10 Aug 2011

CRUISE RESULTS

R/V HENRY B. BIGELOW
Cruise No. HB11-03

Cetacean and Turtle Abundance Survey

CRUISE PERIOD AND AREA

The cruise was scheduled for June 2 – August 1, 2011 and was divided into three legs: June 2 – 22, June 27 – July 15, and July 20 – August 1.

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 64° 30'W longitude), and west of the US coast (about 75° W longitude). This is waters shallower than about 4500 m and 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) determine the distribution and relative abundance of plankton and other trophic levels, 4) collect hydrographic and meteorological data, 5) when possible, collect biopsy samples and photo-identification pictures of cetaceans, and 6) develop data entry programs to improve the collection of visual sightings data of sea birds and 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 four and below) while traveling at about 10 to 12 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 which saved the data into an Access database (version 1 used on leg 1; version 2 used on legs 2 and 3; developed by L. Garrison and 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 the computerized data entry program "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 and height, Beaufort sea state, presence of rain or fog, amount of cloud coverage, visibility (i.e., approximate maximum distance that can be seen), and glare width and glare strength.

VISUAL SEA BIRD SIGHTING TEAM

From an observation station on the flying bridge, about 15.1 m above the sea surface, one to three observers conducted a visual survey dedicated for marine birds during daylight hours, approximately 0600-1800 with a 1 hour break at lunchtime. Seabird observation effort employed a modified 300 m strip and line transect methodology, where 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 zone, with frequent scans of the perimeter using hand-held binoculars for cryptic hard to detect species. Binoculars were used for scanning and to confirm identification. All birds including non-marine species, such as herons and swallows, were recorded.

Operational limits are higher for seabird surveys as compared to the above marine mammal and turtle surveys. As a result, seabird survey effort was possible in sea states above Beaufort 4, 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, but this was modified on legs 1 and 2 when frequently two observers would be on effort simultaneously.

All data were entered in real time into a laptop computer running *Seebird* linked to the ship's navigation system via a serial/RJ-45 cable. The *Seebird* software 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 molt condition, if possible, 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 to 10 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 acoustic monitoring team consisted of 2 – 3 people who operated the system in two-hour shifts from 0600 – 1800 or later. The hydrophone array was deployed at about 0545 each morning, and was retrieved at about 1130 for the midday bongo/CTD casts and at about 1800 at the end of the survey day. The acoustic team collected the passive acoustic data during all hours when the visual team was on-effort, with the following two exceptions: 1) during Leg 1, repairs to the hydrophone array resulted in the loss of approximately 15 hours of acoustic monitoring effort; 2) during Legs 2 and 3, the array was not deployed along coastal tracklines, where it was considered too shallow for safe deployment. The acoustic team also monitored on some occasions when weather conditions prevented the visual team from operating.

Passive acoustic data were collected via one of two different oil-filled towed hydrophone arrays, towed 300 m behind the vessel. The primary array, used for 63% of the survey days, was comprised of three mid-frequency elements being sampled at a rate of 192 kHz. The secondary array, utilized during the remaining survey days, was comprised of two mid-frequency elements, also sampled at a rate of 192 kHz. The high-frequency system, sampled at a rate of 500 kHz, failed two days into the survey and was not used for subsequent data collection.

Acoustic data were routed to a desktop computer via an external RME Fireface 400 soundcard and were recorded continuously utilizing the software package PAMGUARD (http://www.pamguard.org/home.shtml), at all times when the array was deployed. Two-channel data were also routed to a second set of computers via an external M-Audio soundcard, sampling at 44kHz, for real-time detection and tracking of vocal animals utilizing 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. Acoustic detection data were manually saved to an Access database, which also included real-time GPS positions of the ship.

CTD casts made at the start of each day and at midday provided data on temperature, depth and salinity at the tow depth of the array (typically from 8 -15 m). These data were used to calculate the sound speed for the purpose of estimating accurate bearing to vocal animals.

Passive acoustic data were also opportunistically collected using the ship's centerboard-mounted hydrophone, during instances when the ship was not travelling and animals were in the area.

HYDROGRAPHIC AND PLANKTON CHARACTERISTICS

In addition to the ship's SCS logger system that continuously recorded oceanographic data from the ship's sensors, a SEACAT 19 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, if the oceanography profiles showed an area of steady salinity values, a vertical profile was done with the CTD and a Niskin bottle attached to the wire above the CTD to collect a water sample which will be used to calibrate the conductivity sensor of the CTD.

A 61 cm bongo plankton net equipped with one 333 µm and one 505 µm mesh net with the 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 MARMAP 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.

Special samples of gelatinous zooplankton were also collected. Samples were either taken from standard bongos tows, with species and quantities removed noted on the log sheets or taken from non-quantitative bongo tows in areas which showed large numbers of gelatinous zooplankton in the Video Plankton Recorder (VPR) images. All samples were put in labeled ziplock bags and immediately frozen.

During the night time hours, tows were made as close as possible to the visual team's previous day's transect lines using a Seascan V-fin mounted, internally recording, black and white Video Plankton Recorder (VPR). The VPR was also equipped with a Seabird Fastcat CTD, a Wetlabs fluorometer / turbidity sensor and a Benthos altimeter. A second SEACAT 911 CTD profiler was mounted above the V-fin and connected to the 322 conducting core cable to provide real time data on gear depth and oceanographic conditions. The camera and strobe were set to image a 4 cm x 5 cm x 11 cm (s3) or 2.3 cm x 3 cm x 8 cm (s2) volume of water 20 times a second. Camera settings were based on the average zooplankton size seen in the bongo nets and previous VPR hauls. The VPR was either towed in an undulating pattern along the transect line to characterize oceanographic conditions and vertical plankton structure or to target layers of plankton shown on the active acoustic sensor EK60 which could then characterize plankton patchiness. Upon retrieval, the data were downloaded to one of three computers in the Chemical Lab for processing. In focus regions of interest (ROIs) individual plankton pictures were extracted from each image frame using Autodeck programming from Seascan. Along track profiles of temperature, salinity, density, raw chlorophyll and raw turbidity values were created for each tow using MATLAB. Plankton images were stored for identification at the NMFS Woods Hole lab. Images will be used to create 1 m depth stratified plankton profiles for comparison with the echo profiles from the 120 kHz and 200 kHz sensors of the EK60.

Sippican T-7 Expendable Bathythermograph (XBT) probes were launched on the third leg of the cruise to record temperature profiles during four shelf break crossings. Shelf break crossings were opportunistically chosen for XBT sampling based on the potential to complete all sampling stations along a transect line within a 24 hour period. XBT stations along the transect line were placed to ensure sampling of the shelf break front. Probes were deployed with the ML-3A hand-held launcher every 5.6 km (3 nmi) when crossing the steepest slope of the shelf break and every 5.6 – 9.3 km (3 – 5 nmi) at the beginning and/or end of the shelf break track line. One probe was launched directly after one of the evening CTD cast to compare the XBT temperature data to the calibrated CTD data. All launches were recorded with the MK21 data acquisition system installed on a computer in the ship's Dry Lab.

The ship's Simrad EK60 multi-frequency echosounder system was operational every night after marine mammal operations ended and every other day when the marine mammal team was on-effort. The EK60 system consists of five frequencies, 18 kHz, 38 kHz, 70 kHz, 120 kHz, and 200 kHz that synchronously emit pings and recorded returned acoustic backscatter. These five frequencies were appropriate for measuring acoustic backscatter from zooplankton and fishes. When the ship was in water depths shallower than 1000 m, a ping was emitted every 2 s. When the ship was in water depths greater than 1000 m, a ping was emitted every 5 s. Data were recorded to 3000 m depth. All five transducers were mounted on a retractable centerboard that was 6 m below the waterline when flush with the hull and 7.5 m below the waterline when the centerboard was extended to its intermediate depth position. When the EK60 system was operational, active data were continuously recorded to the ship's acoustic server. Five minutes of passive acoustic data were recorded through the 70 kHz, 120 kHz, and 200 kHz transducers most days after the passive acoustic array was brought on board. The SCS Event Log was used during the cruise to record all operational events (e.g., begin and end recording, change in centerboard position, change in ping rate). The EK60 transducers were calibrated in March 2011 before the NMFS Northeast Fishery Science Center's (NEFSC) spring bottom trawl survey.

Current velocities were recorded with the ship's Acoustic Current Doppler Profiler (ADCP). The ADCP was synchronized to the EK60 system to lessen interference and was operational only when the EK60 system was operational.

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 5047 km in total. However, some track lines initially surveyed in poor sighting conditions were re-surveyed at a later time in better conditions. Thus resulting in 3811 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 52% of the survey transects were conducted in very good weather conditions, Beaufort sea state 2 or less (Table 3).

During the on-effort track lines, 24 species or species groups and 2 identifiable sea turtles were recorded (Table 4). For cetaceans, the upper team detected 792 groups (11,455 individuals) and the lower team detected 609 groups (8,458 individuals). For turtles, the upper team detected 14 groups (14 individuals) and the lower team detected 7 groups (7 individuals). Note some, but not all, groups of cetaceans and turtles detected by one team were also detected by the other team. One seal was detected. In addition, 18 (17) basking sharks and 41 (15) ocean sunfish was detected by the upper (and lower) teams.

Distribution maps of sighting locations of the cetaceans, turtles and sunfish are displayed in Figures 2 to 4. Note these are locations of sightings seen by both teams, where some groups of animals were seen by both teams and other groups were seen by only one of the teams.

A software package called *VisSurv-NE* was initially developed by Lance Garrison (of the Southeast Fisheries Science Center- SEFSC) and then major modifications were made by Debra Palka (of the NEFSC) to accommodate the data collection methods used by the NEFSC. Version 1 was used during Leg 1; Version 2 was used during legs 2 and 3. In addition, a post-processing editing and archive extension was developed by Elizabeth Josephson and used during all three legs and after the cruise was completed. This software package worked well and it is expected that a slightly modified version will be used in future NEFSC shipboard surveys.

VISUAL SEA BIRD SIGHTING TEAM

Seabird survey effort was conducted on 43 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 was collected on every sea-day except for three days when the vessel was hove-to due to weather (Figure 5a).

A summary of all 5148 birds seen while on-effort broken down by species is presented in Table 5 and Figures 5b to 7F. Nomenclature follows that reported in The Clements Checklist of Birds of the World. 6th edition, Cornell University Press 2007, with electronic updates to 2010. This consists of 45 species of birds, in addition to six unidentified species groups (e.g., unidentified jaeger, unidentified storm-petrel). Four species comprised 86% of the total birds seen. In declining order of abundance these were: great shearwater *(Puffinus gravis)*, Wilson's storm-petrel *(Oceanites oceanicus)*, Leach's storm-petrel *(Oceandroma leucorhoa)* and Cory's shearwater *(Puffinus diomedea)*. Meanwhile, others, such as Audubon's shearwater *(Puffinus lherminieri)* and bridled tern *(Onychoprion anaethetus),* being tropical and sub-tropical species, were closely associated with habitat type; in this case, warm Gulf Stream water.

A software package, *Seebird*, a real-time computer data entry program developed at the Southwest Fisheries Science Center, underwent a successful introduction and implementation during all three legs of the survey. The ease of use for entry-level users was a valuable asset in maintaining data consistency when facing frequent observer turnover. The final version used on the survey was version 4.3.6.

PASSIVE ACOUSTIC DETECTION TEAM

The acoustic team collected passive acoustic data during all hours when the visual team was on-effort, with the following two exceptions: 1) during Leg 1, repairs to the hydrophone array resulted in the loss of approximately 15 hours of acoustic monitoring effort; and 2) during Legs 2 and 3 when the tracklines were in waters considered too shallow for safe deployment. The acoustic team also monitored on some occasions when weather conditions prevented the visual team from operating. Thus, over the course of the survey, there were 40 days with acoustic monitoring effort, for a total of 311.5 hours of continuous data collection (Table 6).

Real-time monitoring resulted in the detection of 356 acoustic groups (Figures 8 and 9). Of these, approximately 37% corresponded to the visual detection of small odontocetes, including 8 species of delphinids, and 1 species of beaked whale (Table 7). In some cases, it was impossible in real-time to acoustically differentiate subgroups of animals that were visually distinguished and counted as separate sightings, resulting in the underestimate of acoustic detections as compared to visual detections.

Sperm whales were detected on 32 survey days, with a total of 87 different individuals or groups of individuals, comprising 24% of all acoustic detections (Table 8; Figure 10). At the times when many individuals were present, they were treated as one acoustic detection for practicality of real-time tracking. Approximately 11 of these groups were detected visually; therefore 87% of sperm whale detections were solely acoustic.

Approximately 40% of acoustic detections (not including sperm whales) were not linked in real-time with visual sightings. This includes both groups that were detected solely through acoustic monitoring, as well as groups that may correspond to visual sightings with further post-processing analyses. Acoustic detections of beaked whales are under-represented in the current summary, as it was not feasible to monitor for both delphinids and beaked whales simultaneously.

Post-processing of acoustic data will be conducted towards several main objectives. These include: 1) re-analyses of acoustic groups that may correspond to visual sightings but were not confirmed in the field, 2) implementation of acoustic detectors for beaked whales, which were not feasible to detect in real-time, with the exception of one species, and 3) analyses of sperm whale data for preliminary calculation of abundance. In addition, whistles and echolocation clicks will be extracted for instances in which high-quality recordings were collected of unambiguously-identified species, for the eventual development of automatic species classifiers.

