2013

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

Stenella frontalis taken by Thomas Johnson under NOAA Fisheries Service SEFSC MMPA Permit 779-1633

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

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

2013 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

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 – and between NOAA Fisheries Service and the US Navy – IA number NEC-11-009. These two IAs specify that the NOAA Fisheries Service will provide services to BOEM and the US Navy in the form of the Atlantic Marine Assessment Program for Protected Species (AMAPPS) in the US Atlantic Ocean from Maine to the Florida Keys. The NOAA Fisheries Service work is being conducted by the Northeast Fisheries Science Center (NEFSC) and the Southeast Fisheries Science Center (SEFSC). 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 2013.

AMAPPS is a comprehensive research program to assess the abundance and spatial distribution of marine mammals, sea turtles, and sea birds in US waters of the western North Atlantic Ocean. This program includes collecting data on seasonal vessel and aerial surveys for marine mammals, sea turtles, and sea birds, data on tagging projects, and data on other related projects, in addition to the analyses of these data with the goal to quantify abundance and spatial distribution and to produce spatially explicit density distribution maps. The data collection and analysis efforts are conducted by the NOAA Fisheries Service NEFSC and SEFSC and the USFWS Division of Migratory Birds. AMAPPS is funded by BOEM, NOAA Fisheries Service, USFWS, and the US Navy.

The AMAPPS data are being used to improve the assessment of marine mammal, seabird and sea turtle stocks and 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 is done by providing data to support updated abundance estimates for US Atlantic oceanic stocks of marine mammals (e.g., Waring *et al.*, 2013) and data on the seasonal and inter-annual variability in distribution, ecology, and behavior to estimate the potential for mortality or other impacts on protected species due to localized activities (e.g., military exercises, energy exploration, shipping traffic, etc.).

SUMMARY OF 2013 ACTIVITIES

During 2013 under the AMAPPS initiative, 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 data (Table 1). In addition, NOAA Fisheries Service continued analyzing past data collected under AMAPPS (Table 2). Five papers related to AMAPPS had been published in 2013, three more were in review, and five were in progress during 2013 (Table 3). A summary of the 2013 projects follows, with more details in the appendices.

<u>Field activities</u>

During February – March 2013 the SEFSC conducted an aerial line transect abundance survey using a NOAA Twin Otter targeting marine mammals and sea turtles that were in northern Atlantic continental shelf waters from South Carolina to New Jersey from the shore to about the 200 m depth contour (Figure 1; Table 1). This area was targeted to cover areas missed during the previous 2011 winter survey. During July – September 2013, the NEFSC and SEFSC conducted shipboard line-transect abundance surveys using NOAA ships targeting marine mammals, sea birds and sea turtles. The summer surveys covered northern Atlantic continental shelfbreak waters, from South Carolina to the southern tip of Nova Scotia, Canada, from about the 100 m depth contour to the EEZ, with additional coverage on the continental shelf in the prospective wind planning areas (Figure 2; Table 1). These data will be used to develop density/abundance estimates of marine mammals, sea turtles and sea birds that are at or above the ocean surface within the study area and to develop spatially and temporally explicit density maps that incorporate environmental factors. During the winter aerial survey, approximately 7,300 km of track lines were completed. During the summer shipboard surveys, about 10,500 km of track lines were completed, with nearly 900 hrs of passive acoustic monitoring using towed hydrophone arrays. During the winter aerial survey there were about 330 groups of 18 detected species or species groups of cetaceans and sea turtles, where the most common where bottlenose dolphins (*Tursiops truncatus*) and loggerhead turtles (*Caretta caretta*; Table 4). Detections during the summer 2013 shipboard surveys included over 1300 groups of 32 cetacean species or species groups; 38 groups of 3 turtle species or species groups, 7 seal groups (Table 4), and nearly 8000 individual birds of 81 species or species groups (Table 5). The most commonly seen small cetaceans were bottlenose dolphins and Risso's dolphins (*Grampus griseus*), commonly seen larger whales were beaked whales (Mesoplodon and Ziphius spp.) and sperm whales (*Physeter macrocephalus*), commonly seen turtles were loggerhead turtles (*Caretta caretta*), and commonly seen birds were Cory's shearwaters (*Calonectris diomedea*) and Wilson's storm-petrels (*Oceanites oceanicus*). On the shipboard surveys 45 biopsies and hundreds of photographs of cetaceans were collected. In addition, data on physical oceanographic and lower trophic levels were also collected on the shipboard surveys using conductivity, temperature and depth profilers (CTDs), expendable bathythermographs (XBTs), EK60 active acoustics, bongo nets, a visual plankton recorder (VPR), a multiple opening closing net environmental sensing system (MOCNESS), and an Isaacs-Kidd midwater trawl. Five bottom-mounted archival acoustic recorders (MARUs) were deployed by the NEFSC in the area encompassing the shelf break of Georges Bank and the Great South Channel in May 2013; four of the recorders were successfully recovered on the AMAPPS shipboard survey in July/August. Details of the surveys can be found in Appendices A (SEFSC aerial winter survey), B (NEFSC shipboard summer survey) and C (SEFSC shipboard summer survey). These sightings and effort data are archived in the NEFSC Oracle database and will be sent to the OBIS SEAMAP online database.

NEFSC participated in a loggerhead turtle tagging study that was primarily funded by the Coonamessett Farm Foundation and Virginia Aquarium and Marine Science Center. Data from this study will be used to establish dive time correction factors for the proportion of loggerhead 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, these data will provide information on loggerhead turtle habitat use, behavior, and life history. In May 2013, 20 satellite tags were deployed on loggerhead turtles primarily in waters 40 – 80 statute miles off Delaware through Virginia. Tagged loggerhead turtles were measured and weighed; biopsy samples for genetic analyses were collected; and blood samples were collected to analyze testosterone levels (to identify sex) and general blood chemistry (for health assessment). More details can be found in Appendix D. These 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.

A multi-agency team conducted the first non-pup gray seal (*Halichoerus grypus grypus*) live capture, tagging, and biological sampling in U.S. waters. This took place at Chatham Harbor, MA from 13 – 17 June 2013, which was the end of the annual molt. Fifteen seals were sampled and nine animals were fitted with electronic tags (7 GPS cell phone and 2 satellite tags). All seals were flipper tagged. A suite of biological measurements and samples were collected for various studies including: health assessment, diet, disease, age, and genetics. Electronic tagged animals remained within or adjacent to the capture region for several months. One cell-phone tagged seal died from a fatal shark bite and stranded in Chatham Harbor in early August. After summer, the remaining seals exhibited longer distance excursions to offshore waters, including one to Sable Island, and others used haul-out sites in eastern Nantucket Sound in late autumn, prior to the start of the December-February pupping and breeding period. More details can be found in Appendix E. The computerized data from the cell phone tags are archived at Duke University. Argos data from one satellite tag is archived at Whelock College (Whalenet) and the second at NEFSC. All digital photographs and samples are archived in the NEFSC Oracle database. The collected biological samples were sent to several organizations that are analyzing the samples, including Woods Hole Oceanographic Institution, Cornell University, and National Institute of Standards and Technology.

Analyses

In collaboration, the United State Navy, Coonamessett Farm Foundation, Virginia Aquarium & Marine Science Center, NEFSC, SEFSC, and University of St. Andrews (Scotland) are analyzing the tag data from loggerhead turtles to estimate spatially- and temporally- explicit availability corrections. More details can be found in Appendix D.

To model the spatial/temporal distribution of marine mammals and sea turtles using data collected since 2010, three frameworks are being developed that use different types of models: Bayesian hierarchical models, generalized linear and additive models, and nonparametric multiplicative regression models. During 2013, preliminary results were available for a few species: fin whales using the Bayesian hierarchical framework, bottlenose dolphins using the generalized additive framework, and common dolphins using the nonparametric multiplicative regression framework. An additional person was hired during 2014 and the plan is to complete at least two of these frameworks and apply them to as many species as the data and time allow. For more details see Appendix F.

During 2012, new standardized passive acoustic hydrophone array systems were built by staff from all of the NOAA Fisheries Service Science Centers. Two of those array systems were used during the summer 2013 AMAPPS shipboard surveys, one on the NEFSC survey and one on the SEFSC survey. In addition, the passive acoustic team at the NEFSC constructed a new acoustic recording system, which houses all of the circuitry for the filter, gain, A/D conversion, and power conversion for the array. This recording system utilizes voltage regulators to control electrical noise generated by devices on-board the ship. This new recording setup was tested during the AMAPPS 2013 shipboard survey and was found to perform extremely well in comparison with past systems.

In addition, the passive acoustic data collected on the 2011 and 2013 Northeast AMAPPS shipboard surveys are being used in four primary ongoing projects: (1) generating abundance estimates for sperm whales (*Physeter macrocephalus*) using acoustic data; (2) determination of acoustic detection rates for beaked whales; (3) continuation of work on acoustic species classification for delphinids, focusing on testing the new Atlantic whistle classifier; and (4) evaluating the spring/summer acoustic occurrence of baleen whales around Georges Bank, utilizing a new automated baleen whale classification algorithm. In addition, collaborations are ongoing to contribute data for the development of a species-specific echolocation classifier for Risso's dolphins. 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). Details on the passive acoustic work can be found in Appendix G.

The models and density maps being developed in Appendix F 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 more directly driving 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 2013, the active acoustic backscatter data from the 2011 survey was cleaned up and classified into taxa categories with cruise-specific templates which can now be used to more quickly process the other years' data. Also, in 2013 the video plankton images from the 2011 survey were processed and classified into taxa categories using specially created algorithms, which again will make processing data from other years faster. In addition, some of the preserved net samples were sorted and enumerated; other will be enumerated in 2014. More details can be found in Appendix H.

The AMAPPS ORACLE database that stores the data collected during the field activities and associated environmental variables that were derived from other sources was updated in 2013, additional datasets were added, and the structure was improved to make it more flexible and connective between all of the different types of data. Details can be found in Appendix I.

REFERENCES CITED

Waring GT, Josephson E, Maze-Foley K, Rosel, PE, editors. 2013. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2012. NOAA Tech Memo NMFS NE 223; 419 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 2013: 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.

2013 field collection projects	Platform(s)	Dates in 2013	Location	Appendix
Winter abundance survey (SEFSC)	NOAA Twin Otter aircraft	19 Feb - 23 Mar	Shelf waters from South Carolina to New Jersey	A
Summer abundance survey (NEFSC)	NOAA ship Henry B. Bigelow	1 Jul - 19 Aug	North Carolina to Massachusetts, near coast to beyond the US EEZ	B
Summer abundance survey (SEFSC)	NOAA ship Gordon Gunter	13 Jul - 15 Sep	South Carolina to Virginia, near coast to the US EEZ	C
Northern sea turtle tagging (NEFSC)	F/Vs Kathy Ann and Ms. Manya	20 – 25 May	40 – 80 statute miles offshore of Delaware to Virginia	D
Gray seal tagging (NEFSC)	small boats	13 - 17 Jun	off Chatham Harbor, MA	E

Table 2. A brief description of the purpose of the AMAPPS NOAA Fisheries Service analyses projects that occurred during 2013 and the appendix where more information on the project can be found.

2013 analysis projects	Purpose	Appendix
Spatially- and temporally-explicit estimates of availability of loggerhead sea turtles	Use tag data to estimate the percent of time loggerheads are available to be seen by the survey platforms.	D
Spatially- and temporally-explicit density models and maps	Develop Bayesian hierarchical and generalized additive models to quantify relationship between marine mammals and sea turtles and habitat	F
Acoustic abundance estimate of sperm whales	Utilize towed hydrophone array data to estimate abundance of sperm whales using passive acoustic techniques	G
Encounter rates of beaked whales	Compare the visual detection rates of beaked whales and the acoustic detection rates from towed hydrophone array data	G
Delphinid whistle and echolocation classification	Test performance of whistle classifier for western Atlantic delphinid species; develop echolocation classifier for Risso's dolphins	G
Evaluation of new acoustic baleen whale call classifier	Incorporate new acoustic classification methodology into analyses of baleen whale presence using bottom-mounted recorder data	G
Offshore spring/summer occurrence of baleen whales in the Great South Channel and Georges Bank	Using bottom-mounted recorders to document presence of baleen whale vocalizations during Mar - Jun 2012 and May - Aug 2013	G
Process and compare EK60 acoustic backscatter data	Process active acoustic backscatter data (represents middle level trophic taxa), then compare with distributions of marine mammals and sea turtles	H
Process and compare the Visual Plankton Recorder images	Process images of plankton from the Visual Plankton Recorder, then compare with distributions of marine mammals, sea turtles and sea birds	H
Process and compare the organisms in net tows	Enumerate samples from bongo nets, MOCNESS and Isaacs-Kidd midwater trawl, then compare with distributions of marine mammals, sea turtles and birds	H
Expand AMAPPS database	Built on the existing NEFSC Oracle database, the AMAPPS data are being added to the database in order to store and process these data	I

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

Completed in 2013

Waring GT, Josephson E, Maze-Foley K, Rosel, PE, editors. 2013. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments -- 2012. NOAA Tech Memo NMFS NE 223; 419 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026, or online at http://www.nefsc.noaa.gov/publications/tm/tm223/

Avens L, Goshe LR, Pajuelo M, Bjorndal KA, MacDonald BD, Lemons GE, Bolten AB, Seminoff JA. 2013. Complementary skeletochronology and stable isotope analyses offer new insight into juvenile loggerhead sea turtle oceanic stage duration and growth dynamics. *Marine Ecology Progress Series* 491: 235-251.

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

Cholewiak D, Risch D, Valtierra R, Van Parijs SM. 2013. Methods for passive acoustic tracking of marine mammals: estimating calling rates, depths and detection probability for density estimation. Chapter 6 in Adam, O. (ed) Detection, Classification and Localization of marine mammals, pp. 107 - 145.

Valtierra RD, Holt RG, Cholewiak D, Van Parijs SM. 2013. Calling depths of baleen whales from single sensor data: Development of an autocorrelation method using multipath localization. *Journal of the Acoustical Society of America* 143(3): 2571-2581.

In review

Waring GT, Josephson E, Maze-Foley K, Rosel, PE, editors. In review. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2013. Will be submitted as a NOAA Tech Memo NMFS NE.

Waring GT, Josephson E, Maze-Foley K, Rosel, PE, editors. In review. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2014. Will be submitted as a NOAA Tech Memo NMFS NE.

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 3 cont. New papers (completed, in review, or in progress) that document some aspect of the AMAPPS work.

In progress
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.
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.
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. Will be submitted as a manuscript to a peer-reviewed journal.
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.

Table 4. Approximate number of groups detected during the aerial winter (February – March) and shipboard summer (July – September) 2013 AMAPPS abundance surveys.

