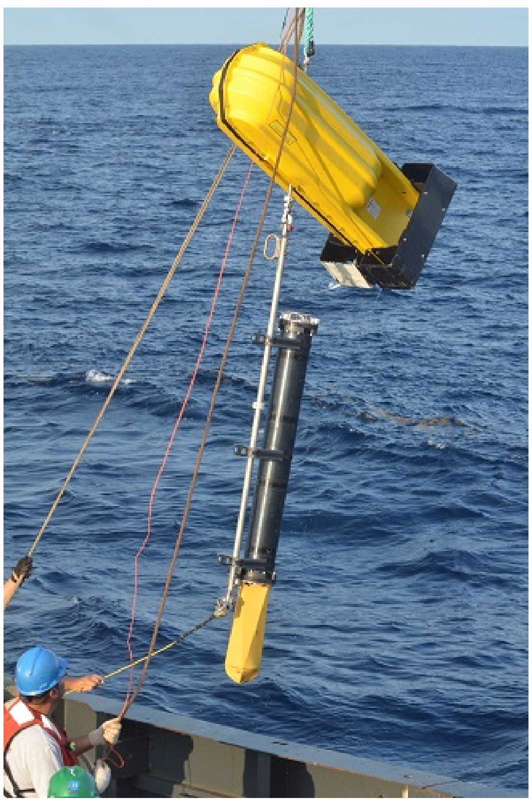
2014

Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean



Autonomous Multichannel Acoustic Recorder (AMAR) deployed on 26 July 2014 from the NOAA ship *Henry B. Bigelow*. Picture taken by Suzanne Yin.

Northeast Fisheries Science Center
166 Water St.
Woods Hole, MA 02543

Southeast Fisheries Science Center
75 Virginia Beach Dr.
Miami, FL 33149

2014 Annual Report to
A Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the western North Atlantic Ocean

Table of Contents

BACKGROUND

In general the intent of the Atlantic Marine Assessment Program for Protected Species (AMAPPS) project is to improve the assessment of marine mammal, seabird and sea turtle stocks in US waters of the western North Atlantic Ocean and to provide information needed to evaluate and mitigate the impacts of activities as required under the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), National Environmental Policy Act (NEPA) and Migratory Bird Treaty Act (MBTA).

This program includes the collection and analyses of various types of data. Marine mammal, sea turtle and sea bird data are collected from seasonal shipboard and aerial surveys, tagged animals, passively listenin hydrophones and other sources. One major goal is to quantify abundance and spatial distributions and to produce spatially-explicit density distribution maps.

To conduct this work inter-agency agreements (IAs) were established between NOAA National Marine Fisheries Service (NOAA Fisheries Service) and the Bureau of Ocean Energy Management (BOEM) – IA number M10PG00075 (2010 – 2014) – and between NOAA Fisheries Service and the US Navy – IA number NEC-11-009 (2011 – 2015). The NOAA Fisheries Service work is being conducted by the Northeast Fisheries Science Center (NEFSC) and the Southeast Fisheries Science Center (SEFSC). Under AMAPPS additional work is being carried out by the US Fish and Wildlife Service (USFWS). This is a report of the work conducted by NOAA Fisheries Service during 2014.

AMAPPS has evolved into a larger collaborative program involving researchers from a variety of organizations, in addition to BOEM, NOAA Fisheries Service, USFWS, and the US Navy. This collaborative effort has the benefit of increasing the amount of field and analytical work. The network of collaborators are identified under the specific projects within the Appendices.

SUMMARY OF 2014 ACTIVITIES

During 2014 under the AMAPPS program, NOAA Fisheries Service conducted field studies to collect cetacean, sea turtle, seal, and sea bird seasonal distribution and abundance data and studies to collect sea turtle and seal telemetry and biological data (Table 1). In addition, NOAA Fisheries Service continued analyzing past and present data collected under AMAPPS (Table 2). Two papers related to AMAPPS were published in 2014, one was in review, and eleven more were in progress during 2014 (Tables 3 and 4). A summary of the 2014 projects follows, with more details in the appendices.

Field activities

During February – April 2014 the NEFSC and SEFSC conducted two aerial and one shipboard surveys. The aerial line transect abundance surveys used NOAA Twin Otter airplanes targeting marine mammals and sea turtles in Atlantic continental shelf waters from Nova Scotia to South Carolina, from the shore to about the 100 m or 2000 m depth contour, depending on the location (Figure 1; Table 1). The shipboard habitat survey used the NOAA ship *Gordon Gunter* targeting marine mammals, sea turtles, and sea birds in addition to their biotic and abiotic habitat in waters from Virginia to Massachussetts, from the coast to the 2000 m depth contour. The aerial surveys completed about 12,700 km of track lines, while the shipboard survey completed about 4000 km of track lines, with about 150 hrs of passive acoustic monitoring using towed hydrophone arrays.

During these surveys there were about 800 groups of 29 detected species or species groups of cetaceans and sea turtles, where the most commonly detected species were common dolphins (*Delphinus delphis*) and loggerhead turtles (*Caretta caretta*), with fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) being the most commonly detected large whales (Table 5). On the shipboard survey, in addition to the marine mammals and turtles, about 6940 birds within 2491 groups of 62 species (or species groups) were detected while on-effort, where the most common were Herring Gull (*Larus argentatus*), Northern Gannet (*Morus bassanus*) and Dovekie (*Alle alle*). Also, to sample the biotic and abiotic habitat, active acoustic backscatter data from a Simrad EK60 were collected nearly 24 hrs per day, and physical and biological oceanographic data were sampled from over 510 collection stations. This included 64 casts of conductivity, temperature and depth profilers (CTDs), 127 bongo deployments, 13 visual plankton recorder (VPR) deployments, 2 Isaac-Kidd midwater trawl (IKMT) deployments, 3 Multiple Opening Closing Net Environmental Sensing System (MOCNESS) deployments, 70 beam trawl deployments and 233 bottom sediment grabs. To assist in documenting spring-time distributions of whales, 10 bottom-mounted marine autonomous recording units (MARUs) were deployed during this cruise, of which 9 were retrieved in September 2014. More information is found in Appendices A – C.

During 25 – 30 July 2014, the NEFSC conducted a short shipboard survey to document the relationships between the distribution and abundance of cetaceans, sea tutles and sea birds relative to their physical and biological environment, focusing on beaked whales on Georges Bank (Figure 1; Table 1). During over 800 km of surveyed track lines, there were 43 hours of passive acoustic recordings, and the visual observers detected over 1800 cetaceans and 800 birds and tracked six groups of Sowerby's beaked whales (*Mesoplodon bidens*) to document their dive time patterns, where the longest track was about 23 minutes. To document the physical and biological habitat, 11 bongo nets+CTD, 3 rosettes+CTD, 1 water only CTD, 1 IKMT and 3 midwater trawls were deployed, in addition to continuously recording data from various ship sensors and the Simrad EK60. More information is found in Appendix D.

NEFSC started a winter aerial abundance survey 4 Dec 2014, which ended 19 Jan 2015, and so will be reported in the 2015 annual report.

NEFSC participated in loggerhead and leatherback turtle tagging studies that were in collaboration with Coonamessett Farm Foundation. The focus was centered on filling the data gap in the Northeastern portion of the loggerhead turtle range. These studies deployed 20 satellite relayed data loggers on loggerhead sea turtles, and one temporary suction cup video and time-depth recorder on a leatherback turtle north of Martha's Vineyard. In addition, while tracking the leatherback turtle, three CTD casts were deployed to collect data on the physical structure of the water column, and video profiles were collected to determine the species identification and distribution of gelatinous zooplankton in the vicinity of the leatherback. The time/depth data from this study will be used to establish dive time correction factors for the proportion of turtles that were in the study area but were underwater and therefore, not available to be detected at the surface during the abundance surveys. In addition, all of these data will provide information on turtle habitat use, behavior, and life history. The satellite tag data are archived in the Northeast Sea Turtle Collaborative Oracle database, maintained by the NEFSC and displayed on their website http://www.nefsc.noaa.gov/psb/turtles/turtleTracks.html. Photographs and other computerized data are stored on NEFSC servers. Biological samples are stored in freezers at the NEFSC and the NOAA Fisheries Service Southwest Fisheries Science Center. More information is found in Appendix E.

A multi-agency team conducted a project on weaned gray seal (*Halichoerus grypus grypus*) pups on Muskeget Island, MA. During 14 – 18 January 2014 researchers conducted live captures, tagging, and biological sampling. One hundred and three pups (37 female; 62 male, 4 gender not noted) were captured. A suite of biological measurements and samples (e.g., weight, lengths, girth, blood, hair, skin, whisker, and mucous swabs) were collected and small plastic tags were attached to hind flippers. Electronic versions of the photos and the capture and samplings logs are archived at NEFSC. More information is found in Appendix F.

<u>Analyses</u>

In collaboration, the United State Navy, Coonamessett Farm Foundation, Virginia Aquarium & Marine Science Center, NEFSC, SEFSC, and University of St. Andrews (Scotland) completed an analysis of tag data from loggerhead turtles to estimate spatially- and temporally- explicit availability corrections. More information is found in Appendix E.

Existing leatherback Wildlife Computer satellite telemetry data collected by the Large Pelagics Research Center between 2008 and 2010 were examined to determine if the existing data can be useful to inform AMAPPS leatherback availability estimates. Unfortunately, it appears that about 18% of the records from our study area, the Northeast US shelf, showed no surface intervals and so will probably not be usable. More information is found in Appendix E.

Existing *in situ* video data collected from ROVs during 2007 – 2014 are currently being analyzed to describe offshore juvenile and adult loggerhead behavior by depth and to identify predator-prey relationships. More information is found in Appendix E.

To model the spatial/temporal distribution of marine mammals and sea turtles using data collected since 2010, two frameworks are being developed that use the same input data but different types of statistical models: Bayesian Hierarchical models and Generalized Linear and Additive models. During 2014, survey data from the ship and plane surveys conducted by the NEFSC and SEFSC were further reviewed for quality control, formatted similarly, and summarized by grid cells that are 10x10 km and 8-day averages. Additional environmental variables were compiled and divided into the grid cells. Dive and surface times are being derived from DTAG data collected by other researchers to be used to address availability bias. The two statistical models were expanded to be more flexible, double checked for accuracy, goodness-of-fit statistics derived, measures of uncertainity developed, and code was expanded to use a derived model to create seasonal spatial maps of the animal density. More information is found in Appendix G.

In addition, to collecting passive acoustic data collected on the 2014 Northeast AMAPPS shipboard surveys, there are five primary ongoing projects related to passive acoustic data: (1) estimating the abundance of sperm whales (*Physeter macrocephalus*) using acoustics, where the ultimate goal is to integrate these with visual abundance estimates to account for availability bias; (2) quantifying acoustic detection rates for beaked whales, with the goals of comparing to visual detection rates and estimating acoustic abundance for this taxon, if possible; (3) testing the performance of a newly-developed Atlantic version of the Real-time Odontocete Call Classification Algorithm (ROCCA), where the ultimate goal is to determine which delphinid species may be confidently identified acoustically in the absence of visual species identification; (4) documenting the offshore spring/summer occurrence of baleen whales in the Great South Channel and Georges Bank regions to supplement visual sighting data, and (5) assessing geographic variation in the echolocation clicks of Risso's dolphins (*Grampus griseus*). Both the NEFSC and SEFSC also continue to collaborate with other Science Centers and Scripps for the development of a standardized acoustic database system (Tethys). More information is found in Appendix H.

The models and density maps developed in Appendix G are correlative models describing species distributions as a function of physical environmental variables (e.g., bottom depth and sediment type) and potential proxies to biological environmental variables that are readily available (e.g., sea surface temperature and surface chlorophyll). However, these efforts do not explicitly account for biological processes that may be a more direct driver of the target species' distributions. To investigate this, the distribution and density patterns of marine mammals, sea turtles and sea birds will be compared with the distribution patterns of species in other trophic levels, in addition to the patterns of the physical environment variables. To start this investigation, the physical oceanographic and lower trophic-level data collected during the shipboard surveys are being processed to be used in this comparison. During 2014, most of the physical data from the 2009 – 2014 surveys have been post-processed and most of the biological samples collected have been enumerated. During 2015, the post-processing should be completed which will then allow a more thorough comparison between distributions of predators (marine mammals, sea turtles and sea birds) and their prey as documented in the EK60, VPR and other sampling devices. More information is found in Appendix I.

The AMAPPS ORACLE database that stores the data collected during the field activities and the associated environmental variables that were derived from other sources was updated in 2014, additional datasets were added, queries for combining and outputting the data were developed, and data collection methods and data structures across the NEFSC and SEFSC are being standardized when possible. More information is found in Appendix J.

REFERENCES CITED

Waring GT, Josephson E, Maze-Foley K, Rosel, PE, editors. 2014. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2013. NOAA Tech Memo NMFS NE 228; 464 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

Table 1. General information on the AMAPPS NOAA Fisheries Service field data collection projects that occurred during 2014: the project name (NOAA Fisheries Service principal investigating center), platforms used, dates and general location of the field study, and the appendix within this document where more information on the project can be found.

Note, the NEFSC aerial survey conducted during 4 Dec 2014 – 19 Jan 2015 will be reported in the 2015 annual report.

2014 field collection projects	Platform(s)	Dates in 2014	Location	Appendix
Spring abundance survey (NEFSC)	NOAA Twin Otter aircraft	17 Feb - 27 Mar	Shelf waters from New Jersey to Nova Scotia	A
Spring abundance survey (SEFSC)	NOAA Twin Otter aircraft	24 Mar - 28 Apr	Shelf waters from New Jersey to Florida	B
Spring habitat survey (NEFSC)	NOAA ship *Gordon Gunter*	11 Mar - 1 May	North Carolina to Massachesetts, near coast to 2000 m depth contour	C
Summer habitat survey (NEFSC)	NOAA ship *Henry B. Bigelow*	25-30 Jul	Shelf break Massachesetts to Georges Bank	D
Northern sea turtle tagging (NEFSC)	F/V *Kathy Ann*	27 May - 1 Jun; 3 - 5 Sep	Offshore of Cheaspeake Bay; Offshore of Rhode Island and Massachusetts	E
Gray seal tagging (NEFSC)	small boats	14 - 18 Jan	Muskeget Island, MA	F

Table 2. A brief description of the purpose of the AMAPPS NOAA Fisheries Service analyses projects that occurred during 2014 and the appendix where more information can be found.

2014 analysis projects	Purpose	Appendix
Availability of loggerhead turtles	Use tag data to estimate spatially- and temporally-explicit estimates of the percent of time loggerheads are available to be seen by the survey platforms	E
Availability estimates for leatherback turtle	Using existing telemetry data for leatherback turtles to determine if it can be useful to inform AMAPPS leatherback turtle availability estimates	E
Offshore loggerhead turtle behavior	Using existing video data collected via ROVs during 2007 - 2014 identify predator-prey relationships and classify behaviors into behavior-depth categories	E
Enviormental time-series	Collalate and calculate time series for environmental variables from available NOAA, satellite and ocean model databases	G
Spatially- and temporally-explicit density models and maps	Develop Bayesian hierarchical and generalized linear/additive models to quantify relationship between marine mammals and sea turtles and habitat	G
Availability estimates for cetaceans using DTAGs	Estimate dive patterns to be used to account for availability bias using data from DTAGs on a variety of cetaceans collected by other researcher	G
Acoustic and visual abundance estimate of sperm whales	Use the acoustic and visual detection rates collected in AMAPPS surveys to estimate a more accurate abundance estimate of sperm whales	H
Beaked whale acoustics	Quantify acoustic detection rate of beaked whales and compare with visual detection rates	H
Whistle and echolocation classification	Test the performance of a newly-developed Atlantic version of the Real-time Odontocete Call Classification Algorithm (ROCCA)	H
Offshore occurrence of baleen whales on Georges Bank	Using bottom-mounted recorders, document presence of baleen whale calls during Apr - Sep 2014	H
Geogrphic variation in echolocation clicks of Risso's dolphins	Characterize the spectral banding patterns of Risso's dolphins from around the world and determine if geographic differences indicate population structure	H
Process and compare EK60 active acoustic backscatter data	Process active acoustic backscatter data (represents middle level trophic level taxa), then compare with distributions of marine mammals and sea turtles	I

2014 analysis projects	Purpose	Appendix
Process and compare the Visual Plankton Recorder images	Process images of plankton from the Visual Plankton Recorder to they can be used to compare with distributions of marine mammals, sea turtles and sea birds	I
Process and compare the organisms in net tows	Enumerate samples from bongo nets, MOCNESS and midwater trawls, then compare with distributions of marine mammals, sea turtles and birds	I
Expand database to include the AMAPPS data	Build on the existing NEFSC Oracle databases to store and process data collected under the various AMAPPS projects	J

Table 3. New papers (completed and in review) that document aspects of the AMAPPS research.

Completed in 2014
Scott-Hayward, L.A.S., D.L. Borchers, M.L. Burt, S. Barco, H.L.Hass, C.R. Sasso and R.J. Smolowitz. 2014. Use of Zero and One-Inflated Beta Regression to Model Availability of Loggerhead Turtles off the East Coast of the United States. Final Report. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command (NAVFAC) Atlantic, Norfolk, Virginia, under Contract No. N62470-10-D-3011, Task Order 40, issued to HDR Inc., Norfolk, Virginia. Prepared by CREEM, University of St. Andrews, St. Andrews, Scotland. July 2014.
Waring GT, Josephson E, Maze-Foley K, Rosel, PE, editors. 2014. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2013. NOAA Tech Memo NMFS NE 228; 464 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/
In review
Gilbert JR, Waring GT, DiGiovanni, R, Josephson E. Gulf of Maine harbor seal abundance estimate. In review as a NOAA Tech Memo NMFS NE

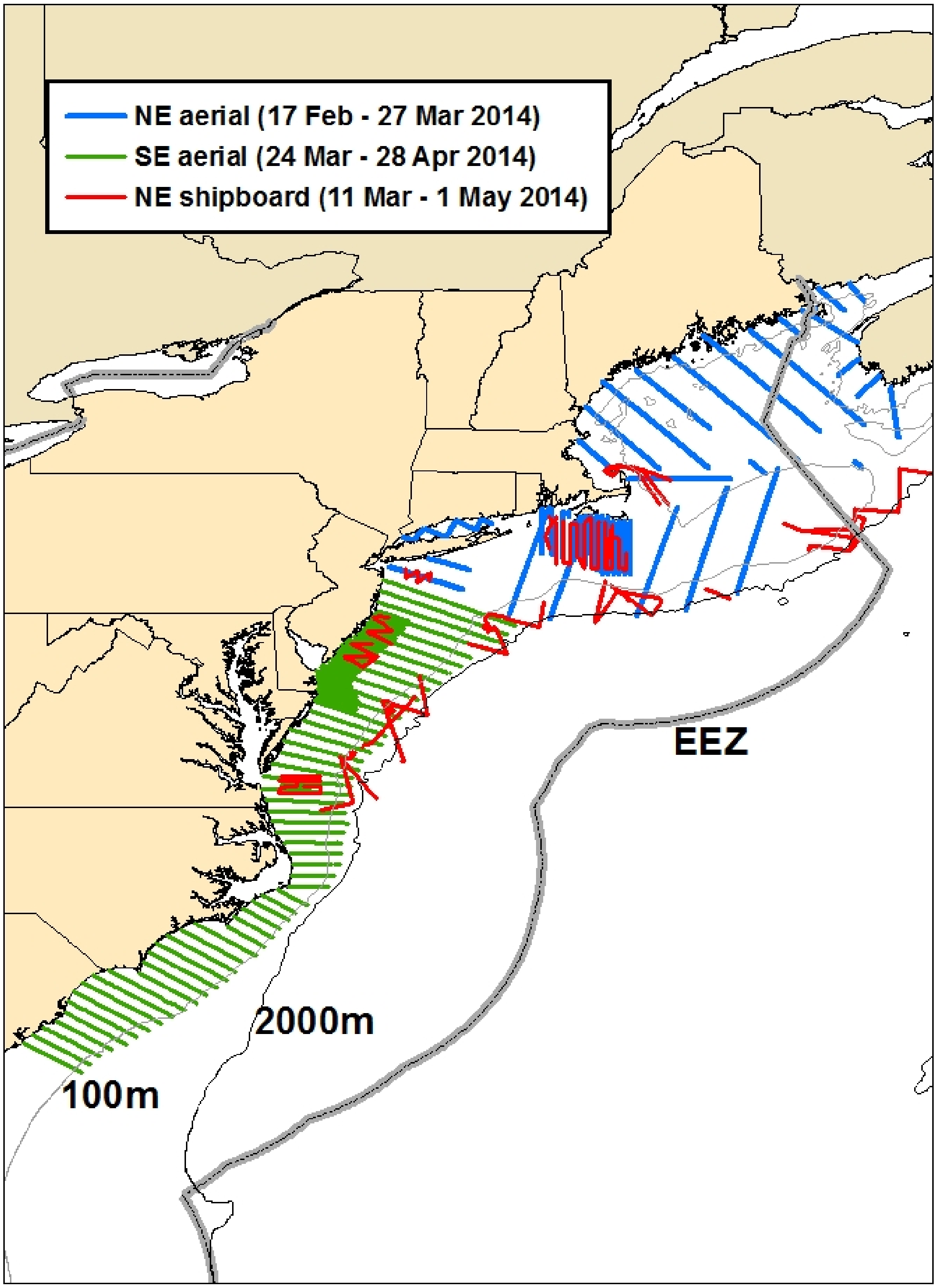
Table 4. Papers currently in progress that document aspects of the AMAPPS research.

Cholewiak D, Haver S, Gurnee J, Van Parijs SM. Acoustic abundance estimates for sperm whales (Physeter macrocephalus) in the northeast U.S. EEZ based on line-transect surveys.
Garrison L, Ortega-Ortiz J. Spatially explicit density-habitat models of cetaceans and sea turtles using a generalized additive model with data from 2010 - 2014.
Garrison LP, Barry K, Mullin KD. Abundance of cetaceans along the southeastern U.S. coast from aerial and vessel based visual line transect surveys. Will be submitted as a NOAA Tech Memo NMFS SE.
Gilbert JR, Waring GT, DiGiovanni, R, Josephson E. Gulf of Maine harbor seal abundance estimate. In review as a NOAA Tech Memo NMFS NE.
Gilbert JR, Waring GT. Aerial survey design proposal for 2011 New England harbor seal abundance survey. Will be submitted as a NOAA Tech Memo NMFS NE.
LaBrecque E, Lawson G, Jech JM, Halpin P. Distribution of acoustic regions of interested derived from multi-frequency data in a dynamic shelfbreak system.
LaBrecque E, Lawson G, Palka D, and Halpin P. Fine scale cetacean habitat classification in a dynamic shelfbreak system.
Palka D, Chavez S, Josephson E, Orphanides C, Hatch J, Murray K. Collation and processing of data collected during AMAPPS shipboard and aerial surveys and associated habitat data from NOAA, satellite and ocean model databases: 2010 - 2014.
Palka D, Jech M, Lawson G, Broughton E. Northwestern Atlantic spatial-temporal relationships between cetaceans and lower trophic levels.
Sigourney D, Chavez S, Palka D, Josephson E. Spatially explicit density-habitat models of cetaceans using a Bayesian hierarchical framework with data from 2010 - 2014.
Sigourney D, Cholewiak D, Palka D. Integrating passive acoustic information with visual surveys in a Bayesian hierarchical model to predict the spatial distribution of sperm whales in the Atlantic Ocean.
Soldevilla MS, Garrison L, Baumann-Pickering S, Cholewiak D, Van Parijs S, Hodge LEW, Read A, Oleson EM, and Rankin S. Geographic variation in Risso's dolphin echolocation click spectral features. .
Warden M, Palka D. plus others. Estimates of availability of cetaceans using DTAG data.

Table 5. Approximate number of groups detected during the aerial and shipboard spring (February – April 2014) 2014 AMAPPS surveys.

Species		ship	planes
Atlantic spotted dolphin	*Stenella frontalis*	1	1
Blue whale	*Balaenoptera musculus*	1	
Bottlenose dolphin spp.	*Tursiops truncatus*	24	70
Bottlenose whale	*Hyperoodon ampullatus*	0	
Common dolphin	*Delphinus delphis*	84	31
Cuvier's beaked whale	*Ziphius cavirostris*	3	2
False killer whale	*Pseudorca crassidens*		1
Fin whale	*Balaenoptera physalus*	40	4
Fin/sei whales	*B. physalus or B. borealis*	22	
Harbor porpoise	*Phocoena phocoena*	13	30
Humpback whale	*Megaptera novaeangliae*	41	3
Killer whale	*Orcinus orca*	1	
Minke whale	*B. acutorostrata*	11	5
Pilot whales spp.	*Globicephala spp.*	44	4
Right whale	*Eubalaena glacialis*	18	8
Risso's dolphin	*Grampus griseus*	19	3
Sei whale	*Balaenoptera borealis*	4	
Sowerby's beaked whale	*Mesoplodon bidens*	1	
Sperm whale	*Physeter macrocephalus*	32	2
Striped dolphin	*Stenella coeruleoalba*	7	
True's beaked whale	*Mesoplodon mirus*	1	
White-sided dolphin	*Lagenorhynchus acutus*	20	17
Unid. Dolphin	*Delphinidae*	52	33
Unid. Whale	*Mysticeti*	121	5
Unid. Mesoplodon	*Mesoplodon spp.*	17	
Total cetaceans		577	219
Unid. Hardshell turtle		1	172
Kemp's Ridley			10
Leatherback turtle	*Dermochelys coriacea*		7
Loggerhead turtle	*Caretta caretta*	1	335
Total turtles		2	524

Figure 1. Tracklines completed during the February – April 2014 AMAPPS aerial and shipboard surveys.



Appendix A: *Northern leg of aerial abundance survey during Feburary - March 2014: Northeast Fisheries Science Center*

Debra L. Palka
Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

SUMMARY

During 17 February – 27 March 2014, the Northeast Fisheries Science Center (NEFSC) conducted aerial abundance surveys targeting marine mammals and sea turtles. The southwestern extent was New Jersey and the northeastern extent was the southern tip of Nova Scotia, Canada. This survey covered waters from the coast line to about the 2000 m depth contour. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots). The two-independent team methodology was used to collect the data. In Beaufort sea states of six and less, about 4900 km of on-effort track lines were surveyed. About 430 individuals within 155 groups of 11 species (or species groups) of cetaceans, seals and large fish were detected by one or both teams. The most regularly detected small cetacean species were white-sided dolphins, bottlenose dolphins and harbor porpoises; right whales and minke whales were the most common large whales. No sea turtles were detected.

OBJECTIVES

The objectives of these aerial flights were to collect the data needed to estimate abundance of cetaceans and turtles in the study area, and to investigate how the animal's distribution and abundance relate to their physical and biological ecosystem.

CRUISE PERIOD AND AREA

This survey was conducted during 17 February – 27 March 2014. The study area extended from New Jersey to the southern tip of Nova Scotia, Canada, from the coast line to about the 2000 m depth contour (Figure A1).

METHODS

The aerial surveys were conducted on a DeHavilland Twin Otter DHC-6 aircraft over Atlantic Ocean waters off the east coast of the U.S. and Canada. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots), when Beaufort sea state conditions were six and below, and when there was at least two miles of visibility.

When a cetacean, seal, turtle, sunfish, or basking shark was observed the following data were collected:

- Time animal passed perpendicular to the observer;
- Species identification;
- Species identification confidence level (certain, probable, not sure);
- Best estimate of the group size;
- Angle of declination between the track line and location of the animal group when it passed abeam (measured to the nearest one degree by inclinometers or marks on the windows, where 0º is straight down);
- Cue (animal, splash, blow, footprint, birds, vessel/gear, windrows, disturbance, or other);

- Swim direction (0º indicates animal was swimming parallel to the track line in the same direction the plane was flying, 90º indicates animal was swimming perpendicular to the track line and towards the right, etc.);
- If the animal appeared to react to the plane (yes or no);
- If a turtle was initially detected above or below the surface, and;
- Comments, if any.

Other fish species were also recorded opportunistically. Species identifications were recorded to the lowest taxonomic level possible.

At the beginning of each leg, and when conditions changed the following effort data were collected:

- Initials of person in the pilot seats and observation stations;
- Beaufort sea state (recorded to one decimal place);
- Water turbidity (clear, moderately clear or turbid);
- Percent cloud cover (0-100%);
- Angle glare swath started and ended at (0-359º), where 0º was the track line in the direction of flight and 90º was directly abeam to the right side of the track line;
- Magnitude of glare (none, slight, moderate, and excessive); and
- Subjective overall quality of viewing conditions (excellent, good, moderate, fair, and poor), where data collected in poor conditions indicated conditions were so poor that that part of the track line should not be used in analyses.

In addition, the location of the plane was recorded every two seconds with a GPS that was attached to the data entry program. Sightings and effort data were collected by a computer program called VOR.exe, version 8.75 originally created by Phil Lovell and Lex Hiby.

To help correct for perception bias data were collected to estimate the parameter *g(0)*, the probability of detecting a group on the track line. This was accomplished by using the two independent team data collection method (Laake and Borchers 2004).

Onboard, in addition to two pilots, were six scientists who were divided into two teams. One team, the primary forward team, consisted of a recorder and two observers viewing through the two forward right and left bubble windows. The other team, the independent back team, consisted of one observer viewing through the back belly window, one observer viewing through either the right or left back window (depending on which side the sighting conditions were best), and a recorder. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

When at the end of track lines or about every 30-40 minutes, scientists rotated between the observations positions. The belly window observer was limited to approximately a 30º view on both sides of the track line. The bubble window and back side observers searched from straight down to the horizon, with a concentration on waters between straight down (0º) and about 60º up from straight down.

When both teams could not identify the species of a group that was within about 60º of the track line and there was a high chance that the group could be relocated, sighting effort was broke off, and the plane returned to the group to confirm the species identification and group size. The marine mammal and turtle data will be reviewed at a later time to identify duplicate sightings made by the two teams based upon time, location, and position relative to the trackline.

In addition, to determine the approximate area that a species can be detected, when possible the front team also collected the time a group was initially seen and then also collected the time and angle of declination of that same group when it was perpendicular to the observers position. The initial time a group was seen was identified in the sightings data by a species identification of "FRST".

RESULTS

The observers and pilots who collected these data are listed in Table A1.

Twelve of the 39 days had sufficiently good weather and a working plane to conduct the survey. There were about 4900 km of "on-effort" track lines, where 72% of the track lines were surveyed in Beaufort 2 and 3 (Table A2).

On the on-effort portions of the track lines, 243 and 264 individual cetaceans within 58 and 71 groups were detected by the back and front teams, respectively (Table A3). The locations of sightings seen on the on-effort transect legs, by species, are displayed in Figures A2 – A5, where harbor porpoises are in Figure A2, dolphins in Figures A3, whales in Figures A4, and seals and other species in Figure A5. The sightings included six species of identifiable cetaceans: minke whales, fin whales, right whales, white-sided dolphins, bottlenose dolphins, and harbor porpoises. In addition, sunfish and seals (most likely either harbor or gray seals) were also seen. No sea turtles were detected. The most regularly detected small cetacean species were white-sided dolphins, bottlenose dolphins and harbor porpoises. Right whales and minke whales were the most common large whales.

DISPOSITION OF DATA

All data collected during this survey will be maintained by the Protected Species Branch at NEFSC in Woods Hole, MA and are available from the NEFSC's Oracle database.

PERMITS

NEFSC was authorized to conduct these research activities during this survey under US Permit No. 17355 issued to the NEFSC by the NMFS Office of Protected Resources. The NOAA aircraft was granted diplomatic overflight clearance in Canadian airspace with the overflight clearance number 0039-US-2014-02-TC. NEFSC was authorized to conduct these research activities in Canadian airspace under the Species at Risk Permit license number 330996.

ACKNOWLEDGEMENTS

Funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Flight time and other aircraft costs were funded by NOAA Aircraft Operations Center (AOC). Staff time was also provided by the NOAA Fisheries Service, Northeast Fisheries Science Center (NEFSC) and NOAA AOC. We would like to thank the pilots and observers involved in collecting these data.

REFERENCES CITED

Laake JL, Borchers DL. 2004. Methods for incomplete detection at distance zero, In: Advanced distance sampling, edited by S. T. Buckland, D. R. Andersen, K. P. Burnham, J. L. Laake, and L. Thomas, pp. 108–189, Oxford University Press, New York.

Table A1. List of observers and pilots that participated in the spring 2014 Northeast AMAPPS aerial survey, along with their affiliations.

Name	Affiliation
OBSERVERS	
Tim Cole	Northeast Fisheries Science Center, Woods Hole, MA
Peter Duley	Northeast Fisheries Science Center, Woods Hole, MA
Allison Henry	Northeast Fisheries Science Center, Woods Hole, MA
Christin Khan	Northeast Fisheries Science Center, Woods Hole, MA
Val Sherlock	Integrated Statistics, Inc, Woods Hole, MA
Robert DiGiovanni	Integrated Statistics, Inc, Woods Hole, MA
Rachel Hardee	Integrated Statistics, Inc, Woods Hole, MA
Richard Holt	Integrated Statistics, Inc, Woods Hole, MA
PILOTS	
Dave Gothan	NOAA Aircraft Operations Center, Tampa, FL
Francisco Fuenmayor	NOAA Aircraft Operations Center, Tampa, FL
Mike Marino	NOAA Aircraft Operations Center, Tampa, FL
Sandor Silagi	NOAA Aircraft Operations Center, Tampa, FL

Table A2. Length of on-effort track lines (in km) surveyed by Beaufort sea state.

	Beaufort sea state						
	1	2	3	4	5	6	Total
track length (km)	130.6	1406.9	2097.8	949.7	215.6	103.9	4904.5
% of total	3	29	43	19	4	2	100

Table A3. Spring 2014 Northeast AMAPPS aerial survey: Number of groups and individuals of species detected while on-effort by the front and back teams. Some of the groups seen by the back team were also seen by the front team.

		Number of groups		Number of individuals	
Species		**Back**	**Front**	**Back**	**Front**
Bottlenose dolphin spp.	*Tursiops truncatus*	3	3	75	35
Common or white-sided dolphin		4	2	14	7
Fin whale	*Balaenoptera physalus*	0	2	0	2
Harbor porpoise	*Phocoena phocoena*	25	28	30	51
Minke whale	*B. acutorostrata*	1	3	1	4
Right whale	*Eubalaena glacialis*	1	6	1	6
Unid dolphin	*Delphinidae*	9	9	61	27
Unid large whale	*Mysticeti*	1	1	1	1
White-sided dolphin	*Lagenorhynchus acutus*	14	17	60	131
Total cetaceans		58	71	243	264
Ocean sunfish	*Mola mola*	2	2	2	2
Unid seal	*Pinniped*	23	26	23	26
Total all species		83	99	268	292

Figure A1. Spring 2014 Northeast AMAPPS aerial survey (17 February – 27 March 2014): completed on-effort track lines. The 100 m and 2000 m depth contours and the US economic exclusion zone (EEZ) are shown.

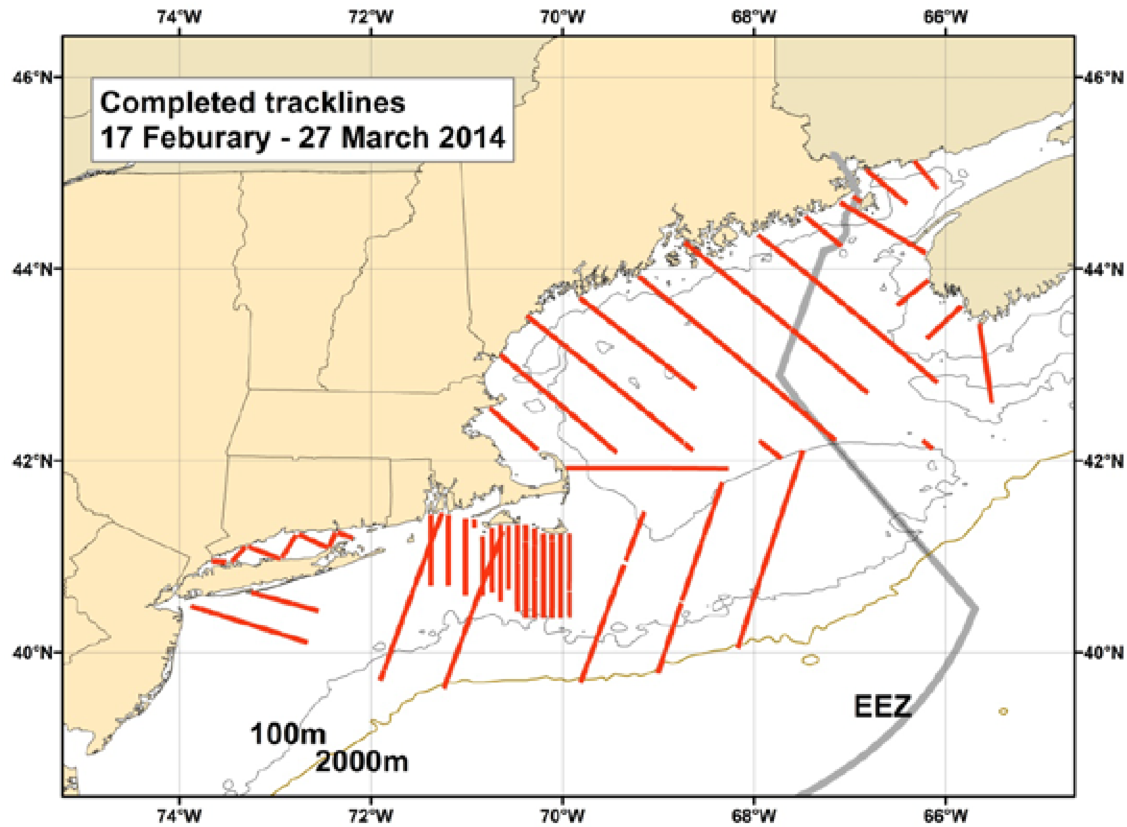


Figure A2. Spring 2014 Northeast AMAPPS aerial survey (17 February – 27 March 2014): Locations of harbor porpoises detected by either one or both teams. The 100 m and 2000 m depth contours and the US economic exclusion zone (EEZ) are shown.

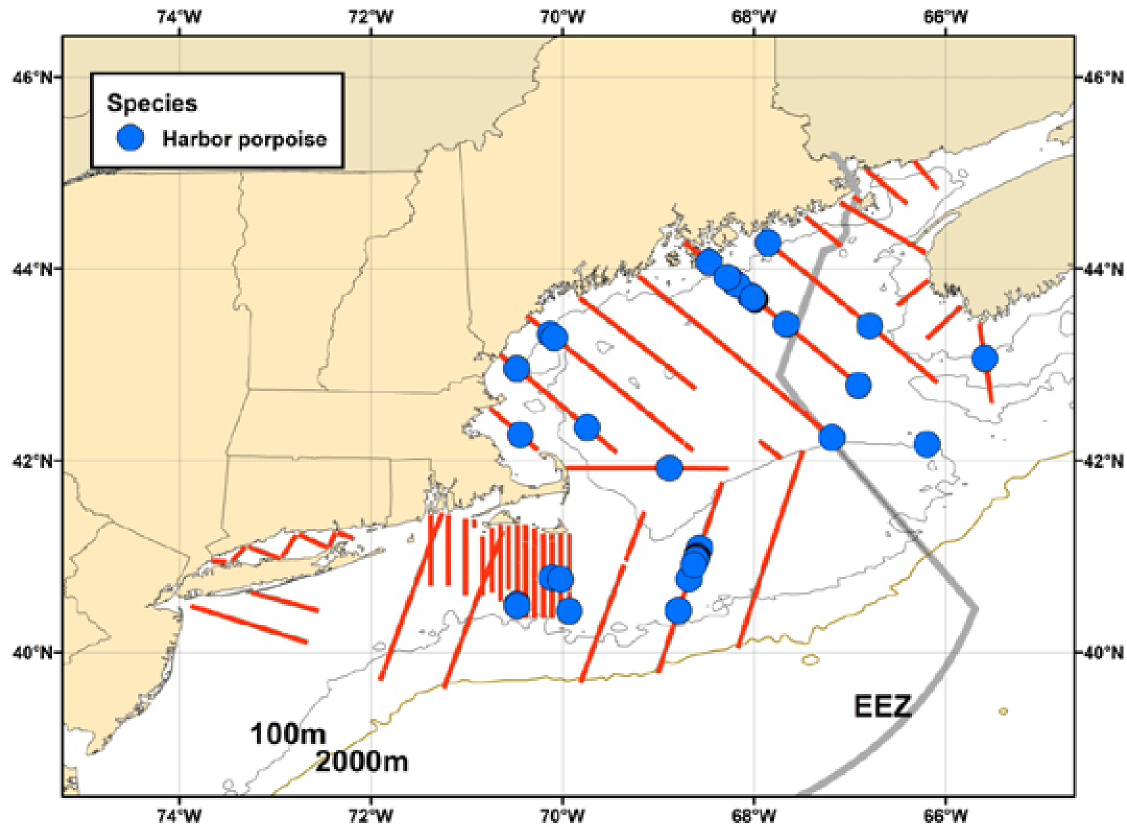


Figure A3. Spring 2014 Northeast AMAPPS aerial survey (17 February – 27 March 2014): Locations of bottlenose dolphins (red circles), white-sided dolphins (green square), common or white-sided dolphins (blue triangle), and unidentified dolphins (black cross) detected by either one or both teams. The 100 m and 2000 m depth contours and the US economic exclusion zone (EEZ) are shown.

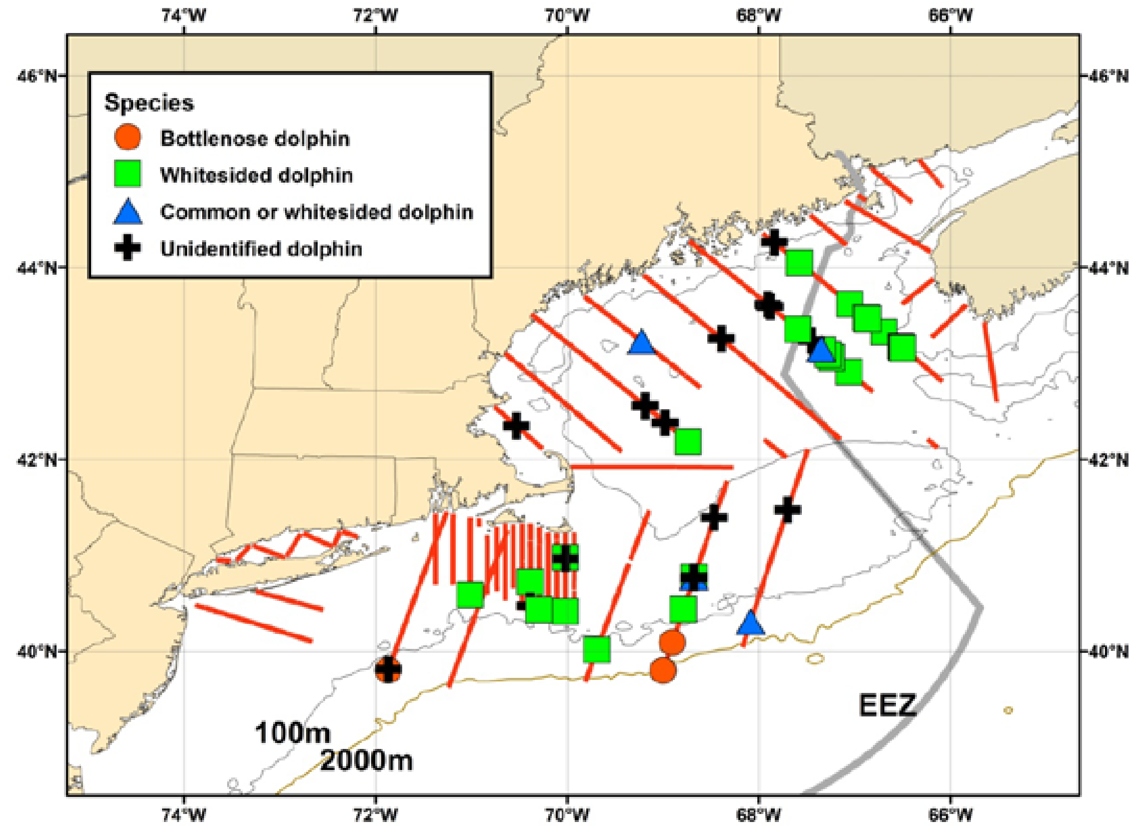


Figure A4. Spring 2014 Northeast AMAPPS aerial survey (17 February – 27 March 2014): Locations of fin whales (green square), minke whales (blue triangle), right whales (red circle) and unidentified large whales (black cross) detected by either one or both teams. The 100 m and 2000 m depth contours and the US economic exclusion zone (EEZ) are shown.

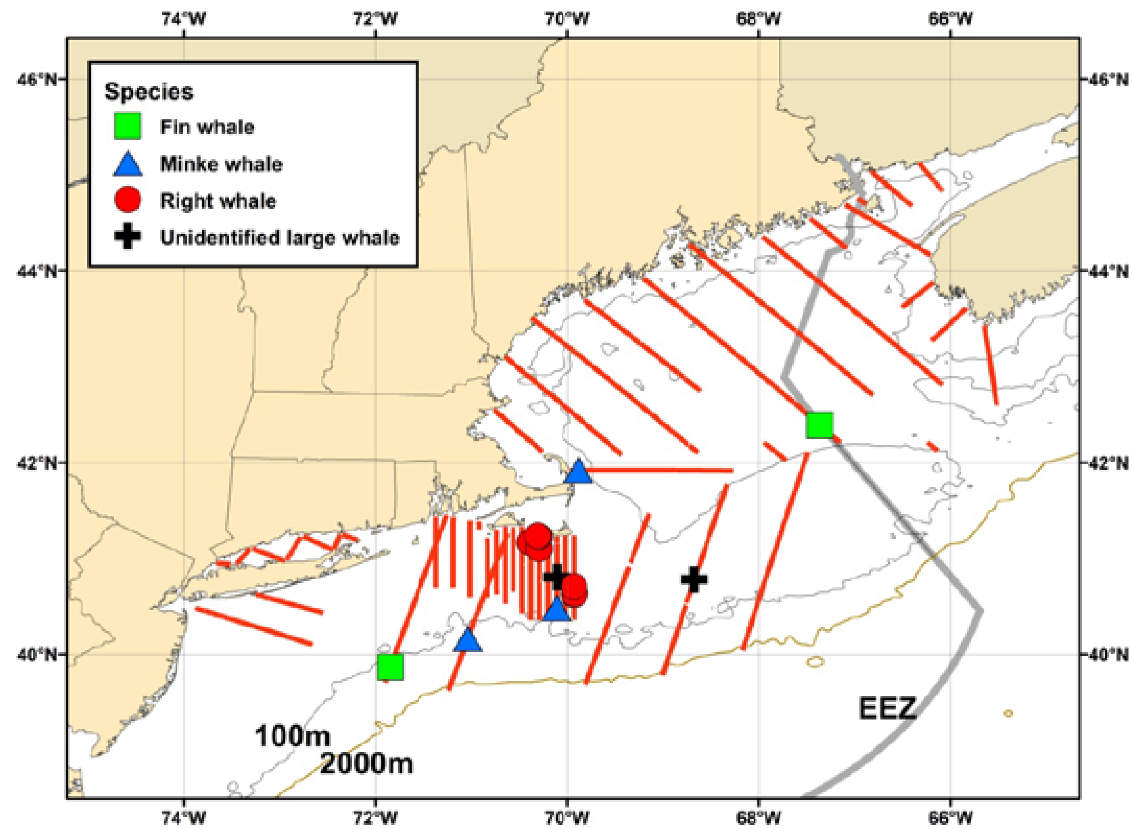
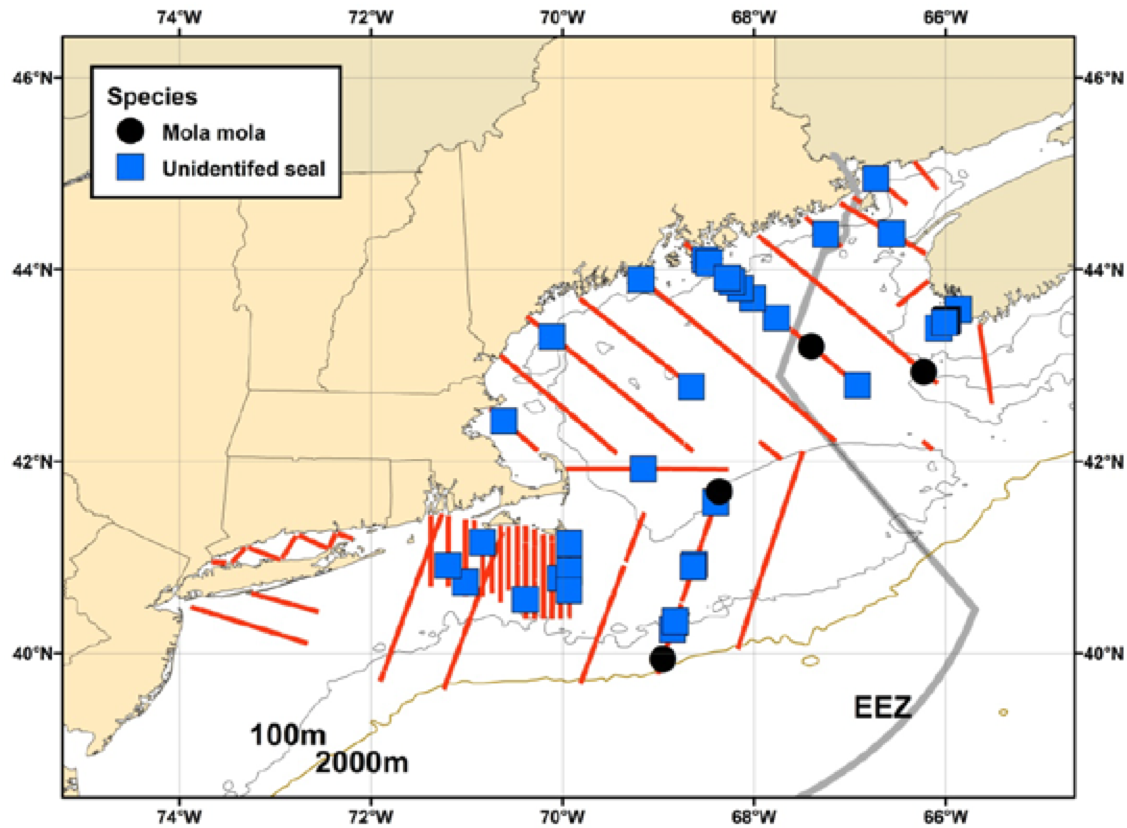


Figure A5. Spring 2014 Northeast AMAPPS aerial survey (17 February – 27 March 2014): Locations of sunfish, *Mola mola* (black circle), and unidentified seals (blue square) detected by either one or both teams. The 100 m and 2000 m depth contours and the US economic exclusion zone (EEZ) are shown.



Appendix B: Southern leg of aerial abundance survey during March - April 2014: Southeast Fisheries Science Center

Lance P. Garrison[1], Joel Ortega-Ortiz[1], Kevin P. Barry[2]

[1]Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149
[2]Southeast Fisheries Science Center, 3209 Frederic St., Pascagoula, MS 39567

SUMMARY
As part of the AMAPPS program, the Southeast Fisheries Science Center conducts aerial surveys of continental shelf waters along the US East Coast from Southeastern Florida to Cape May, New Jersey. Aerial survey TOSE14SPR was conducted during 2014 between 24 March and 28 April. The survey was conducted along tracklines oriented perpendicular to the shoreline that were latitudinally spaced 20 km apart aboard a NOAA Twin Otter aircraft at an altitude of 600 feet (183 m) and a speed of 110 knots. The survey was designed for analysis using Distance sampling and a two-team (independent observer) approach to correct for visibility bias in resulting abundance estimates. The survey covered waters from Cape May, NJ to South Carolina including "fine-scale" tracklines in waters offshore of New Jersey and Virginia. A total of 7,778 km of trackline were surveyed on effort. Thirteen species of marine mammals were identified, with the majority being bottlenose dolphins (67 groups sighted totaling 719 animals) and common dolphins (31 groups, 1221 animals). Three species of sea turtles were identified, with the majority of identified animals being loggerhead turtles (335 sightings totaling 366 animals). The data collected from this survey will be analyzed to estimate the abundance and spatial distribution of mammals and turtles along the US east coast.

OBJECTIVES
The goal of the survey was to conduct line-transect surveys using the Distance sampling approach to estimate the abundance and spatial distribution of marine mammals and turtles in waters over the continental shelf (shoreline to 200m isobaths) from Southeast, Florida to Cape May, New Jersey. Due to weather conditions during the survey, only effort from South Carolina to Cape May, New Jersey was completed.

CRUISE PERIOD AND AREA
The survey was conducted during 2014 between 24 March and 28 April. The survey covered waters from Cape May, NJ to South Carolina including "fine-scale" tracklines in waters offshore of New Jersey and Virginia.

METHODS

The survey was conducted aboard a DeHavilland Twin Otter DHC-6 flying at an altitude of 183m (600 ft) above the water surface and a speed of approximately 200 kph (110 knots). Surveys were typically flown only when wind speeds were less than 20 knots or approximately sea state 4 or less on the Beaufort scale. The survey was conducted along tracklines oriented perpendicular to the shoreline and spaced latitudinally at approximately 20 km intervals from a random start point (Figure B1). Offshore of Virginia and New Jersey within designated "Wind Areas", fine-scale tracklines were flown that were spaced 5 km apart.

There were two pilots and six scientists onboard the airplane. The scientists operated as two teams to implement the independent observer approach to correct for visibility bias (Laake and Borchers 2004). The forward team (Team 1) consisted of two observers stationed in bubble windows on either side of the airplane and an associated data recorder. The bubble windows allowed downward visibility including the trackline. The aft team (Team 2) consisted of a belly observer looking straight down through a belly port, an observer stationed on one side of the aircraft observing through a large window, and a dedicated data recorder. The side bubble window observer was stationed in a large "vista" window that provided trackline visibility while the belly observer can see approximately 35 degrees on either side of the trackline. Therefore, the aft team has limited visibility of the left side of the aircraft. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

Data was entered by each team's data recorded onto a laptop computer running data acquisition software that recorded GPS location, environmental conditions entered by the observer team (e.g., sea state, water color, glare, sun penetration, visibility, etc.), effort information, and surface water temperature.

During on effort periods (e.g., level flight at survey altitude and speed), observers searched visually from the trackline (0˚) to approximately 50˚ above vertical. When a turtle, mammal, or other organism was observed, the observer waited until it was perpendicular to the aircraft and then measured the angle to the organism (or the center of the group) using a digital inclinometer or recorded the angle in 10˚ intervals based upon markings on the windows. The belly observer only reported the interval for the sighting. Fish species were recorded opportunistically.

Sea turtle sightings were recorded independently, without communication, by each team. For marine mammal sightings, if the sighting was made initially by the forward team, they waited until it was aft of the airplane to allow the aft team an opportunity to observe the group before notifying the pilots to circle over the group. Once both teams had the opportunity to observe the group, the observers asked the pilots to break effort and circle the group. The aircraft circled over the majority of the marine mammal groups sighted to verify species identification and group sizes and to take photographs. The data recorders indicated at the time of the sighting whether or not the group was recorded by one or both teams.

The turtle data were reviewed to identify duplicate sightings by the two teams based upon time, location, and position relative to the trackline.

RESULTS

The survey was conducted during 24 March – 28 April, 2014, but survey flights could only be conducted on 13 days during that period due to weather conditions, mechanical issues, or transits between cities. A total of 7,778 km of trackline were covered on effort along 85 tracklines (Figure B1, Table B1). Survey effort was planned to cover waters as far south as Florida, but weather only allowed lines between South Carolina and Cape May, NJ to be completed. The average sea state during the survey was 2.7 on the Beaufort scale with the majority of the survey effort flown in sea states of 2 or 3 (Figure B2). However, some sections of trackline, particularly the outer portion of tracklines, were flown in sea states as high as 5.

There were a total of 524 unique sightings of sea turtles for a total of 584 individuals. Turtles were identified as loggerhead, Kemp's Ridley, leatherback and unidentified hardshells (Table B2). Of these, the majority of identified turtle sightings were loggerhead turtles (Figure B3).

Turtle sightings were restricted from the area south of Maryland, with the majority of turtles sighted south of Virginia (Figure B3 – B4).

There were a total of 152 groups of marine mammals sighted for a total of 2,280 individuals. The primary species observed were bottlenose dolphins and common dolphins. Large whales including right whales, humpback whales, minke whales and fin whales were seen in the northern portion of the survey area (Table B3, Figures B5 – B7).

Fish species sighted included primarily sharks, manta rays, and sunfish (Figure B8).

DISPOSITION OF DATA

All data collected during this survey will be maintained by the Southeast Fisheries Science Center (SEFSC) and are also available from the Oracle database maintained by the Northeast Fisheries Science Center.

PERMITS

The SEFSC was authorized to conduct marine mammal research activities during the cruise under Permit No. 779-1633-02 issued to the SEFSC by the National Marine Fiseries Science Office of Protected Resources.

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Staff time was also provided by the NOAA Fisheries Service, SEFSC. We would also like to thank the plane's pilots and observers that were involved in collecting these data.

REFERENCES CITED

Laake, J.L. and D.L Borchers. 2004. Methods for incomplete detection at distance zero. In: Advanced Distance Sampling. Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., and Thomas, L. (eds.). Oxford University Press, 411 pp.

Table B1. Daily summary of survey effort and protected species sightings during Southeast AMAPPS Spring 2014 aerial survey.

Date	Effort (km)	Marine Mammal Sightings	Turtle Sightings	Average Sea State
3/24/2014	386.9	1	0	3.2
3/27/2014	479.8	5	0	3.0
4/1/2014	1,138.3	17	0	2.5
4/2/2014	483.9	4	0	2.5
4/3/2014	1,070.9	15	0	2.8
4/6/2014	243.0	6	1	2.7
4/10/2014	469.7	15	28	1.4
4/12/2014	696.2	15	10	2.2
4/13/2014	438.9	33	222	2.8
4/22/2014	246.7	4	11	3.4
4/25/2014	495.8	5	34	2.8
4/26/2014	719.1	11	107	2.8
4/28/2014	908.8	21	111	2.6
Total	7,778.0	152	524	2.7

Table B2. Summary of sea turtle sightings during Southeast AMAPPS Spring 2014 aerial survey.

Species	Number of sightings	Number of animals
Unid. Hardshell	172	200
Kemp's Ridley	10	10
Leatherback	7	8
Loggerhead	335	366
Total	524	584

Table B3. Summary of marine mammal sightings during Southeast AMAPPS Spring 2014 aerial survey.

Species	Number of groups	Number of animals
Atlantic spotted dolphin	1	40
Bottlenose dolphin	67	719
Bottlenose/Atl. spotted dolphin	2	38
Common dolphin	31	1,221
Cuvier's beaked whale	2	5
False killer whale	1	13
Fin whale	2	4
Harbor porpoise	2	3
Humpback whale	3	5
Minke whale	2	2
North Atlantic right whale	2	2
Pilot whales	4	43
Risso's dolphin	3	26
Sperm whale	2	2
Unid. baleen whale	1	1
Unid. dolphin	23	147
Unid. large whale	2	2
Unid. odontocete	1	1
Unid. small whale	1	6
Total	152	2,280

Figure B1. On-effort tracklines during the Southeast AMAPPS Spring 2014 aerial survey.

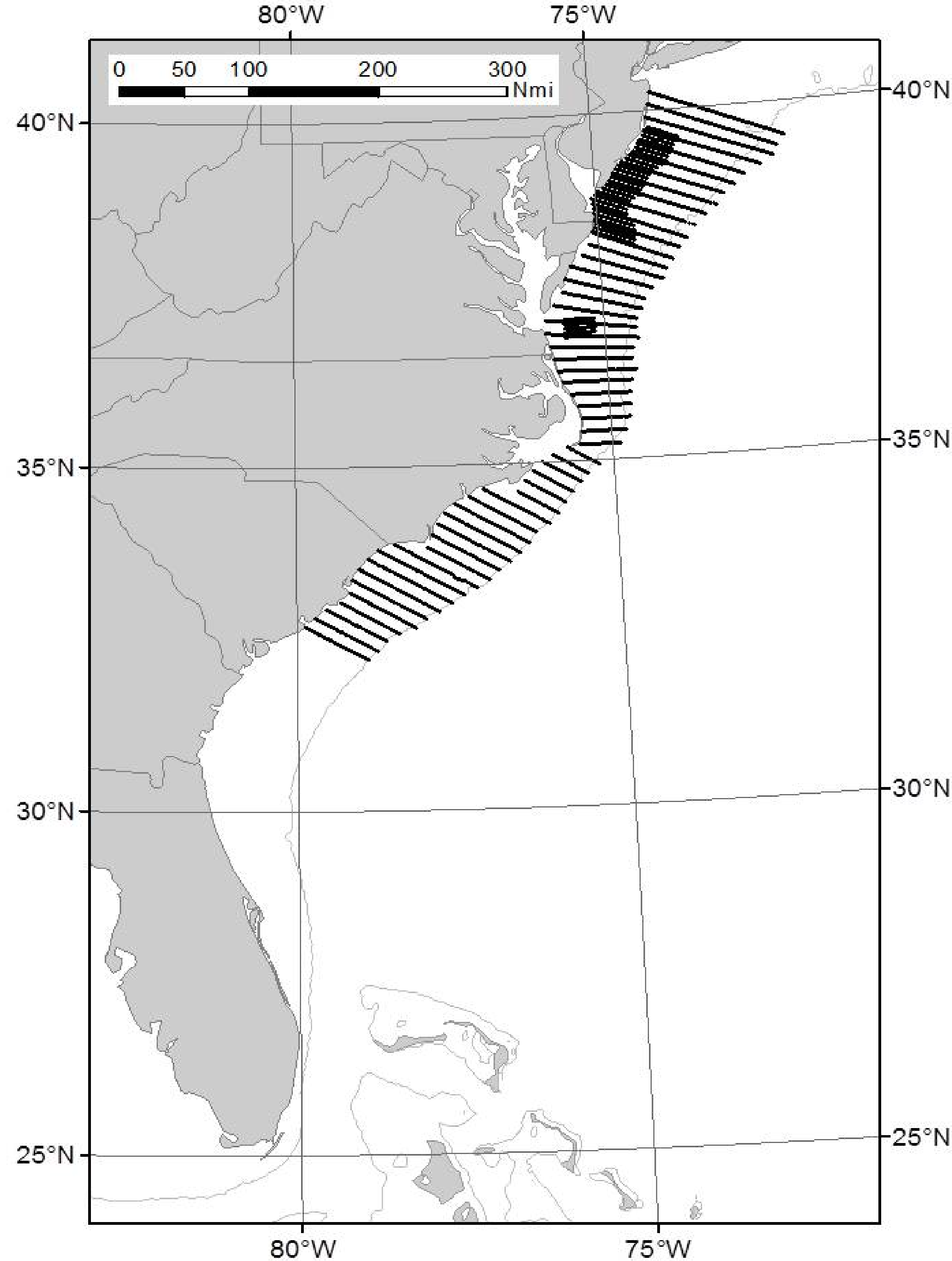


Figure B2. **Sea state conditions during the Southeast AMAPPS Spring 2014 aerial survey.**

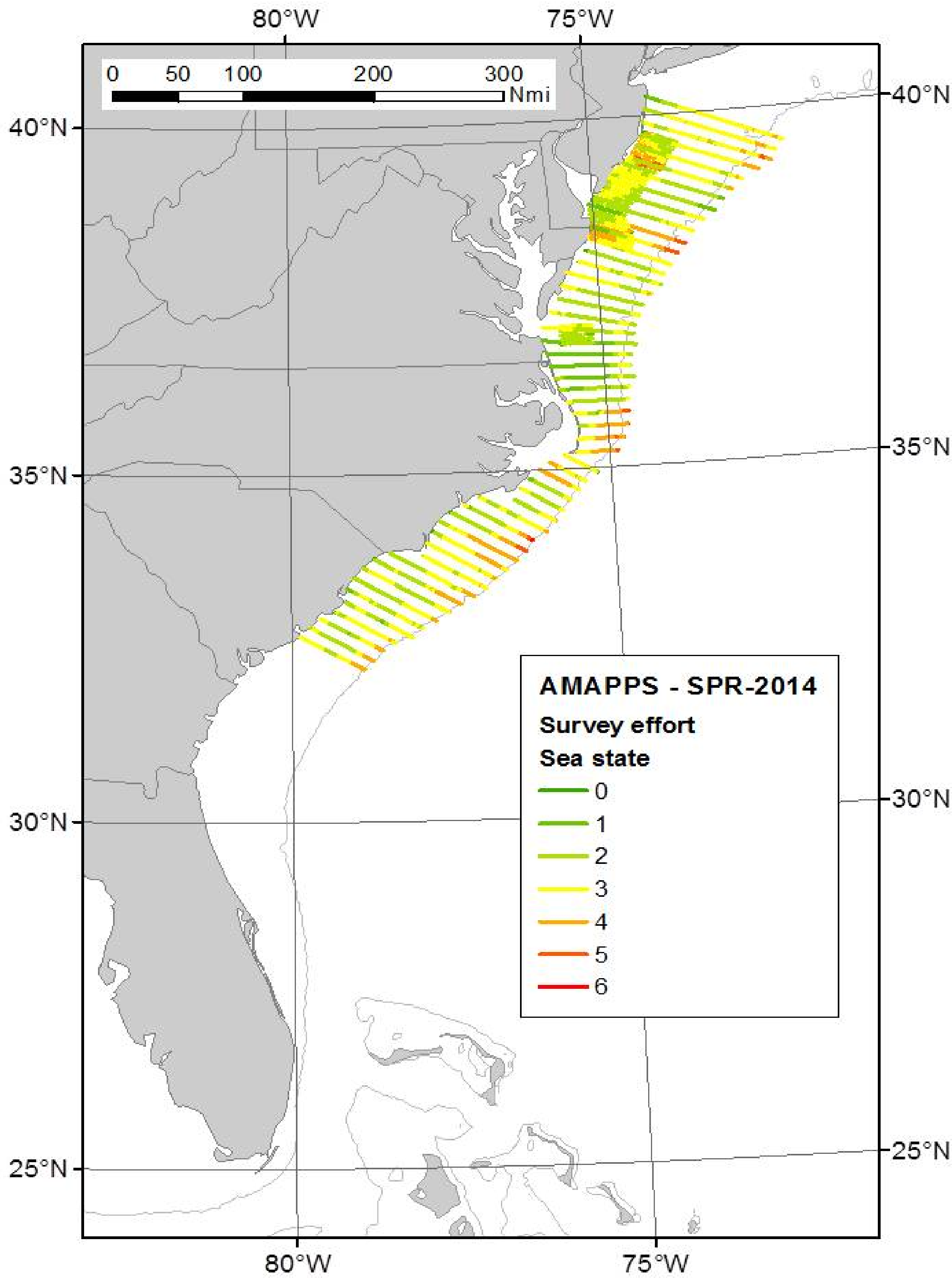


Figure B3. Loggerhead turtle sightings during the Southeast AMAPPS Spring 2014 aerial survey.