HYDROGRAPHIC/BONGO/PLANKTON SAMPLES

A total of 21 vertical CTD profiles, 90 double oblique bongo hauls with CTD, and 81 VPR with CTD hauls were conducted (Table 9; Figure 11).

Special samples of 12 bags of gelatinous zooplankton of various species were frozen on legs 1 and 2 for Kara Dodge.

Oceanographic profiles varied strongly within the study area (Figures 12 – 15). Offshore profiles were strongly affected by the Gulf Stream on the southern end and a warm core ring on the northern end of the sampling area. Oceanography along the shelf slope edge tended to be cooler with 4 – 5°C thermoclines in June and warmer with 6 – 12°C thermoclines in July. Depth of the thermocline varied from 15 – 50 m with most being around 20 – 25 m. Northern stations tended to have lower temperatures and salinities than the southern Mid-Atlantic Bight stations. All shelf slope stations with a noticeable thermocline also had increased chlorophyll and turbidity in the area of the thermocline. Inshore stations showed well mixed oceanographic conditions with warm temperatures in both northern and southern stations but lower salinities at the Nantucket shoals stations.

Plankton layers in the offshore stations associated with layers seen on the EK60 were generally Euphasiids (krill). Southern offshore stations had higher densities of krill than northern stations as well as numerous siphonophores. Mid Atlantic bight samples had extremely high densities of gelatinous zooplankton (Figure 16). At least four species of Euphausiid were noted including*: Meganyctiphanes norvegica*, *Euphausia superba* and *Nematoscelis* spp. (Figure 17). Both the adult blastozooid with juveniles and the solitary oozoid forms of the salp T*halia democratica* were imaged (Figure 18). Ctenphora of the species *Pleurobrachi a* spp*., Bolinopsis* spp. and Beroe spp. and the hydromedusae of numerous species were also detected (Figure 19). Shelf slope edge stations from along Georges Bank had low densities of ctenophores and siphonophores but no salps. Stations also had medium densities of copepods, mostly *Calanus finmarchicus*, and the Hyperiid *Themisto gaudichaudii*.

A total of 44 XBTs were launched over three shelf break trackline crossings and one nighttime shelf break transit (Figure 20).

An XBT was launched directly after an evening CTD was deployed. When comparing these two temperature profiles, temperatures from the XBT probe were an average of 0.02 degrees (SD = 0.41) greater than temperatures from CTD at the same depths (Figure 21). Temperature profiles varied across the shelf break, most noticeably along trackline 7 when the northwest wall of a warm core ring was at the shelf break (Figure 22). Surface temperatures ranged from 15 – 30°C. Bottom temperatures in deep water were approximately 5°C. Bottom temperatures in the shelf ranged between 10 – 13°C.

The EK60 and ADCP systems were operational every other day that the marine mammal team was on-effort and during all nighttime operations (Table 10). Echo layers observed in the EK60 real time display were targeted for VPR sampling. Archived EK60 data will be analyzed via frequency differencing to determine a broad acoustic classification of middle trophic level biological data. When possible the classified sections will be checked against the bongo tows and VPR images. Preliminary assessment of the multi-frequency data show strong scattering in the lower frequencies around shelf break areas. These scattering regions are spatially patchy and temporally ephemeral. The diel vertical plankton migration is best seen on the higher frequencies at dusk and dawn. ADCP data have been archived and will be analyzed at a later date.

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 available from the NEFSC's Oracle database.

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 are currently available by request only.

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

XBT data will be maintained by Erin LaBrecque (Duke University) and Garath Lawon (WHOI). XBT data are currently available by request only.

Gelatinous zooplankton samples will be processed by Kara Dodge of the University of New Hampshire.

Table 1. SCS data collected continuously every second during the visual survey time periods (0600 – 1800).

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 three legs of this survey. FN = Foreign National.

Personnel	Title	Organization
Leg 1 (Jun 2-22)		
Gordon Waring	Chief Scientist	NMFS, NEFSC, Woods Hole, MA
Elizabeth Broughton	Oceanographer	NMFS, NEFSC, Woods Hole, MA
Allison Henry	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Richard Holt	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
Aija Irene Briga	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Betty Lentell	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Alexandra McFarland	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Michael Force (FN)	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Christopher Vogel	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Joy Stanstreet	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Robert Valtierra	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Cara Hotchkin	Volunteer	Pennsylvania State University, University Park, PA
Leg 2 (Jun 27 – Jul 15)		
Allison Henry	Chief Scientist	NMFS, NEFSC, Woods Hole, MA
Marjorie Rossman	Fishery Biologist	NMFS, NEFSC, Woods Hole, MA
Peter Duley	Fishery Biologist	NMFS, NEFSC, Woods Hole, MA
Elizabeth Broughton	Oceanographer	NMFS, NEFSC, Woods Hole, MA
Carol Fairfield	Fishery Biologist	NMFS, SEFSC, Miami, FL
Gary Friedrichsen	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Kelly Slivka	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Todd Pusser	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Jennifer Gatzke	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Michael Force (FN)	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Michael Sylvia	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Robert Valtierra	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Danielle Cholewiak	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Reuben Darlington	Chemist	Sunburst Sensors LLC, Missoula, MT
Jeffery Gleason	Seabird Biologist	Bureau of Ocean Energy Management, Regulation and Enforcement, New Orleans, LA
Leg 3 (Jul 20 – Aug 1)		
Debra Palka	Chief Scientist	NMFS, NEFSC, Woods Hole, MA
Peter Duley	Fishery Biologist	NMFS, NEFSC, Woods Hole, MA
Elizabeth Broughton	Oceanographer	NMFS, NEFSC, Woods Hole, MA
Gary Friedrichsen	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Kalyn MacIntyre	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Jennifer Gatzke	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Aija Irene Briga	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Carol Roden	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Michael Force (FN)	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Marie-Caroline Martin (FN)	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Robert Valtierra	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Sandra Smith	Fishery Biologist	Integrated Statistics, Woods Hole, MA
Erin LaBrecque	Volunteer	Duke University, NC
Christopher Faist	Volunteer	Teacher-at-sea, Calif.
Deborah Epperson	Biologist	Bureau of Ocean Energy Management, Regulation and Enforcement, New Orleans, LA

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

		Track line length (km) within Beaufort sea state levels						
strata	area (km^2)	0	1	2	3	4	5	total
Shelfbreak	54,376	0	192.5	415.1	494.6	372.5	34.9	1509.6
offshore	197,953	129.9	194.2	607.8	355.6	253.7	56.6	1597.8
BOEM-MidAtl	2,563	0	0	29.1	10.9	194.6	7.3	241.9
BOEM-MA	8,672	48.5	168.1	191	54.5	0	0	462.1
TOTAL	263,564	178.4	554.8	1243	915.6	820.8	98.8	3811.4
cumulative percent of total		0.05	0.19	0.52	0.76	0.97	1.00	

Table 4. Number of groups and individuals of marine mammals, turtles and large fish species detected by the two marine mammal - turtle visual teams, upper and lower. Note, some, but not all, groups detected by one team were also detected by the other team.

		num of groups		num of indiv	
Species		upper	lower	upper	lower
Atlantic spotted dolphin	*Stenella attenuata*	27	19	860	542
Bottlenose dolphin spp.	*Tursiops truncatus*	84	63	1050	566
Common dolphin	*Delphinus delphis*	112	114	3642	3621
Cuviers beaked whale	*Ziphius cavirostris*	30	15	63	34
Dwarf sperm whale	*Kogia simus*	12	3	18	4
Fin whale	*Balaenoptera physalus*	40	22	51	35
Fin/sei whales	*B. physalus or B. borealis*	5	10	7	14
Gervais beaked whale	*Mesoplodon europacus*	4	3	16	9
Harbor porpoise	*Phocoena phocoena*	4	1	6	1
Humpback whale	*Megaptera novaeangliae*	11	12	12	13
Killer whale	*Orcinus orca*	1	1	4	4
Minke whale	*B. acutorostrata*	15	12	17	6
Pantropical spotted dolphin	*Stenella frontalis*	0	1	0	6
Pilot whales spp	*Globicephala spp.*	44	25	386	253
Pygmy sperm whale	*Kogia breviceps*	8	5	11	7
Pygmy/dwarf sperm whales	*Kogia spp.*	6	2	7	2
Rissos dolphin	*Grampus griseus*	88	73	572	433
Rough-toothed dolphin	*Steno bredanensis*	4	2	48	21
Sei whale	*Balaenoptera borealis*	7	4	8	4
Sowerbys beaked whale	*Mesoplodon bidens*	7	5	15	12
Sperm whale	*Physeter macrocephalus*	43	34	64	48
Stenella sp.	*Stenella spp.*	14	9	347	176
Striped dolphin	*Stenella coeruleoalba*	66	43	2594	1870
Unid. Dolphin	*Delphinidae*	130	97	1575	734
Unid. Whale	*Mysticeti*	18	30	18	34
unidentified mesoplodon	*Mesoplodonts spp.*	11	4	30	9
White-sided dolphin	*Lagenorhynchus acutus*	1	0	34	0
TOTAL CETACEANS		792	609	11,455	8,458
Basking shark	*Cetorhinus maximus*	16	17	18	17
Ocean sunfish	*Mola mola*	38	15	41	15
Leatherback turtle	*Dermochelys coriacea*	3	1	3	1
Loggerhead turtle	*Caretta caretta*	5	5	5	5
Unid turtle	*Chelonioidea*	6	1	6	1
Unid seal	*Pinniped*	1	0	1	0
TOTAL ALL SPECIES		861	648	11,529	8,497

Table 5. Number of individual birds detected within the 300 m strip during the NOAA ship *Henry B. Bigelow* abundance survey conducted during Jun 2 – Aug 1, 2011.

Species		Number seen	Percent seen
Northern Fulmar	*Fulmarus glacialis*	3	0.06
Herald (Trindade) Petrel	*Pterodroma (heraldica) arminjoniana*	15	0.29
Fea's Petrel	*Pterodroma feae*	2	0.04
Black-capped Petrel	*Pterodroma hasitata*	33	0.64
Cory's Shearwater	*Calonectris diomedea*	518	10.06
Great Shearwater	*Puffinus gravis*	1991	38.68
Sooty Shearwater	*Puffinus griseus*	156	3.03
Manx Shearwater	*Puffinus puffinus*	55	1.07
Barolo Shearwater	*Puffinus baroli*	1	0.02
Audubon's Shearwater	*Puffinus lherminieri*	147	2.86
unidentified shearwater	*Puffinus sp.*	41	0.80
Wilson's Storm-Petrel	*Oceanites oceanicus*	1182	22.96
White-faced Storm-Petrel	*Pelagodroma marina*	2	0.04
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	749	14.55
Band-rumped Storm-Petrel	*Oceanodroma castro*	64	1.24
Leach's/Band-rumped Storm-Petrel	*Oceanodroma leucorhoa/castro*	1	0.02
unidentified storm-petrel	*Oceanodroma sp.*	8	0.16
White-tailed Tropicbird	*Phaethon lepturus*	5	0.10
Northern Gannet	*Morus bassanus*	3	0.06
Double-crested Cormorant	*Phalacrocorax auritus*	5	0.10
Yellow-crowned Night-Heron	*Nyctanassa violacea*	1	0.02
Red Phalarope	*Phalaropus fulicarius*	10	0.19
unidentified shorebird	*Sp. sp.*	7	0.14
Bonaparte's Gull	*Chroicocephalus philadelphia*	1	0.02
Laughing Gull	*Leucophaeus atricilla*	24	0.47
Herring Gull	*Larus argentatus*	5	0.10
Great Black-backed Gull	*Larus marinus*	5	0.10
Sooty Tern	*Onychoprion fuscatus*	1	0.02
Bridled Tern	*Onychoprion anaethetus*	5	0.10
Common Tern	*Sterna hirundo*	13	0.25

Species		Number seen	Percent seen
Arctic Tern	*Sterna paradisaea*	1	0.02
Royal Tern	*Thalasseus maximus*	2	0.04
Sandwich Tern	*Thalasseus sandvicensis*	1	0.02
Great Skua	*Stercorarius skua*	1	0.02
South Polar Skua	*Stercorarius maccormicki*	16	0.31
unidentified skua	*Stercorarius sp.*	3	0.06
Pomarine Jaeger	*Stercorarius pomarinus*	13	0.25
Parasitic Jaeger	*Stercorarius parasiticus*	8	0.16
Long-tailed Jaeger	*Stercorarius longicaudus*	13	0.25
unidentified jaeger	*Stercorarius sp.*	1	0.02
Dovekie	*Alle alle*	14	0.27
Atlantic Puffin	*Fratercula arctica*	1	0.02
Rock Pigeon	*Columba livia*	1	0.02
Tree Swallow	*Tachycineta bicolor*	1	0.02
Barn Swallow	*Hirundo rustica*	10	0.19
Yellow Warbler	*Dendroica petechia*	3	0.06
Blackpoll Warbler	*Dendroica striata*	1	0.02
Common Yellowthroat	*Geothlypis trichas*	1	0.02
Chipping Sparrow	*Spizella passerina*	1	0.02
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	1	0.02
Brown-headed Cowbird	*Molothrus ater*	2	0.04
TOTAL		5148	100

Table 6. Summary of acoustic monitoring effort during HB1103 survey.