Species		Number of groups Winter	Summer
Atlantic spotted dolphin	*Stenella frontalis*	9	79
Atlantic spotted or Bottlenose dolphin		2	14
Blainville's beaked whale	*Mesoplodon densirostris*		3
Blue whale	*Balaenoptera musculus*		3
Bottlenose dolphin spp.	*Tursiops truncatus*	76	154
Bottlenose dolphin + pilot whales			7
Bottlenose dolphin + fin whale			1
Bottlenose dolphin + Atlantic spotted dolphin			1
Bottlenose dolphin + Risso's dolphin			1
Clymene dolphin	*Stenella clymene*		3
Common dolphin	*Delphinus delphis*	25	60
Cuvier's beaked whale	*Ziphius cavirostris*		58
Dwarf sperm whale	*Kogia sima*		10
Fin whale	*Balaenoptera physalus*	6	34
Fin or sei whale	*B. physalus or B. borealis*		10
Harbor porpoise	*Phocoena phocoena*	8	1
Humpback whale	*Megaptera novaeangliae*	3	25
Minke whale	*B. acutorostrata*	3	3
Right whale	*Eubalaena glacialis*	3	3
Risso's dolphin	*Grampus griseus*	10	104
Rough-toothed dolphin	*Steno bredanensis*		5
Pantropical spotted dolphin	*Stenella attenuata*		3
Pilot whale spp.	*Globicephala spp.*	1	96
Pygmy sperm whale	*Kogia breviceps*		14
Pygmy/Dwarf sperm whale	*K. breviceps or K. sima*		44
Sei whale	*Balaenoptera borealis*		1
Sowerby's beaked whale	*Mesoplodon bidens*		12
Sperm whale	*Physeter macrocephalus*	2	107
Striped dolphin	*Stenella coeruleoalba*		49
Unid beaked whales	*Mesoplodons spp*		102
Unid dolphin	*Delphinidae*	31	245
Unid whale	*Mysticeti*	5	69
Total cetaceans		**184**	**1321**
Leatherback turtle	*Dermochelys coriacea*	3	1
Loggerhead turtle	*Caretta caretta*	69	21
Unid hardshell turtle	*Chelonioidea*	70	16
Total turtles		**142**	**38**
Harbor seal	*Phoca vitulina*		4
Gray seal	*Halichoerus grypus*		2
Unid seal	*Pinniped*	1	1
Total all species		**327**	**1366**

Table 5. Birds detected during the shipboard summer (July – September) 2013 AMAPPS Northeast Fisheries Science Center's (NE) and Southeast Fisheries Science Center's (SE) abundance surveys.

		Number of individuals	
Species		**NE**	**SE**
Trindade (Herald) Petrel	*Pterodroma (heraldica) arminjoniana*	1	34
Black-capped Petrel	*Pterodroma hasitata*	16	154
Cory's Shearwater	*Calonectris diomedea*	1177	1113
Great Shearwater	*Puffinus gravis*	735	25
Sooty Shearwater	*Puffinus griseus*	34	
Manx Shearwater	*Puffinus puffinus*	16	6
Barolo (Little) Shearwater	*Puffinus baroli*	7	
Audubon's Shearwater	*Puffinus lherminieri*	661	323
unidentified shearwater	*Puffinus sp.*	66	246
Wilson's Storm-Petrel	*Oceanites oceanicus*	1469	198
White-faced Storm-Petrel	*Pelagodroma marina*	18	1
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	778	6
Band-rumped Storm-Petrel	*Oceanodroma castro*	90	157
unidentified storm-petrel	*Oceanodroma sp.*	12	32
Leach's/Harcourt's Storm-Petrel	*Oceanodroma leucorhoa/castro*	35	
White-tailed Tropicbird	*Phaethon lepturus*	7	22
Red-billed Tropicbird	*Phaethon aethereus*	1	1
unidentified tropicbird	*Phaethon sp.*	1	2
Northern Gannet	*Morus bassanus*	4	
Double-crested Cormorant	*Phalacrocorax auritus*	1	
Great Blue Heron	*Ardea herodias*	1	
Black-bellied Plover	*Pluvialis squatarola*	1	3
Semipalmated Plover	*Charadrius semipalmatus*		4
Greater Yellowlegs	*Tringa melanoleuca*	1	1
Lesser Yellowlegs	*Tringa flavipes*		13
Willet	*Tringa semipalmata*		1
Ruddy Turnstone	*Arenaria interpres*	1	7
Semipalmated Sandpiper	*Calidris pusilla*	3	7
Least Sandpiper	*Calidris minutilla*	2	5
White-rumped Sandpiper	*Calidris fuscicollis*	7	
Pectoral Sandpiper	*Calidris melanotos*		10
Short-billed Dowitcher	*Limnodromus griseus*		1
unidentified dowitcher	*Limnodromus griseus/scolopaceus*	1	

Table 5 cont. Birds detected during the shipboard summer (July – September) 2013 AMAPPS Northeast Fisheries Science Center's (NE) and Southeast Fisheries Science Center's (SE) abundance surveys.

		Number of individuals	
	Species	**NE**	**SE**
Red Phalarope	*Phalaropus fulicarius*	3	5
unidentified phalarope	*Phalaropus sp.*	2	
unidentified shorebird	*Sp.*	16	7
Laughing Gull	*Leucophaeus atricilla*	14	
Herring Gull	*Larus argentatus*	46	
Great Black-backed Gull	*Larus marinus*	31	
Arctic Tern	*Sterna paradisaea*	1	
Black Tern	*Chlidonias niger*		16
Bridled Tern	*Onychoprion anaethetus*	5	14
Common Tern	*Sterna hirundo*	23	12
Least Tern	*Sternula antillarum*	2	1
Royal Tern	*Thalasseus maximus*	2	20
Sandwich Tern	*Thalasseus sandvicensis*		1
Sooty Tern	*Onychoprion fuscatus*		29
unidentified tern	*Sp.*	9	14
South Polar Skua	*Stercorarius maccormicki*	3	
Pomarine Jaeger	*Stercorarius pomarinus*	10	4
Parasitic Jaeger	*Stercorarius parasiticus*	14	
Long-tailed Jaeger	*Stercorarius longicaudus*	3	1
unidentified jaeger	*Stercorarius sp.*	2	
Brown Pelican	*Pelecanus occidentalis*		1
Snowy Egret	*Egretta thula*		2
Mourning Dove	*Zenaida macroura*	1	
Tree Swallow	*Tachycineta bicolor*	1	
Barn Swallow	*Hirundo rustica*	8	11
Cliff Swallow	*Petrochelidon pyrrhonota*		1
Cape May Warbler	*Setophaga tigrina*	1	
Yellow Warbler	*Dendroica petechia*	1	
Black Throated Blue Warbler	*Setophaga caerulescens*		1
Prairie Warbler	*Setophaga discolor*		1
Red-winged Blackbird	*Agelaius phoeniceus*	2	
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	1	
Brown-headed Cowbird	*Molothrus ater*	5	1
American Redstart	*Setophaga ruticilla*		1
Blue-winged Teal	*Anas discors*		16

Table 5 cont. Birds detected during the shipboard summer (July – September) 2013 AMAPPS Northeast Fisheries Science Center's (NE) and Southeast Fisheries Science Center's (SE) abundance surveys.

		Number of individuals	
	Species	**NE**	**SE**
Common Nighthawk	*Chordeiles minor*		2
Northern Waterthrush	*Parkesia noveboracensis*		1
Orchard Oriole	*Icterus spurius*		1
unidentified passerine	*Sp.*		2
Whimbrel	*Numenius phaeopus*		2
unidentified petrel	Sp.		1
Yellow-breasted Chat	*Icteria virens*		1
TOTAL		5352	2541

Figure 1. Tracklines completed during the winter (February – March) 2013 AMAPPS aerial survey.

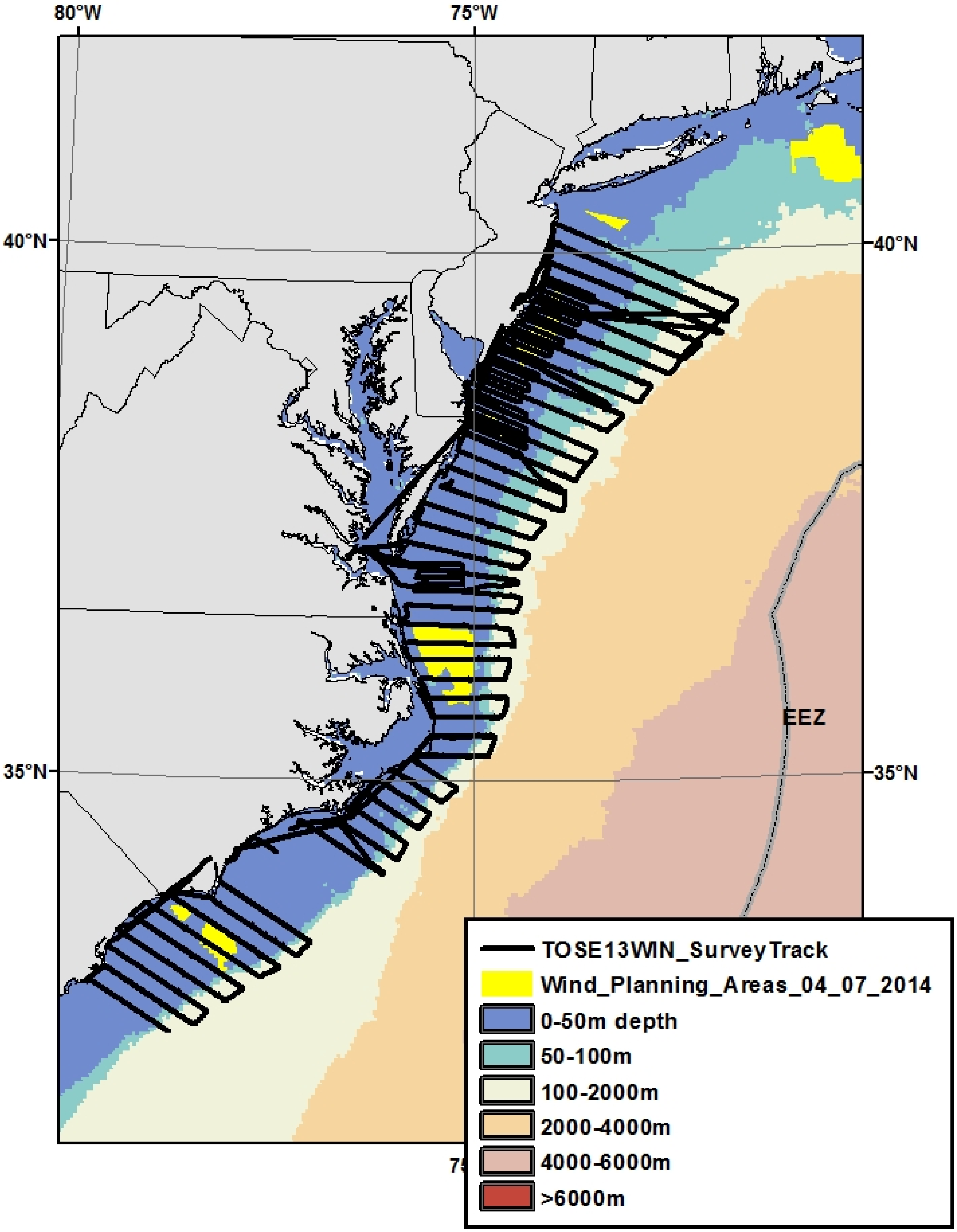
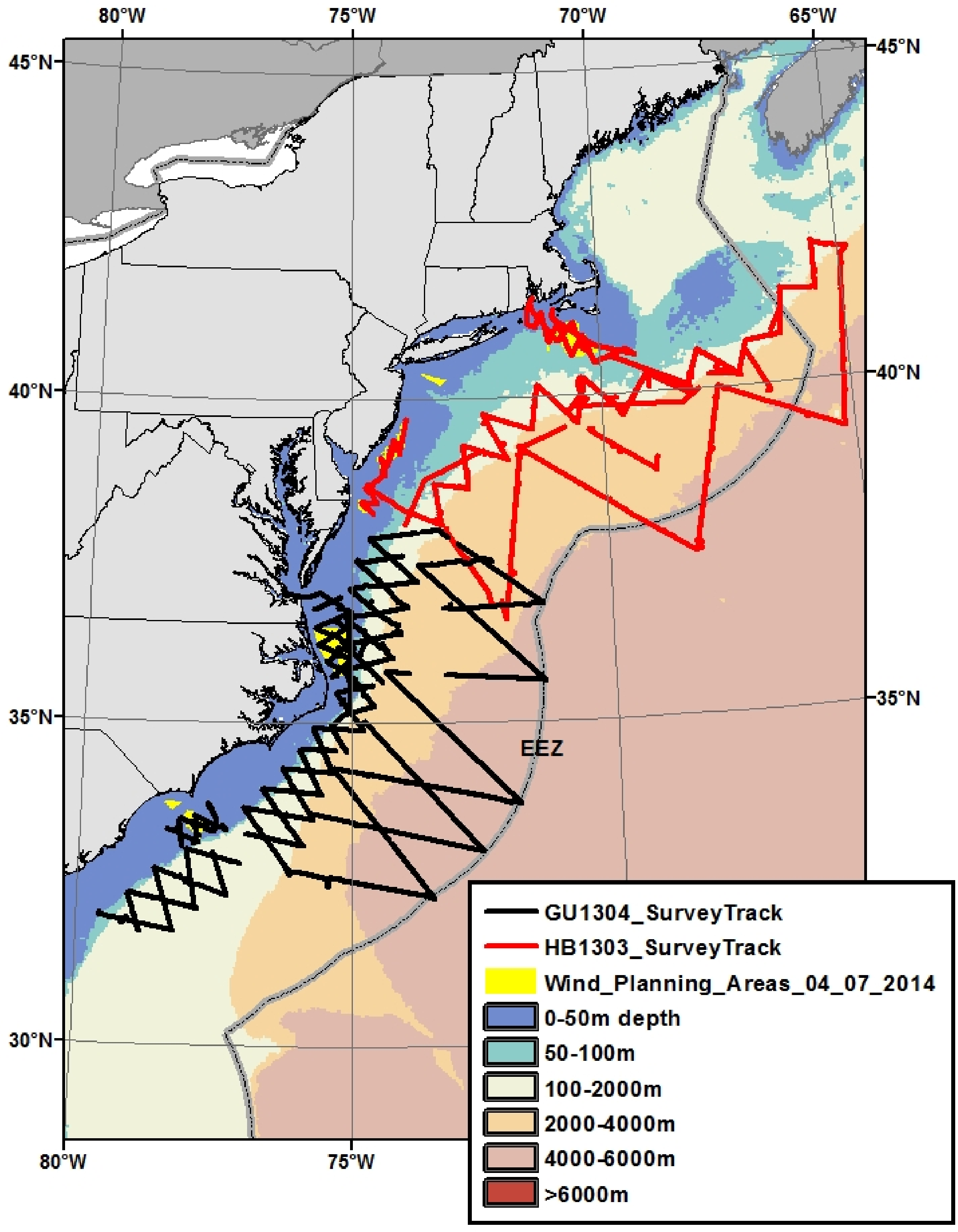


Figure 2. Tracklines completed during the summer (July – September) 2013 AMAPPS shipboard surveys.



Appendix A: *Aerial abundance survey during February-March 2013: Southeast Fisheries Science Center*

Lance P. Garrison[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. One aerial survey was conducted during 2013 between 19 February and 23 March. 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 (204 km/hr). The survey was designed for analysis using Distance sampling and a two-team (independent observer) approach to correct for perception 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 7,284 km of trackline were surveyed on effort. Twelve species of marine mammals were identified, with the majority being bottlenose dolphins (76 groups sighted totaling 1,052 animals). Two species of sea turtles were identified, with the majority of identified animals being loggerhead turtles (69 sightings totaling 70 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 2011 winter survey only effort south of Cape Hatteras, NC were able to be completed. Thus the priority area for this survey was north of Cape Hatteras, NC.

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 A1). 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 perception 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 were 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.

