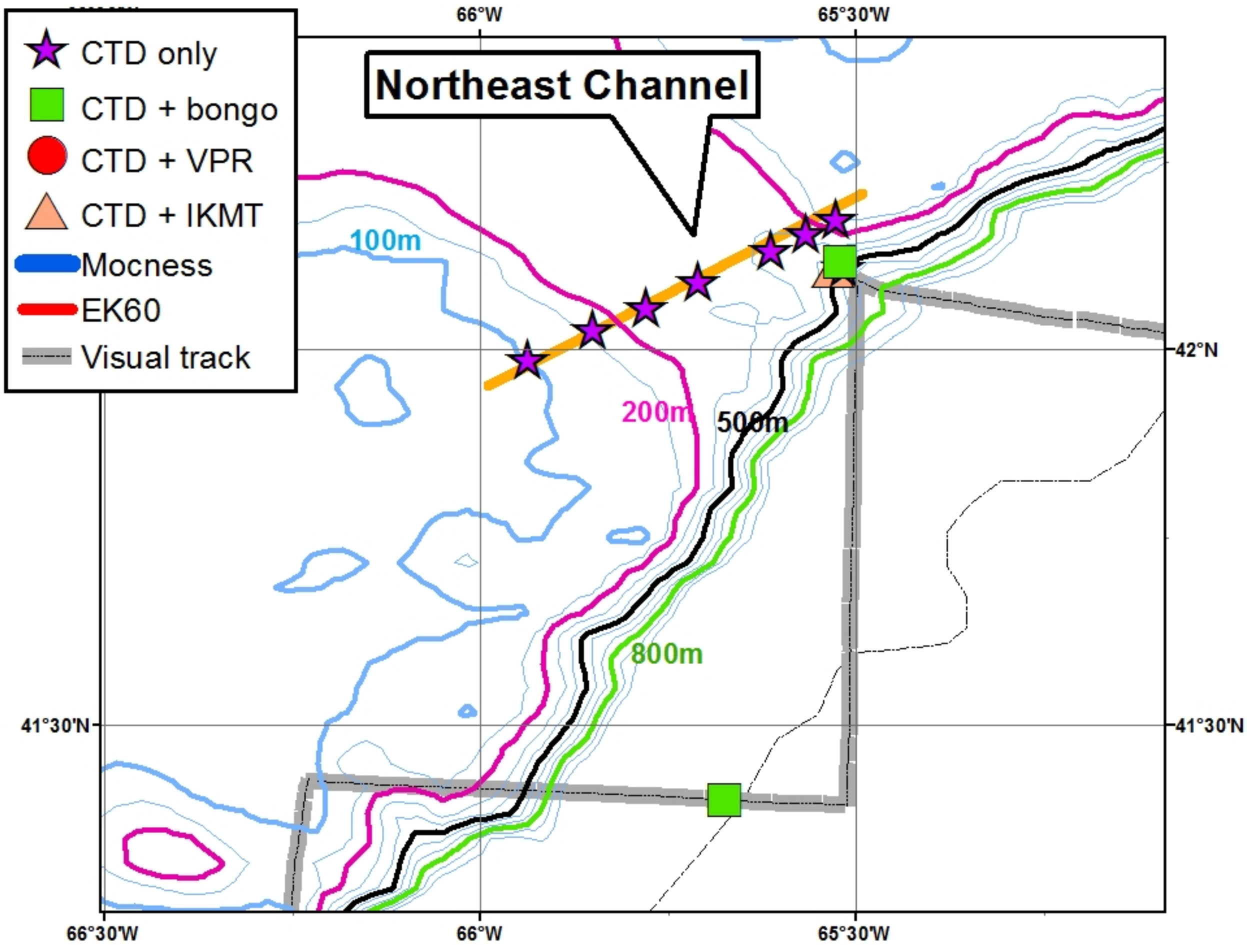


Figure 34. Raw EK60 Multi-frequency acoustic data collected along the mid-canyon transect in Wilmington Canyon showing strong scattering layers, especially at the lower (18 and 38 kHz) frequencies.