	Leg 1	Leg 2	Leg 3	TOTAL
Days with acoustic effort	17	15	8	40
Recording time (hh:mm)	136:45	99:59	74:51	311:35
Number of acoustic detections	138	147	71	356

Table 7. Summary of acoustic detections during the HB1103 survey. Species were assigned to acoustic detections when real-time tracking confirmed the correspondence of acoustic detections with visual sightings. Note that in some cases, acoustic detections include multiple individuals (in the case of sperm whales) or multiple subgroups (in the case of delphinids). “Unknown species” include both groups for which no visual data exist, as well as groups which could not be definitively linked to visual sightings in real-time.

Common Name	Leg 1	Leg 2	Leg 3	TOTAL
Bottlenose dolphin	11	8	1	20
Common dolphin	12	8	6	26
Striped dolphin	5	15	3	23
Atlantic spotted dolphin	2	15	3	20
Risso's dolphin	3	3	3	9
Rough-toothed dolphin	1	2		3
Pilot whale	2	5	5	12
Clymene's dolphin	1			1
Mixed species groups	3	9	3	15
Sperm whale	45	27	15	87
Sowerby's beaked whale		2		2
Unknown species	53	53	32	138
TOTAL				356

Table 8. Summary of acoustic detections of sperm whales. Note that detections may include individuals or groups of individuals; in areas where many individuals were detected, they were included into one acoustic detection.

	Leg 1	Leg 2	Leg 3	TOTAL
Days with sperm whale detections	15	11	6	32
Number of sperm shale detections	45	27	15	87

Table 9. The number of oceanographic and plankton sampling on each leg.

Sampling type	Leg 1	Leg 2	Leg 3	Total
Vertical CTD	10	7	4	21
Bongo	33	31	26	90
VPR	33	26	22	81
undulating VPR	19	17	10	46
horizontal VPR	14	9	12	35
VPR camera setting s3	33	21	10	64
VPR camera setting s2	0	5	12	17

Table 10: Start and end times of EK60 and ADCP data collection.

Start Date -Time (GMT)	End Date - Time (GMT)
6/3/2011 15:36:23	6/5/2011 09:39:55
6/5/2011 22:09:29	6/7/2011 09:23:05
6/7/2011 22:13:51	6/9/2011 09:49:04
6/9/2011 23:15:09	6/11/2011 09:26:07
6/12/2011 16:42:08	6/13/2011 09:33:04
6/13/2011 22:01:37	6/15/2011 09:31:33
6/15/2011 21:41:56	6/17/2011 09:28:40
6/17/2011 22:57:13	6/19/2011 13:54:24
6/19/2011 22:08:10	6/21/2011 09:22:24
6/21/2011 21:48:48	6/22/2011 10:58:45
6/28/2011 19:35:04	6/30/2011 09:29:56
6/30/2011 23:02:49	7/2/2011 09:19:42
7/3/2011 05:32:22	7/4/2011 09:22:37
7/4/2011 21:36:42	7/6/2011 09:25:05
7/6/2011 22:17:05	7/8/2011 09:40:47
7/8/2011 21:41:27	7/10/2011 09:40:23
7/10/2011 23:38:06	7/12/2011 09:07:25
7/13/2011 00:30:37	7/13/2011 09:21:18
7/13/2011 22:22:28	7/14/2011 17:55:14
7/20/2011 20:12:08	7/23/2011 09:42:23
7/23/2011 22:01:55	7/25/2011 09:22:57
7/25/2011 22:42:04	7/27/2011 09:36:19
7/27/2011 22:33:56	7/29/2011 11:36:05
7/29/2011 22:11:16	7/31/2011 09:11:56
7/31/2011 21:38:29	8/1/2011 11:24:16

Figure 1.Location of track lines surveyed during the June 2 – August 1, 2011 shipboard abundance survey on the NOAA ship Henry B. Bigelow.

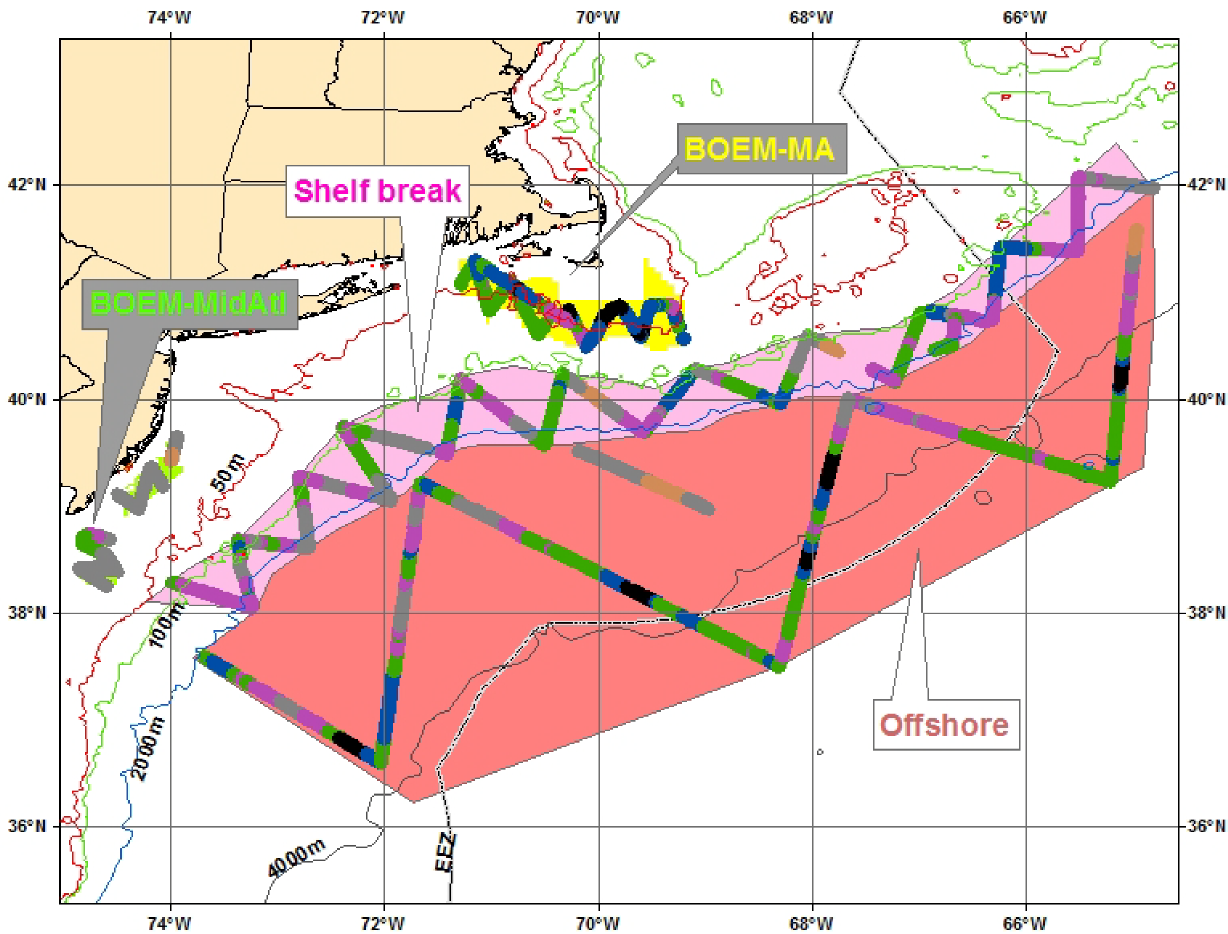

Figure 2. Distribution of the following species: A. Atlantic spotted dolphins; B. Bottlenose dolphins; C. Common dolphins; D. Risso's dolphins; E. Striped dolphins; F. Pilot whales.

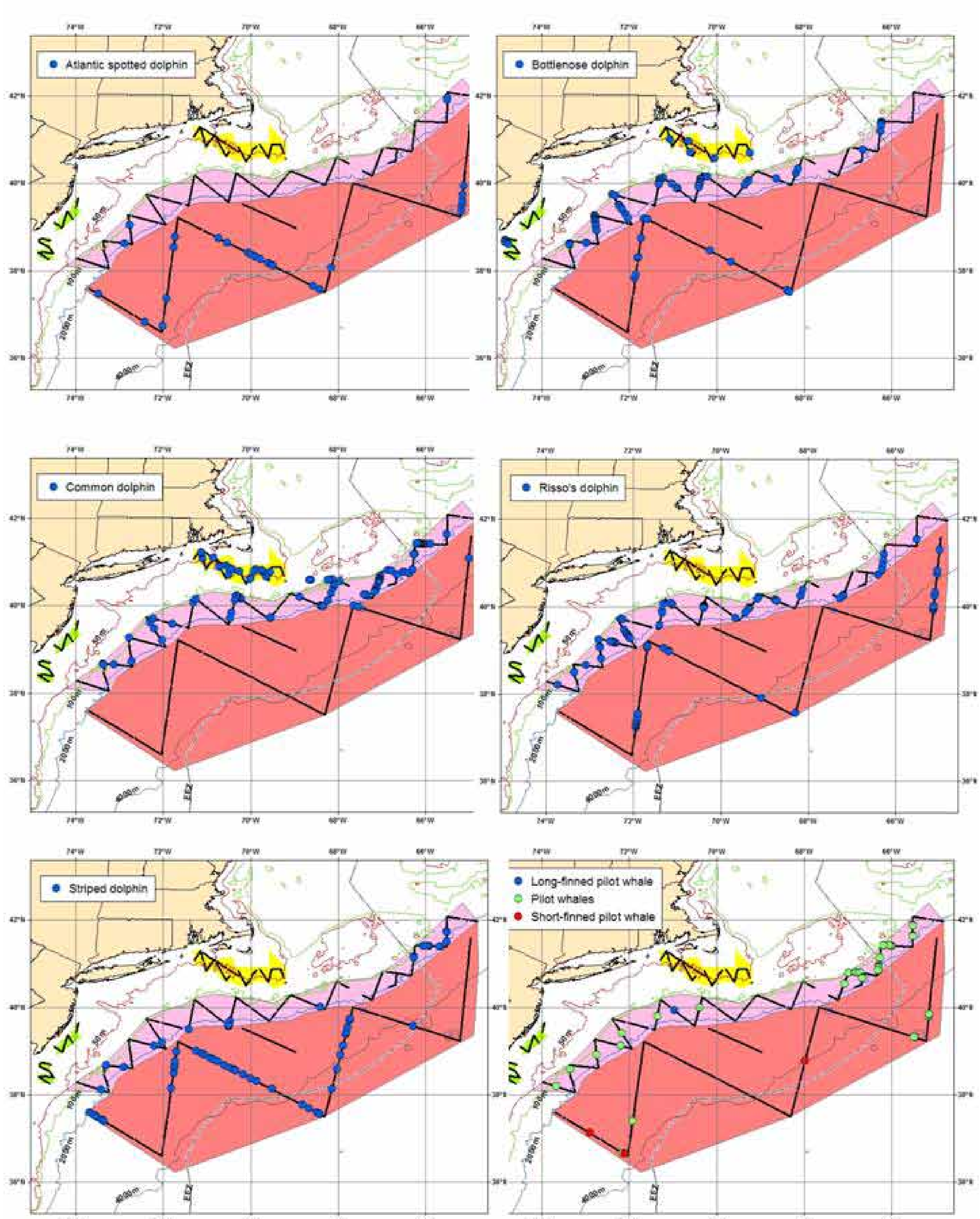

Figure 3. Distribution of the following species: A. Cuvier's beaked whales; B. Gervais', Sowerby's and unidentifed beaked whales; C. Humpback whales; D. Dwarf sperm and pygmy sperm whales; E. Fin and sei whales; F. Minke whales, killer whales, and harbor porpoise.