Post survey, 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 19 February – 23 March 2013, but survey flights could only be conducted on 15 days during that period due to weather conditions, mechanical issues, or transits between cities. A total of 7,284 km of trackline were covered on effort along 82 tracklines (Figure A1, Table A1). 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 3.0 on the Beaufort scale with the majority of the survey effort flown in sea states of 2 or 3 (Figure A2). 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 142 unique sightings of sea turtles for a total of 149 individuals. Turtles were identified as loggerhead turtles, leatherback turtles, and unidentified hardshells (Table A2).

Of these, the majority of identified turtle sightings were loggerhead turtles (Figure A3). Turtle sightings were restricted to the area south of Cape Hatteras, NC (Figure A3 – A4).

There were a total of 188 groups of marine mammals sighted for a total of 2,296 individuals. The primary species observed was bottlenose dolphins. Large whales including right whales, humpback whales, minke whales and fin whales were seen in the northern portion of the survey area (Table A3, Figures A5 – A7).

Fish species sighted included primarily sharks, rays, and sunfish (Figure A8).

DISPOSITION OF DATA

All data collected during the aerial survey are archived and managed at the Southeast Fisheries Science Center, Miami, FL.

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 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 NOAA Fisheries Service, SEFSC. We would also like to thank the airplane's crew and observers that were involved in collecting these data.

REFERENCES CITED

Laake, J.L. and Borchers, D.L. 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 A1. Daily summary of survey effort and protected species sightings during Southeast AMAPPS February-March 2013 aerial survey.

Date	Effort (km)	Marine Mammal Sightings	Turtle Sightings	Average Sea State
2/19/2013	192.0	2	1	5.4
2/22/2103	891.3	26	0	3.1
2/25/2013	616.1	17	0	2.6
2/26/2013	710.9	0	0	3.7
2/28/2013	572.1	3	0	2.4
3/1/2013	381.4	10	0	3.7
3/2/3013	132.7	1	0	2.6
3/5/2013	306.5	10	0	2.5
3/10/2013	835.7	23	0	2.6
3/11/2013	793.8	31	1	2.3
3/15/2013	358.9	36	17	3.3
3/17/2013	26.1	1	0	3.1
3/20/2013	367.6	8	44	3.2
3/22/2013	765.5	16	53	2.9
3/23/2013	333.6	4	26	3.2
Total	7,284	188	142	3.0

Table A2. Summary of sea turtle sightings during Southeast AMAPPS February-March 2013 aerial survey.

Species	Number of sightings	Number of animals
Unid. Hardshell	70	76
Leatherback	3	3
Loggerhead	69	70
Total	142	149

Table A3. Summary of marine mammal sightings during Southeast AMAPPS winter 2013 aerial survey.

Species	Number of groups	Number of animals
Atlantic spotted dolphin	9	198
Bottlenose Dolphin	76	1,052
Bottlenose/Atl Spotted Dolphin	2	2
Common Dolphin	25	670
Fin Whale	6	7
Harbor porpoise	8	14
Humpback Whale	3	3
Minke Whale	3	3
North Atlantic Right Whale	3	4
Pilot Whales	1	30
Risso's Dolphin	10	46
Sperm Whale	2	2
Stenella sp.	3	22
Unid. Baleen whale	3	3
Unid. Dolphin	28	204
Unid. Odonocete	1	1
Unid. Large Whale	1	1
Unid. Seal	1	1
Unid. Small Whale	1	1
Total	188	2,296

Figure A1. Aerial survey tracklines during the Southeast AMAPPS February-March 2013 aerial survey.

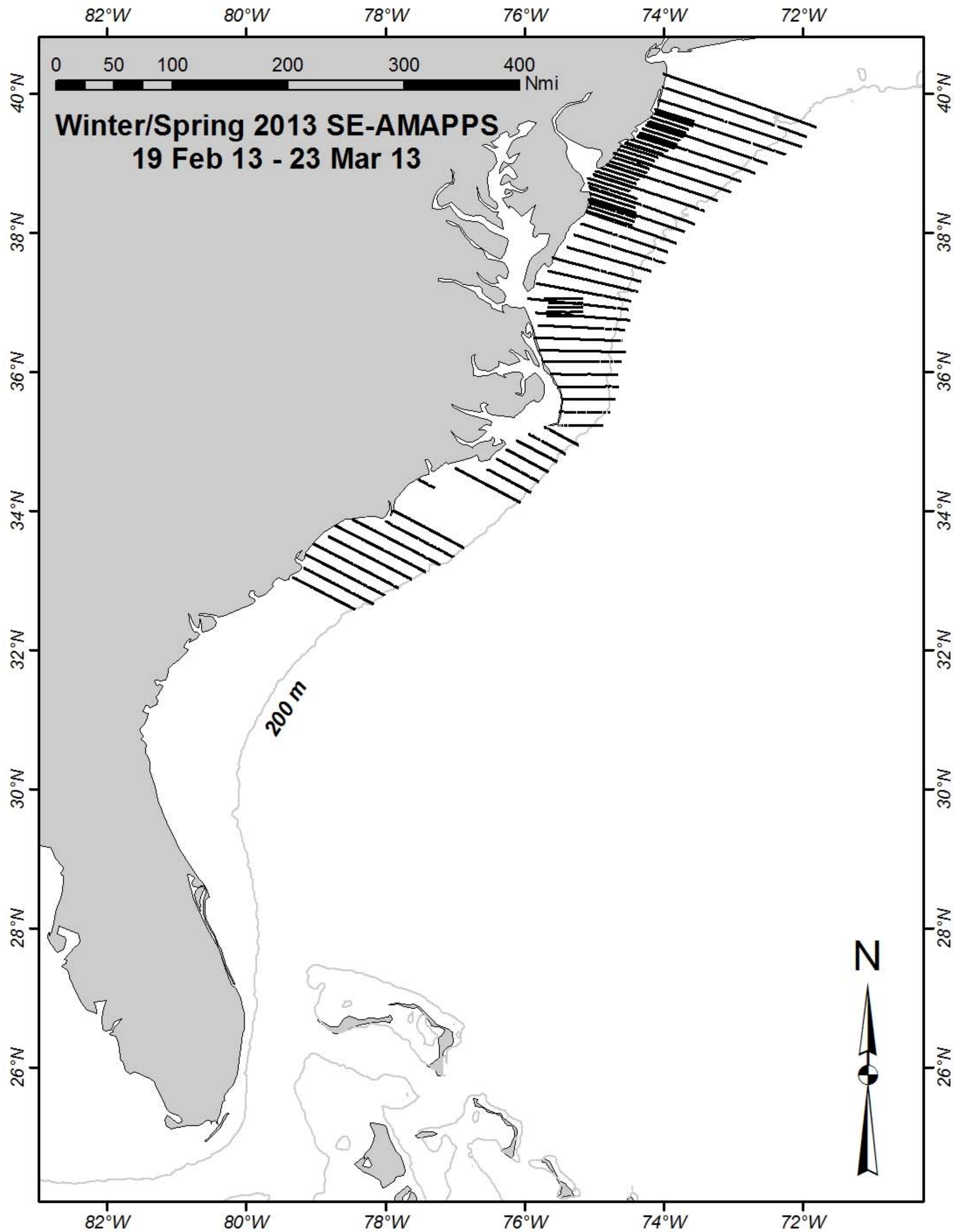


Figure A2. Beaufort sea states during the Southeast AMAPPS February-March 2013 aerial survey.

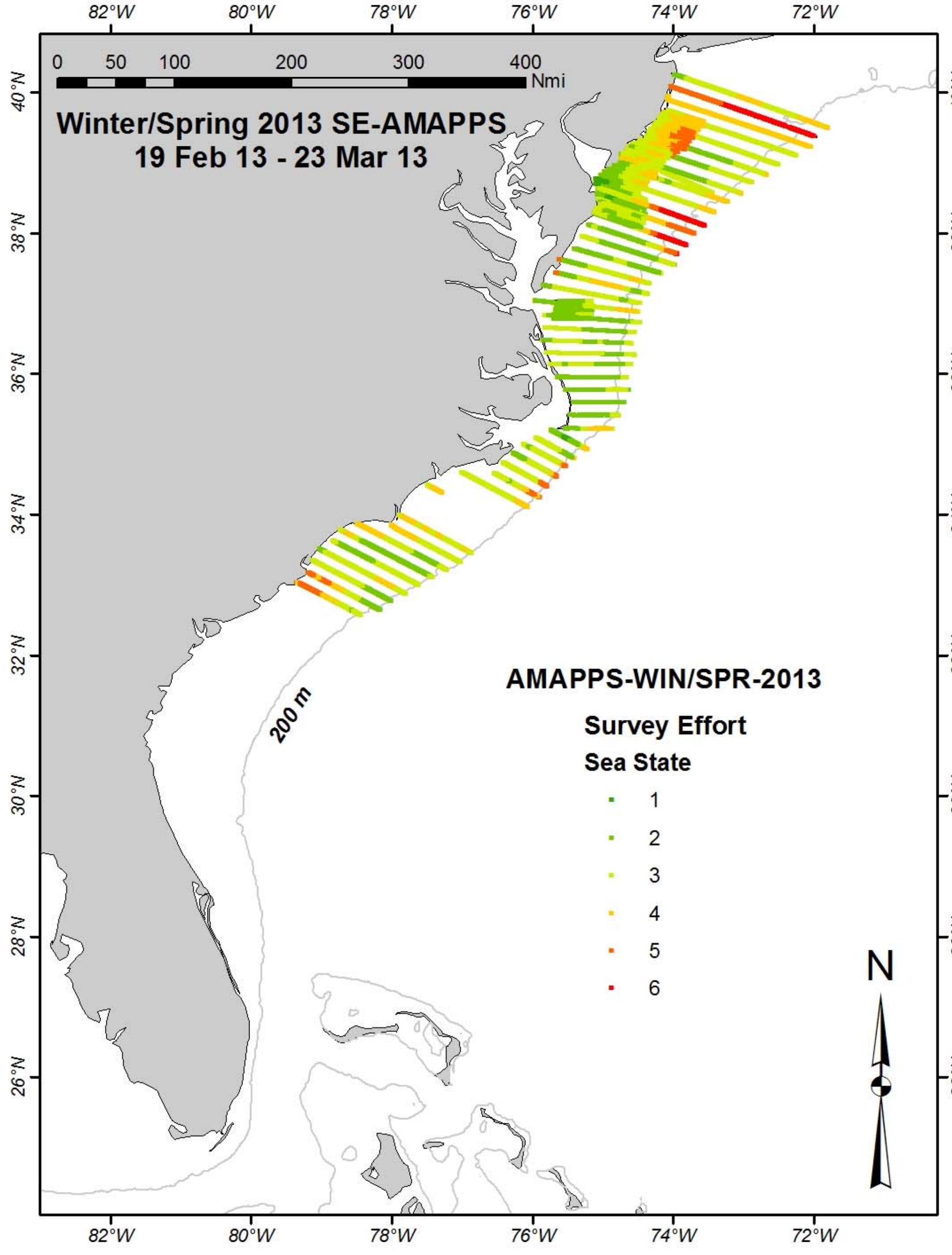


Figure A3. Loggerhead turtle sightings during the Southeast AMAPPS February-March 2013 aerial survey.

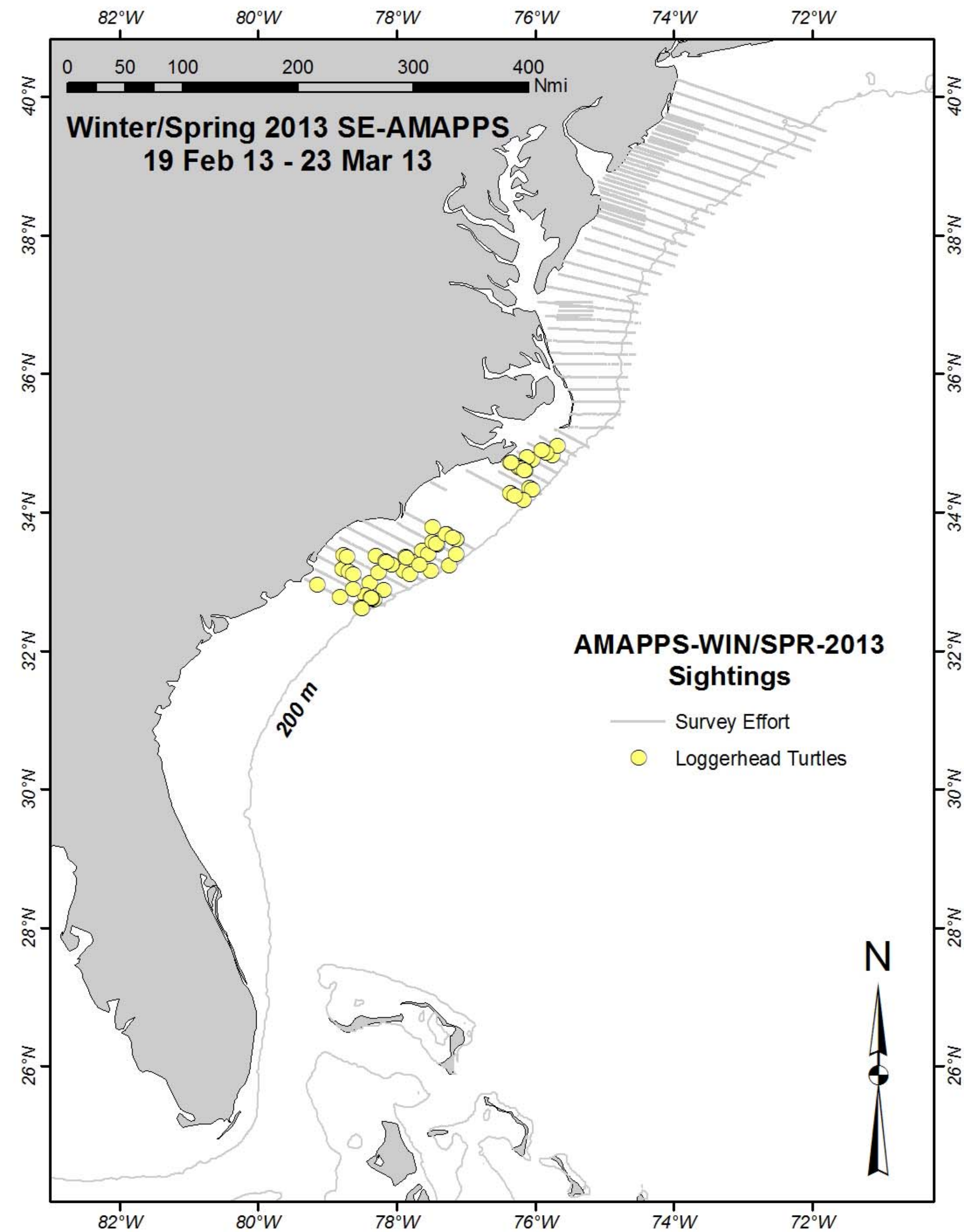


Figure A4. Other turtle sightings during the Southeast AMAPPS February-March 2012 aerial survey.