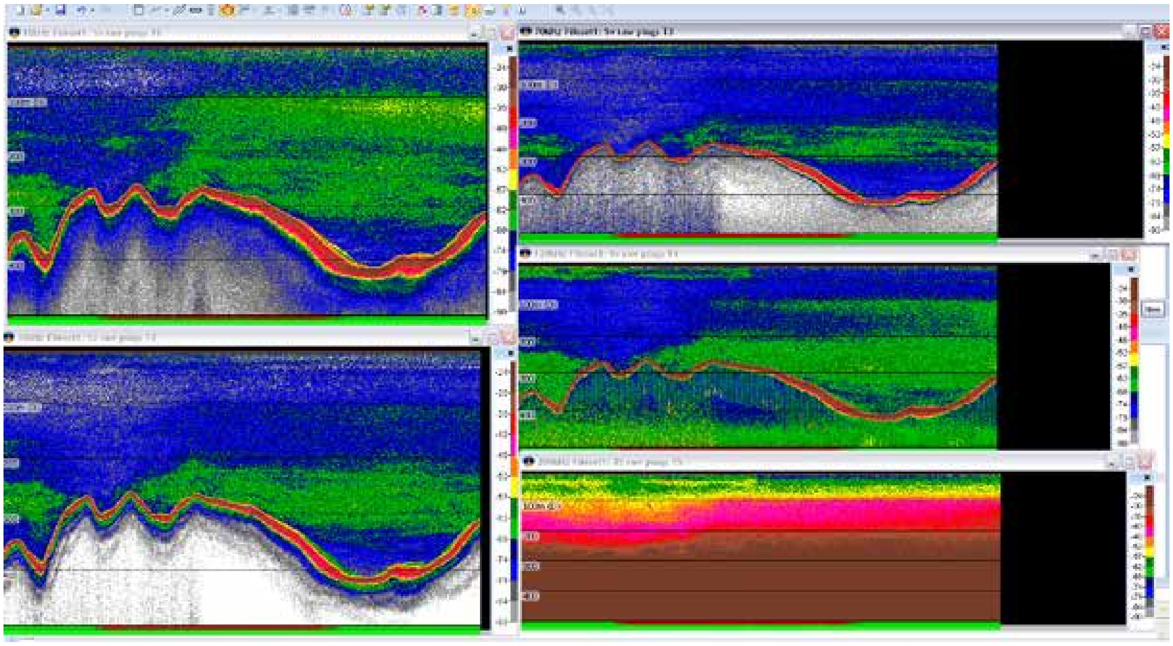


Figure 35. (a, upper panel) Processed EK60 Multi-frequency acoustic data collected along the shelfbreak transect east of Welker Canyon showing strong scattering layers at the 18kHz frequency. Post-processing involves removal from the raw data of unwanted returns from the seafloor, as well as removal of noise (e.g., surface bubbles, vessel noise, interference from other acoustic devices). (b, lower panel) Acoustic frequency response (i.e., backscattering vs. frequency) for the polygon denoted by 31 in the echogram of panel a. Scattering was highest at the lowest survey frequency (18 kHz), consistent with larger scatterers and/or small swimbladdered fish.