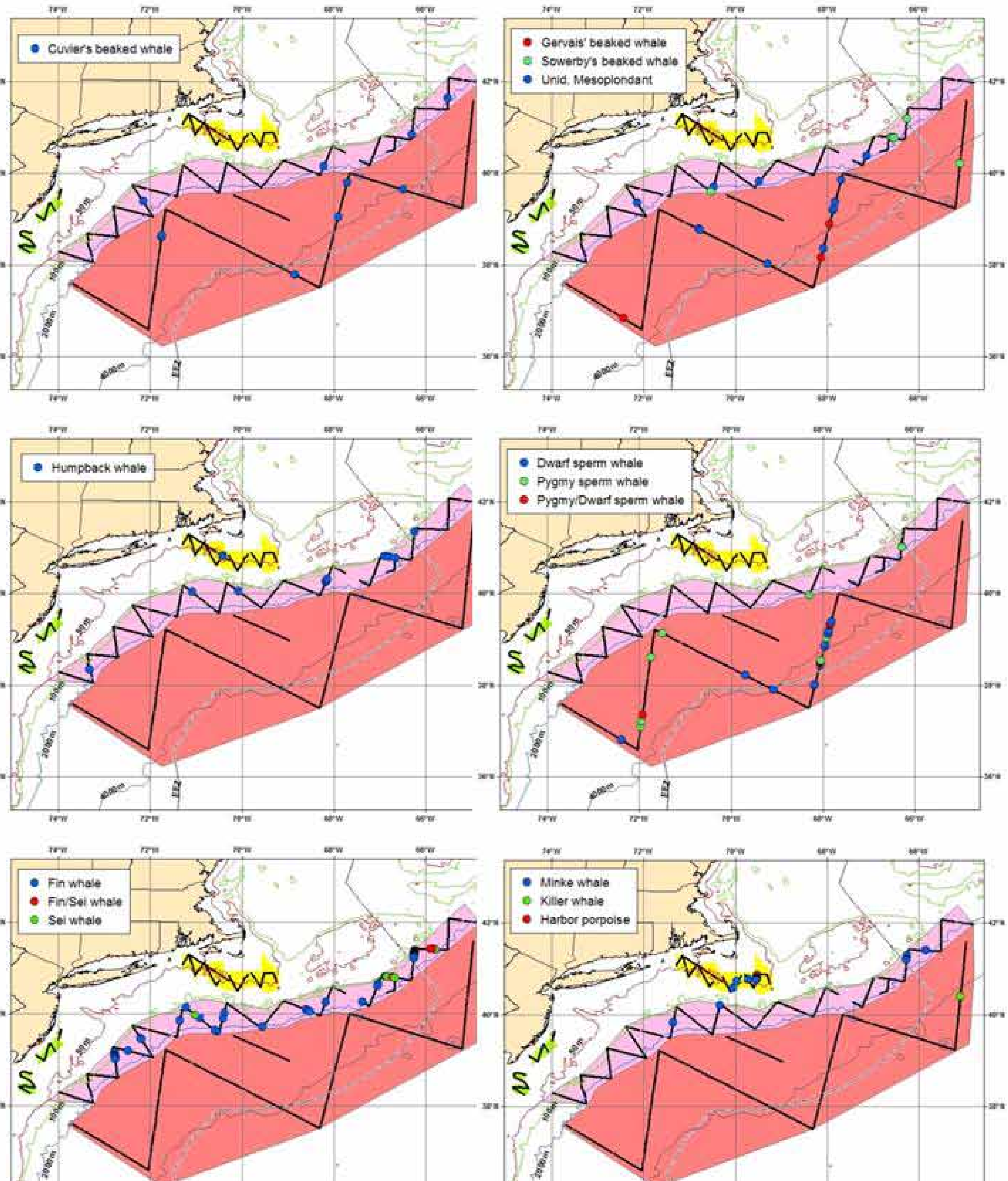

Figure 4. Distribution of the following species: A. Rough-toothed dolphins and sperm whales; B. Leatherback, loggerhead and unidentified hardshell turtles; C. Basking sharks; D. Ocean sunfishs.

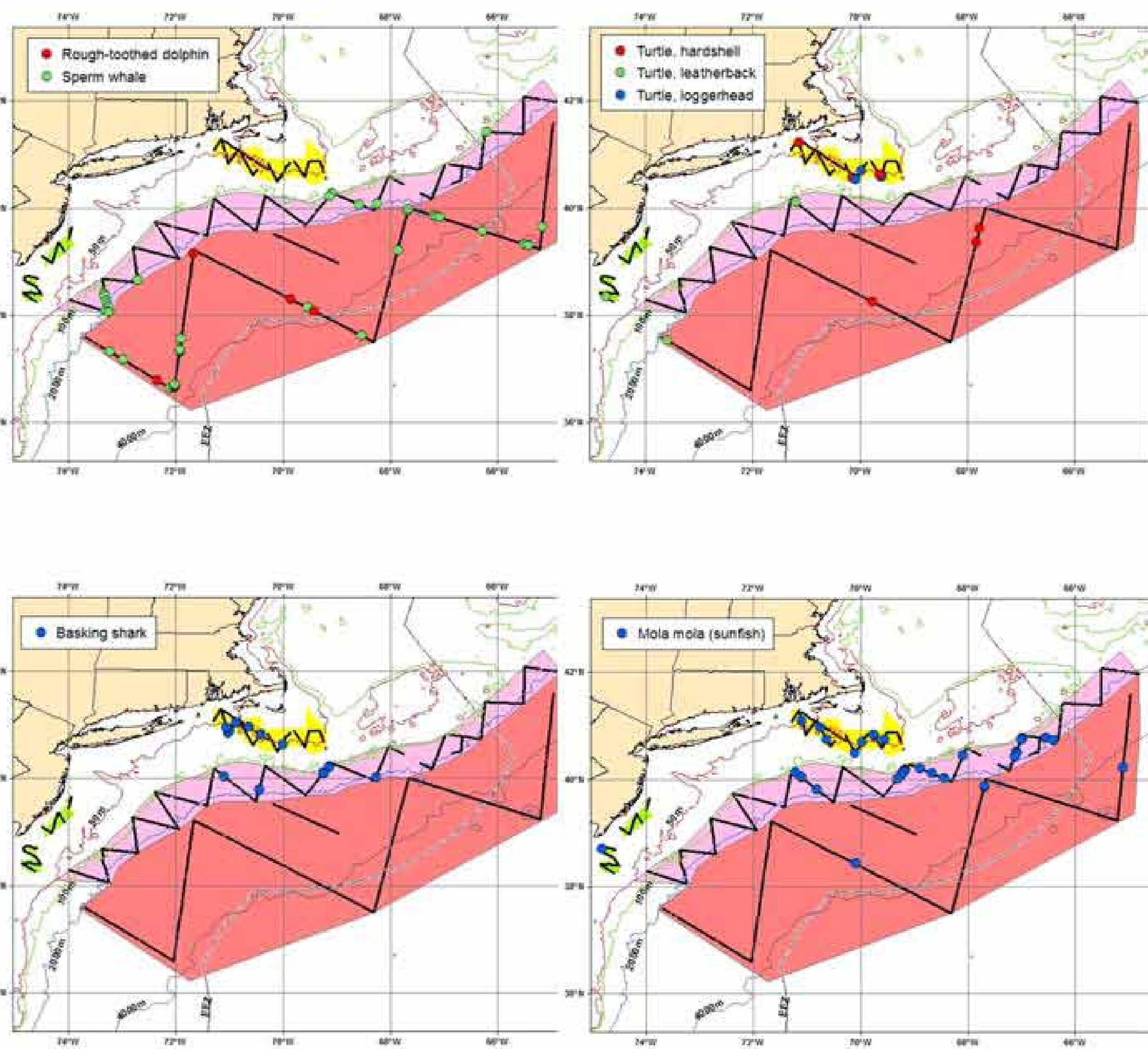

Figure 5. A. On-effort track lines surveyed for sea birds. Distribution of the following species: B. Audubon shearwaters; C. Band-rumped storm petrels; D. Black-capped petrels; E. Common terns; F. Cory's shearwaters.

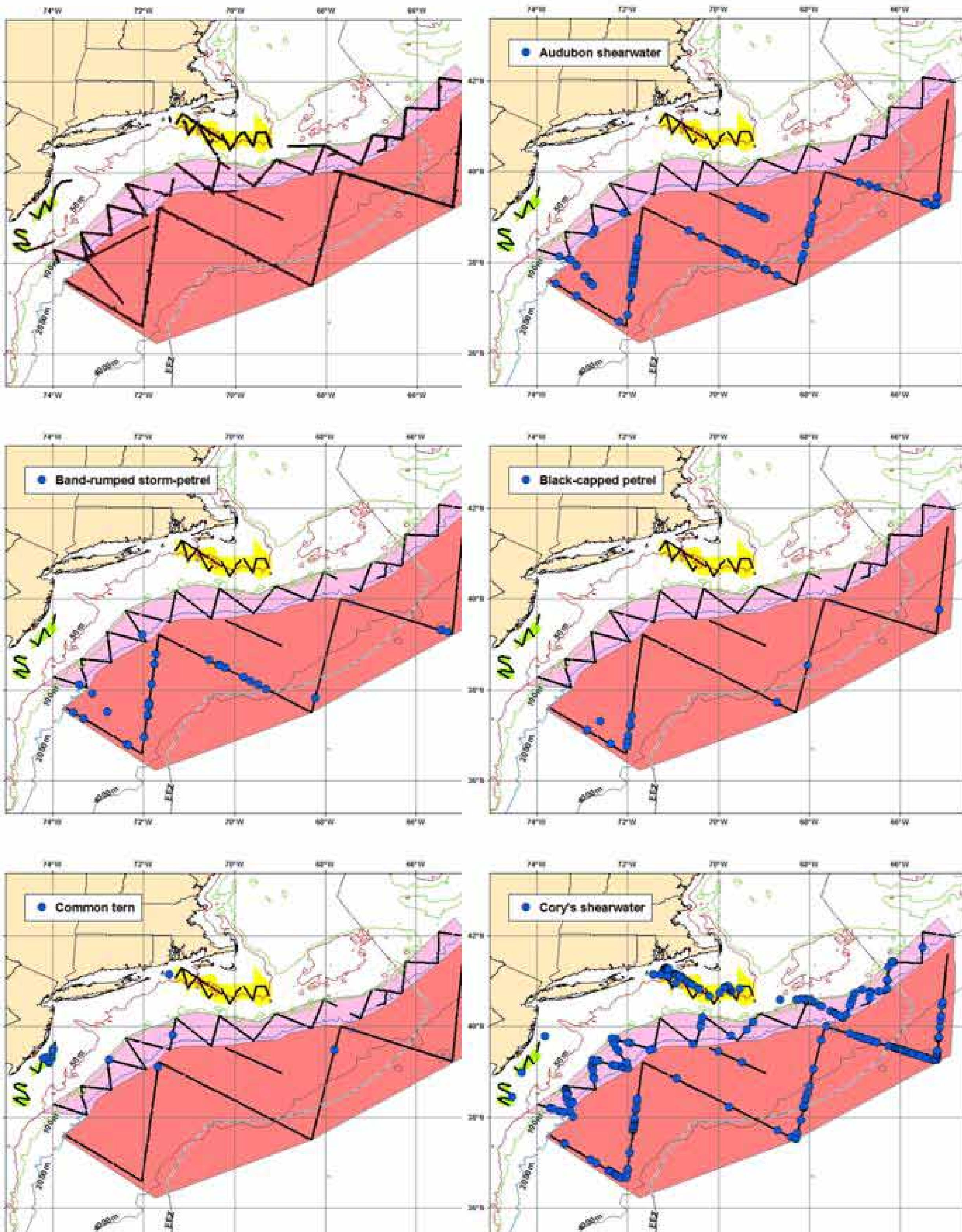

Figure 6. Distribution of the following species: A. Dovekies; B. Greater shearwaters; C. Laughing gulls; D. Leach's storm petrels; E. Long-tailed jaegers; F. Manx shearwaters.

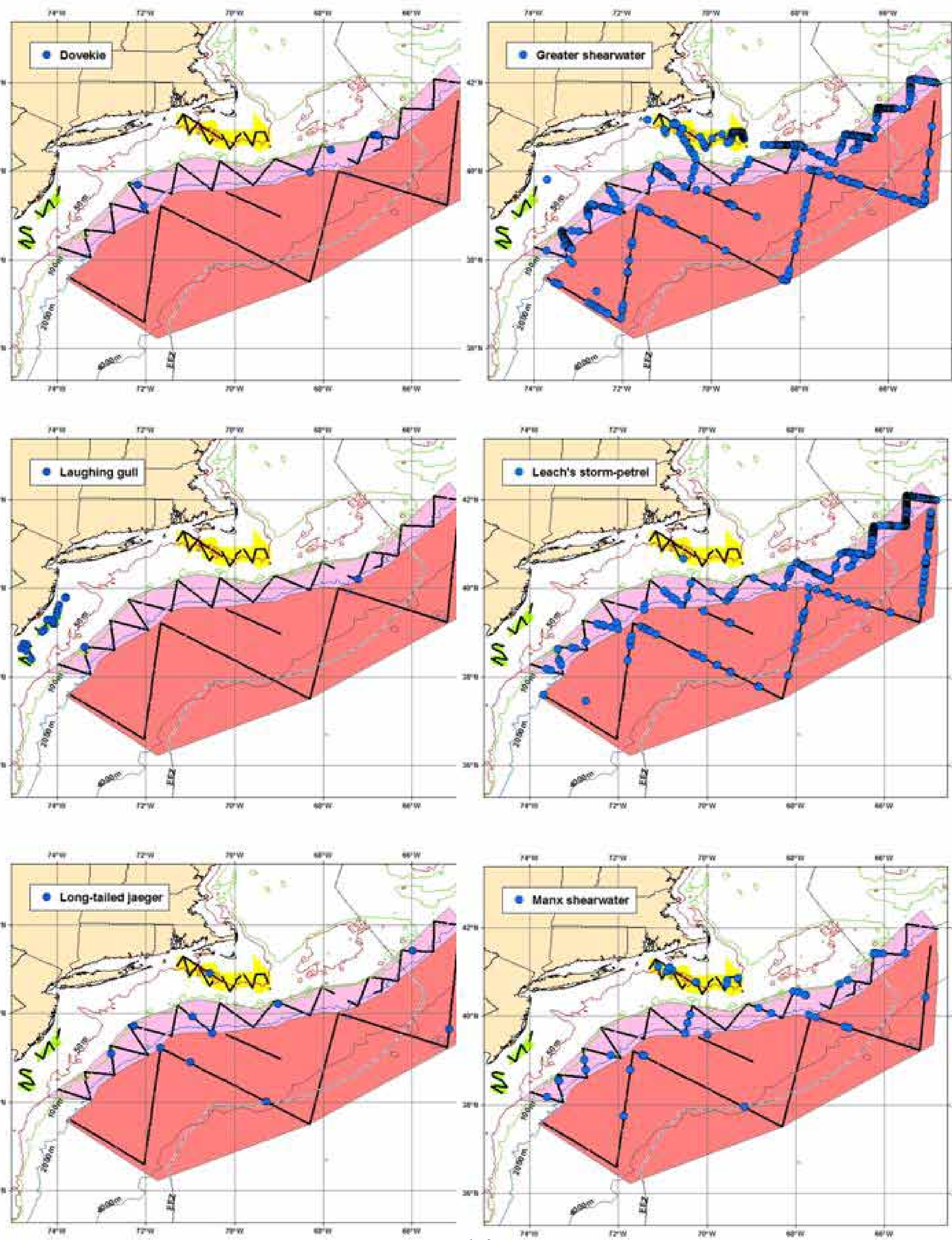

Figure 7. Distribution of the following species: A. Bonaparte's gulls, great black-backed gulls and herring gulls; B. Arctic terns, Atlantic puffins, Fea's petrels, Trindade petrels, unidentified storm-petrels, and white-faced storm petrels; C. Bridled terns, double-crested cormorants, Exocoetus sp., Great skuas, Northern fulmars, Northern gannets, Pomarine jaegers, and red phalaropes; D. Arctic terns, royal terns, sandwich terns, sooty terns; E. Sooty shearwaters; F. Wilson's storm petrels.