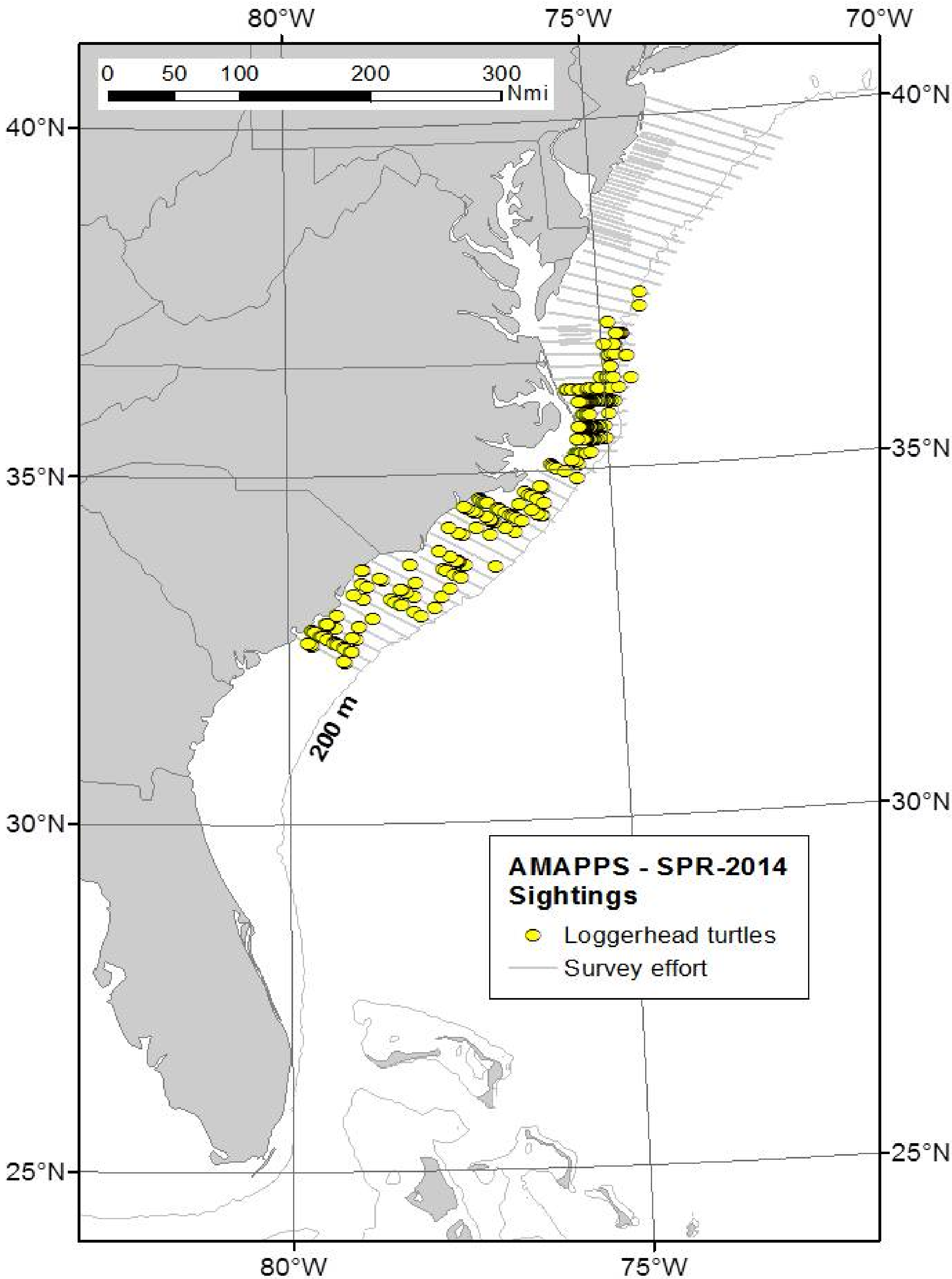


Figure B4. **Other turtle sightings during the Southeast AMAPPS Spring 2014 aerial survey.**

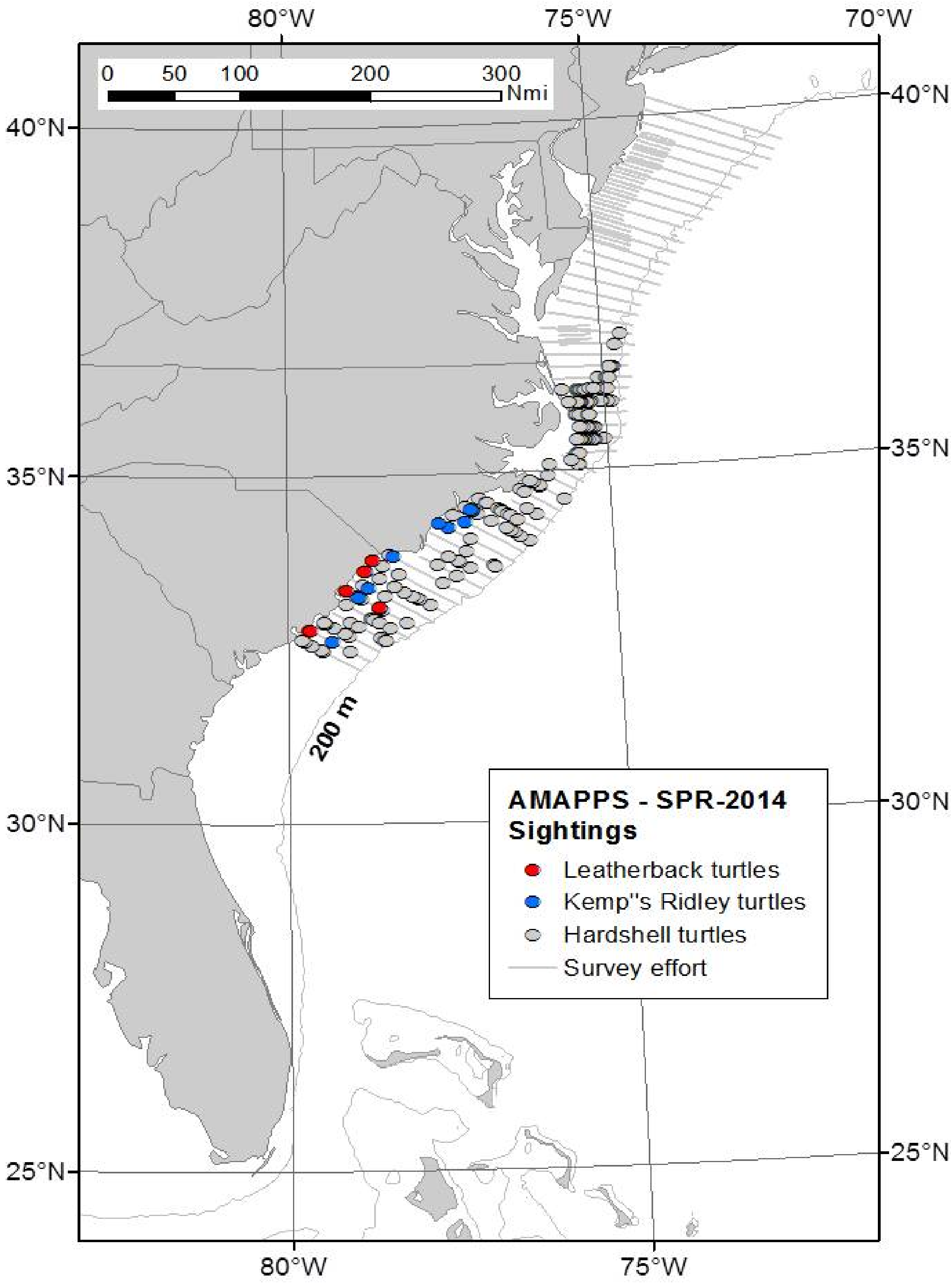


Figure B5. **Bottlenose and common dolphin sightings during the Southeast AMAPPS Spring 2014 aerial survey.**

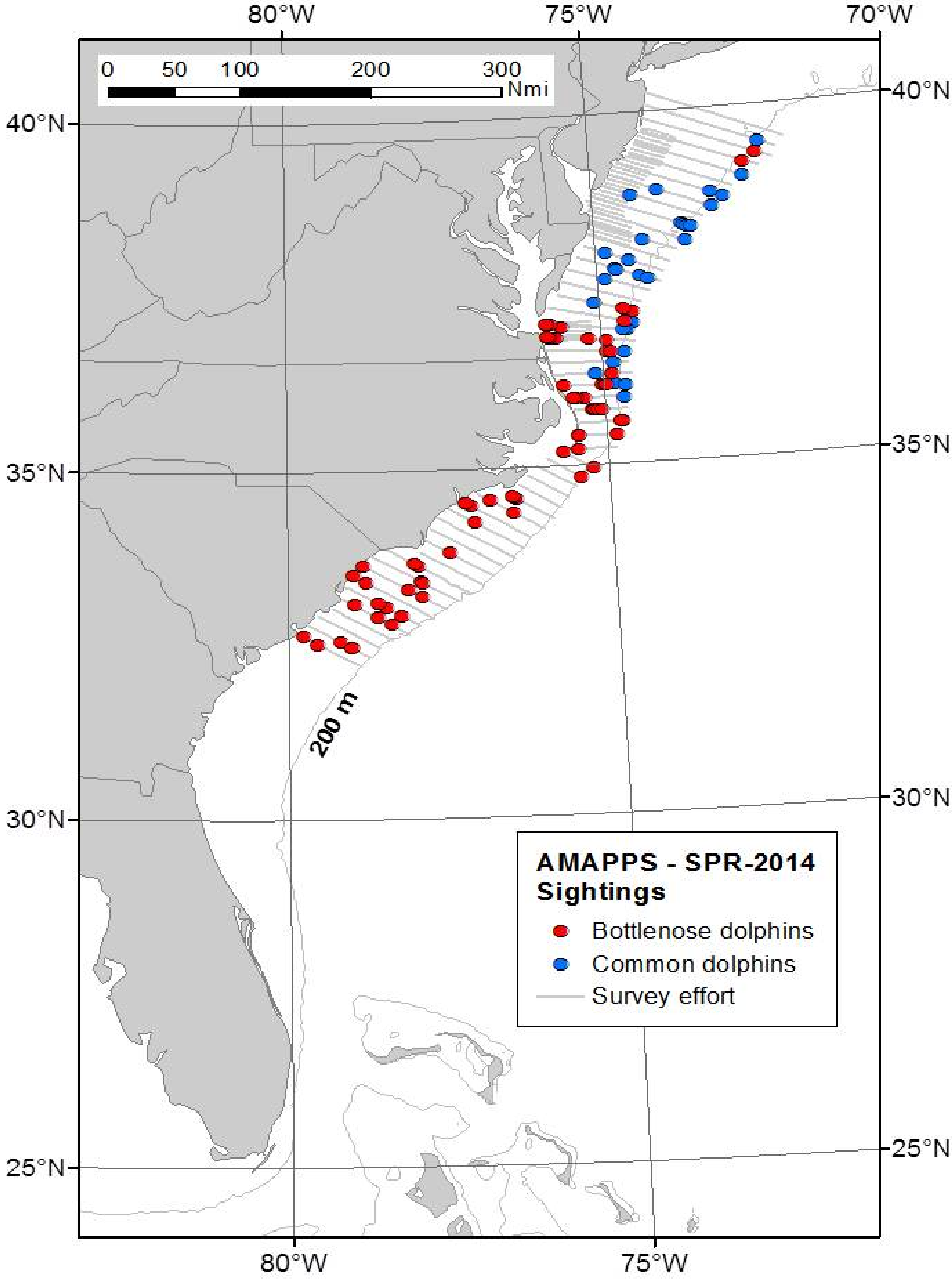


Figure B6. **Other dolphin and porpoise sightings during the Southeast AMMAPS Spring 2014 aerial survey.**

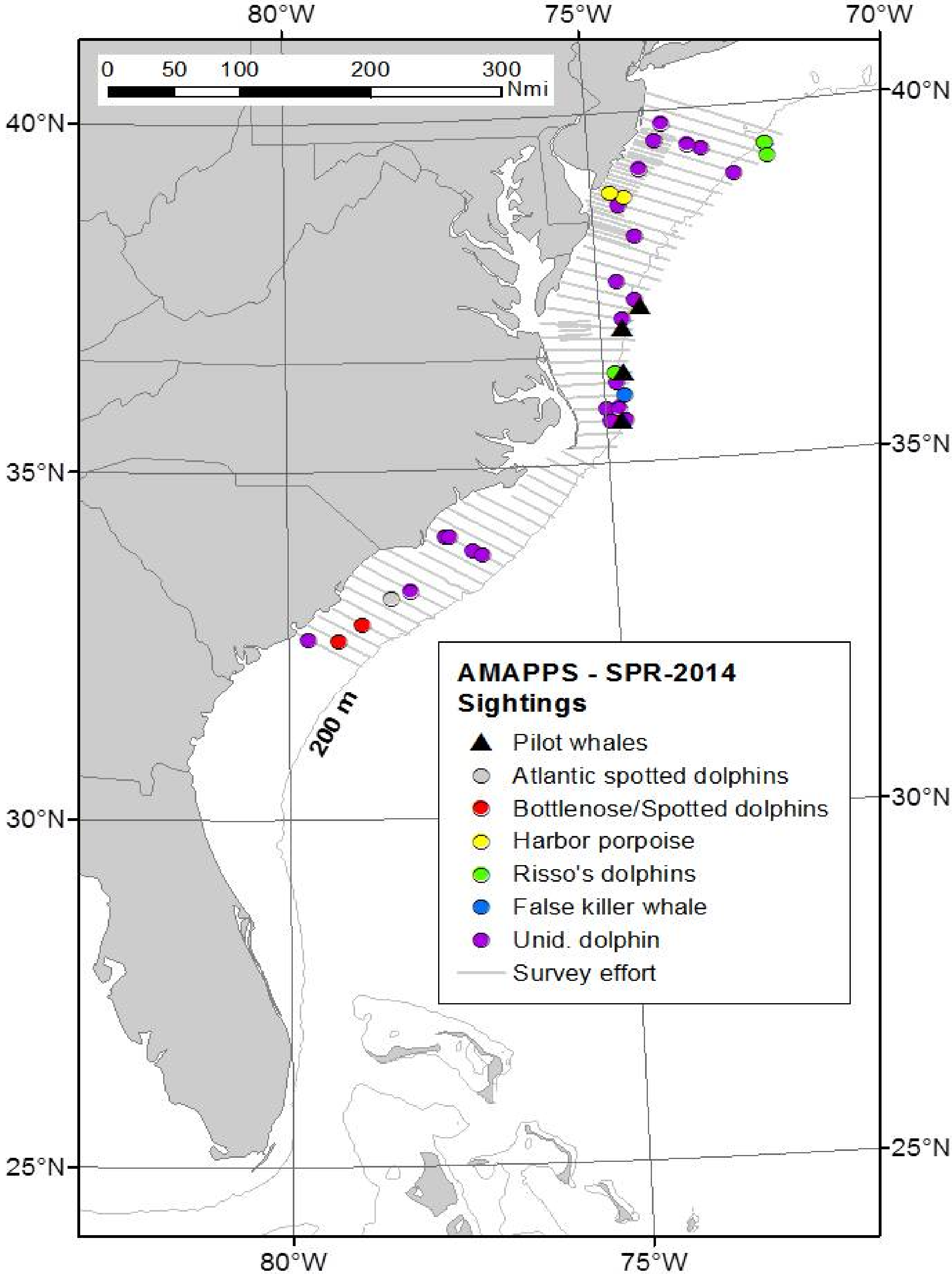


Figure B7. Whale sightings during the Southeast AMAPPS Spring 2014 aerial survey.

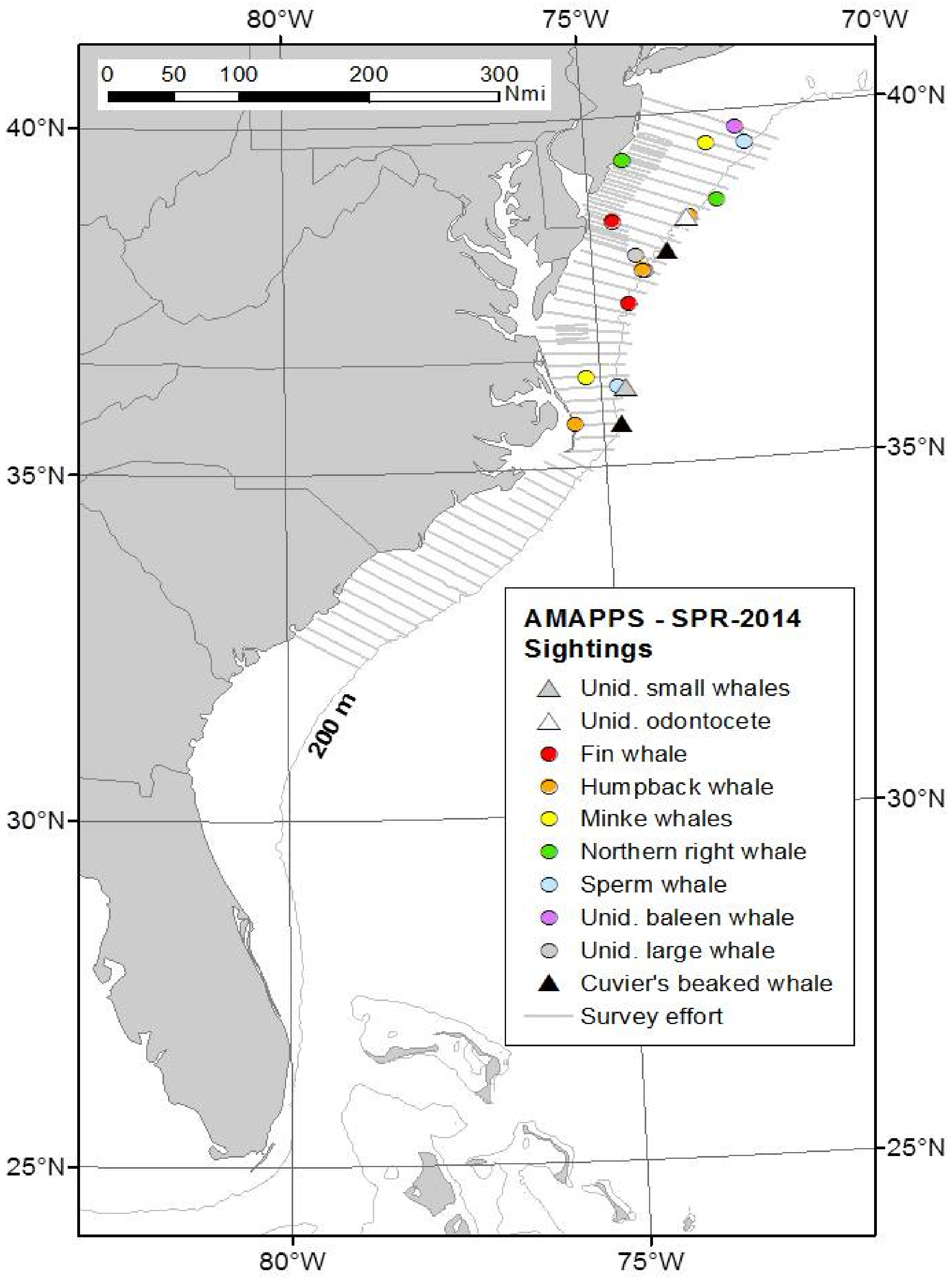
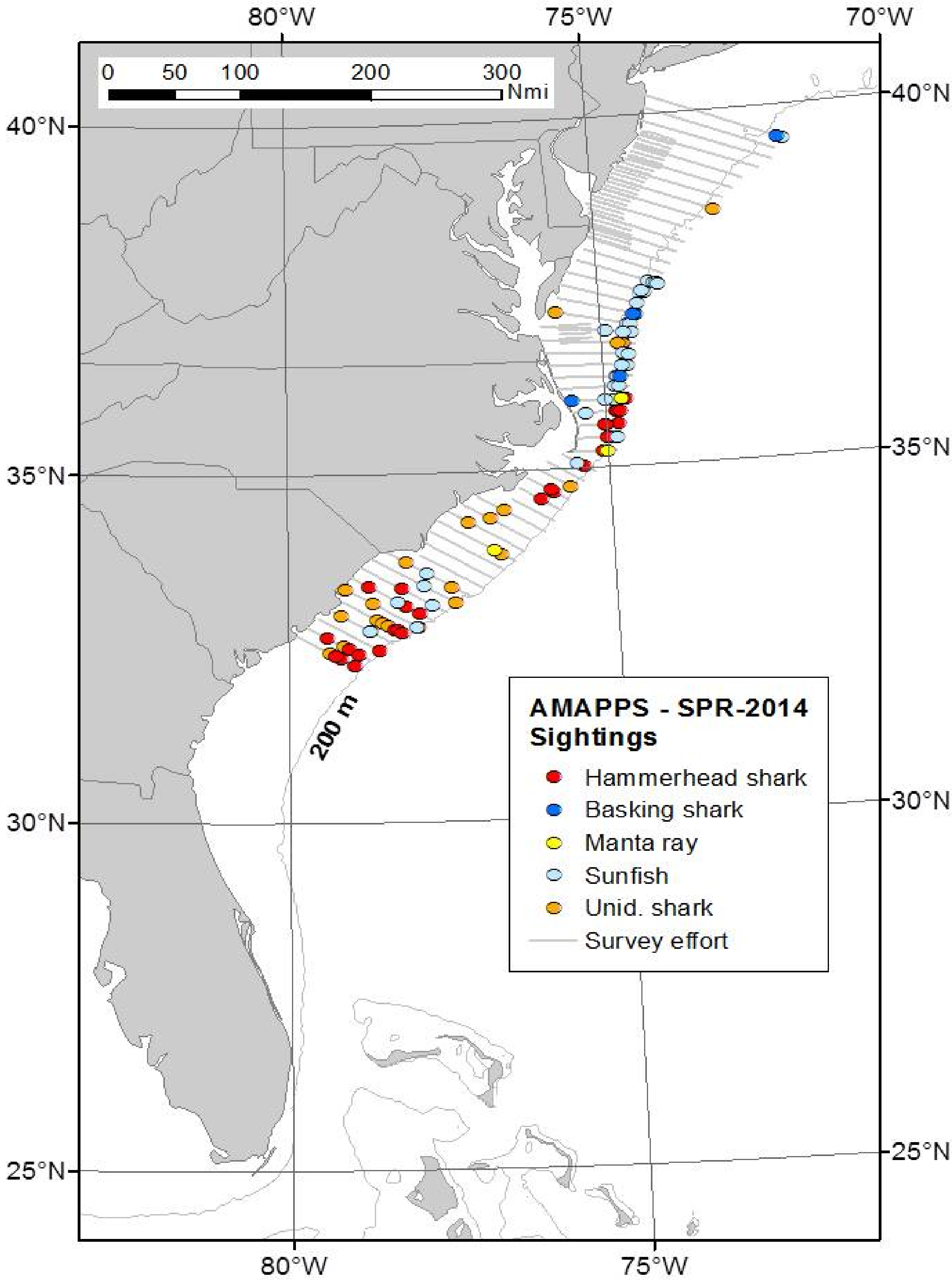


Figure B8. Fish sightings during the Southeast AMAPPS Spring 2014 aerial survey.



Appendix C: *Shipboard habitat survey during March – April 2014: Northeast Fisheries Science Center*

Debra L. Palka[1], Danielle Cholewiak[2], Elisabeth Broughton[1], Michael Jech[1], Michael Force[2], Vince Guida[3], Michael Lowe[4], Gareth Lawson[4]

[1] Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2] Integrated Statistics, 16 Sumner St., Woods Hole, MA 02543
[3] Northeast Fisheries Science Center, Sandy Hook, NJ
[4] Woods Hole Oceanographic Institution, Woods Hole, MA 02543

SUMMARY
During 11 March – 3 April and 7 April – 1 May 2014, the Northeast Fisheries Science Center (NEFSC) with the help from staff at Integrated Statistics, Inc and Woods Hole Oceanographic Institution conducted a shipboard survey to document the relationship between the distribution and abundance of cetaceans, sea turtles and sea birds and their physical and biological environment. The study area included waters from Cape Cod, MA to North Carolina, and from the southern tip of Nova Scotia to the US Atlantic coastline. Track lines were surveyed at about 10 kts (18.5 km/hr), using the two-independent visual team line transect methodology to collect marine mammal and turtle data, while the one-team strip transect methodology was used to collect sea bird distribution and abundance data. At the same time passive acoustic hydrophones were used to detect vocal cetaceans. In addition, physical and biological oceanographic data were collected using a bongo net, visual plankton recorder (VPR), Multiple Opening/Closing Net Environmental Sensing System (MOCNESS), Isaacs-Kidd midwater trawl (IKMT), Conductivity, Temperature, and Depth Profiler (CTD), multifrequency echosounder (EK60), Van Veen benthic grab, and beam trawl. Over 4000 km of on-effort track lines were surveyed during the daytime with about 150 hours of passive acoustic recordings. The upper visual team detected 3,713 individuals within 626 groups of 31 species (or species groups) of cetaceans, seals and large fish. In addition 54 groups of vocally-active odontocetes from 5 species (or species groups) were heard with the hyrophones. Common dolphins (*Delphinus delphis*) and bottlenose dolphins (*Tursiops truncatus*) were the most regularly detected small cetacean species. Fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) were the most common large whales. One loggerhead turtle (*Caretta caretta*) and an unidentified hard shell turtle were also detected. About 6940 birds within 2491 groups of 62 species (or species groups) were detected while on effort. Seven species comprised about 75% of the total birds seen. In declining order of abundance these were: Herring Gull (*Larus argentatus*), Northern Gannet (*Morus bassanus*), Dovekie (*Alle alle*), Great Black-backed Gull (*Larus marinus*), Atlantic Puffin (*Fratercula arctica*), Northern Fulmar (*Fulmarus glacialis*) and Red Phalarope (*Phalaropus fulicarius*). Over 510 physical and biological oceanographic collection stations were sampled. This included 64 casts of the CTD, 127 bongo deployments, 13 VPR deployments, 2 Isaac-Kidd midwater trawl (IKMT) deployments, 3 MOCNESS deployments, 70 beam trawl deployments and 233 bottom sediment grabs. In addition, 10 bottom-mounted marine autonomous recording units (MARUs) were deployed during this cruise, of which 9 were retrieved in September 2014.

OBJECTIVES

The overall goal of both legs was to document the relationship between the distribution and abundance of cetaceans, sea turtles and sea birds within the study area relative to their physical and biological environment. To do so the specific objectives were, within the study area: (1) determine the distribution and abundance of cetaceans, sea turtles and sea birds; (2) collect vocalizations of cetaceans using passive acoustic towed hydrophone arrays; (3) determine the distribution and relative abundance of plankton, micronekton, and benthic species, (4) collect hydrographic and meteorological data, (5) document spring baleen whale migration by deploying bottom-mounted marine autonomous recording units (MARUs) and (6) when possible, collect biopsy samples and photo-identification pictures of cetaceans.

The institutions that were involved in this survey included:

- Northeast Fisheries Science Center, Woods Hole, Protected Species Branch
- Northeast Fisheries Science Center, Woods Hole, Oceanography Branch
- Northeast Fisheries Science Center, Sandy Hook, Behavioral Ecology Branch
- Northeast Fisheries Science Center, Narragansett, Oceanography Branch
- Woods Hole Oceanographic Institution, Woods Hole, MA
- Integrated Statistics, Inc., Woods Hole, MA

CRUISE PERIOD AND AREA

The cruise period was divided into two legs: 11 March – 3 April and 7 April – 1 May 2014.

The study area included waters from around Cape Cod, MA (about 42° N latitude), to north of North Carolina (about 35° 30’ N latitude), east of the southern tip of Nova Scotia (about 65° W longitude), and west of the US coast (about 76° W longitude). This is waters shallower than about 2000 m which includes waters within the US and Canadian economic exclusive zones (EEZ). This study area was divided into five spatial strata that represent different habitats, an offshore shelf break area (between the 100 and 2000 m depth contours) and four onshore Bureau of Ocean Energy Management (BOEM) wind energy areas (WEA): BOEM-MA, BOEM-NY, BOEM-NJ, and BOEM-VA (Figure C1).

METHODS

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

A line transect survey was conducted during daylight hours (approximately 0700 – 1900 with a one hour break at lunchtime) using the two independent team procedure. Surveying was conducted during acceptable weather conditions (Beaufort six and below) while traveling at about 10 knots, as measured over the ground.

Scientific personnel formed two independent visual marine mammal-sea turtle sighting teams. The teams were on the flying bridge (13.7 m above the sea surface) and bridge wing (11.8 m above the sea surface). The flying bridge team was composed of two on-effort observers who searched using 25x150 powered binoculars and the bridge wing team consisted of one on-effort observer who also searched using 25x150 powered binoculars. Both teams reported their sightings data to a single recorder stationed inside the bridge using a different radio frequency for each observation team so that the two teams were independent of each other. In addition there were two off-effort team members that rotated in. All six scientists rotated, 30 minutes per station, between left flying bridge observer, right flying bridge observer, recorder, right bridge wing observer, off-effort station 1 then off-effort station 2. In total, a scientist was on-effort for 2 hrs and off-effort for 1 hr. The composition of the teams changed every leg.

The right flying bridge observer surveyed waters from 90° abeam on the right side of the boat to about 10° to the left of the track line, where 0° indicates the track line ahead. The left flying bridge observer surveyed waters from 90° abeam on the left side of the boat to about 10° to the right of the track line. Thus, there was an overlap of 10° to either side of the forward track line. The right bridge wing observer surveyed waters from as far as they could see to the left side of the boat (about 60° left of the track line) to 90° abeam on the right side. In addition, when the recorder was not entering data, the recorder surveyed with naked eye for 90° abeam right to 90° abeam left.

Position, date, time, ship's speed and course, water depth, surface temperature, salinity, and conductivity, along with other variables (Table C1) 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 4) 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 and the group was within 3 nmi of the track line, 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).

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 into 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 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) 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 min 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 within the glare swath (none, slight, moderate, severe).

VISUAL SEABIRD SIGHTING TEAM

From an observation station on the flying bridge, about 13.7 m above the sea surface, one on-effort observer conducted a visual daylight survey for marine birds, approximately 0700 – 1900 with a one hour break at lunchtime. In addition there was one off-effort observer who rotated to with the on-effort observer every 2 hrs. Data collection procedures 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. Seabird survey effort was suspended, however, if the ship's speed over ground fell below six knots. 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.

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 software was linked to the ship's navigation system via a serial/RJ-45 cable. The following data were collected for each sighting:

1) species identification,
2) number of birds within a group,
3) distance between the observer and the group,
4) angle between the track line and the line of sight to the group,
5) behavior,
6) flight direction,
7) flight height,
8) age, sex and, if possible, molt condition.

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. *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. 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 two people who operated the system in two-hour shifts, from approximately 0700 – 1900 or later. The deployment time for the hydrophone array varied greatly each day depending on weather conditions. Typical deployment was at 0700, but this was sometimes delayed due to poor weather. The hydrophone array was usually retrieved from 1130 – 1230 for the midday bongo/CTD casts. Daytime data collection ended at approximately 1900, 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 track lines, 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 track lines. Night recordings were also collected opportunistically, which was determined by oceanographic sampling priorities.

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 section 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 section of the array consisted of three "mid-frequency" elements (APC International, 42-1021). The array was towed 300 m behind the ship. Array depth typically varied between 8 – 12 m at the 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.

In addition to collecting towed array data, the passive acoustic team, together with the ship's crew, also deployed ten Marine Autonomous Recording Units (MARUs) along survey track lines on the shelf break. Details for deployment methodology can be found in the GG 14-02 Cruise Announcement.

HYDROGRAPHIC, PLANKTON, AND BENTHIC CHARACTERISTICS

Nearly continuously day and night, the EK60 multi-frequency echosounders were recording active acoustic backscatter to determine the distribution and abundance of plankton, micronekton, and fish which will be used to characterize spatial distributions of potential prey and investigate relationships among predator (marine mammals), prey, and oceanography. In addition, the ship's SCS logger system recorded oceanographic data from the ship's sensors nearly continuously.

During the daytime, Conductivity, Temperature, and Depth Profilers (CTD) and bongo nets were deployed several times during the visual survey time periods to characterize the spatial distribution of plankton.

During nighttime when the visual teams were off-effort, one of two types of sampling procedures was followed. When offshore on the shelf break, the canyon and inter-canyon regions were sampled. When in the inshore shelf BOEM WEAs, benthic sampling occurred.

Continuous Active Acoustic Sampling

Active acoustic data were collected with the ship's multifrequency (18, 38, 120, and 200 kHz) scientific Simard 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 the actual ping rates were slower due to two-way travel time and signal processing requirements of the EK60. The EK60 was synchronized to the Simrad ES60 on the bridge, the RDI 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 processing procedures. Survey speeds for underway acoustic data collection were 10 kts or less.

The EK60 system was calibrated using the standard target method at the Newport Naval Anchorage on the first day of leg 2. A 38.1-mm tungsten carbide with 6% cobalt binder sphere was suspended at about 20 m range from the transducers and was used to calibrate all frequencies. A wireless calibration system, consisting of three remotely controlled downriggers, and automated software were used to initially position the target under the split-beam transducers and the software automatically moved the sphere throughout the acoustic beams. The data were collected and then the Simrad Lobe program was used during data playback for each EK60 individually.

Daytime Sampling

During the daytime, SEACAT 19+ CTDs were 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 CTD profile was conducted, where a Niskin bottle was attached to the wire above the CTD. The Niskin bottle was used to collect a sample of water 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 333µm nets 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 1900, 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 shelf break Sampling

When the ship was not in one of the BOEM benthic sampling areas, physical and biological sampling of the water column was conducted employing a combination of underway and station-based sampling. The goal was to sample two site types: shelfbreak canyons and shelfbreak inter-canyon regions, where the top priority was 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 ships location in the BOEM benthic sampling areas, and the desired start location the following day, the distance to the targeted sampling area, and the bottom depth.

Sampling equipment included:

- EK60 multifrequency echosounder for plankton, micronekton, and fish distribution.
- ADCP (Acoustic Doppler Current Profiler) for currents, synchronized to the EK60 to minimize interference. (Note: ADCP was turned off for Leg II due to interference with passive acoustic operations).
- CTDs for hydrography. (max depth 1500 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-truthing 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)

When possible, canyons were surveyed acoustically at night then surveyed again by the visual teams during the day either before or after the acoustic surveys. Acoustic survey transects were positioned half-way up a canyon and near the canyon head and included both ADCP and EK60 data collection. In each canyon, 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). Also at night usually after the acoustic surveys, nets were deployed to ground truth the acoustic finds.

Inter-canyon shelf break

Shelf break inter-canyon surveys consisted of a transect running across the shelf break from the 90 to 1000 m isobaths . ADCP, EK60, and towed hydrophone data were conducted continuously during a pass and then regularly spaced CTD casts were made in the opposite direction along the second pass of the same transect. The target was roughly 3 nmi distances between CTD stations. If possible, net samples were to be taken after the CTD casts.

Nighttime Inshore Benthic Sampling:

A series of benthic sampling stations was laid out within five BOEM WEAs so as to characterize benthic habitats in those areas. Three kinds of benthic data were sought on each station: benthic infaunal assemblages, sediment textures, and benthic epifaunal assemblages.

At each of the stations three major sampling activities occurred: a CTD (vertical or diagonal bongo cast, as desired), three replicate Van Veen grabs, and a beam trawl. Repositioning of the ship was not undertaken between sampling activities at each station. The order of the three activities at each station was not critical and was altered as circumstances dictated.

Benthic Grab Sampling

Three replicate grabs for grain size and benthic infaunal analysis were taken at each of station using either a 0.04 m^2 or 0.10 m^2 Young-modified Van Veen grab sampler. The grab sampler was cocked and lowered over the side and sent down to the bottom at the fastest speed allowable by the winch till it hit the bottom, then it was brought back up and lowered onto its wooden stand. The lids on top of the Van Veen buckets were opened and the sample inspected for adequacy of the sample. Success or failure of the grab was reported immediately to the bridge. No more than three unsuccessful attempts were made to obtain any sample.

Grabs were recorded and if successful, a photo of its surface was taken, then a 3 cm diameter plastic core tube was used to take a subsample of at least 5 cm depth for grain size analysis. That tube was capped on top, carefully removed from the grab, capped on the bottom, recorded, labeled, and stored upright in a freezer. Unsuccessful grabs for each replicate were recorded in the Notes block for the appropriate replicate on the Benthic Grab Field Log sheet.

After the grain size core sample was obtained, the rest of the sample was dropped into a dishpan under the grab sampler stand by opening the grab jaws. The grab sampler jaws were washed out with a small quantity of clean salt water (not exceeding the receiving pan’s capacity) with a squeeze bottle or hose, as necessary, to wash any remaining sample from the inside of the jaws into the receiving pan. The sample in the pan with any wash water was then removed for sieving. More thorough washing of the grab with water from a hose was done, if needed, once the pan was removed. The grab was re-cocked to prepare for the next deployment at this point.

Grain size analyses were performed by standard geological sieving methods at the NEFSC J.J. Howard Lab and recorded both in Wentworth size classes and by the standard Folk classification scheme.

Samples from the 0.04 m^2 grab were sieved in their entireties through a 1.0 mm (standard #18) sieve, a small quantity at a time using salt water from a hose and gently agitating it to allow material finer than 1.00 mm to pass through and be discarded. Samples from the 0.20 m^2 grab were divided in half, one half being sieved as above, and the other half discarded so as to make sample sizes roughly comparable with 0.04 m^2 grabs. Where present, samples were pre-screened through a coarser sieve to remove that material and reduce the sample size. Any organisms in that very coarse fraction were retained, but inanimate coarse material was discarded. Material retained by the 1.0 mm screen was collected in labeled polypropylene jars. These samples were preserved in 10% buffered formalin in seawater with Rose Bengal dye. Following cruises, these were transferred to 70% denatured ethanol for examination. Benthic infauna in these will be identified to genus level by a benthic sorting contractor outside NOAA.

Trawl Sampling

One beam trawl sample was performed at each station, time permitting. A 2 m beam trawl with ¼ inch mesh net was deployed on a single 0.25" trawl wire. Trawling was done at a speed of about 2 kt using a scope of 2:1. The first trawl (B87 station in the MA BOEM WEA) was performed for 20 minutes. This was reduced to 5 minutes in the two subsequent MA BOEM WEA stations (B92 and B86) due to the size and complexity of the catch, then increased to 6 minutes at B85 (also in the MA BOEM WEA). All subsequent trawls in all of the sampled BOEM WEAs were performed for 7 minutes. Unsuccessful trawls were repeated after adjustments of weight and scope until successful. The catch was sorted to the lowest practicable taxon. Each taxon was weighed as a group. Individual weights were not taken. Total lengths of individual fish were determined to the nearest centimeter. Carapace widths of brachyuran crabs were also measured. IDs, sizes, species weights, and individual counts were recorded on trawl log forms. Catches were discarded following on-board processing.

RESULTS

Scientists involved in this survey are detailed in Table C2.

<u>*VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM*</u>

The visual marine mammal and turtle team surveyed about 4,014 km while on effort during 33 of the 41 possible sea-days; the weather conditions were too poor to survey on the other 8 sea-days. (Figure C2; Table C3). About 64% of the survey track lines were conducted in acceptable weather conditions, Beaufort sea states 4 or less, similar to that when conducting a summer survey. However, given this was not summertime, there was considerable more surveying in worst sighting conditions (Beaufort sea states of 5 and 6).

During the on-effort track lines, 23 cetacean species or species groups, 2 turtle species or species groups, 3 seal species or species groups, and 3 fish species or species groups were recorded (Tables C4 and C5). For cetaceans, the upper team detected 577 groups (3,661 individuals) and the lower team detected 278 groups (2,027 individuals). For turtles, the upper team detected 1 group (1 individual) and the lower team detected 2 groups (2 individuals). Nineteen and 8 seals was detected by the upper and lower teams. In addition, 4 (2) basking shark groups and 22 (4) ocean sunfish groups was detected by the upper (and lower) teams. Note some, but not all, groups of animals detected by one team were also detected by the other team.

Distribution maps of sighting locations of the cetaceans, turtles, seals and fish are displayed in Figures C3 – C12. Note these are locations of sightings seen by one or both teams. The most abundance species were common dolphins (*Delphinus delphis*) and bottlenose dolphins (*Tursiops truncatus*), displayed in Figure C3. The most numerous whales included fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*), displayed in C8. Species detected in both the inshore BOEM WEAs and offshore shelf break include common dolphins, fin whales, sei whales (*Balaenoptera borealis*), humpback whales, and minke whales (*Balaenoptera acutorostrata*). Species detected in mostly the inshore BOEM WEAs include harbor porpoises (*Phocoena phocoena*), white-sided dolphins (*Lagenorhynchus acutus*), and right whales (*Eubalaena glacialis*). Species detected mostly on the offshore shelf break include bottlenose dolphins, Atlantic spotted dolphins (*Stenella frontalis*), striped dolphins (*Stenella coeruleoalba*), pilot whales (*Globicephala spp.*), Risso's dolphins (*Grampus griseus*), beaked whales (*Mesoplodon spp.*), sperm whales (*Physeter macrocephalus*), blue whales (*Balaenoptera musculus*), and bottlenose whales (*Hyperoodon ampullatus*). Nearly all of the basking sharks (*Cetorhinus maximus*) and sunfish (*Mola mola*) were on the offshore shelf break, while seals were close to shore (Figure C11). Only two turtles were detected, a loggerhead turtle (*Caretta caretta*) off North Carolina in waters that were x degrees, and an unidentified hardshelled turtle near the EEZ on the US side in waters that were x degrees (Figure C12).

VISUAL SEABIRD SIGHTING TEAM

The NOAA ship *Gordon Gunter's* flying bridge provided a stable platform and afforded good visibility for the seabird team. Seabird survey effort was conducted on 34 days; however, data collection effort was truncated on several days due to weather constraints. 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 2013.

About 6,940 birds were seen while on effort (Table C6). This survey recorded 50 species of birds and 12 unidentified species groups (e.g., unidentified shearwater or unidentified storm-petrel). About 40% of the species most frequently seen includes Herring Gulls (*Larus argentatus*) and Northern Gannets (*Morus bassanus*; Figure C13). Distributions of a variety of other species are displayed in Figures C14 – C18. The relatively high species diversity is partly attributable to the onset of spring migration occurring towards the end of the cruise, resulting in a number of displaced non-marine species. At least 15 species can be included in the latter category, including Brown Thrasher, American Robin, and Dark-eyed Junco. Diversity was sparse in the offshore avifauna, primarily alcids and a few gulls. Moreover, with the exception of a scattering of Wilson's Storm-Petrels (Figure C17), austral breeders had not yet arrived from their southern hemisphere nesting grounds (e.g., no Great Shearwaters were seen). Throughout the shelf break survey lines, seabird distribution was patchy, yet often predictable. For example, high numbers of alcids, particularly Atlantic Puffin (Figure C16) and Dovekie (Figure C15), often occurred over the 900 to 1000 m depth isobaths. Storm-petrels (Figure C17) were occasionally found in small scale clusters, often concentrating in upwelling areas seaward of the shelf break. Red Phalaropes (Figure C16), often in association with storm-petrels, also frequently occurred in dense patches along the shelf break, which accounts for their high relative abundance but low encounter rate. Northern Gannet and Herring Gull (Figure C13) were widespread throughout the study area, with the latter species being seen daily. The age distribution of Northern Gannets strongly favoured adults: only seven immatures, primarily second year types, were seen (about 0.9%). This is a typical Northern Gannet winter age class distribution in the northwest Atlantic Ocean, the immature birds tending to winter farther south. Black-capped Petrel (Figure C17) is a tropical and sub-tropical species traditionally associated with warm Gulf Stream water. However, several of the nine Black-capped Petrels we saw were over water less than 10°C, including one as far north as Nova Scotia, which is very rare.

This year's survey provides valuable additional distributional data on Bermuda Petrel (aka Cahow; Figure C17). One photographed at Georges Canyon is not only a first for Canada, but also the most northerly sighting of this endangered seabird. Its status in North American waters remains poorly known, based on a handful of sightings off North Carolina and inferred from recently deployed data-loggers. With an estimated global population of around 350 birds, it remains very rare anywhere in the north Atlantic Ocean.

The seabird team also collected useful distributional information in areas that historically have received little systematic observer effort at this time of year. Towards the end of Leg 2, spring migrants such as Pomarine, Parasitic and Long-tailed Jaegers (Figure C18), and Arctic Tern, began to arrive. Data obtained on this cruise clarifies the temporal distribution for several seabirds, including all three jaegers and Arctic Tern. Migrants of these species were seen flying north, slightly earlier than what was generally realised, for example.

All other seabirds were regularly occurring northwest Atlantic Ocean species; however, compared to summer surveys, relatively few Procellariiformes (shearwaters, petrels, etc.; Figure C17) were seen. The preponderance of ducks, loons and gulls on this year's survey is not only a reflection of seasonality, but also because of the time spent surveying at the near shore WEA's. Of the non-marine species observed, seven were Passerines (e.g., songbirds), rounding out with a raptor (Osprey), woodpecker (Northern Flicker) and a Great Blue Heron (Figure C18). The most abundant Passerine was Song Sparrow, with up to four at one time on the fantail, followed by Dark-eyed Junco.

<u>PASSIVE ACOUSTIC DETECTION TEAM</u>

Over the course of the survey, acoustic monitoring effort was conducted on 17 out of 33 survey days, with a total of 113.7 h of daytime recording on survey track lines. In addition, evening/nighttime recordings were made opportunistically on 10 occasions, for a total of 29.4 h (Figure C19, Table C7). The hydrophone array was not deployed on days during which shallow, coastal lines were surveyed.

Real-time monitoring resulted in the detection of 54 groups of vocally-active odontocetes (Figure C19). Of these, approximately 11% corresponded to simultaneous visual detection of groups, allowing for species assignment (Table C8). 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 in real-time on 8 of 17 acoustic survey days, for a total of 19 vocally-active groups (Figure C20, Table C9). 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.

Two Marine Autonomous Recording Units (MARUs) were deployed on Leg 1 of the survey, and eight units were deployed during Leg 2 (Figure C1). All of the units, except one (number 9) were recovered in September 2014.

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.

HYDROGRAPHIC/BONGO/PLANKTON SAMPLES

Continuous Active Acoustic Sampling

Nearly continuously, day and night, active acoustic multifrequency (18, 38, 120, and 200 kHz) backscatter data from scientific EK60 echosounders and split-beam transducers were collected to characterize spatial distributions of potential prey and investigate relationships among predator (marine mammals), prey, and oceanography. Backscatter data were recorded to 3000 m, regardless of bottom depth. The EK60 was calibrated on 7 April 2014 in the bay near the Newport Naval Station.

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. Data are also archived at NOAA's National Geophysical Data Center (NGDC) in Boulder, CO.

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.

Sampling Stations

During both legs, in the day and night over 512 sampling stations were conducted. This included 64 casts of the CTD, 127 bongo deployments, 13 VPR deployments, 70 beam trawl deployments, 233 bottom grabs, 2 IKMT, deployments, and 3 MOCNESS deployments (Table C10; Figure C21).

At night after the visual teams were off-effort, oceanographic sampling was successfully conducted at 7 shelf break canyon sites and 1 shelf break non-canyon site (Table C11). Due to poor weather conditions and equipment failures, net deployment was limited during both legs of the cruise (Table C10). However, MOCNESS and IKMT tows were conducted where possible and the catch was largely comprised of krill, mesopelagic fish, and small zooplankton.

A single shelf break survey was conducted along a transect running across the shelf break from the 90 to 1000 m isobaths (Table C11). ADCP, EK60, and towed hydrophone data were conducted continuously during one pass and seven regularly spaced (~1.4 nmi) CTD casts made in the opposite direction along the second pass. The target was roughly 3 nmi distances between CTD stations. No net samples were taken during this operation.

CTD data (Table C10) were obtained with three Seabird Electronics SBE Model 19+ profiling CTDs (s/n 4493, 4758, and 7037) and a Seabird Electronics SBE Model 9/11+ CTD (s/n 2727). Sea water samples were also obtained for the purpose of correcting conductivity. A more detailed report of the CTD station data can be found at the following website: http://www.nefsc.noaa.gov/HydroAtlas/2014/MAR_AMAPPS_GU1402/CTD_REPORT_2014002GU.pdf.

Shelf Break Habitat Descriptions

The Mid Atlantic Bight inshore stations showed very low amounts of zooplankton. Samples did have some marine snow and many chain diatoms in the background of the surface images. Hudson Canyon also had low zooplankton numbers but had large quantities phytoplankton in the form of centrics. Plankton was largely Calanoid copepod and small Euphausiids. Very little gelatinous zooplankton was present in the form of *Bolinopsis sp*. and small hydromedusa.

The Georges Bank shelf break transect was dominated by large quantities of marine snow intermixed with phytoplankton (Figure C22). Images from the VPR were so densely populated with multiple blobs of this matrix that the depth of field had to be minimized in the processing program to limit the number of regions of interest (ROIs) pulled from each image (Figure C23). High densities of marine snow can interfere with the zooplankton counts by obscuring images. For example: numerous small gravid copepods present along the Georges Bank shelf break transect were contained in images within the matrix of the marine snow and thus were classified as marine snow not copepoda. The transect was characterized by cooler temperatures and lower salinities on the Georges Bank which transitioned to much warmer temperatures and higher salinities off Georges Bank. A slight theremocline developed around 50 m depth off Georges Bank. The entire transect showed very high chlorophyll counts in the top 50 m and increased turbidity values on the bank near the bottom.

Corsair Canyon was also dominated by marine snow but had less phytoplankton intermixed. Much of the marine snow appeared to be the remnants of larvacean nets but few active nets were seen (Figure C24). Zooplankton counts were low and consisted of copepod (mostly *C. finmarchicus*), Euphausiids, and *Bolinopsis sp.* Oceanography was consistent across both canyon transects. The canyon had cooler temperatures and lower salinities at the surface transitioning gradually to warmer temperatures and higher salinities by 100 m depth. There was no noticeable thermocline. Cholophyll and turbidity values showed very patchy distributions (Figure C25).

Offshore stations had diverse species but very low zooplankton concentrations. Shrimp, *Calanus finmarchicus*, Euphausiids, a variety of ctenophora, small hydromedusa, and small siphonophores. Noticeably lacking were the large quantities of salps seen in this area during the summer months.

Inshore Benthic Habitat Descriptions

A list of 100 stations was originally planned for the two legs of this cruise, but weather and time limitations reduced the actual number visited to 70 for grab samples and 62 for beam trawls (Figure C26). Results from the infaunal analysis of grab samples were not available for this report.

The results of sediment grain size analysis are depicted in Figure C27. As anticipated, the primary Folk sediment class in most samples was sand with varying amounts of mud and/or gravel. Replicate grabs from the same station were sometimes consistent (belonging to the same class), suggesting uniformity of sediment type over the spatial span of 284 ± 209 m (mean ± SD) between the first and last grabs at each station. Others stations had varied sediments within that span, even ranging from sand (<0.01% gravel) to sandy gravel (30 – 80% gravel) within the same spatial span, indicating small-scale heterogeneity. Gravel content was always the heterogeneous element in these variable stations. Figure C27 distinguishes stations with homogeneous and heterogeneous sediments. Homogeneous sand predominated in the MA WEA, particularly in its eastern half. Elsewhere**,** sand-gravel mixes (homogeneous and heterogeneous) predominated. NY, NJ, and VA WEAs all had at least one heterogeneous station with at least one replicate of gravel-dominated (sandy gravel: 30 - 80% gravel by wt.) sediments.

The results of beam trawling for epibenthic and demersal fauna are presented in Table C12. Important taxa, comprising ≥ 10% of total catch numbers, ≥ 10% of total catch weight, or occurring in ≥ 50% of catches within each WEA, are listed individually. Sand shrimp (*Crangon septemspinosa*) were invariably the most numerous catch, were the heaviest catch in New Jersey and New York, and occurred in every trawl but one. Assemblages were otherwise similar in all WEAs, featuring sand dollars, smallmouth founder, and various skate species among others. The presence of fig (monkey dung) sponges (*Suberites ficus*) and Bryozoans in a few MA WEA samples suggest hard substrate. These trawl locations and areas of sediments dominated by gravel (sG) bear further investigation as possible venues for potentially sensitive hard-bottom patches.

DISPOSITION OF 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.

All benthic data are processed and maintained at the NEFSC J.J. Howard Lab in Sandy Hook, NJ.

All active acoustic data will be archived and maintained by the Data Management Services (DMS) branch at the NEFSC. In addition, all EK60 data will be archived and maintained at NOAA's NGDC in Boulder, CO.

PERMITS

NEFSC was authorized to conduct the marine mammal related research activities during this survey under US Permit No. 17355 issued to the NEFSC by the NMFS Office of Protected Resources, Canadian Species at Risk Permit license number 330996, and Canadian Foreign Fishing Vessel License no 000005 issued under IDR-423.

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Staff time was also provided by the Woods Hole Oceanographic Institution and the NOAA Fisheries Service, Northeast Fisheries Science Center (NEFSC), Protected Species Branch, Oceanography Branch, and Behavioral Ecology Branch.

Table C1. Scientific Computer System (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 C2. Scientific personnel involved in the two legs of this survey. FN = Foreign National.

Personnel	Team	Organization
Leg 1		
Debra Palka	Chief Scientist	NMFS, NEFSC, Woods Hole, MA
Cristina Bascunan	Oceanography	NMFS, NEFSC, Woods Hole, MA
Michael Lowe	Oceanography	Integrated Statistics, Woods Hole, MA
Michael Force (FN)	Seabird	Integrated Statistics, Woods Hole, MA
Peter Duley	Visual mammal	NMFS, NEFSC, Woods Hole, MA
Jennifer Gatzke	Visual mammal	Integrated Statistics, Woods Hole, MA
Samara Haver	Passive acoustic	Integrated Statistics, Woods Hole, MA
Peter Plantamura	Oceanography	NMFS, NEFSC, Sandy Hook, NJ
Betty Lentell	Visual mammal	Integrated Statistics, Woods Hole, MA
Nicholas Metheny	Visual mammal	Integrated Statistics, Woods Hole, MA
Todd Pusser	Visual mammal	Integrated Statistics, Woods Hole, MA
Chris Tremblay	Passive acoustic	Integrated Statistics, Woods Hole, MA
Dan Vendatullia	Oceanography	Integrated Statistics, Woods Hole, MA
Harvey Walsh	Oceanography	NMFS, NESFC, Narragansett, RI
Tim White	Seabird	Integrated Statistics, Woods Hole, MA
Leg 2		
Jennifer Gatzke	Chief Scientist	Integrated Statistics, Woods Hole, MA
Elisabeth Broughton	Oceanography	NMFS, NEFSC, Woods Hole, MA
Genevieve Davis	Passive acoustic	Integrated Statistics, Woods Hole, MA
Michael Force (FN)	Seabird	Integrated Statistics, Woods Hole, MA
Betty Lentell	Visual mammal	Integrated Statistics, Woods Hole, MA
Eric Matzen	Visual mammal	Integrated Statistics, Woods Hole, MA
Melissa Warden	Visual mammal	Integrated Statistics, Woods Hole, MA
John Rosendale	Oceanography	NMFS, NEFSC, Sandy Hook, NJ
Eric Matzen	Visual mammal	Integrated Statistics, Woods Hole, MA
Nicholas Metheny	Seabird	Integrated Statistics, Woods Hole, MA
Todd Pusser	Visual mammal	Integrated Statistics, Woods Hole, MA
Chris Tremblay	Passive acoustic	Integrated Statistics, Woods Hole, MA
Kimberly Gogan	Oceanography	Teacher-at-sea
Brian Dennis	Oceanography	Volunteer
Jerome Prezioso	Oceanography	NMFS,NEFSC, Narragansett, RI

Table C3. Within each Beaufort sea state condition, total length of visual teams' track lines while on effort (in km).

Conditions	Track line length (km) within Beaufort sea state levels							
	0	1	2	3	4	5	6	Total
On effort	70.4	149.1	748.7	625.9	972.6	965.9	481.2	4013.8
Cumulative percentage	0.02	0.05	0.24	0.40	0.64	0.88	1.00	

Table C4. Number of groups and individuals of cetacean species detected by the upper and lower marine mammal - turtle visual teams during on-effort track lines on the NOAA ship *Gordon Gunter* survey conducted during 8 Mar – 28 Apr 2014. Note, some, but not all, groups detected by one team were also detected by the other team.

Species		number of groups		number of individuals	
		lower	upper	lower	upper
Atlantic spotted dolphin	*Stenella frontalis*	0	1	0	7
Blue whale	*Balaenoptera musculus*	0	1	0	1
Bottlenose dolphin spp.	*Tursiops truncatus*	8	24	165	272
Bottlenose whale	*Hyperoodon ampullatus*	2	0	6	0
Common dolphin	*Delphinus delphis*	40	84	1009	1993
Cuvier's beaked whale	*Ziphius cavirostris*	5	3	6	8
Fin whale	*Balaenoptera physalus*	11	40	11	62
Fin/sei whales	*B. physalus or B. borealis*	5	22	6	26
Harbor porpoise	*Phocoena phocoena*	4	13	6	15
Humpback whale	*Megaptera novaeangliae*	20	41	32	60
Killer whale	*Orcinus orca*	1	1	2	4
Minke whale	*B. acutorostrata*	1	11	1	14
Pilot whales spp.	*Globicephala spp.*	27	44	202	256
Right whale	*Eubalaena glacialis*	9	18	11	26
Risso's dolphin	*Grampus griseus*	11	19	41	84
Sei whale	*Balaenoptera borealis*	10	4	10	4
Sowerby's beaked whale	*Mesoplodon bidens*	0	1	0	3
Sperm whale	*Physeter macrocephalus*	24	32	28	39
Striped dolphin	*Stenella coeruleoalba*	4	7	183	139
True's beaked whale	*Mesoplodon mirus*	0	1	0	3
White-sided dolphin	*Lagenorhynchus acutus*	12	20	120	188
Unid. Dolphin	*Delphinidae*	29	52	130	297
Unid. Whale	*Mysticeti*	49	121	51	139
Unid. Mesoplodon	*Mesoplodon spp.*	6	17	7	21
TOTAL CETACEANS		278	577	2,027	3,661

Table C5. Number of groups and individuals of large fish, turtles, and seals detected by the upper and lower marine mammal - turtle visual teams during on-effort track lines on the NOAA ship *Gordon Gunter* survey conducted during 8 Mar – 28 Apr 2014. 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	lower	upper
Basking shark	*Cetorhinus maximus*	2	4	2	5
Ocean sunfish	*Mola mola*	4	22	4	23
Shark spp.		1	3	1	3
Loggerhead turtle	*Caretta caretta*	1	1	1	1
Unid turtle	*Chelonioidea*	1	0	1	0
Gray seal	*Halichoerus grypus*	4	13	4	14
Harbor seal	*Phoca vitulina*	2	4	2	4
Unid seal	*Pinniped*	2	2	2	2
TOTAL ALL SPECIES		295	626	2,044	3,713

Table C6. Number of groups and individual birds detected on effort during the NOAA ship *Gordon Gunter* survey conducted during 8 Mar – 28 Apr 2014.

Species		Number of groups	Total individuals	Relative abundance	Frequency
Herring Gull	*Larus argentatus*	532	1088	15.68	21.36
Northern Gannet	*Morus bassanus*	484	778	11.21	19.43
Dovekie	*Alle alle*	203	936	13.49	8.15
Great Black-backed Gull	*Larus marinus*	201	279	4.02	8.07
Atlantic Puffin	*Fratercula arctica*	150	228	3.29	6.02
Northern Fulmar	*Fulmarus glacialis*	146	313	4.51	5.86
Red Phalarope	*Phalaropus fulicarius*	121	1281	18.46	4.86
Bonaparte's Gull	*Chroicocephalus philadelphia*	88	339	4.89	3.53
Razorbill	*Alca torda*	84	228	3.29	3.37
White-winged Scoter	*Melanitta fusca*	52	217	3.13	2.09
Common Loon	*Gavia immer*	50	65	0.94	2.01
Sooty Shearwater	*Puffinus griseus*	42	131	1.89	1.69
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	40	58	0.84	1.61
Manx Shearwater	*Puffinus puffinus*	35	43	0.62	1.41
Thick-billed Murre	*Uria lomvia*	29	41	0.59	1.16
Wilson's Storm-Petrel	*Oceanites oceanicus*	26	235	3.39	1.04
Common Murre	*Uria aalge*	24	34	0.49	0.96
Pomarine Jaeger	*Stercorarius pomarinus*	24	25	0.36	0.96
Black Scoter	*Melanitta americana*	23	138	1.99	0.92
Red-throated Loon	*Gavia stellata*	18	23	0.33	0.72
Long-tailed Duck	*Clangula hyemalis*	10	35	0.50	0.40
Black-capped Petrel	*Pterodroma hasitata*	9	9	0.13	0.36
unidentified Passerine	*Passerine sp.*	9	9	0.13	0.36
Surf Scoter	*Melanitta perspicillata*	8	65	0.94	0.32
Laughing Gull	*Leucophaeus atricilla*	7	96	1.38	0.28
unidentified phalarope	*Phalaropus sp.*	7	76	1.10	0.28
Lesser Black-backed Gull	*Larus fuscus*	6	6	0.09	0.24
Common Eider	*Somateria mollissima*	5	14	0.20	0.20
Long-tailed Jaeger	*Stercorarius longicaudus*	5	6	0.09	0.20
Iceland Gull	*Larus glaucoides*	5	5	0.07	0.20
unidentified shearwater	*Puffinus sp.*	3	10	0.14	0.12
Song Sparrow	*Melospiza melodia*	3	6	0.09	0.12

Species		Number of groups	Total individuals	Relative abundance	Frequency
Dark-eyed Junco	*Junco hyemalis*	3	3	0.04	0.12
unidentified alcid	*sp.*	3	3	0.04	0.12
Double-crested Cormorant	*Phalacrocorax auritus*	2	62	0.89	0.08
Black-legged Kittiwake	*Rissa tridactyla*	2	13	0.19	0.08
Arctic Tern	*Sterna paradisaea*	2	4	0.06	0.08
Brown-headed Cowbird	*Molothrus ater*	2	2	0.03	0.08
Red-breasted Merganser	*Mergus serrator*	2	2	0.03	0.08
unidentified *Pterodroma*	*Pterodroma sp.*	2	2	0.03	0.08
unidentiifed Skua	*Stercorarius sp.*	2	2	0.03	0.08
unidentified storm-petrel	*Oceanodroma/Oceanites sp.*	2	2	0.03	0.08
unidentified duck	*sp.*	1	8	0.12	0.04
Leach's/Band-rumped Storm-Petrel	*Oceanodroma leucorhoa/castro*	1	2	0.03	0.04
Canada Goose	*Branta canadensis*	1	1	0.01	0.04
Green-winged Teal	*Anas crecca*	1	1	0.01	0.04
Bermuda Petrel	*Pterodroma cahow*	1	1	0.01	0.04
Audubon's Shearwater	*Puffinus lherminieri*	1	1	0.01	0.04
Great Blue Heron	*Ardea herodias*	1	1	0.01	0.04
Osprey	*Pandion haliaetus*	1	1	0.01	0.04
unidentified shorebird	*sp.*	1	1	0.01	0.04
Glaucous Gull	*Larus hyperboreus*	1	1	0.01	0.04
unidentified large gull	*Larus sp.*	1	1	0.01	0.04
Parasitic Jaeger	*Stercorarius parasiticus*	1	1	0.01	0.04
South Polar Skua	*Stercorarius maccormicki*	1	1	0.01	0.04
Black Guillemot	*Cepphus grylle*	1	1	0.01	0.04
unidentified murre	*Uria sp.*	1	1	0.01	0.04
Northern Flicker	*Colaptes auratus*	1	1	0.01	0.04
Brown Thrasher	*Toxostoma rufum*	1	1	0.01	0.04
American Robin	*Turdus migratorius*	1	1	0.01	0.04
Eurasian Starling	*Sturnus vulgaris*	1	1	0.01	0.04
Red-winged Blackbird	*Agelaius phoeniceus*	1	1	0.01	0.04
Total		2491	6940		

Table C7. Summary of passive acoustic recording effort during the NOAA ship Gordon Gunter March – April 2014 survey.

	Leg 1	Leg 2	Total
Days w/ acoustic effort	7	10	17
Daytime recording time (hh:mm)	54:06	61:33	115:39
Nights w/ acoustic effort	3	7	10
Evening/night recording time (hh:mm)	4:36	24:46	29:22

Table C8. Summary of acoustic events detected in real-time during the NOAA ship Gordon Gunter March - April 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	0	1	1
Common dolphin	1	2	3
Pilot whales	1	1	2
Sperm whales	6	13	19
Groups without species assignment	11	18	29
Total	19	35	54

Table C9. Summary of acoustic detections of sperm whales. Note that most detections include multiple animals.

	Leg 1	Leg 2	Total
Days w/ sperm whale detections	3	5	8
Number of groups detected	6	13	19

Table C10. The number of hydrographic and oceanographic sampling stations attempted.

Sampling type	Leg 1	Leg 2	Total
CTD only	51	13	64
Bongo + CTD	86	41	127
VPR + CTD	9	4	13
IKMT + CTD	2	0	2
MOCNESS	3	0	3
Beam Trawl	53	17	70
Grabs	156	77	233
Total	360	152	512

Table C11. Oceanographic sampling at the shelf break canyon and non-canyon areas.

Canyon	Transect Type	Date	Time (Local)	Leg	EK60	CTD	MOC	IKMT	VPR
Baltimore (night)	Canyon (Z)	3/20/14	2118	I	X	X		X	
Baltimore (day)	Canyon (Z)	3/21/14	0700	I	X				
Washington (night)	Canyon (Z)	3/21/14	2225	I	X	X	X		
Washington (day)	Canyon (Z)	3/22/14	0700	I	X				
Norfolk	Canyon (Z)	3/22/14	2250	I	X	X			X
North of Washington	Cross-shelf	3/28/14	1934	I	X	X			
Wilmington	Canyon (Z)	3/29/14	1817	I	X	X			
Hudson	Canyon (Z)	4/1/14	1652	I	X	X			
Atlantis	Canyon (Z)	4/13/14	2158	II	X	X			
Munson	Canyon (Z)	4/21/14	2219	II	X				

Table C12. Beam trawl summary for epibenthic and demersal fauna.