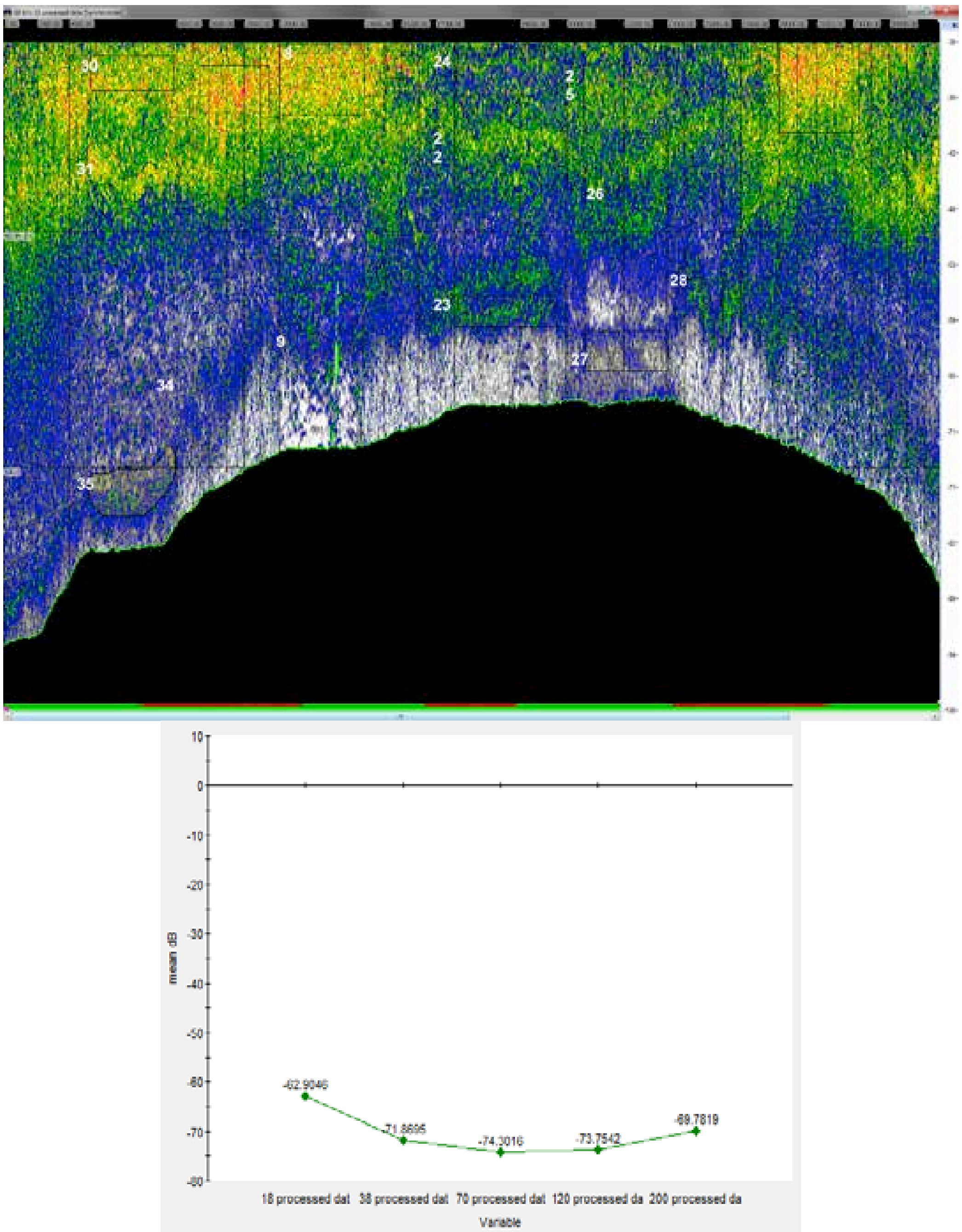


Figure 36. Euphausiids, *Thysanoessa sp.*, (right) and Hyperiids, *Themisto gaudichaudii*, (left) which were commonly collected in the 1m MOCNESS and IKMT.

Figure 37. Mesopelagic fishes, (a) pearlsides and (b) myctophids, commonly collected in the 1m MOCNESS and IKMT.