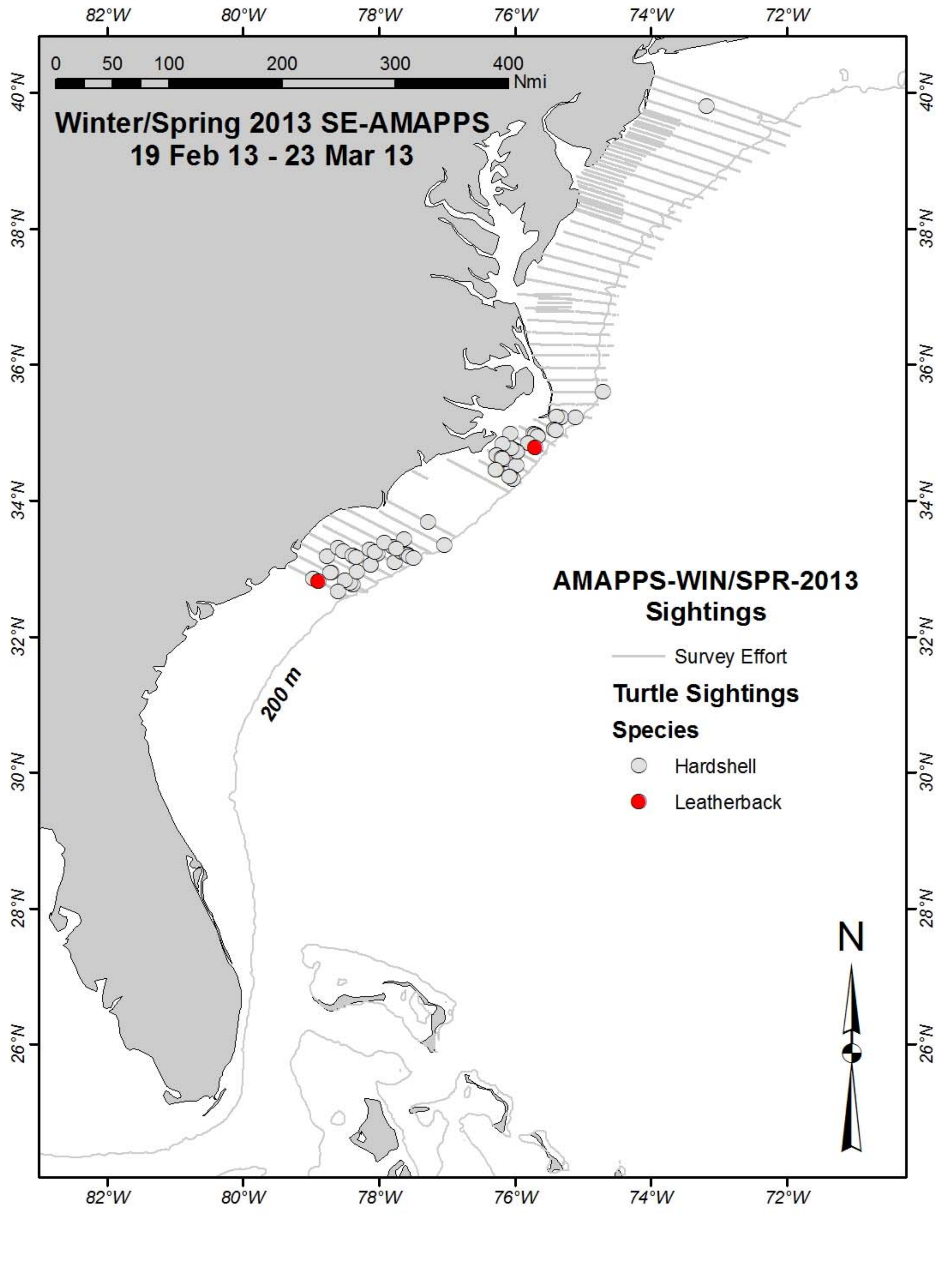


Figure A5. Bottlenose dolphin sightings during the Southeast AMAPPS February-March 2013 aerial survey.

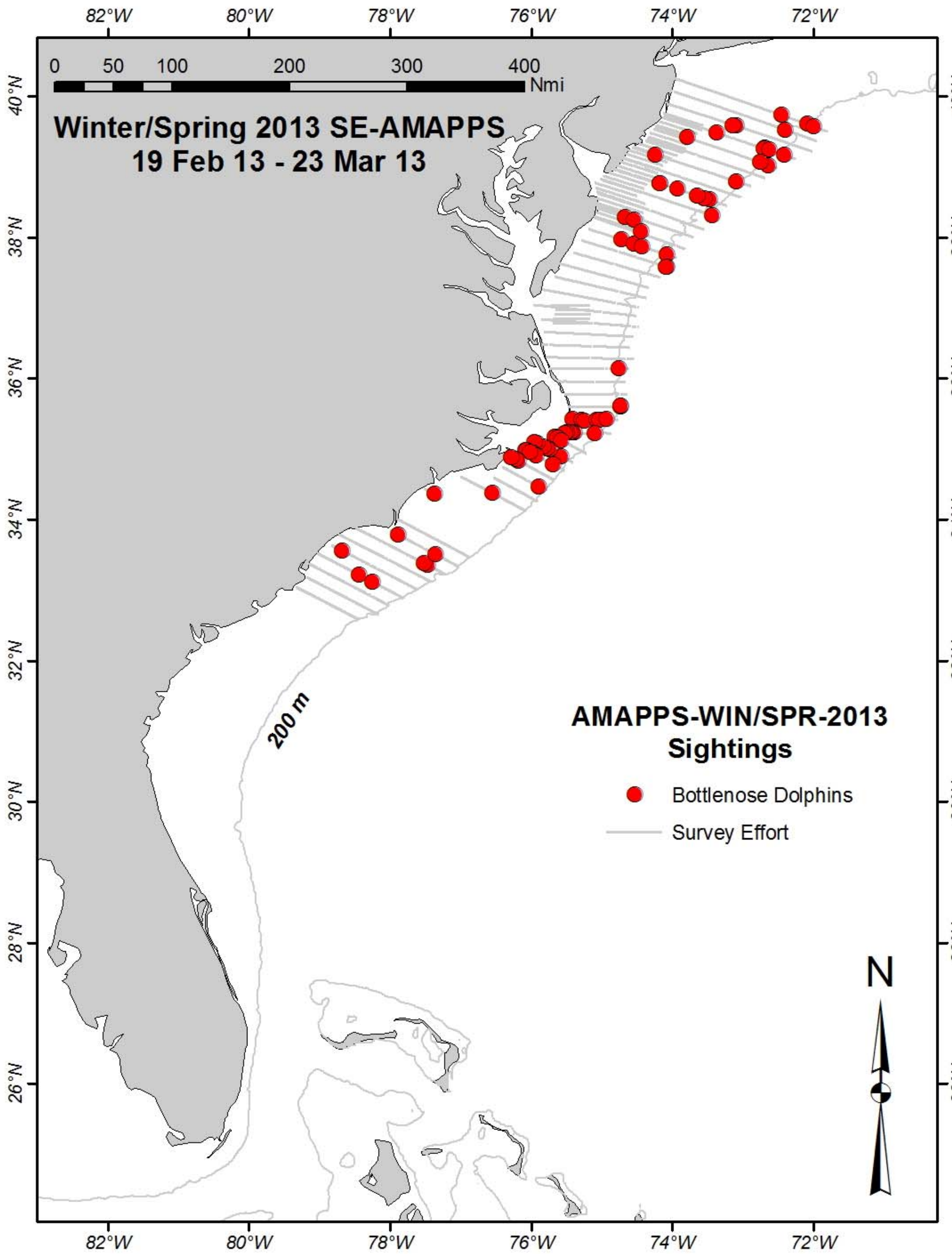


Figure A6. Other dolphin sightings during the Southeast AMAPPS February-March 2013 aerial survey.

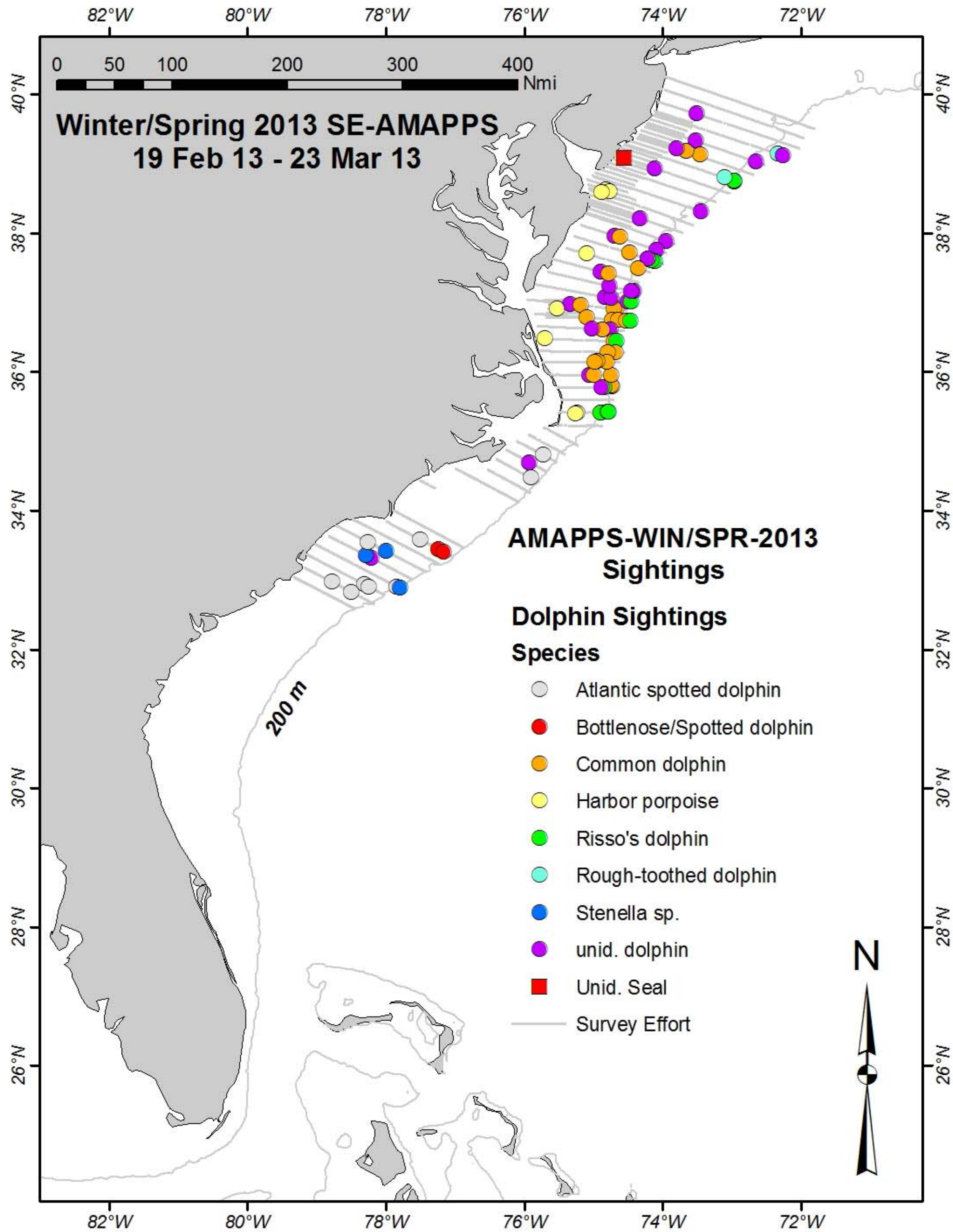


Figure A7. Whale sightings during the Southeast AMAPPS February-March 2013 aerial survey.

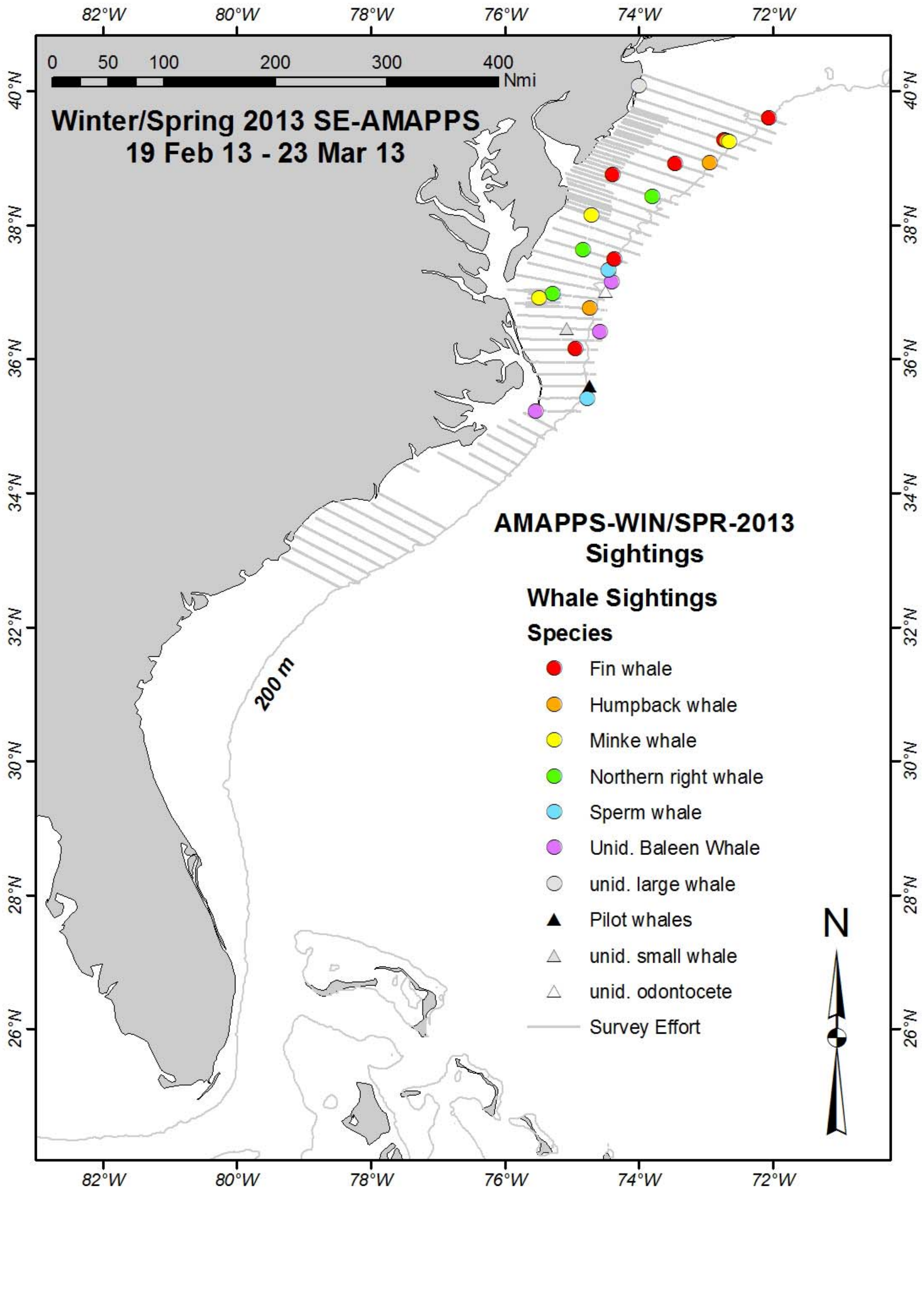
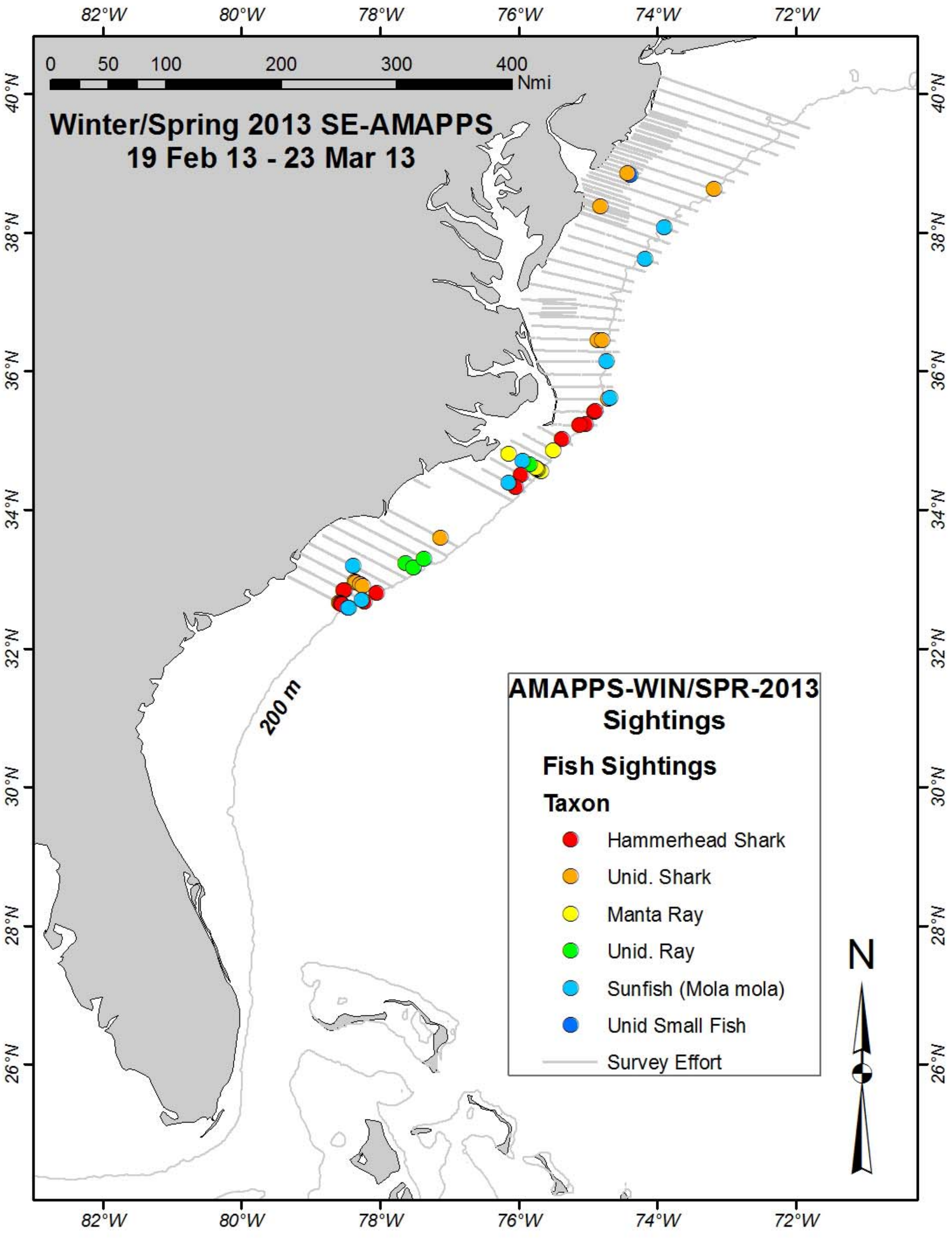