VA WEA, 12 trawls, 29 taxa		VA	VA	VA
common name	taxonomic name	%count	%wt	%freq
sand shrimp	*Crangon septemspinosa*	**43.4%**	3.0%	**100.0%**
snails unclassified	Gastropoda	**14.3%**	3.1%	**100.0%**
dwarf surf clam	*Mulinia lateralis*	**13.7%**	**16.8%**	**83.3%**
spotted hake	*Urophycis regia*	7.1%	7.3%	**100.0%**
smallmouth flounder	*Etropus microstomus*	4.8%	1.5%	**100.0%**
searobin	*Prionotus* sp.	4.5%	1.6%	**100.0%**
sand dollar	*Echinarachnius parma*	1.6%	2.5%	**50.0%**
sea slug	Opisthobranchia	0.9%	0.2%	**75.0%**
white shrimp	*Litopeneaus setiferus*	0.8%	0.2%	**50.0%**
sand lance	*Ammodytes* sp.	0.5%	0.9%	**50.0%**
goby	Gobiidae	0.5%	0.1%	**66.7%**
rock sea bass	*Centropristis philadelphica*	0.4%	0.3%	**75.0%**
freckled skate	*Leucoraja lentiginosa*	0.1%	**15.7%**	16.7%
rosette skate	*Leucoraja garmani*	0.0%	**18.9%**	8.3%
clearnose skate	*Raja eglanteria*	0.0%	**12.2%**	8.3%
SUBTOTAL		92.6%	84.1%	--
14 additional taxa		7.4%	15.9%	--

MA WEA, 23 trawls, 59 taxa		MA	MA	MA
common name	taxonomic name	%count	%wt	%freq
sand shrimp	*Crangon septemspinosa*	**70.5%**	5.7%	**95.7%**
sand dollar	*Echinarachnius parma*	**17.4%**	**47.6%**	39.1%
pandalid shrimp	Pandalidae	0.5%	0.1%	**52.2%**
monkey dung sponge	*Suberites ficus*	0.1%	**15.4%**	26.1%
little skate	*Raja erinacea*	0.3%	**15.8%**	34.8%
SUBTOTAL		88.9%	84.6%	--
54 additional taxa		11.1%	15.4%	--

NJ WEA, 13 trawls, 24 taxa		NJ	NJ	NJ
common name	taxonomic name	%count	%wt	%freq
sand shrimp	*Crangon septemspinosa*	**92.5%**	**34.0%**	**100.0%**
sea slug	Opisthobranchia	3.2%	3.3%	**100.0%**
smallmouth flounder	*Etropus microstomus*	0.7%	1.5%	**100.0%**
sand dollar	*Echinarachnius parma*	0.6%	6.5%	**61.5%**
thorny skate	*Amblyraja radiata*	0.1%	**31.8%**	30.8%
SUBTOTAL		97.1%	77.2%	--
19 additional taxa		2.9%	22.8%	--

NY WEA, 10 trawls, 19 taxa		NY	NY	NY
common name	taxonomic name	%count	%wt	%freq
sand shrimp	*Crangon septemspinosa*	**95.3%**	**40.5%**	**100.0%**
sea slug	Opisthobranchia	1.9%	2.9%	**70.0%**
sand dollar	*Echinarachnius parma*	1.8%	**20.9%**	**100.0%**
snails unclassified	Gastropoda	0.5%	0.5%	**70.0%**
hermit crab	*Pagurus* spp.	0.1%	0.2%	**80.0%**
smallmouth flounder	*Etropus microstomus*	0.1%	0.2%	**60.0%**
thorny skate	*Amblyraja radiata*	0.1%	**16.6%**	**60.0%**
comb jellies	Ctenophora	0.01%	**11.7%**	10.0%
SUBTOTAL		99.7%	93.6%	--
11 additional taxa		0.3%	6.4%	--

RIMA WEA, 4 trawls, 20 taxa		RIMA	RIMA	RIMA
common name	taxonomic name	%count	%wt	%freq
sand shrimp	*Crangon septemspinosa*	**96.3%**	**21.8%**	**100.0%**
true crabs	Brachyura	1.2%	2.7%	**50.0%**
sand dollar	*Echinarachnius parma*	0.5%	**25.6%**	25.0%
American sand lance	*Ammodytes americanus*	0.5%	4.9%	**50.0%**
pipefish	Sygnathidae	0.1%	0.1%	**75.0%**
silver hake	*Merluccius bilinearis*	0.1%	0.5%	**75.0%**
ocean pout	*Zoarces americanus*	0.1%	2.6%	**75.0%**
clam unlass.	Pelecypoda	0.0%	0.4%	**50.0%**
SUBTOTAL		98.7%	58.6%	--
12 additional taxa		1.3%	41.4%	--

Table C1. Proposed track lines (blue lines), benthic sampling stations (green circles), and deployment sites for the bottom mounted Marine Autonomous Recording Units (MARUs; red stars). Also shown are the location of the Bureau of Ocean Energy Management wind energy areas (BOEM WEAs in pink), the shelf break stratum (between the 100 and 2000 m depth contours) and the US exclusive economic zone (EEZ) line.

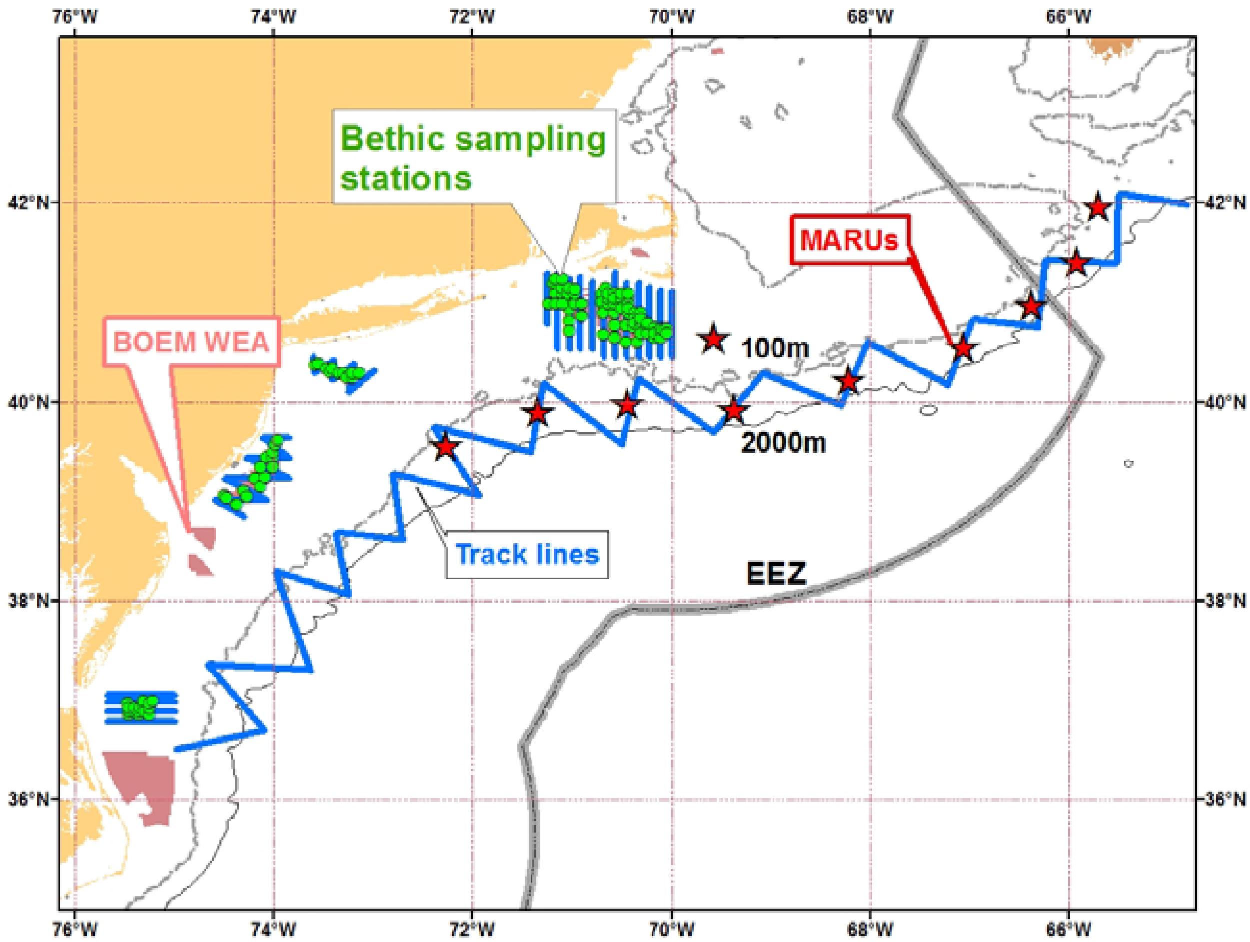


Figure C2. Location of and Beaufort sea states of the completed track lines (colored lines) and the actual locations of the Marine Autonomous Recording Units (MARUs; pink stars). Also shown are the location of the Bureau of Ocean Energy Management wind energy areas (BOEM WEAs in blue), the 100 and 2000 m depth contours and the US exclusive economic zone (EEZ) line.

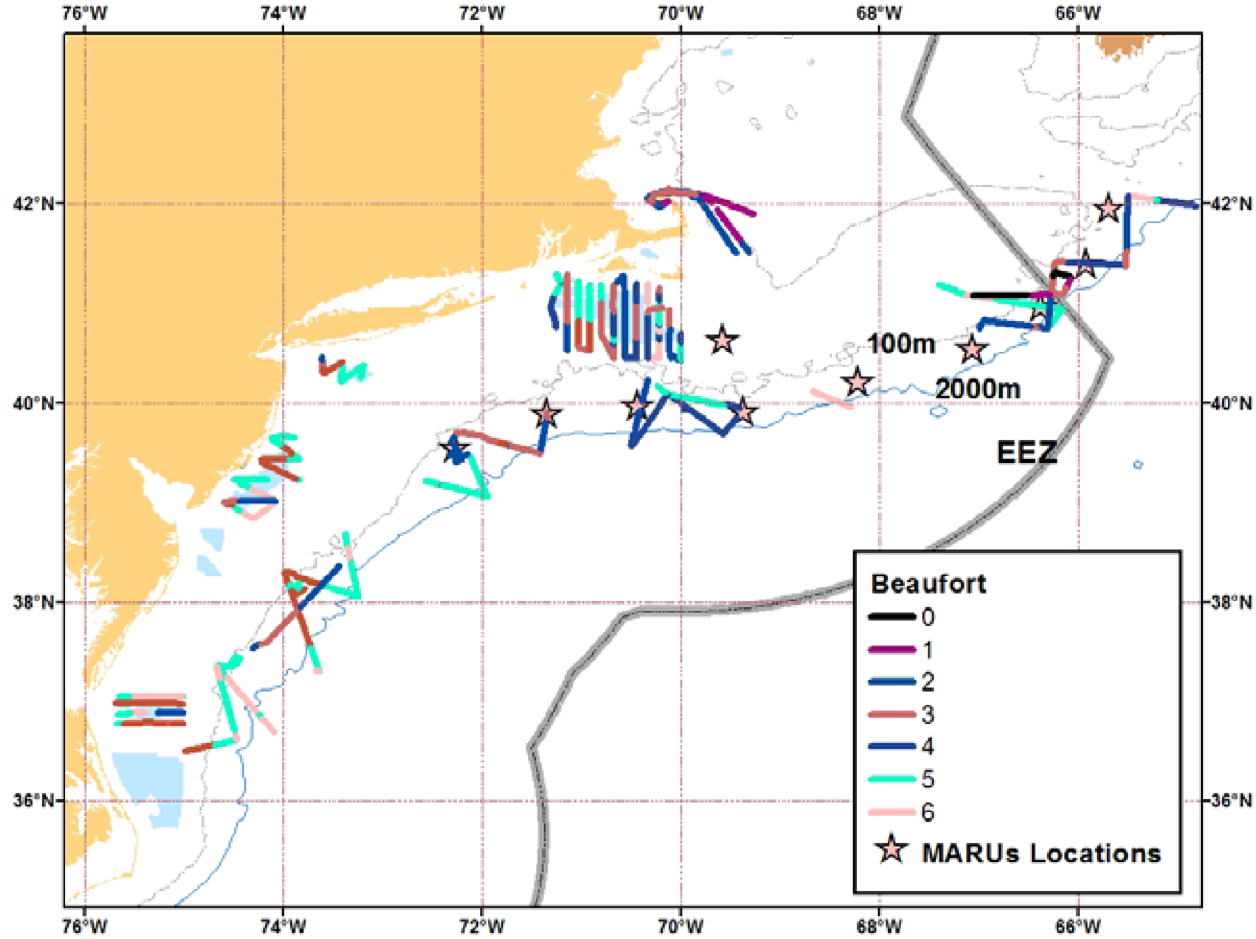
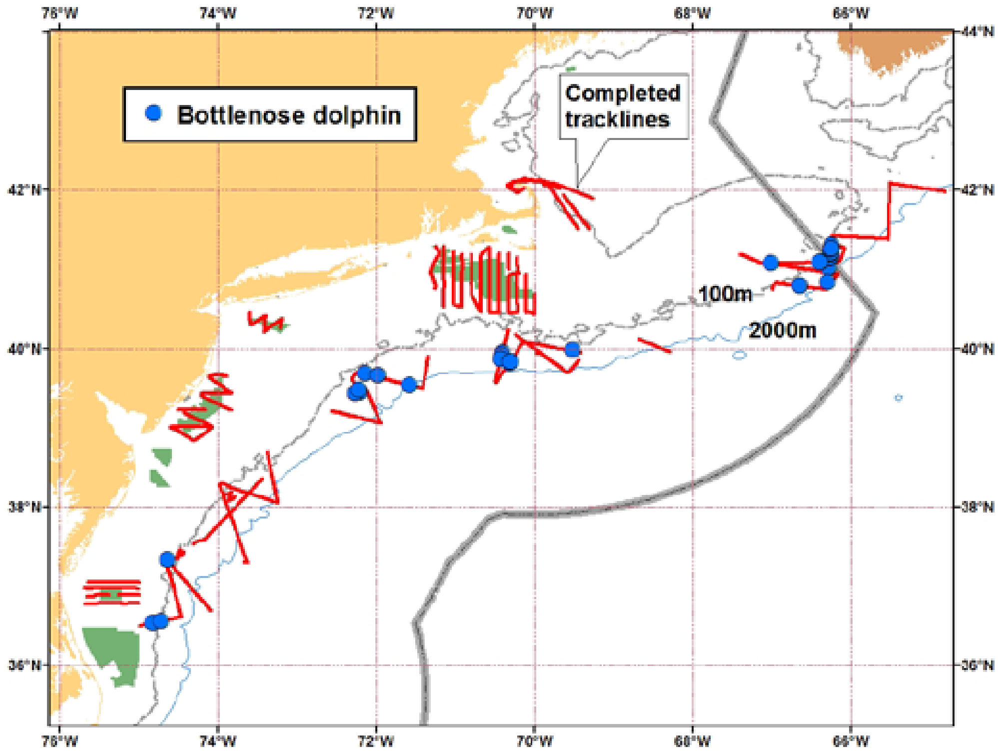


Figure C3. Location of bottlenose spp. dolphin (*Tursiops truncatus*; top) and common dolphin (*Delphinus delphis*; bottom) sightings detected by the upper and/or lower team during on-effort tracklines.



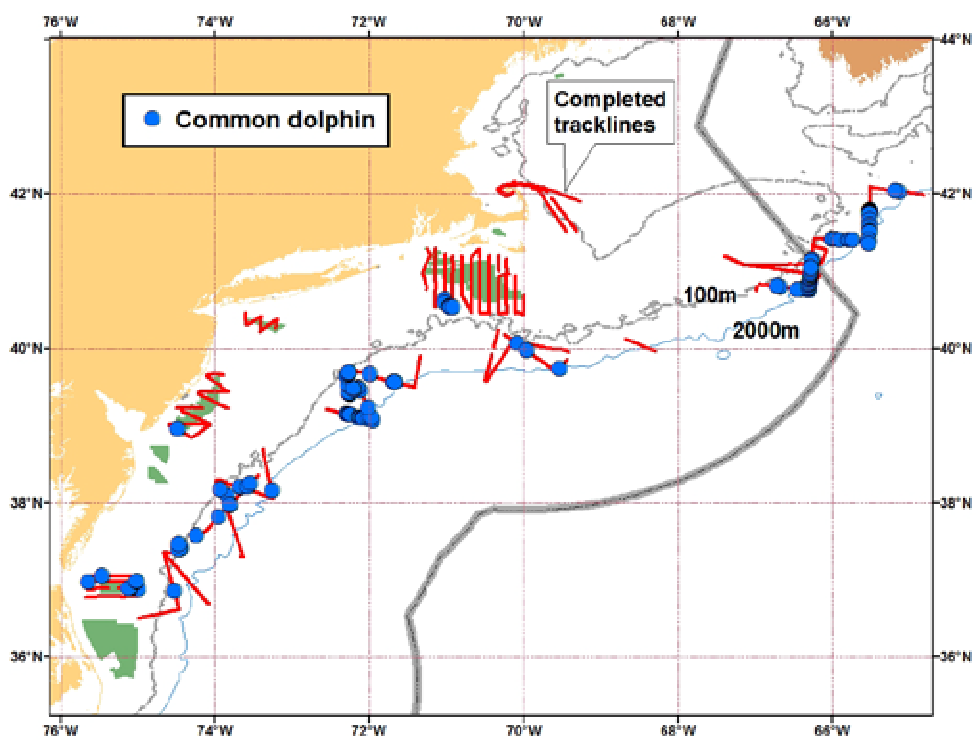


Figure C4. Location of harbor porpoise (*Phocoena phocoena*; top) and white-sided dolphin (*Lagenorhynchus acutus*; bottom) sightings detected by the upper and/or lower team during on-effort tracklines.

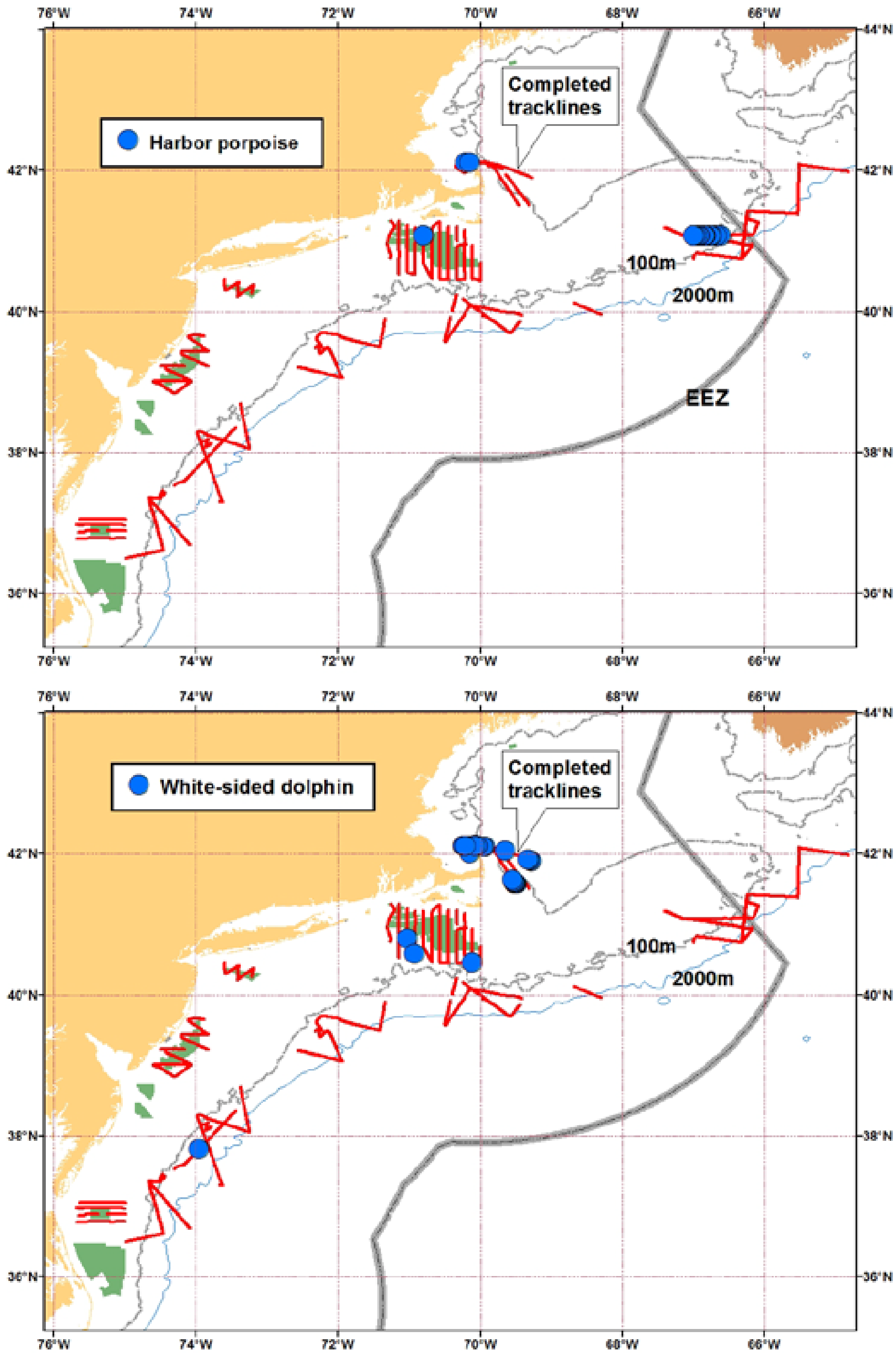


Figure C5. Location of Atlantic spotted dolphins (*Stenella frontalis*), and striped dolphins (*Stenella coeruleoalba*) (top) and unidentified dolphin (bottom) sightings detected by the upper and/or lower team during on-effort tracklines.

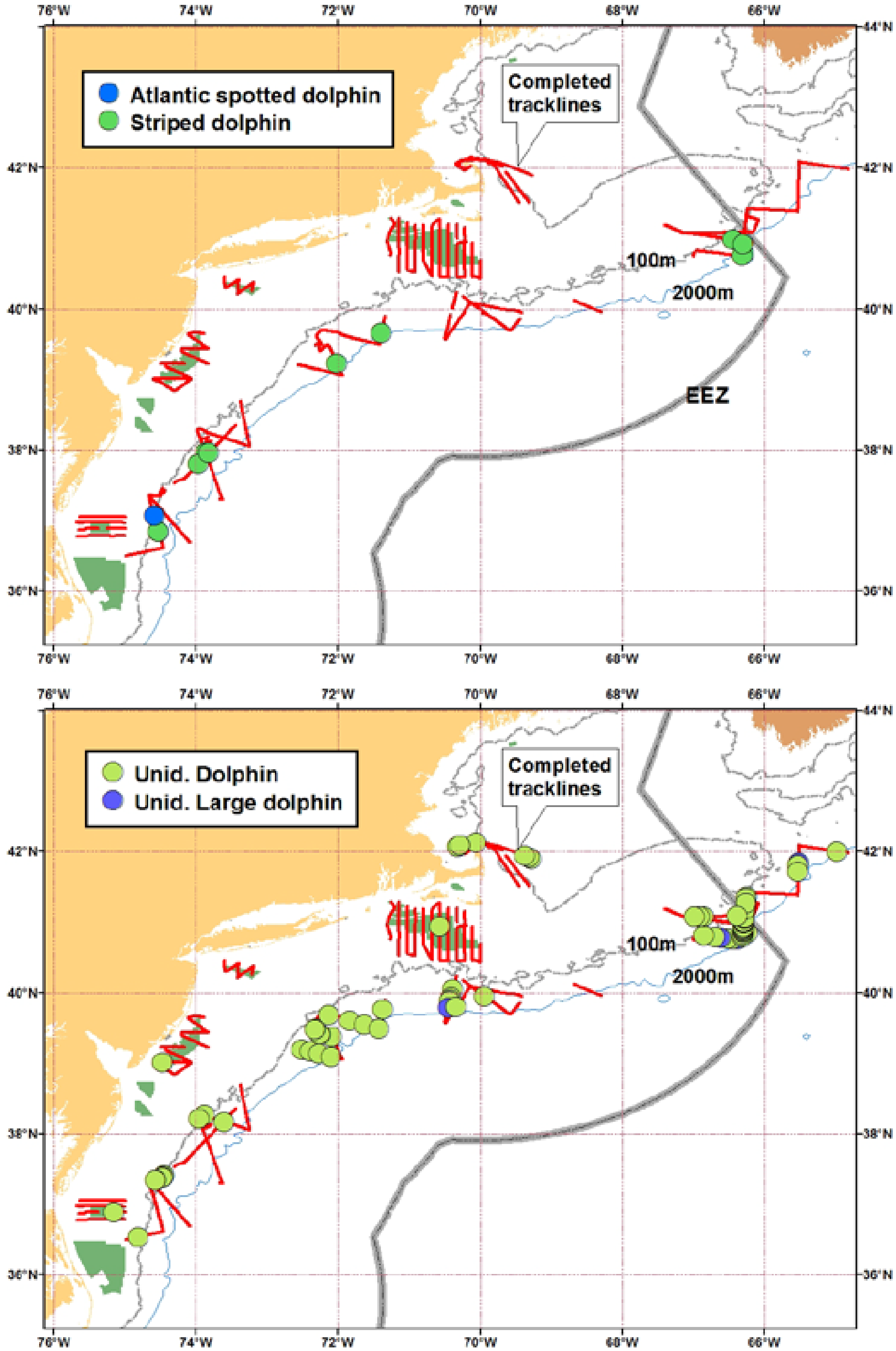
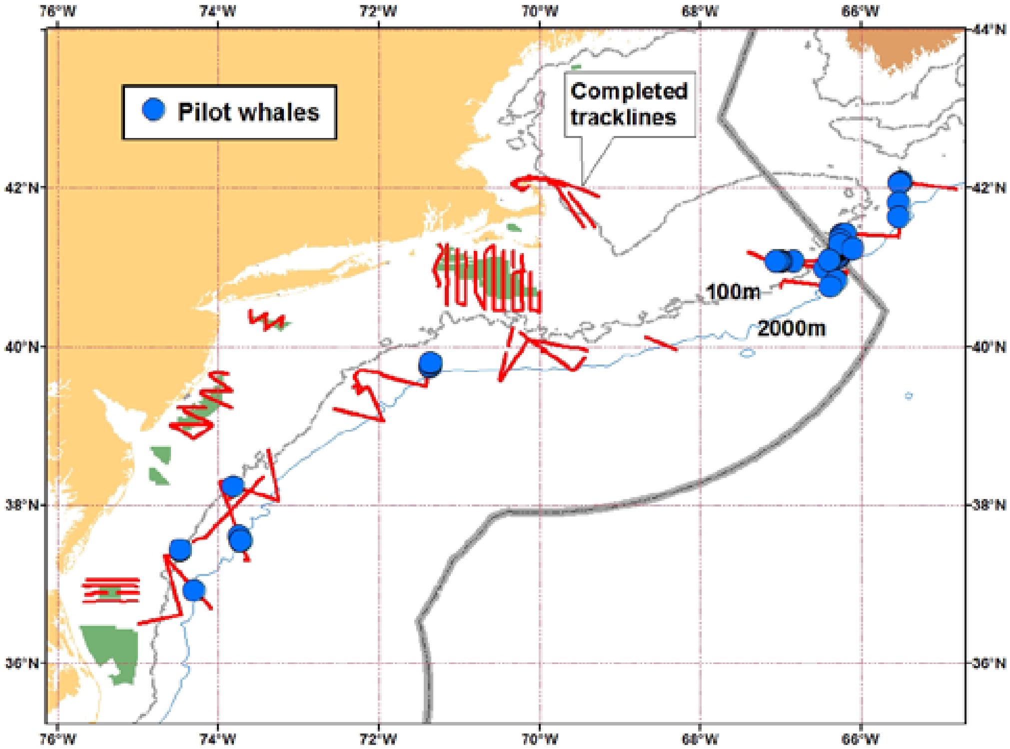


Figure C6. Location of pilot whale spp. (Globicephala spp.; top) and Risso's dolphin (*Grampus griseus*; bottom) sightings detected by the upper and/or lower team during on-effort tracklines.



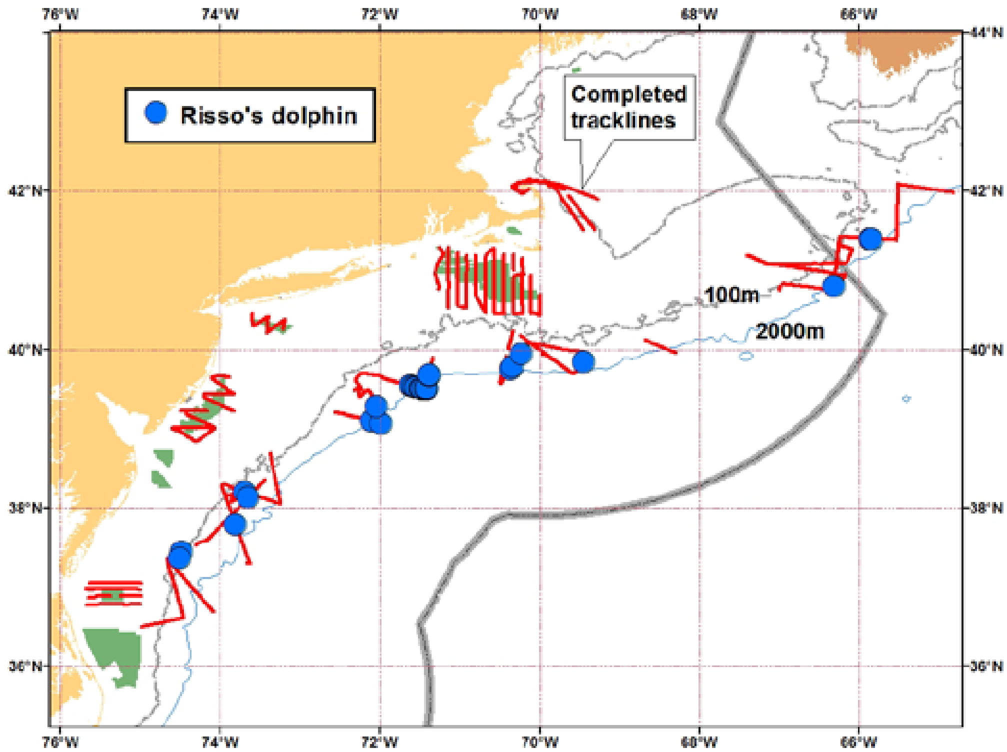


Figure C7. Location of Cuvier's beaked whales (*Ziphius cavirostris*), Sowerby's beaked whales (*Mesoplodon bidens*), True's beaked whale (*Mesoplodon mirus*), unidentified Mesoplodant and unidentified Ziphiid sightings detected by the upper and/or lower team during on-effort tracklines.

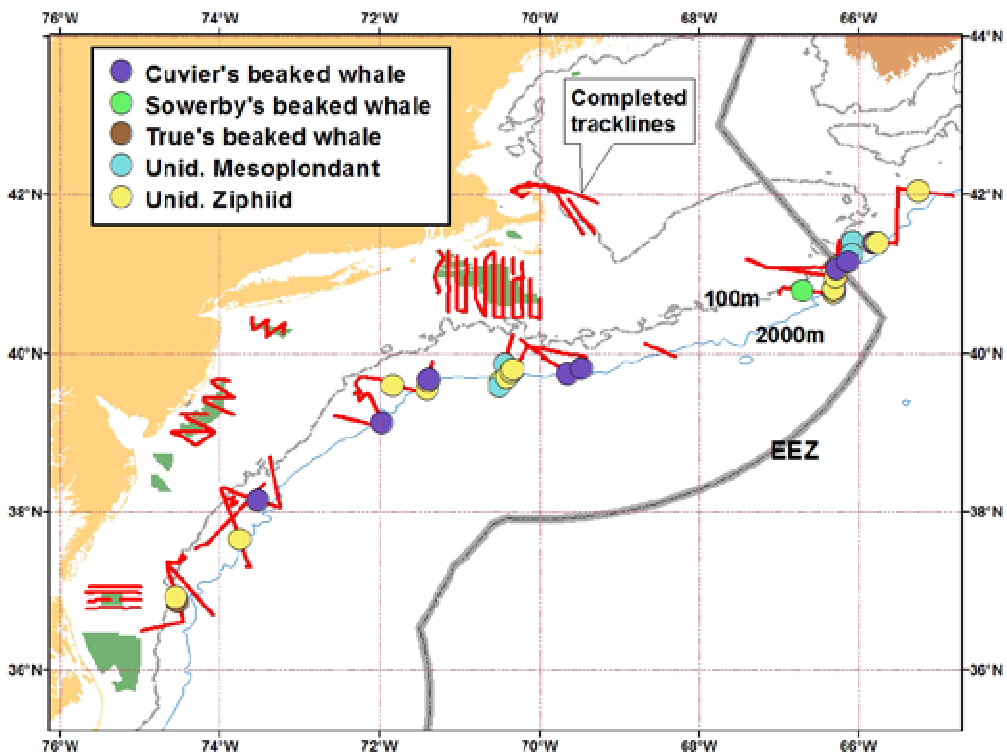


Figure C8. Location of fin whales (*Balaenoptera physalus*), and sei whales (*Balaenoptera borealis*; top) and humpback whale (*Megaptera novaeangliae*; bottom) sightings detected by the upper and/or lower team during on-effort tracklines.

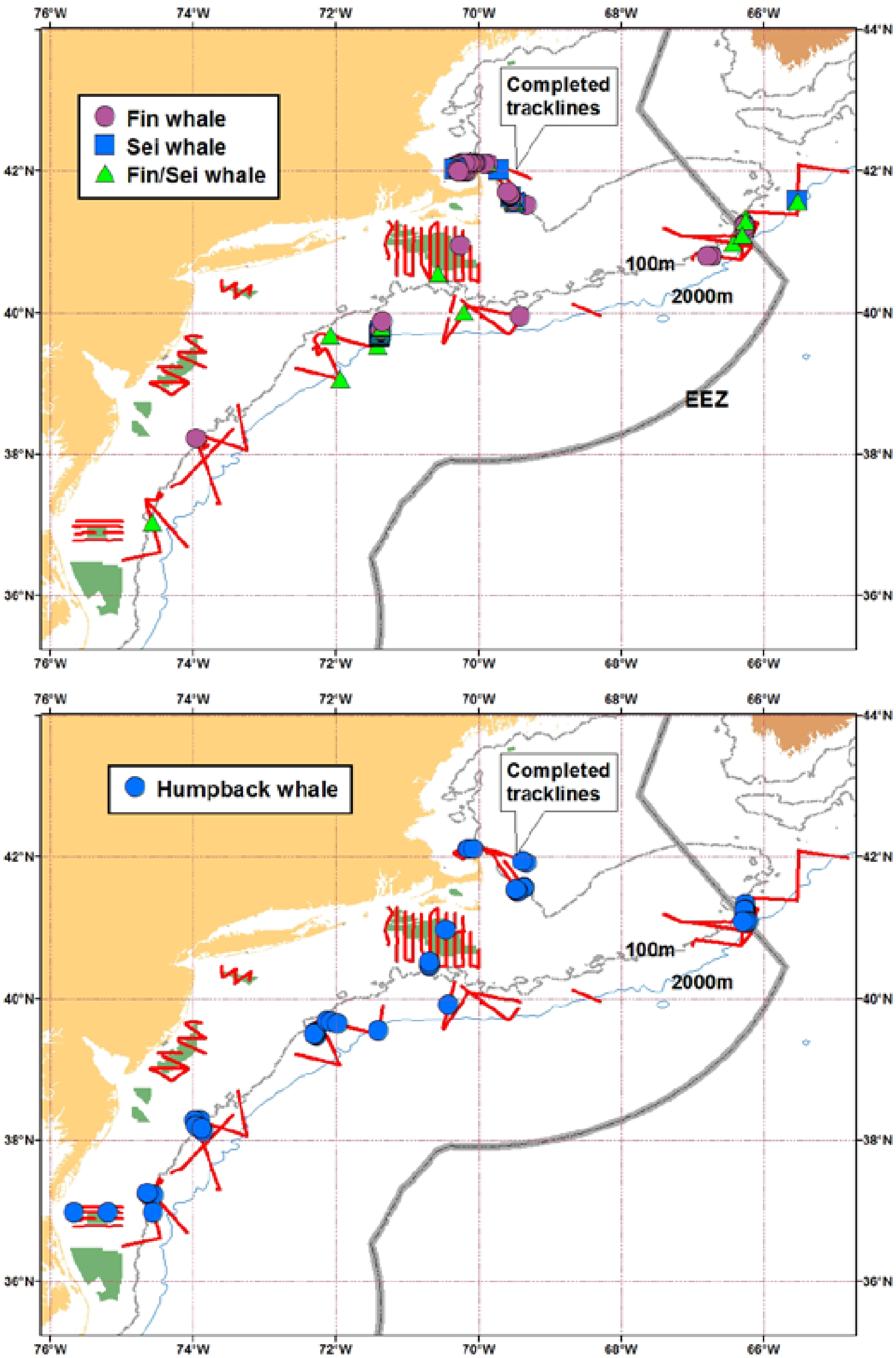


Figure C9. Location of right whale (*Eubalaena glacialis*; top) and sperm whale (*Physeter macrocephalus*; bottom) sightings detected by the upper and/or lower team during on-effort tracklines.

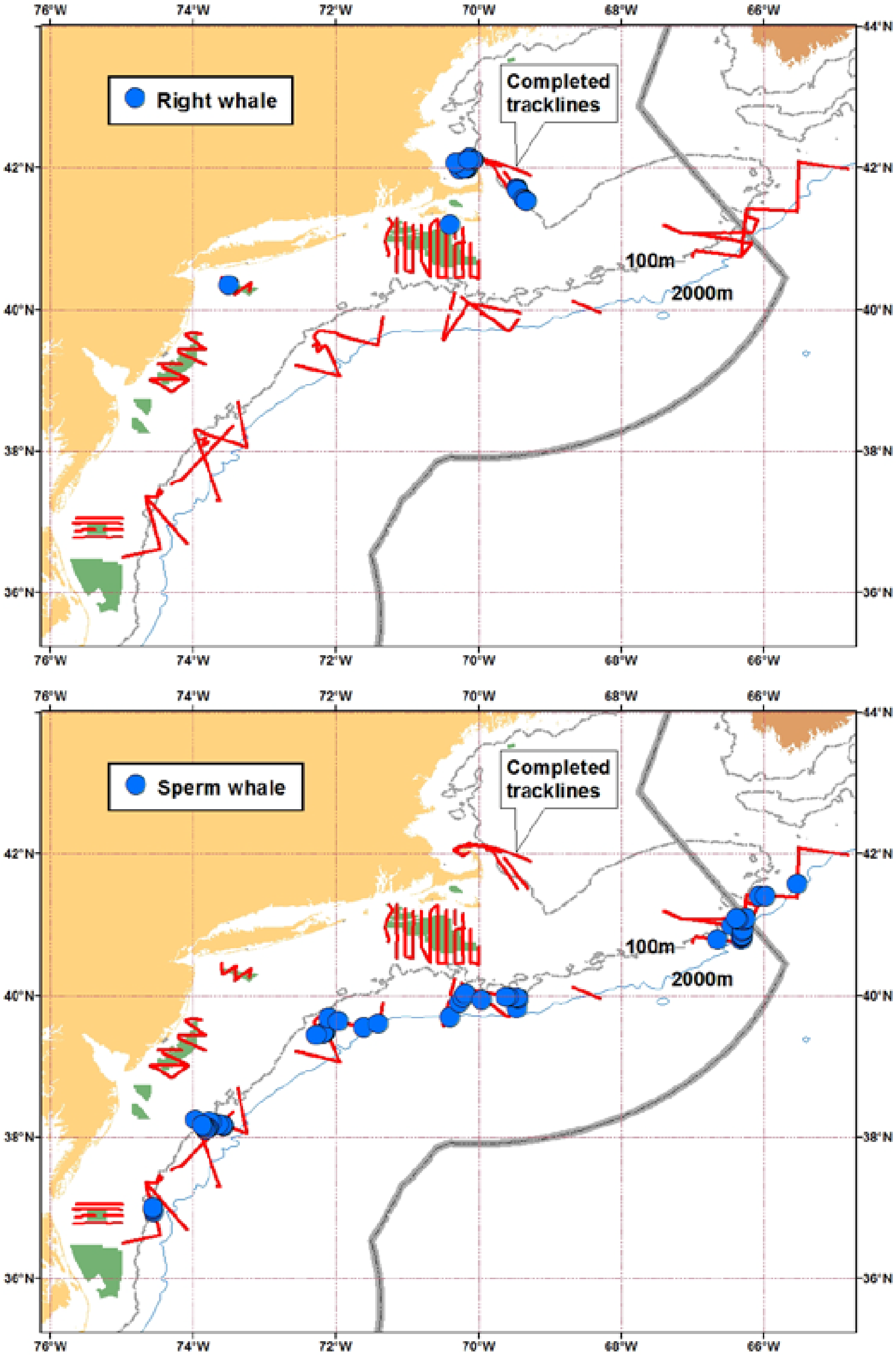


Figure C10. Location of blue whales (*Balaenoptera musculus*), bottlenose whales (*Hyperoodon ampullatus*), killer whales (*Orcinus orca*) and minke whales (*Balaenoptera acutorostrata;* top) and unidentified whale (bottom) sightings detected by the upper and/or lower team during on-effort tracklines.

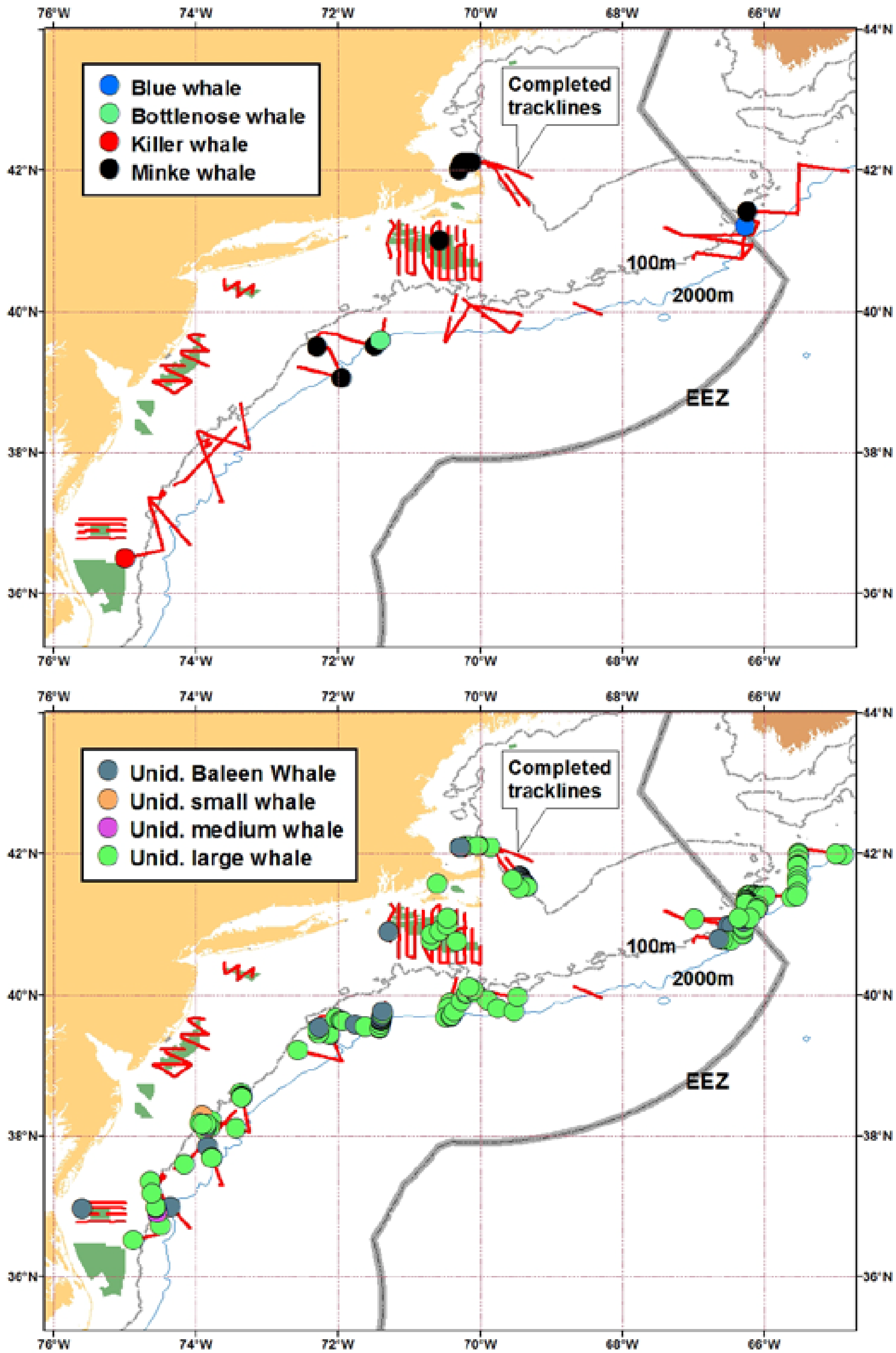


Figure C11. Location of basking sharks (*Cetorhinus maximus*), sunfish (*Mola mola*) and unidentified sharks (top), gray seals (*Halichoerus grypus*), harbor seals (*Phoca vitulina*) and unidentified seal (Pinniped; bottom) sightings detected by the upper and/or lower team during on-effort tracklines.

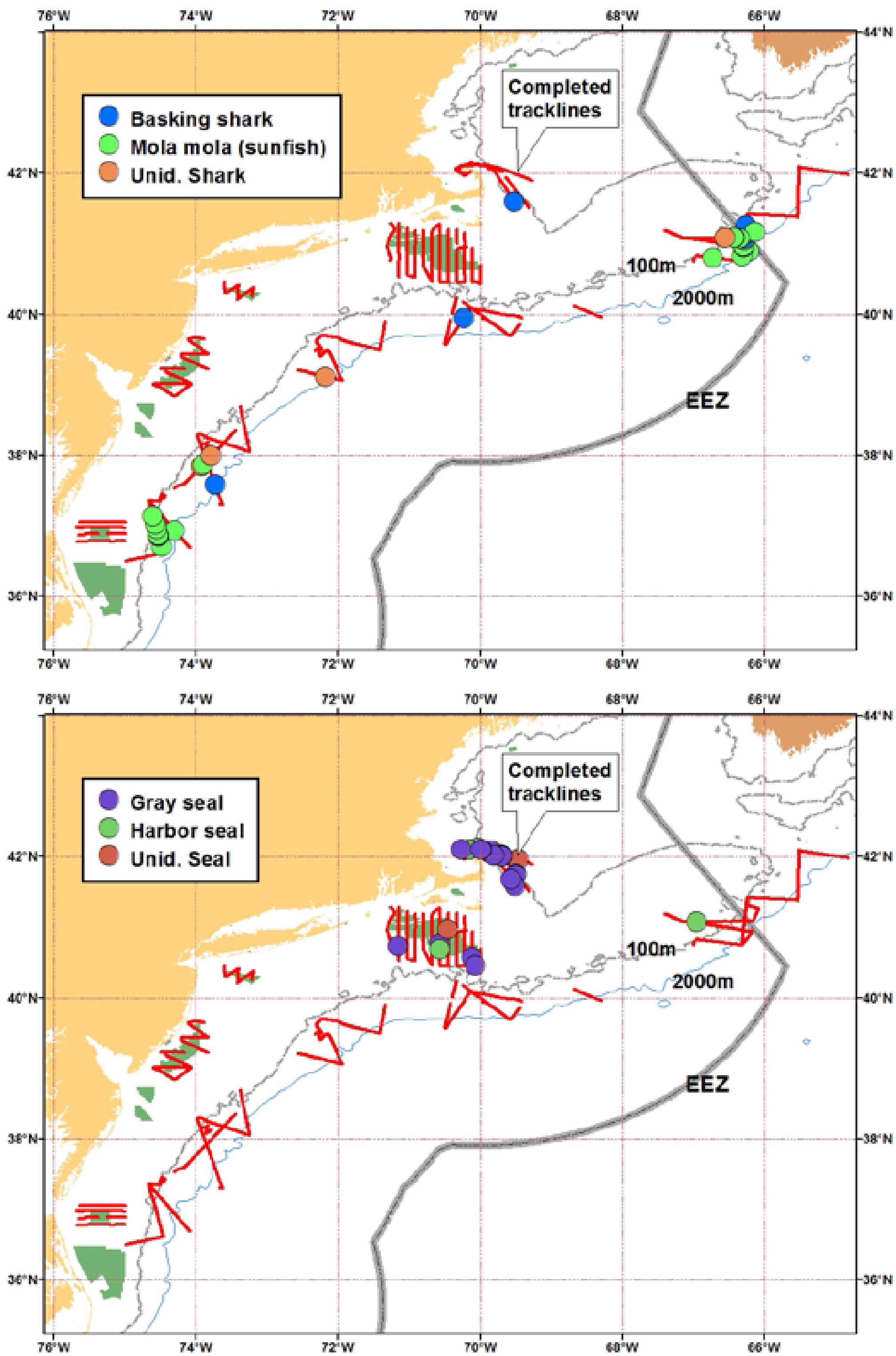


Figure C12. Location of loggerhead turtle (*Caretta caretta*), and unidentified hardshell turtle sightings detected by the upper and/or lower team during on-effort tracklines.

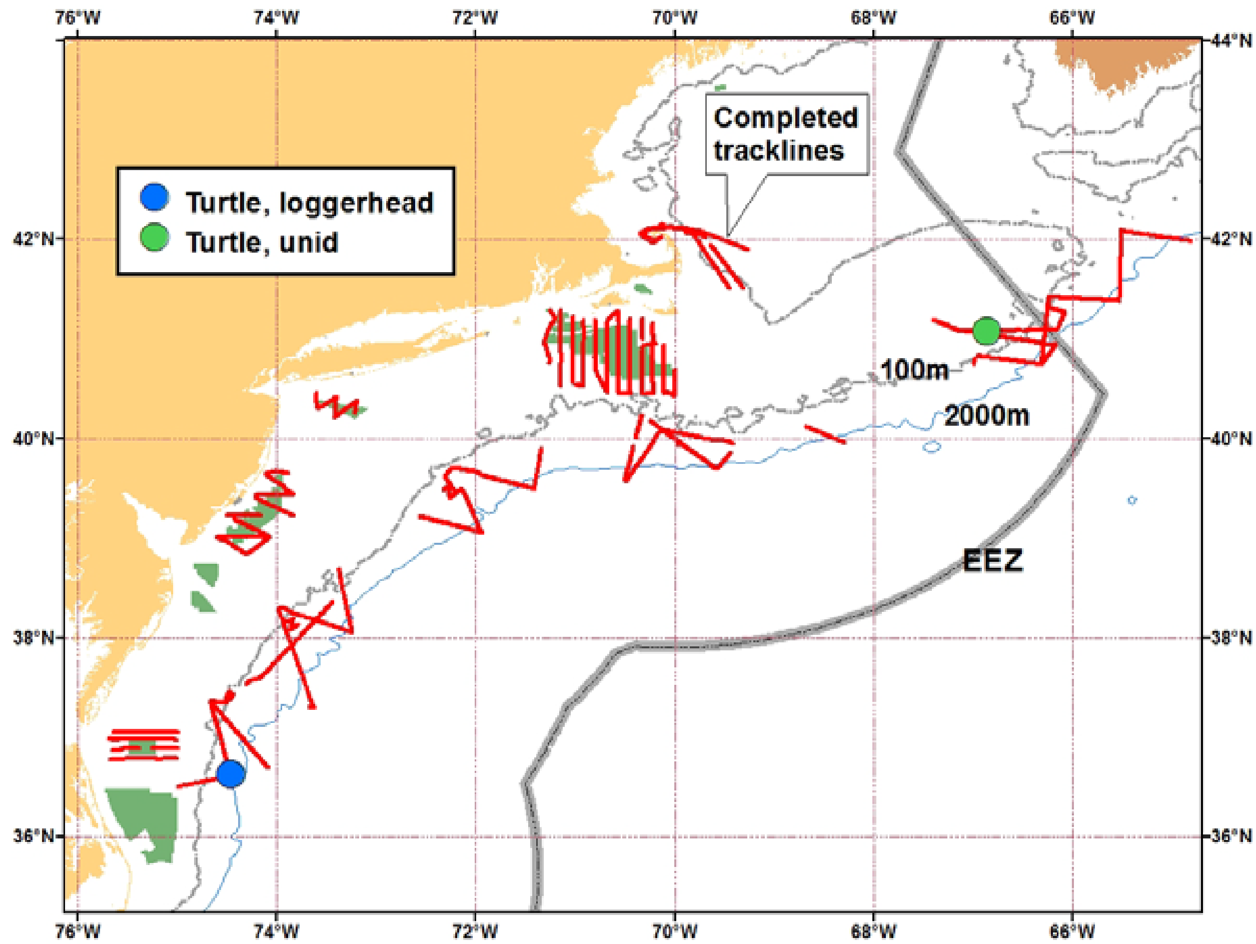


Figure C13. Location of Herring Gull (*Larus argentatus*; top) and Northern Gannet (*Morus bassanus*; bottom) sightings detected by the seabird team.

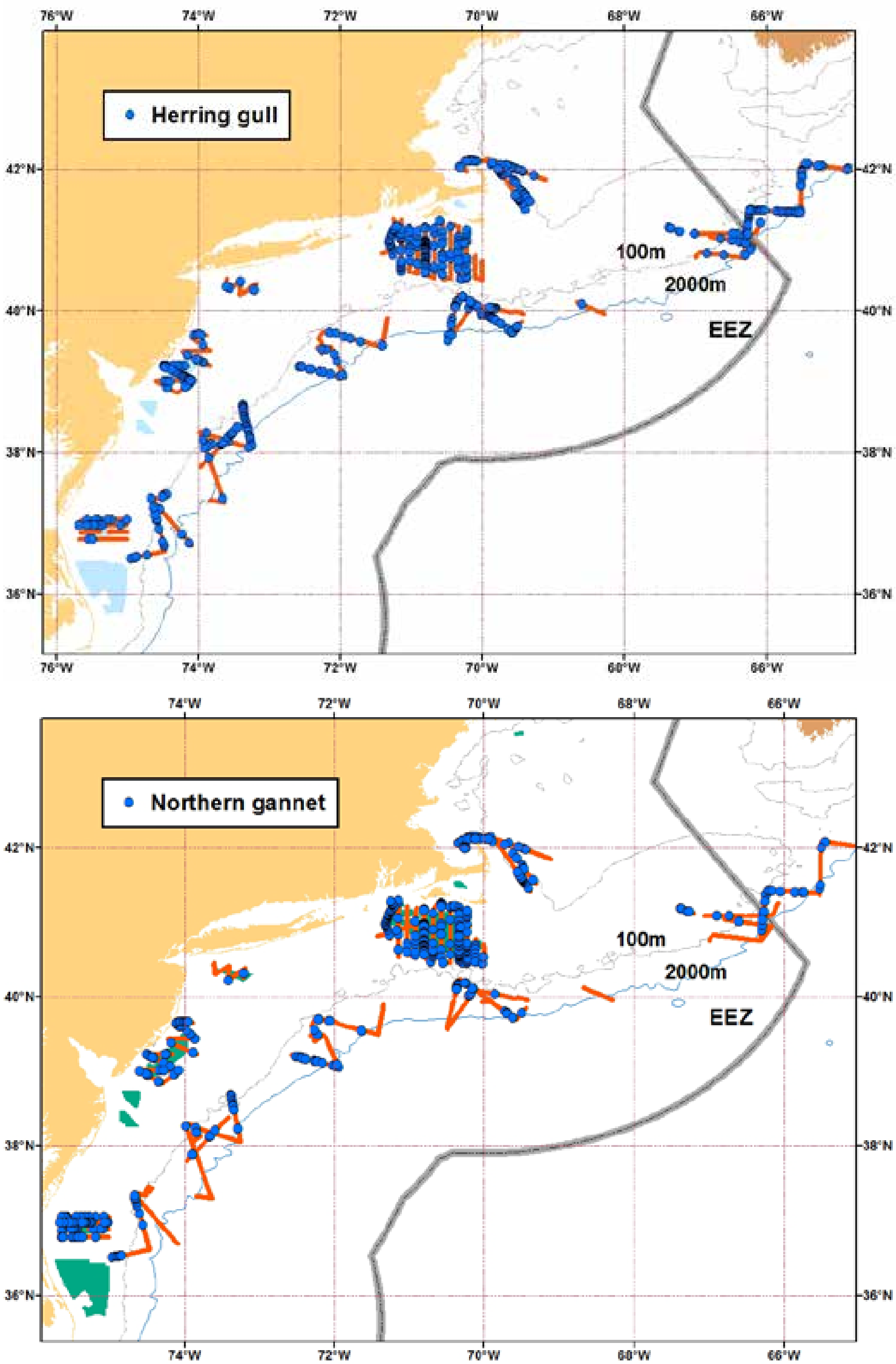


Figure C14. Location of Great Black-backed Gull (*Larus marinus*; top), and Northern Fulmar (*Fulmarus glacialis*; bottom) sightings detected by the seabird team.

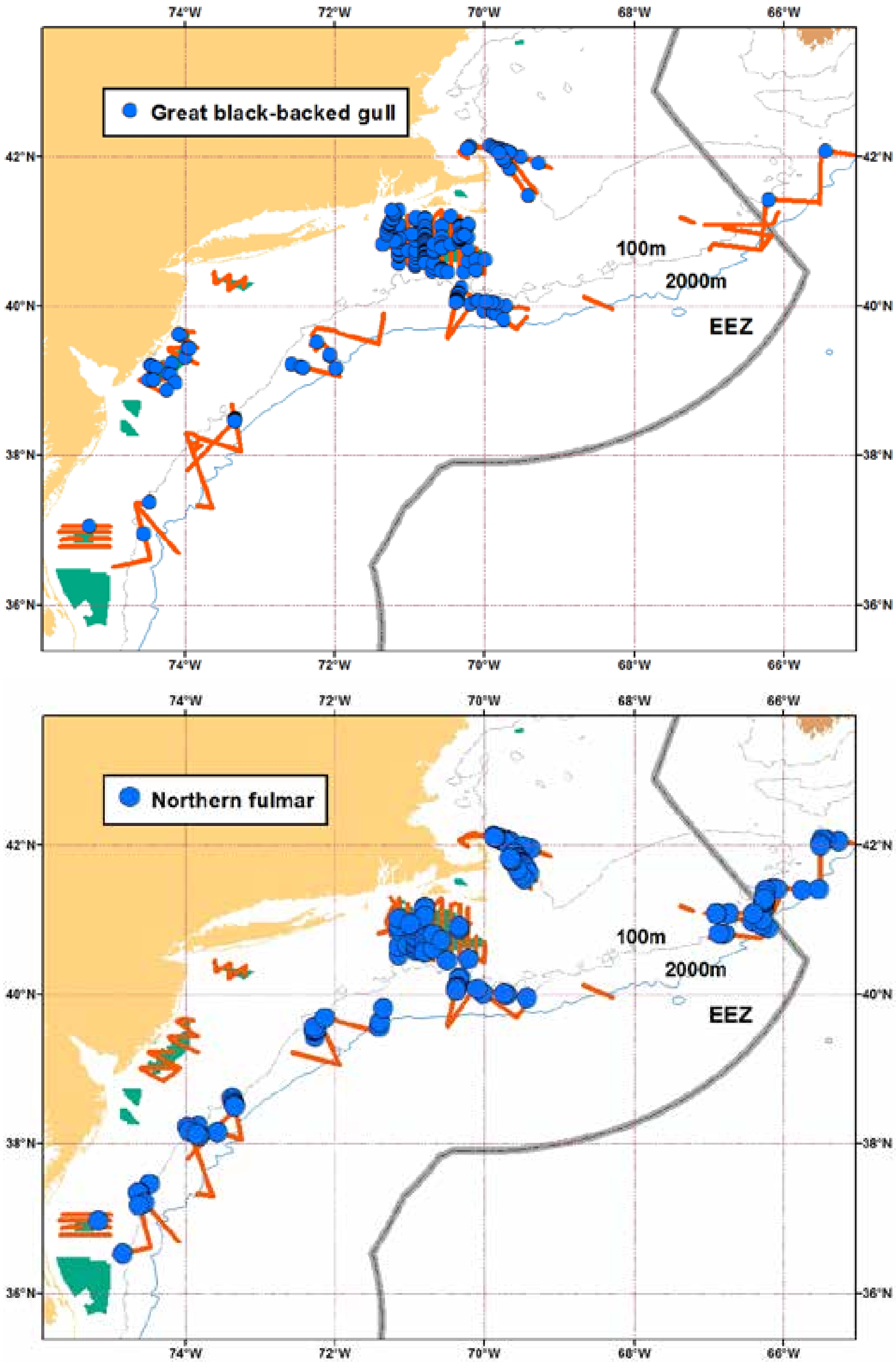


Figure C15. Location of Bonaparte's Gull (*Chroicocephalus philadelphia*; top), and Dovekie (*Alle alle*; bottom) sightings detected by the seabird team.

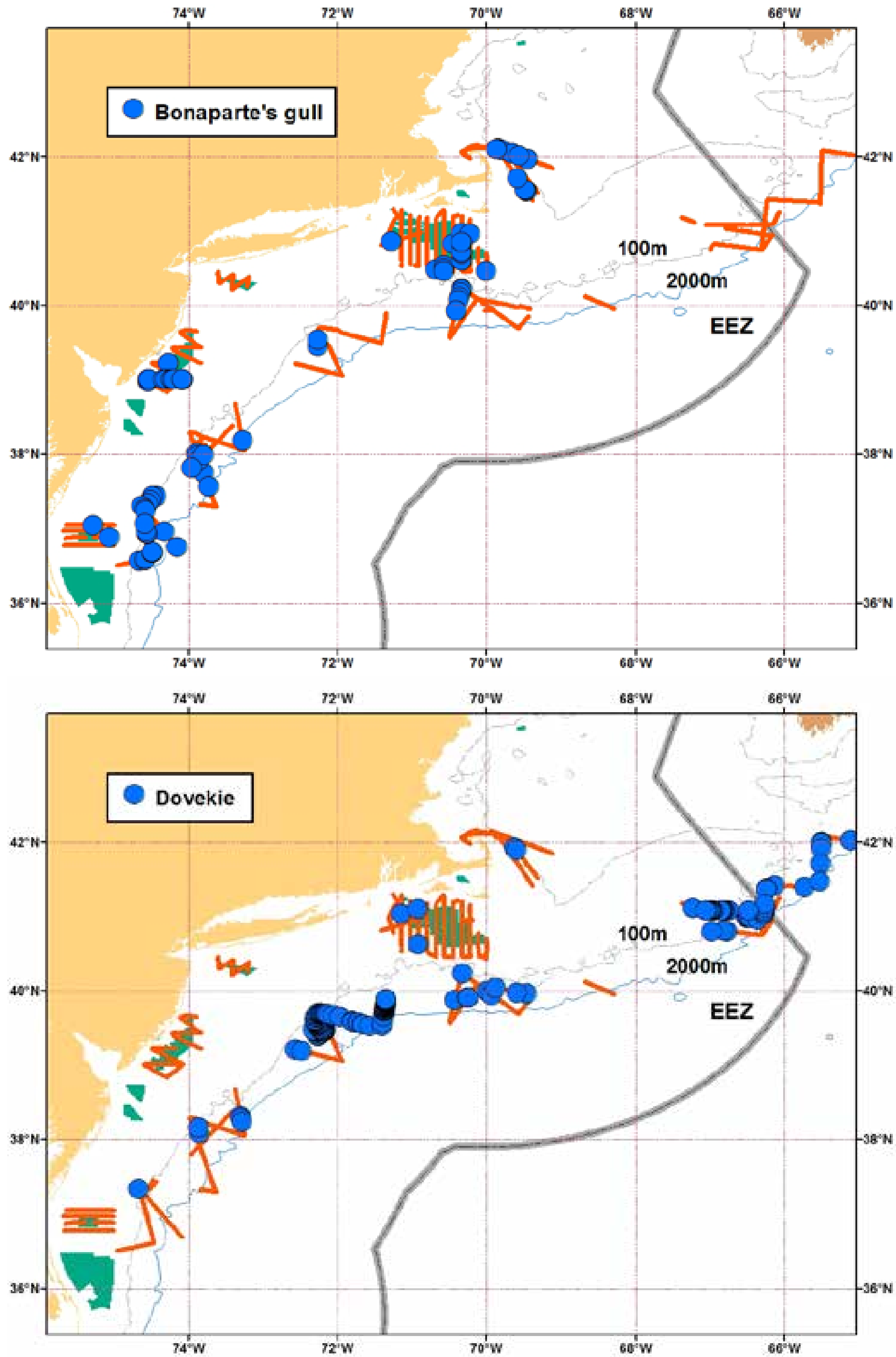
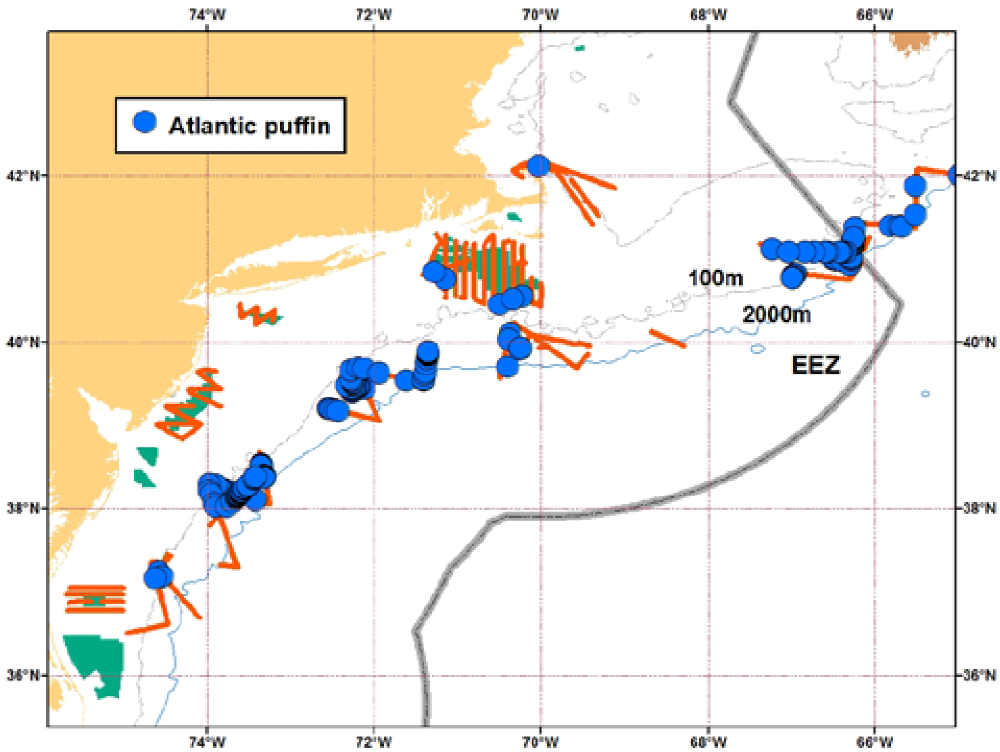


Figure C16. Location of Atlantic puffin (*Fratercula arctica*; top), and Red phalarope (*Phalaropus fulicarius*; bottom) sightings detected by the seabird team.