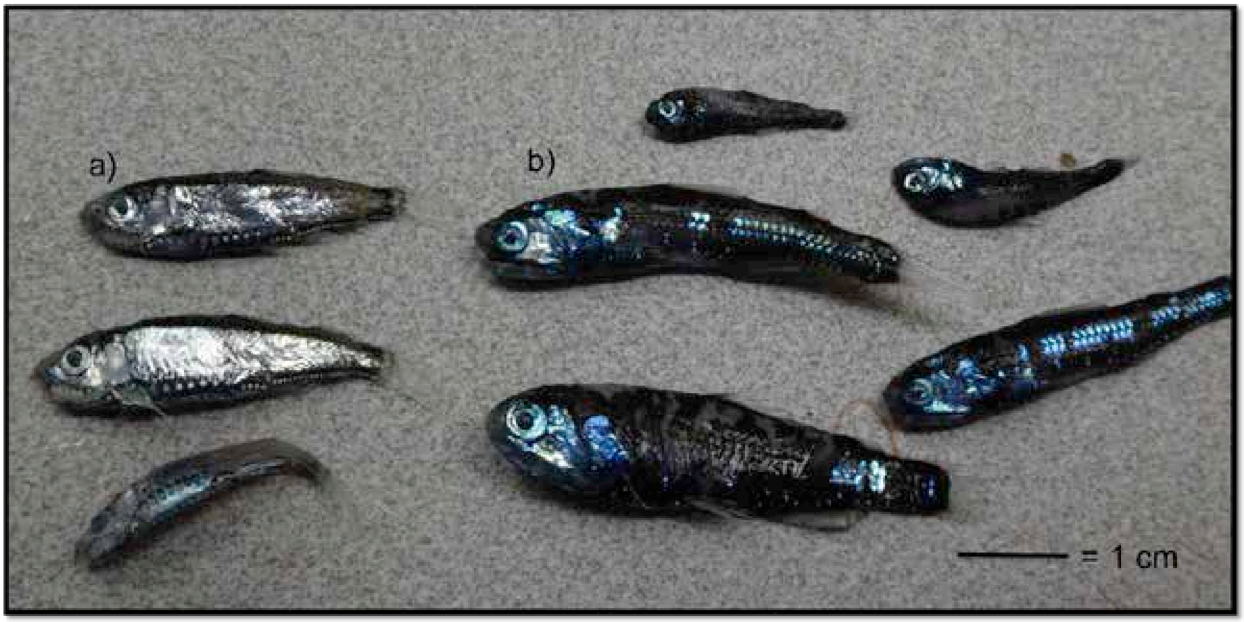


Figure 38. Typical oceanographic profile from the offshore transects characterized by high salinities and very low chlorophyll counts.

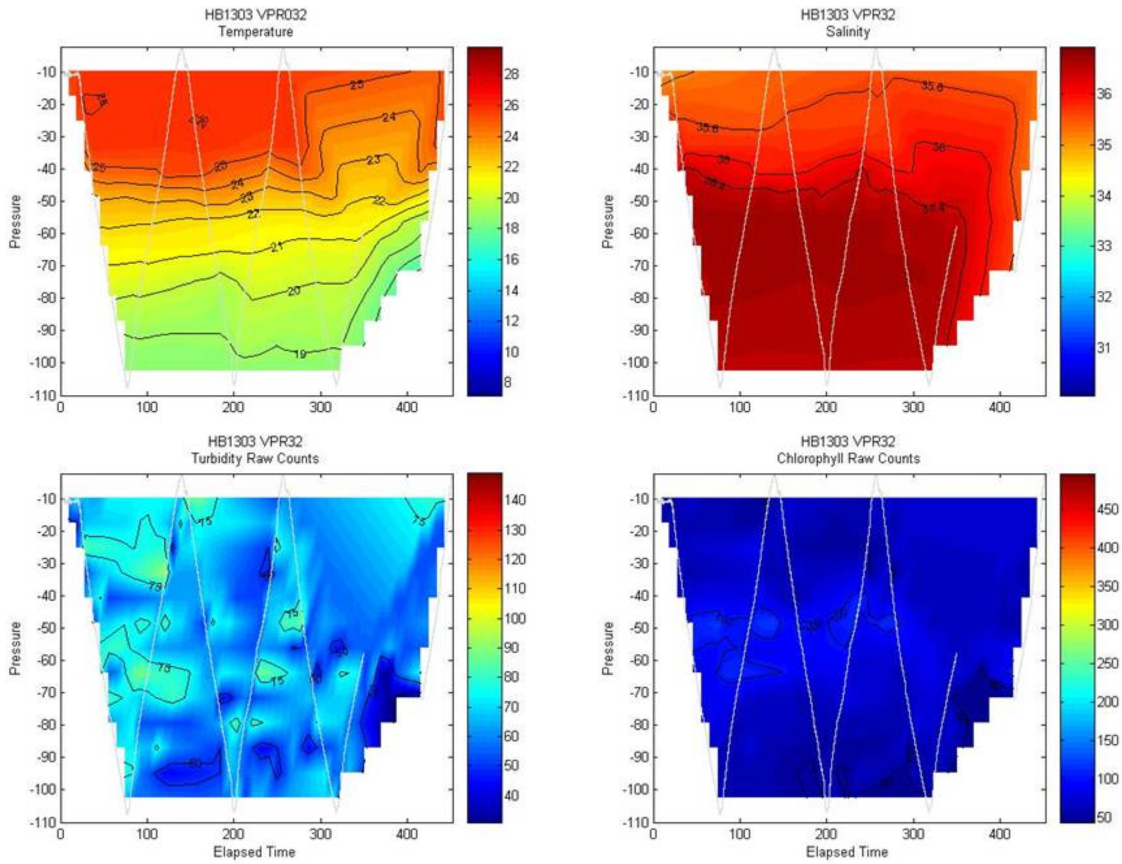


Figure 39. Gelatinous zooplankton images taken with the color VPR. From top left: leptomedusa (a), larvacean (b), siphonophore (c), dolid (d), hydromedusa (e).