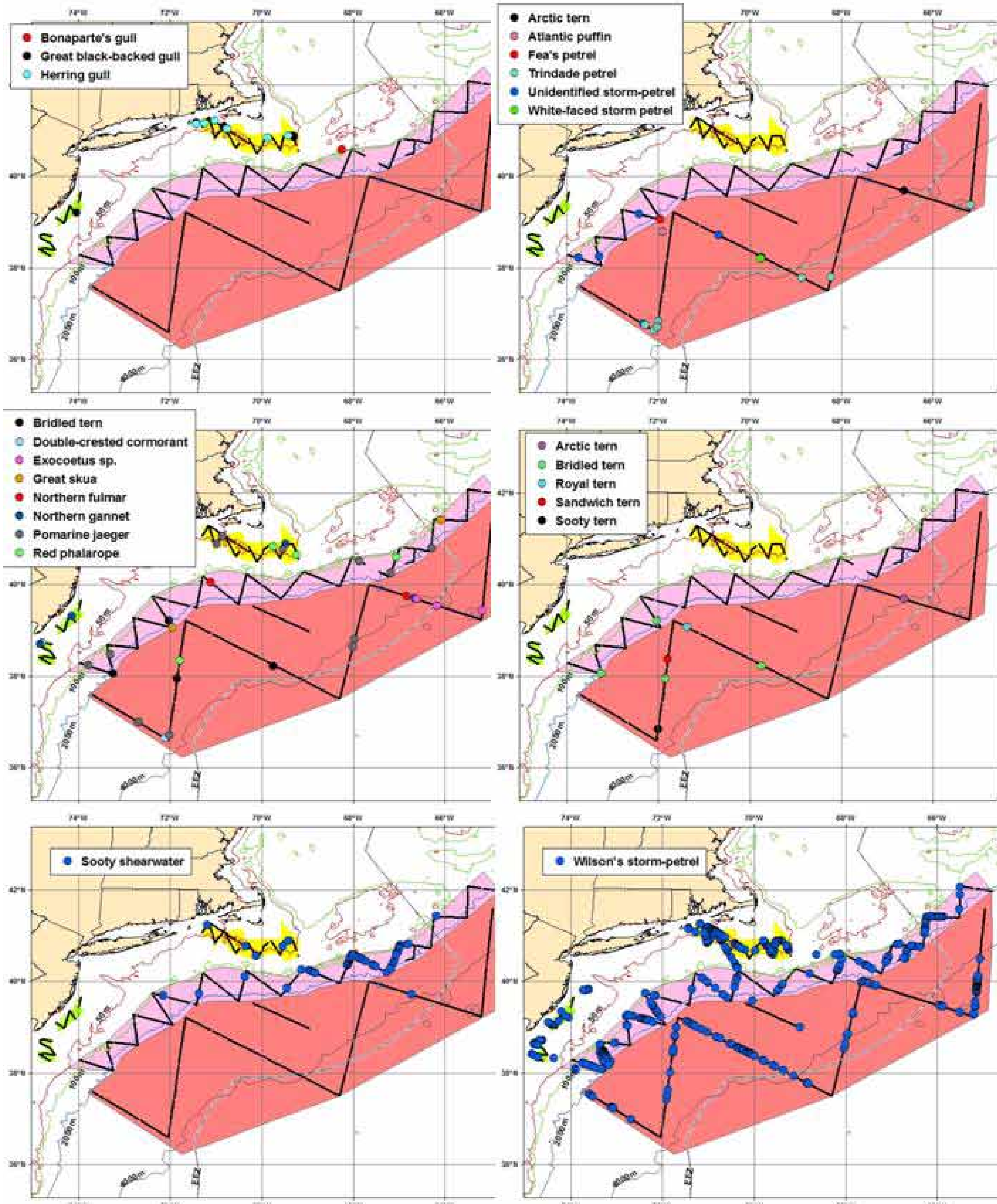

Figure 8. Location of the NOAA ship Bigelow during acoustic detections of vocally-active cetacean groups. Yellow lines indicate proposed survey track lines; dots indicate acoustic detection events where each leg is a different color. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

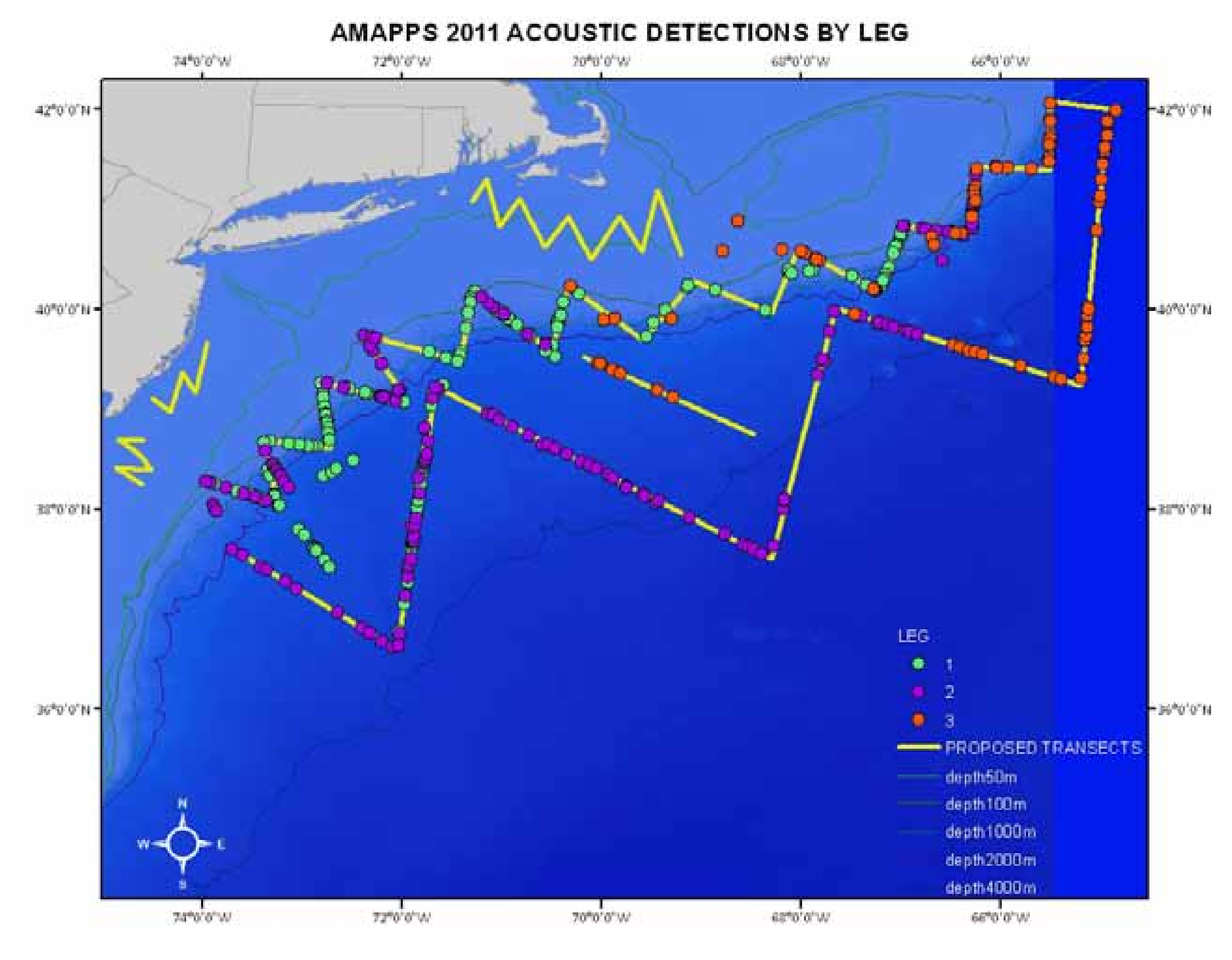

Figure 9. Location of the NOAA ship Bigelow during acoustic detection of vocally-active cetacean groups. Yellow lines indicate proposed survey track lines; other symbols represent acoustic detection events. Groups for which species identity was confirmed visually are indicated by distinct colors. The species code "MIX" indicates groups in which more than one species was present. The species code "UNID" indicates groups for which species identification was not possible at the time of data collection. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

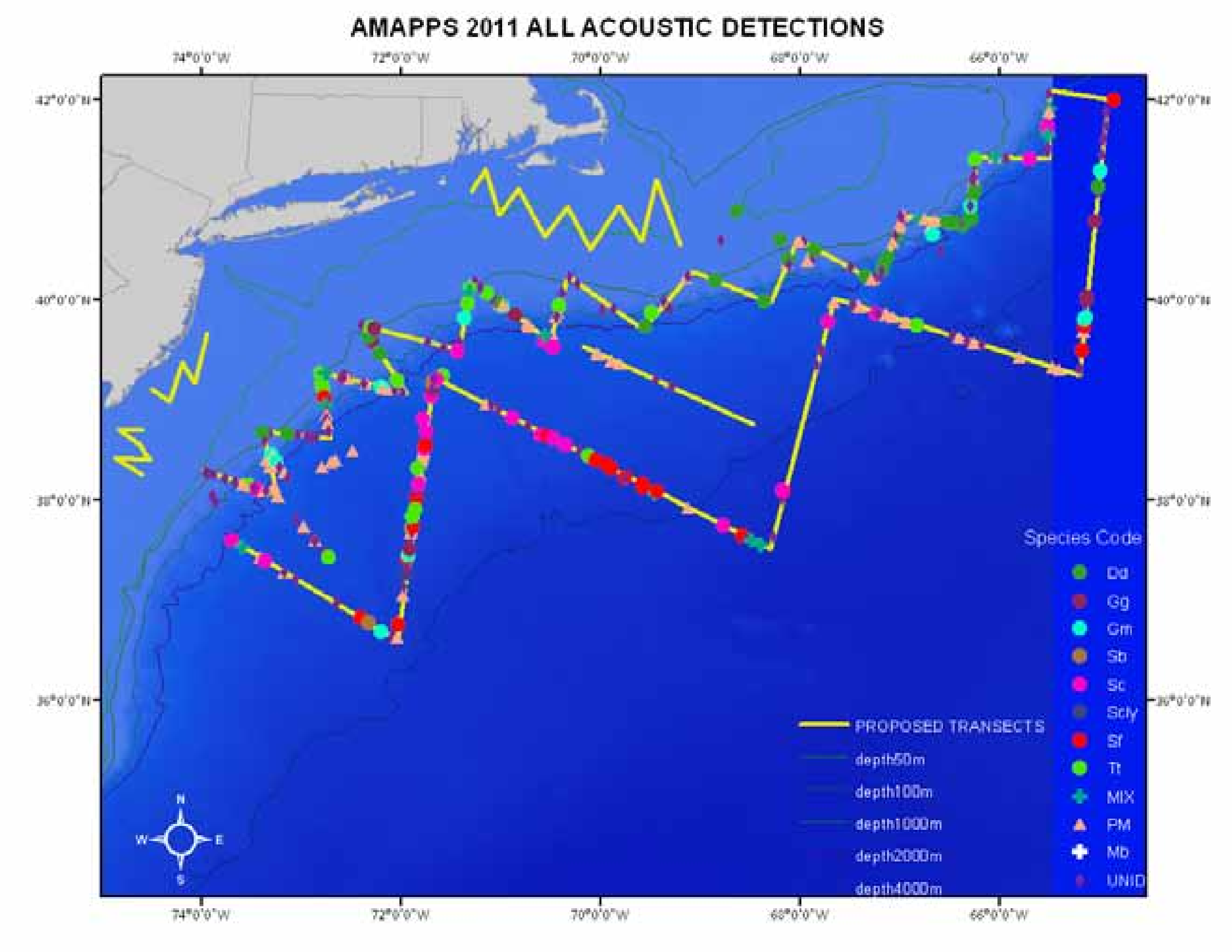

Figure 10. Location of the NOAA ship Bigelow during acoustic detections of sperm whale individuals or groups of individuals. Yellow lines indicate proposed survey track lines, orange dots indicate sperm whale acoustic detection events. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