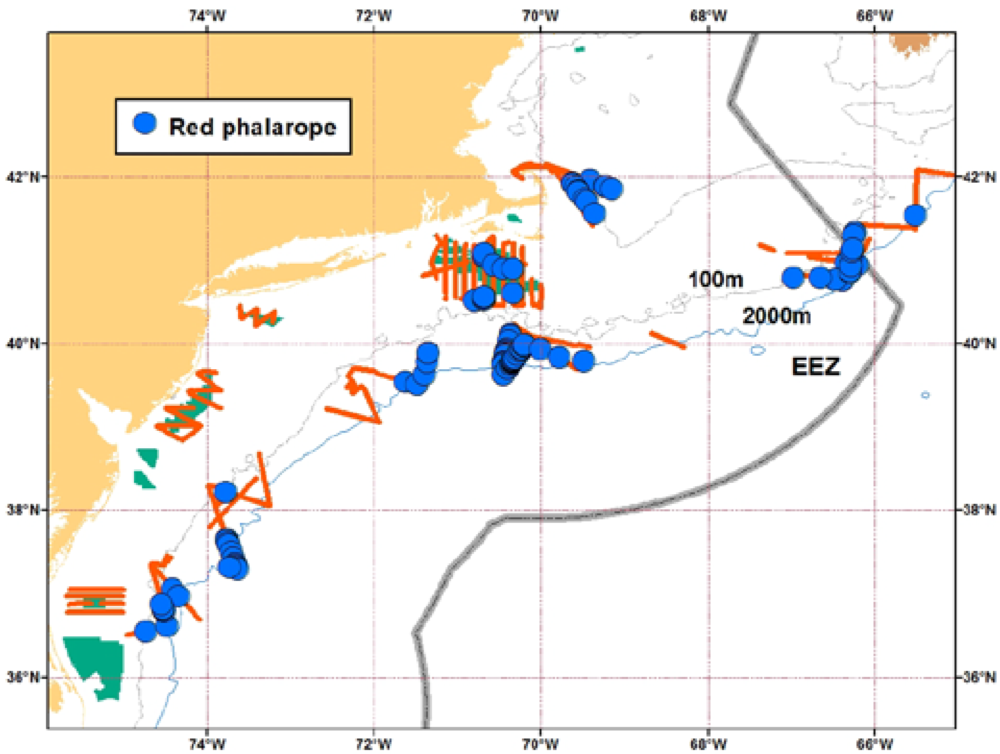


Figure C17. Location of various petrel and storm-petrel sightings (top) and shearwaters (bottom) detected by the seabird team.

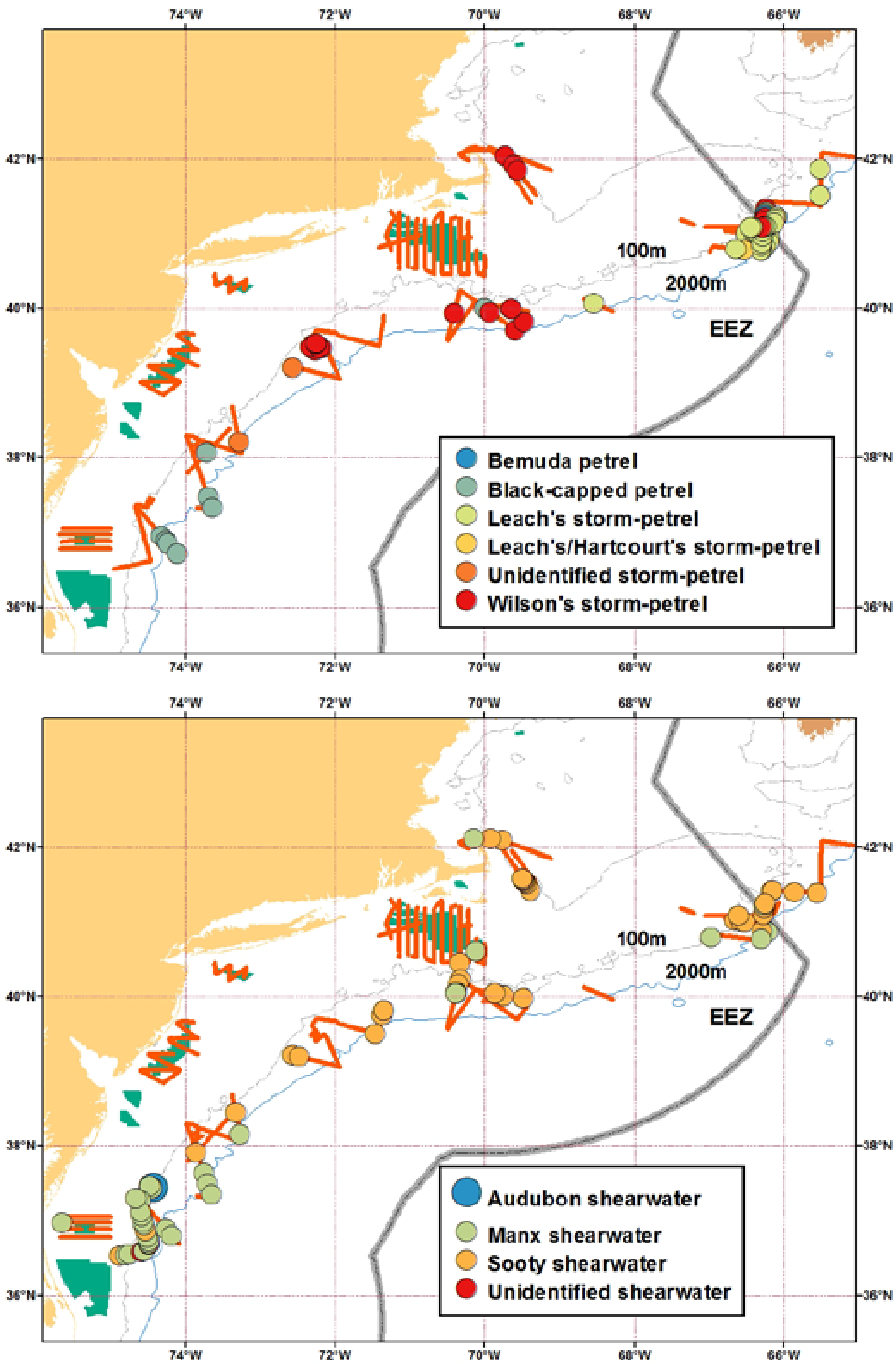


Figure C18. Location of petrel and jaeger sightings (top), and various shore bird (bottom) sightings detected by the seabird team.

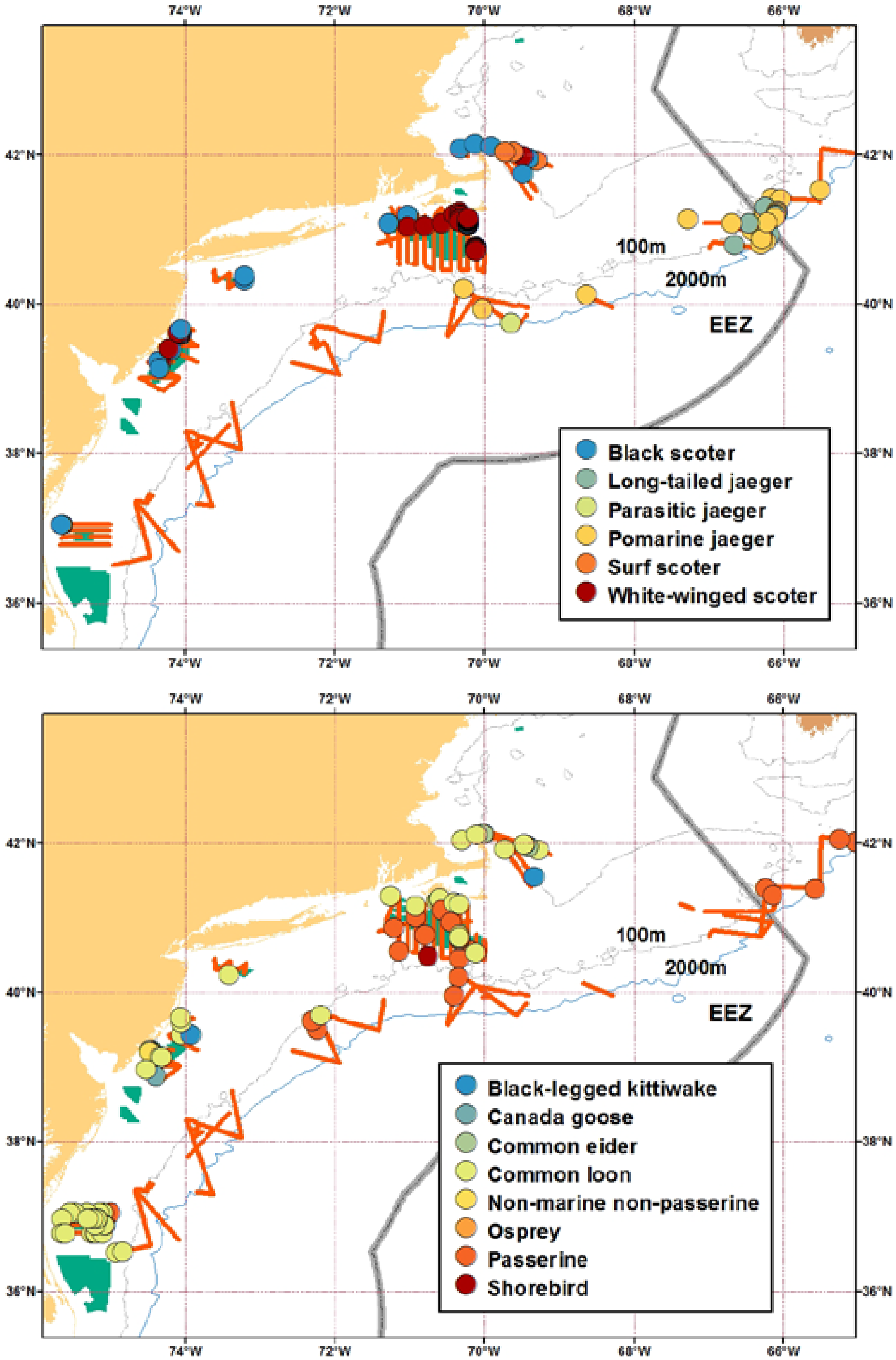


Figure C19. Acoustic recording effort. Pink lines indicate trackline coverage when the hydrophone array was deployed and acoustic data were collected. Green lines indicate tracklines where the hydrophone array was not deployed due to the shallow water depth.

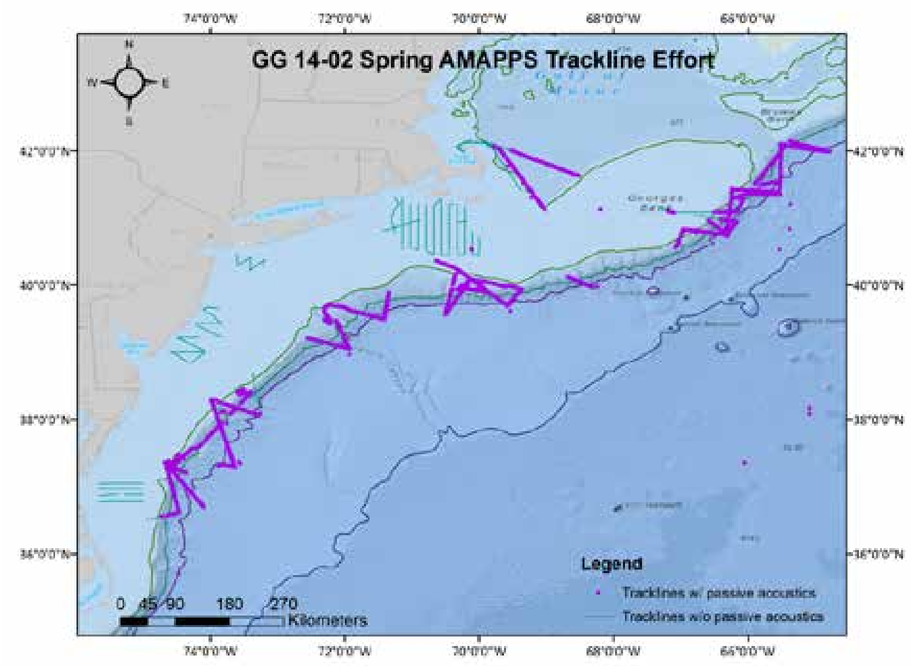


Figure C20. Acoustic detection of sperm whales. Pink lines indicated recording effort; green squares indicate the locations of sperm whales that were acoustically detected in real-time.

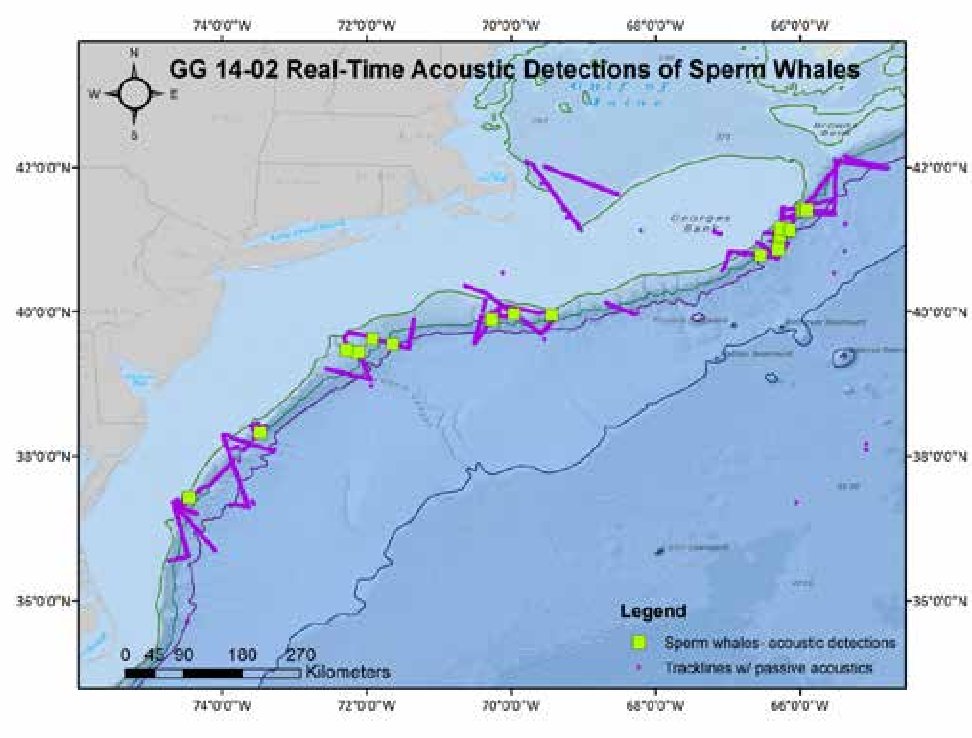


Figure C21. Overall view of the locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac's-Kidd mid-water trawls (IKMT), and the MOCNESS.

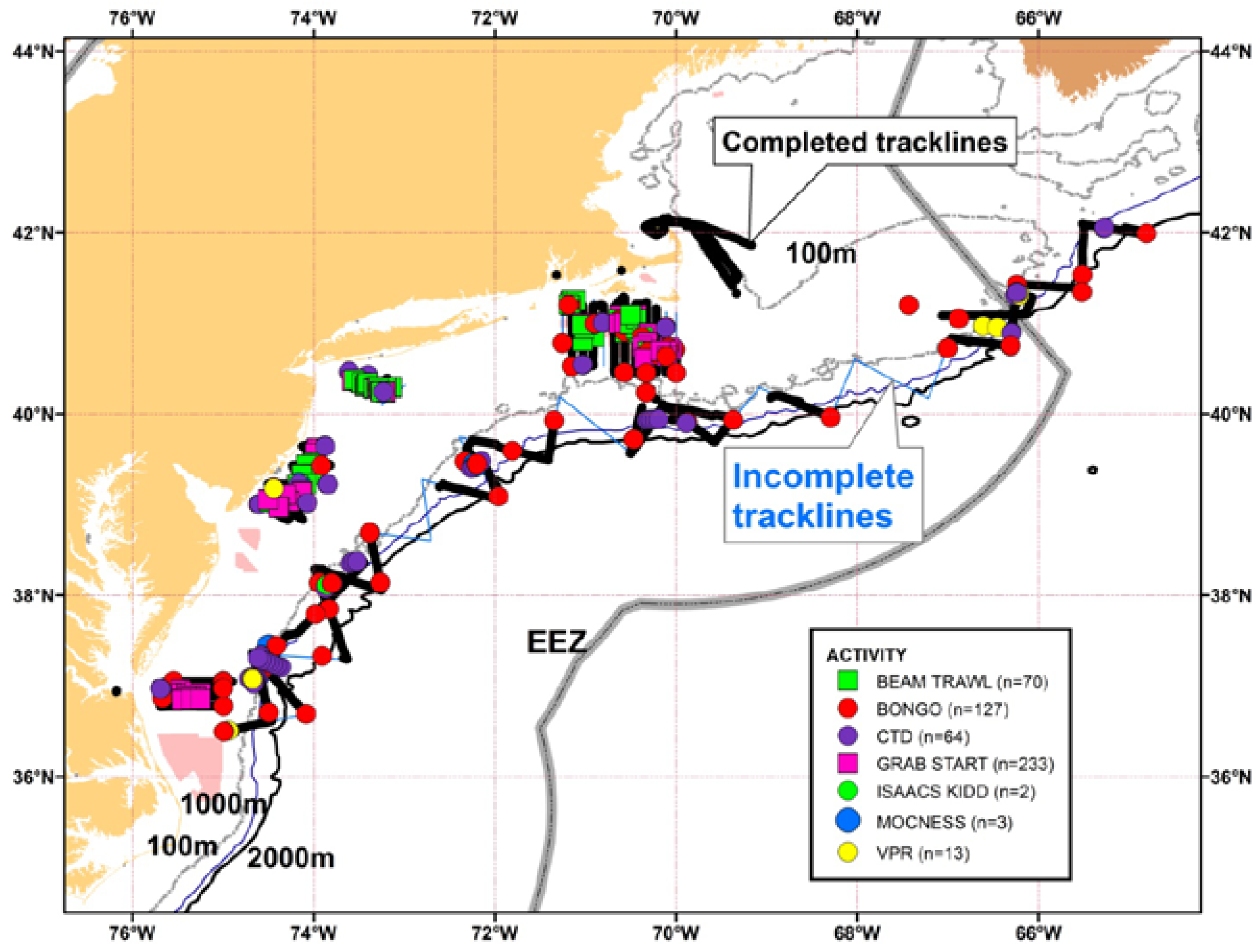


Figure C22. Oceanography from the VPR cross break transect from the southern flank of Georges Bank.

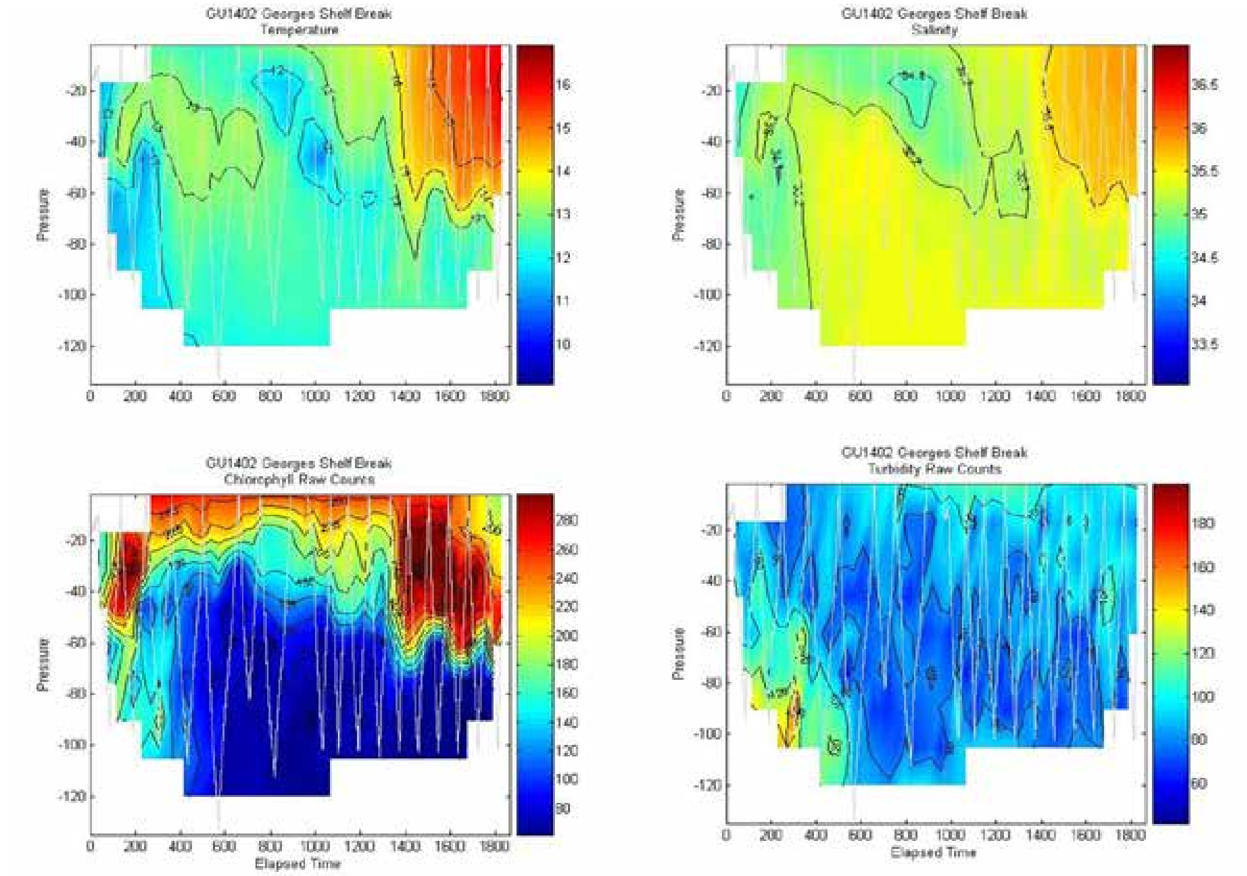


Figure C23. VPR marine snow images from Hudson Canyon with a background of centric diatoms (A) and marine snow from the Mid Atlantic bight with a background of chain diatoms (B). This phytoplankton was not enumerated by the VPR image processing software but was indicated in the chlorophyll values.

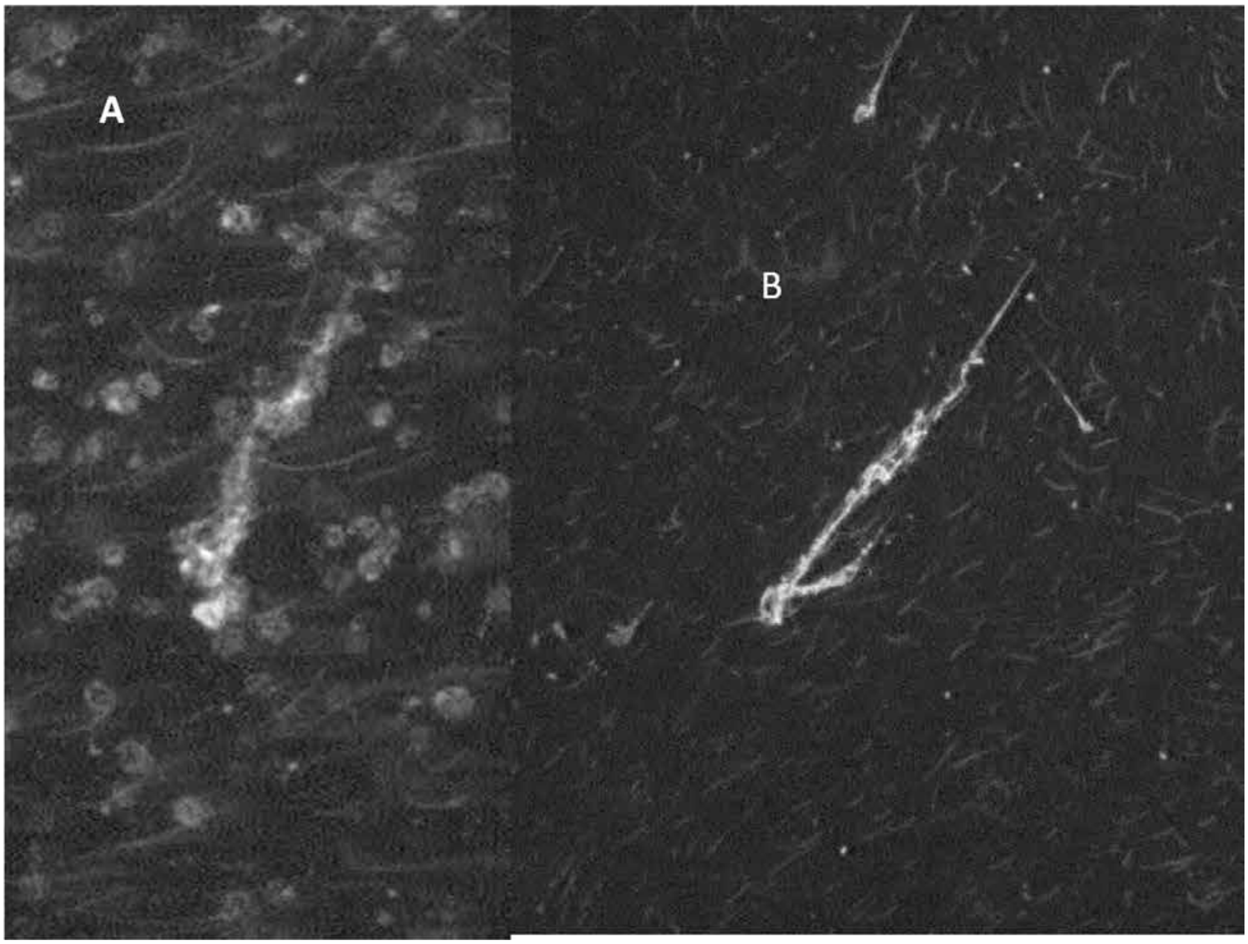


Figure C24. Marine snow from the Georges Bank shelf break transect (A) showing a gravid copepoda (B) and Corsair Canyon showing both marine snow (D) and marine snow combined with larvacean feeding nets (C).

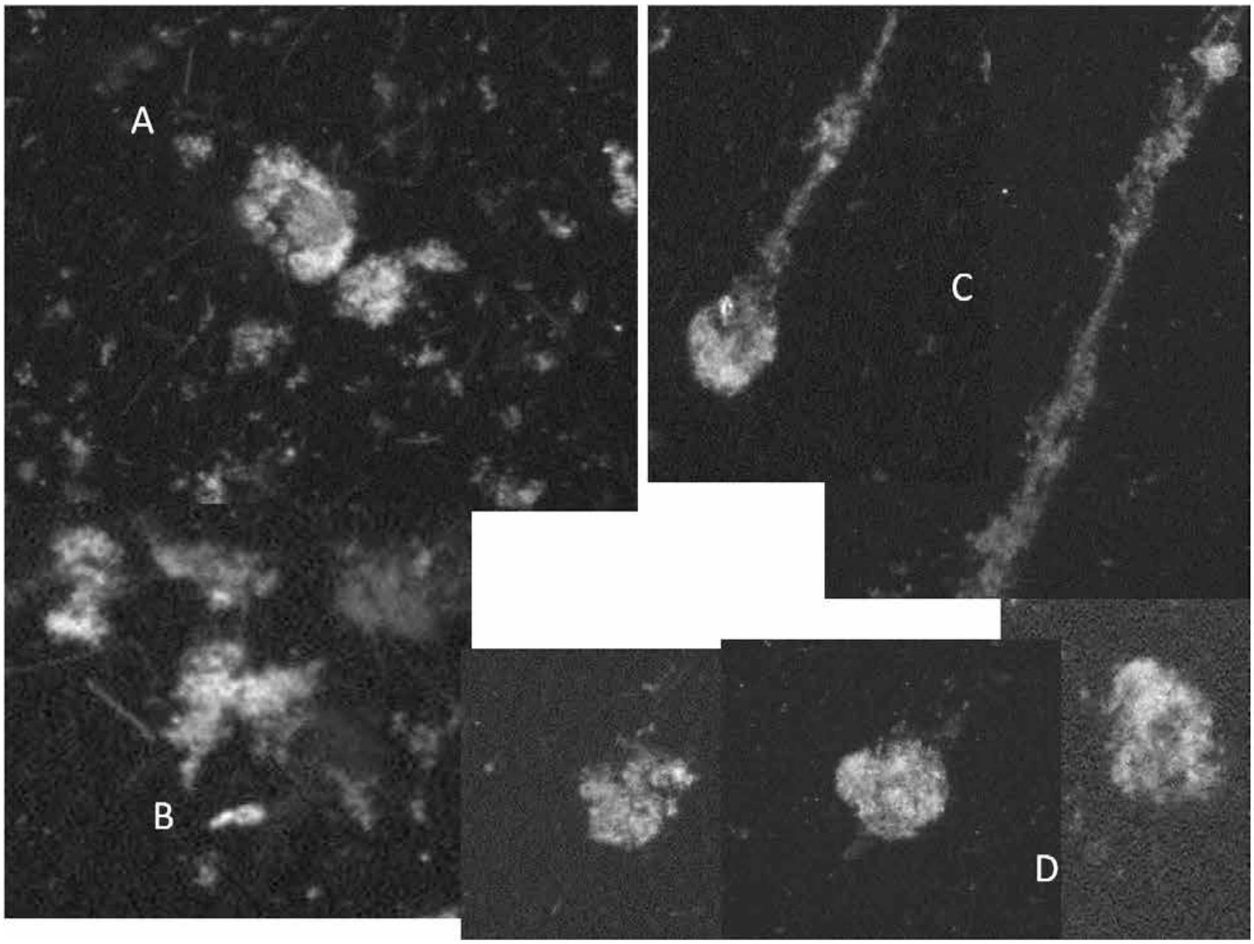


Figure C25. Transect from Corsair Canyon starting with a transect across the mouth of the canyon from SW to NE and continuing to a mid canyon transect from NE to SW.

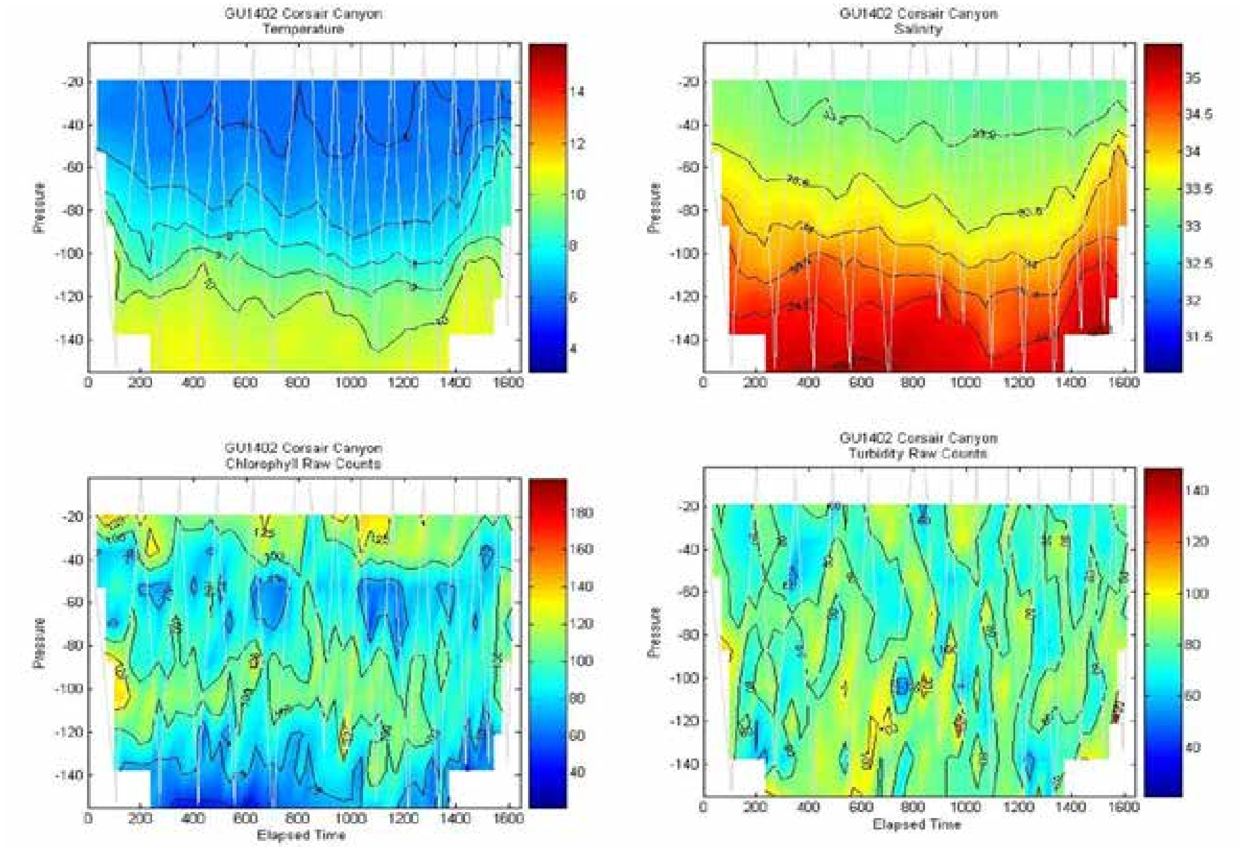


Figure C26. Locations of the completed BOEM WEA benthic stations.

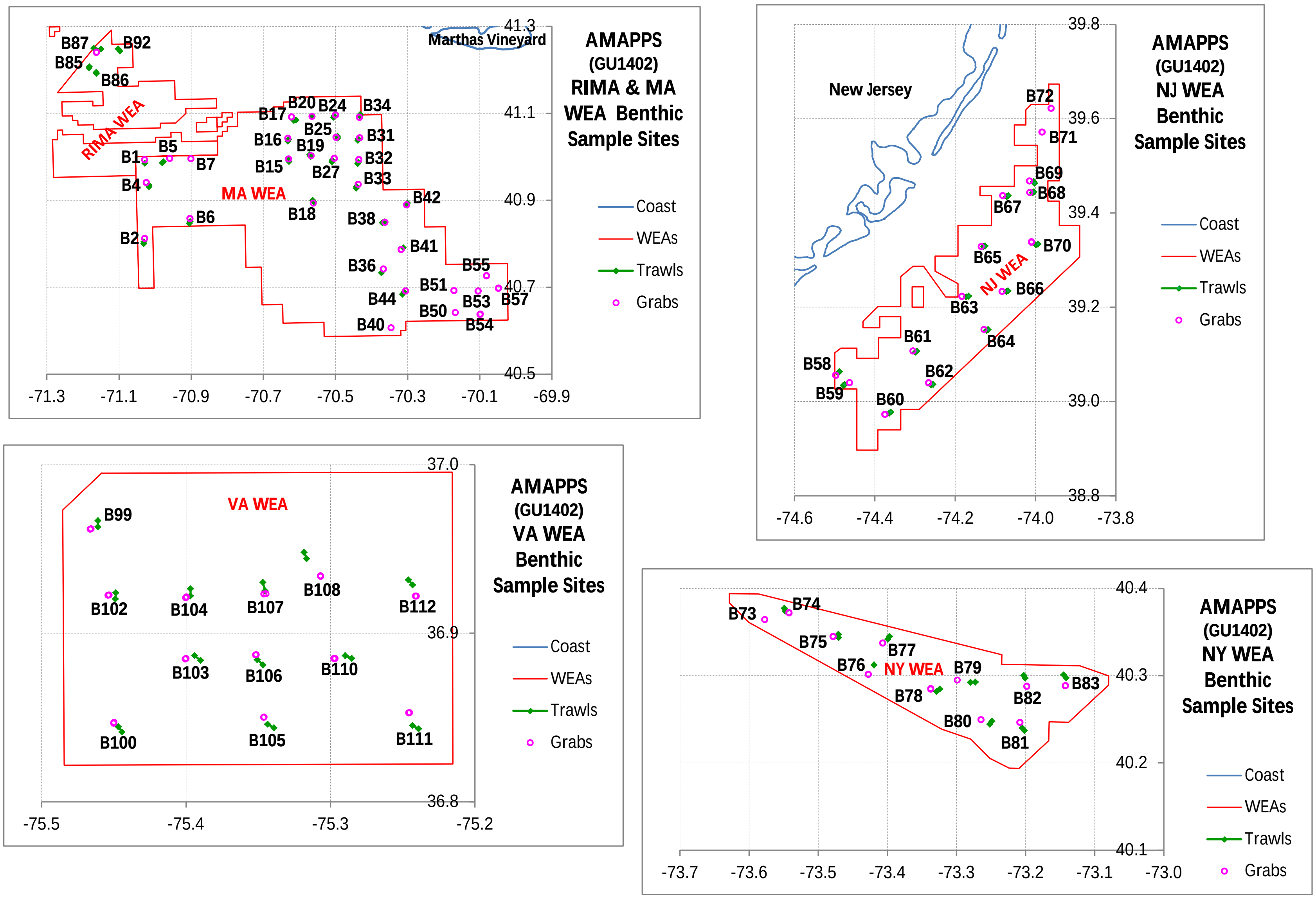
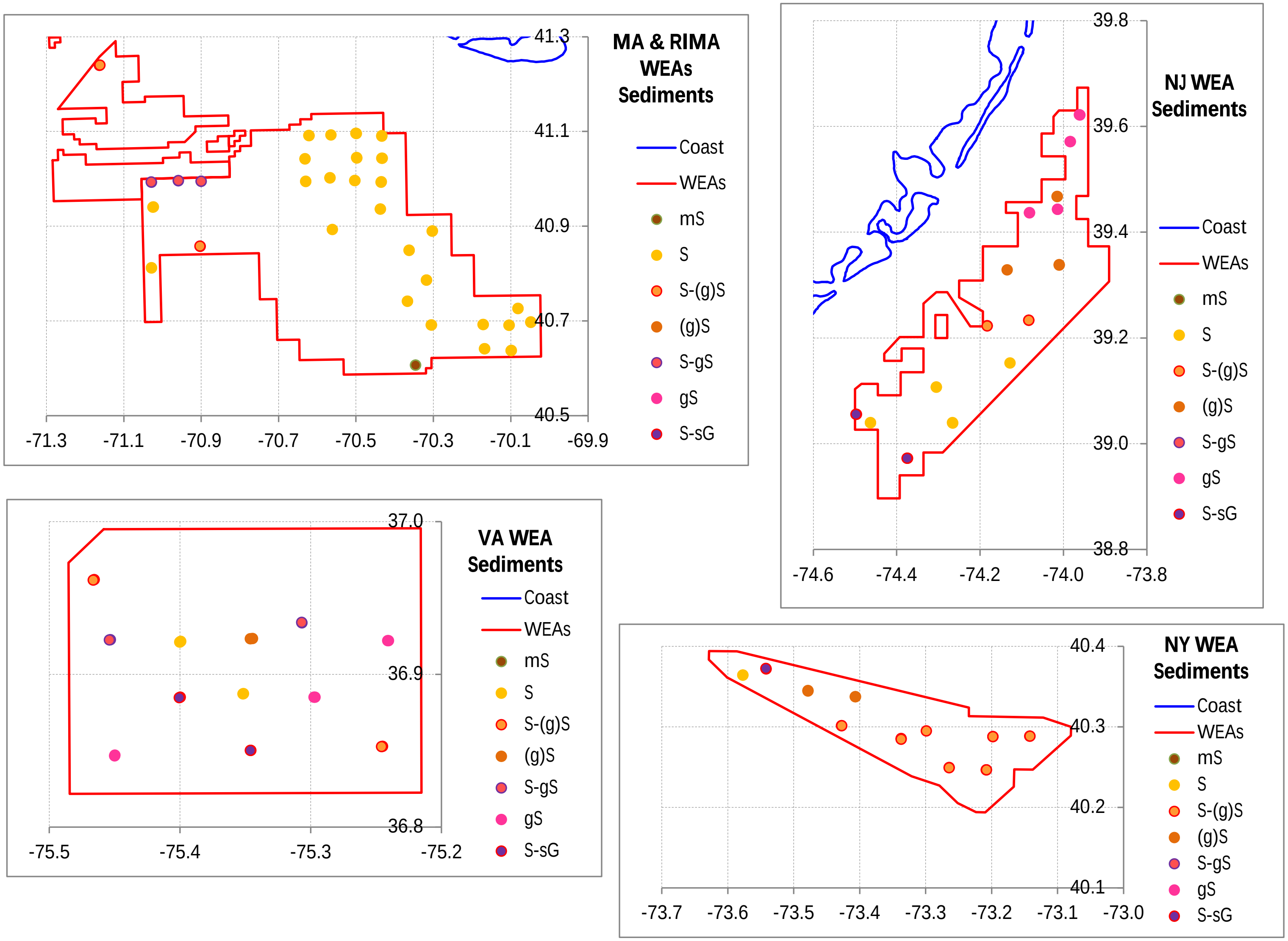


Figure C27. Sediment Grain Size Classification Summary. Folk classes: mS – muddy sand (5-30% mud); S – sand; (g)S – slightly gravelly sand (0.01 – 5% gravel); gS – gravelly sand (5-30% gravel); sG – sandy gravel (30-80% gravel).



Appendix D. *Shipboard summer beaked whale survey: Northeast Fisheries Science Center*

Debra L. Palka[1], Danielle Cholewiak[2], Elisabeth Broughton[1], Michael Jech[1], Michael Force[2], Michael Lowe[3], Gareth Lawson[3], Tamara Holzwarth-Davis[1]

[1]Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2]Integrated Statistics, Inc., 16 Sumner St., Woods Hole, MA 02543
[3]Woods Hole Oceanographic Institution, Woods Hole, MA 02543

SUMMARY

During 25 – 30 July 2014, the Northeast Fisheries Science Center (NEFSC) conducted a shipboard survey on the *NOAA ship Henry B. Bigelow* to document the relationship between the distribution and abundance of cetaceans, sea turtles and sea birds within the study area relative to their physical and biological environment, focusing primarily on beaked whale species. The survey designation was HB1403. The study area included waters along the shelf break southeast of Cape Cod, near the New England Seamount chain. Track lines were surveyed at about 10 kts (18.5 km/hr), using the two-independent visual team methodology to collect cetacean and turtle data, while the one-team strip transect methodology was used to collect sea bird data. At the same time, a towed hydrophone array was used to detect and record vocal cetaceans. In addition, physical and biological oceanographic data were collected using a bongo net, Isaacs-Kidd midwater trawl (IKMT), additional small midwater trawl, conductivity, temperature, and depth profilers (CTDs), and multi-frequency echosounders (EK60). During over 800 km of surveyed track lines, there were 43 hours of passive acoustic recordings, and the visual observers detected over 1800 cetaceans and 800 birds and tracked six groups of Sowerby's beaked whales (*Mesoplodon bidens*), where the longest track was about 23 minutes. To document the physical and biological habitat, 11 bongo nets+CTD, 3 rosettes+CTD, 1 water only CTD, 1 IKMT and 3 midwater trawls were deployed, in addition to continuously recording data from various ship sensors and the EK60.

OBJECTIVES

The overall goal of the survey was to document the relationship between the distribution and abundance of cetaceans, sea turtles and sea birds within the study area relative to their physical and biological environment. This study focused primarily on beaked whale species, with the following objectives:

1) Develop a better understanding of beaked whale habitat use and dive time patterns,
2) Quantify efficacy of passive acoustic monitoring for detection and abundance of these species, through controlled methodological tests and in comparison to a bottom-mounted recorders (AMAR),
3) Determine the distribution and relative abundance of plankton and prey species,
4) When possible, collect identification photographs and biopsy samples.

CRUISE PERIOD AND AREA

This cruise is designated as HB1403. The cruise period was originally scheduled for 17 days, from 8 – 24 July 2014. However, due to the lack of engineering staff, the cruise was delayed several times and the dates were shifted. Ultimately, the cruise departed Newport, RI early in the morning of 25 July 2014 and returned to port on 30 July 2014 at sunrise, resulting in five survey days (25 – 29 July 2014).

The primary study area included waters along the shelf break southeast of Cape Cod, MA from about 39° 30'N – 41°30'N latitude and 66°40' – 68°00' W longitude (Figure D1). This region included waters less than depths of 4000 m and were within the US economic exclusive zone (EEZ). Additional surveying and data collection occurred between the primary study area and the Newport, RI dock (Figure D1).

METHODS

Scientists involved in this survey are detailed in Table D1. Because the cruise was not able to be conducted until after the originally scheduled time period, two scientists who were originally scheduled to participate were unable to participate in the survey, while only one other person was able to be found to fill in for these two people.

VISUAL MARINE MAMMAL- TURTLE SIGHTING TEAM

Line transect survey

A line transect survey was conducted during daylight hours (approximately 0600 – 1800 with a one hour break at lunchtime) using the two independent team procedure. Ideally surveying would be conducted during good weather conditions (Beaufort five and below) while traveling at about 10 knots, as measured over the ground. However, some surveying was attempted in worst weather conditions.

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). Because the cruise was not able to be conducted until after the originally scheduled time period, these teams were understaffed by one person, and thus the methods to collect the visual data had to be modified. To detect animal groups, both teams were originally designed to be 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 and be rotated into the on-effort positions. However, due to the loss of the observer, the lower team was actually composed of one on-effort observer using 25x150 powered binoculars and a recorder, while the upper team was composed as originally planned. Every 30 min observers rotated between all positions on both teams.

At times when it was not possible to positively identify a species or when training the observers on species identifications and the group was within 3 nmi of the track line, 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).

The upper team searched waters from 90˚ starboard to 90˚ port, where 0˚ is the track line that the ship was traveling on. Because there was only one observer searching with binoculars on the lower team, that observer searched from 90˚ on the side the observer was on, through the track line, then to 10˚ on the opposite side. Recorders on both teams search with naked eye from 90˚ starboard to 90˚ port, when not recording data. Sightings and visual team effort data were entered by the scientists onto hand held data entry computerized systems called VisSurv-NE (version 4) which was initially developed by L. Garrison and customized by D. Palka. For either team, when an animal group (porpoise, dolphin, whale, seal, turtle or a few large fish species) was detected the following sightings 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 these factors changed (at least every 30 min 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).

Dive time patterns

As a pilot study, the teams attempted to record the dive patterns of groups of beaked whales. When it was decided to attempt this, survey mode was changed to "Focal animal", code 8 in the VisSurv-NE data entry program. Then observers and a recorder worked together to document the number of animals that were at the surface using the "Collect Surfacings" button in the

VisSurv-NE data entry program. The location (bearing and distance between the ship and group, in addition to the latitude and longitude of the ship) was recorded as an initial position. Then the size of the group at the surface was recorded (along with the time and ship's location) until the entire group dove, at which time the bearing and distance was recorded again. When at least one individual of the group resurfaced the surface group size composition was again recorded.

VISUAL SEABIRD SIGHTING TEAM

From an observation station on the flying bridge, about 15.1 m above the sea surface, one observer conducted a dedicated visual daylight survey for marine birds, approximately 0600 – 1800 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 and travelling over 6 kts. 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. There were two dedicated seabird observers, who rotated, generally, on a two hours on, two hours off schedule.

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 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 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 five 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 four people who operated the system in four-hour shifts. During each shift, one person was designated as the primary data collector and a second person was designated as stand-by, while the other two team members were off-effort. The passive acoustic team schedule was arranged so that data could be collected 24 h.

Although the goal for hydrophone array deployment was to collect data for 24 h, due to the abbreviated nature of the survey, array deployment only averaged approximately 12.4 hours per day from 26 – 28 July, and 6 hours on 29 July. The array was retrieved at night for prey sampling activities, which were conducted each of the four nights in the study area. Additionally, the array was retrieved from 11:30 am – 12:30 pm to allow for the deployment of a bongo/CTD cast, and then redeployed at about 12:30 pm.

The hydrophone array was comprised of two modular, oil-filled sections, separated by 30 m of cable. The end-array consisted of three APC International elements (model 42-1021), two Reson elements (model TC 4013), and a depth sensor (Keller America, PA7FLE). The in-line section of the array consisted of three APC International elements (model 42-1021). The array was towed 300 m behind the ship. Array depth usually 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 Analog/Digital conversion, filtering, and gain. Data were high-pass filtered at 1000 Hz, and variable gain between 20 – 40 dB was added depending on the relative levels of signal and noise. Any changes in gain settings were noted. The recording system incorporated two National Instruments soundcards (NI USB-6356). One soundcard sampled the six APC ("mid-frequency") channels at 192 kHz, the other sampled the two Reson ("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, a fixed, archival recorder (AMAR, Autonomous Multichannel Acoustic Recorder) was deployed on the shelf break to collect data for one year.

HYDROGRAPHIC AND PREY SAMPLING

Abiotic and biotic data were collected using ship's sensors. Data were collected nearly continuously using the ship's Simrad EK60 system, and at stations using bongos with an attached device collecting conductivity, temperature and depth (CTD) data, a rosette with an attached CTD, a 10-ft Iassac-Kidd midwater trawl (IKMT), and a small pelagic midwater trawl.

Bongos with attached CTDs were deployed several times a day. 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 original goal was to sample 6 sites in total over the course of the survey; 3 where beaked whales had been seen, and 3 where they were not. However, due to the shortening of the survey this was not achieved.

Continuous Operations

Position, date, time, ship's speed and course, water depth, surface temperature, salinity, chlorophyll, and weather characteristics, along with other variables (Table D2) were obtained from the ship's sensors and logged into the Science Computer System (SCS). These data were routinely collected and recorded every second.

Active Acoustic Sampling with the Simrad EK60

Active acoustic data were collected nearly continuously during the survey to characterize spatial distributions of potential prey and investigate relationships among predator (marine mammals), prey, and oceanography. These data were collected with the ship’s multifrequency (18, 38, 70, 120, and 200 kHz) Simrad scientific EK60 echo sounders and split-beam transducers mounted downward-looking on the retractable keel in either active or passive mode.

On the first day of the survey the EK60s were calibrated using the standard target method at the Newport Naval Anchorage. A 38.1-mm tungsten carbide with 6% cobalt binder sphere was suspended at about 20 m range from the transducers and was used to calibrate all frequencies. A wireless calibration system, consisting of three remotely controlled downriggers, and automated software were used to initially position the target under the split-beam transducers and the software automatically moved the sphere throughout the acoustic beams. The data were collected and then the Simrad Lobe program was used during data playback for each EK60 individually.

During the survey, data were collected to 3000 m regardless of bottom depth. The ping interval was set to 1 ping per second, which allowed the EK60s to ping as fast as they could. Taking into account the sample range of 3000 m and signal processing time, this resulted in the EK60s transmitting about once every 5 – 6 sec. 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.

In active mode, each frequency transmitted a 1-ms CW pulse. In passive mode the EK60s were in “receive mode” only. At daily intervals throughout the survey EK60 data were recorded in passive mode to assist with noise removal processing procedures. The ship was generally traveling at 10 kts or less when the acoustic data were being collected. EK60 data were collected continuously, except when beaked whales were encountered and on some parts of transects on 26 and 27 July, at which time the EK60 was in passive mode.

During the survey the EK60 data were processed daily by removing the echo from the seabed and any electronic, acoustic, or bubble noise. The data were stored on a portable hard drive and archived at the NEFSC and additionally will be sent to NOAA's National Geophysical Data Center for permanent archive.

Bongo deployments

A 61 cm bongo plankton net equipped with one 333 μm and one 505 μm mesh net with a Seacat 19+ 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 (about 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 43 m/min (1.5 kn). 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.

Rosette deployments

Several sampling stations on the shelf were standard fixed station locations from the ECOMON program. At these stations a 911 CTD with a 12 bottle Rosette was deployed for more detailed oceanographic data collection and for the collection of water samples. The CTD was deployed from the port side A-frame. Wire out/in during casts did not exceed 40 m/min and the winch stopped at various predetermined depths on the up-cast to collect water samples. Casts were made to a maximum of 500 m. Once back on deck, water samples were collected and preserved by the oceanography team while the ship was underway to the next station. A bongo/CTD cast using standard ECOMON protocols was conducted in conjunction with the CTD operations to collect complimentary plankton data. Bongo/CTD casts were to a maximum of 200 m.

Midwater trawl deployments

The 10-ft IKMT was deployed to target depth-specific layers that were observed at the lower frequencies of the EK60 and so were consistent with mesopelagic fish and euphausiids. The 10-ft IKMT was deployed off the stern using the ships stern A-frame and the oceanographic winch. The net was fished to a maximum of 500 m. Acoustic net sensors were attached to the net’s tow bar to monitor the depth of the net in realtime. To maximize the sampling depth in relation to tow duration, the IKMT was first lowered below its target depth with the ship maintaining minimal speed without sacrificing steerage. Then the ship increased speed to 2 – 3 kts (speed over the ground, SOG) when the net reached maximum tow depth. As the IKMT rose through the water with the increased SOG, the IKMT trawl depth was maintained in the target depth-specific layer by adjusting the amount of wire out. After the target layer was sampled, the net was retrieved as fast as safely possible. Upon retrieval, samples were rinsed from the nets using seawater and preserved in 5% formaldehyde and seawater. Samples were transported to the NMFS lab at Narragansett, RI for future processing.

In addition to the 10-ft IKMT an additional pelagic midwater trawl was used to collect biological samples and verify species composition of acoustic backscatter. The midwater trawl was designed to be fished obliquely at speeds of about 3 kts to a maximum depth of about 600 m. The duration and depth of the trawls were not standardized, thus it was incumbent upon the Chief Scientist and Watch Chief to communicate with the bridge officers the haul duration and depths.

The pelagic midwater trawl was monitored using the FS70 and Scanmar systems. The Simrad FS70 trawl monitoring system is required for pelagic trawling. It is a third-wire device that provides real-time trawl performance information through its sonar images of the trawl opening. The Scanmar wireless trawl sensors provided point measurements of the trawl depth, and horizontal and vertical opening. The scientific party recorded measurements at specified intervals during each deployment.

Bridge officers recorded the time, date, navigational, and station data in the Fisheries Science Computer System (FSCS). The scientists recorded the catch data for each station deployment using the FSCS on-board entry system.

RESULTS

VISUAL MARINE MAMMAL- TURTLE SIGHTING TEAM

The visual marine mammal and turtle team surveyed about 740 km while on effort during the five possible sea-days (Table D3). During the good weather conditions that occurred during about 3.5 days, line transect and dive time monitoring was conducted resulting in about 544 km of track line. During the poor weather conditions within the remaining 1.5 days for about 197 km of track line, one on-effort observer surveyed for marine mammals and sea turtles from the inside the bridge. This on-effort observer rotated every 30 minutes.

During the on-effort track lines, 16 cetacean species or species groups, 1 turtle species, and 4 fish species or species groups were recorded (Table D4). For cetaceans, the upper team detected 166 groups (1,839 individuals) and the lower team detected 95 groups (922 individuals). Note some, but not all, groups of cetaceans detected by one team were also detected by the other team. The upper and lower teams both detected one individual leatherback turtle and no seals. In addition, 4 (4) basking sharks (*Cetorhinus maximus*) and 3 (1) ocean sunfish (*Mola mola*) was detected by the upper (and lower) teams.

Distribution maps of sighting locations of the cetaceans, turtles, seals and fish are displayed in Figures D2 – D6. Note these are locations of sightings seen by only the upper team. The most abundant dolphin species was the common dolphin (*Delphinus delphis*). The most commonly detected large whales included the sperm whale (*Physeter macrocephalus*) and fin whale (*Balaenoptera physalus*).

On 26 – 27 July 2014, as part of the pilot study, six groups of Sowerby's beaked whales (*Mesoplodon bidens*) were followed to attempt to record dive patterns (Table D5). It took a couple tries to work out a system between an observer searching through big eyes and a recorder using a new aspect of the data entry program, but it was eventually possible to record the number of animals that were at the surface as the group moved about. One group was followed for about 23 minutes. So it is concluded that it is possible to use this method to record dive patterns, but the hardest part is when the group has a long dive and there are many groups of whales of the same species in the vicinity.

VISUAL SEABIRD SIGHTING TEAM

Seabird survey effort was conducted on all five survey days, resulting in 756 km of on-effort surveying. Like the visual sighting team, some effort was conducted from the bridge when the Beaufort sea state was high.

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 2013. About 802 birds, within 335 groups, were seen while on-effort (Table D6; Figures D7 – D9). This survey recorded 15 species of birds and 4 unidentified species groups (e.g., unidentified shearwater or unidentified storm-petrel). About 90% of the individuals detected belonged to one of five species or species groups: Wilson's Storm-Petrels (*Oceanites oceanicus*), Cory's Shearwaters (*Calonectris diomedea*), Audubon's Shearwaters (*Puffinus lherminieri*), unidentified storm-petrels, and Great Shearwaters (*Puffinus gravis*).

In addition to these common species, several rarer, warm water offshore species were detected. For example, White-faced Storm-Petrels (*Pelagodroma marina*) are considered to be rare summer visitors in these waters, but they were seen almost daily over deep water seaward of the shelf break. Two Trinidade Petrels (*Pterodroma arminjoniana*) were detected. These sightings are considered the first live sighting of this species in New England waters (one washed up dead on a Maine beach this spring) and constitute the first documented occurrence in Massachusetts. Other noteworthy warm-water species included 9 Black-capped Petrels (*Pterodroma hasitata*) and 16 groups (25 individuals) of Band-rumped Storm-Petrels (*Oceanodroma castro*).

PASSIVE ACOUSTIC DETECTION TEAM

Over the course of the survey, the towed hydrophone array was deployed on all five survey days when the ship was in waters deeper than 100 m, totaling over 800 km of acoustic effort for approximately 43 h of recording. On the transit out to the study area on 25 July 2014, the array was not deployed until reaching the shelf break at approximately 2200 h ET, so only two hours of data were collected on this day. The array was not deployed on 30 July 2014, as the ship was back at the dock by sunrise.

Real-time monitoring during the survey resulted in the detection of 51 groups of vocally-active odontocetes, including four groups of beaked whales (Table D7; Figure D10). Sperm whales were detected on 4 out of the 5 survey days; they were not detected the day when the ship transited out to the study area.

The AMAR was deployed on 26 July 2014 at approximately 40º 5'N 68ºW near Lydonia Canyon, at a depth of approximately 800 m.

Passive acoustic data were post-processed to identify all putative beaked whale events. The acoustic software Pamguard was used to run an automated click detector, which identified odontocete echolocations clicks, as well as noise. Clicks were manually reviewed to identify encounters with beaked whales, based on temporal and spectral criteria, including inspection of the time series, Wigner plot, and spectral density plot. Acoustic encounters were divided into three main categories: definite beaked whale (over 10 clicks, at least 5 of which have upsweeps); probable beaked whale (less than 10 clicks, 3 – 4 of which have upsweeps), and possible beaked whale (less than 5 clicks, with at least 1 upsweep). Twenty-nine encounters were identified in those categories: 9 definite, 5 probable, and 15 possible (Table D8; Figure D10).

Additional processing of passive acoustic data will be conducted to identify and localize all sperm whale events.

HYDROGRAPHIC/BONGO/PLANKTON SAMPLES

The EK60 multifrequency backscatter data were collected continuously in either active or passive mode. Two types of midwater trawls were deployed 4 times, a bongo net with an attached CTD was deployed 11 times, a rosette with attached CTD was deployed 3 times and a CTD alone was deployed 1 time (Table D9). More details are provided below.

EK60 Data

Multifrequency (18, 38, 70, 120, and 200 kHz) Simrad EK60 data were collected continuously throughout the cruise, in either active or passive mode. For more details on the EK60 data from this and other surveys, please refer to Appendix I, in particular Figures I10A – I10B. Unlike other AMAPPS surveys, a trained EK60 expert was on the survey, so the EK60 data were processed daily while on the ship by removing the echo from the seabed and any electronic, acoustic, or bubble noise. The data were then stored on a portable hard drive and archived at the NEFSC and additionally will be sent to NOAA's National Geophysical Data Center for permanent archive.

The echograms from the EK60 data typically showed a scattering layer between 500 and 600 m depth and a layer in the top 200 m. A portion of the shallower layer migrated diurnally into the top 50 – 100 m (Figures I11 – I12 in Appendix I). These layers were sampled with a pelagic midwater trawl and an IKMT trawl.

Trawl Data

A midwater trawl was deployed four times during the cruise. Two tows were set to sample the acoustic scattering layer at 500 – 600 m, and two tows sampled the shallow layer in the top 50-100 m. The shallow tows were dominated by myctophids such as *Benthosema* and *Diaphus* species. The deep tows captured shortfin squid (*Illex illecebrosus*), other cephalopod species, and a number of mesopelagic fish species, such as slender snipe eels (*Nemichthys scolopaceus*), ridgehead species (Melamphaidae), and viperfish species (*Chauliodus*).

After the Sowerby's beaked whales were tracked to document dive patterns, the 10-ft IKMT was deployed at night in the same vicinity as the sightings to the acoustic scattering layer at about 500 m. Some of the samples in this tow included species that were found in stomachs of Sowerby's beaked whales taken in the drift net fishery along the shelf break east of Georges Bank (Table I2 in Appendix I).

Bongo/Rosette/CTD data

During 25 – 30 July 2014 a CTD was deployed 15 times (Figure D11). Of these, 11 were Seabird Electronics SBE Model 19+ profiling CTDs deployed with a bongo net to collect plankton; 3 were a Seabird Electronics SBE Model 911 CTD deployed with a 12 Niskin bottle rosette to collect water samples; and 1 was the Model 19+ profiling CTD deployed with a Niskin bottle to collect a water sample. A dissolved oxygen sensor was attached to both instruments and the data were corrected. The SBE911 also had a WetLabs ECO-AFL/FL fluorometer installed, whose data have not been calibrated but are included in the data archives.

DISPOSITION OF DATA

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

All hydrographic data collected are 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 are 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 active acoustic data are archived and maintained by the Data Management Services (DMS) branch at the NEFSC. In addition, all EK60 data are archived and maintained at NOAA's NGDC in Boulder, CO.

PERMITS

NEFSC was authorized to conduct the marine mammal related research activities during this survey under US Permit No. 17355 issued to the NEFSC by the NMFS Office of Protected Resources.

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Staff time was also provided by the Woods Hole Oceanographic Institution and the NOAA Fisheries Service, Northeast Fisheries Science Center (NEFSC), Protected Species Branch, Oceanography Branch, and Behavioral Ecology Branch.

Table D1. Scientific personnel involved in the HB1403 survey. FN = Foreign National. * = Scientists who arrived for the survey but ultimately did not sail due to delays in the ship schedule.

Personnel	Title	Organization
Danielle Cholewiak	Chief Scientist	Integrated Statistics, Woods Hole, MA
Jessica Aschettino	Visual observer	Integrated Statistics, Woods Hole, MA
Elisabeth Broughton	Oceanographer	NMFS, NEFSC, Woods Hole, MA
Shannon Coates	Passive acoustics	Integrated Statistics, Woods Hole, MA
Peter Duley	Visual observer	NMFS, NEFSC, Woods Hole, MA
Michael Force (FN)	Seabird observer	Integrated Statistics, Woods Hole, MA
Rachel Hardee	Visual observer	Integrated Statistics, Woods Hole, MA
Samara Haver	Passive acoustics	Integrated Statistics, Woods Hole, MA
Richard Holt	Visual observer	Integrated Statistics, Woods Hole, MA
Annamaria Izzi	Passive acoustics	Integrated Statistics, Woods Hole, MA
Michael Jech	Oceanographer	NMFS, NEFSC, Woods Hole, MA
Nicholas Metheny	Seabird observer	Integrated Statistics, Woods Hole, MA
Hilary Moors-Murphy (FN)*	Passive acoustics	Department of Fisheries & Oceans, Canada
Chris Orphanides*	Visual observer	NMFS, NEFSC, Narragansett, RI
Debra Palka	Visual observer	NMFS, NEFSC, Woods Hole, MA
Todd Pusser	Visual observer	Integrated Statistics, Woods Hole, MA
Joy Stanistreet	Passive acoustics	Integrated Statistics, Woods Hole, MA
Suzanne Yin	Visual observer	Integrated Statistics, Woods Hole, MA

Table D2. Science Computer System (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 D3. Distribution of effort (in km) conducted by the marine mammal-sea turtle visual team during various activities and Beaufort sea states while on the July 2014 survey (HB1403). Activities included standard line transect surveys (line-transect), collecting beaked whale dive patterns (dive time), and non-standard line transect surveys conducted by transiting during poor weather conditions (transiting).

	Beaufort sea state							
Activity	1	2	3	4	5	6	7	Total
Line-transect	1.4	223.3	207.6	71.5	12.9	2.6		519.2
Dive time	15.6	8.9						24.5
Transiting				3.9	32.9	104.7	55.2	196.7
Total	17.0	232.2	207.6	75.4	45.8	107.3	55.2	740.4

Table D4. Numbers of groups and individuals of cetaceans, sea turtles, and fish detected by the upper and lower visual teams during the July 2014 survey (HB1403).