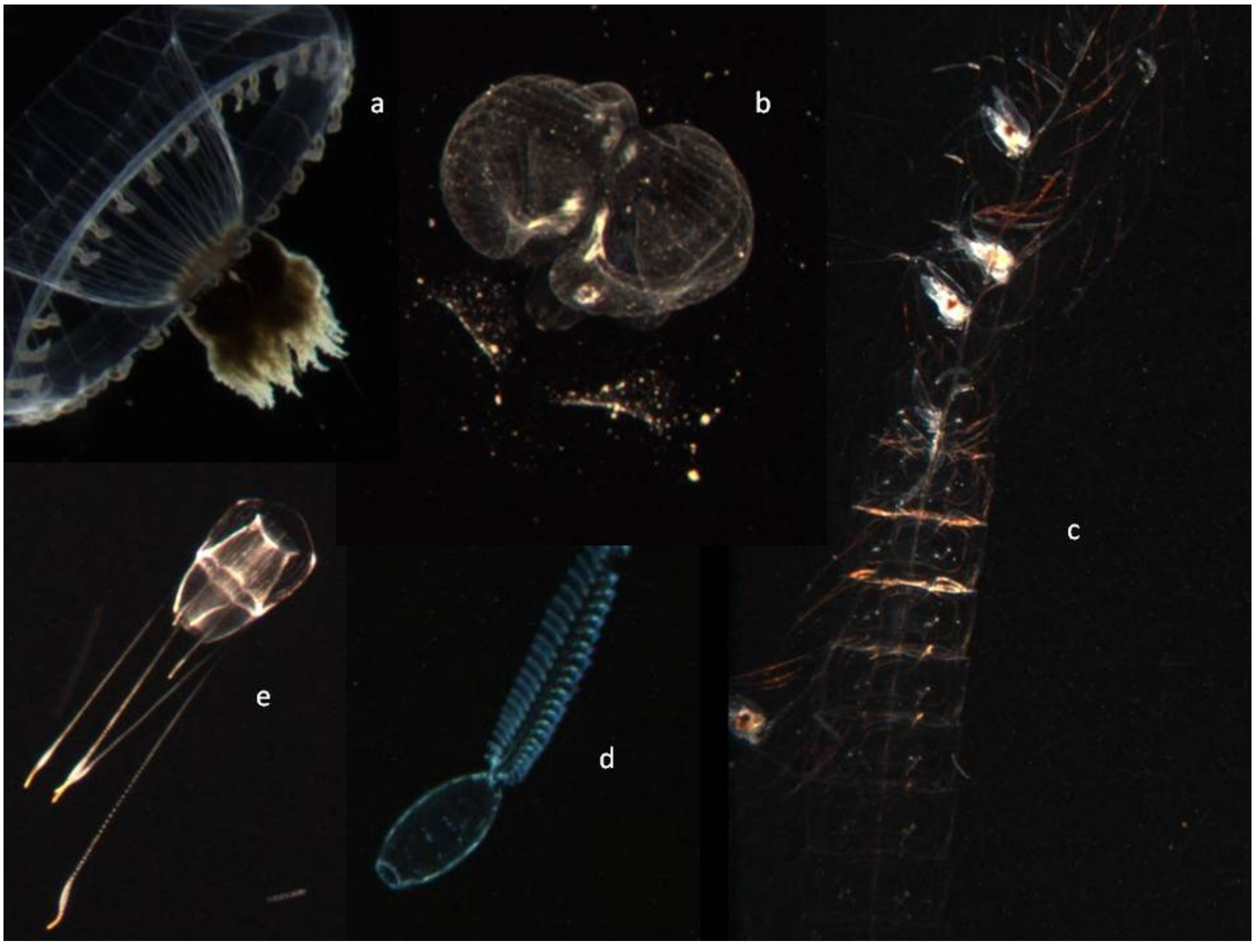


Figure 40. Salpa fusiformes was present in two forms: solitary (a) and colonial chains up to 1m in length (b).