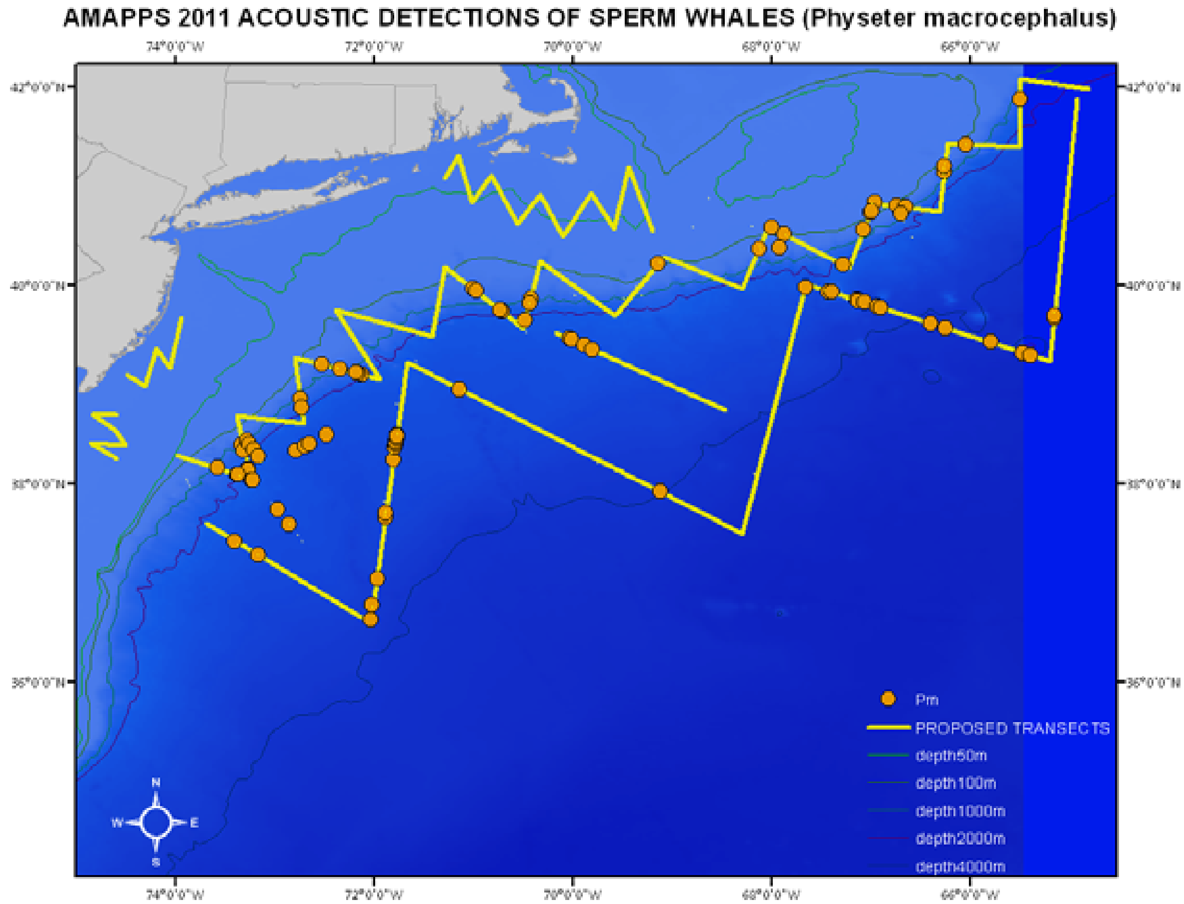

Figure 11. Location of the bongo, VTR and CTD sampling stations (colored dots) and actual track lines (line).

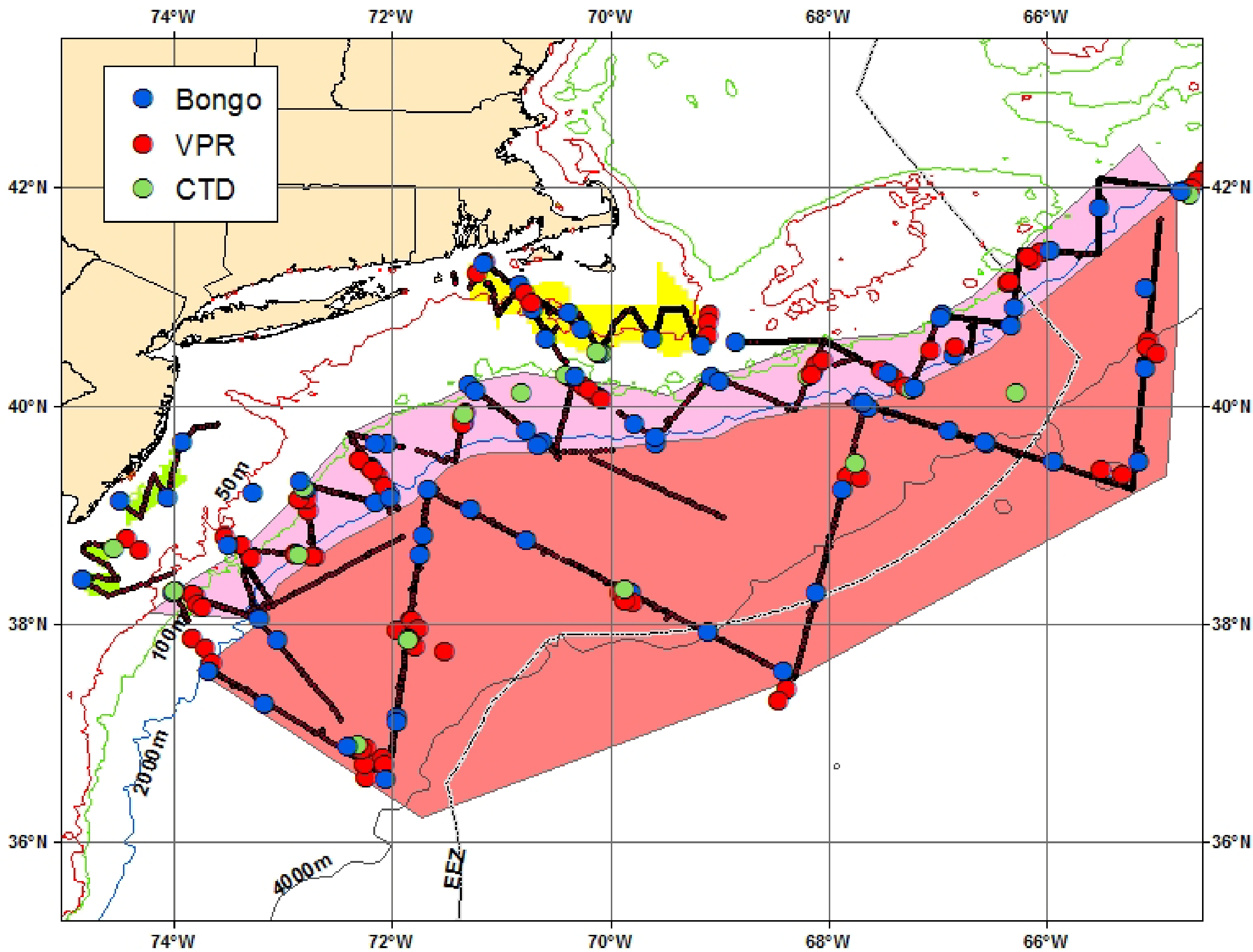

Figure 12. Oceanographic features typical of water along the shelf slope front on the southern flank of Georges Bank.

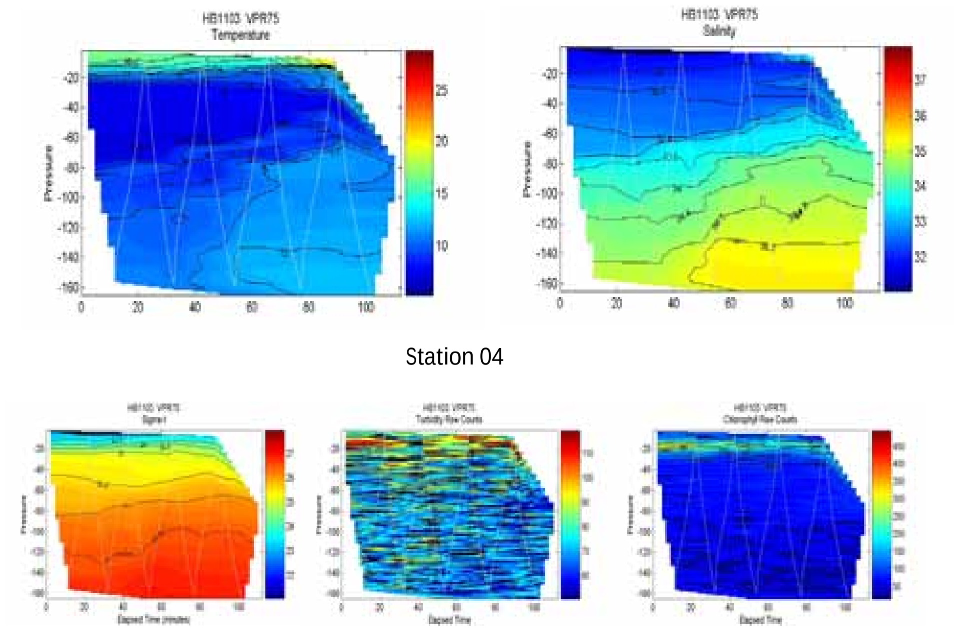

Figure 13. Oceanographic conditions typical of waters along the shelf slope front in the Mid-Atlantic Bight.

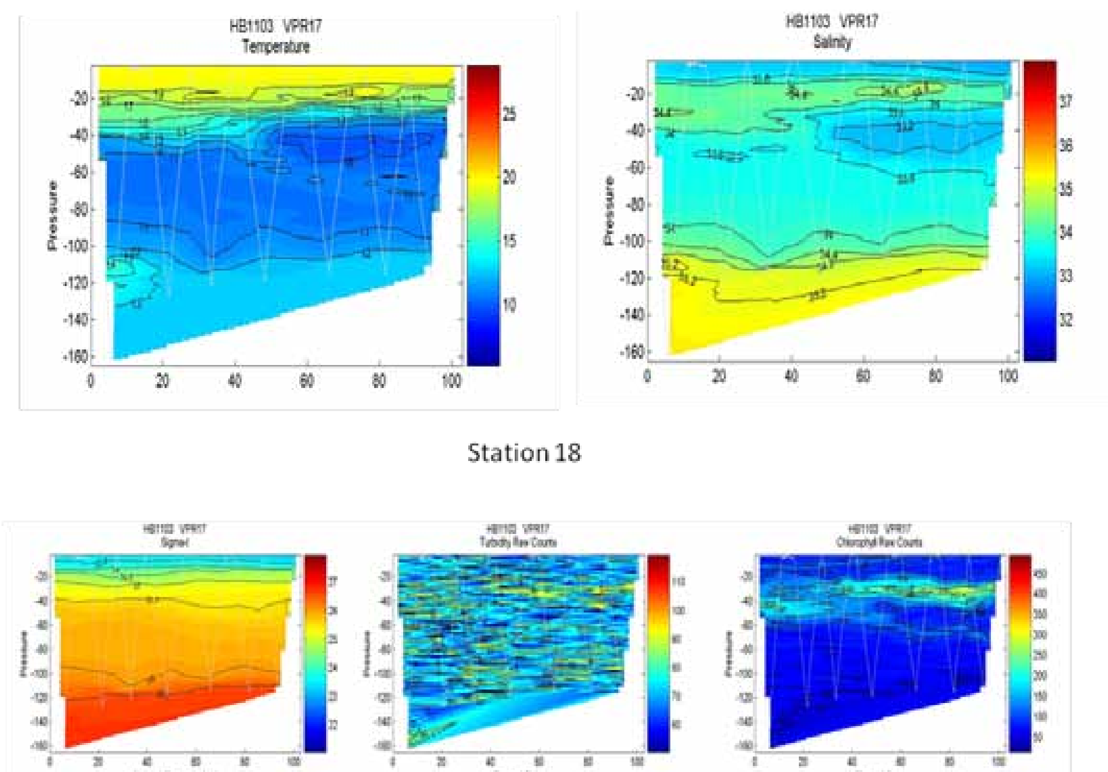

Figure 14. Oceanographic conditions typical of the offshore transects in areas not influenced by the Gulf Stream.