		Number of groups		Number of individuals	
Species		lower	upper	lower	upper
Atlantic spotted dolphin	*Stenella frontalis*	2	1	17	35
Bottlenose dolphin spp.	*Tursiops truncatus*	3	9	30	145
Common dolphin	*Delphinus delphis*	12	26	310	683
Cuvier's beaked whale	*Ziphius cavirostris*	3	14	11	45
Fin whale	*Balaenoptera physalus*	13	17	21	30
Humpback whale	*Megaptera novaeangliae*		1		1
Minke whale	*B. acutorostrata*		1		1
Pilot whales spp.	*Globicephala spp.*	1	4	5	28
Risso's dolphin	*Grampus griseus*	9	18	56	120
Sowerby's beaked whale	*Mesoplodon bidens*	6	3	21	9
Sperm whale	*Physeter macrocephalus*	11	19	21	38
Striped dolphin	*Stenella coeruleoalba*	1	1	6	25
Stenella sp.	*Stenella*	7	9	177	209
Unid. Dolphin	*Delphinidae*	12	25	216	436
Unid. Whale	*Mysticeti*	7	8	11	12
Unid. Mesoplodon	*Mesoplodon spp.*	8	10	20	22
TOTAL CETACEANS		95	166	922	1839
Basking shark	*Cetorhinus maximus*		4		4
Ocean sunfish	*Mola mola*	1	3	1	4
Manta spp.	*Manta* spp.		2		2
Shark spp.		1	6	1	6
Leatherback turtle	*Dermochelys coriacea*	1	1	1	1
TOTAL ALL SPECIES		98	182	925	1856

Table D5. Summary of the groups of Sowerby's beaked whales (*Mesoplodon bidens*) that were followed to record dive time patterns.

Date	Initial latitude	Initial longitude	Group size	Time followed (min)
26-Jul-14	40.18688	-67.47079	2	0.38
26-Jul-14	40.19140	-67.46797	2	3.28
26-Jul-14	40.20063	-67.45946	4	2.80
26-Jul-14	40.21745	-67.46672	3	23.23
26-Jul-14	40.23660	-67.48537	3	2.20
27-Jul-14	40.32035	-67.30568	3	0.73

Table D6. Numbers of groups and individuals of birds detected by the seabird team during the July 2014 survey (HB1403).

Species		Number of groups	Total indivs	Relative abundance of individuals	Frequency of groups
Wilson's Storm-Petrel	*Oceanites oceanicus*	118	379	0.473	0.352
Cory's Shearwater	*Calonectris diomedea*	67	171	0.213	0.200
Audubon's Shearwater	*Puffinus lherminieri*	49	96	0.120	0.146
unidentified storm-petrel	*Oceanites/Oceanodroma*	2	37	0.046	0.006
Great Shearwater	*Puffinus gravis*	23	30	0.037	0.069
Band-Rumped Storm-Petrel	*Oceanodroma castro*	16	25	0.031	0.048
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	16	20	0.025	0.048
White-Faced Storm-Petrel	*Pelagodroma marina*	10	10	0.012	0.030
Black-capped Petrel	*Pterodroma hasitata*	9	9	0.011	0.027
Passerine	Passerine	8	8	0.010	0.024
Great Black-backed Gull	*Larus marinus*	4	4	0.005	0.012
Parasitic Jaeger	*Stercorarius parasiticus*	3	3	0.004	0.009
Herring Gull	*Larus argentatus*	2	2	0.002	0.006
Manx Shearwater	*Puffinus puffinus*	2	2	0.002	0.006
Trindade Petrel	*Pterodrama arminjoniana*	2	2	0.002	0.006
Barolo Shearwater	*Puffinus boroli*	1	1	0.001	0.003
South Polar Skua	*Stercorarius maccormicki*	1	1	0.001	0.003
unidentified murre	*Uria sp.*	1	1	0.001	0.003
unidentified shearwater	*Puffinus sp.*	1	1	0.001	0.003
Total		335	802	1	1

Table D7. Summary of acoustic events detected and/or localized in real-time during the survey. Dolphin groups were not definitively linked to visual sightings in real-time, therefore species assignments have not yet been made for the acoustic data. Note that in some cases, acoustic detections include multiple individuals (in the case of sperm whales) or multiple subgroups (in the case of delphinids), and therefore cannot be compared directly to the numbers of groups sighted visually.

Acoustic Species ID	# of Encounters		
	Not Localized	Localized	Total
Unidentified Dolphin	12	21	**33**
Sperm Whale	10	4	**14**
Probable Cuvier's beaked whale	-	2	**2**
Probable Mesoplodon beaked whale	-	2	**2**
Total	**22**	**29**	**51**

Table D8. Summary of beaked whale acoustic encounters identified through post-processing of towed array data. Most events represent individual animals, though in some cases acoustic detections may include multiple individuals.

	Localized	Not Localized	Total
Definite beaked whale	5	4	**9**
Probable beaked whale	3	2	**5**
Possible beaked whale	1	14	**15**
Total	**9**	**20**	**29**

Table D9. Summary of the number of oceanographic sampling stations.

Sampling type	Number of stations
CTD only	1
Rosette + CTD	3
Bongo + CTD	11
Iassac-Kidd midwater trawl	1
Pelagic midwater trawl	3
Total	19

Figure D1. Track lines (black) covered during 25 – 29 July 2014 on the NOAA ship *Henry B. Bigelow* (HB1403). The 200 m, 1000 m, 2000 m and 4000 m depth contours are also shown.

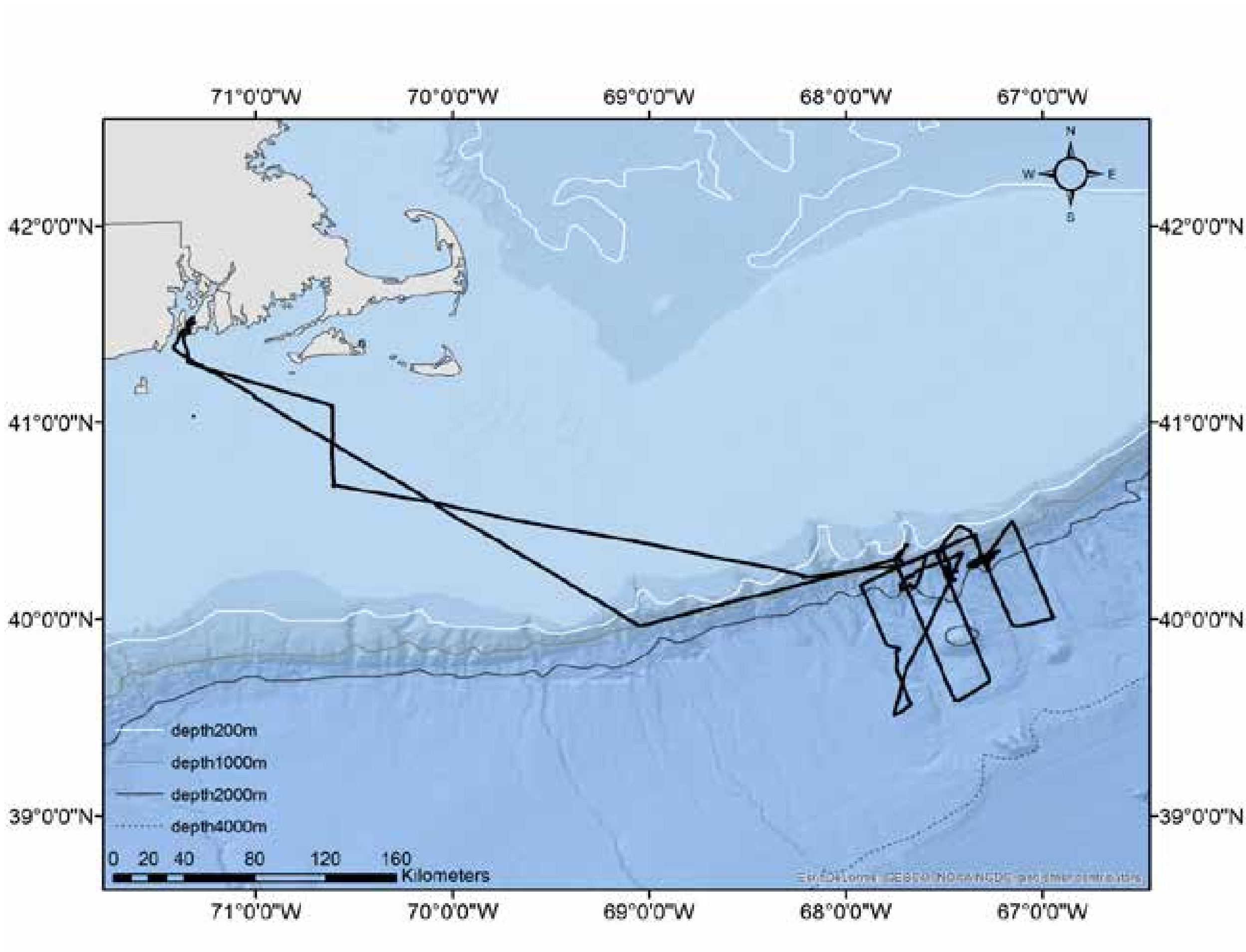


Figure D2. Locations of groups of common dolphins (*Delphinus delphis*) detected by the upper team during 25 – 29 July 2014 (HB1403).

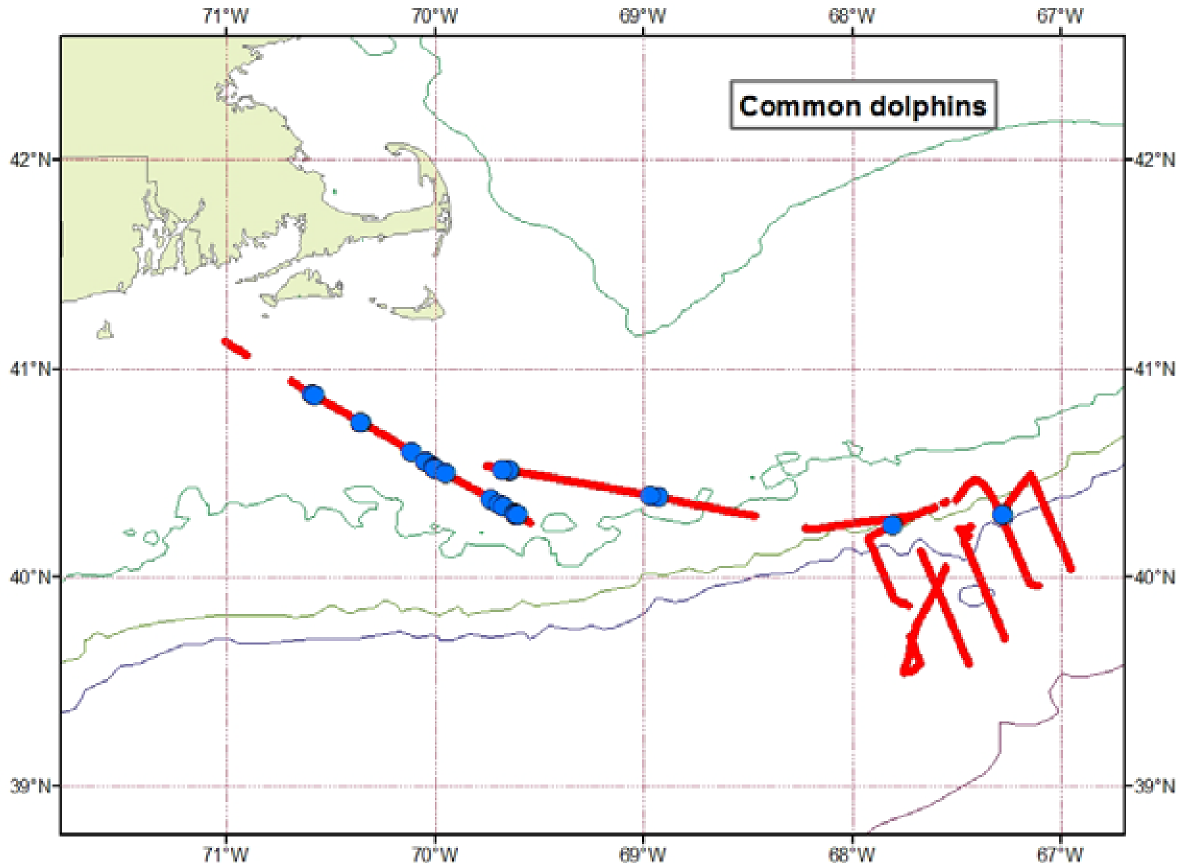


Figure D3. Locations of groups of common bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus*), striped dolphins (*Stenella coeruleoalba*), and Stenella spp. that were detected by the upper team during 25 – 29 July 2014 (HB1403).

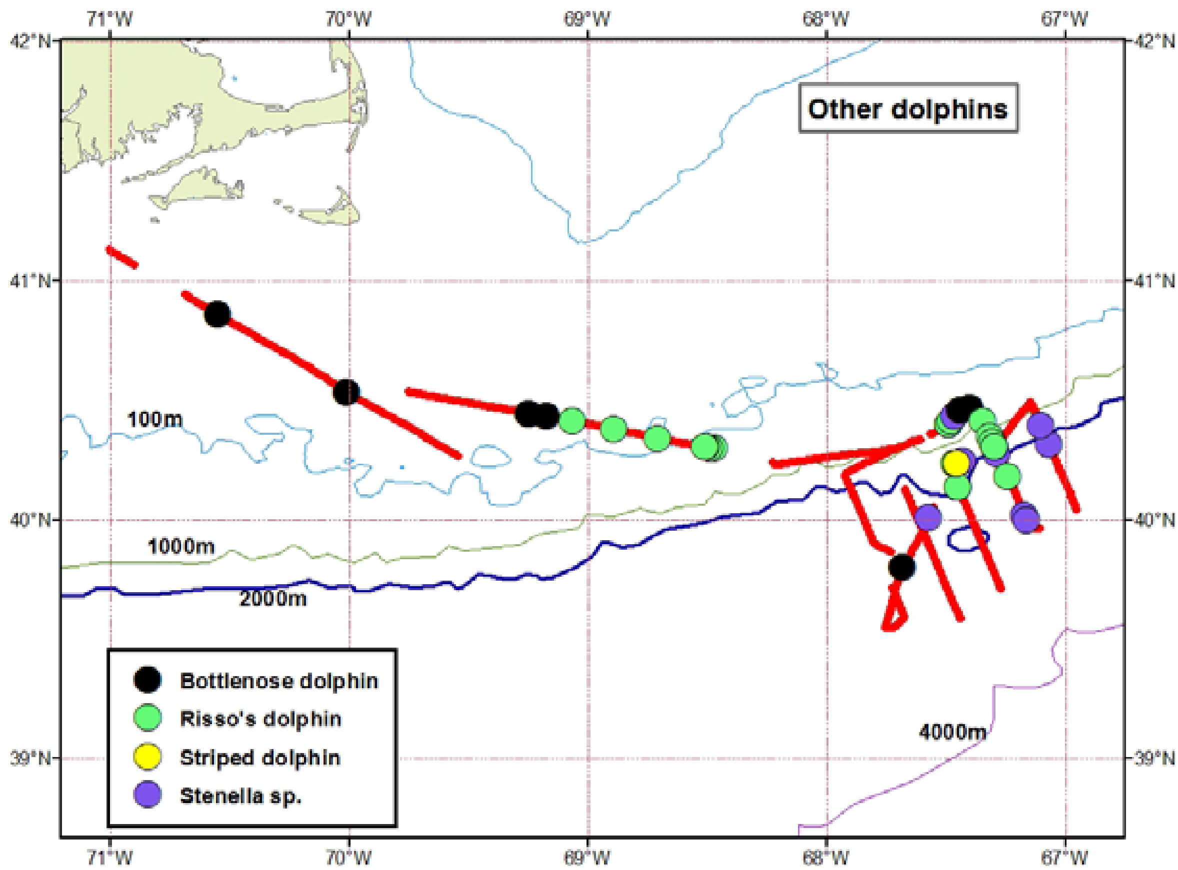


Figure D4. Locations of groups of Cuvier's beaked whale (*Ziphius cavirostris*), Sowerby's beaked whale (Mesoplodon bidens), unidentified Mesoplodons and unidentified Zipiid that were detected by the upper team during 25 – 29 July 2014 (HB1403).

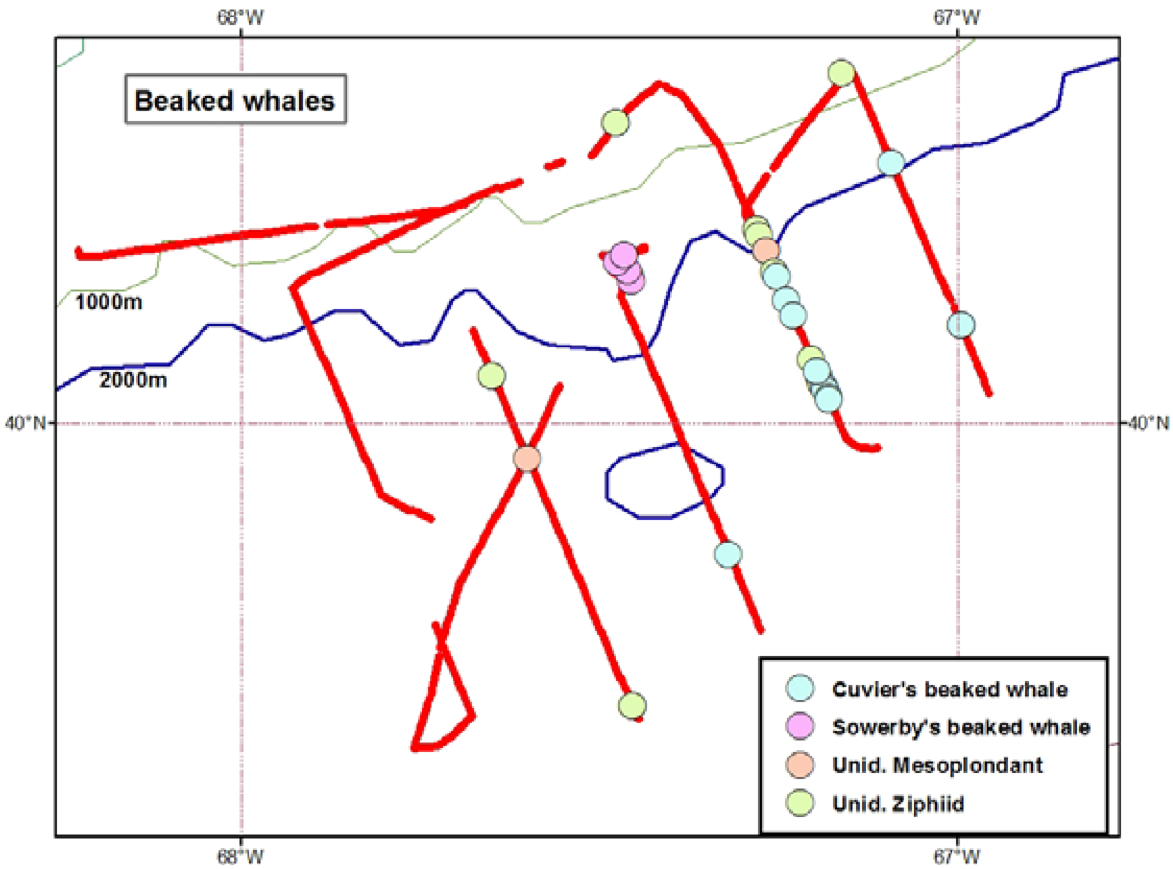


Figure D5. Locations of groups of fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), minke whales (*B. acutorostrata*), sperm whales (*Physeter macrocephalus*) and pilot whales (*Globicephala* spp.) that were detected by the upper team during 25 – 29 July 2014 (HB1403).

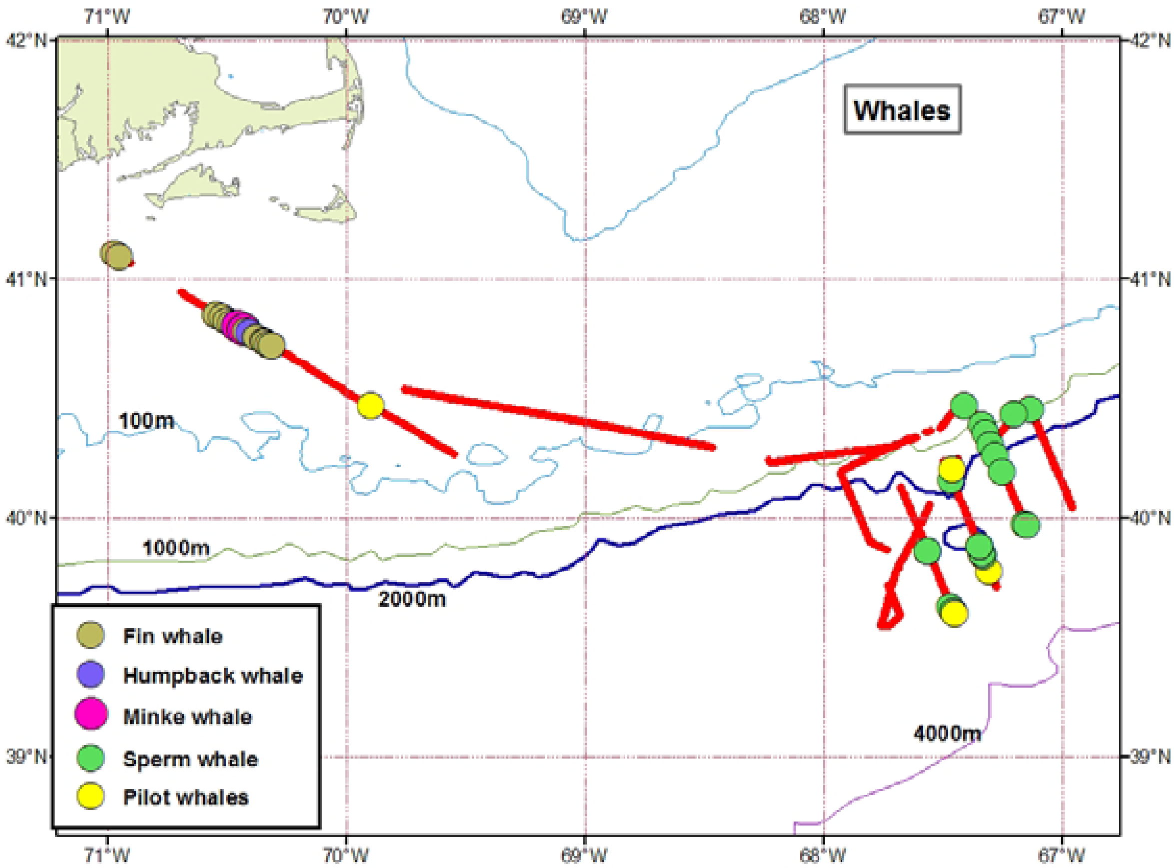


Figure D6. Locations of groups of basking sharks (*Cetorhinus maximus*), mantas, sunfish (*Mola mola*), unidentified sharks, and a leatherback turtle (*Dermochelys coriacea*) that were detected by the upper team during 25 – 29 July 2014 (HB1403).

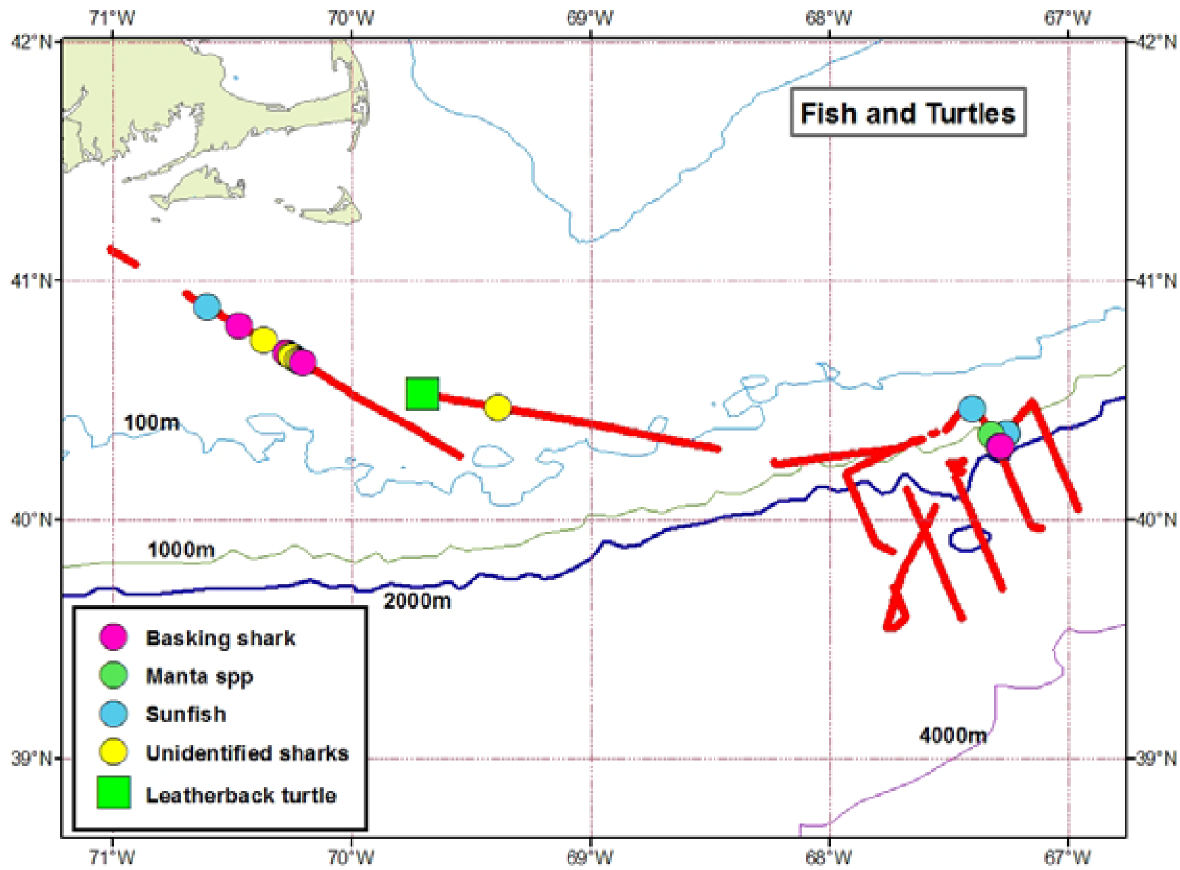


Figure D7. Locations of groups of shearwaters detected during 25 – 29 July 2014 (HB1403).

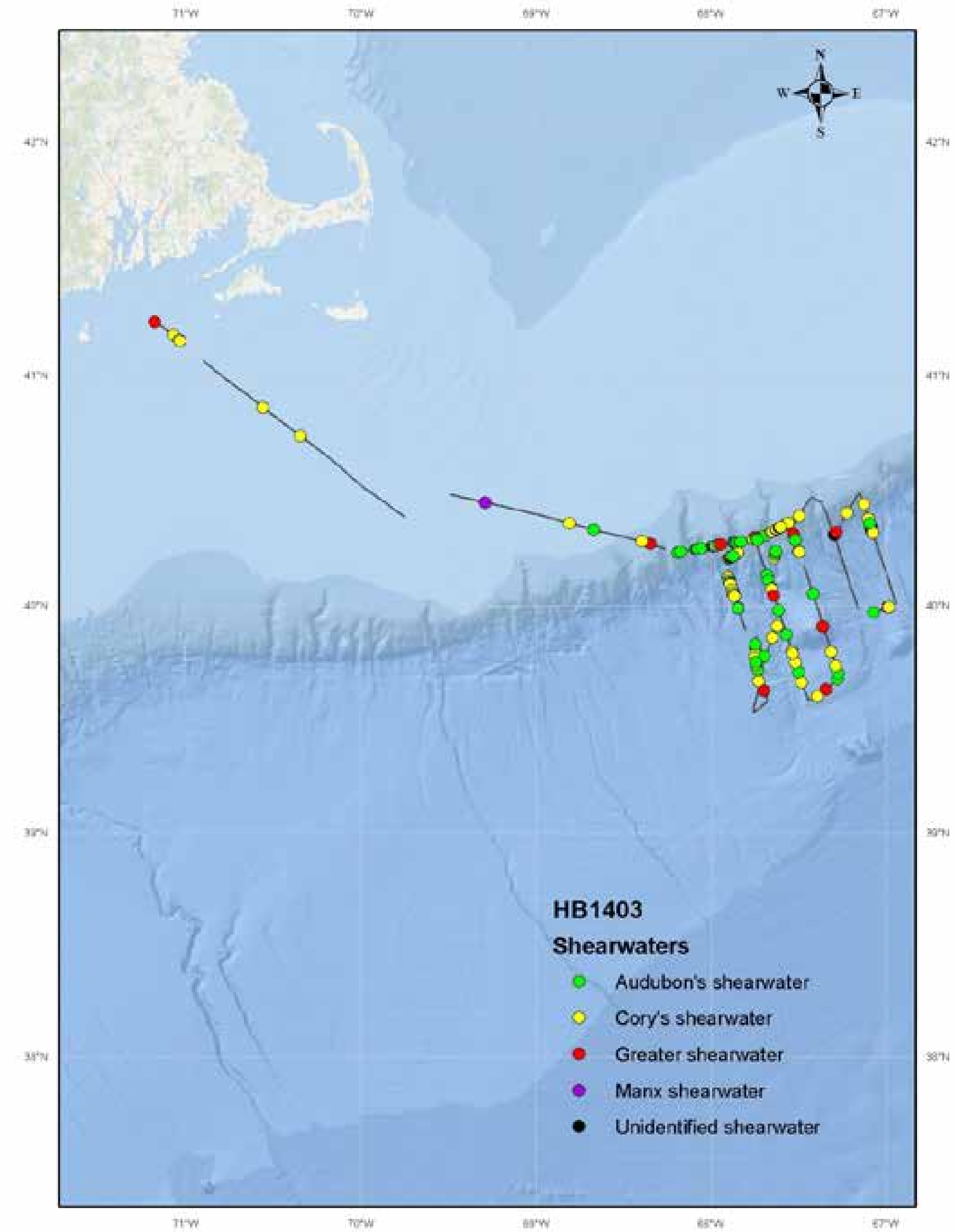


Figure D8. Locations of groups of petrels detected during 25 – 29 July 2014 (HB1403).

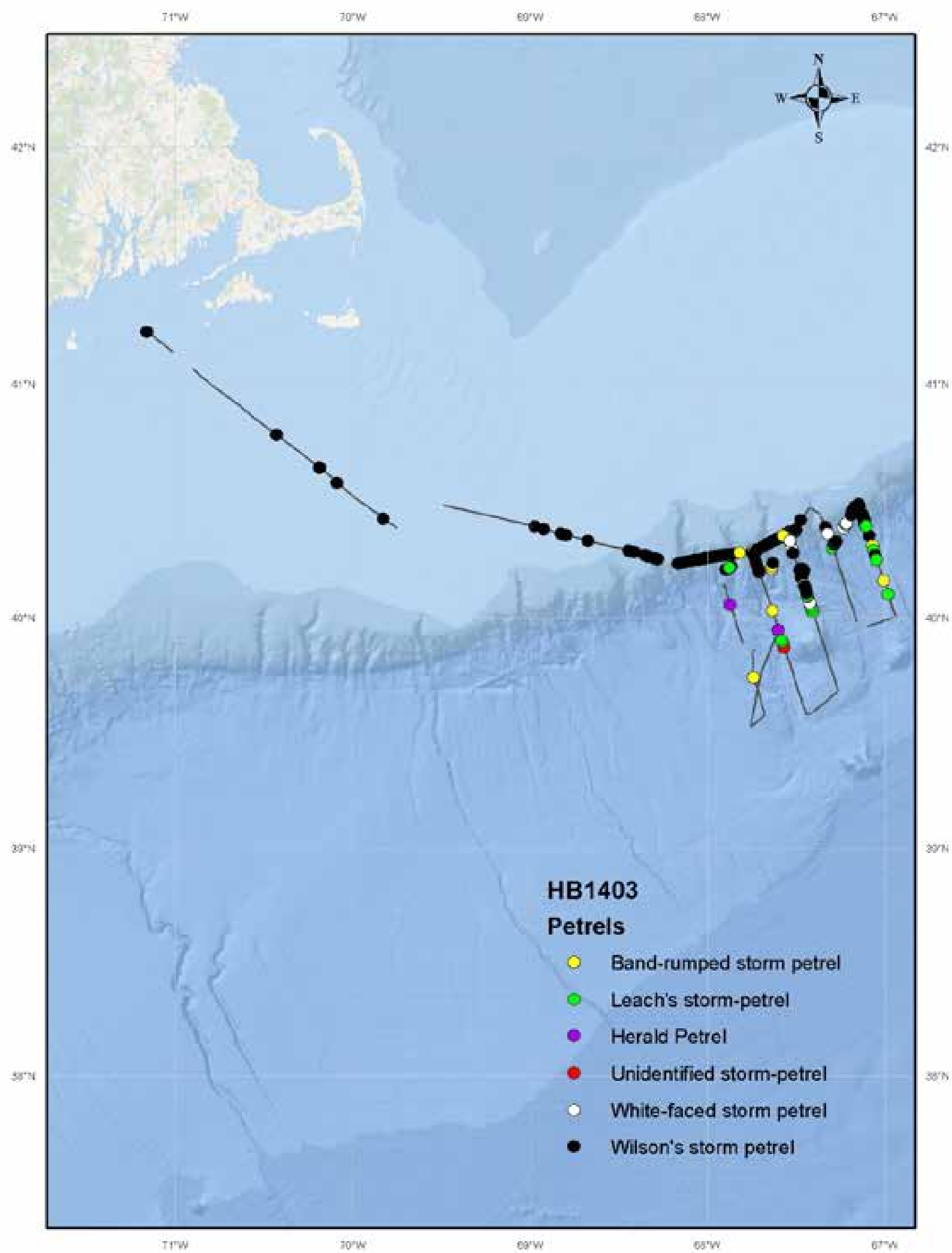


Figure D9. Locations of bird groups of other species detected during 25 – 29 July 2014 (HB1403).

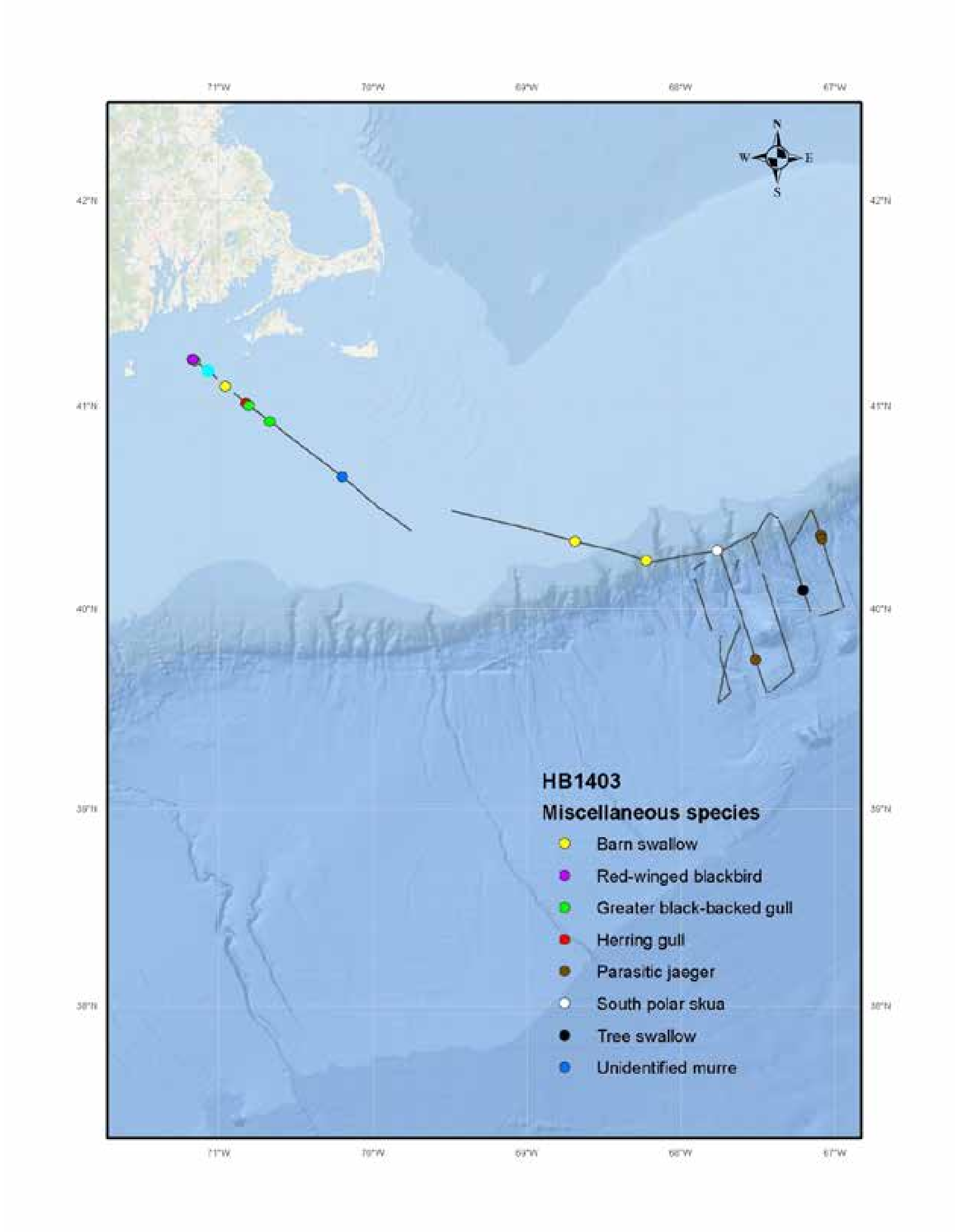
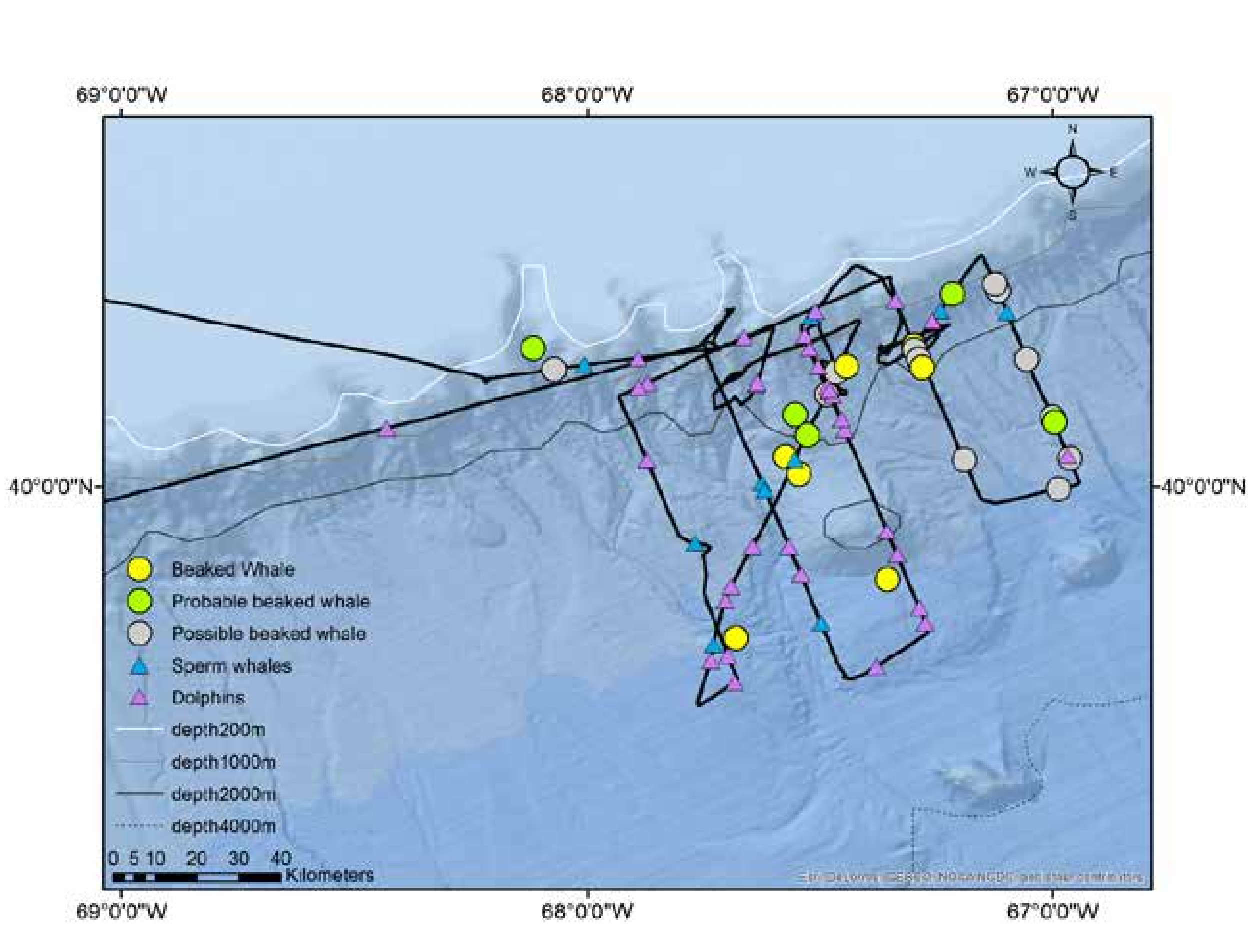
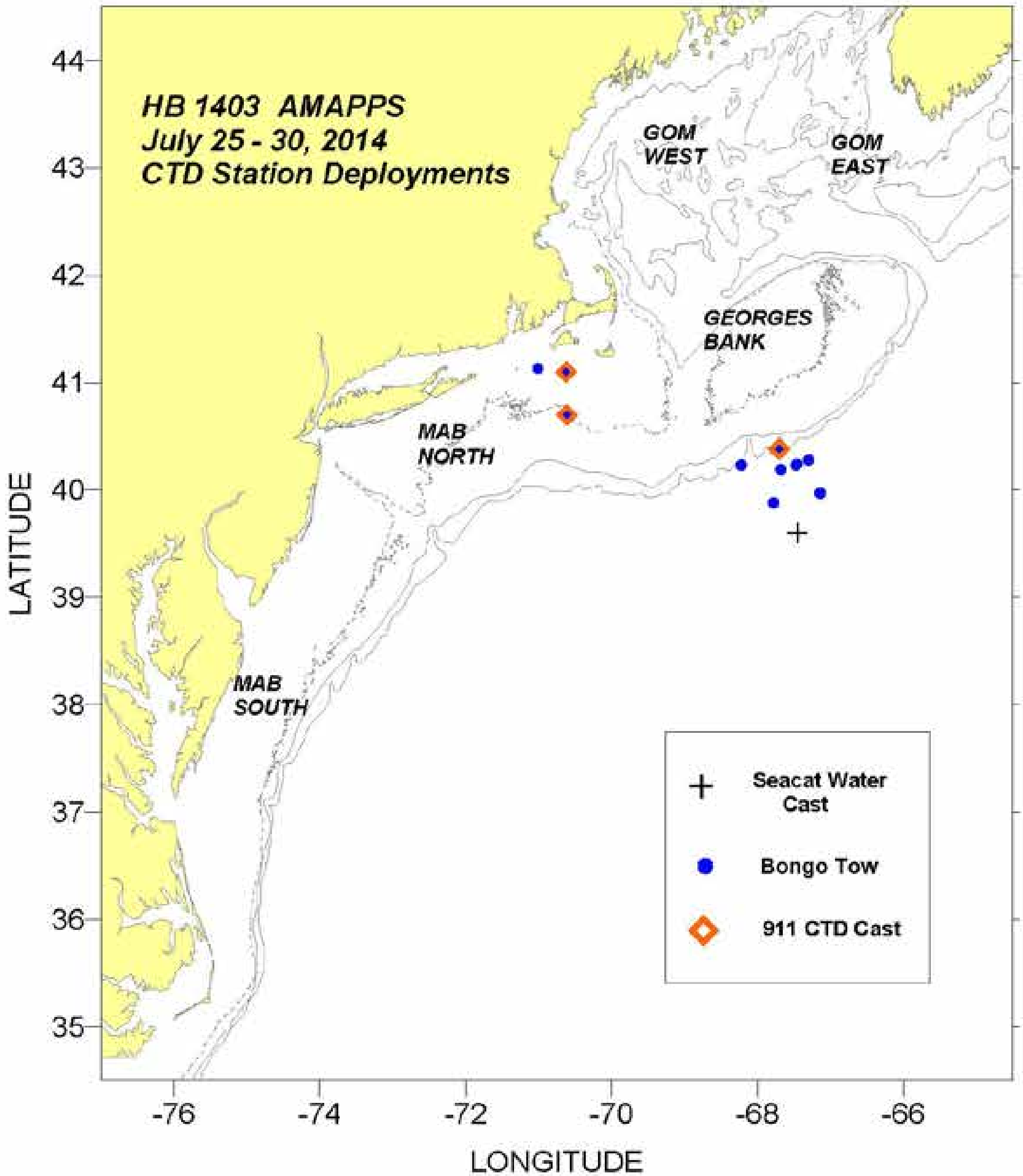


Figure D10. Acoustic detections of odontocetes. Black lines indicate tracklines; towed array was only deployed in waters deeper than 100m. Triangles indicate the location of the NOAA ship *Henry B. Bigelow* during acoustic encounters with sperm whales (blue), and dolphins (pink) that were detected in real-time. Circles indicate locations of acoustic encounters with beaked whales, combining detections in real-time and those identified in post-processing of towed array data. Twenty-nine potential encounters were identified, including 9 which were considered definite beaked whale events (yellow), 5 probable events (green) and 15 possible events (gray).



F igure D11. Locations of deployments of CTDs that were used for water casts, bongo tows and rosette casts.



Appendix E: Loggerhead turtle tagging project: Northeast Fisheries Science Center

Heather Haas[1], Ron Smolowitz[2], Kara Dodge[3], Chris Sasso[4]

[1] Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2] Coonamessett Farm Foundation, 277 Hatchville Rd., E. Falmouth, MA 02536
[3] Integrated Statistics, 16 Sumner Street, Woods Hole, MA 02543
[4] Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL 33149

SUMMARY

In summer 2014 we focused on sampling Mid-Atlantic turtles at the beginning of their northward migration, and we undertook pilot work in southern New England to assess the feasibility of future directed research in these relatively northern waters. Our focus was centered on the need to fill the data gap in the Northeastern portion of the loggerhead turtle range. Together with partners, we deployed 20 Satellite Relayed Data Loggers (SRDLs) on loggerhead sea turtles, and one temporary suction cup video and time-depth recorder (TDR) on a leatherback turtle north of Martha's Vineyard. We also continued our collaboration with CREEM (Centre for Research into Ecological and Environmental Modelling at the University of St Andrews), Virginia Aquarium & Marine Science Center (VAQ), the Southeast Fisheries Science Center (SEFSC), and the Naval Facilities Engineering Command (NAVFAC) to explore a new method to use behavior data to produce estimates of loggerhead availability to aerial observers.

OBJECTIVES

The main objectives for 2014 were to combine resources from AMAPPS and the Atlantic Sea Scallop set-aside grants to:

1. Tag at least 10 loggerhead turtles at the beginning of their migration, before they settle into their summertime foraging residency.
2. Complete pilot work to explore the feasibility of tagging loggerheads and leatherbacks in southern New England.
3. Collaborate with partners to explore a new method to use behavior data to produce estimates of loggerhead availability.
4. Investigate whether sufficient leatherback availability data already exits.
5. Collaborate with partners to use existing *in situ* video data to describe offshore loggerhead behavior.

CRUISE PERIOD AND AREA

Cruise 1: On the evening of 27 May 2014 the commercial scallop F/V *Kathy Ann* departed from Barnegat Light, NJ for a six-day cruise with 5 scientific crew (Ron Smolowitz, Eric Matzen, Henry Milliken, Heather Haas, Brianna Valenti) and 4 vessel crew (Captain Mike Francis, Corey Karch, James Gutowski, George West) to locate, capture, and tag loggerheads in Mid-Atlantic continental shelf waters offshore of the Chesapeake Bay.

Cruise 2: On the morning of 3 September 2014, the commercial scallop F/V *Kathy Ann* departed from the NEFSC dock in Woods Hole, MA for a two and half day cruise with 5 scientific crew

(Ron Smolowitz, Henry Milliken, Shea Miller, Heather Haas, Kara Dodge) and 4 vessel crew (Captain Mike Francis, Corey Karch, Forest Hammerstron, Steve Levan) to locate, capture, and tag turtles in southern New England continental shelf waters offshore of Rhode Island and Massachusetts.

Between the Mid-Atlantic and southern New England cruises, we collaboratively deployed 20 satellite tags. CFF provided the vessels, spotter plane, 70% of the crew, and 13 of the satellite tags and associated Argos fees.

METHODS

PROJECT 1. MID-ATLANTIC SAMPLING

When loggerhead turtles were located, we deployed a small boat (16 ft) to capture the turtles using a large dipnet. All captured loggerheads were transferred to the F/V *Kathy Ann* for biological sampling. We used epoxy to attach 19 Sea Mammal Research Unit's (SMRU) Fastloc GPS Satellite Relay Data Logger (SRDL) to a central carapace scute of each captured turtle.

We completed basic sampling (measured the length and width of captured turtles, photographed, flipper and PIT tagged, and took biopsy samples for genetic analysis); plus we also measured weight and body depth, took biopsy samples for stable isotope analysis, and took blood samples to analyze for testosterone levels (to identify sex) and general blood chemistry (for health assessment).

The SMRU satellite tags were programmed to transmit every day, though local conditions often prevent the tags from transmitting. Specifications for the SMRU Fastloc GPS Satellite Relay Data Loggers (SRDLs) are provided in Appendix E1. The Fastloc GPS supplies highly accurate locations. The tag also uses precision wet/dry, pressure, and temperature sensors to form individual dive (max depth, shape, time at depth, etc.) records along with temperature profiles and binned summary records. Since 2011 we also have variables to assess the average duration of a surfacing bout and average duration of a diving bout. The SMRU tag stores information in its memory and then relays an unbiased sample of detailed individual dive records and summary records.

PROJECT 2. SOUTHERN NEW ENGLAND PILOT WORK

We steamed from Woods Hole on the first day, and with the aid of a Coonamessett Farm Foundation (CFF) sponsored spotter plane, we found one loggerhead near the end of the day; but we were not able to capture it. The second day we spotted (unaided by a plane) a loggerhead turtle. We captured and tagged it. Unfortunately the tag only transmitted once after it was deployed. The tag was successfully tested by both the manufacturer and by the researchers prior to deployment, so it is not clear why it only made one transmission after deployment. The quality of the SMRU tags is generally high (only 1 other failure out of over a 100 deployments).

On the morning of the third day, we tagged a leatherback at the water surface by approaching it with the small boat and hand placing the suction cup tag on the carapace. We tracked the turtle at depth from the small boat using the acoustic tag, with additional spotting from the F/V *Kathy Ann* when the turtle surfaced. The tag remained on for 30 minutes before detaching from the turtle and floating at the surface for retrieval. During the tracking period, three CTD casts and video profiles were conducted from the F/V *Kathy Ann* to collect data on the physical structure of the water column and the species/distribution of gelatinous zooplankton, respectively. We also collected gelatinous zooplankton samples using a surface dipnet for bomb calorimetry and stable isotope analysis.

PROJECT 3. METHODS DEVELOPMENT

At no cost to AMAPPS, we collaborated with CREEM, VAQ, SEFSC, and NAVFAC in accordance with existing data sharing agreements.

PROJECT 4. LEATHERBACK AVAILABILITY DATA

As part of a contract funded by AMAPPS, existing leatherback Wildlife Computer (WC) satellite telemetry data collected by the Large Pelagics Research Center between 2008 and 2010 has been examined to determine if the existing data can be useful to inform AMAPPS leatherback availability estimates. The data have been subset to include only locations and dive data for the Northeast US shelf (hereafter referred to as NES). These data were previously filtered to exclude erroneous locations (results reported in Dodge et al. 2014) and interpolated to a three-hour time step. Visual inspection of the NES data subset showed a large number of "0" values in the 0 – 2 m time-at-depth bin (18% of all values were zero). Because the binned data represent 6-hour time periods during which turtles are expected to surface to breathe, it is problematic to have 18% of records show no surface intervals.

We contacted Wildlife Computers support staff for an explanation of these values. After some dialog, they decided the suspicious values were probably due to sensor drift.

Because leatherbacks are deep divers, all WC tags deployed on leatherbacks use 0 – 1700 m pressure sensors. The actual accuracy of the depth sensor is +/- 1% of the reading (+/- 2 resolutions). The resolution in the 0 – 1700 m depth sensing tags is 0.5 m. Therefore the accuracy is +/- 1% of the reading (+/- 1 m). For example, at 1.5 m, the accuracy is +/- 1.015m. At 1000 m, the accuracy is +/- 11 m. So a reading from a turtle at 1.5 m could be anywhere between 0.485 and 2.515m, potentially putting turtles at about >1m into the next bin (in our case, 2 – 10 m).

We did not think that sensor drift alone explained why turtles at the surface (0 m) were not showing up in the time-at-depth 0 – 2 m bin during the 6 hr time period, so WC suggested that the accuracy of the depth sensor, in addition to sensor drift, could cause this to happen. Prior to 2013, WC was using the Tab1 pressure sensor and relied on zero-offset correction (ZOC) to correct for any sensor drift over time. The Large Pelagics Research Center had enabled ZOC for all the tags using the "by first dry depth reading" function, but WC said this may not have been enough if the sensor had drifted even 0.1% of full scale (e.g., 1.7 m). They felt that sensor drift, along with the accuracy of the 0 – 1700 m depth sensor, explains the lack of readings in the 0 – 2 m bin.

PROJECT 5. OFFSHORE LOGGERHEAD BEHAVIOR

We are collaborating to analyze existing video of loggerhead sea turtles foraging in offshore Mid-Atlantic waters. *In situ* observations are useful for classifying animal behavior, but are typically rare for large marine vertebrates, including turtles. From 2007 – 2014, CFF conducted detailed assessments via ROV of the at-sea behavior of juvenile and adult loggerheads. The ROV was deployed within the United States mid-Atlantic offshore region, a known foraging ground for juvenile loggerhead turtles. The ROV proved to be a powerful versatile tool and allowed for in-depth investigation of animal behavior throughout the water column. We are currently analyzing the existing video to identify predator-prey relationships and to classify loggerhead behavior into discrete behavior – depth categories.

RESULTS

PROJECT 1. MID-ATLANTIC SAMPLING

We successfully found and tagged loggerhead turtles during their northward migration. Most (17 out of 19) of the loggerheads eventually moved north of our initial tagging location. In order to tag turtles earlier in migration, we would likely need to move south, as we were already targeting turtles near the edge of their physiologic tolerance for cold. The majority (11 out of 19) of the tagged turtles had internal temperatures less than 16° C; only 4 had internal temperatures above 19° C.

Despite successfully targeting the beginning of the northward migration, none of the over 100 loggerheads we have tagged so far has moved northeast of Long Island. Several have arrived at Long Island by early July, leaving plenty of time to move further northeast, but none did. These results emphasize the need to tag loggerheads directly in New England waters.

Data from all SMRU tags are being uploaded weekly into a password-protected Oracle database which contains AMAPPS and non-AMAPPS data. The database is maintained by the NEFSC, and as of December 2014 it contains more than a million uplinks, 317 K ARGOS location records, 140 K GPS location records, 33 K temperature-depth casts, 197 K dive records, and 97 K summarized records of surface availability.

PROJECT 2. SOUTHERN NEW ENGLAND PILOT WORK

Our pilot work shows that given the right conditions, it is feasible for a short cruise to locate and tag loggerheads and leatherbacks in southern New England. Because the relative density of turtles is lower in the New England waters, the amount of required effort will be higher per turtle in the north as compared to that off of Chesapeake Bay. In addition, we hypothesize that loggerheads spend less time at the surface in the north. If loggerhead behavior is different in the north, it will make them more difficult to catch and the data more important to obtain.

Based on our single tagged leatherback, we collected 30 minutes of HD video and fine-scale dive behavior. Preliminary analysis of video and TDR data showed the turtle made five foraging dives (maximum depth range: 16.7 - 22.4 m), feeding on a minimum of 24 scyphozoan jellyfish (*Cyanea capillata* and *Chrysaora quinquecirrha*). In addition to feeding behavior, our video also recorded data on flipper strokes, surface respirations, and commensal fish. We can use data from the CTD and video profile casts to characterize the tagged turtle's biophysical environment, and determine the physical processes associated with the gelatinous zooplankton aggregation found in Vineyard Sound.

PROJECT 3. METHODS DEVELOPMENT

The following report has been produced:

Scott-Hayward, L.A.S., D.L. Borchers, M.L. Burt, S. Barco, H.L.Hass, C.R. Sasso and R.J. Smolowitz. 2014. Use of Zero and One-Inflated Beta Regression to Model Availability of Loggerhead Turtles off the East Coast of the United States. Final Report. Prepared for U.S. Fleet Forces Command. Submitted to Naval Facilities Engineering Command

(NAVFAC) Atlantic, Norfolk, Virginia, under Contract No. N62470-10-D-3011, Task Order 40, issued to HDR Inc., Norfolk, Virginia. Prepared by CREEM, University of St. Andrews, St. Andrews, Scotland. July 2014.

PROJECT 4. LEATHERBACK AVAILABILITY DATA

Given that 18% of the 0 – 2 m bin time-at-depth readings from existing Large Pelagics Research Center leatherback tags were zero, we decided not to use existing data as it would drastically underestimate leatherback surface time. We have only used a small portion (about 15%) of the funds allocated to analysis of leatherback availability data, and we plan to reallocate the contract funds to more fruitful avenues.

PROJECT 5. OFFSHORE LOGGERHEAD BEHAVIOR

Results not yet available. The analysis is still underway.

DISPOSITION OF DATA

Data from all SMRU tags are stored in an Oracle database maintained by the NEFSC. To view the locations of tagged turtles see: http://www.nefsc.noaa.gov/psb/turtles/turtleTracks.html.

PERMITS

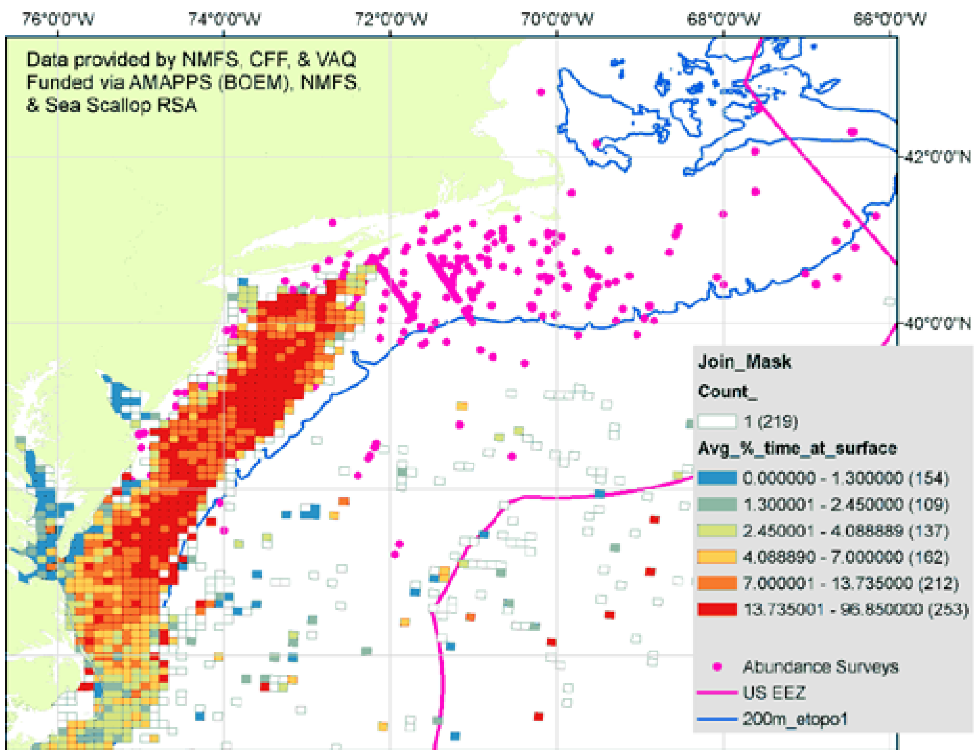
The directed turtle research was authorized by NEFSC permit # 16556.

ACKNOWLEDGEMENTS

This research is part of a collaborative effort to learn more about sea turtles in Northeast region waters. Support has been contributed by Bureau of Ocean Energy Management (BOEM), NMFS (NEFSC, Section 6 Program, RSA set aside program), Coonamessett Farm Foundation, and Virginia Aquarium & Marine Science Center among others. Thanks to NEFSC (Debi Palka and Beth Josephson) and VAQ (Susan Barco) for providing data used to create Figure E1.

We thank James Gutowski of Viking Village Fisheries and the captains, crew and scientists on the F/V *Kathy Ann* for their expert field work; Jon O'Neil for his work managing the Oracle database; Beth Josephson for making and maintaining an interactive webpage to show the turtle tracks; Mike Abbott for docking privileges; and Mark Baumgartner (Woods Hole Oceanographic Institute) for providing his CTD, tagging supplies, and guidance on suction cup tagging and acoustic tracking.

Figure E1. Distribution of behavior data, shown as average percent of time at surface, for tagged loggerheads compared to loggerheads observed in NEFSC abundance surveys (pink). Average percent of time at surface was calculated from summaries of surface durations within AMAPPS grid cells. Locations of loggerheads observed in NEFSC surveys are from all data currently uploaded into the Oracle database (1995 – 2012). The area with pink dots in southern New England represents a key area where more behavior data are needed.