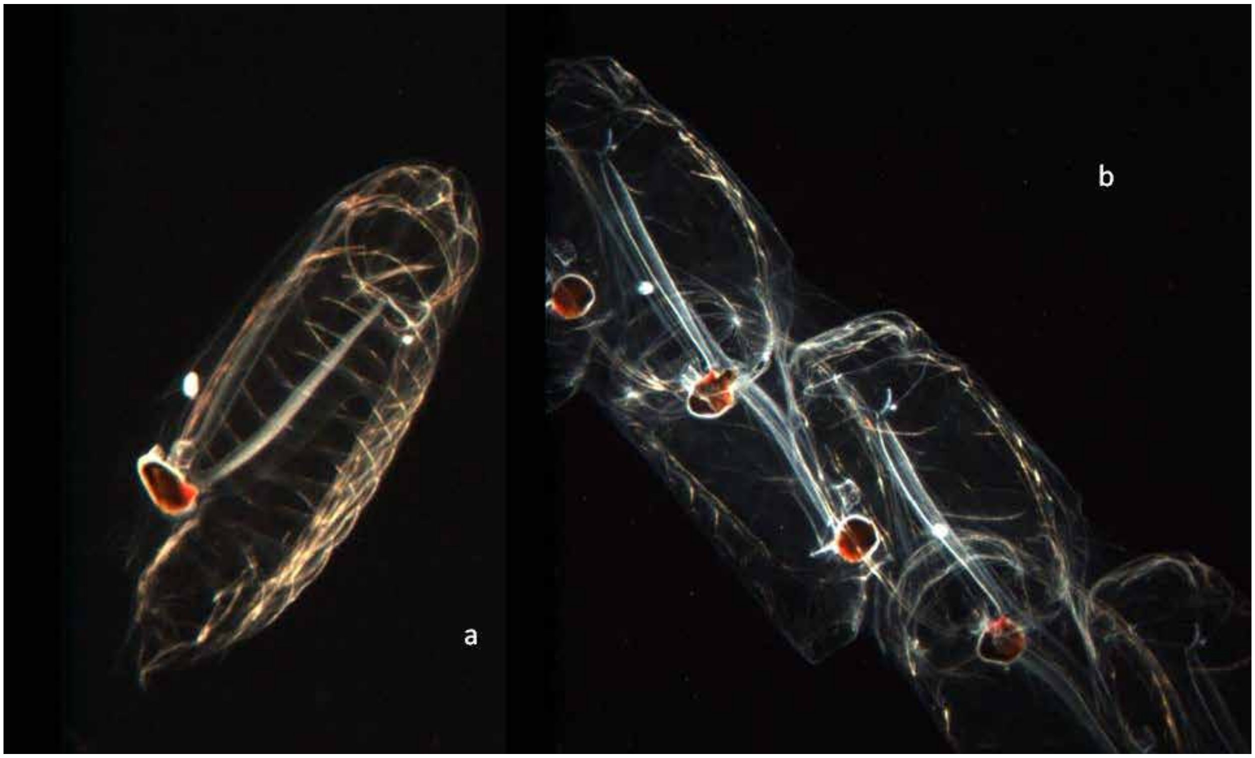


Figure 41. Typical southern NE oceanography showing a well defined thermocline with plankton and chlorophyll layers just below the thermocline.