Figure A8. Fish sightings during the Southeast AMAPPS February-March 2013 aerial survey.



Appendix B: *Northern leg of shipboard abundance surveys during summer 2013: Northeast Fisheries Science Center*

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

SUMMARY
During 1 – 23 July and 29 July – 19 August 2013, the Northeast Fisheries Science Center (NEFSC) conducted a shipboard abundance survey targeting marine mammals, sea birds and sea turtles. The study area included waters south of Cape Cod, MA, north of North Carolina, east of the southern tip of Nova Scotia, and west of the US Atlantic coastline. 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 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), and muli-frequency echosounder (EK60). Over 5000 km of track lines were surveyed during the daytime with about 275 hours of passive acoustic recordings. Over 9,900 individuals within over 780 groups of 39 species (or species groups) of cetaceans, seals and large fish were visually detected and over 260 groups of vocally-active odontocetes from 7 species were heard. Common dolphins (*Delphinus delphis*) and striped dolphins (*Stenella coeruleoalba*) were the most regularly detected small cetacean species; sperm whales (*Physeter macrocephalus*) and fin whales (*Balaenoptera physalus*) were the most common large whales; and loggerhead turtles (*Caretta caretta*) were the most common sea turtles. Over 5300 birds within over 2200 groups of 53 species (or species groups) were detected while on effort. Five species comprised 90% of the total birds seen. In declining order of abundance these were: Wilson's Storm-Petrel *(Oceanites oceanicus)*, Cory's Shearwater *(Calonectris diomedea)*, Leach's Storm-Petrel *(Oceanodroma leucorhoa)*, Great Shearwater *(Puffinus gravis)*, and Audubon's Shearwater *(Puffinus lherminieri)*. Over 250 physical and biological oceanographic collection stations were sampled. This included 116 casts of the CTD, 89 bongo deployments, 30 VPR deployments, 12 Isaac-Kidd midwater trawl (IKMT) deployments, and 9 MOCNESS deployments.

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

CRUISE PERIOD AND AREA

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

The study area included waters south of Cape Cod (about 42° N latitude), north of North Carolina (about 36° N latitude), east of the southern tip of Nova Scotia (about 65° W longitude), and west of the US coast (about 74° 30' W longitude). This is waters shallower than about 4500 m which includes international waters and waters within the US and Canadian economic exclusive zones (EEZ). This study area was divided into four spatial strata that represent different habitats: Shelf Break, Offshore, BOEM-MA, and BOEM-MidAtl (Figure B1).

METHODS

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

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. Surveying was conducted during good weather conditions (Beaufort five and below) while traveling at about 10 knots, as measured over the ground.

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

Position, date, time, ship's speed and course, water depth, surface temperature, salinity, and conductivity, along with other variables (Table B1) were obtained from the ship's Science Computer System (SCS). These data were routinely collected and recorded every second at least while during visual survey operations. Sightings and visual team effort data were entered by the scientists onto hand held data entry computerized systems called VisSurv-NE (version 3) which was initially developed by L. Garrison and customized by D. Palka.

At times when it was not possible to positively identify a species or when training the observers on species identifications 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).

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

1) Time sighting was initially detected, recorded to the nearest second,
2) Species composition of the group,

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

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

The following effort data were recorded every time one of the factors changed (at least every 30 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).

VISUAL SEABIRD SIGHTING TEAM

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

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

All data were entered in real time into a Panasonic Toughbook laptop running *SeeBird (vers 4.3.6),* a data collection program developed at the Southwest Fisheries Science Center. The 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 5 min. All data underwent a quality assurance and data integrity check each evening and saved to disk and to an external backup dataset.

PASSIVE ACOUSTIC DETECTION TEAM

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

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

The hydrophone array used in this survey was constructed in 2012/2013, and was comprised of two modular, oil-filled sections, separated by 30 m of cable. The end-array consisted of 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 filtered at 1000 Hz, and variable gain between 20 – 40 dB was added depending on the relative levels of signal and noise. The recording system incorporated two National Instruments soundcards (NI USB-6356). One soundcard sampled the six mid-frequency channels at 192 kHz, the other sampled the two high-frequency channels at 500 kHz, both at a resolution of 16 bits. Digitized acoustic data were recorded directly onto laptop and desktop computer hard drives using the software program Pamguard (http://www.pamguard.org/home.shtml), which also recorded simultaneous GPS data, continuous depth data, and allowed manual entry of corresponding notes. Two channels of analog data were also routed to an external RME Fireface 400 soundcard and a separate desktop computer, specifically for the purpose of real-time detection and tracking of vocal animals using the software packages WhalTrak and Ishmael. Whenever possible, vocally-active groups that were acoustically tracked were matched with visual detections in real-time, for assignment of unambiguous species classification. Communication was established between the acoustic team and the visual team situated on the flying bridge to facilitate this process.

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

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

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

TRACKER TEAM

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

HYDROGRAPHIC AND PLANKTON CHARACTERISTICS

Daytime Sampling

In addition to the ship's Science Computing System (SCS) logger system that continuously recorded oceanographic data from the ship's sensors, a SEACAT 19+ Conductivity, Temperature, and Depth Profiler (CTD) was used to measure water column conductivity, temperature and depth. The CTD was mounted on 322 conducting core cable allowing the operator to see a real time display of the instrument depth and water column temperature, salinity, density and sound speed on a computer monitor in the ship's Dry Lab. Once a day, a vertical profile was conducted with the CTD, where a Niskin bottle was attached to the wire above the CTD. The Niskin bottle was used to collect a water sample which will be used to calibrate the conductivity sensor of the CTD. The calculated sound speeds from the vertical profiles were used for the daily calibration of both the active and passive 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 one 333 µm and one 505 µm mesh net and a CTD mounted on the wire 1 m above the nets was deployed approximately three times a day: once before the day's surveying started (about 0500 – 0530), at lunch time (about 1200 when the ship stopped surveying), and again after surveying was completed for the day (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.

Nighttime Sampling

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

Sampling equipment included:

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

Canyons (aka Z-type surveys)

Repeat passes of cross-canyon transects were conducted of transects positioned half-way up the canyon and near the canyon head. Which instruments were deployed and the order of operations varied between nights depending on prevailing conditions. Typically though, both transects were run for ADCP and EK60 data collection in a Z- or C-shape. A series of 5 CTD casts (Seabird

19+) were made along the mid-canyon line to near-bottom (targeting one cast on the rim on each side, one about half way down each side to the max depth axis, and one in the axis). Pending available remaining time, MOCNESS, IKMT, and/or VPR tows were conducted targeting acoustic features of high scattering and interesting frequency response (e.g., characteristic of krill, small zooplankton, and mesopelagic fishes) in order to ground-truth the acoustic data.

Shelfbreak (Non-canyon)

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

Slope

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

Shelf

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

<u>Active Acoustic Sampling</u>

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

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

RESULTS

Scientists involved in this survey are detailed in Table B2.

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

The visual marine mammal and turtle team surveyed about 5021 km while on effort during 38 of the 42 possible sea-days; the weather conditions were too poor to survey on the other 4 sea-days. Some track lines initially surveyed while on effort in poor sighting conditions were re-surveyed at a later time in better conditions. Thus resulting in 4333 km of track lines surveyed in the best possible sighting conditions which will be used in the abundance estimation analyses (Figure B1; Table B3). About 70% of the survey track lines were conducted in good weather conditions, Beaufort sea state 3 or less (Table B3).

During the on-effort better condition track lines, 28 cetacean species or species groups, 3 turtle species or species groups, 3 seal species or species groups, and 5 fish species or species groups were recorded (Tables B4 and B5). For cetaceans, the upper team detected 787 groups (9,907 individuals) and the lower team detected 633 groups (5,855 individuals). For turtles, the upper team detected 38 groups (39 individuals) and the lower team detected 26 groups (27 individuals). Note some, but not all, groups of cetaceans and turtles detected by one team were also detected by the other team. Seven seal was detected. In addition, 5 (12) basking sharks and 31 (12) ocean sunfish was detected by the upper (and lower) teams.

Distribution maps of sighting locations of the cetaceans, turtles, seals and fish are displayed in Figures B2 – B11. Note these are locations of sightings seen by only the upper team. The most abundance species (Figure B4) were striped dolphins (*Stenella coeruleoalba)* and common dolphins (*Delphinus delphis*), where the striped dolphins were found in deeper waters (mostly 1000 m or deeper) than the common dolphins (mostly 1000 m or shallower). Of interest, over 140 Cuvier's beaked whales (*Ziphius cavirostris*) were positively identified, where most of them were west of 68° W in waters that were 2000 – 3000 m deep (Figure B6). In contrast, the positively identified Sowerby's beaked whales (*Mesoplodon bidens*) were in shallower waters 1000 – 2000 m deep. In contrast to previous summer surveys in the same waters, there were many humpback whales (*Megaptera novaeangliae*) just south of Massachusetts in the BOEM-MA stratum (Figure B8). Also in contrast to previous summer surveys, 4 right whales (*Eubalaena glacialis*), 3 blue whales (*Balaenoptera musculus*), and 4 minke whales (*Balaenoptera acutorostrata*) were detected (Figure B9).

Biopsy samples were collected from six animals, 4 bottlenose dolphins in 2 groups (2 individuals per group), 1 Atlantic spotted dolphin and 1 striped dolphin (Figure B12).

VISUAL SEABIRD SIGHTING TEAM

Seabird survey effort was conducted on all 42 sea-days. The NOAA ship *Henry B. Bigelow's* flying bridge provided a stable platform and afforded good visibility for the seabird team. Seabird survey data were collected on every sea-day; however, data collection effort was truncated on three days on Leg 1 due to rain and/or fog (Figure B13). Nomenclature of species identifications followed that reported in The Clements Checklist of Birds of the World. 6th edition, Cornell University Press 2007, with electronic updates to 2011.

A summary of all 5353 birds seen while on effort broken down by species is presented in Table B6 most of the species are mapped in Figures B14 – B24. This survey recorded 44 species of birds and nine unidentified species groups (e.g., unidentified shearwater or unidentified storm-petrel). Five species comprised 90% of the total birds seen. In declining order of abundance these were: Wilson's Storm-Petrel *(Oceanites oceanicus)*, Cory's Shearwater *(Calonectris diomedea),* Leach's Storm-Petrel *(Oceanodroma leucorhoa)*, Great Shearwater *(Puffinus gravis)*, and Audubon's Shearwater *(Puffinus lherminieri)*. These widespread species were occasionally found in small scale clusters, particularly storm-petrels, which would often concentrate in upwelling areas seaward of the shelf break. Meanwhile others, such as Bridled Tern *(Onychoprion anaethetus),* and Black-capped Petrel *(Pterodroma hasitata),* are tropical and sub-tropical species closely linked to their preferred habitat; in this case, warm Gulf Stream water. Extensive warm surface waters may have had an influence on the abundance and distribution of Audubon's Shearwater. This species was unusually abundant and widespread with several being seen as far north as Nova Scotia. Similarly, the large number of White-faced Storm-Petrels *(Pelagodroma marina)* seen this year, another warm water species, may be due to the same factors. Notably, one White-faced Storm-Petrel was seen off Nova Scotia which is extremely unusual.

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

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

PASSIVE ACOUSTIC DETECTION TEAM

Over the course of the survey, acoustic monitoring effort was conducted on 35 of 42 sea-days, with a total of 273.2 h of daytime recording on survey tracklines. In addition, evening/nighttime recordings were made opportunistically on 14 occasions, for a total of 49.9 h (Figure B25, Table B7), primarily in canyons and across the shelf break. Evening recordings were not monitored in real-time for acoustic events, but will be included in processing analyses. The hydrophone array was not deployed on days during which shallow, coastal lines were surveyed, nor during transits to and from port.

Real-time monitoring resulted in the detection of 263 groups of vocally-active odontocetes (Figure B25). Of these, approximately 22% corresponded to simultaneous visual detection of groups, allowing for species assignment (Table B8). Seven species of delphinids were represented in the data, along with sperm whales and beaked whales. In some cases, large schools of dolphins that covered a broad spatial range were difficult to localize accurately in real-time, making a direct comparison with visual sighting locations impossible. Additionally, in many cases it was impossible in real time to acoustically differentiate between subgroups of animals that were visually distinguished and counted as separate sightings, resulting in an underestimate of acoustic detections as compared to visual detections. Both of these issues will be addressed in processing analyses.