Appendix E1: SMRU Tag Specifications

```
Software specification for FA_13A deployment
 (Loggerhead GPS Argos)


Valid for dates in years 2013 to 2016

 Transmitting via ARGOS
Page transmission sequences:

        Until day  150:  0 1 2 1 3 4 1 2 3 0 1 2 3 0 1 2 3 1 3 1

        Until day 1464:  0 1 3 1 3 4 1 3 1 3 0 1 3 0 3 1 3 1 3 1
        An additional diagnostics page is sent every 60 transmissions


Airtest for first 7 hours:
        Transmission interval is chosen randomly between 48 and 72 seconds

Satellite availability (UTC):
        00:  --  on --
        01:  --  on --
        02:  --  on --
        03:  --  on --
        04:  --  on --
        05:  --  on --
        06:  --  on --
        07:  --  on --
        08:  --  on --
        09:  --  on --
        10:  --  on --
        11:  --  on --
        12:  --  on --
        13:  --  on --
        14:  --  on --
        15:  --  on --
        16:  --  on --
        17:  --  on --
        18:  --  on --
        19:  --  on --
        20:  --  on --
        21:  --  on --
        22:  --  on --
        23:  --  on --

Transmission targets:

  70000 transmissions after 200 days


   In Haulouts: ON (one tx every 44 secs) for first 1 day
   then cycling OFF for 0, ON for 1 day


Check sensors every 4 secs
```

```
When near surface (shallower than 6m), check wet/dry every 1 sec
Consider wet/dry sensor failed if wet for 30 days or dry for 99 days
Dives start when wet and below 1.5m for 20 secs
  and end when dry, or above 1.5m
Do not separate 'Deep' dives
No cruises
A haulout begins when dry for 6 mins
  and ends when wet for 40 secs

Dive shape (normal dives):
        5 points per dive using broken-stick algorithm

Dive shape (deep dives):
        none

CTD profiles: max 250 dbar up to 2 dbar in 1 dbar bins.

        Temperature: Collected, Stored.
        Conductivity: Not collected.
        Salinity: Not collected.
        Fluorescence: Not collected.
        Oxygen: Not collected.
        Light level: Not collected.
        Construct a single profile for each 4-hour period.
        During profile, sample CTD sensor every 4 seconds.
        Each profile contains 10 cut points
                consisting of 0 fixed points, minimum depth, maximum depth, 8
broken-stick points

GPS fixes:
        Number of GPS attempts allowed: unlimited
        Cut-off date for GPS attempts: 150 days (then increase interval to 0x
normal)
        Discard results with fewer than 5 satellites
        Haulouts: Increase interval to 12x normal after first success in
haulout

TRANSMISSION BUFFERS (in RAM):
Dives in groups of 2 (5.55556 days @ 10mins/dive): 400  = 1600 bytes
No 'deep' dives
Haulouts: 30  = 120 bytes
6-hour Summaries in groups of 1 (15 days): 60  = 240 bytes
No Timelines
No Cruises
No Diving periods
No Spot depths
No Emergence records
No Dive duration histograms
No Max depth histograms
6-hour Depth & Temperature histograms in groups of 1 (15 days): 60 = 240
bytes
CTD casts (8.33333 days): 50 = 200 bytes
GPS fixes (variable: 70.8333 days if interval is 20 mins): 5100  = 20400
bytes
No Spot CTD's
No Vemco VMT's
```

```
 TOTAL 22800 bytes (of about 21000 available)


MAIN BUFFERS (in 8 or 24 Mb Flash):
Dive in groups of 2 (5.55556 days @ 10mins/dive): 400 x 96 bytes = 38400
bytes
No 'deep' dives
Haulout: 30 x 16 bytes = 480 bytes
6-hour summaries in groups of 1 (15 days): 60 x 52 bytes = 3120 bytes
6-hour Depth & Temperature histograms in groups of 1 (15 days): 60 x 24 bytes
= 1440 bytes
No timelines
No cruises
No diving periods
No spot depths
No emergence records
No Duration histograms
No Max depth histograms
CTD casts (8.33333 days): 50 x 60 bytes = 3000 bytes
GPS fixes (variable: 70.8333 days if interval is 20 mins): 5100 x 144 bytes =
734400 bytes
No spot CTD's
No Vemco VMT's

 TOTAL 762 kb (from 8192 kb available)


PAGE CONTENTS (256 bits - 9 overhead):

PAGE 0:
        PTT NUMBER OVERHEAD (28-bit code)
        -----------[8 bits: 0 - 7]

        PAGE NUMBER
        -----------[3 bits: 8 - 10]

        DIVE group in format 0:
        Normal dives transmitted in groups of 2
         Time of start of last dive:  max 7 days 12 hours @ 10 secs= 64800
                tx as raw 16 bits in units of 1  (range: 0 to 65535 )
                (recommended sell-by 7 days 11 hours Actual:  7 days 6 hours
is OK)
         Number of records:  raw 2 bits in units of 1  (range: 0 to 3 )
         Reason for end:  -- not transmitted --
         Group number:  -- not transmitted --
         Max depth:  -- not transmitted --
         Dive duration:  odlog 3/7 in units of 4 s (range: 0 to 130302 s)
         Mean speed:  -- not transmitted --
         Profile data (5 depths/times, 0 speeds):
                  Depth profile:  Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-
6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-
20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-
44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-
68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-
```

140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)
Profile times: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Speed profile: -- not transmitted --
Residual: -- not transmitted --
Calculation time: -- not transmitted --
Surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Dive area: raw 9 bits in units of 2 permille (range: 0 to 1022 permille)
-----------[236 bits: 11 - 246]

Available bits used exactly
=== End of page 0 ===

PAGE 1:
PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]

PAGE NUMBER
-----------[3 bits: 8 - 10]

SUMMARY group in format 0:
Transmitted in groups of 1
Record could be in buffer for 15 days
End time: max 15 days 6 hours @ 6 hours= 61
tx as raw 6 bits in units of 1 (range: 0 to 63)
(recommended sell-by 15 days 5 hours Actual: 15 days is OK)
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Cruising time: -- not transmitted --
Haulout time: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Dive time: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Deep Dive time: -- not transmitted --
Normal dives:
Avg max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)
SD max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)
Max max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-

```
130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240,
>240 in units of 0.1 m (range: 0 to 240 m)
                Avg dive duration:  odlog 3/7 in units of 4 s (range: 0 to
130302 s)
                SD dive duration:  odlog 3/7 in units of 4 s (range: 0 to
130302 s)
                Max dive duration:  odlog 3/7 in units of 4 s (range: 0 to
130302 s)
                Avg surface duration:  odlog 3/7 in units of 4 s (range: 0 to
130302 s)
                SD surface duration:  odlog 3/7 in units of 4 s (range: 0 to
130302 s)
                Max surface duration:  odlog 3/7 in units of 4 s (range: 0 to
130302 s)
                Avg speed in dive:  -- not transmitted --
                Number of dives:  odlog 2/4 in units of 1  (range: 0 to 235.5
)
        Deep dives:
                Avg max dive depth:  -- not transmitted --
                SD max dive depth:  -- not transmitted --
                Max max dive depth:  -- not transmitted --
                Avg dive duration:  -- not transmitted --
                SD dive duration:  -- not transmitted --
                Max dive duration:  -- not transmitted --
                Avg surface duration:  -- not transmitted --
                SD surface duration:  -- not transmitted --
                Max surface duration:  -- not transmitted --
                Avg speed in dive:  -- not transmitted --
                Number of dives:  -- not transmitted --
         Avg SST:  -- not transmitted --
        -----------[111 bits: 11 - 121]

        DEPTH & TEMPERATURE histogram group in format 0:

        Histogram with 5 depth bins:
        Transmitted in groups of 1
        Record could be in buffer for 15 days
         End time:  max 15 days 6 hours @ 6 hours= 61
               tx as raw 6 bits in units of 1  (range: 0 to 63 )
               (recommended sell-by 15 days 5 hours Actual:  15 days is OK)
         Number of records:  raw 1 bits in units of 1  (range: 0 to 1 )
                Max. max depth:  -- not transmitted --
                Dry temperature:  -- not transmitted --
                Dry usage:  raw 10 bits in units of 1 permille (range: 0 to
1023 permille)
                Surface temperature:  -- not transmitted --
                Surface usage (< 1 m):  raw 10 bits in units of 1 permille
(range: 0 to 1023 permille)
                5 depth bins:
                Depth band temperature:  -- not transmitted --
                 Usage of depths 1 to 2 m:  raw 10 bits in units of 1
permille (range: 0 to 1023 permille)
                 Usage of depths 2 to 3 m:  raw 10 bits in units of 1
permille (range: 0 to 1023 permille)
                 Usage of depths 3 to 4 m:  raw 10 bits in units of 1
permille (range: 0 to 1023 permille)
```

```
                  Usage of depths 4 to 5 m:  raw 10 bits in units of 1
permille (range: 0 to 1023 permille)
                  Usage of depths 5 to 2999 m:  raw 10 bits in units of 1
permille (range: 0 to 1023 permille)
        -----------[77 bits: 122 - 198]

        HAULOUT in format 0:
         Number of records:  raw 1 bits in units of 1  (range: 0 to 1 )
         Haulout number:  wraparound 5 bits in units of 1  (range: 0 to 31 )
         Start time:  max 21 days 12 hours @ 2 mins= 15480
                tx as raw 14 bits in units of 1  (range: 0 to 16383 )
                (recommended sell-by 21 days 11 hours Actual:  21 days is OK)
         End time:  max 21 days 12 hours @ 2 mins= 15480
                tx as raw 14 bits in units of 1  (range: 0 to 16383 )
                (recommended sell-by 21 days 11 hours Actual:  21 days is OK)
         Duration:  -- not transmitted --
                cf. Max duration is 1 day
         Reason for end:  -- not transmitted --
         Contiguous:  -- not transmitted --
        -----------[34 bits: 199 - 232]

        DIAGNOSTICS in format 0:

         TX number:  wraparound 14 bits in units of 5  (range: 0 to 81915 )
        -----------[14 bits: 233 - 246]

        Available bits used exactly
 === End of page 1 ===


PAGE 2:
        PTT NUMBER OVERHEAD (28-bit code)
        -----------[8 bits: 0 - 7]

        PAGE NUMBER
        -----------[3 bits: 8 - 10]

        GPS in format 1:

         Timestamp:  max 3 days @ 1 sec= 259200
                tx as raw 18 bits in units of 1  (range: 0 to 262143 )
                (recommended sell-by 2 days 23 hours Actual:  2 days 21 hours
is OK)
         n_sats:  raw 3 bits in units of 1  (range: 5 to 12 )
         GPS mode:  -- not transmitted --
         Best 8 satellites:
                 Sat ID's:  raw 5 bits in units of 1  (range: 0 to 31 )
                 Pseudorange:  raw 15 bits in units of 1  (range: 0 to 32767 )
                 Signal strength:  -- not transmitted --
                 Doppler:  -- not transmitted --
         Max signal strength:  -- not transmitted --
         Noisefloor:  -- not transmitted --
         Max CSN (x10):  raw 5 bits in units of 5  (range: 320 to 475 )
        -----------[186 bits: 11 - 196]

        DIAGNOSTICS in format 1:
```

```
         Driest (max wet/dry):  raw 8 bits in units of 1  (range: 0 to 255 )
         GPS zero satellites:  wraparound 13 bits in units of 1  (range: 0 to
8191 )
         GPS 1-4 satellites:  wraparound 13 bits in units of 1  (range: 0 to
8191 )
         GPS 5 or more satellites:  wraparound 13 bits in units of 1  (range:
0 to 8191 )
         GPS reboots:  wraparound 3 bits in units of 1  (range: 0 to 7 )
        -----------[50 bits: 197 - 246]

        Available bits used exactly
 === End of page 2 ===


PAGE 3:
        PTT NUMBER OVERHEAD (28-bit code)
        -----------[8 bits: 0 - 7]

        PAGE NUMBER
        -----------[3 bits: 8 - 10]

        GPS in format 0:

         Timestamp:  max 382 days @ 1 sec= 33004800
                tx as raw 25 bits in units of 1  (range: 0 to 3.35544e+07 )
                (recommended sell-by 381 days 23 hours Actual:  380 days is
OK)
         n_sats:  raw 3 bits in units of 1  (range: 5 to 12 )
         GPS mode:  -- not transmitted --
         Best 8 satellites:
                 Sat ID's:  raw 5 bits in units of 1  (range: 0 to 31 )
                 Pseudorange:  raw 15 bits in units of 1  (range: 0 to 32767 )
                 Signal strength:  -- not transmitted --
                 Doppler:  -- not transmitted --
         Max signal strength:  -- not transmitted --
         Noisefloor:  -- not transmitted --
         Max CSN (x10):  raw 5 bits in units of 5  (range: 320 to 475 )
        -----------[193 bits: 11 - 203]

        DIAGNOSTICS in format 2:

         GPS zero satellites:  wraparound 13 bits in units of 1  (range: 0 to
8191 )
         GPS 1-4 satellites:  wraparound 13 bits in units of 1  (range: 0 to
8191 )
         GPS 5 or more satellites:  wraparound 13 bits in units of 1  (range:
0 to 8191 )
         GPS reboots:  wraparound 3 bits in units of 1  (range: 0 to 7 )
        -----------[42 bits: 204 - 245]

        UNUSED
        -----------[1 bits: 246 - 246]

 === End of page 3 ===


PAGE 4:
```

```
        PTT NUMBER OVERHEAD (28-bit code)
        -----------[8 bits: 0 - 7]

        PAGE NUMBER
        -----------[3 bits: 8 - 10]

        CTD PROFILE in format 0:

         End time:  max 7 days 12 hours @ 4 hours= 45
                tx as raw 6 bits in units of 1  (range: 0 to 63 )
                (recommended sell-by 7 days 11 hours Actual:  7 days is OK)
         CTD cast number:  -- not transmitted --
         Min pressure:  -- not transmitted --
         Max pressure:  raw 8 bits in units of 1 dbar/10 (range: 2 to 257
dbar/10)
         Min temperature:  raw 12 bits in units of 0.01  (range: 0 to 40.95  =
-5 to 35.95 °C in steps of 0.01 °C)
         Max temperature:  raw 12 bits in units of 0.01  (range: 0 to 40.95  =
-5 to 35.95 °C in steps of 0.01 °C)
         Number of samples:  -- not transmitted --
         10 profile points 0 to 9 (from total of 10 cut points):
                 Temperature:
                         Min pressure is sent separately
                         Max pressure is sent separately
                         8 broken stick pressure bins: raw 8 bits in units of 1
bin (range: 0 to 255 bin)
                         10 x Temperature:  raw 8 bits in units of 3.92157
permille (range: 0 to 1000 permille)
                         Temperature residual:  -- not transmitted --
         Temperature bounds :  -- not transmitted --
         Conductivity bounds :  -- not transmitted --
         Salinity bounds :  -- not transmitted --
         Min fluoro:  -- not transmitted --
         Max fluoro:  -- not transmitted --
         Min DOxy:  -- not transmitted --
         Max DOxy:  -- not transmitted --
         Min Light:  -- not transmitted --
         Max Light:  -- not transmitted --
        -----------[182 bits: 11 - 192]

        HAULOUT in format 0:
         Number of records:  raw 1 bits in units of 1  (range: 0 to 1 )
         Haulout number:  wraparound 5 bits in units of 1  (range: 0 to 31 )
         Start time:  max 21 days 12 hours @ 2 mins= 15480
                tx as raw 14 bits in units of 1  (range: 0 to 16383 )
                (recommended sell-by 21 days 11 hours Actual:  21 days is OK)
         End time:  max 21 days 12 hours @ 2 mins= 15480
                tx as raw 14 bits in units of 1  (range: 0 to 16383 )
                (recommended sell-by 21 days 11 hours Actual:  21 days is OK)
         Duration:  -- not transmitted --
                cf. Max duration is 1 day
         Reason for end:  -- not transmitted --
         Contiguous:  -- not transmitted --
        -----------[34 bits: 193 - 226]

        DIAGNOSTICS in format 3:
```

```
         ADC offset:  raw 6 bits in units of 25 A/D units (range: 0 to 1575
A/D units)
         Max depth ever:  raw 6 bits in units of 5 m (range: 0 to 315 m)
         Driest (max wet/dry):  raw 8 bits in units of 1  (range: 0 to 255 )
        -----------[20 bits: 227 - 246]

        Available bits used exactly
 === End of page 4 ===



PAGE 5 (special diagnostics page sent every 60 transmissions)
        PTT NUMBER OVERHEAD (28-bit code)
        -----------[8 bits: 0 - 7]

        PAGE NUMBER
        -----------[3 bits: 8 - 10]


         TX number:  wraparound 18 bits in units of 1  (range: 0 to 262143 )
         Current state:  raw 3 bits in units of 1  (range: 0 to 7 )
         Tag time (mm:ss):  raw 12 bits in units of 1 secs (range: 0 to 4095
secs)
         ADC offset:  raw 12 bits in units of 1 A/D units (range: 0 to 4095
A/D units)
         Tag hours:  wraparound 16 bits in units of 1 hours (range: 0 to 65535
hours)
         Wet/dry status:  raw 2 bits in units of 1  (range: 0 to 3 )
         Wet/dry fail count:  wraparound 8 bits in units of 1  (range: 0 to
255 )
         Body number:  raw 16 bits in units of 1  (range: 0 to 65535 )
         Max depth ever:  raw 15 bits in units of 0.1 m (range: 0 to 3276.7 m)
         Latest reset hour:  raw 16 bits in units of 1 hours (range: 0 to
65535 hours)
         Number of resets:  wraparound 8 bits in units of 1  (range: 0 to 255
)
         Wettest (min wet/dry):  raw 8 bits in units of 1  (range: 0 to 255 )
         Driest (max wet/dry):  raw 8 bits in units of 1  (range: 0 to 255 )
         GPS zero satellites:  wraparound 14 bits in units of 1  (range: 0 to
16383 )
         GPS 1-4 satellites:  wraparound 14 bits in units of 1  (range: 0 to
16383 )
         GPS 5 or more satellites:  wraparound 14 bits in units of 1  (range:
0 to 16383 )
         GPS reboots:  wraparound 4 bits in units of 1  (range: 0 to 15 )
         Number of depth spikes:  wraparound 8 bits in units of 1  (range: 0
to 255 )
         Number of CTD samples:  wraparound 22 bits in units of 1  (range: 0
to 4.1943e+06 )
        -----------[218 bits: 11 - 228]

        UNUSED
        -----------[18 bits: 229 - 246]

 === End of page 5 ===
```

Appendix F: Gray seal live capture, biological sampling, and flipper tagging on Muskeget Island, January 2014: Northeast Fisheries Science Center

Gordon T. Waring[1], Elizabeth Josephson,[2] Wendy Blay Puryear,[3] Mandy Keogh[4]

[1] Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2] Integrated Statistics, Inc, 16 Sumner St., Woods Hole, MA 02543
[3] Massachusetts Institute of Technology, 77 Mass Ave, 16-719 Cambridge, MA 02139
[4] Mystic Aquarium,Institute for Exploration, Sea Research Foundation Inc, 55 Coogan Boulevard, Mystic, CT 06355

SUMMARY

As part of the AMAPSS program, a multi-agency team conducted gray seal (*Halichoerus grypus grypus*) weaned pup live capture, biological sampling, and flipper tagging on Muskeget Island, MA from 14 – 18 January 2014, which coincided with the peak pupping period. One hundred and three pups (37 female; 62 male, 4 gender not noted) were captured. A suite of biological measurements and samples (e.g., weight, lengths, girth, blood, hair, skin, whisker, and mucous swabs) were collected, as feasible. Small numbered and labeled green Allfex[1] Temple Ear Tags were attached to each hind flippers of each seal, as feasible (i.e., tags were not attached to flippers that had open wounds).

OBJECTIVES

The goals of this project were to:

1) Collaborate with and expand Massachusetts Institute of Technology (MIT)'s influenza A virus (IAV) study in gray seal populations,
2) Collect biological samples for baseline health assessments, stable isotope, and heavy metal studies'
3) Expand external collaboration with other universities, government and non-government organizations and,
4) Evaluate the utility of using small boats from Northeast Fisheries Science Center (NEFSC) to support winter seal research at remote locations.

METHODS

SITE SELECTION, TIMING, LOGISTICS

Site selection and timing of the 14 – 18 January 2014 gray seal capture operations on Muskeget Island (Figure F1) were based on prior MIT and NEFSC experience capturing weaned grey seals on the major pupping colony in U.S. waters, expected dates of peak pupping based on NEFSC aerial monitoring surveys, and availability of boats, field personnel and weather. Field personnel were divided into two independent sampling teams. One team stayed at the Snow Cabin on Muskeget Is., whereas, the second team made weather dependent daily small boat excursions from Madaket Harbor, Nantucket, MA. Personnel were rotated between the teams.

[1] References to any specific commercial products, process, or service by trade name, trademark, or manufacturer are for descriptive purposes only and do not constitute or imply endorsement, recommendation, or favoring by the United States Government.

CAPTURE, SAMPLING AND TAGGING

Gay seal capture operations followed protocols used in prior NEFSC projects (Wood LaFond 2009) which are similar to procedures followed in other regions (Bowen et al. 2003, 2007; Debier et al. 2003) Weaned pups were captured by walking up to an animal and physically restraining it, then transferring it to a seal bag (Figure F2) for weighing. Once weighed, seals were removed from the bag and physically restrained during sampling and flipper tagging (Figure F3). The full sampling and tagging protocol for most seals included external examination, morphometrics, sex, molt stage, blood draw, whisker and hair clipping, mucous swabs, and flipper tagging, which provide skin samples. Numbered and labeled flipper tags were attached to each hind flipper. The complete sampling protocols, however were not conducted for each animal due to logistics, researchers requests (e.g. white coats only), animal activity level, or behavioral concerns (e.g., gray gums, open mouth breathing), presence of preexisting wounds, injuries, or infections. Digital images were taken of each seal. At completion of sampling, seals were left undisturbed.

RESULTS

Scientists from eight different organizations participated in this project (Table F1).

Of the one hundred and three seals that were captured, two were not flipper tagged due to behavioral concerns which led to sampling being discontinued and one pup was single tagged due to preexisting wounds on the flipper (Table F2). Tissue samples (e.g., blood, skin, hair, whiskers, mucous membranes) were collected for multiple research requests as well as for archiving, but the full suite of samples were not collected from each seal based on sample size requests and/or animal condition.

Of 103 pups sampled, 7 showed signs of actively shedding virus (with one animal shedding from 2 of the sampled sites). In addition, sera from 99 animals was screened for influenza antibodies; 13 were found to be seropositive. Of the sites sampled, conjunctiva yielded the highest number of positive samples, followed by nasal, with very few positive rectal samples.

DISCUSSION

The 2014 project continued both the MIT longitudinal study on the ecology of influenza A virus in marine animal populations, and earlier collaborative studies initiated by NEFSC. The suite of biological samples will be analyzed to address research questions pertaining to: disease, diet, contaminants, stock structure, population growth, and habitat requirements.

The 2014 effort will be continued and expanded in January 2015 in the Cape Cod and the Islands region. Further, participants on this project are also collaborating with seal researchers in Atlantic Canada, Greenland, and the UK to obtain a North Atlantic-wide understanding of gray seal population ecology. Findings from the New England component will be presented at scientific fora (e.g., 2015 Marine Mammal Biennial Conference), and in peer-reviewed journals.

The live capture and biological sampling conducted in this study demonstrated the value of collaborative research. The collective expertise of the participants helped to ensure that the project protocols were implemented in an efficient and safe manner. The collaboration also provided researchers the opportunity to share their expertise, provide in-the field training, and was critical to meeting project goals and objectives.

DISPOSITION OF THE DATA

Electronic versions of the photos and the capture and samplings logs are archived at NEFSC.

PERMITS

NEFSC was authorized to conduct seal research activities during the study under Permit No. 17670-01 issued to the NEFSC by the NMFS Office of Protected Resources.

ACKNOWLEDGEMENTS

The funds for this project came from the Massachusetts Institute of Technology, Centers for Excellence in Influenza Research and Surveillance, Bureau of Ocean Energy Management (BOEM) and the US Navy through two Interagency Agreements for the AMAPPS project. We would like to thank Mr. Crocker Snow for permission to access Muskeget Is and use of the Snow Cabin, the NMFS National Marine Mammal Health and Stranding Response Program for providing biological sampling supplies, the Nantucket Harbormaster and Madaket Marine for docking space on Nantucket, and Dr. Sarah Oakley, University of Massachusetts Boston School for the Environment Nantucket Field Station

REFERENCES CITED

Bowen, W. D., J. I. McMillan, and W. Blanchard 2007. Reduced population growth of grey seals at Sable Island: evidence from pup production and age of primiparity. Mar. Mammal Sci. 23(1):48–64.

Bowen, W. D., J. McMillan, and R. Mohn 2003. Sustained exponential population growth of grey seals at Sable Island, Nova Scotia. ICES J. Mar. Sci. 60:1265–1274.

Debier, C., P. P. Pomeroy, C. Dupont, C. Joiris, V. Comblin, E. Le Boulengé, Y. Larondelle, and J. P. Thomé 2003. Quantitative dynamics of PCB transfer from mother to pup during lactation in UK grey seals *Halichoerus grypus*. Mar. Ecol. Prog. Ser. 247:237–248.

Wood LaFond, S. A. 2009. Dynamics of recolonization: A study of the gray seal (*Halichoerus grypus*) in the northeast U.S. Ph.D. thesis. University of Massachusetts, Boston.

Table F1. Participants in the January 2014 gray seal live capture, sampling, and tagging project.

Name	Affiliation
Andrea Bogomolni	WHOI/UCONN
Erin Czeczotka	Mystic Aquarium
Rob DiGiovanni	Riverhead Foundation for Marine Research and Preservation
Lynda Doughty	Marine Mammals of Maine
Kim Durham	Riverhead Foundation for Marine Research and Preservation
Walter ‘Skip’ Graf	Mystic Aquarium
Megan Jabour	Mystic Aquarium
Beth Josephson	NOAA/NMFS/NEFSC
Mandy Keogh	Mystic Aquarium
Laura Leach	Mystic Aquarium
Milton Levin	UCONN
Ally McNaughton	Mystic Aquarium
Richard Pace	NOAA/NMFS/NEFSC
Shannon Prendiville	MARC/UNE
Justin Richard	URI
Asheley Simpson	MARC/UNE
Noel Vezzi	Mystic Aquarium
Kristen Waddell	Mystic Aquarium
Melissa Wands	Mystic Aquarium
Gordon T. Waring	NOAA/NMFS/NEFSC
Frederick Wenzel	NOAA/NMFS/NEFSC
Stephanie Wood	NOAA/NMFS/NEFSC

Table F2. Summary of the January 2014 gray seal pup captures, Muskeget Island.

Date	Start time	End time	Lat	Long	Tag ID#	Sex	Pup+Bag Mass (kg)	Straight Length (cm)	L Fore Flipper Length (cm):	L Rear Flipper Length (cm):	Ax. Girth (cm):	Body Condition
1/17/2014	13:13	13:26			157	M		117.7	18.7	25.8	104.9	Good
1/17/2014	16:05	16:16			158	M	35.2	106.3	17.3	21.2	87.4	Good
1/17/2014	10:15	10:30			159	F	51.5	114	18.2	25.6	106	not noted
1/17/2014	11:17	11:28			160	F	45.8	107.5	18.2	25.6	96	
1/17/2014	13:03		41°20.035	070°17.622	165	M	60	108	22	28	112	Good
1/17/2014	12:49	12:58	41°20.035	070°17.622	167	M	45.8	112	19	25	109	Good
1/17/2014	11:17		41°20.035	070°17.577	168	M	35.2	110	21	29	93	Good
1/17/2014	11:48	11:59	41°20.046	070°17.585	169	F	46.2	122	18	29	105	Good
1/17/2014	15:00	15:11			170	F	39.4	113.8	19.8	26.7	94.6	Good
1/17/2014	12:04	12:15	41°20.046	070°17.585	171	M	29.2	104	22	27	83	Good
1/17/2014	15:38	15:46			172	F	40.2	117.8	17.7	25.6	93.4	Good
1/18/2014	8:49	9:04			173	M	44.8	112.3	18	26.7	94.3	Good
1/17/2014	13:50	13:59	41°20.021	070°17.635	174	M	45.6	116	20	26	100	Good
1/17/2014	15:13	15:24			175	M	60.6	119.5	22.8	30.8	114.3	Excellent
1/17/2014	11:30	11:42	41°20.046	070°17.585	176	F	41.4	109	21	26	98	Good
1/17/2014	11:58	12:10			177	M	47	109.3	17.8	25.8	94	Good
1/17/2014	16:18				178	M	35.2	109.6	19.7	25.9	93.8	good
1/17/2014	10:13	10:24	41°20.033	070°17.603	179	F	39.4	99	19	27	95	Good
1/17/2014	12:35	12:45	41°20.034	070°17.626	180	M	43.4	108	19	27	108	-
1/15/2014	11:49	12:02	41°20.08	070°17.70	181	F	35.2	106	16	24	95	Good
1/15/2014	9:34	9:50	41˚20.03	70˚17.63	183	M	54.2	118	22	29	NA	Good
1/17/2014	8:09	8:22	41°20.021	070°17.629	184	F	45.6	112	18	27	111	
1/15/2014	10:51	11:05	41˚20.03	70˚17.64	185	M	51.4	113	13	24.5	107	Good
1/16/2014	15:22	15:36	41°20.036	070°17.595	186	M	47.2	100	21	26	107	Good

1/15/2014	1:32	1:42	41°20.16	70°17.67	187	F	45.4	116	19	27	-	Good
1/15/2014	12:57		41˚20.16	70˚17.67	188	M	45.2	112	18	25	-	Good
1/17/2014	9:50	10:02	41°20.021	070°17.622	189	M	37.4	103	21	26	99	Good
1/16/2014	13:12	13:32	41°20.037	070°17.595	190	F	58.7	120	18	29	na	not noted
1/16/2014	16:34	16:44	41°20.037	070°17.597	191	F	45.6	98	18	26	107	Good
1/15/2014	9:14	9:24	41˚20.03	70˚17.63	192	M	46.4	103	17	27	103	Good
1/17/2014	11:44	11:57			193	M	39	110.5	17	26.8	91.5	Good
1/15/2014	8:33	8:50	41˚20.03	70˚17.63	194	F	53.6	109	18	25	106	Good
1/15/2014	1:52	2:06	41°20.23	70°17.77	195	F	40.8	107	21	28	101	
1/15/2014	12:11	12:25	41°20.08	70°17.70	196	M	37.6	114	18	27	94	Good
1/15/2014	8:54	9:11	41˚20.03	70˚17.63	197	F	47	114	19	25.5	na	Good
1/15/2014	16:12	16:22	41˚20.057	70˚17.634	198	M	44.2	105	22	26	104	Good
1/15/2014	2:12		41°20.22	70°17.81	199	M	47.4	121	(R) 22	25	-	Good
1/15/2014	14:26	-			200	F	29.4	93	17	25	87	Good
1/15/2014	11:29	11:41	41˚20.08	70˚17.70	201	M	43.8	111	20.2	26.5	99	Good
1/15/2014	13:00	13:21	41˚20.20	70˚17.646	202	F	37.8	104	15	27	97	Good
1/15/2014	12:10	12:22	41˚20.13	70˚17.688	203	M	44.4	107	21	27	103	Good
1/16/2014	11:13	na	41°20.027	070°17.621	204	M	42.8	122	na	31	n	Good
1/15/2014	12:57		41˚20.16	70˚17.67	205	F	35	103	18	26	93	Good
1/17/2014	8:24	8:35	41°20.021	070°17.628	206	M	39.6	104	19	21	93.5	Good
1/15/2014	10:32	10:44	41˚20.03	70˚17.64	207	F	35.2	108	14	27	88	Good
1/15/2014	14:00	14:14	41˚20.186	70˚17.623	208	F	42.8	107	18	24	101.5	Good
1/15/2014	11:10		41˚20.03	70˚17.64	209	M	42.8	107	19	26	103	Good
1/15/2014	11:49	12:03	41˚20.08	70˚17.7	210	M	42	113	19	25	98	Good
1/17/2014	13:49				211	F	52.4	110.8	21.7	24.8	110.8	Good
1/16/2014	9:50	10:05	41°20.027	070°17.620	213	M	45.6	107	18	27	102	Good
1/14/2014	3:50	4:02	41˚19.99	70˚17.58	214	M	51.4	116.5	NA	NQ	NA	Good
1/14/2014	3:21	3:42	41˚20.024	70˚17.633	215	F	38.4	106	19	23	94	Good
1/15/2014	12:27	12:39	41˚20.182	70˚17.671	216	M	44.4	107	24	28.7	111	Good
1/14/2014	4:07	4:21	41˚19.99	70˚17.58	217	M	36.6	-	18	25.5	97	

1/15/2014	12:14	12:26	41˚20.03	70˚17.64	218	M	35.8	106	20	27	91	not noted
1/15/2014	13:34	-	41˚20.20	70˚17.646	219	M	42.6	107	18	28	99	not noted
1/17/2014	10:59	11:16			220	not noted	50.2	112.5	17.6	25.2	107	
1/14/2014	2:37	3:01	41˚20.025	70˚17.635	221	M			21.5	26.5	90	Good
1/14/2014	4:25	4:39	41˚19.999	70˚17.58	223	F	37.6	111	18	26	87.5	Good
1/17/2014	10:45	10:57			224	M	37.8	114	na	24	na	
1/15/2014	3:00	15:11	41°20.150	70°17.600	225	not noted	23.8	96	18	27	80	Fair, small
1/17/2014	9:14	9:26	41°20.022	070°17.622	226	M	41	103	19	25	94	Good
1/17/2014	11:02	11:14	41°20.035	070°17.577	227	M	31.4	93	17	25	88	Good
1/18/2014	9:45	9:59			229	M	47.4	123.1	-	27.1	-	Good
1/17/2014	7:57	8:08	41°20.023	070°17.629	230	M	44.6	110	20	27	93	Good
1/17/2014	14:00	14:08	41°20.021	070˚17.631	231	M	54	118	19	29	106.5	Good
1/17/2014	13:36	13:45	41°20.035	070˚17.622	232	M	44.2	117	19	26	na	Good
1/17/2014	13:15	13:25	41°20.035	070˚17.622	234	F	42.4	106	17	26	100	Good
1/18/2014	9:07	9:19			236	F	44.4	112.6	19.6	25.9	99.7	Good
1/18/2014	9:24	9:39			237		47.8	116.3	19.1	25.5	NA	Good
1/17/2014	15:48	16:03			239	M	47	118.5	15.7	26.6	99.8	Good
1/17/2014	13:02	13:10			242	F		114.3	17.5	27.1	110.5	good/Excellent
1/17/2014	10:30	10:42	41°20.032	070°17.602	243	M	51	122	21	27.5	105	Good
1/17/2014	10:32	10:44			244	M	47.4	110	18.6	27.6	101.5	not noted
1/17/2014	13:32	13:44			245	M	36.8	111.6	20.9	28.6	93.7	Good
1/17/2014	10:46	10:56	41°20.033	070°17.602	247	M	47.8	107	19	27	104	Good
1/17/2014	11:30	11:41			249	F	38.4			26.8		
1/17/2014	15:25	15:35			250	M	52.8	121.2	20.2	27.8	108.3	Excellent
1/15/2014	15:34	15:46	41˚20.152	70˚17.559	251	F	46.4	101	18	28	107	Good
1/16/2014	12:27	12:41	41°20.025	070°17.621	252	F	27	93	16	23	68	fair; small
1/16/2014	9:29	9:47	41°20.021	070°17.622	253	M	31.6	91	21	27	84	Fair
1/16/2014	10:06	10:20	41°20.026	070°17.621	254	not noted	57.6	120	25	30	109	good
1/16/2014	12:44	12:57	41°20.031	070°17.606	255	M	48.2	106.5	R 21	29	N/A	Good
1/15/2014	15:15	15:30	41˚20.141	70˚17.584	256	M	51	125	20	32	104.5	Good

1/16/2014	10:56	11:07	41°20.026	070°17.620	257	M	42.4	108	21	28	97	Good
1/16/2014	12:58	13:11	41°20.029	070°17.606	258	F	37.8	96	21	25	98	Good
1/16/2014	8:57	9:11	41°20.023	070°17.620	259	F	52.4	116	20	28	108	Good
1/16/2014	13:40	14:49	41°20.036	070°17.595	261	F	45.2	100	18	27	104	Good
1/15/2014	15:55	16:04	41˚20.109	70˚17.660	262	F	44.7	110	20	25	N/A	Good
1/16/2014	10:41		41°20.025	070°17.620	263	M	46.8	113	28	19	109	Good
1/17/2014	8:51	9:08	41°20.017	070°17.627	265	F	53.6	110	18	26	109	Good
1/16/2014	15:38	15:48	41°20.038	070°17.597	266	F	43.4	99	19	25	98	between fair/good
1/16/2014	16:05	16:15	41°20.037	070°17.597	267	M	41.2	101	19	28	102.5	Good
1/16/2014	12:13	12:25	41°20.026	070°17.620	268	M	40	100	19	29	95	Good
1/17/2014	12:11	12:26			269	M	42.2	112.4	17.6	26.4	101.2	Good
1/16/2014	10:26	10:39	41°20.025	070°17.621	270	M	51	113	20	27	107	Good
1/16/2014	14:48	15:00	41°20.021	070°17.626	271	M	39	113	19	28	99	fair/good
1/16/2014	15:07	15:20	41°20.037	070°17.596	272	M	50.2	117	19	26	106	Good
1/16/2014	16:20	16:31			273	M	46	112	R: 19	30	107	Good
1/16/2014	8:33	8:46	41°20.024	070°17.632	274	M	40.4	111	17	27	101.5	Good
1/17/2014	8:36	8:49	41°20.021	070°17.628	276	F	26.2	100	18	25	76	Fair
1/17/2014	12:47	12:59			162-no tag	M	42.2	112.3	18.7	27.6	101.7	Good
1/16/2014	15:49	15:58	41°20.037	070°17.597	260-no tag	F	44.8	113	na	29	na	

Figure F1. Muskeget Island. Image credit: Google Earth June 2014.

Figure F2. Weaned gray seal pup in seal bag. Photo credit: Milton Levin, UCONN .

Figure F3. Flipper tagged weaned gray seal pup. Photo credit

Appendix G: *Progress on processing input data and developing density models and maps: Northeast and Southeast Fisheries Science Centers*

Samuel Chavez[1], Lance Garrison[2], Joshua Hatch[1], Elizabeth Josephson[1], Christopher Orphanides[3], Joel Ortega-Ortez[4], Debra Palka[5], Doug Sigourney[1], Melissa Warden[1]

[1] Integrated Statistics, Inc., 16 Sumner St., Woods Hole, MA 02543
[2] Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149
[3] Northeast Fisheries Science Center, 28 Tarzwell Dr., Narragansett, RI 02882
[5] Northeast Fisheries Science Center, 166 Water St., Woods Hole MA 02536

SUMMARY
During 2014 we further developed two frameworks to model the spatial/temporal distribution of marine mammals and sea turtles: generalized linear and additive models (GLM/GAM), and Bayesian hierarchical models. The overall goal is to develop a tool box of methods that could be used to model the spatial/temporal distribution of marine mammals, sea turtles and seabirds. Since each species presents their own particular issues, the hope is at least one of the modeling frameworks will prove effective at modeling distribution for any given species or species group. Comparing model results across frameworks will also serve to validate the conclusions from individual modeling approaches. It is also possible a model ensemble approach could be developed. After hiring an additional scientist, this year we focused on dividing the study area into 10 km x10 km grid cells, obtaining new environmental variables, summarizing the survey and environmental variables for each grid cell, collating and calculating dive and surface times to account for availability bias in the density estimate, exploring the data, conducting initial analyses to investigate the relationships between predicted density and environmental variables to identify important environmental variables, and reworking the modeling frameworks to be more flexible and efficient. The initial analyses conducted this year involved bottlenose dolphins and large whales (fin whales, sei whales, humpback whales, sperm whales, right whales and minke whales). To improve the accuracy of the visual teams' distance measurements, a NEFSC engineer is collaborating with AMAPPS to develop an electronic range finder. An update on this development is provided.

INTRODUCTION
One of the objectives of the AMAPPS project is to develop spatially- and temporally-explicit density maps of marine mammals, sea turtles, and sea birds that incorporate environmental variables. To achieve this the Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) are developing two modeling frameworks: the "two-step" generalized linear/additive modeling framework, and the "one-step" heirarchical Bayesian framework. To utilize either of these frameworks, the input data must be collected, processed, and formatted, where the basic input data includes the sightings and effort data collected at sea and environmental variables collected from various NOAA, satellite and ocean model databases. Then both frameworks expand the observed density of individuals detected during a survey to the predicted density of individuals in that region by incorporating the following concerns. The predictions account for perception bias by using the probabability of detecting the groups of animals, which might depend on covariates such as sighting conditions, and accounts for other correction factors such as expected group size and availability bias (bias due to animals not being available due to diving). The prediction also account for environmental associations by

developing statistical models that describe the relationship between the observed density estimates and environmental factors. All of these concerns are then incorporated into the spatially- and temporally-explicit density maps.

This appendix will briefly provide a progress report of the work conducted in 2014 that relates to the estimation of the density maps.

RESULTS

WORK RELATED TO BOTH FRAMEWORKS

To prepare the data needed for both modeling frameworks, the following occurred: 1) survey data collected by the Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) were processed, 2) environmental data were collated for the entire time period from June 2010 to December 2014, 3) dive time parameters were calculated from tag data or taken from the literature, and 4) initial analyses were conducted to determine the density of the animals and the relationships between density and habitat. Each of these steps are futher explained below.

Survey data

The shipboard and aerial survey data were QA/QC'd, processed to configure the data in a consistent format, and entered into the Oracle database. Then for each 8-day temporal window within each 10 km x10 km grid cells within the study area, which is the basic sampling unit, the following was summarized:

1) amount of on-effort trackline, which is used as the effort offset in the models,
2) numbers of sightings and individuals detected for each species group, and
3) average observation conditions as recorded on the survey vessel (e.g., beaufort sea state, glare, etc.), which is used to define the detection function of the species group.

Environmental data

Environmental data are being used in the models of the spatial-temporal density of species groups. The sources of the environmental data include various NOAA, satellite and ocean model databases. The available data include physiographic parameters (Table G1) and environmental variables (Table G2). Methods to incorporate ocean fronts and sea surface height were also explored but are not completed yet. Also, analyses were conducted on the most appropriate sources and scales of sea surface temperature (SST).

In general for the physiographic parameters, the data were downloaded from the source using a bounding box whose extent covered the AMAPPS study region. Then data were re-sampled to the AMAPPS 10 km x 10 km oblique Mercator grid using primarily bilinear interpolation. In some cases a nearest-neighbor interpolation scheme based on the great circle chord length between centroids of the data source and AMAPPS grid cells was used.

The environmental variables were obtained on a 8-day basis when available. The images were retrieved starting on January 4 of each year and were "spatially synced" applying the 'spatial.tools' R package http://cran.r-roject.org/web/packages/spatial.tools/spatial.tools.pdf) to the AMAPPS grid cells. The syncing process altered the original raster image so that it conformed to the same extent, projection and grid resolution as the AMAPPS grid cells and bilinear interpolations of values were used to create a new raster layer. Where the 8-day means were not available, daily images were downloaded and spatially synced to the 10 km x 10 km grid, each 8 days averaged, and an annual raster brick constructed from the 8-day mean and standard deviation rasters.

In case of missing environmental variables data within the AMAPPS study area, a simple interpolation was used to replace missing values. The hierarchy for the sources of replacement values was, first, the calculated mean from the nearest-neighbor from the non-missing data grid cells, and then if that was not sufficient, the mean value for the specific grid cell of the 8-day period before and after.

Dive data

Dive time patterns are used to correct the density estimates derived from survey data where there are high chances of missing a group of animals that are close to the track line because the animal spends a long time under the surface. This is particularly needed for long-diving species detected during the aerial surveys; species such as sea turtles, sperm whales, and beaked whales. The information needed to develop the correction factor are the average time spent at the surface (area where animal could be seen from the survey platform) and average time spent below the surface. Examples of studies that have utilized such correction factors includes NMFS (2011) and Borchers *et al.* (2013).

To obtain the surface and dive times several sources are being explored. First, the literature on previous dive studies of cetaceans was searched and collated. Second, loggerhead turtle dive data collected from satellite tags were analyzed and are described in more detail in Appendix E. And third, dive data collected from DTAGs that were attached to a variety of cetaceans by a variety of researchers were analyzed to derive the average surface and dive times.

A literature search found 75 papers that provided surface and dive times for the following species: sperm whales, minke whales, blue whales, fin whales, Bryde’s whales, humpback whales, right whales, bowhead whales, Blaineville’s beaked whales, Cuvier’s beaked whales, killer whales, false killer whales, white-sided dolphins, white-beaked dolphins, belugas, bottlenose dolphins, common dolphins, striped dolphins, Atlantic spotted dolphins, pantropical spotted dolphins, Risso’s dolphins, short-finned pilot whales, long-finned pilot whales, and harbor porpoises. These animals were from around the world, including the North Atlantic (Gulf of Maine, Bay of Fundy, Florida, St. Lawrence estuary, Caribbean, Venezuela, Greenland, Iceland, Svalbard, Faroe Islands, Canary Islands, Azores, Madeira Island, UK, Scotland, Denmark, Italy, Ligurian Sea, Mediterranean, and Adriatic Sea), North Pacific (Southern California bight, California, Mexico, Oregon, Washington, British Columbia, Hawaii, Galapagos, Bering Strait, Russia, Alaska, Beaufort Sea, and Japan), Gulf of Mexico (Tampa Bay), and the Southern Hemisphere (Antarctica, South Georgia, and New Zealand).

Several researchers who have put on DTAGs on cetaceans over the last few years have generously provided us with part of the processed data from these tags. From Michael Thompson at the NOAA Stellwagon Santuary we received data from 63 tags from humpback whales from the Atlantic that were tagged during 2005 – 2012. From Ari Friedlaender who collaborated with Andy Read and collegues, we received data from 20 pilot whales and 2 fin whales from the Atlantic that were tagged during 2010 – 2012. From Ari Friedlander in collaboration with Brandon Southall and collegues, we received data from 52 blue whales, 17 fin whales, 2 minke whale, 29 Rissos dolphins, 6 Cuvier's beaked whale, and 1 Baird's beaked whale from the Southern California region that were tagged during 2011 – 2014.

All of these DTAG data contain a time series of dives and surfacings. A dive was defined as ≥ 2 m below the surface. A dive cycle was defined as a complete dive followed by a complete surfacing interval. The first dive cycle after the animal was tagged was deleted because of possible reaction to the tagging. The last dive cycle was also deleted because the tag had most likely become detached from the animal. Day time and night time dives were defined according to cutoffs at 0600 and 1930, which generally correspond to sunrise and sunset in summer months (most tagging took place June – August). Several tags had only the relative time that the tag was on the animal (i.e., the time of day that the animal was tagged was unknown), and so day and night could not be defined. For each animal, the average dive duration and its standard error were calculated, and the average surfacing duration and its standard error were also calculated. Dive cycles were stratified by day and night when that information was available.

Electronic range finder "eRanger"

An electronic range finder "eRanger" was developed by NEFSC at the request of the Protected Species Branch. The finished design was initially tested on a Marine Mammal cruise in FY12 on board the NOAA Ship *Henry Bigelow* (Figure G1).

In FY13, testing was done dockside to see how well the eRanger would perform with the new mounting unit design. The mounting assembly performed well. The eRanger device remained securely fastened to the mounting assembly and remained stable. NEFSC personnel performed functional tests on the device to see how well the eRanger could compute the range to various known objects in the water. This additional testing revealed a flaw in the electronics design. Accurate ranges were obtained for objects that were close to the eRanger/BigEyes binoculars. However, when attempting to obtain range measurements for objects that were closer to the horizon, the eRanger device could not effectively separate the object's distance with the distance to the horizon. It was determined that the digital inclinometer used in the eRanger design did not have enough angular resolution to discriminate ranges at this distance. The MEMs digital inclinometer used in this design had a Pitch/Roll angular resolution of 0.1 degrees. A more accurate inclinometer with a resolution of 0.001 degrees will be needed for this design.

Finding a high resolution inclinometer with a resolution of 0.001 degrees was difficult. All inclinometers with this type of resolution proved to be cost prohibitive. As a result, design of the eRanger electronics will be overhauled. The new design will incorporate an InvenSense MPU-9150 9-axis motion processing unit (MPU) which incorporates a 3-axis accelerometer, a 3-axis gyroscope, and a 3-axis magnetometer into a single micro electro-mechanical (MEM) chip (Figure G2). Data fusion will need to be done using either a "Kalman" filter, or a "Complimentary" filter, to get precise roll, pitch, and yaw information. This design will include an Intel Edison mini-CPU to handle the complex mathematics needed for the data fusion.

Initial general analyses

Four initial analyses were conducted before either of the modeling frameworks were applied. During 2014, these initial analyses were applied mostly to the large whales (fin whales, sei whales, sperm whales, humpback whales, right whales, and minke whales). One, to address a modeling assumption, the statistical relationships between the environmental variables were explored. Two, to explore the data, locations of track lines and sightings were mapped, and histogram distributions of the perpendicular distances were plotted for each species and platform. Three, to speed up data processing and to prevent extrapolating outside a species' habitat, for each species, the spatial habitat for each species was defined. Four, to further explore the data and since the Bayesian hierarchical framework is computer intensive, we conducted some initial explorations between the density of animals and environmental variables to determine a set of environmental variables that highly related to the density of the animals. Each of these analyses are described in more details below.

One, to explore the statistical relationships between the environmental data, the environmental variables in Tables G1 – G2 were tested for correlations among themselves. The consequence of this is sets of environmental variables that are highly correlated will not be used together within a density model. For example, bottom depth and bottom roughness are linearly related to each other so a final density model would not contain both of these variables, but if significant, the model would contain only one of these two variables.

Two, the maps of the distribution of sightings were used in defining the spatial habitats. The histograms of perpendicular distances were used in determining which species, if any, have to be pooled in order to conduct analyses with sufficient sample sizes.

Three, to define the spatial habitat for each species, the following was considered: locations of sightings seen during the AMAPPS 2010 – 2014 surveys; locations of sightings seen during other surveys (for example, Stock Assessment Reports and the OBIS-SEAMAP database); locations the species was heard on bottom mounted passive acoustic detection devices; and a cluster analysis of the environmental variables as related to the density of AMAPPS sightings.

Four, initial explorations into the relationship between the density of animals and environmental variables were to determine a set of environmental variables that are highly related to the density of the animals. This involved first estimating density of each species using the DISTANCE computer package, then modeling the relationships between the density (derived from DISTANCE) and environmental variables within the grid cells that had survey effort. The species investigated during 2014 were the large whales: fin whales, sei whales, humpback whales, sperm whales, minke whales, right whales and a unidentified fin or sei whale group.

The species density was estimated for each grid cell using the information collected by the NEFSC and SEFSC during spring, summer and winter from 2010 to 2013 aerial and shipboard surveys following the methodology described in Palka (2012) with the assistance of the DISTANCE package (Thomas *et al*., 2010). The detection function models calculated the probability of detecting a group on the track line and species density using mark-recapture with the independent observer fitting method, which assumed two independent teams of observers per platform. The truncation distance for a better fit was adjusted for each group of species and observation platform, and the model selection was based on the goodness-of-fit using the AIC score (Akaike information criterion, Akaike, 1974), Chi-square test, Kolmogorov-Smirnov Goodness-of-Fit Test, and a visual inspection of the fit.

All possible predictors (Tables G1 – G2) were tested for autocorrelation to avoid redundancy in the analysis, by using a series of generalized additive models to identify the significant covariates to the species density previously calculated. All analyses were performed with R statistical software (R core team, 2014) and the mgcv R package (Wood 2011). Separate GAM models were fitted to species density using the static parameters and oceanographic covariates. The models were defined under the Tweedie distribution with the p parameter value set at 1.2

with null space penalization, thin plate splines with shrinkage (bs="ts") and REML set as optimization criterion. In addition, the k value was set at 5, limiting the smooth to 4 degrees of freedom. Any covariate with $p<0.05$ on each individual model was recommended to be further analyzed using the Bayesian hierarchical framework.

BAYESIAN HIERARCHICAL FRAMEWORK

The Bayesian hierarchical framework used to model and predict the spatial distribution of protected species in the Atlantic Ocean, is often referred to as a "one-stage approach" because both the observation uncertainty and process uncertainty are integrated within one comprehensive modeling framework (Miller *et al.* 2013). The Bayesian approach allows for straightforward probabilistic conclusions to be derived directly from the posterior distributions of the model. In addition, the Bayesian framework allows for prior information to be integrated into future predictions. Despite these advantages there are relatively few examples of applying Bayesian hierarchical methods to estimate habitat-density relationships in marine environments.

Using visual line transect data

In 2013 our work focused on trying to implement previously published models as well as developing our own statistical framework. During 2014 we continued to build upon the modeling framework developed in 2013. We expanded the model to accommodate multiple platforms (i.e., aerial and shipboard surveys) and combine data from surveys conducted by both the Northeast Fisheries Science Center (NEFSC) and the Southeast Fisheries Science Center (SEFSC). We also included species-specific information on dive cycles to correct for availability bias. We tested the model a number of times with simulated data to verify that all components were working properly. We continued to model data on fin whales to test the model performance. We also expanded the model to look at other species of large whales including minke whales, humpback whales and sperm whales. Finally we worked on writing code to organize and summarize results including making figures of the detection function and all habitat functions, summarizing posterior estimates for all parameters and computing goodness of fit statistics and model selection criteria. In addition we explored how to incorporate spatial autocorrelation. Although some methods exist, at this time we choose not to incorporate these techniques in the modeling process as the low densities of animals most likely will result in a negligible amount of spatial autocorrelation (SAC). However, we will calculate the amount of SAC from the final models and summarize the degree of SAC using the Moran's I test statistic.

Additional work to be done in 2015 includes:

- As available, incorporate additional habitat variables that may help explain distribution patterns
- Explore modeling group size separately from the detection function and habitat relationship
- Include estimates of uncertainty in all maps
- Use auxiliary information to validate the models including information collected in hydroacoustic surveys
- Develop spatially explicit maps for each season for a number of species.

Using visual and passive acoustic data

It continues to be one of the modeling goals of AMAPPS to incorporate information from the passive acoustic surveys into the overall modeling framework. This information can be invaluable as it will allow us to address availability bias, and hence, be able to derive more accurate estimates of population size. It will also provide an important subsidy of data for more cryptic species such as beaked whales that are difficult to detect at the surface. We are collaborating with members of the passive acoustic group to organize data for sperm whales and explore methods to use that information in spatial density estimation. We have begun to explore methods such as Hidden Markov Models in modeling the information available from acoustic surveys. We plan to continue this work in 2015.

GENERALIZED LINEAR AND GENERALIZED ADDITIVE MODELING FRAMEWORK

Regression modeling is one of the most commonly used techniques to model relationships between cetacean distributions and habitat variables (Redfern *et al.* 2006). This framework involves a four step process:

(1) First the observed numbers of animals within a basic unit (grid cell or segment of the trackline) is corrected for the probability of detection derived from Distance sampling theory (e.g., Laake and Borchers, 2004).

(2) Then the spatially and temporally referenced density in each spatial unit that had survey effort is modeled as a function of habitat, space and time covariates.

(3) Finally a predicted density surface is created using these two relationships and the distribution of environmental factors in the un-sampled units.

(4) Estimates of uncertainty in the predictions can be generated using bootstrap resampling approaches. Variance estimation reflects the uncertainty in both the estimation of detection probabilities and the variability associated with the habitat/spatial model.

During 2013, this framework was explored using bottlenose dolphin data collected from the Southeast aerial surveys and monthly 10-year climatological averages of some environmental variables. During 2014, work was conducted to stratify survey and environmental variables into 10 km x 10 km grid cells and 8-day temporal windows. This involved creating weighted averages within each cell for survey data such as track line effort, and sea state conditions. Also all of the SE aerial and shipboard data were extensively QA/QC'd, standardized and then entered into the Oracle database.

In 2014, the code behind the GLM/GAM framework was updated to work within the grid cell environment. In addition, the bootstrap method was also further developed during 2014. For example, this involved creating the bootstrap resampling segments of the track lines.

In addition, in 2014 the hidden Markov modeling technique (Borchers *et al.* 2013) was investigated. Though this looks like a promising advancement, at this point in time it is difficult to blend this technique with the two-team mark-recapture technique, so this avenue was temporarily set aside.

REFERENCES CITED

Borchers, D.L., W. Zucchini, M.P. Heide-Jørgensen, A. Caňadas and R. Langroch. 2013. Using hidden Markov models to deal with availability bias on line transect surveys. *Biometrics* 69, 703-713.

Miller, D.L., L.M. Burt, E.A. Rexstad and L Thomas. 2013. Spatial models for distance sampling data: recent developments and future directions. Methods in Ecology and Evolution. doi: 10.1111/2041-210X.12105

Northeast Fisheries Science Center. 2011. Preliminary summer 2010 regional abundance estimate of loggerhead turtles (Caretta caretta) in northwestern Atlantic Ocean continental shelf waterst. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 11-03; 33 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

Palka, D. 2012. Cetacean abundance estimates in US northwestern Atlantic Ocean waters from summer 2011 line transect survey. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 12-29: 37 p. Available from National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications/

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: http://www.R-project.org.

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

Wood, S.N. 2011. Fast stable restricted maximum likelihood and marginal likelihood estimation of semi parametric generalized linear models. Journal of the Royal Statistical Society (B) 73(1):3-36

Table G1. Physiographic parameters considered in the modeling frameworks

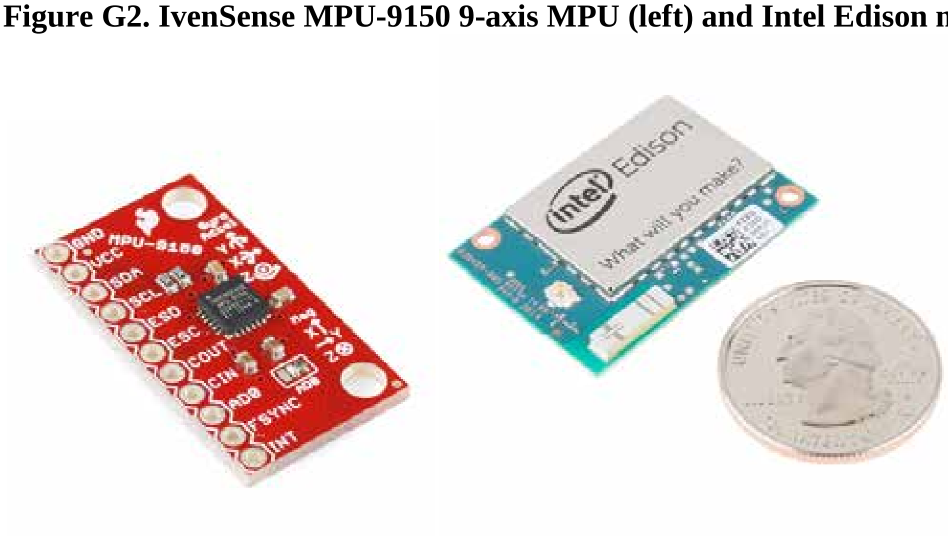
Parameter	Description	Source
DEPTH	Bathymetry (m)	http://www.ngdc.noaa.gov/mgg/global/global.html
DIST2SHORE	Distance to coastline (m)	http://oceancolor.gsfc.nasa.gov/DOCS/DistFromCoast/
SLOPE	Seafloor slope (degrees)	http://www.ngdc.noaa.gov/mgg/global/global.html
TRI	Terrain position index	http://www.ngdc.noaa.gov/mgg/global/global.html
TPI	Terrain ruggedness index	http://www.ngdc.noaa.gov/mgg/global/global.html
ROUGH	Roughness	http://www.ngdc.noaa.gov/mgg/global/global.html
SED	Sediment (ϕ)	http://pubs.usgs.gov/ds/2005/118/
DIST200	Distance to 200 m isobaths	Calculated
DIST1000	Distance to 1000 m isobath	Calculated

Table G2. Environmental variables considered in the modeling frameworks

Variable	Description	Source
SST	Sea surface temperature (°C)	http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdGAssta8day.graph
CHLa	Chlorophyll a (mg m^{-3})	2010-2011 http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdMEchla8day.graph 2012-2013 http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdVHchla8day.graph
PP	Primary productivity (mgC m^{-2} yr^{-1})	http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdPPbfp28day.graph
PIC	Particulate inorganic carbon (mol m^{-3})	http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdMPIC8day.graph
POC	Particulate organic carbon (mg m^{-3})	http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdMPOC8day.graph
BOTTEMP	Bottom temperature (°C)	https://hycom.org/data
SALINITY	Salinity (psu)	http://www.marspec.org
MLD	Mix layer depth, depth at which the temperature changes from the surface by 0.2 deg °C (m)	https://hycom.org/dataserver/glb-analysis

Figure G1. eRanger mounted to BigEyes Binoculars.

Figure G2. IvenSense MPU-9150 9-axis MPU (left) and Intel Edison mini CPU (right).



Appendix H: *Progress on passive acoustic data analyses: Northeast and Southeast Fisheries Science Centers*

Danielle Cholewiak[1] and Melissa Soldevilla[2]

[1]Integrated Statistics, Inc., 16 Sumner Street, Woods Hole, MA 02543
[2]Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149

SUMMARY

The goal of the AMAPPS-related work conducted by the Northeast, Southeast and Southwest Fisheries Science Center's passive acoustic groups is to collect acoustic data that complement the visual-based analyses of animal occurrence and abundance, particularly for species that are difficult to detect by the visual observers, or in times of year and regions where visual surveys are not conducted. There are currently five primary analyses involving towed array and archival bottom-mounted recorder data collected during the AMAPPS surveys. These are: (1) estimating the abundance of sperm whales (*Physeter macrocephalus*) using acoustics, where the ultimate goal is to integrate these with visual abundance estimates to account for availability bias; (2) quantifying acoustic detection rates for beaked whales, with the goals of comparing to visual detection rates and estimating acoustic abundance for this taxon, if possible; (3) testing the performance of a newly-developed Atlantic version of the Real-time Odontocete Call Classification Algorithm (ROCCA), where the ultimate goal is to determine which delphinid species may be confidently identified acoustically in the absence of visual species identification; (4) documenting the offshore spring/summer occurrence of baleen whales in the Great South Channel and Georges Bank regions to supplement visual sighting data, and (5) assessing geographic variation in the echolocation clicks of Risso's dolphins (*Grampus griseus*).

Additional collaborative projects related to AMAPPS are ongoing with colleagues, including the development of an acoustic database, Tethys (http://tethys.sdsu.edu/). Tethys is being developed in collaboration with scientists from the Scripps Institution of Oceanography and the other NOAA Science Centers, and will utilize standardized formats for archival of metadata associated with our acoustic data collection and analyses, including AMAPPS data.

BACKGROUND AND OBJECTIVES

Passive acoustic technologies have become a critical component of marine mammal monitoring, contributing information about the spatial and temporal occurrence, distribution, and acoustic behavior for a variety of species. Some species, such as beaked whales, have low visual detection rates (Barlow *et al.* 2005); while reliable sighted of most species cannot be detected visually at night or when conditions are poor. Data collected from acoustic studies provide important new insights about species occurrence, including abundance estimation for species that are often poorly detected visually (e.g., Marques *et al.* 2009), presence of species in regions that are difficult to otherwise survey (e.g., Moore *et al.* 2012), and the response of individuals to anthropogenic activities that produce underwater sound (e.g., Castellote *et al.* 2012). Archival recorders, gliders, and towed hydrophone arrays offer the opportunity to collect data on cetacean occurrence and distribution that complements traditional visual survey methodologies.

The goals of the passive acoustic groups at the Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) include improving our understanding of cetacean acoustic ecology, so that we may improve abundance estimation and develop more effective monitoring and management strategies where needed.

The main objectives of incorporating passive acoustic data into AMAPPS include:

1) Improve abundance estimates of odontocetes in the western North Atlantic using acoustic data collected from towed hydrophone arrays, particularly for sperm whales, beaked whales, and delphinids;
2) Improve our understanding of the spatial and temporal distribution and relative abundance of baleen whales along the western North Atlantic using bottom-mounted archival recorders; and
3) Evaluate the efficacy of towed hydrophone array and archival recorder data collection with comparison to traditional visual data collection to determine where data from these different platforms may be integrated.

METHODS

Processing of passive acoustic data took place using a variety of software packages. Automated detection and tracking of sperm whales (*Physeter macrocephalus*) and beaked whales from towed hydrophone array data were conducted using Pamguard (version 1.12.05 Beta, Gillespie et al. 2008), as well as custom-written Matlab scripts. Abundance estimation was conducted using the software package DISTANCE. Visual and aural reviews of spectrograms and extraction of delphinid whistles were conducted using the software packages Raven (version 1.4, Bioacoustics Research Program 2011) and Xbat (Figueroa and Robbins 2008), executed in Matlab. Bottom-mounted recorder data were reviewed for baleen whale acoustic activity using custom-written software, the Low-Frequency Detection Classification System (LFDCS, Baumgartner et al., 2013).

RESULTS

PROJECT 1. ACOUSTIC ABUNDANCE ESTIMATES OF SPERM WHALES: NEFSC AND SEFSC

NEFSC

Sperm whale analyses conducted in 2014 focused on finalizing the extraction of sperm whale acoustic event data from the northeast AMAPPS 2013 survey (HB13-03). The software package Pamguard was used to apply specialized echolocation click detectors to quantify the number of acoustic sperm whale encounters, and two-dimensional localization algorithms were used to localize and track individual animals. Approximately 790 sperm whales were detected acoustically during the survey; 528 could be localized and tracked in two-dimensions (Figure H1). Some of these may represent repeat detections of the same individuals, as some tracklines were covered more than once during the survey. The software package DISTANCE is being used to estimate sperm whale abundance based on the acoustic data from both the AMAPPS 2011 and 2013 surveys.

SEFSC

With the hire of an acoustic technician in November 2014, SEFSC efforts in 2014 focused on finalizing sperm whale analyses from the AMAPPS 2011 summer survey. Data were reanalyzed using Pamguard detection and localization algorithms similar to those applied by NEFSC. Approximately 214 sperm whales were detected acoustically during the survey, with 199 localized and tracked in two-dimensions. Similar analyses are beginning for the AMAPPS 2013 summer survey so that sperm whale abundance can be estimated based on both surveys using DISTANCE software.

PROJECT 2: ACOUSTIC DETECTIONS OF BEAKED WHALES (family: Ziphiidae): NEFSC

Analyses in 2014 focused on quantifying the acoustic detection rate for all beaked whale species using towed hydrophone array data collected during the NEFSC AMAPPS 2013 and 2014 shipboard surveys. Individuals were also localized in 2-D, and species were identified where possible. Three surveys were analyzed: HB13-03 (summer 2013), GG 14-02 (spring 2014), HB 14-03 (summer 2014). Beaked whales were detected most often in the summer AMAPPS 2013 shipboard survey, with over 120 positive acoustic events (Table H1). The software package Pamguard is being used for the review and localization of acoustic echolocation events. Custom-written Matlab scripts are being used to compare acoustic beaked whale events to templates of known species for the purposes of species identification. Analyses are in process; once complete, acoustic detections will be compared to visual sightings. In addition, analyses will test whether acoustic detection rates for these taxa vary depending on the use of active acoustic echosounders during shipboard surveys. Similar analyses using SEFSC AMAPPS survey data are scheduled to begin in 2015.

PROJECT 3: EVALUATION OF ROCCA (REAL-TIME ODONTOCETE CALL CLASSIFICATION ALGORITHM)-NEFSC AND SEFSC

An algorithm for classifying delphinid whistles to species called the Real-time Odontocete Call Classification Algorithm (ROCCA) has been developed by Dr. Julie Oswald (Biowaves). In 2012, both NEFSC and SEFSC contributed data for the development of an Atlantic species-specific version of ROCCA. The first Atlantic version of ROCCA was completed and implemented into the software platform Pamguard in 2013. This version includes automated whistle classifiers for five species (*Globicephala sp., T. truncatus, D. delphis, S. frontalis, S. coeruleolaba*).

To test the performance of ROCCA, data collected by both the NEFSC and SEFSC during the AMAPPS 2013 shipboard surveys were analyzed. Visual sightings were reviewed to identify visually-confirmed encounters with single-species delphinid groups. Specific criteria were applied to select appropriate encounters for acoustic analyses (including: distance from vessel, distance to other groups, visual sighting conditions, etc.). Whistles from seventeen single-species groups were extracted for analyses from towed hydrophone array recordings from each of the NEFSC and SEFSC datasets (n=349 NE whistles; n=563 SE whistles). In the NEFSC data, whistles from encounters with *Tursiops truncatus* had the highest overall correct classification rate (73%), followed by *Stenella frontalis* (33%), *Globicephala spp.* (16%), and *Stenella coeruleoalba* (13%). *Tursiops truncatus* also had the highest overall correct classification rate in SEFSC data (83%), followed by *Stenella frontalis* (53%) and *Globicephala spp.* (12%). Confusion matrices show that whistles that were misclassified were most often classified as *Tursiops* (Tables H2 and H3). Further data are being provided to Dr. Oswald for continued development and improvement of the classifier.

PROJECT 4: BALEEN WHALE SPRING/SUMMER OCCURRENCE IN THE NORTHEAST OFFSHORE REGION- NEFSC

Ten archival, bottom-mounted recorders (MARUs) were deployed along the shelf break from the northern region of Georges Bank to Hudson Canyon on the NEFSC spring AMAPPS shipboard survey, in April 2014. The units were programmed to record continuously, at a sampling rate of 2 kHz. Nine units were successfully recovered in September 2014; one unit was not recovered (Figure H2). Of the nine recovered units, eight recorded for the entire deployment period, while one unit failed several weeks after the initial deployment. Acoustic data have been extracted and are currently being prepared for analyses.

PROJECT 5: GEOGRAPHIC COMPARISON OF RISSO'S DOLPHIN ECHOLOCATION FEATURES - SEFSC

A large-scale comparison of the spectral features of Risso's dolphin echolocation clicks is being conducted at the SEFSC as part of a collaborative effort with researchers at NEFSC, PIFSC, SEFSC, Scripps Institution of Oceanography, and Duke University Marine Laboratory. The goals of this study are to 1) determine if Risso's dolphins around the globe exhibit similar spectral banding patterns to those found off southern California which allow them to be acoustically classified, and 2) determine if there are geographically-driven differences among the acoustic frequencies of spectral bands which may indicate population structure. In 2013, click detectors were run on recordings from forty-six Risso's dolphin encounters, including twenty from AMAPPS surveys, using custom detectors built in a Matlab-based software, Triton. Two methods were used to extract and compare spectral peaks within encounters and across locations, including a click spectrum clustering algorithm and a peak picking algorithm and MANOVA analysis (Figure H3). Across all encounters, spectral banding was a consistent feature of Risso's dolphin echolocation clicks (Figure H4). Among encounters, both methods show similar results, with distinct acoustic groupings in the Pacific Ocean, and greater variability within and among encounters in the Atlantic Ocean and Gulf of Mexico. This suggests acoustic methods can accurately identify Risso's dolphins in all regions, and may be useful for investigating population variability in the North Pacific. This work was presented at the Spring 2014 Acoustical Society of America conference in Providence, RI and a manuscript is being prepared for publication in a peer-reviewed journal.

DISPOSITION OF DATA

Acoustic data are stored on-site at the Northeast Fisheries Science Center and the Southeast Fisheries Science Center.

ACKNOWLEDGEMENTS

The Bureau of Ocean Energy Management (BOEM) and the US Navy through Interagency Agreements for the AMAPPS project provided the funds for the 2014 acoustic data collection and partially funded the analysis projects. Additional funding was provided by the Navy's Living Marine Resources Program for analyses and by NOAA Fisheries NEFSC for staff time.

We would like to thank the crew of the NOAA ships *Henry B. Bigelow* and *Gordon Gunter*, the AMAPPS visual observers and field acousticians, and the NEFSC Large Whale team for assistance in data collection. We would also like to thank Julianne Cossavella for assistance with the ROCCA analyses, Samara Haver and Annamaria Izzi for assistance with the NEFSC analyses, and Brijonnay Madrigal and Kimberly Prince for assistance with SEFSC sperm whale analyses.

REFERENCES CITED

Barlow, J., M. Ferguson, W. Perrin, L. Balance, T. Gerrodette, G. Joyce, C. MacLeod, K. Mullin, D. Palka and G. Waring. 2005. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). J. Cet. Res. Manag. 7:263-270.