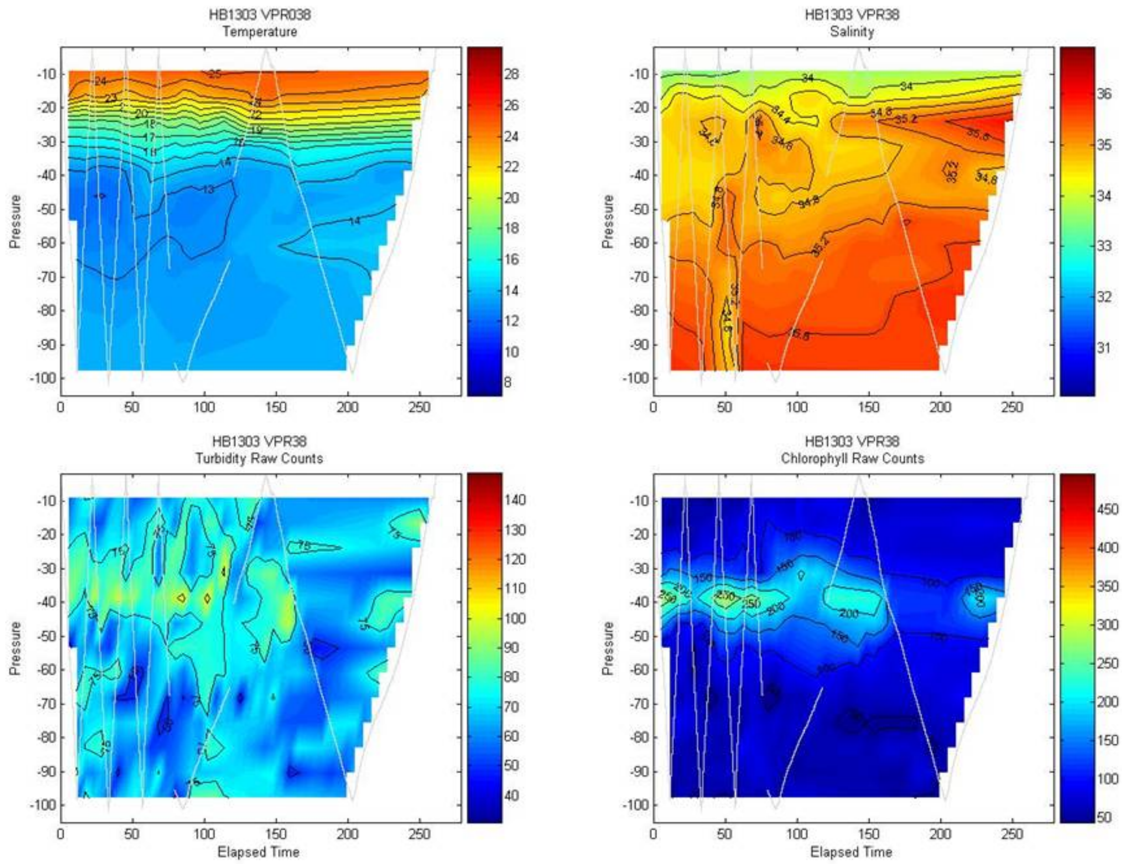


Figure 42. Oceanography offshore from the NE Channel of Georges Bank. The area shows the low chlorophyll and high salinity associated with offshore stations but has the well developed thermocline typical of the Georges Bank area.