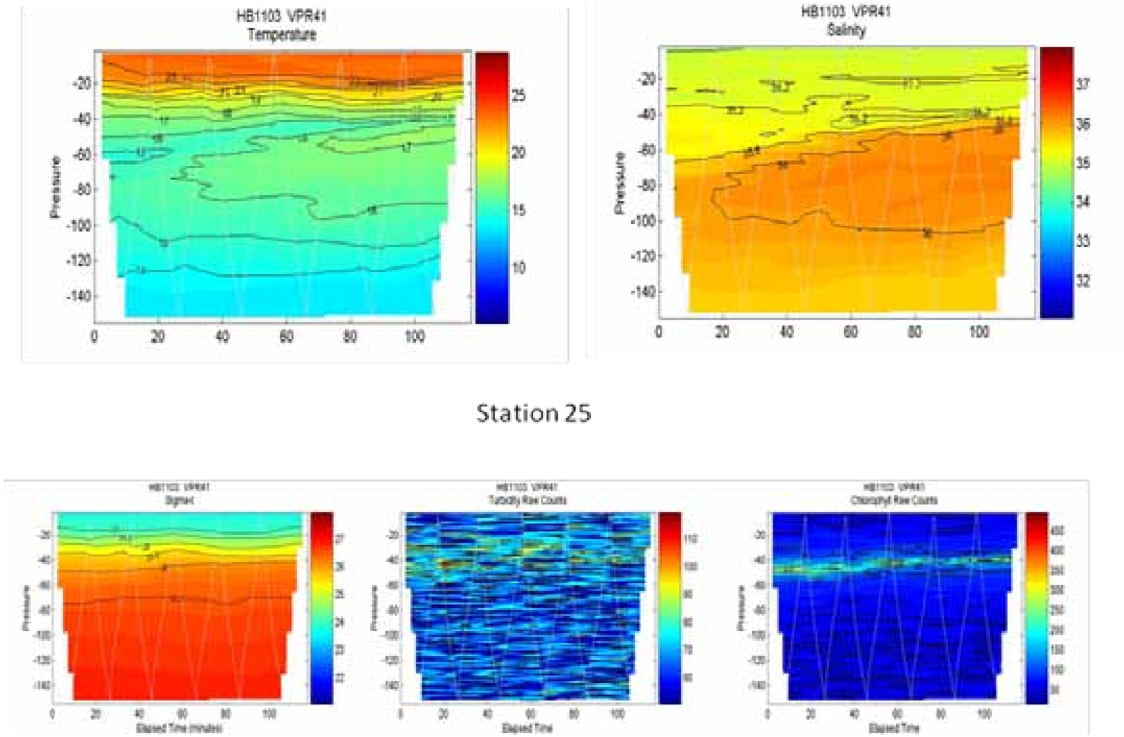

Figure 15. Oceanographic conditions typical of offshore transects in the Gulf Stream (south near waypoint 28) or the July warm core ring (north near Bear Sea Mount).

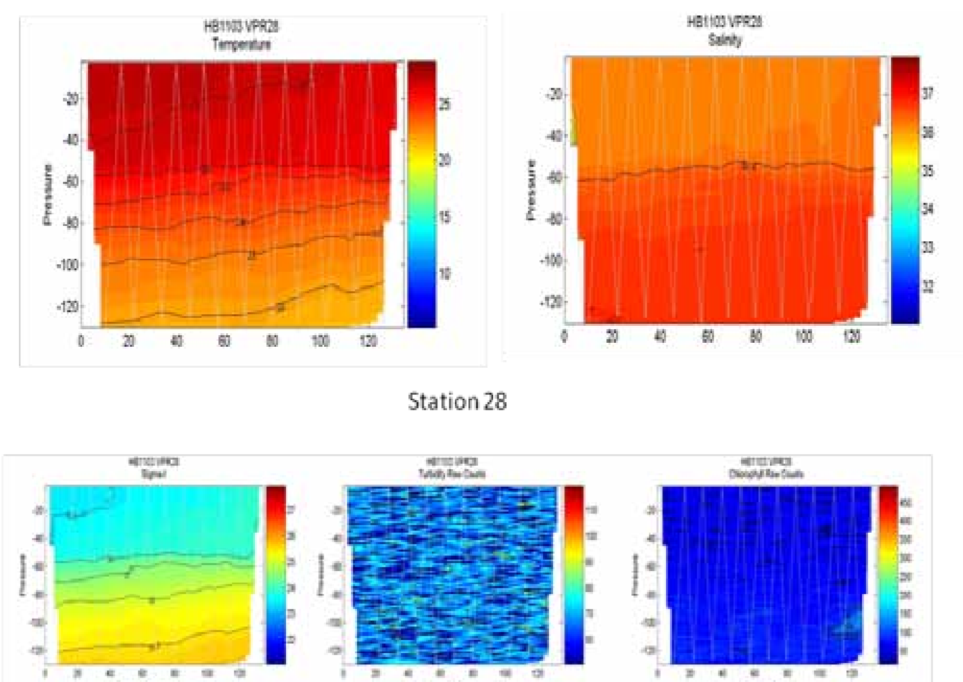

Figure 16.   . Gelatinous zooplankton VPR images. From top left: *Pleurobrachia pileus, Bolinopsis* sp, anthomedusa, leptomedusa, scaphozoa (true jellyfish) and *Beroe* sp.

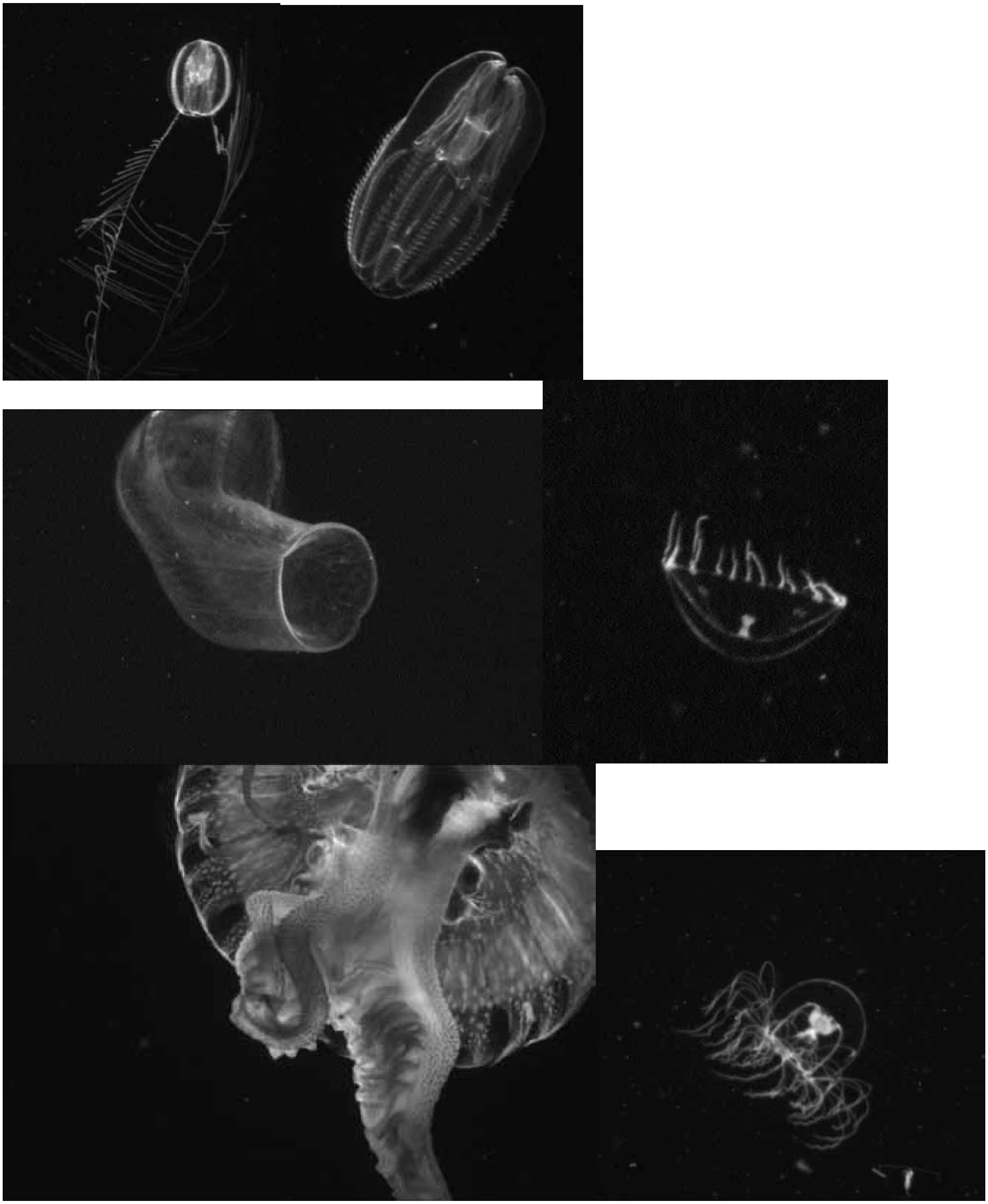

Figure 17. Crustaceans detected in the VPR images. From top left Euphasiid, probably *Meganytiphanes norvegica*, gravid euphausiid, *Themisto gaudichaudi, gammaridea*

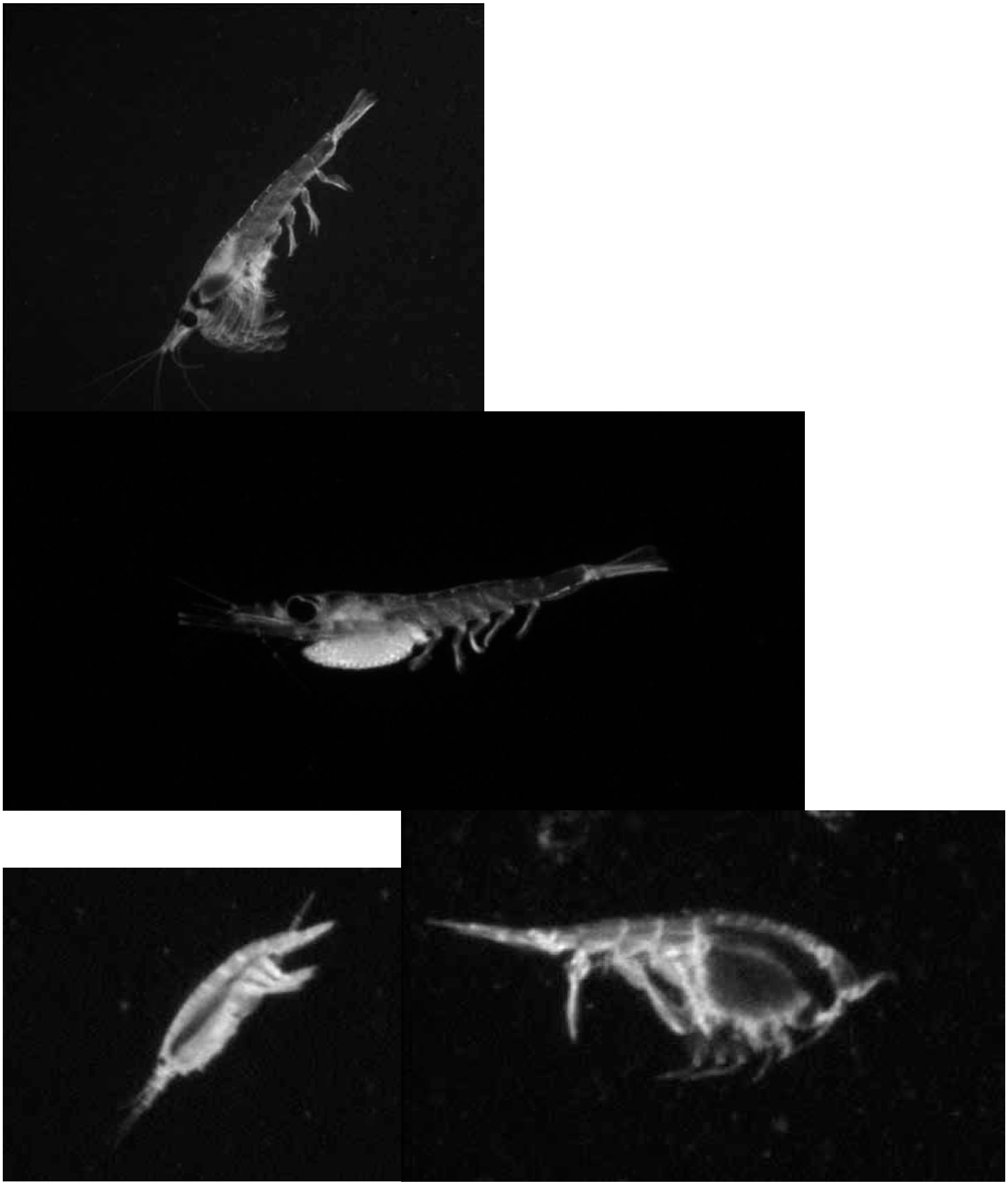

Figure 18. Other VPR images. From top left: larval fish, *Cerianthus* sp.,*Limacina* sp.,*Clione limacina*, *Tomopterus* sp.,phytoplankton.