Baumgartner, M, D. Fratantoni, T. Hurst, M. Brown, T. Cole, S. Van Pajis and M. Johnson M. 2013. Real-time reporting of baleen whale passive acoustic detections from ocean gliders. Journal of the Acoustical Society of America 134:1814-1823

Bioacoustics Research Program 2011. Raven Pro: Interactive Sound Analysis Software (Version 1.4) [Computer software]. Ithaca, NY: The Cornell Lab of Ornithology. Available from http://www.birds.cornell.edu/raven

Castellote, M., C.W. Clark and M.O. Lammers. 2012. Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise. Biological Conservation **147**, 115–122.

Cholewiak, D., S. Baumann-Pickering, S.M. Van Parijs. 2013. Description of sounds associated with Sowerby's beaked whales (*Mesoplodon bidens*) in the western North Atlantic Ocean. Journal of the Acoustical Society of America 134(5): 3905-3912.

Figueroa, H.K. and M. Robbins. 2008. "XBAT: An Open-Source Extensible Platform for Bioacoustic Research and Monitoring," In K.-H. Frommolt, R. Bardeli, and M. Clausen (Eds.), Computational bioacoustics for assessing biodiversity(Bundesamt für Naturschutz, Bonn), pp. 143–155.

Gillespie, D., J. Gordon, R. McHugh, D. Mclaren, D. Mellinger and P. Redmond. 2008. PAMGUARD: semiautomated, open source software for real-time acoustic detection and localisation of cetaceans. Proc Inst Acoust 30(5).

Marques, .T, L. Thomas, J. Ward, J. DiMarzio and P. Tyack P. 2009. Estimating cetacean population density using fixed passive acoustic sensors: an example with Blainville's beaked whales. Journal of the Acoustical Society of America, 125: 1982-1994.

Moore, S.E., K.M. Stafford, D. Mellinger, C. Berchok, Ø. Wiig, K.M. Kovacs and C. Lydersen. 2011. Comparing marine mammal acoustic habitats in Atlantic and Pacific sectors of the High Arctic: year-long records from Fram Strait and the Chukchi Plateau. Polar Biology **35**, 475–480.

Northeast Fisheries Science Center (NEFSC), Southeast Fisheries Science Center (SEFSC). 2011. 2010 Annual Report to the Inter-Agency Agreement M10PG00075/0001: A Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the western North Atlantic Ocean or online at http://www.nefsc.noaa.gov/psb/AMAPPS/docs/Final_2010AnnualReportAMAPPS_19Apr2011.pdf

Table H1. Acoustic detections of beaked whales and number of individuals localized (in parentheses) in analyses of NEFSC AMAPPS 2013 and 2014 shipboard survey data. Positive, probable and possible indicate the degree of certainty that a given acoustic event is correctly classified as a beaked whale.

Survey	Species	Positive	Probable	Possible
HB13-03	Cuvier's	71 (58)	26 (19)	28 (6)
	Mesoplodon	51 (44)	6 (4)	10 (2)
	Total	122 (102)	32 (23)	38 (8)
GG14-02	Cuvier's	0 (0)	1 (1)	0 (0)
	Mesoplodon	0 (0)	1 (0)	2 (0)
	Total	0 (0)	3 (1)	3 (0)
HB14-03	Cuvier's	4 (3)	5 (2)	8 (0)
	Mesoplodon	2 (1)	2 (2)	2 (0)
	Total	6 (4)	7 (4)	10 (0)

Table H2. ROCCA confusion matrix using passive acoustic data collected during the NEFSC AMAPPS 2013 shipboard survey. A total of 349 whistles extracted from 17 single-species encounters were subjected to classification testing. Most misclassifications were assigned to *Tursiops*. Tt = Tursiops truncatus; Sf=Stenella frontalis; Gm=Globicephala spp; Sc=Stenella coeruleoalba; Dd=Delphis delphis; Ambig=ambiguous.

	Classified as species					
Actual species	Tt	Sf	Gm	Sc	Dd	Ambig
Tt	73%	23%	5%	0	0	0
Sf	57%	33%	9%	0	1%	0
Gm	40%	34%	16%	9%	1%	0
Sc	43%	12%	7%	13%	5%	0

Table H3. ROCCA confusion matrix using passive acoustic data collected during the SEFSC AMAPPS 2013 shipboard survey. A total of 563 whistles extracted from 17 single-species encounters were subjected to classification testing. Most misclassifications were assigned to *Tursiops*. Tt = Tursiops truncatus; Sf=Stenella frontalis; Gm=Globicephala spp; Sc=Stenella coeruleoalba; Dd=Delphis delphis; Ambig=ambiguous.

	Classified as species					
Actual species	Tt	Sf	Gm	Sc	Dd	Ambig
Tt	83%	11%	5%	0.4%	0.4%	0.4%
Sf	45%	53%	2%	0	0	0
Gm	56%	31%	12%	0	0	1%

Figure H1. Map showing locations sperm whales that were acoustically detected and localized using a towed hydrophone array during the NEFSC AMAPPS 2013 summer shipboard survey. Approximately 790 individuals were detected; 528 of these were localized. The light blue lines indicate daytime tracklines during which the hydrophone array was deployed. The dark blue lines indicate nighttime tracklines during which the hydrophone array was deployed. Orange dots indicate acoustically-detected sperm whales.

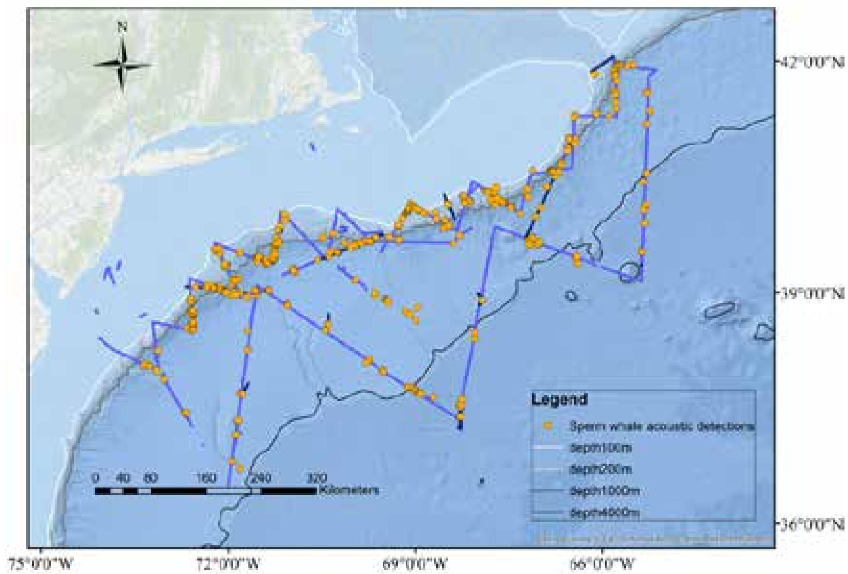


Figure H2. Map showing locations of the archival marine autonomous recording units (MARUs) deployed during the spring northeast AMAPPS survey. Recorders were deployed from April – September 2014. The recorder at Site 1 failed two weeks into the deployment; the recorder at Site 9 was lost.

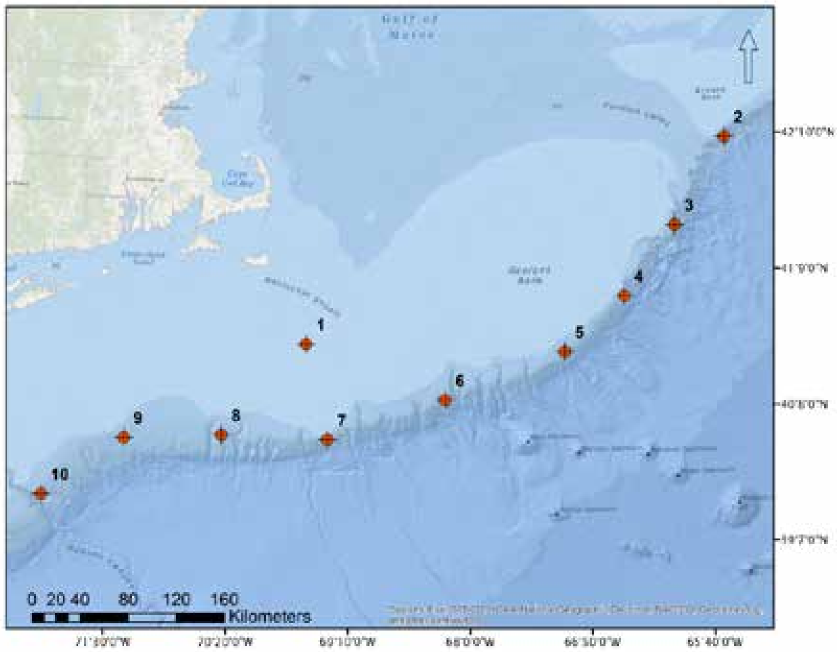


Figure H3. Spectral comparison of Risso's dolphin stocks. Mean click spectra by NOAA stock (a) and MANOVA clustering of click frequency peaks by stock (b). Significantly distinct stocks are indicated by differences in color in the MANOVA dendrogram.

A. B.

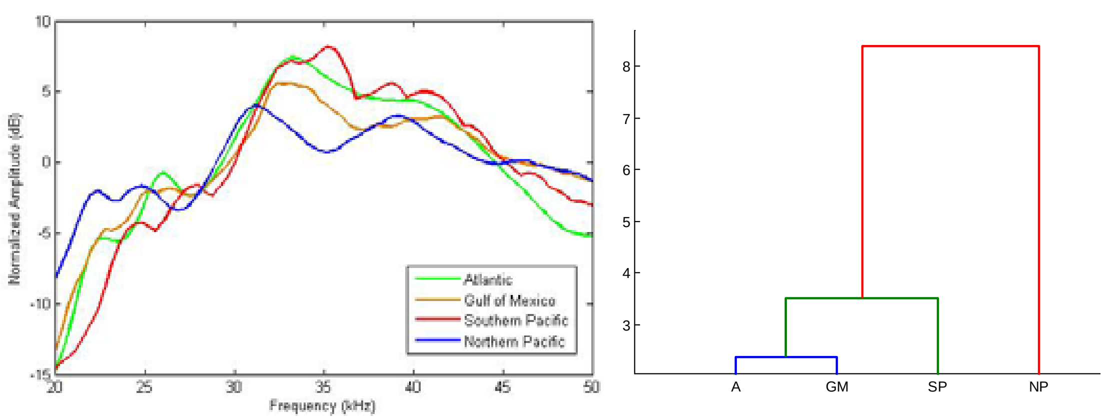
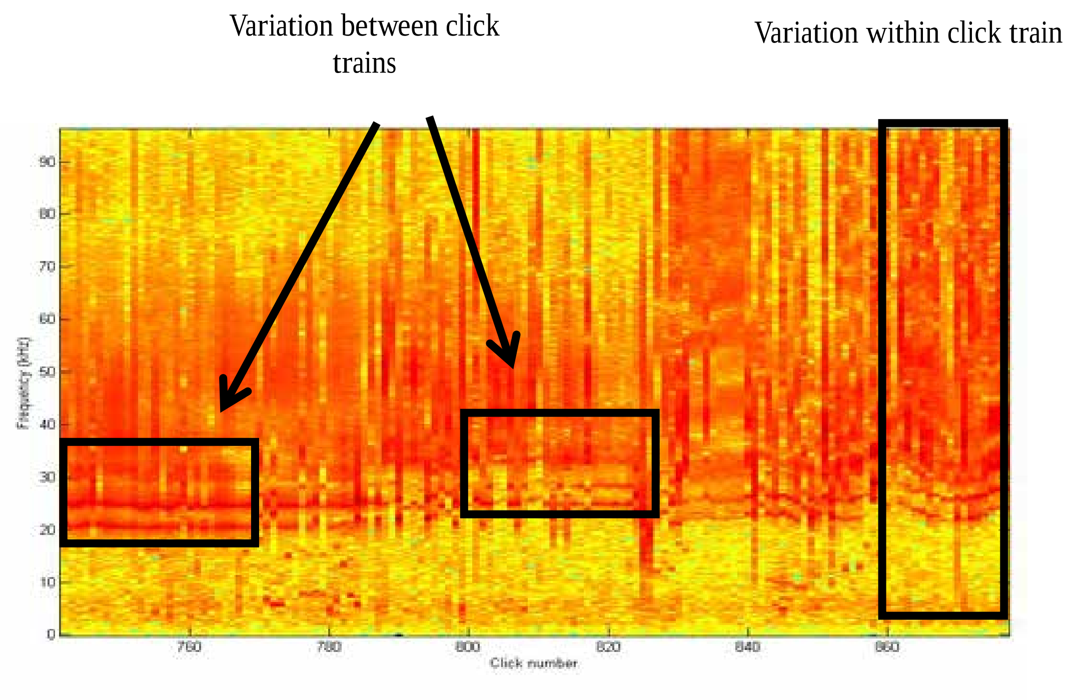


Figure H4. Concatenated spectrogram of automatically detected clicks from an Atlantic Ocean encounter indicating presence of frequency banding within an encounter, as well as variability in band frequencies throughout an encounter which represent variation between individuals' click trains and within an individual's click train.



Appendix I: Progress on analyses of oceanographic, acoustic, and plankton data: Northeast Fisheries Science Center

Elisabeth Broughton[1], Michael Jech[1], Gareth Lawson[2], Michael Lowe[2] and Erin LaBrecque[3]

[1]Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2]Woods Hole Oceanographic Institution, Biology Dept, MS34, Woods Hole, MA 02543
[3]Duke Marine Lab, 135 Duke Marine Lab Rd, Beaufort, NC 28516

SUMMARY

To attempt to gain a better understanding of the underlying processes that may drive the distribution and abundance of predators, such as marine mammals, sea turtles, and sea birds, the hydrographic characteristics of the water column and distributions of lower trophic level organisms such as fish and plankton relative to distribution patterns of protected species are being investigated. The data have been collected during shipboard surveys conducted during the 2009, 2011, 2013, and 2014 AMAPPS NEFSC surveys. Physical water characteristics and distribution and densities of various fish and planktonic trophic levels were documented using: Seabird 19+ and 911 CTD, Video Plankton Recorder (VPR), 61cm bongo net, 1-m^2 Multiple Opening/Closing Net Environmental Sensing System (MOCNESS), a 6 ft and 10 ft Issac Kidd Midwater Trawl (IKMT), a midwater trawl, and multifrequency Simrad EK60 echosounders. During 2014 good progress has been made to post-process most of the physical data and enumerate most of the biological samples. In addition, work has started on comparing the distributions of cetaceans relative to the distribution of prey detected by the EK60. During 2015, the post-processing should be completed which will then allow a more through comparison between distributions of predators (marine mammals, sea turtles and sea birds) and their prey as documented in the EK60, VPR and other sampling devices.

BACKGROUND AND OBJECTIVES

One of the objectives of the AMAPPS initiative is to develop spatially explicit density maps of cetaceans, sea turtles, and sea birds that incorporate environmental habitat characteristics. We are currently using static and dynamic environmental variables that are readily available (such as satellite-derived sea surface temperature), see Appendix G. However, as Palacios et al. (2013) state these types of variables are simply correlative and not related to the processes that are the important drivers of animal distribution. One way to attempt to account for the underly processes is to compare the distribution and density patterns of marine mammals, sea turtles, and sea birds with the patterns of other trophic levels and patterns of the physical environment. Hydrographic, active acoustic, and plankton data were collected during the 2009, 2011, 2013, and 2014 AMAPPS NEFSC surveys to map the lower trophic levels and oceanographic conditions of the study area.

METHODS

Physical water characteristics and distribution and densities of various fish and planktonic trophic levels were documented using: Seabird 19+ and 911 CTD, Video Plankton Recorder (VPR), 61cm bongo net, 1-m^2 Multiple Opening/Closing Net Environmental Sensing System (MOCNESS), a 6 ft and 10 ft Issac Kidd Midwater Trawl (IKMT), a midwater trawl, and multifrequency Simrad EK60 echosounders. The daytime sampling schedule was set by the visual observation teams. Bongo samples were collected along the visual-observation transect line three times daily and a hydrographic cast was made at the start and end of each day's line to provide sound speed data for the active and passive acoustic sampling. During all cruises, night sampling targeted biological layers shown by acoustic backscatter data collected from the ship's Simrad EK60 multifrequency scientific echosounder systems. In 2009 and 2011, nighttime sampling was conducted as close as possible to the daytime visual transect lines.

In 2013 and 2014 nighttime in addition to the sampling along the shelf break canyons, cross shelf transects at locations away from any canyon were also sampled for comparison. This will allow the examination of the degree to which these bathymetric features concentrate lower trophic levels. Canyon sampling was conducted along cross-canyon transects positioned approximately mid-canyon and at the head of the canyon. Hydrographic casts were conducted along the mid-canyon line at the canyon rims on either side, half way down each flank, and at the canyon axis. Acoustic data were collected continuously and biological sampling directed at scattering features of interest. Cross-shelf lines ran approximately perpendicular to depth contours with hydrographic casts made at about 3 nmi intervals.

VPR DATA

During the nighttime hours, tows were conducted with a Seascan V-fin mounted, internally recording, black and white VPR. The VPR was also equipped with a Seabird Fastcat CTD, a Wetlabs fluorometer / turbidity sensor and a Benthos altimeter. The VPR sampled at 16 frames per second with each frame representing a known volume of water. A second SEACAT 19+ CTD profiler was mounted above the V-fin and connected to the 0.322 dia conducting core cable to provide real time data on gear depth and oceanographic conditions. Tows were conducted at 3-4knots speed through the water to minimize image frame overlap. VPR haul depth was limited to 300m but most hauls were deployed to less than 100m depth to maximize sampling time in the strongest biological layers.

Two types of tows were conducted. Single depth tows to target clear layers of backscattering seen on the 120 and 200 kHz EK60 frequencies to help calibrate the EK60 data and study plankton patchiness. Tow-yo hauls (oscillating between the surface and a predetermined depth) through the biological layers seen on the EK60 to quantify plankton vertical distributions. Because the net samplers were negatively impacted by the large numbers of gelatinous zooplankton present in all years of the study, the VPR was also used to quickly survey the plankton in the sampling area before deciding if/how to deploy the larger net samplers.

Upon retrieval, the compressed data from the VPR were downloaded to specialized image processing computers. Data were decompressed, oceanographic data files were created, and in focus regions of interest (ROIs) were extracted from each image frame using Autodeck programming from Seascan. Interpolated profiles of temperature, salinity, density, raw chlorophyll and raw turbidity values were created for each tow-yo type haul using MATLAB. Each haul ROI set was processed to remove images of air bubbles and duplicate images. ROIs were then identified to general taxonomic grouping using a modified version of Visual Plankton developed by Cabell Davis of the Woods Hole Oceanographic Institution.

BONGO DATA

Plankton and hydrographic sampling was conducted by making double oblique tows using the 61-cm bongo net and a Seabird CTD. Standard ECOMON sampling protocols were employed.

The tows were made to approximately 5 m above the bottom, or to a maximum depth of 200 m. All plankton tows were conducted at a ship speed of 1.5 – 2.0 knots. The bongo 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 timing of the sunset). Bongos were also deployed at night to fill special sample requests.

MOCNESS DATA

Additional plankton sampling was conducted with a 1-m^2 MOCNESS equipped with 9 nets, each with 333 µm mesh, targeting larger plankton towed at 1-1.5 knots to maintain close to a 45º net angle. The MOCNESS system was also equipped with a color VPR and strobes that increase the catchability of euphausiids. The 1-m^2 MOCNESS was deployed in the canyon and cross shelf transect areas to further quantify scattering layers observed on the EK60 120 and 38 kHz frequencies. Deployment sites were selected in areas of high backscatter and low quantities of gelatinous zooplankton (as determined by visual inspection of the VPR images). Deployments were a single double oblique tow to depths around 500m with one net remaining open during the entire downcast and 8 nets opened during the upcast providing vertically discrete plankton samples. Depths selected for net opening and closing were based on oceanographic features and backscattering layers seen on the EK60.

IKMT DATA (2013 AND 2014 ONLY)

Larger zooplankton and small, mesopelagic fishes in the canyon and cross shelf transect areas was also sampled using a 6 ft beam Issac Kidd mid-water trawl (IKMT) with a ¼ in mesh net and 1mm mesh cod end. The IKMT was deployed off of the side in a single double oblique profile. Sampling depth was determined by targeting the deepest scattering layers seen on the 38kHz frequency of the EK60 that could be reached with the length of wire available (about 350 m). While the IKMT only provides depth integrated samples it can be towed at speeds up to 3.5 knots so can be more successful at capturing mesopelagic fish than the 1-m^2 MOCNESS.

In 2014 a larger IKMT with a 10 foot beam was deployed off the stern of the ship. The stern deployment allowed faster tow speeds and deeper hauls. This sampling method combined with the larger net area significantly increased the catches of mesopelagic fish and larger pelagic crustaceans such as shrimp that are a primary food of beaked whales.

MIDWATER TRAWL (2014 only)

A modified Marinovich midwater trawl (i.e., “shallow water midwater trawl”) was used as the primary trawl to sample pelagic fish and macrozooplankton. The shallow water midwater trawl was deployed with 1.8 m superkrub doors, 100 lb tom weights, 30 fathom bridles, and was fished at about 3 knots. The mouth opening when “fishing” was approximately 6 x 8 m (horizontal x vertical). The codend liner was ¼” knotless nylon. A polytron midwater rope trawl was brought as a backup, but was not deployed. The midwater trawl was monitored during deployment by a Simrad FS70 trawl sonar mounted on the head rope, and by two Vemco temperature-depth recorders with one mounted on the head rope and one on the foot rope. The FS70 provides real-time data, which were recorded to a file and archived at the NEFSC. The Vemco recorders were initialized immediately prior to each deployment and the data were downloaded to a PC after each deployment.

SIMRAD EK60

Acoustic backscatter was collected using multifrequency (NOAA ship *Henry Bigelow*: 18, 38, 70, 120, and 200 kHz; NOAA ship *Gordon Gunter*: 18, 38, 120, and 200 kHz) Simrad EK60s. In 2009 (HB0903), 2011 (HB1103), and 2013 (HB1303), active acoustic data (when the EK60 transmits a sound pulse (i.e., "ping") and listens for echoes) were collected continuously during nighttime. In addition, active acoustic data were collected during daytime on every second day or during periods where visual surveying was not conducted (e.g., transit). During periods where active data were not collected, the EK60 was typically secured (so that it was not transmitting or receiving) or it was set to passive mode (when the EK60 only listens and there is no transmit pulse). The purpose for securing the EK60 or collecting data in passive mode was to evaluate whether the EK60 affected marine mammal behavior. During 2014 (GU1402 and HB1403), active acoustic data were collected continuously throughout a cruise, mostly in active mode and occasionally in passive mode. The EK60s were set to transmit at 1 ping per second, which allowed the EK60s to ping as fast as they could given the sample range of 3000 m and signal processing time. In general the EK60s transmitted once every 5-6 seconds when off the continental shelf. In active mode, each frequency transmitted a 1-ms CW pulse.

The EK60s were calibrated at the end of GU1402 and at the beginning of HB1403 using the standard target method at the Newport Naval Anchorage. A 38.1-mm tungsten carbide with 6% cobalt binder sphere was suspended at about 20 m range from the transducers and was used to calibrate all frequencies. A wireless calibration system, consisting of three remotely controlled downriggers, and automated software were used to initially position the target under the split-beam transducers and the software automatically moved the sphere throughout the acoustic beams. The data were collected and then the Simrad Lobe program was used during data playback for each EK60 individually.

As an example of how the EK60 backscatter data can be compared to marine mammal distribution, of all of the ship's tracklines during the 2011 summer survey in which the EK60 was recording data, 19 cross shelf tracklines with marine mammal sightings were chosen to investigate the distribution of acoustic regions of interest. Seven tracklines were surveyed once. Six tracklines were either fully or partially surveyed twice at least 24 hours after the initial pass. For this analysis, the EK60 tracklines were named according to continuous acoustic data collection, not marine mammal survey tracklines.

After the initial cleaning of the 2011 EK60 data, acoustic shelf break transects with marine mammal sightings were visually inspected in Echoview to define acoustic regions of interest (acoustic ROIs) based on intensity of scattering at 18 and 200 kHz. These regions were exported to MATLAB and the frequency response, using all five frequencies, of each region was compared to the frequency response of fish with swim bladders, euphausiids and copepods based on theoretical backscattering models developed at WHOI. Parameters for the euphausiid and copepod theoretical backscattering models were based on Lavery et al. (2007) and fish scattering model parameters were based on Lee (2013). Because ground-truthing net tows were not conducted during the 2011 survey, length and abundance distributions for each category of acoustic scatters (fish with swim bladders, euphausiids, copepods) were approximated based on the primary literature. The acoustic ROIs were classified into categories: fish-like, euphausiid-like/large micronekton, copepod-like/small micronekton, U-shaped, and other.

To investigate the distribution of ROIs along shelf break tracklines we employed simple multiple linear regression models to explore the relationship between depth of an ROI, its morphology, and/or the region along the trackline in which it was found. Ripley's K analysis was used to describe the spatial point pattern. We postulated that the depth of an ROI can be explained by its morphology, either a patch or a layer, and the region of the trackline in which it was found: shelf, shelf break and offshore of the shelf break. Shelf break regions were assigned as follows:

- shelf break region – 15 km shoreward to 15 km off shore of the shelf break;
- shelf region – the trackline over the continental shelf not assigned to the shelf break region;
- off shore of the shelf break region – the off shore region of the trackline not assigned to the shelf break region.

For this analysis, the 150 m isobaths was used as the shelf break. ROI depth was measured at the centroid of the ROI. For the most part, the assumptions of linear regression were not violated. Residuals did not appear over or underestimated when plotted against raw values and residuals appeared to follow normality on a Q-Q plot. No outliers were detected with Cook's distance. Significance of the models was set at an alpha of 0.05 and models were compared using analysis of variance and Akaike Information Criterion (AIC). Adjusted-R^2 values were calculated to assess how much variability was explained by the models. All statistical analyses were performed in R (R Core Team 2014) with the addition of the package 'spatstat' (Braddeley and Turner 2005) to perform the Ripley's K analysis.

RESULTS

VPR DATA

Oceanographic data from the VPR mounted sensors tow-yo VPR hauls have been plotted to characterize the shelf slope boundary, inshore, and offshore areas sampling areas. Data from the fluorometer and turbidity sensors represent relative intensities of fluorescence and water clarity, respectively. In general tracklines crossing the shelf/slope boundary were difficult to conduct on a regular schedule due to the amount of fixed gear (long line and lobster pots) found in this environment. Oceanographic data from the single depth hauls has also been processed and plotted to visualize small scale variations in oceanographic conditions at a distinct depth.

Seacat 19+ CTD data from the first upcast of each haul has been processed and posted to the oceanography branch website (http://www.nefsc.noaa.gov/epd/ocean/MainPage/).

VPR plankton ROIs (extracted images) have been used to create several classification databases for various camera settings. Each taxonomic level, grouped by the lowest taxonomic grouping possible, has a minimum of 200 images. Image sets were combined into larger groupings to create a set of images used with Visual Plankton to create a generic plankton classifier for each camera setting to run on the unidentified ROIs from each individual VPR haul.

The generic classifiers for each camera setting have seven categories:

- *Gelatinous* – salps, ctenophores, hydromedusae, dolids, Scaphozoa
- *Marine snow*
- *Large Crustacea* – Euphasiids (krill), Hyperidea, Gammaridea, shrimp
- *Copepoda* – copepods, Brachyura zoea, Ostrocoda
- *Phytoplankton*
- *Line like* – Larvacean, Chaetognatha (arrow worm), Polychaeta, some phytoplankton

- *Other* – larval fish, veligers, unknowns, pteropoda….

Specialized classifiers for unique areas such as Nantucket Shoals or Delaware Bay have also been developed to increase classification accuracy. Currently the classifier puts about 40% of the ROIs into the *Other* category. Work has been started to create a secondary classifier that will be used to more accurately identify the *Other* category ROIs. As more precise classifiers are created ROIs for all AMAPPS cruises will be re-classified.

Significant changes were made to the post identification MATLAB routines to create plots and databases that can be used to further the AMAPPS goals of describing the lower trophic levels. Spreadsheets have been created that include oceanographic data and both numeric and area plankton category densities. Data be can be interpolated in both time and/or depth bins allowing for a wide variety of visualizations. Data are available upon request.

VPR data have also been binned to match the EK60 processed data. Formulas are being developed to compute the time delay between each EK60 data bin and VPR data bin. This will allow the direct comparison of plankton densities and the 200 kHz and 120 kHz scattering signals from the active acoustics. Signal strength calibrations will also begin considering if the acoustic signal is affected by the type of plankton present and the size limitations of each frequency. At sea observations from the 2011 – 2014 cruises have suggested that small, insubstantial plankton like marine snow, phytoplankton, or small hydromedusa are imaged by the VPR but are not ensonified by the 200 kHz frequency.

The next step being taken is to create environmental descriptions that can be compared to the distributions of marine mammals and birds, which will involve determining the number and size of sampling sub-areas to be described, and level of detail of needed to delimitate distinct habitats.

A general overview of habitat in the study area shows both annual and geographical variation. Comparing a set of VPR hauls conducted in July (HB1303 in 2013, HB1103 in 2011, HB0903 in 2009) near the middle of Visual Transect 25 show very consistent oceanographic conditions between hauls from the same cruise, and consistent conditions between years (Figure I1).

Because slightly different classifiers were used each year, plankton data was merged into 4 larger categories.

- Crustacea = includes the *Large Crustacea* and *Copepoda* catagories
- Gelatinous = the *Gelatinous* category
- Snow/Phyto = includes the *Marine Snow*, *Line like* and *Phytoplankton* categories
- Other = the *Other* category

These categories were selected with the EK60 data in mind. The Crustacea category includes all the plankton with a hard carapace, the Gelatinous category has a wide size range but has no hard parts, the Snow/Phyto category is most likely not seen by the EK60, and the Other category is a combination of the previous three categories. Comparison of the plankton from the same VPR hauls from transect 25 (Figure I2) shows consistency between hauls from the same cruise (HB0903) but large differences in plankton densities and the species composition of the gelatinous category between years.

For comparison the study area was divided into four large scale habitats:

- Offshore = bottom depth over 3000 m,

- Slope = bottom depths between 200 and 2000 m
- Shelf = bottom depths between 60 and 200 m
- Inshore = bottom depth less than 60 m

Comparing hauls from each area covered by the AMAPPS cruise in 2011 show all areas with a thermocline between 20 and 40 m but with highly variable temperature and salinity ranges (Figure I3). Plankton densities are highest around the thermocline in all areas but overall densities increase as you move from offshore up the slope towards the shelf and inshore areas (Figure I4).

While offshore habitat conditions show consistent oceanographic and plankton densities between VPR hauls from the same year (Figures I1 – I2, HB0903), the inshore and shelf hauls strongly vary. A comparison of two hauls done on Nantucket Shoals in August 2013 processed using station specific classifiers show just how variable oceanographic conditions, plankton densities, and species composition can be (Figure I5).

NET PLANKTON DATA

The bongo samples were shipped to the Polish Sorting Center for processing. The zooplankton from the nets with 333 μm mesh were split to subsamples of 500 – 1000 individuals and identified to the lowest possible taxonomic and lifestage level possible and enumerated. All ichthyoplankton from the 505 μm mesh nets was identified to the lowest taxonomic level possible, enumerated, and the standard lengths of a subset measured. Completed data have been loaded into the NMFS oracle plankton database.

The MOCNESS and 6 ft IKMT samples are currently being processed at the Polish Sorting Center. All Ichthyoplankton will be removed, identified to the lowest taxonomic level possible, enumerated, a subset measured, and all preserved in EtOH for additional study. Each net sample will then be split to subsamples of 500 – 1000 individuals and identified to the lowest possible taxonomic and lifestage level possible and enumerated. Data are currently available upon request but will soon be loaded into the NMFS Oracle plankton database.

Samples from the small midwater trawl and l0 ft IKMT were identified to major taxonomic grouping at sea and identified to species by the Woods Hole and Narragansett laboratories (Table I1).

MIDWATER TRAWL

Four midwater trawl deployments were conducted in July 2014 (HB1403). Two tows sampled the acoustic scattering layer between 500 and 600 m, and two tows sampled acoustic scattering layers between 50 and 100 m. The deep tows captured shortfin squid, other cephalopod species, and a number of mesopelagic fish species, such as slender snipe eels, ridgehead species, and viperfish species. The shallow tows were dominated by myctophids such as *Benthosema* and *Diaphus* species.

SIMRAD EK60

Multifrequency echosounder data were collected intermittently during HB0903 (Figure I6). During HB1103, data were collected on the two-day cycle, with continuous day and night acquisition on day “1” and with the echosounders secured during daylight observation efforts on day “2” (Figure I7). EK60 data were collected continuously throughout each survey in 2013 and 2014 (Figures I8 – I10), with intervals of active and passive modes. EK60 data were stored on a portable hard drive, archived at the NEFSC, and sent to NOAA's National Geophysical Data Center for permanent archive.

Postprocessing of EK60 data has been prioritized based on area, time, and activities. Postprocessing of active acoustic data includes removing the echo from the seabed and any electronic, acoustic, or bubble noise. All data collected during HB1403 were postprocessed daily at sea (Figure I10), whereas no HB0903 (Figure I6) or GU1402 (Figure I9) data have yet been postprocessed. The majority of data collected during daylight hours have been postprocessed for HB1103 (Figure I7) and HB1303 (Figure I8), whereas night data during HB1303 have been postprocessed during specific activities, such as surveys of canyons or cross-shelf transects at selected sites.

Representative echograms are shown in Figures I11 – I13. Shelf-breaks typically have increased acoustic backscatter (Figure I11), which is a combination of higher densities of organisms as well as greater diversity of organisms, i.e., the shelf break is the transition from continental shelf to deep oceanic water. Echograms from oceanic water typically showed a scattering layer between 400 and 600 m depth, a portion of which did not vertically migrate, and layers in the top 300 m that did often vertically migrate at dawn and dusk (Figure I12). These layers were sampled with a midwater trawl and an IKMT net in 2014 (Table I2). Localized surveys of canyons show spatial distributions of organisms within canyons and often show disparities in acoustic backscatter between sides of the canyon and/or longitudinal location within the canyon (Figure I13).

In the comparison of the 2011 EK60 results and marine mammal distributions (Figure I14), acoustic ROIs were classified based on the frequency response of visually selected acoustic patches and layers (example is centroids shown in Figure I15 as asterisks). The modeled frequency response of euphausiids between 1 – 6 cm and the backscatter values from the EK60 for four acoustic ROIs are shown in Figure I16 (curve and asterisk colors are not comparable to that in I15). Modeled results are an individual’s acoustic target strength (TS) in decibels while data from the EK60 system are volumetric backscatter (Sv) in decibels. If multiple animals of the same size are within the ROI, the modeled scattering curve will shift upward and predict greater scattering levels while the location of the inflection point of the curve will not change. The frequency response of these four acoustic ROIs follows the general shape of the modeled backscatter for euphausiids – lower scattering values at 18 kHz, higher scattering values at 120kHz that decrease at 200kHz. The first inflection point of the acoustic ROIs is comparable to the first inflection point of the 6 cm euphausiid backscatter model, but is shifted above the theoretical curve indicating more than one individual.

Of the 19 acoustic legs processed, 13 – 63 acoustic ROIs were classified per leg. Most were classified as fish-like (with a swim bladder), euphausiid/large micronekton-like, or copepod/small micronekton-like. A U-shaped curve was observed in 11 of the 19 shelf break tracklines but does not resemble a known frequency response curve. Acoustic ROIs categorized as “possible” represent regions where the general shape of the frequency response curve matched one of the scattering models but did not conclusively fit the curve. The U-shape curve is possibly the frequency response of a mixed assemblage of middle trophic organisms. The average depth of acoustic ROIs per trackline ranged from 33 m to 259 m for fish-like acoustic ROIs, 16 m to 359 m for euphausiid-like acoustic ROIs, and 65 m to 330 m for copepod/small micronekton-like acoustic.

Each acoustic ROI was also classified as either a "patch" or a "layer" to describe its morphology. A simple linear model suggest that patches were found deeper than layers (Figure I17). Adding the region of the trackline into the model as both an additive effect and a multiplicative effect did not improve the model (Table I3). The assumption of independence for a linear model was violated because the observations were spatially autocorrelated, but these simple models suggest there is a unique spatial distribution to the types and morphologies of acoustic ROIs. We used Ripley's K analysis (Ripley 1977) to summarize the point pattern of the ROIs and to explore questions of spatial distribution and pattern association. This analysis is currently being written up and will be submitted for publication in 2015. Two manuscripts describing the distribution of acoustic ROIs in relation to hydrographic properties (mentioned above) and sighting of marine mammals in the shelf break region will be submitted to peer-reviewed journals in 2015.

ACKNOWLEDGEMENTS

The data collection was funded by the Bureau of Ocean Energy Management (BOEM) and the US Navy through two Interagency Agreements for the AMAPPS project and by the NOAA Fisheries Service. Data processing and analysis of the plankton data was funded by the Fishery Oceanography Branch of the Northeast Fisheries Science Center. In addition, the data processing and analyses of the hydrographic and hydro-acoustic data from 2011 was primarily funded by the Nancy Foster Scholarship Program with additional support from the Oak Foundation (XBTs), and the WHOI-Duke Fellowship in Marine Conservation.

REFERENCES CITED

Baddeley, A. and R. Turner. 2005. Spatstat: an R package for analyzing spatial point patterns. *Journal of statistical software*, *12*(6), 1-42.

Lavery, A. C., P. H. Wiebe, T. K. Stanton, G. L. Lawson, M. C. Benfield, and N. Copley. 2007. Determining dominant scatterers of sound in mixed zooplankton populations. The Journal of the Acoustical Society of America 122:3304–3326.

Lee, W.-J. 2013. Broadband and statistical characterization of echoes from random scatterers: application to acoustic scattering by marine organisms. Dissertation: Massachusetts Institute of Technology, Boston, MA.

Palacios DM, Baumgarter MF, Laidre KL and Gregr EJ. 2013. Beyond correlation: integrating environmental and behaviourally mediated processes in models of marine mammal distribution. Endang Species Res 22: 191-203.

Ripley, B.D. 1977. Modelling spatial patterns (with discussion). J. R. Statist. Soc. B 39, 172-212.

Wenzel FW, Polloni PT, Craddock JE, Gannon DP, Nicolas JR, Read AJ and Rosel PE. 2013. Food habits of Sowerby's beaked whales (Mesoplodon bidens) taken in the pelagic drift gillnet fishery of the western North Atlantic. Fishery Bulletin 111(4): 381-389.

Table I1. Processing status of oceanographic and plankton samples. Complete = data are available, identified = sample is processed but data have not yet been posted to a database, shipped = sample is in Poland being identified, in progress = samples are being processed.

Cruise		HB0903	HB1103	HB1303	GU1402	HB1403
CTD	# Sta	65	104	242	202	15
	Status	complete	complete	complete	complete	in progress
Bongo Z	# Sta	25	85	83	125	11
	Status	complete	complete	complete	shipped Oct14	
Bongo I	# Sta	24	84	81	125	11
	Status	shipped Oct14	complete	complete	shipped Oct14	shipped Oct14
VPR TowYo	# Sta	25	46	16	10	none
	Status	complete	complete	complete	complete	NA
VPR Fixed	# Sta	0	35	14	0	0
	Status	NA	complete	complete	NA	NA
MOC 1m I	# Sta	0	0	8	1	none
	Status	NA	NA	77 nets identified	7 nets shipped Oct14	NA
MOC 1m Z	# Sta	0	0	8	1	0
	Status	NA	NA	75 nets identified	7 nets shipped Oct14	NA
MOC/VPR	# Sta	0	0	8	none	0
	Status	NA	NA	in progress	NA	NA
IKMT 6'	# Sta	0	0	10	1	0
	Status	NA	NA	identified	shipped Oct14	NA
IKMT 10'	# Sta	0	0	0	0	1
	Status	NA	NA	NA	NA	in progress
Midwater	# Sta	0	0	0	0	3
	Status	NA	NA	NA	NA	identified

Table I2.Taxa collected using a 10 ft Isaacs-Kidd Midwater Trawl on HB1403 at a station located at 40º20.3 N 67 º15.0 W. The taxa shaded in gray were identified from the stomachs of Sowerby's beaked whale (*Mesoplodon bidens*) taken in the drift net fishery along the shelf break east of Georges Bank (Wenzel et al. 2013).

Taxa	Common Name	Number Collected	Standard Length (mm)		
			Minimum	Maximum	Mean
Nemichthys scolopaceus	Slender Snipe-Eel	3	110.0	900.0	598.3
Nettastoma melanurum	Blackfin Sorcerer	8	230.0	430.0	351.9
Bathylagichthys greyae	Grey's Deepsea Smelt	1	48.0	48.0	48.0
Cyclothone spp.	Unidentified Bristlemouth	134	15.0	54.0	27.9
Gonostoma spp.	Unidentified Bristlemouth	2	170.0	270.0	220.0
Argyropelecus aculeatus	Longspine Silver Hatchetfish	5	19.0	52.0	35.2
Maurolicus spp.	Unidentified Hatchetfish	3	13.0	26.0	19.5
Borostomias spp.	Unidentified Barbeled Dragonfish	1	95.0	95.0	95.0
Stomias spp.	Unidentified Dragonfish	1	57.0	57.0	57.0
Arctozenus risso	White Barracudina	1	83.0	83.0	83.0
Benthosema glaciale	Glacier Lanternfish	46	13.0	64.0	39.0
Ceratoscopelus maderensis	Horned Lanternfish	5	9.0	33.0	22.2
Myctophidae damaged	Damaged Myctophidae	2			
Melamphaes longivelis	Eyebrow Bigscale	1	96.0	96.0	96.0
Scopelogadus beanii	Bean's Bigscale	4	35.0	74.0	60.3
Gobiidae	Unidentified Goby	1	11.5	11.5	11.5
Gempylidae	Unidentified Snake Mackerel	1	25.0	25.0	25.0
Bothus spp.	Unidentified Lefteye Flounder	2	15.0	20.0	17.5
Aluterus heudelotii	Dotterel Filefish	1	38.0	38.0	38.0

Table I3. Summary of linear model between depth of an EK60 region of interest (ROI) and the shape of that region (either a patch or a layer).

Model Number	Formula	AIC
1	ln(depth ~ ROI shape)	5859.780
2	ln(depth ~ ROI shape + trackline region)	5831.657
3	ln(depth ~ ROI shape * trackline region)	5827.655

Figure I1. Temperature and salinity traces for 7 VPR hauls conducted near the middle of Visual Transect 25.

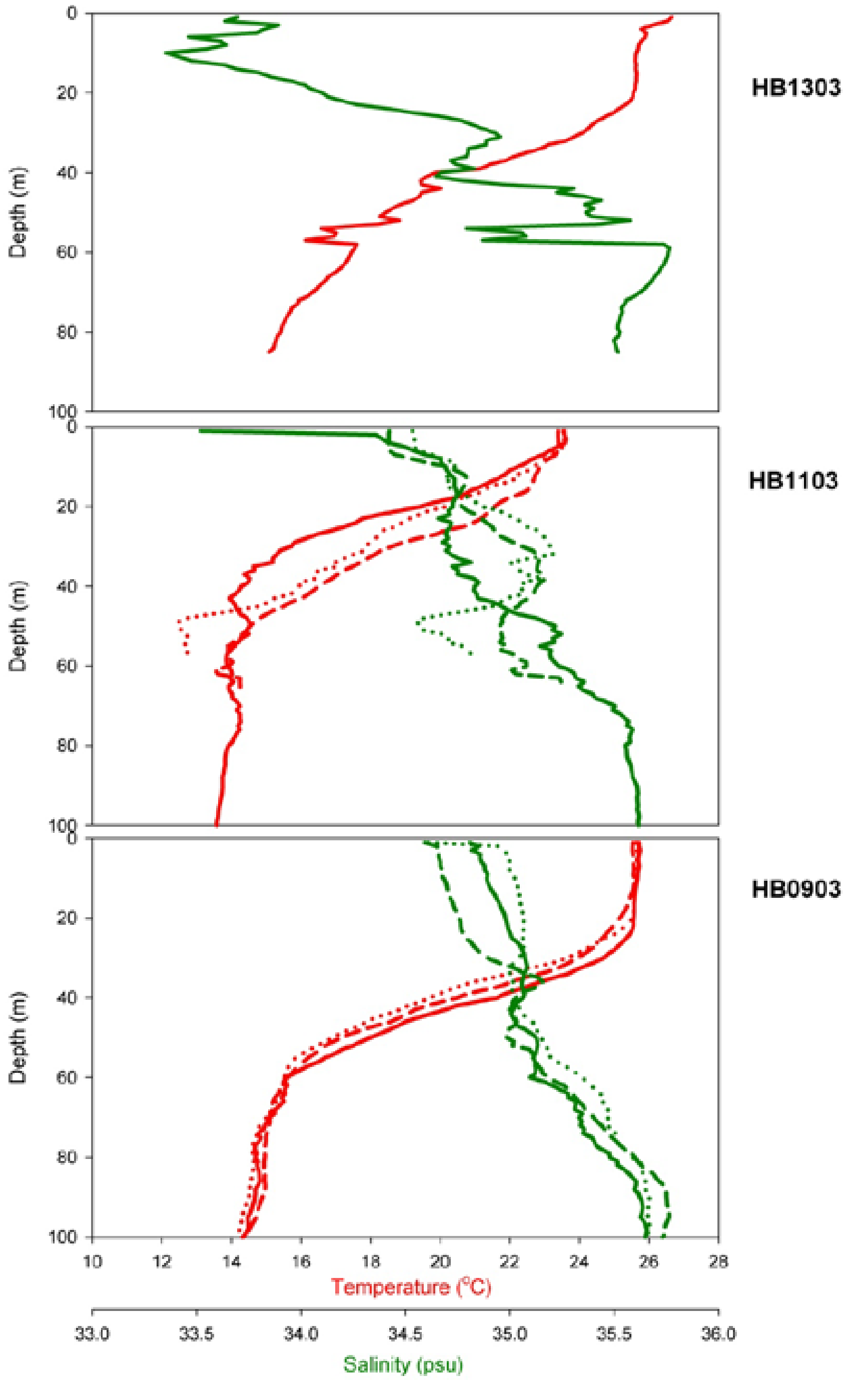


Figure I2. Mean plankton densities in 1 m increments from 6 video plankton recorder (VPR) hauls conducted near the middle of Visual Transect 25.

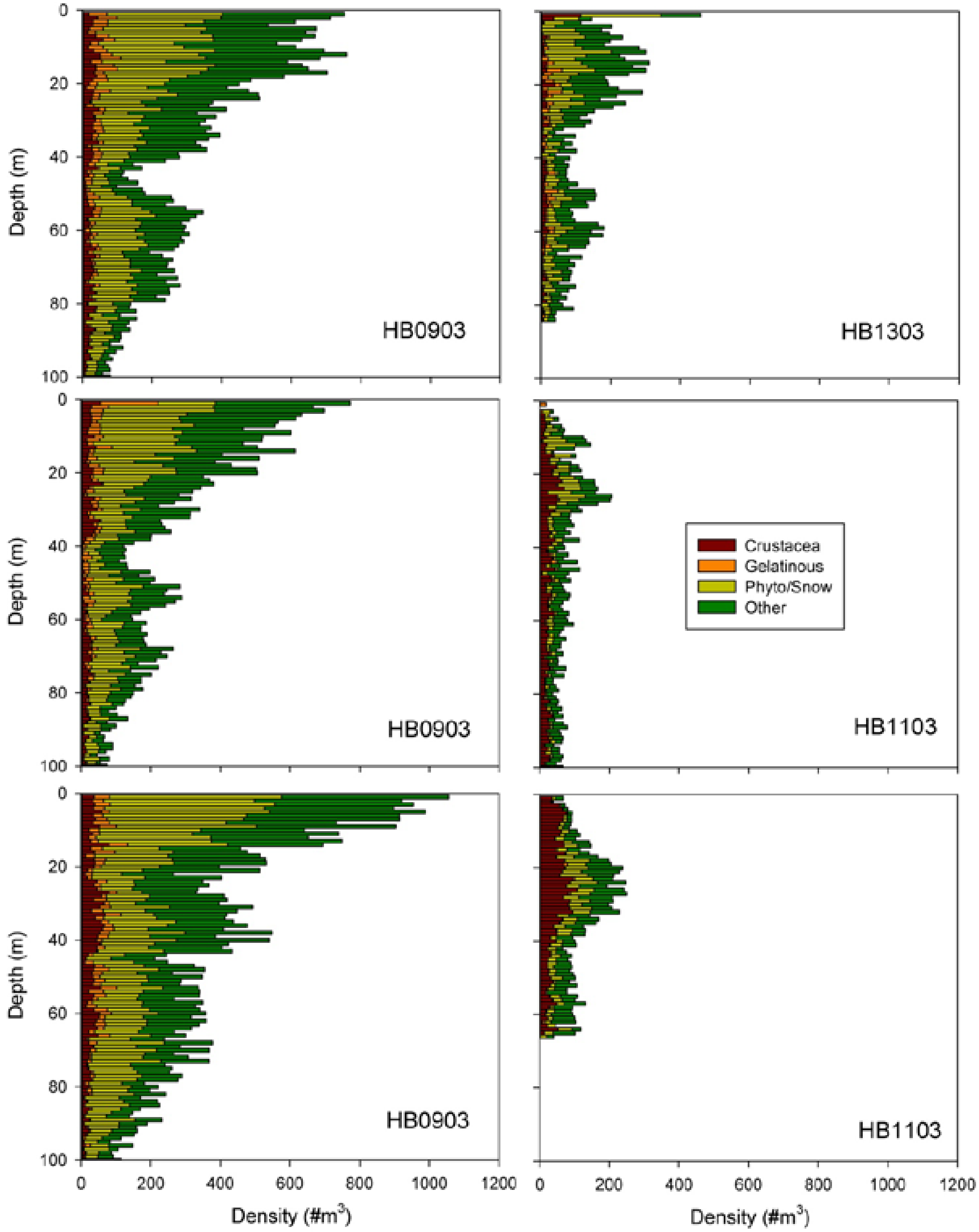


Figure I3. Temperature and salinity traces from HB1103, July 2011 from four major habitat areas

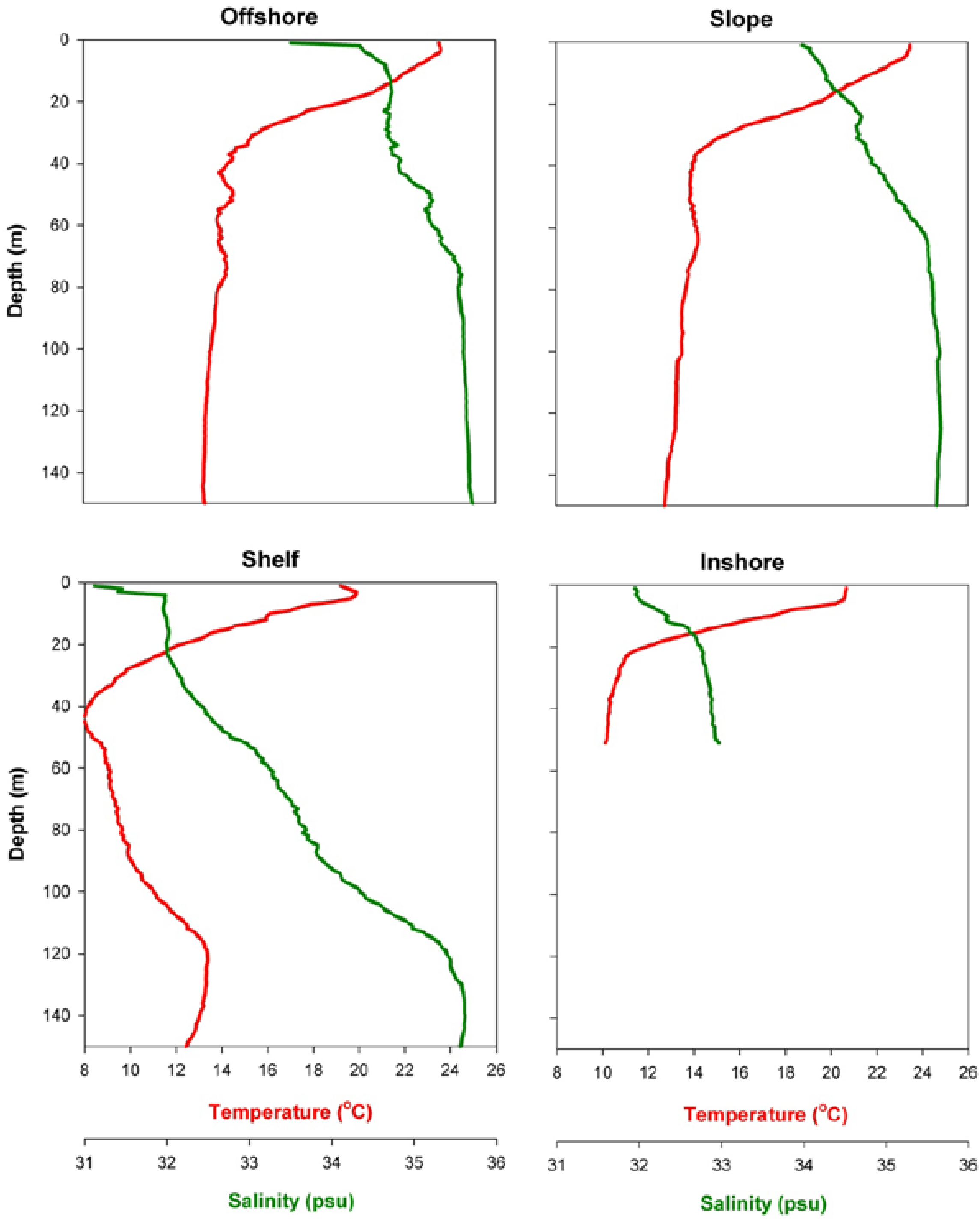


Figure I4. Plankton densities in 1 m bins from HB1103, July 2011.

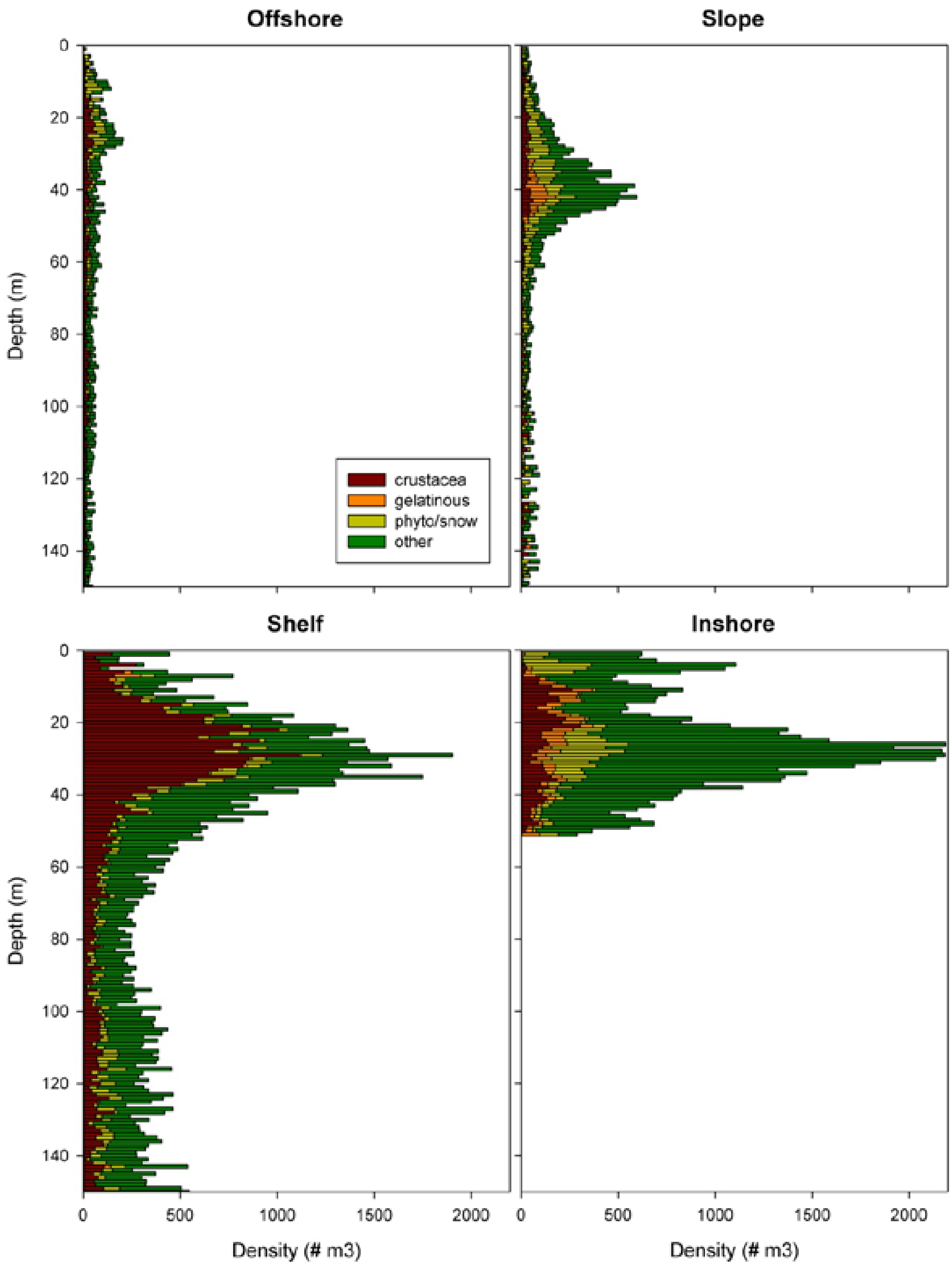


Figure I5. Plankton densities and oceanographic properties from two video plankton recorders (VPR) hauls conducted in August of 2013 on the eastern and western side of Nantucket Shoals showing strongly variable environments.

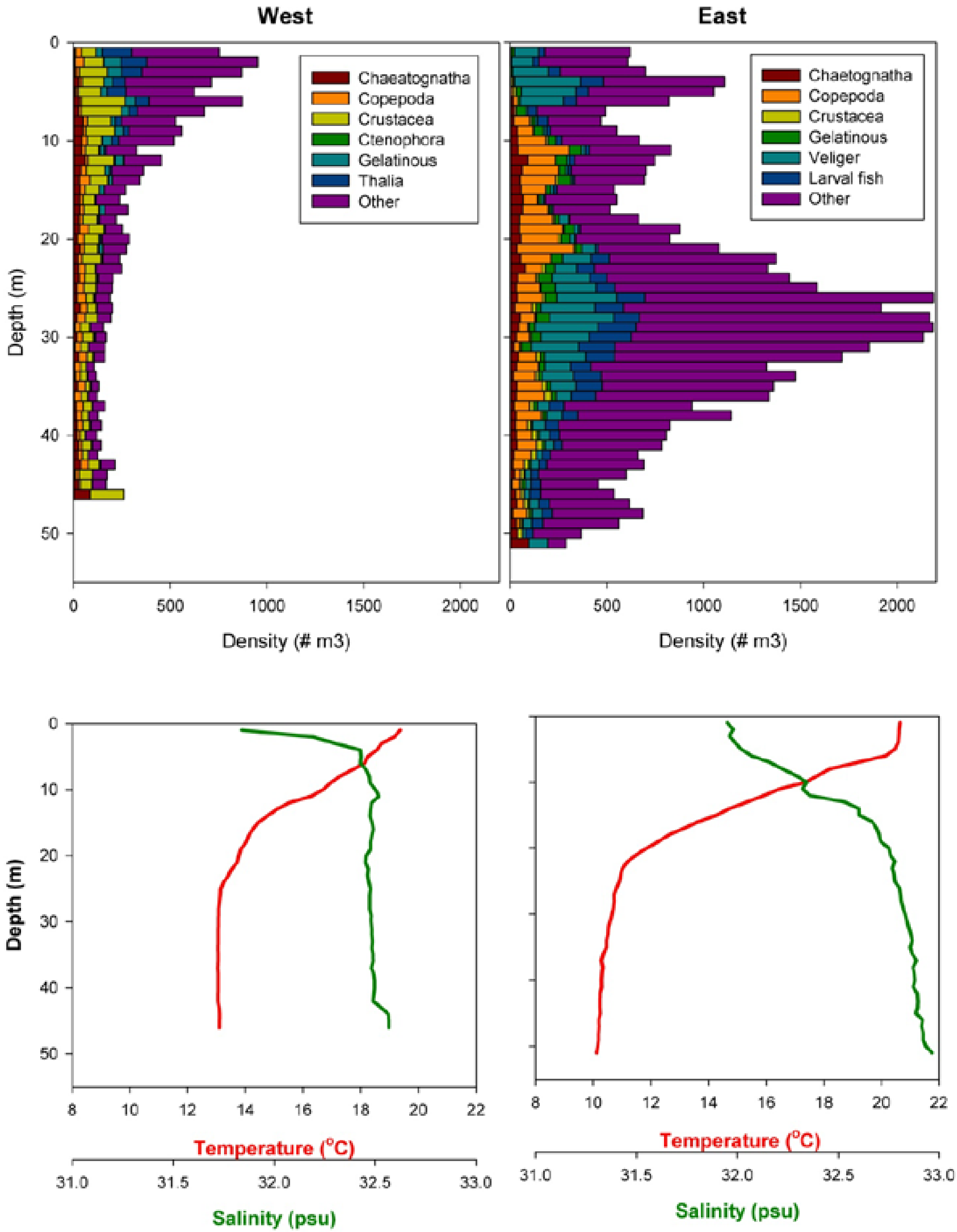


Figure I6A. Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) for HB0903.

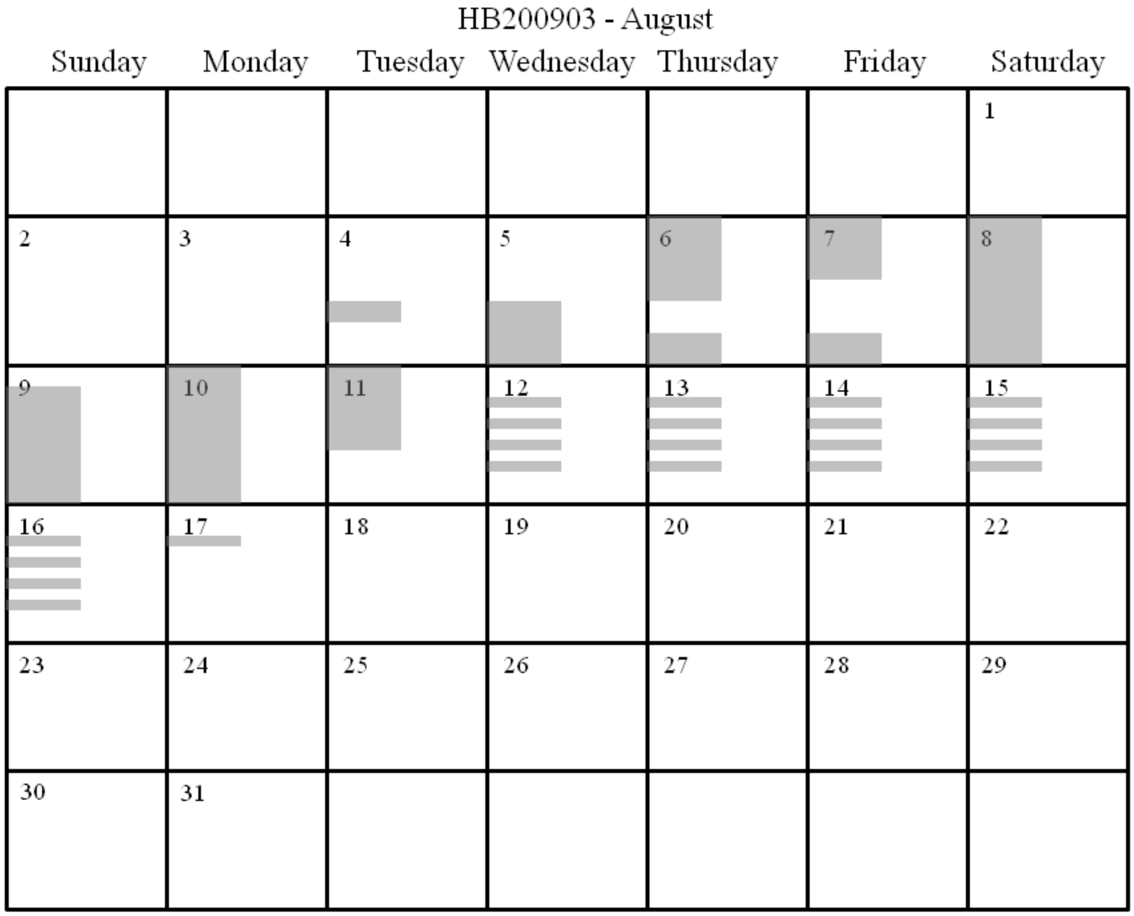


Figure I6B. Multifrequency Simrad EK60 data acquisition tracks (black line) for HB0903.