Sperm whales were detected on at least 25 survey days (15 days in Leg 1 and 10 in Leg 2), for a total of 65 vocally-active groups (Figure B26, Table B8). In many cases, these acoustic events represent multiple individuals. Total number of individual sperm whales will be calculated through localization and tracking in processing analyses.

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

Four of five marine autonomous recording units (MARUs) were successfully recovered during the survey (Figure B27). The unrecovered unit (number 4 in Figure B27) did not respond to attempts to communicate with it acoustically, nor did it surface at its pre-programmed date and time. This unit is considered lost. Data from the other units will be extracted and included in processing analyses.

On 9 August 2013, one of the modular sections of the towed passive acoustic hydrophone array was lost, presumably due to failure of the attachment mechanism. Subsequent acoustic recordings were collected only with the "in-line" section of the array. Reconstruction of the array section, with modifications to prevent similar failure from re-occurring, took place in spring 2014.

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

TRACKER TEAM

The tracker team (surveying with one set of 25x150 powered big eye binoculars) was on effort during the same times that the upper and lower marine mammal and turtle teams were on effort. Since they were located behind the upper team they did not have as good a viewing area as the upper team. Despite this disadvantage, they were still able to detect 114 groups of cetaceans, 497 individuals (Tables B4 – B5), where the goal was to record mostly only small sized groups (less than 5 individuals per group).

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

HYDROGRAPHIC/BONGO/PLANKTON SAMPLES

During both legs, in the day and night over 250 sampling stations were conducted. This included 116 casts of the CTD, 89 bongo deployments, 30 video plankton recorder, VPR, deployments, 12 Isaac Kid mid-water trawl, IKMT, deployments, and 9 MOCNESS deployments (Table B9; Table B28). At night after the visual teams were off-effort, oceanographic sampling was successfully conducted at 9 canyon sites, 4 shelfbreak non-canyon sites, 5 slope water sites, and 2 shelf sites (Table B10; Figures B29 – B33). More details from these sampling stations and gear types are below.

Acoustic Sampling

Large and dense acoustic scattering layers, consistent with small-bodied organisms, were frequently observed in canyons (Figure B34) and across the shelfbreak (Figure B35a). Net tows in these layers with the MOCNESS and IKMT typically sampled large numbers of euphausiids (Figure B36), copepods, hyperiid amphipods (Figure B36), mesopelagic fish, especially pearlsides (Figure B37a) and myctophids (Figure B37b), and/or salps. Of particular interest are pervasive scattering layers often observed where scattering was highest at the lower frequencies (18 and 38 kHz; Figure B37a,b). This kind of pattern is typical of scatterers bearing a small gas inclusion, such as myctophids with small or partially-filled swimbladders.

Future analysis will involve processing of the raw data to remove unwanted signal (e.g., from the seafloor) and noise (e.g., Figure B35a). Differences in scattering levels at the different frequencies (e.g., Figure B5b) will be used to identify features attributable to different kinds of scatters and the net and VPR data will be used to ground-truth the taxonomic composition of these features. The distribution of different kinds of scatters will then be examined in light of bathymetry, hydrography, and the distribution of marine mammal predators.

MOCNESS Sampling

Where possible, a 1m^2 MOCNESS was deployed in conjunction with the acoustic surveys to provide depth-integrated samples of plankton and larger organisms such as mesopelagic fish and euphausiids. A total of 9 1m^2 MOCNESS hauls were conducted (Table B9; Figure B28). The MOCNESS was towed at 1-1.5 kn speed and was equipped with 9, 333 µm mesh nets, conductivity and temperature sensors, a color VPR, and two banks of strobes. The 1m^2 MOCNESS is designed to sample plankton under 1.5 cm in size and the strobes were included to increase capture efficiency of larger plankton by disorienting euphausiids and mesopelagic fishes. Sampling locations, depth, and net open/close depths were determined by observations made during the acoustic transects, ocean conditions, and weather.

While use of the MOCNESS was often limited by the large quantities of salps in the sampling areas, the gear was successful in depicting the invertebrate composition of layers seen on the EK60. Though the MOCNESS may not have been as successful capturing mesopelagic fish, those that were captured were in very good condition (Figure B37).

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

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

IKMT Sampling

The IKMT was also deployed, when possible, with the site surveys to target depth-specific layers that were observed at the lower frequencies of the EK60 and consistent with mesopelagic fish and euphausiids. A total of 11 hauls were conducted (Table B9; Figure B28) The IKMT had a 1mm mesh cod end and was mounted below a CTD. To maximize the sampling depth, the IKMT was lowered to below its target depth with the ship maintaining minimal speed without sacrificing steerage. The ship then increased its speed to 2 – 3 kn (speed over the ground, SOG). As the IKMT rose through the water with the increased SOG, the IKMT trawl depth was maintained by adjusting the amount of wire out. Oftentimes, the wire angle became too steep, causing the wire to rub on the aft block. As a result, tow speed was limited. The IKMT deployments were also limited by the large numbers of salps present, as well as wind and currents. A deployment targeting a layer thought to be mesopelagic fish yielded over 15 gallons of salps and a limited numbers of fish.

V-fin VPR Sampling

When bottom depths were shallow, large volumes of plankton, especially salps, were present, or we were not near any of the survey areas the self contained black and white V-fin VPR (Davpr 05) was deployed. A total of 30 hauls were conducted (Table B9; Figure B28). The V-fin was towed at speeds of 2 – 4 kn for 1 – 1.5 h and was equipped with a Seabird SBE49 Fastcat CTD and a Wet Labs combination fluorometer and turbidity sensor. The camera imaging area was set based on location, previous VPR hauls, or the types of plankton collected with the bongo nets. Two types of tows were conducted. The first type was a single depth tows targeted distinct layers on the EK60 to provide temporally fine scale plankton data to assist in the ground truthing of the EK60 data and to examine plankton patchiness. The second type was a tow-yo haul which was used to describe water column structure and plankton depth distributions. Tow-yo hauls were conducted if there were no distinct layers on the EK60 or the oceanography looked interesting. Tow-yo hauls were also used to quantify plankton, especially salps, before deciding whether to deploy the larger nets samplers.

Habitat Descriptions

The mid Atlantic bight shelf break and slope areas (BOEM-MidAtl stratum) were distinguished by very warm, salty water (Figure B38) and were dominated by gelatinous zooplankton (Figure B39). *Salpa aspera* (Figure B40) was present in large numbers from mid shelf break out into slope waters. *S. aspera* ranged from 2 – 5 cm in size and was an active dial migrator residing below 1000 m during the day and rising at dusk to 50 – 500 m. Moderate numbers of siphonophores, hydromedusa and dolids were also noted. Deeper layers contained the euphausiids: *Euphausia sp* and *Thysanoessa longicaudata*. These were both smaller euphausiid species and were also diel migrators.

The southern New England shelf break and slope areas had more complex oceanography characterized by strong thermoclines, variable salinities, and chlorophyll layers associated with the bottom of the thermocline (Figure B41). The plankton was more diverse but the biomass continued to be dominated by *S.aspera*. *Thalia democratica* was present in moderate numbers on the outer shelf and the shallow areas of the shelf break. *T.democratica* ranged in size from 5 – 15 mm in size and was not a dial migrator. The zooplankton contained large numbers of crustaceans including the copepod *Calanus finmarchicus*, the Euphausiids, *Euphasia sp* and *T. longicaudata*; and the hyperid amphipod *Thermisto gaudichaudii*. A significant number of phoronids were also present.

The Georges Bank shelf break and slope areas had highly variable oceanography with generally strong thermoclines of varying depths. Oceanography was affected by proximity to canyons or channels (Figure B42). Plankton varied with depth and locations. Slope stations continued to have high numbers of *S. aspera* with increased numbers of the copepod *C. finmarchicus* and the euphasiids *Euphasia sp* and *T. longicaudata*. In areas with colder temperatures the larger euphausiid *Meganyctiphanes norvegica* was present. The salp *T.democratica* was present in moderate numbers along the southern flank of Georges Bank.

The Nantucket shoals area (BOEM-MA stratum) was characterized by highly variable bottom depth, strong currents, moderate thermoclines, variable salinities (Figure B43), and very diverse, locally patchy plankton. The western side had high numbers of larval fish and the VPR images captured a gastropoda spawning event. The eastern side was dominated by the epibenthic amphipod, *Gammarus annulatus*, ctenophores and siphonophores (Figure B44).

Special Sampling

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

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

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

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

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

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

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

Active Acoustic Data Collection

Active acoustic data were collected on a portable hard drive, which was sent to the NEFSC and the data were archived at the NEFSC at the completion of each leg. The start and end times of the EK60 data collection are specified in Table B11.

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

DISPOSITION OF 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.

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 and under Canadian Species at Risk Permit license number 330996.

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, Northeast Fisheries Science Center (NEFSC).

Table B1. 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 B2. Scientific personnel involved in the two legs of this survey. FN = Foreign National.

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

Table B3. Within each Beaufort sea state condition, total length of visual teams' track lines while on effort (in km).

	Track line length (km) within Beaufort sea state levels						
Conditions	**0**	**1**	**2**	**3**	**4**	**5**	**TOTAL**
Better	45.5	451.6	1427.9	1094.7	864.1	448.9	4332.7
Worst	0	9.3	52.6	94.8	409.2	122.5	688.4
TOTAL	45.5	460.9	1480.5	1189.5	1273	571.4	5021.1
% of better conditions	0.01	0.10	0.33	0.26	0.20	0.10	1
cumulative percentage	0.01	0.11	0.44	0.70	0.90	1.00	

Table B4. Number of groups and individuals of cetacean species detected by the three marine mammal - turtle visual teams, upper, lower and tracker, during on-effort good condition track lines. Note, some, but not all, groups detected by one team were also detected by the other team.

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

Table B5. Number of groups and individuals of large fish, turtles, and seals detected by the three marine mammal - turtle visual teams, upper, lower and tracker, during on-effort good condition track lines. Note, some, but not all, groups detected by one team were also detected by the other team.

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

* Off effort sightings

Table B6. Number of groups and individual birds detected within the 300 m survey strip during the NOAA ship *Henry B. Bigelow* abundance survey conducted during 1 Jul – 18 Aug 2013.

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

Table B6 (cont). Number of groups and individual birds detected within the 300 m strip during the NOAA ship *Henry B. Bigelow* abundance survey conducted during 1 Jul – 18 Aug 2013.

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

Table B7. Summary of passive acoustic recording effort.

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

Table B8. Summary of acoustic events detected or tracked in real-time during the survey. Species were assigned to acoustic detections when acoustic localization and tracking resulted in direct correspondence with visual sightings. Groups without species assignment include both those that were not visually detected, as well as groups that could not be definitively linked to visual sightings in real-time. Note that in many cases, acoustic detections include multiple individuals (in the case of sperm whales) or multiple subgroups (in the case of delphinids), and therefore cannot be compared directly to the numbers of groups sighted visually.

	Number of events (may include multiple groups)
Bottlenose dolphin	12
Common dolphin	11
Atlantic spotted dolphin	8
Striped dolphin	17
Risso's dolphin	20
Pilot whales	7
Clymene's dolphin	1
Mixed species groups	7
Sperm whales	65
Beaked whales	2
Stenella spp.	2
Groups without species assignment	111
TOTAL	263

Table B9. The number of hydrographic and oceanographic sampling stations.

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

Table B10. Nighttime shelfbreak and canyon surveys summary.

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

Table B11. Start and end times of EK60 data collection.

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

Table B1. Strata locations (colored regions) and Beaufort sea states that the tracklines (colored lines) were surveyed under. Strata include: offshore (purple), shelfbreak (blue), BOEM-MA wind energy area (green), and BOEM-MidAtl wind energy areas (red). The US exclusive economic zone (EEZ) and the 100 m, 2000 m, and 4000 m depth contours are also displayed.

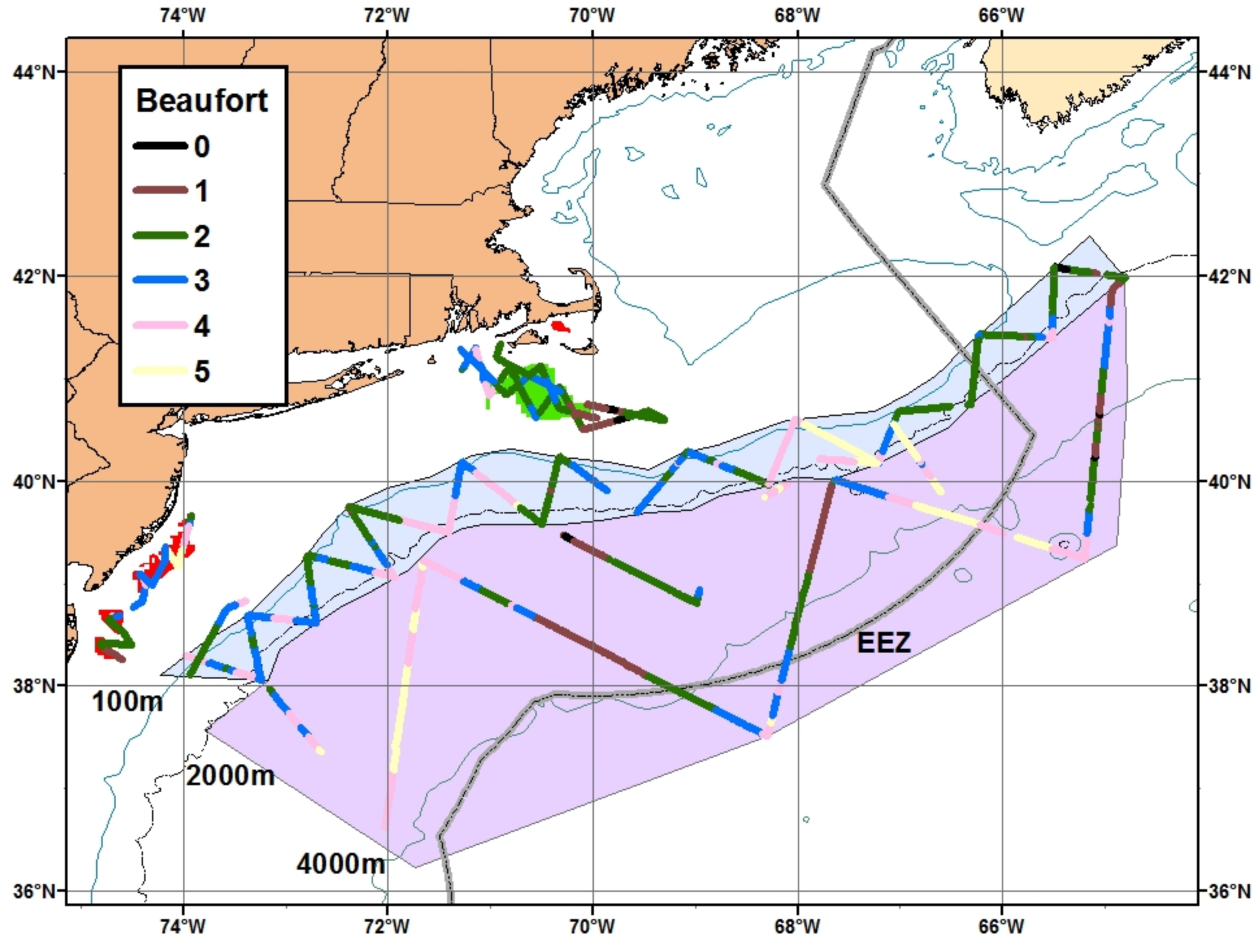
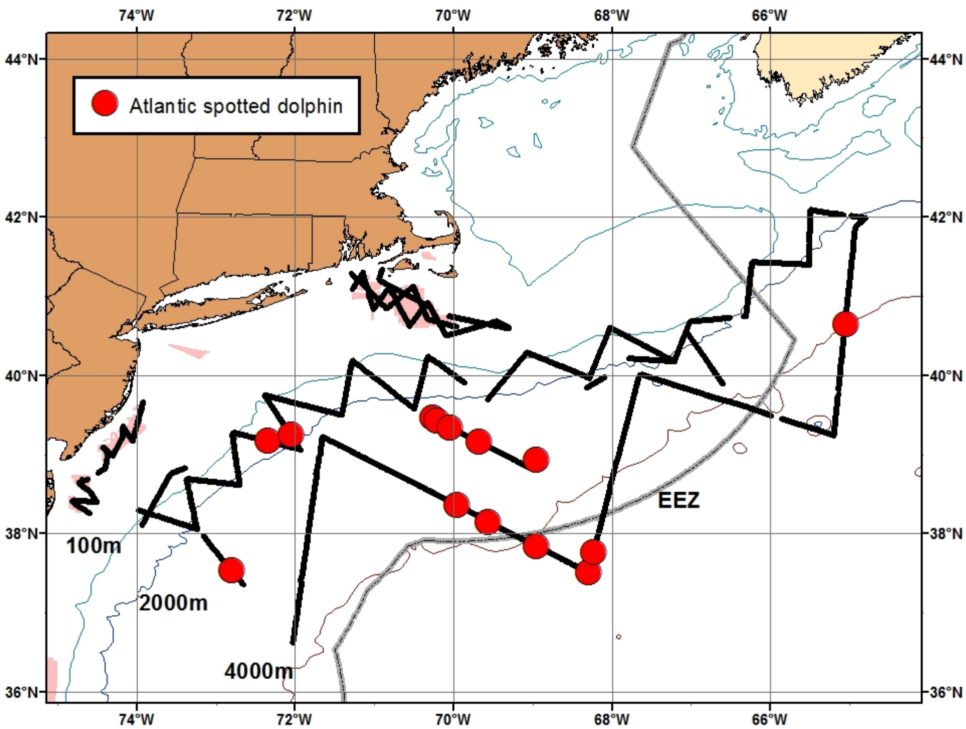