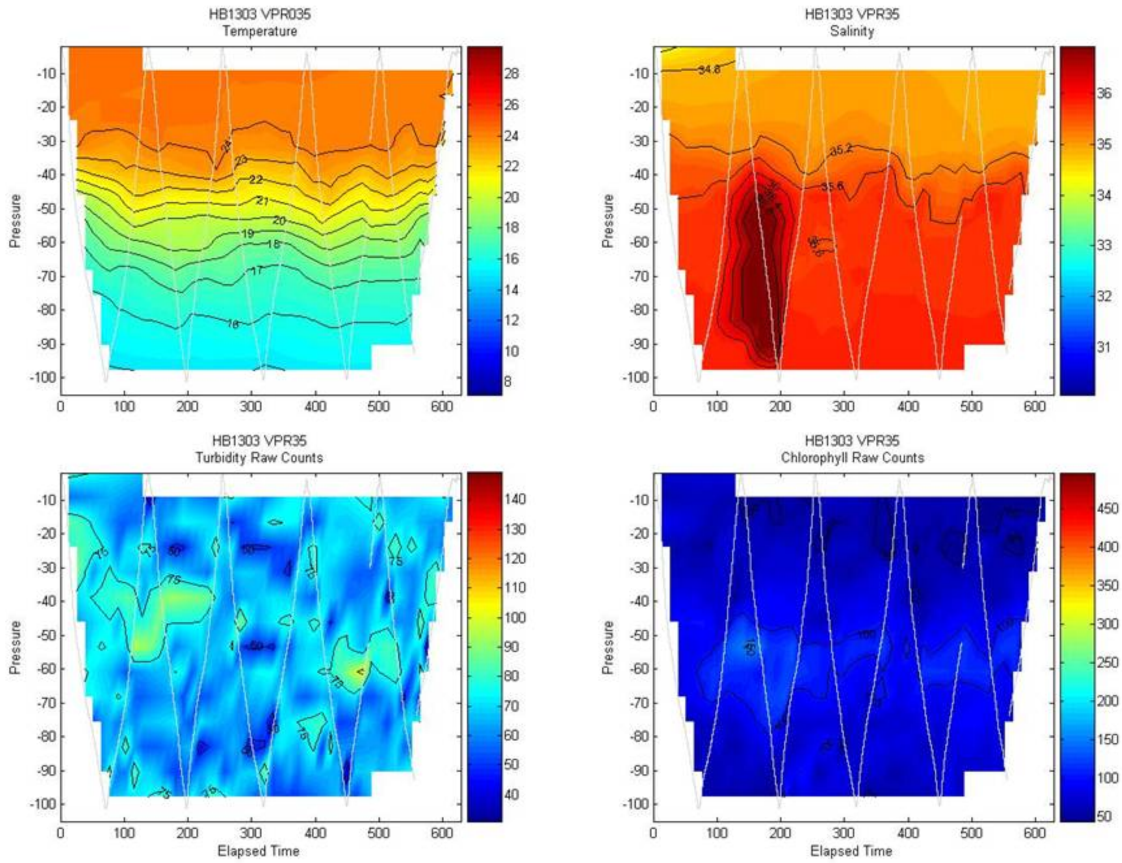


Figure 43. Oceanography on Nantucket shoals showing cooler water temperatures, moderate thermoclines, with strong layers of chlorophyll and plankton associated with the thermocline.

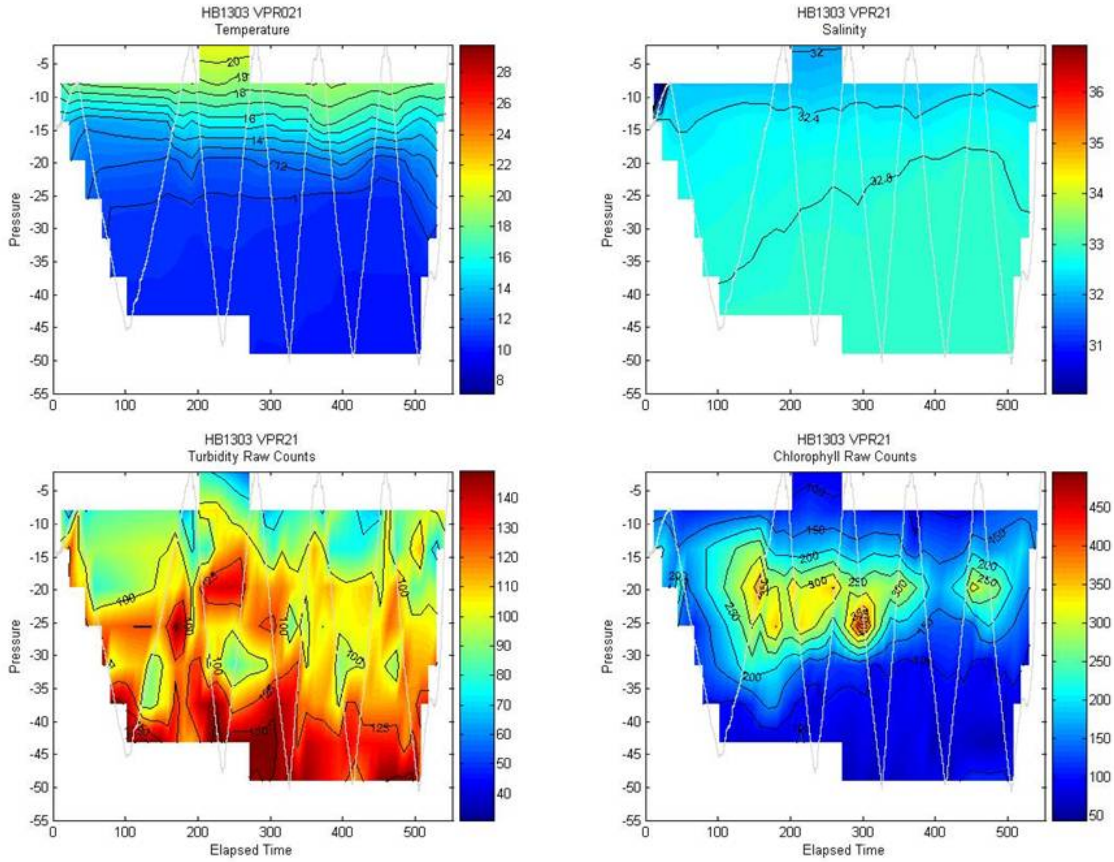


Figure 44. plankton images taken with the color VPR. From top left *Themisto gaudichaudii* (a), *Meganyctiphanes norvegica* (b), *Phoronima sp.* (c), copepod (d), gammarid amphipoda (e).