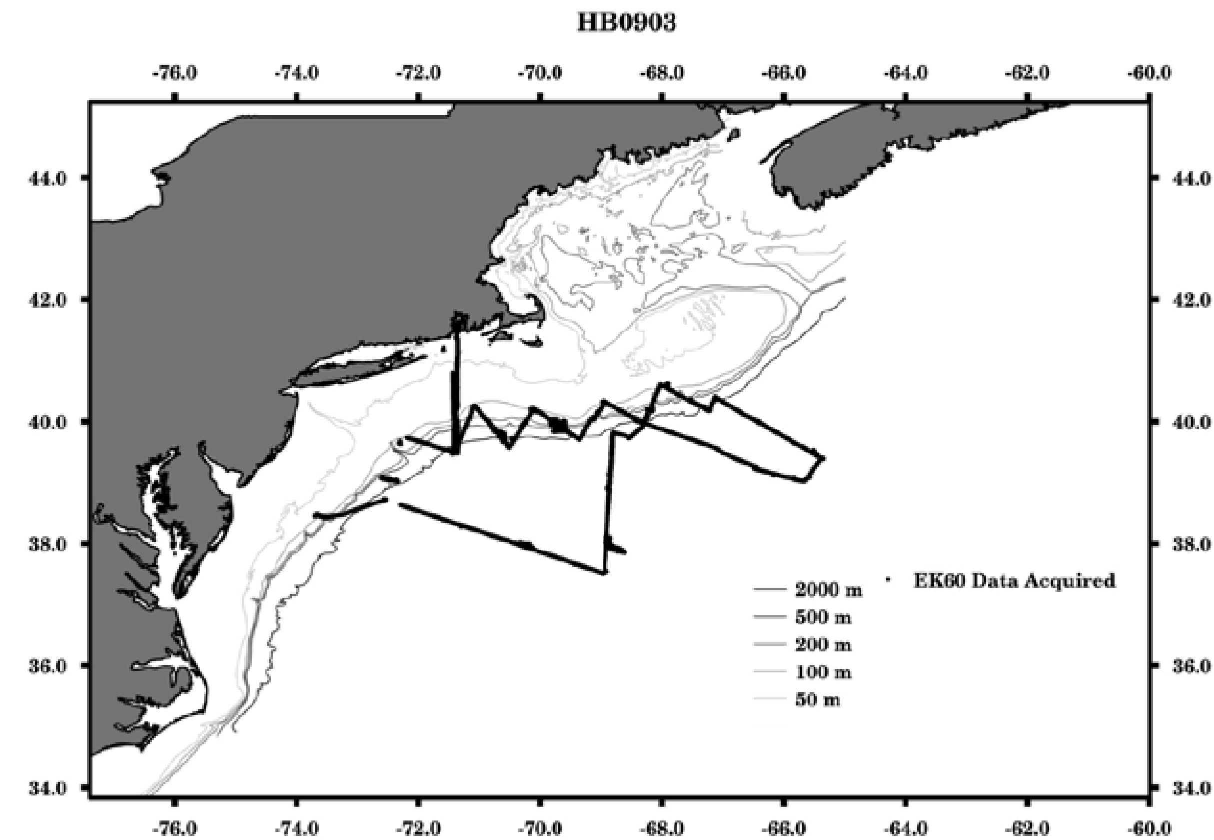


Figure I7A. Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) and postprocessed periods (hatched periods on the right side for each day) for HB1103.

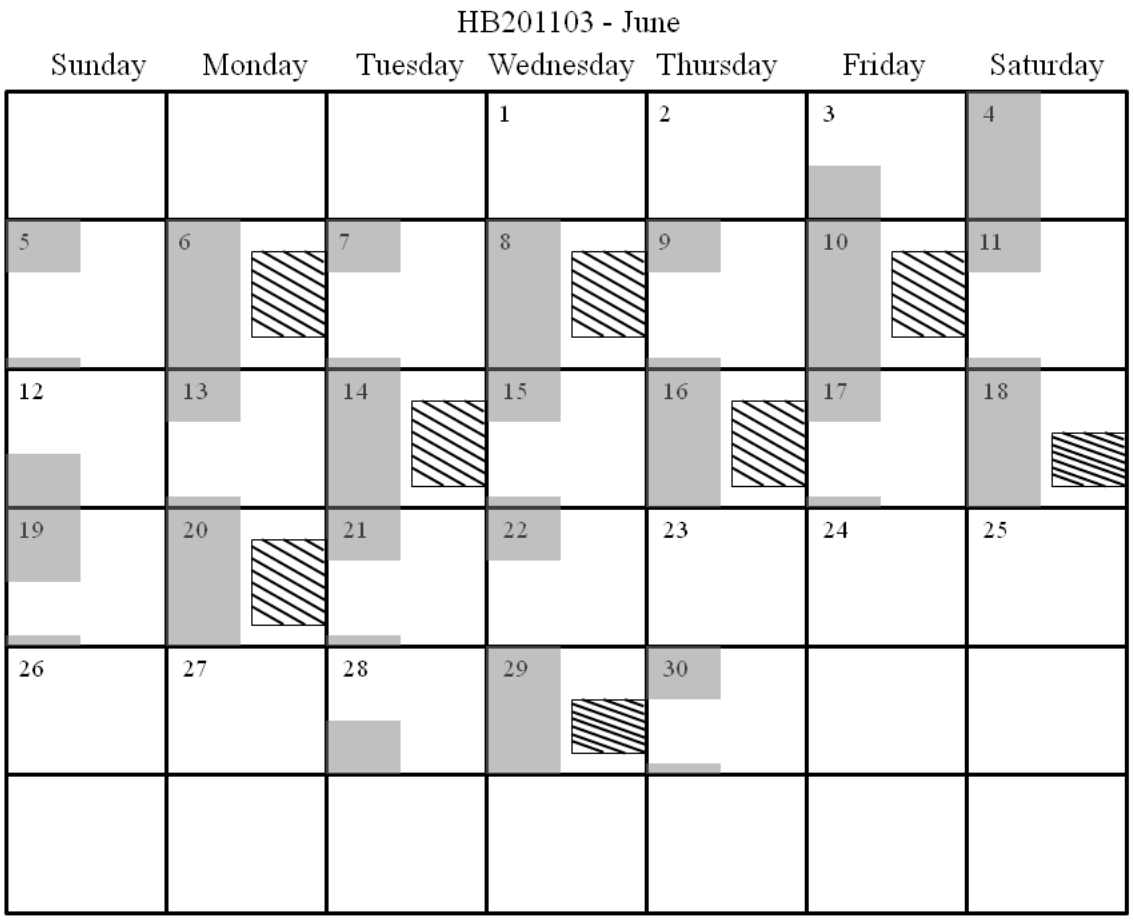


Figure I7A (continued). Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) and postprocessed periods (hatched periods on the right side for each day) for HB1103.

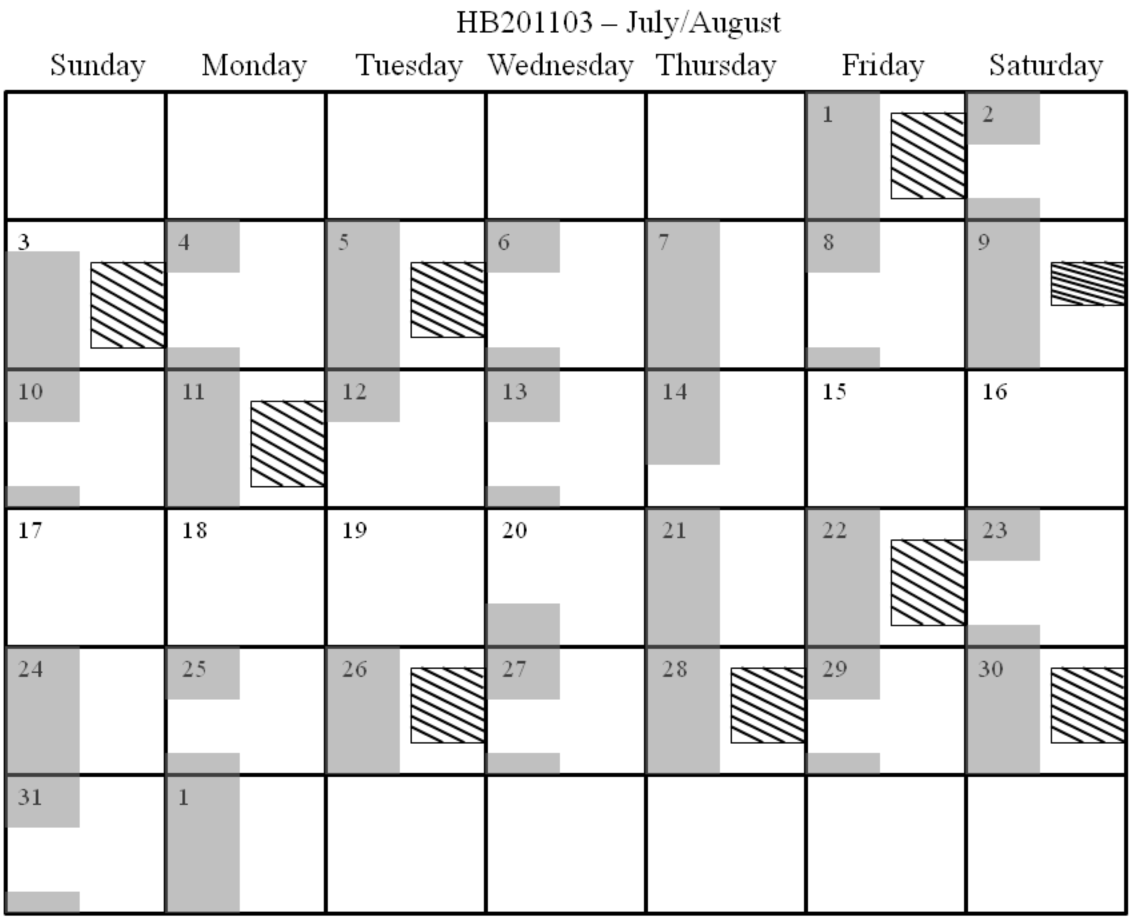


Figure I7B. Multifrequency Simrad EK60 data acquisition tracks (black line) for HB1103.

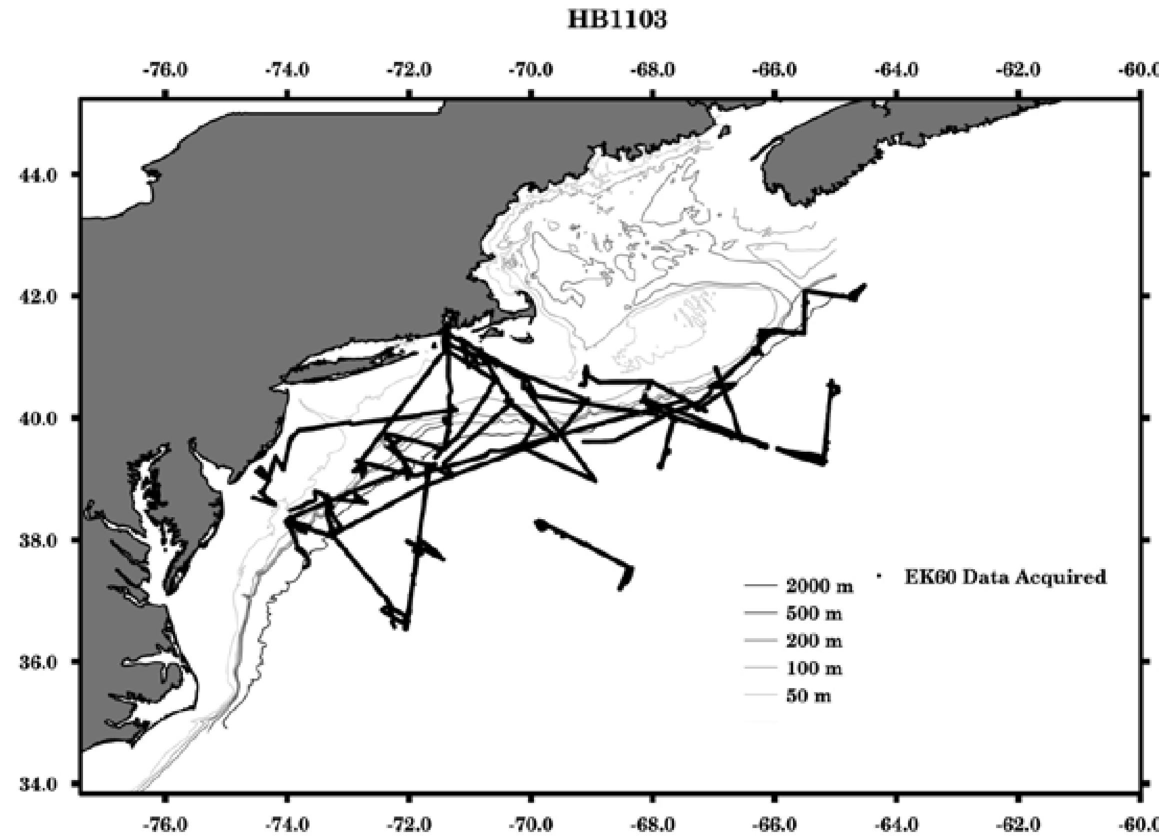


Figure I8A. Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) and postprocessed periods (light hatched periods on the right side for each day and dark hatched periods for each night) for HB1303.

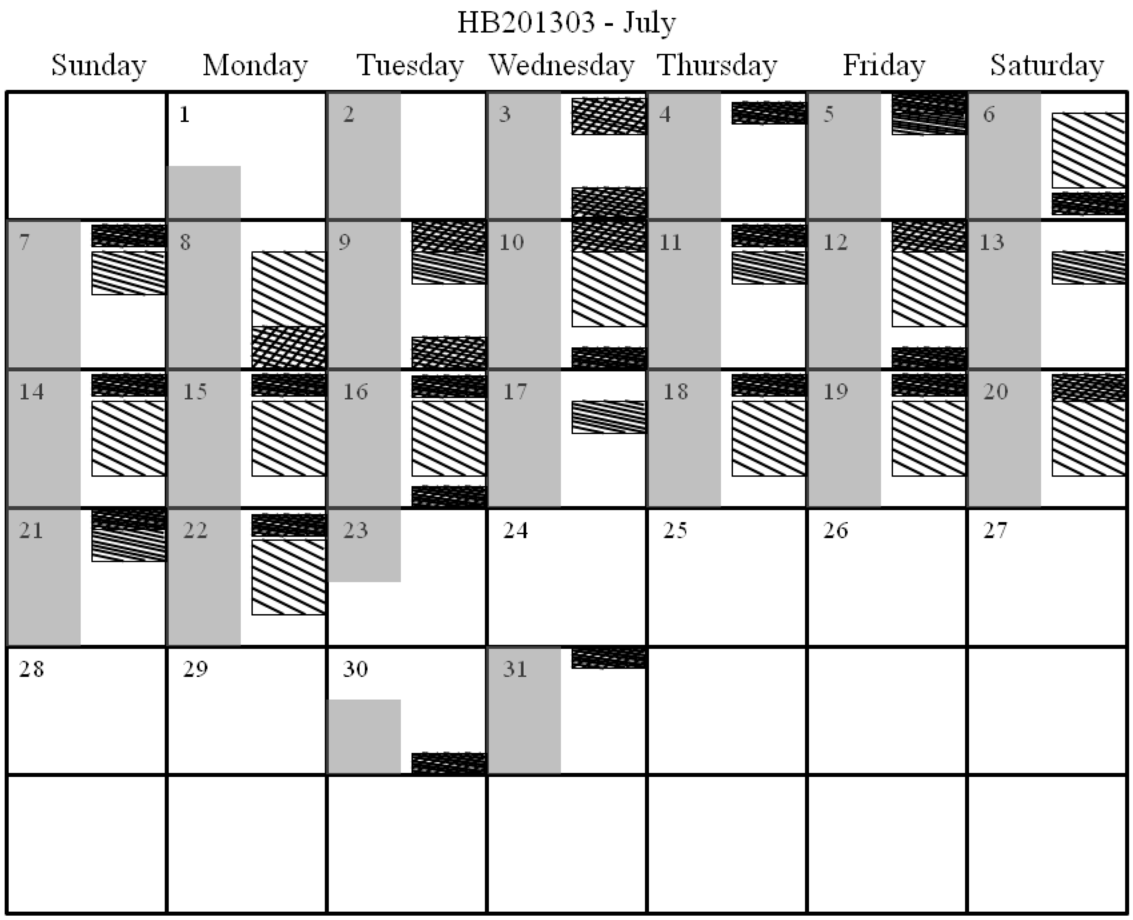


Figure I8A (continued). Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) and postprocessed periods (light hatched periods on the right side for each day and dark hatched periods for each night) for HB1303.

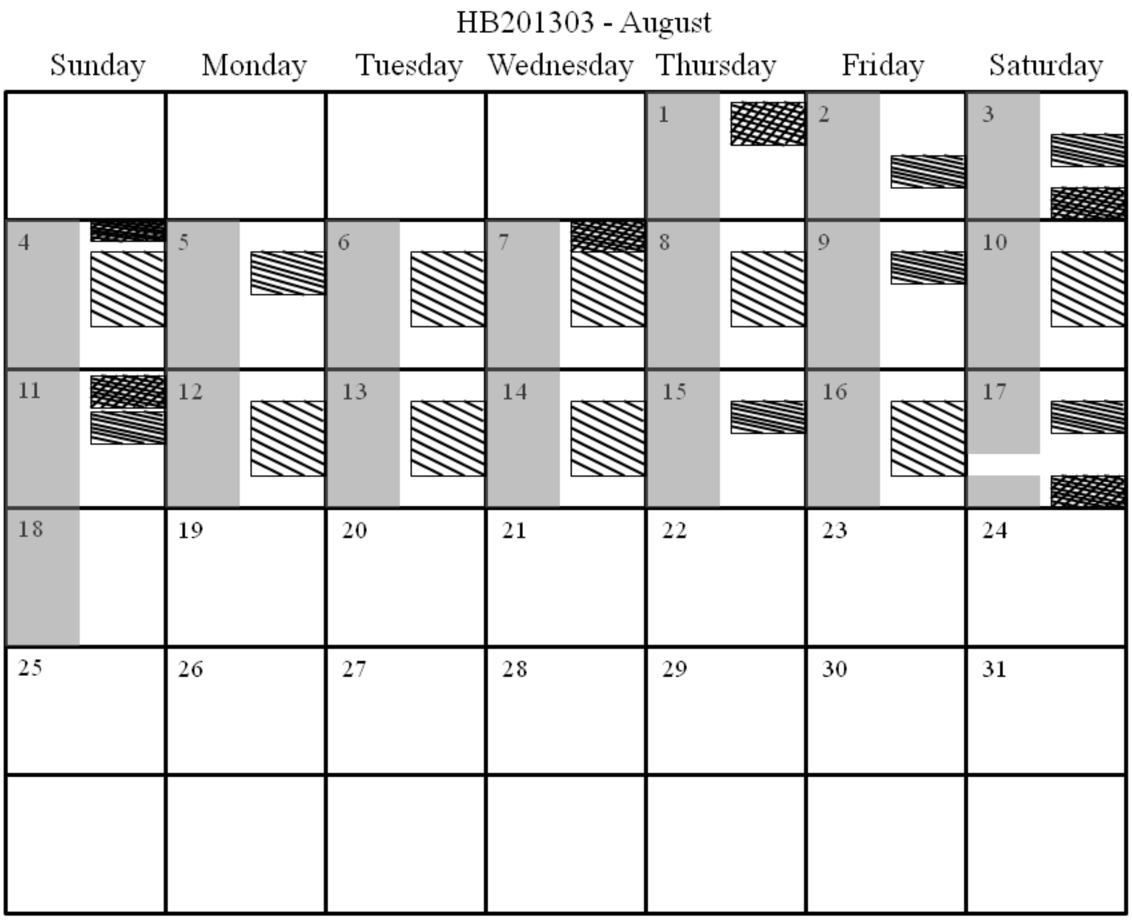


Figure I8B. Multifrequency Simrad EK60 data acquisition tracks (black line) for HB1303.

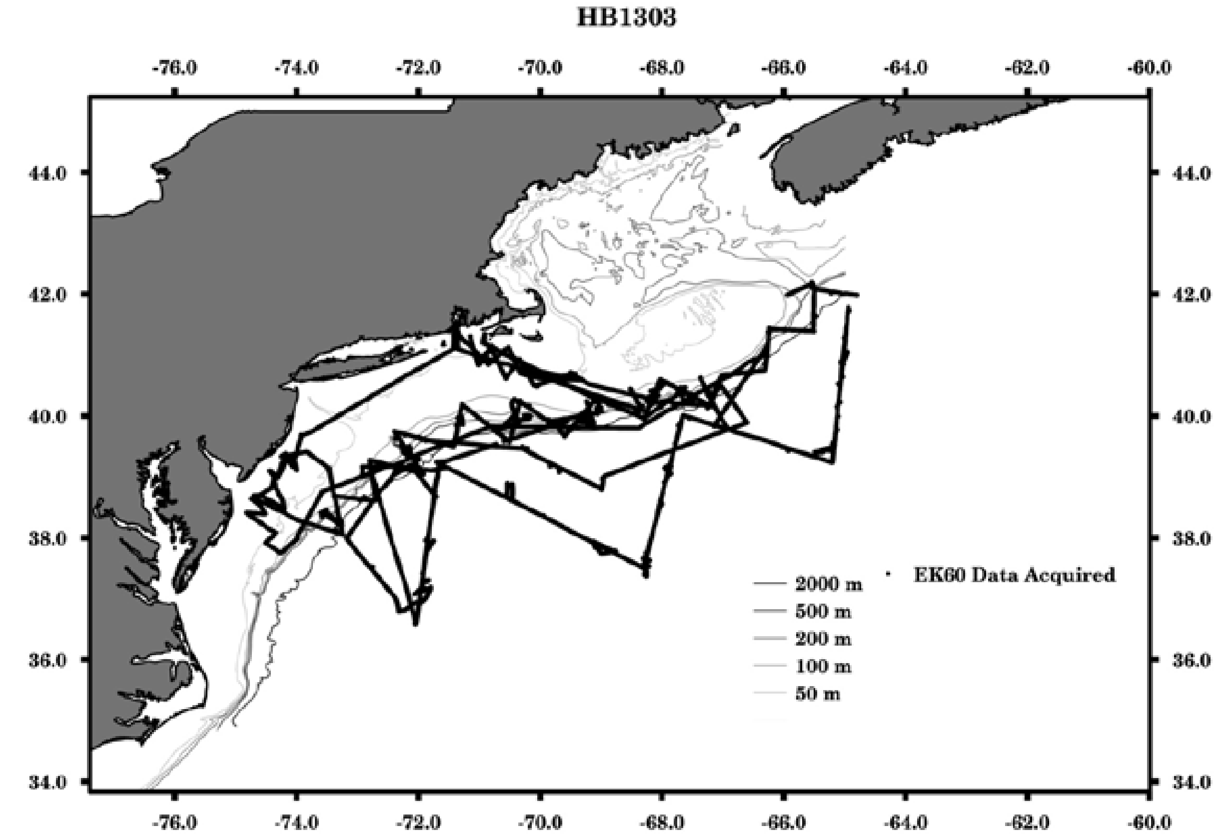


Figure I9A. Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) for GU1402.

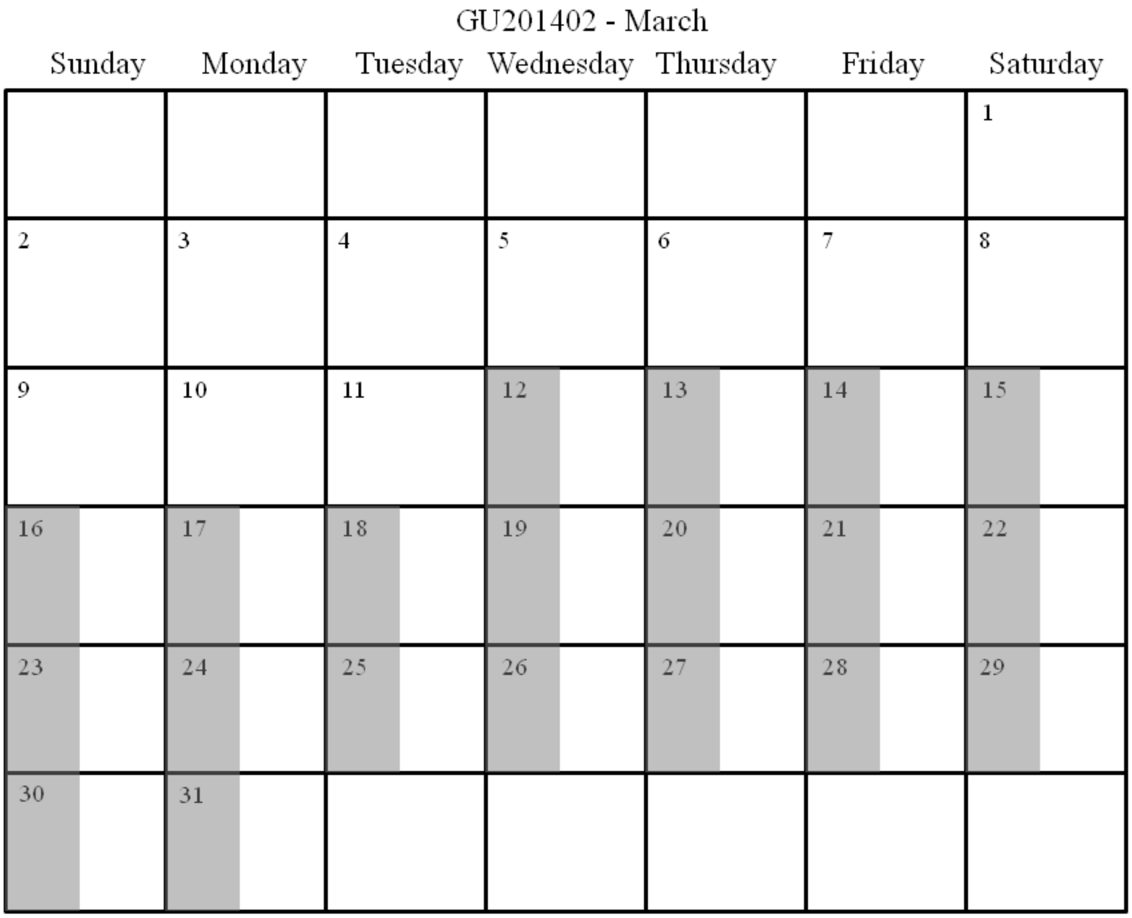


Figure I9A (continued). Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) for GU1402.

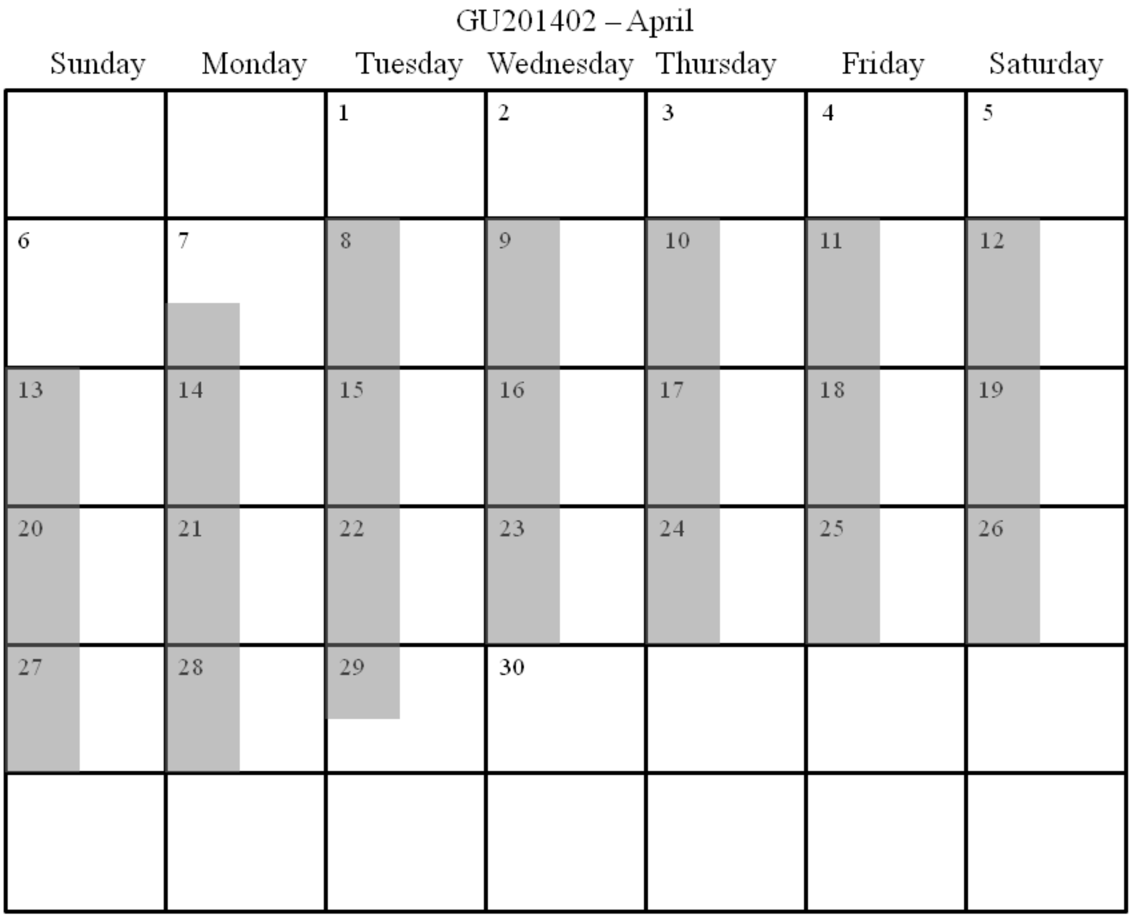


Figure I9B. Multifrequency Simrad EK60 data acquisition tracks (black line) for GU1402.

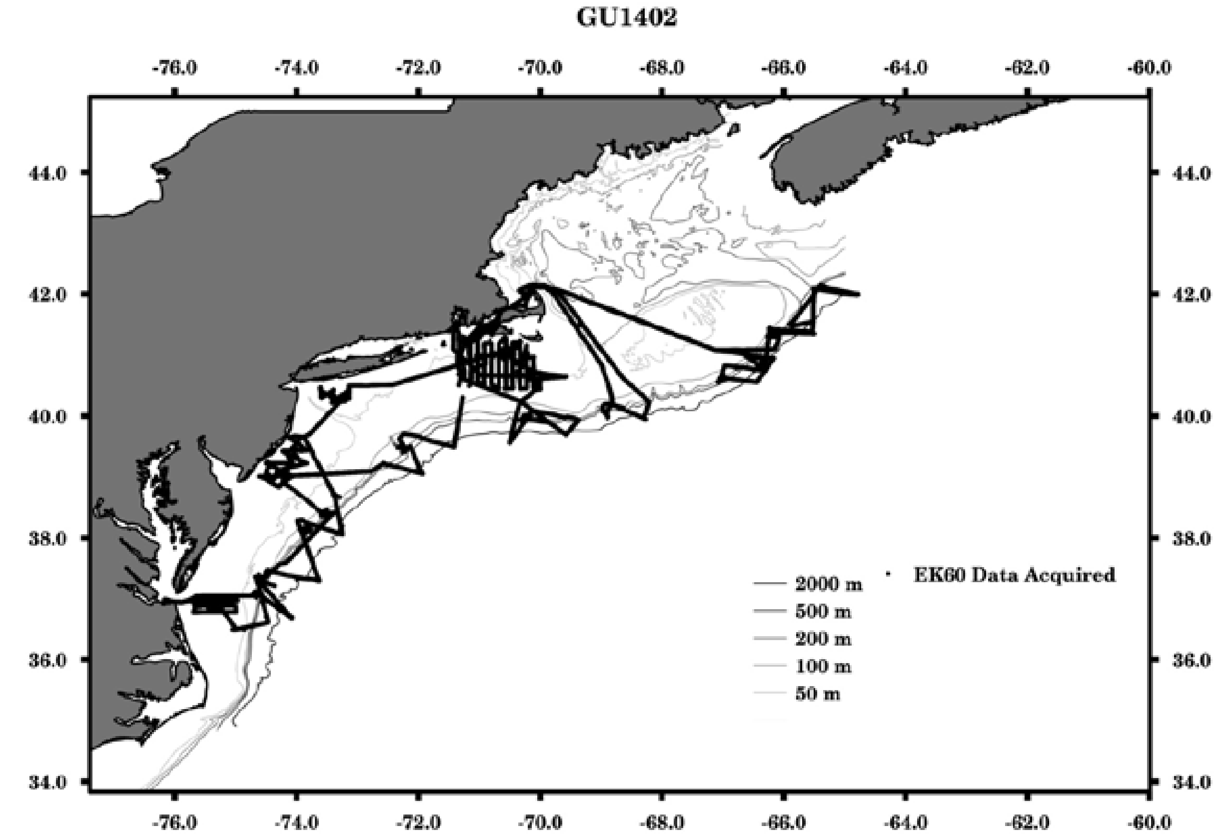


Figure I10A. Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) and postprocessed periods (light hatched periods on the right side for each day and dark hatched periods for each night) for HB1403.

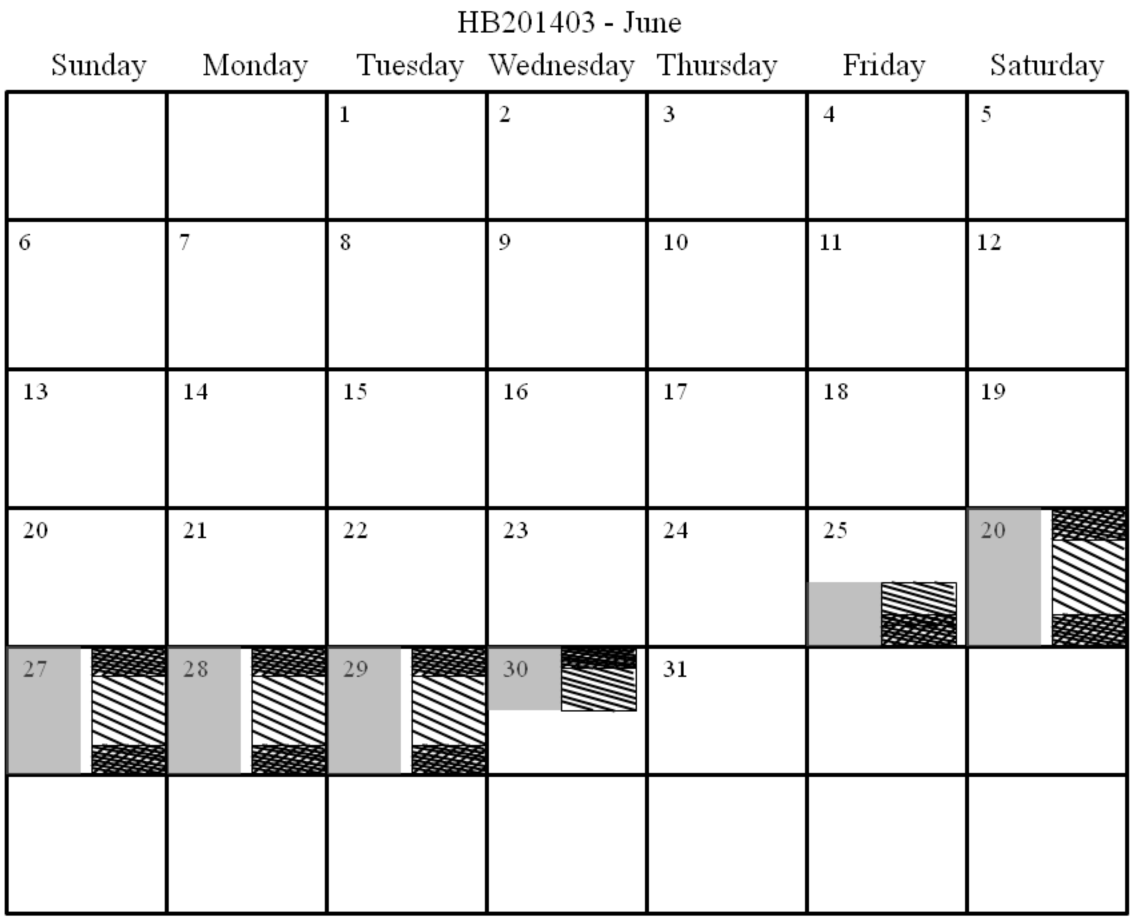


Figure I10B. Multifrequency Simrad EK60 data acquisition tracks (black line) for HB1403.

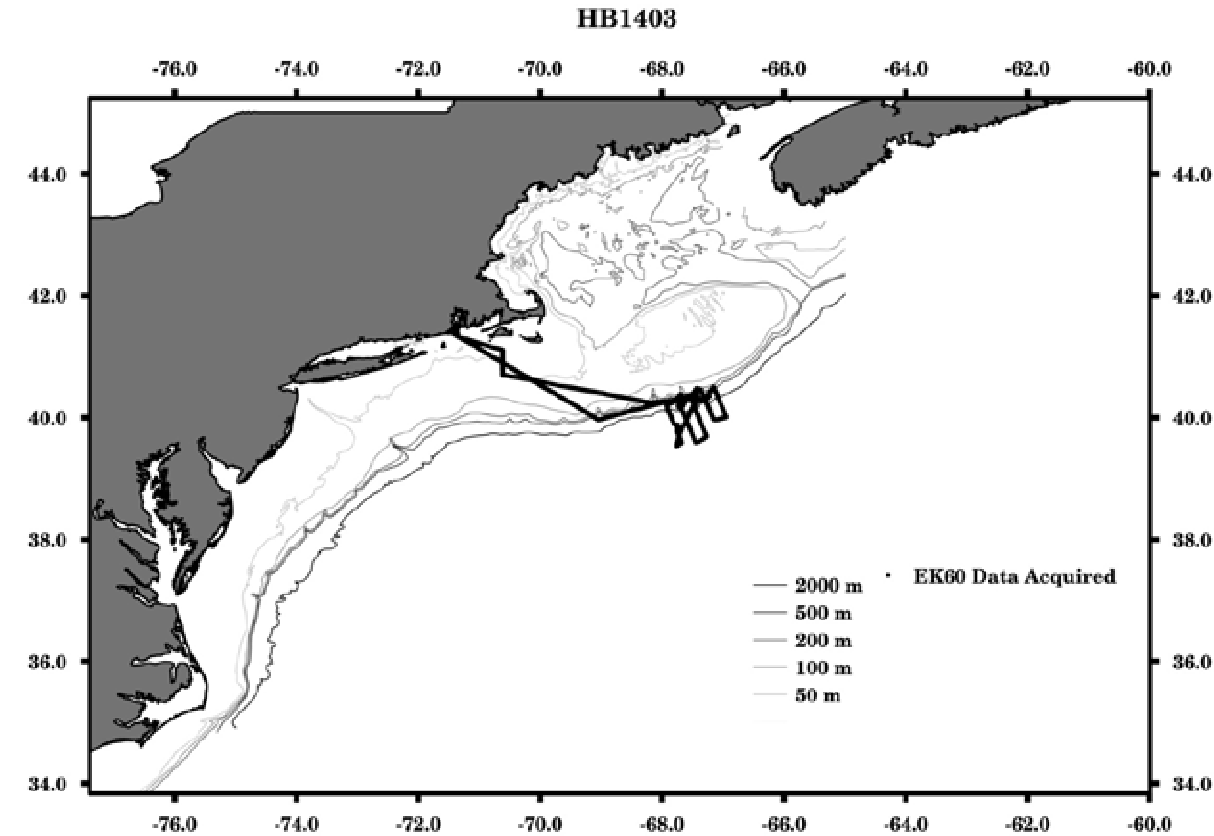


Figure I11. Multifrequency (18, 38, 70 kHz) echograms of Simrad EK60 echosounder data collected during HB1403 (27 July 2014) near the shelf break. The "empty" segment represents the EK60s set to passive mode. Each vertical line represents 1 km distance intervals and each horizontal line represents 100 m depth intervals.

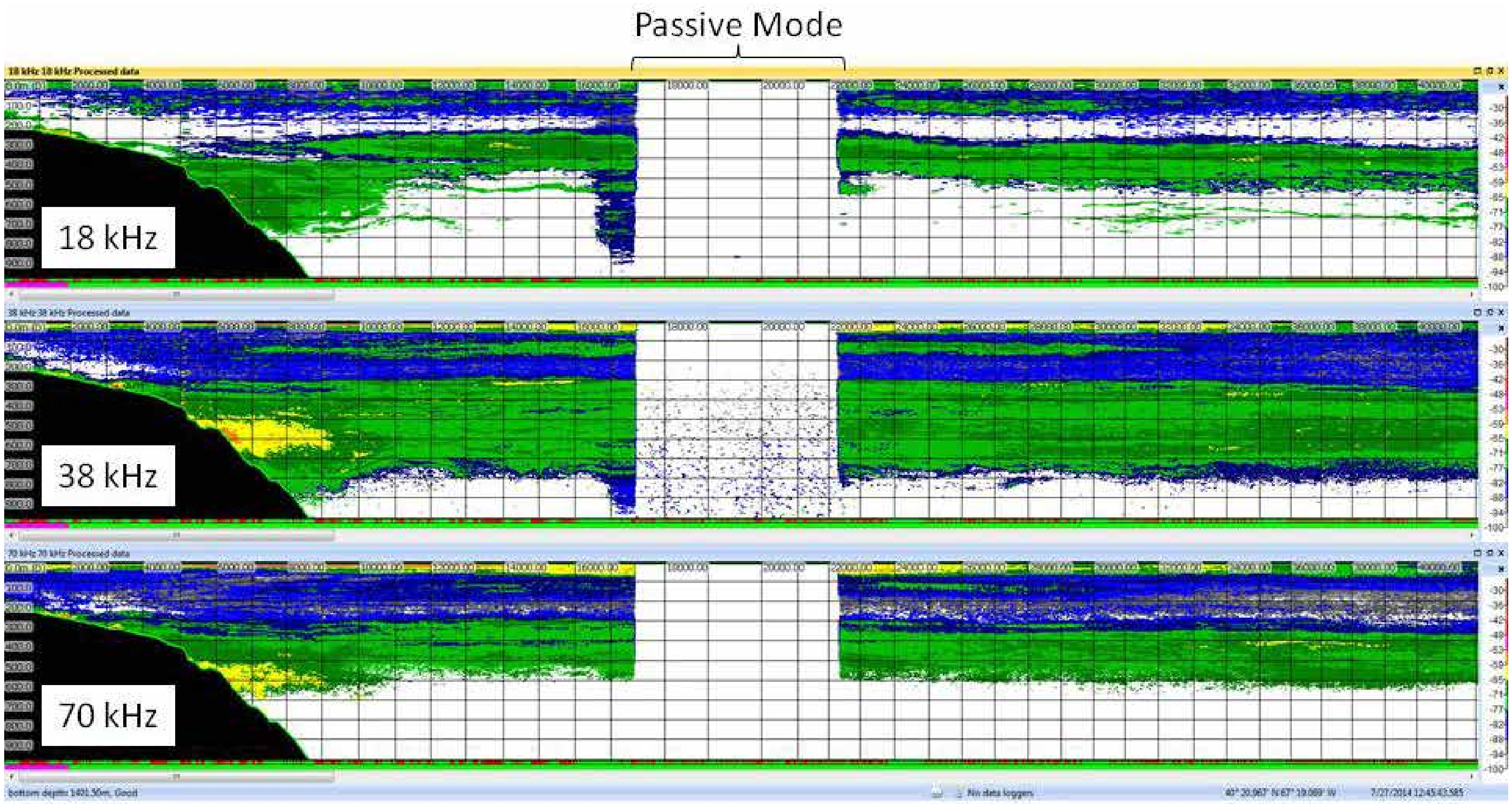


Figure I12. Multifrequency (18, 38, 70 kHz) echograms of Simrad EK60 echosounder data collected during HB1403 (27 July 2014). Echograms show the vertical migration from about 300 m to near the surface of fish and macrozooplankton at dusk, and the non-migrating layer that remains at about 400 to 600 m depth. Each vertical line represents 1 km distance intervals and each horizontal line represents 100 m depth intervals.

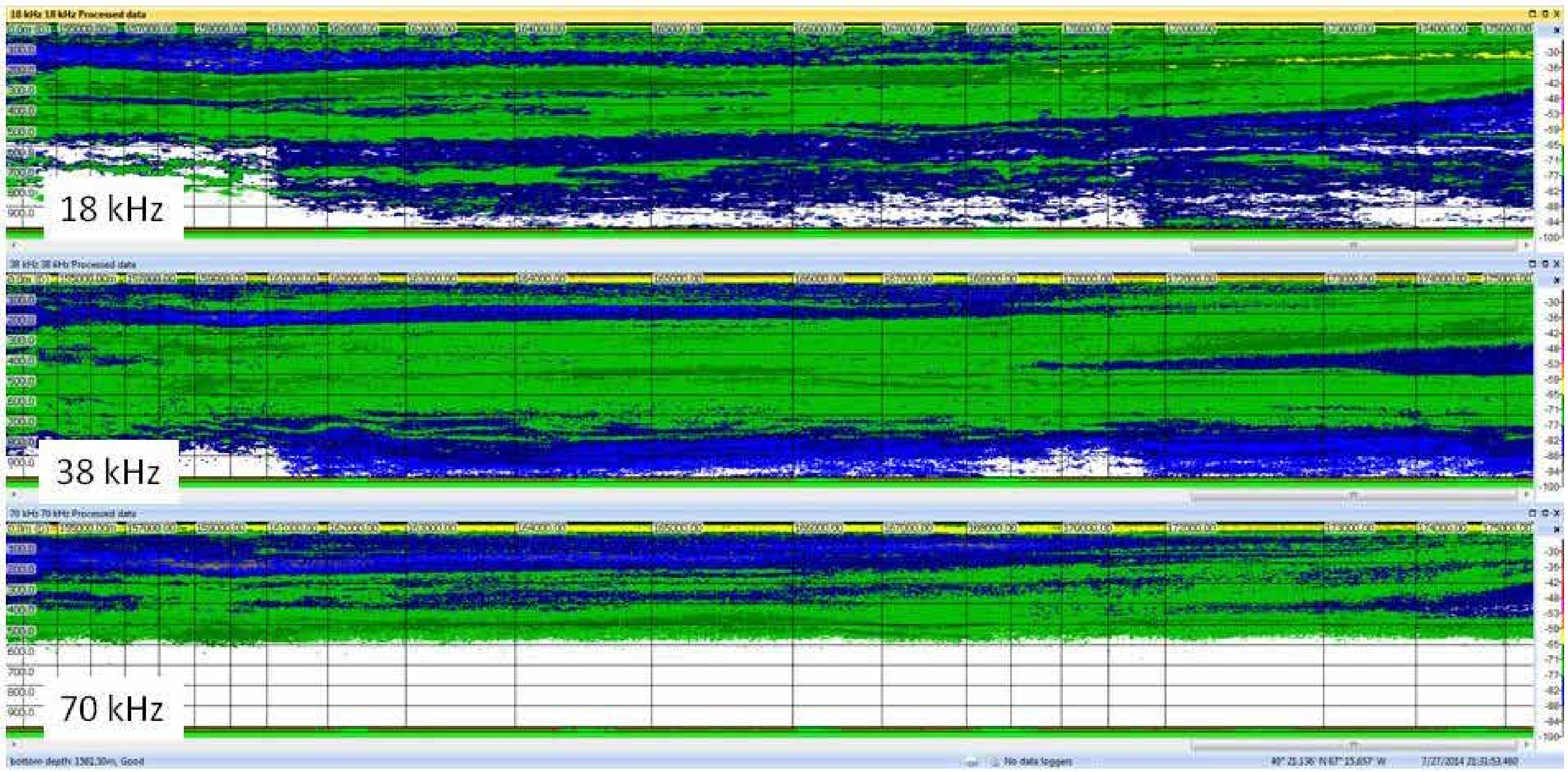


Figure I13. Multifrequency (18 and 38 kHz) echograms of Simrad EK60 echosounder data and the survey track (inset map) collected during a local survey of Atlantic Canyon during HB1303 (10 July 2014).

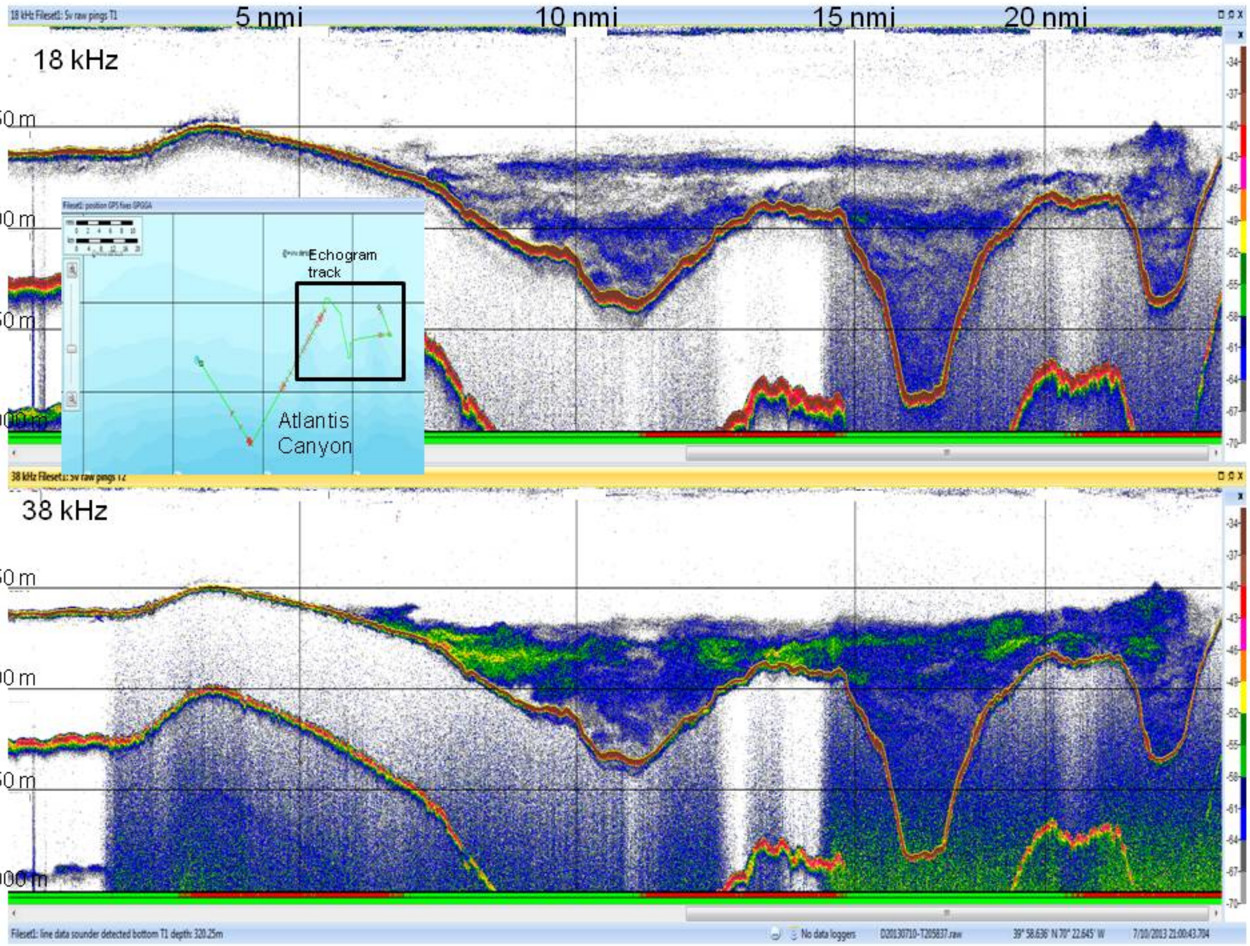


Figure I14. Analyzed EK60 shelf break tracklines from the 2011 survey. All tracklines have at least one marine mammal sighting. Trackline numbers are based on EK60 lines, not marine mammal tracklines. Tracklines with two or more numbers are spatial duplicates.

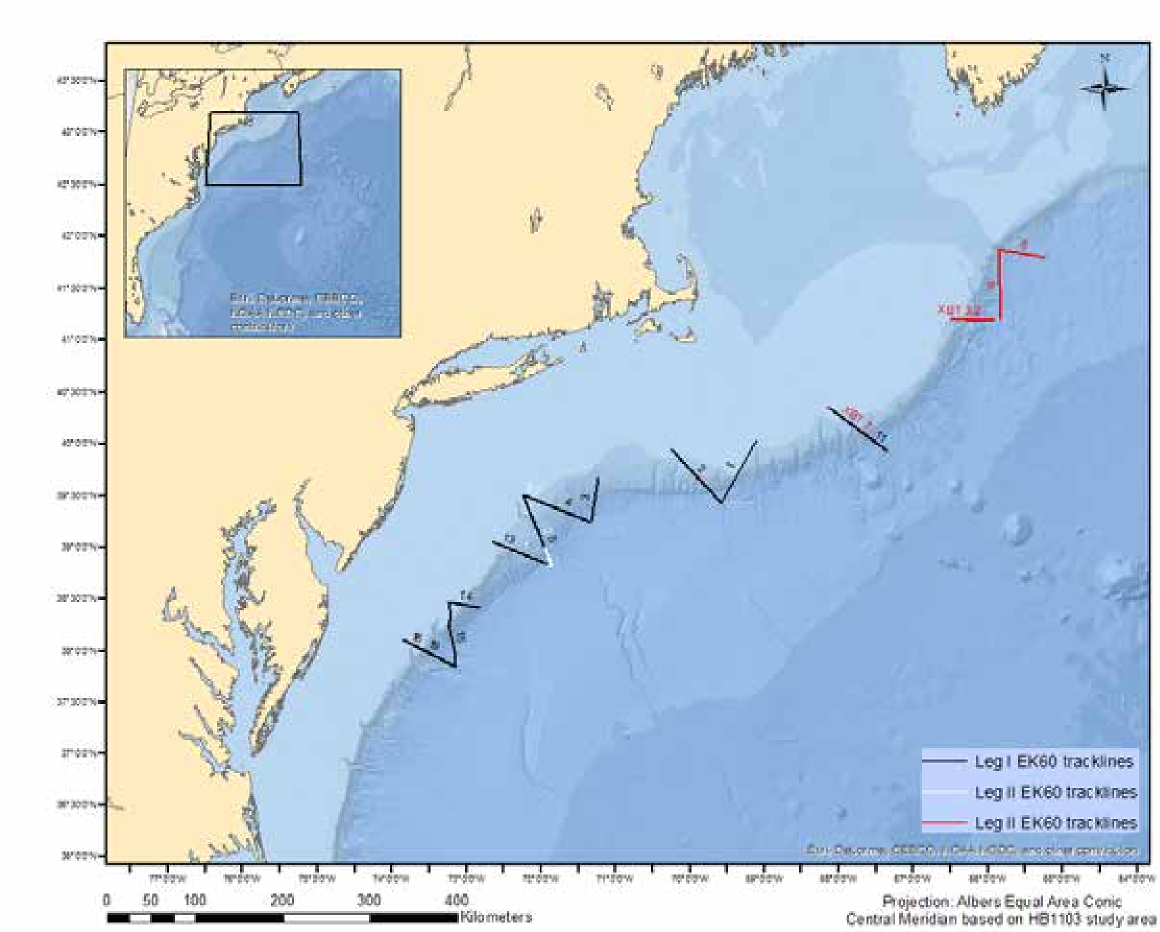


Figure I15. Acoustic trackline Leg 1 Ln01 as straight line transect. The x axis is distance along track (km); y axis is depth (m). Color shows intensity of volumetric backscatter (Sv) in dB at 18 kHz. Symbols along the trackline at 0 meters are marine mammal sightings. Asterisks (*) are centroids of acoustic areas of interest.

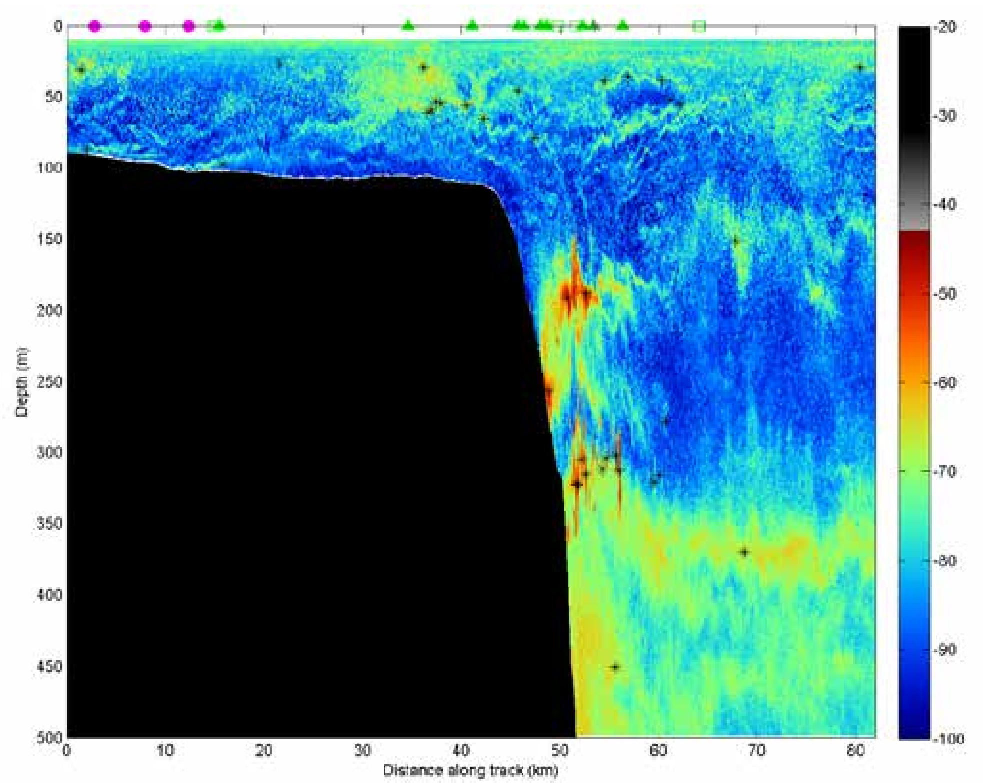


Figure I16. Theoretical frequency response curves (6 lines) for euphausiids between 1 cm and 6 cm (model parameters from Lavery et al. 2007). Colored asterisks (*) are scattering values from the centroid of an acoustic ROIs. Black circles on the x-axis are the frequencies of the EK60. These four ROIs (asterisks are of four colors) were categorized as "euphausiid-like" because they follow the general shape of the theoretical backscattering model: lower scattering values at 18 kHz, higher scattering values at 120 kHz that decrease at 200 kHz. The inflection point of each asterisk color group is similar to the first inflection point of the 6 cm euphausiid curve and shifted above the model curve indicating a greater abundance individuals.

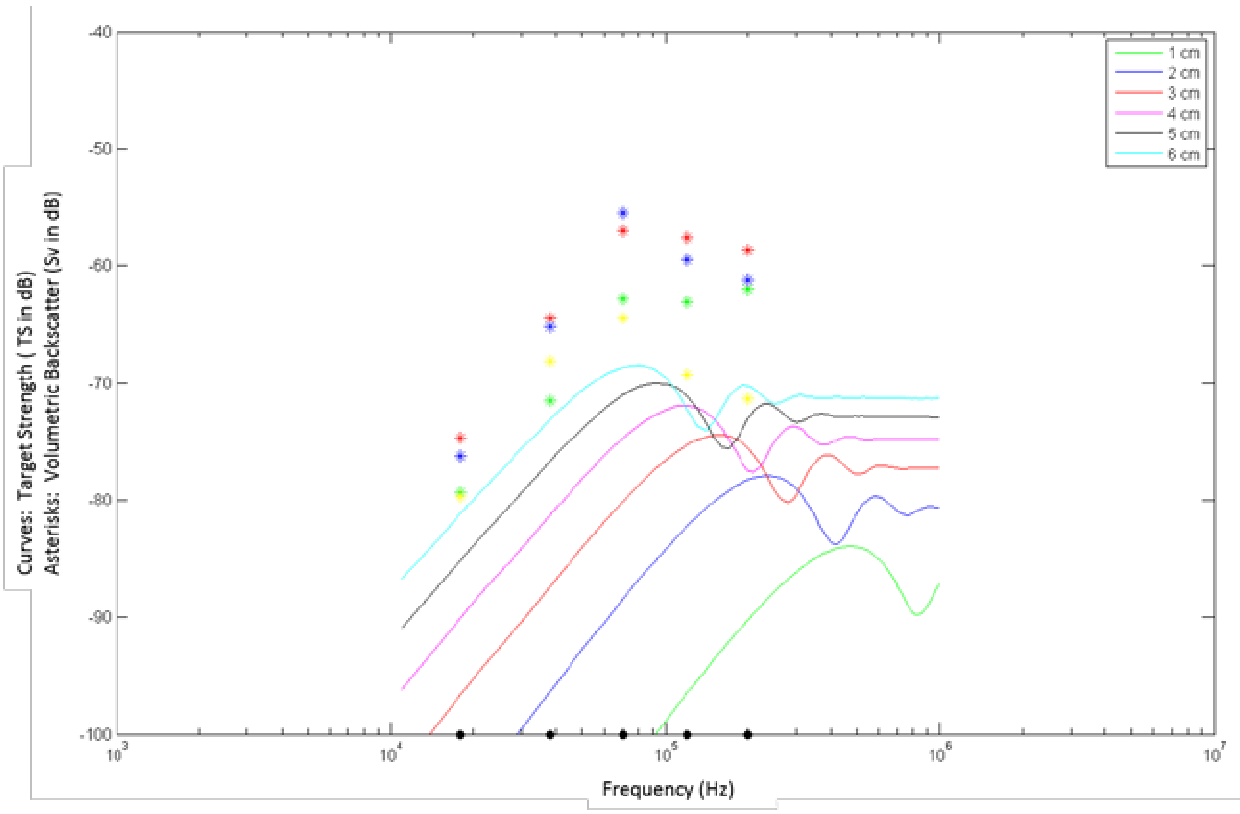
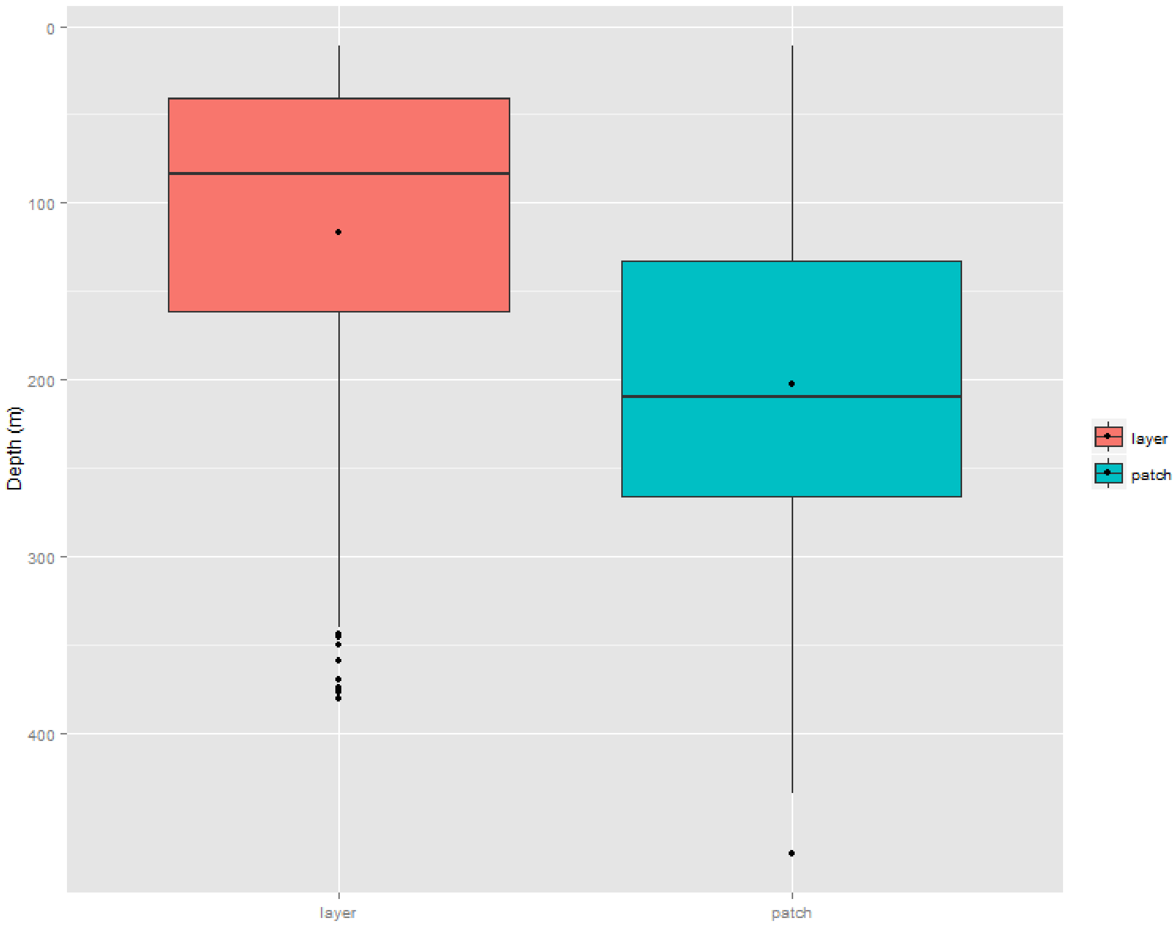


Figure I17. Box plots of the depth of patches and layers. The dot with each box is the mean depth. The y-axis is reversed to depict depth through the water column with 0 equivalent to the sea surface.



Appendix J: *Progress on the development of an Oracle database to store the data collected on the AMAPPS surveys: Northeast and Southeast Fisheries Science Centers*

Elizabeth Josephson[1]

[1]Integrated Statistics, Inc, 16 Sumner St., Woods Hole, MA 02543

SUMMARY

During 2013, NEFSC expanded its Oracle database to include the NEFSC and SEFSC strip-transect shipboard seabird data, new AMAPPS shipboard and aerial marine mammal and sea turtle data, and new tag data from loggerhead turtles and seals. In 2014, data from 2013 and 2014 surveys were added, as well as additional turtle tag data. In November 2014, the number of tag position records (includes pre-AMAPPS funded tags as well as partner data) exceeded the one million record mark. The interactive map on the NEFSC webpage was expanded to include 5 years of loggerhead turtle tracking information. Queries and procedures were developed to output survey data from the Oracle database in formats appropriate for Distance analysis as well as for other modeling objectives. Programs were developed to link SST, chlorophyll, mixed layer depth, and bottom temperatures from satellites and ocean models to AMAPPS data at appropriate spatial and temporal scales.

OBJECTIVES

One of the objectives of the AMAPPS initiative is to quantify abundance and spatial distribution and to produce spatially-explicit density distribution maps that incorporate habitat characteristics. To do this a database has been developed to store and to optimize retrieval of the data collected during the surveys as well as satellite and model-derived environmental data.

2014 ACTIVITIES

During 2014, the NEFSC continued to expand its Oracle database with new survey, tag and environmental data. In 2014 the major activities included:

1. Adding more data into the Oracle database. In 2014 the following components were added to the database:

    1) GPS trackline data for NEFSC and SEFSC AMAPPS summer shipboard surveys (HB1303 and GU1304)
    2) Mammal and turtle sightings data from summer shipboard surveys HB1303 and GU1304
    3) Mammal and turtle effort data from summer shipboard surveys HB1303 and GU1304, and the SE spring 2014 aerial survey
    4) Bird data from summer shipboard surveys HB1303 and GU1304. These data were also submitted to the Seabird Consortium.

2. Developing queries for combining and outputting survey and environmental data in formats for direct consumption by the Distance sampling program, as well as for other modeling efforts.

3. Working toward standardization of data collection methods and data structures across AMAPPS NEFSC and SEFSC partners.

ACKNOWLEDGEMENTS

The databases were originally developed and funded by the NEFSC. During 2014 updates of the database to incorporate the AMAPPS data were funded by the Bureau of Ocean Energy Management (BOEM) and the US Navy through two Interagency Agreements for the AMAPPS project.