Figure B2. Location of Atlantic spotted dolphin (*Stenella frontalis*; top) and bottlenose spp. dolphin (*Tursiops truncatus*; bottom) sightings detected by the upper team during on-effort better conditions.



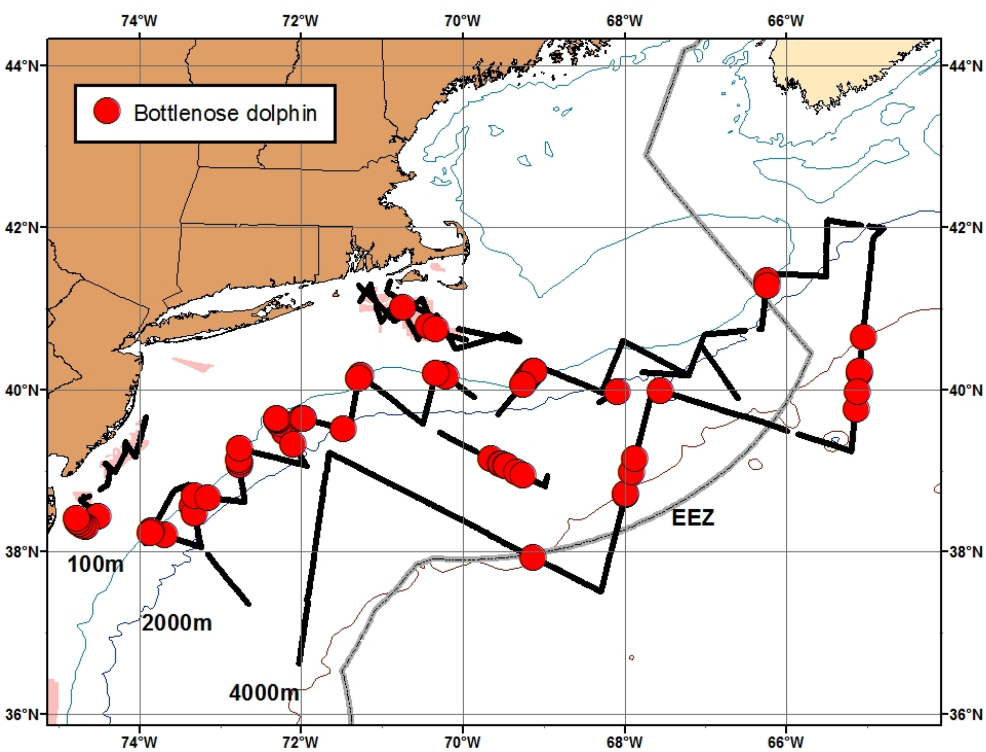
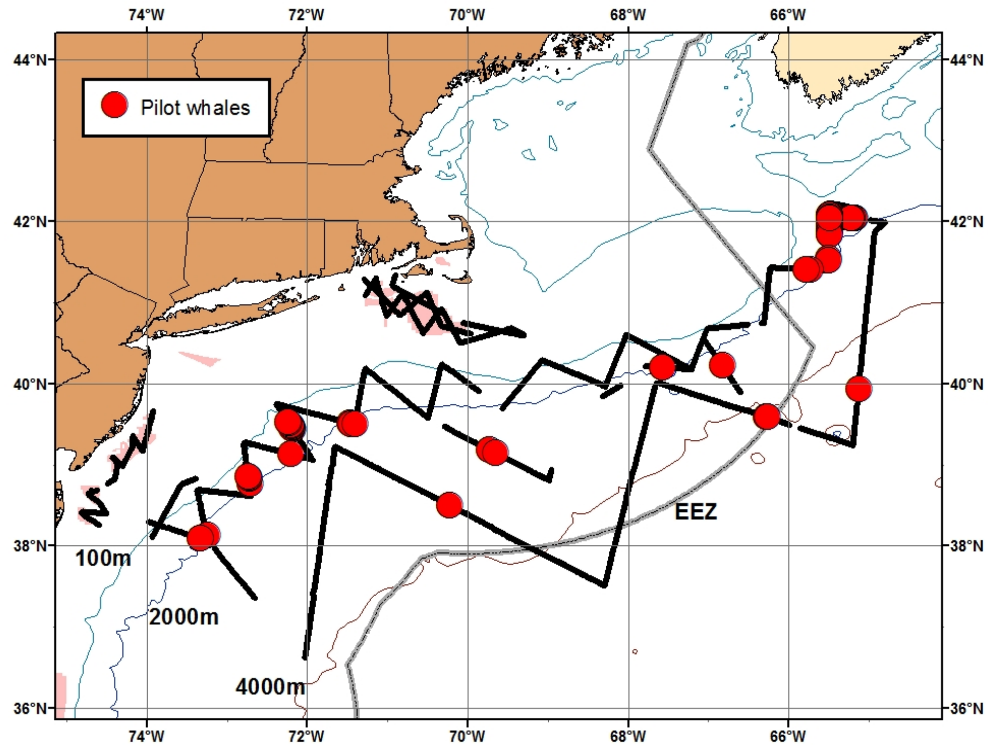


Figure B3. Location of pilot whale spp. (Globicephala spp.; top) and Risso's dolphin (*Grampus griseus*; bottom) sightings detected by the upper team during on-effort better conditions.



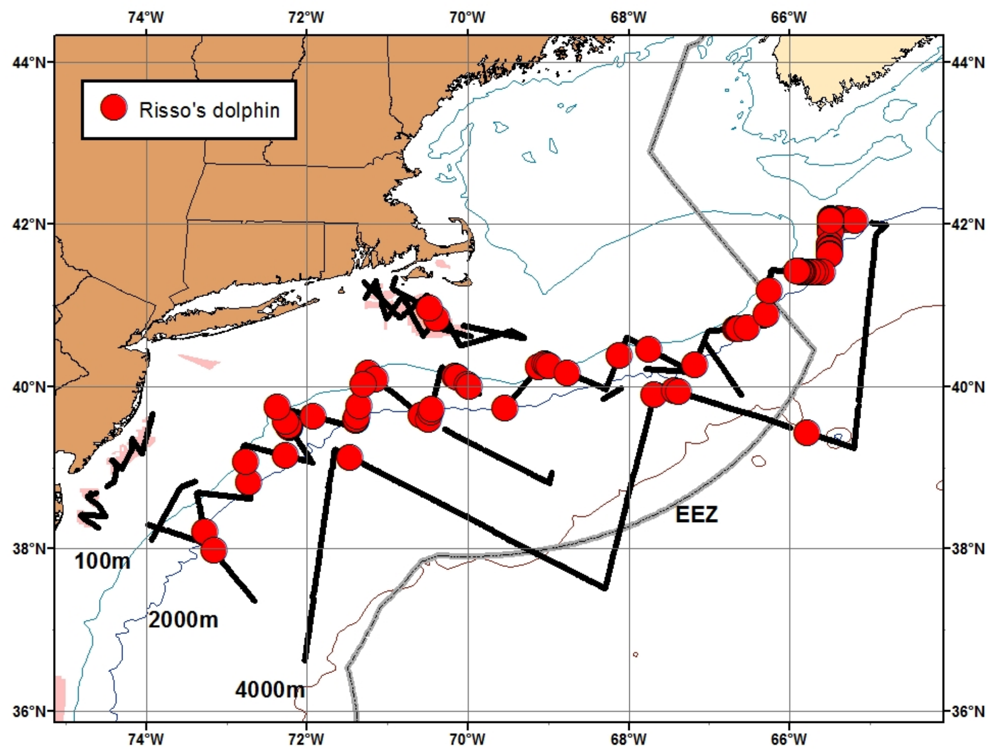


Figure B4. Location of common dolphin (*Delphinus delphis*; top) and striped dolphin (*Stenella coeruleoalba*; bottom) sightings detected by the upper team during on-effort better conditions.

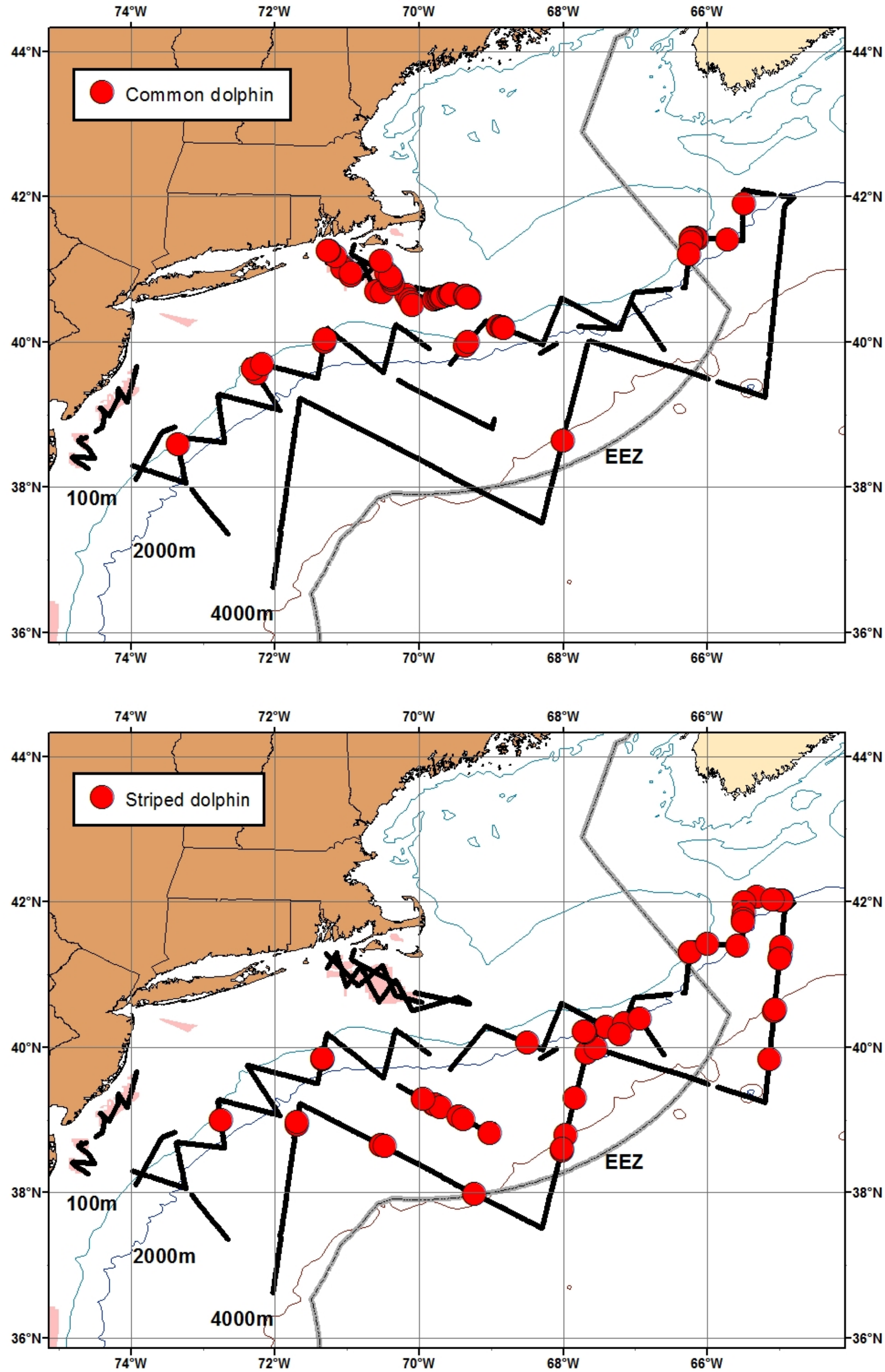
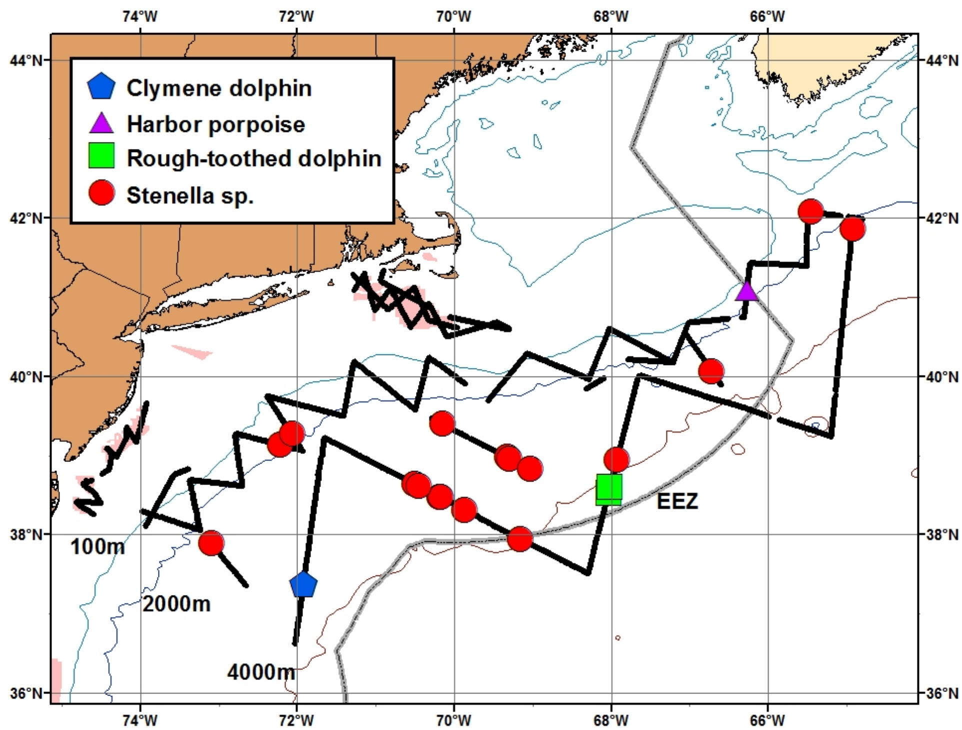


Figure B5. Location of Clymene dolphins (*Stenella clymene*), harbor porpoises (*Phocoena phocoena*), rough-toothed dolphins (*Steno bredanensis*), Stenella spp. (top) and unidentified dolphin (bottom) sightings detected by the upper team during on-effort better conditions.