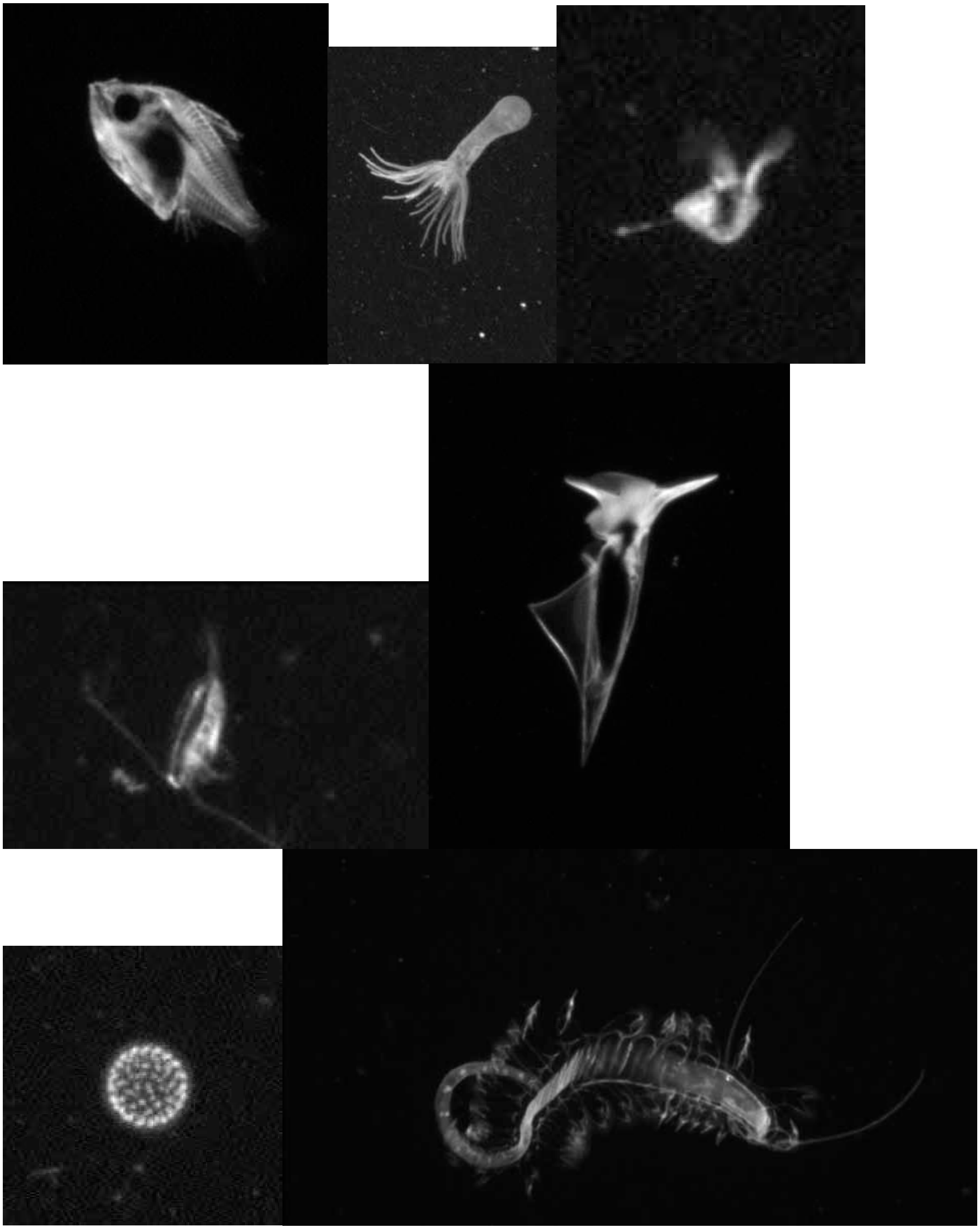

Figure 19 top row: *Thalia democratica* adult and colony of juveniles. Bottom row: two species of siphonophora.

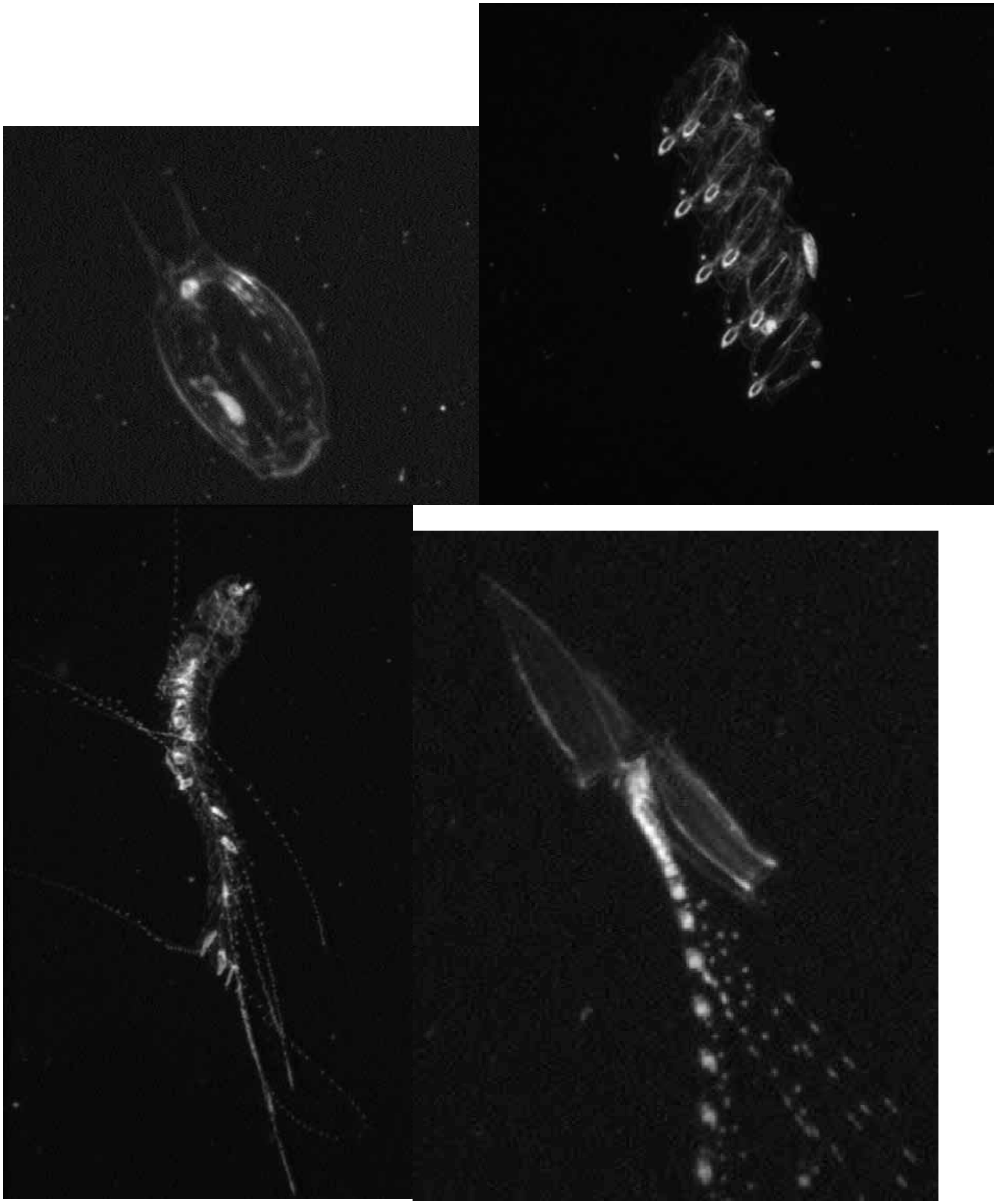

Figure 20: Location of XBT launches (dots) relative to the proposed track lines (lines).

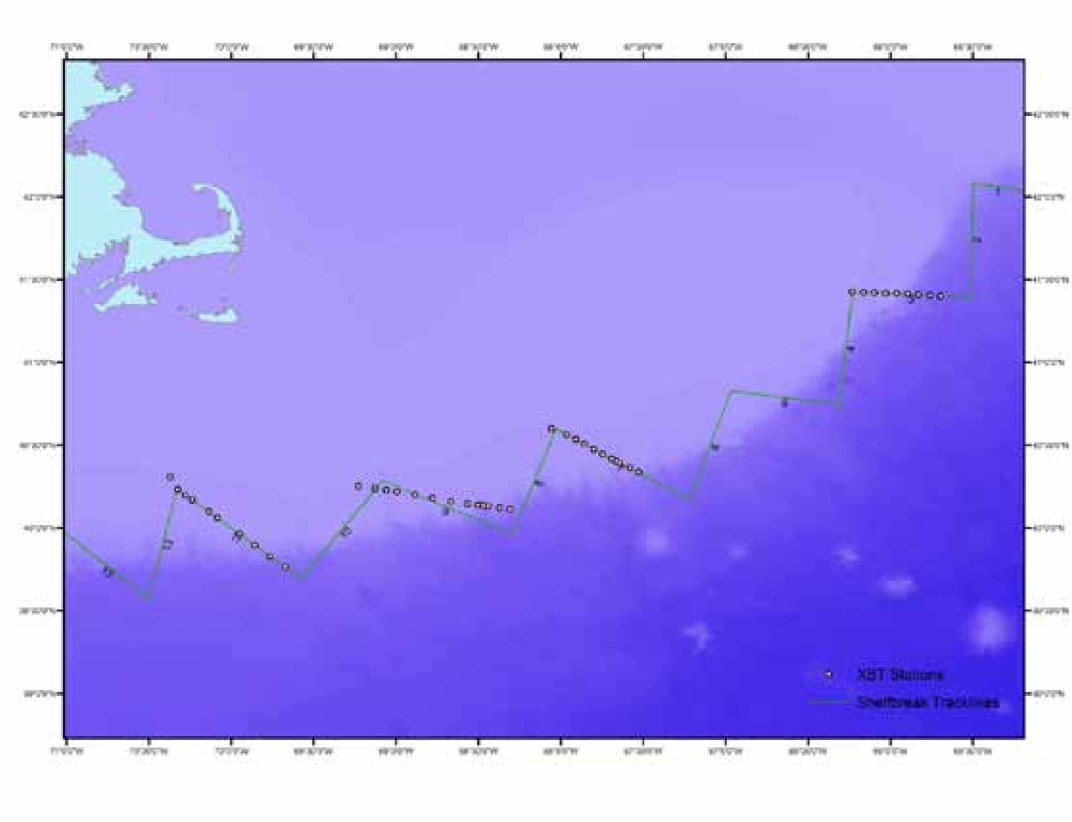

Figure 21 : Comparison of XBT temperature data to CTD upcast temperature data.

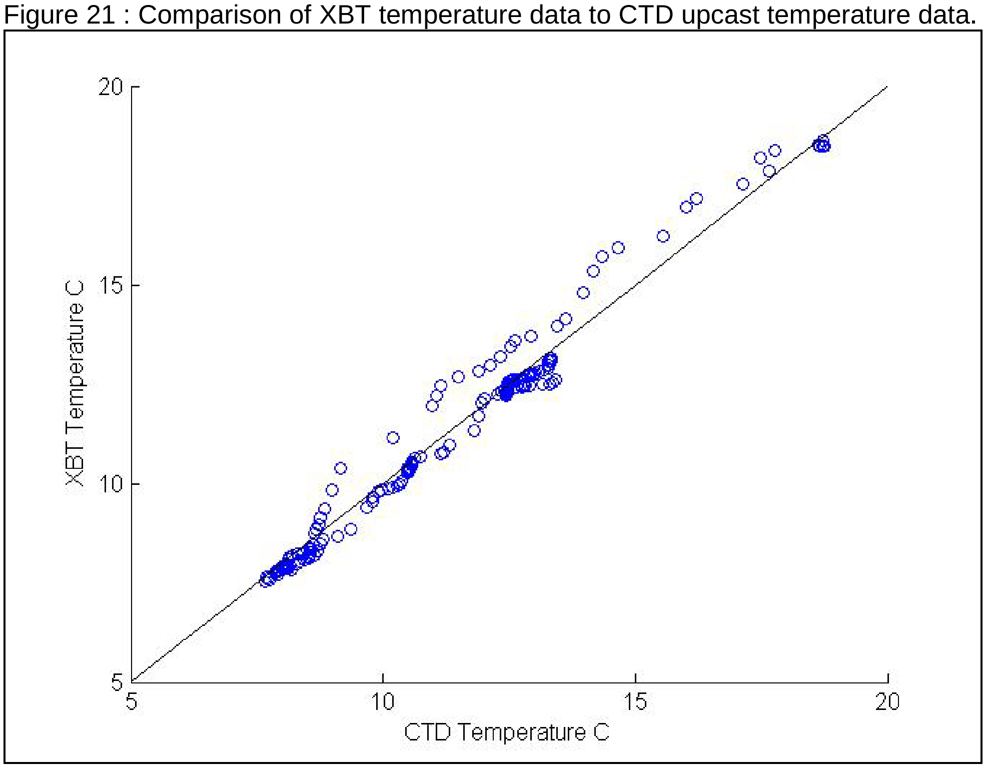

Figure 22 : XBT temperature profiles along trackline 7.