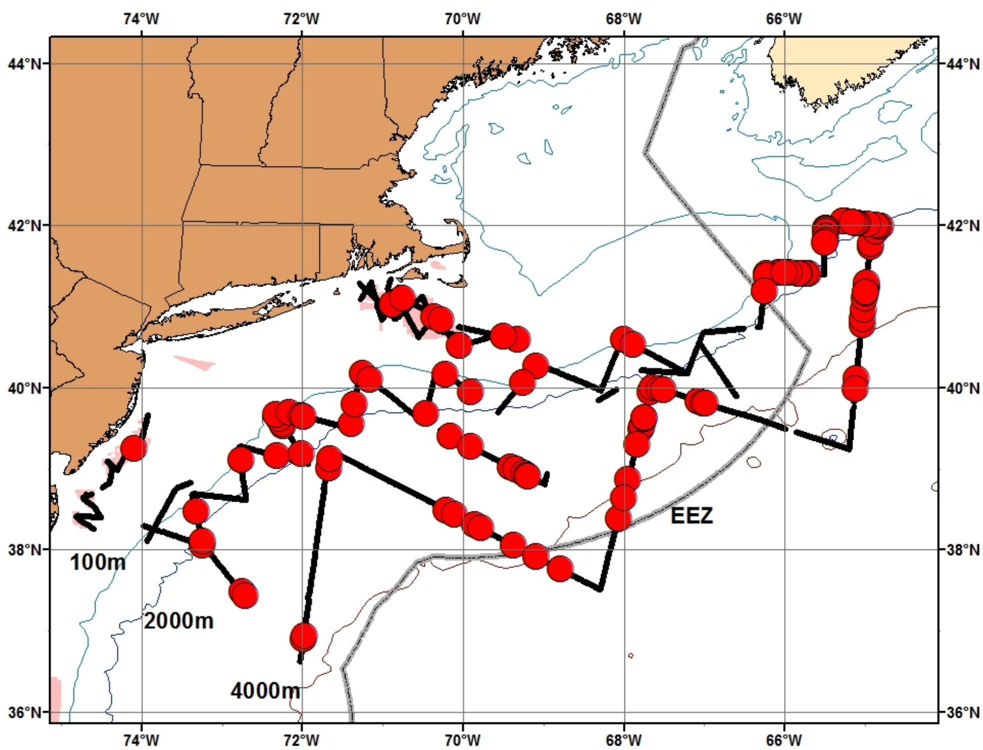
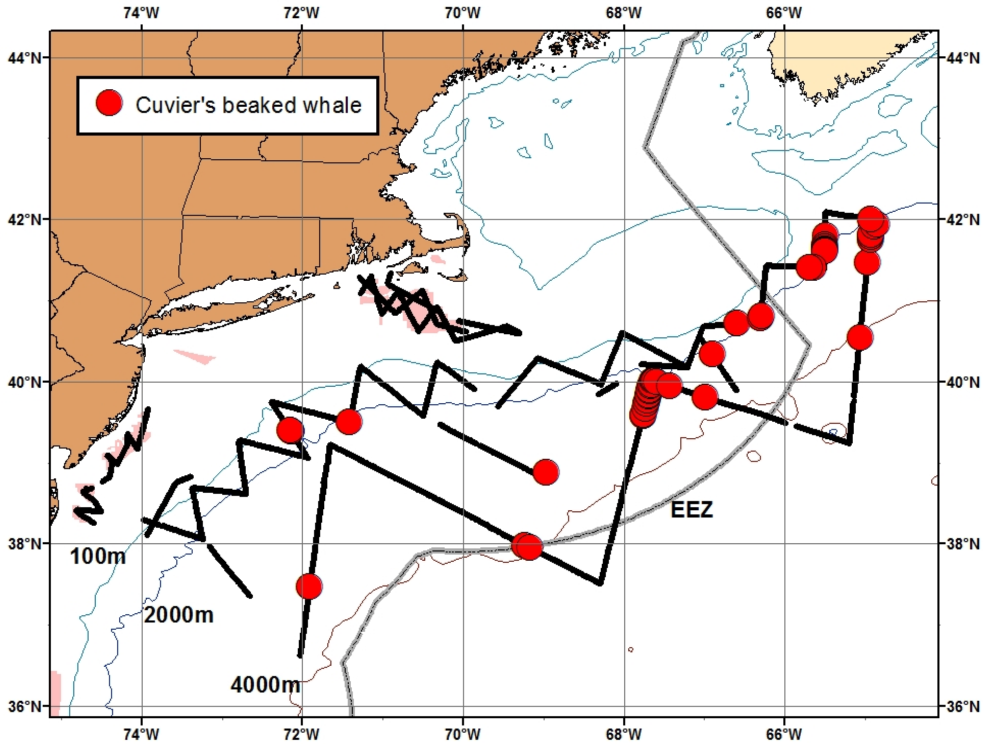


Figure B6. Location of Cuvier's beaked whale (*Ziphius cavirostris*; top) and Sowerby's beaked whale (*Mesoplodon bidens*; bottom) sightings detected by the upper team during on-effort better conditions.



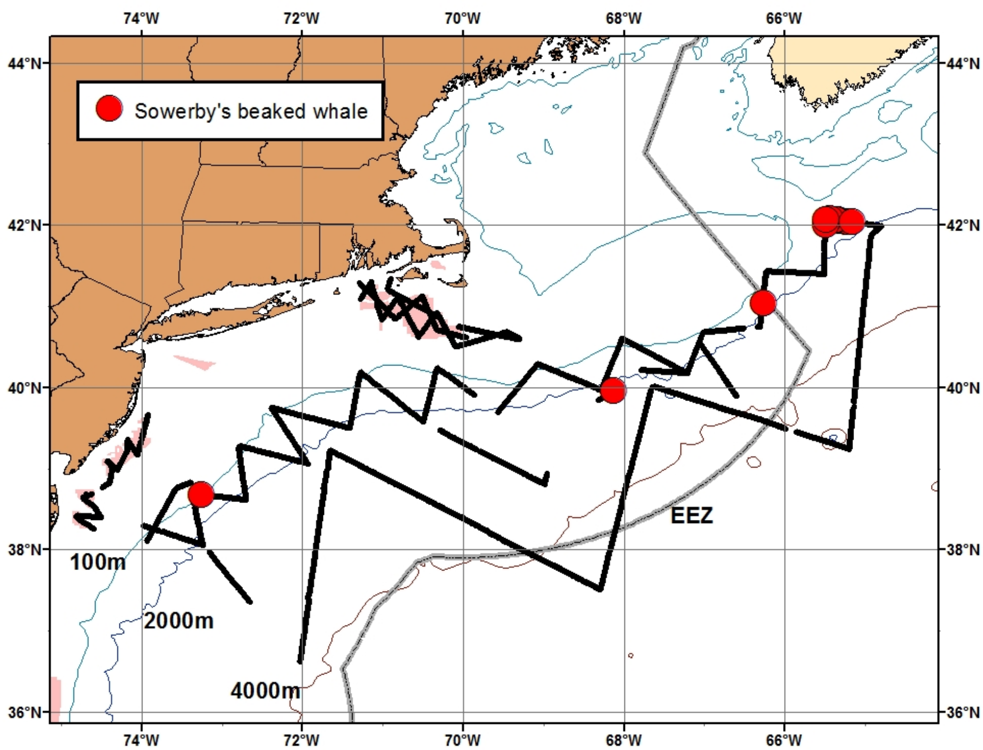


Figure B7. Location of unidentified beaked whales (Mesoplodon spp.; top) and dwarf sperm whales (*Kogia simus*), pygmy sperm whale (*Kogia breviceps*; bottom) sightings detected by the upper team during on-effort better conditions.

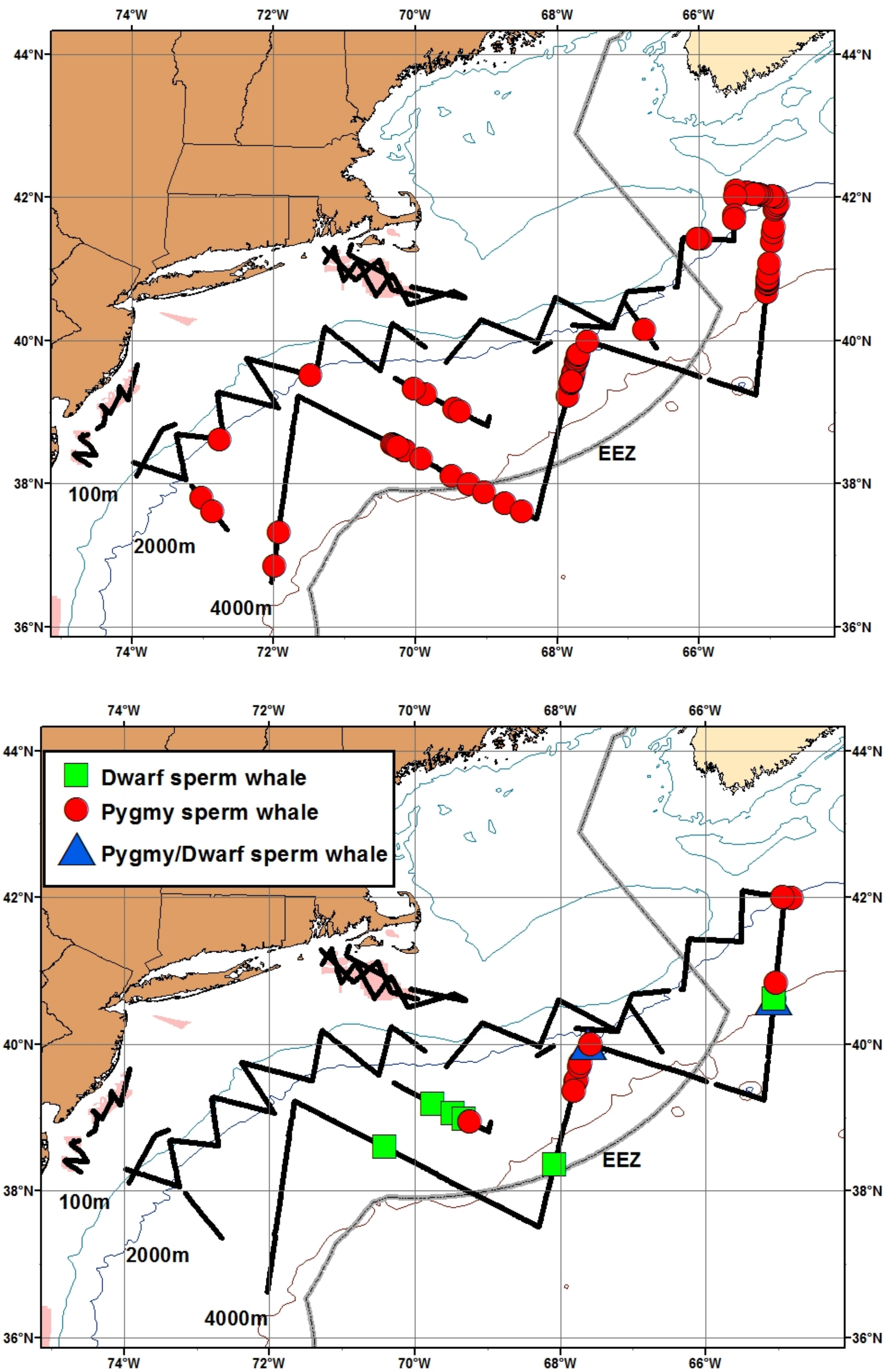
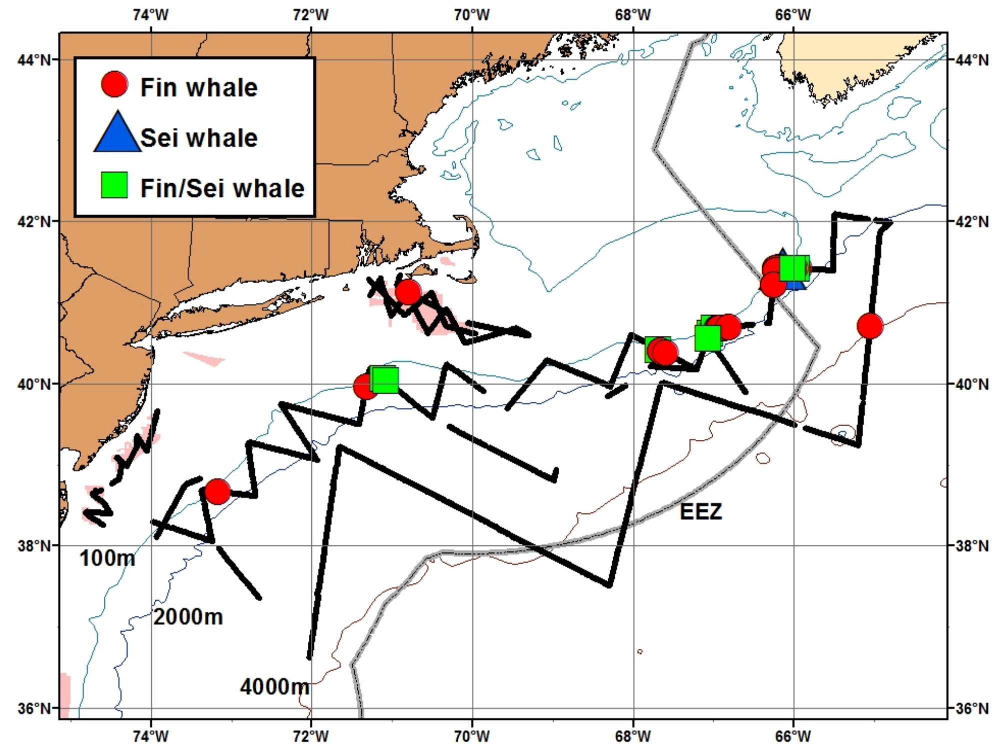


Figure B8. Location of fin whales (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*; top) and humpback whale (*Megaptera novaeangliae*; bottom) sightings detected by the upper team during on-effort better conditions.



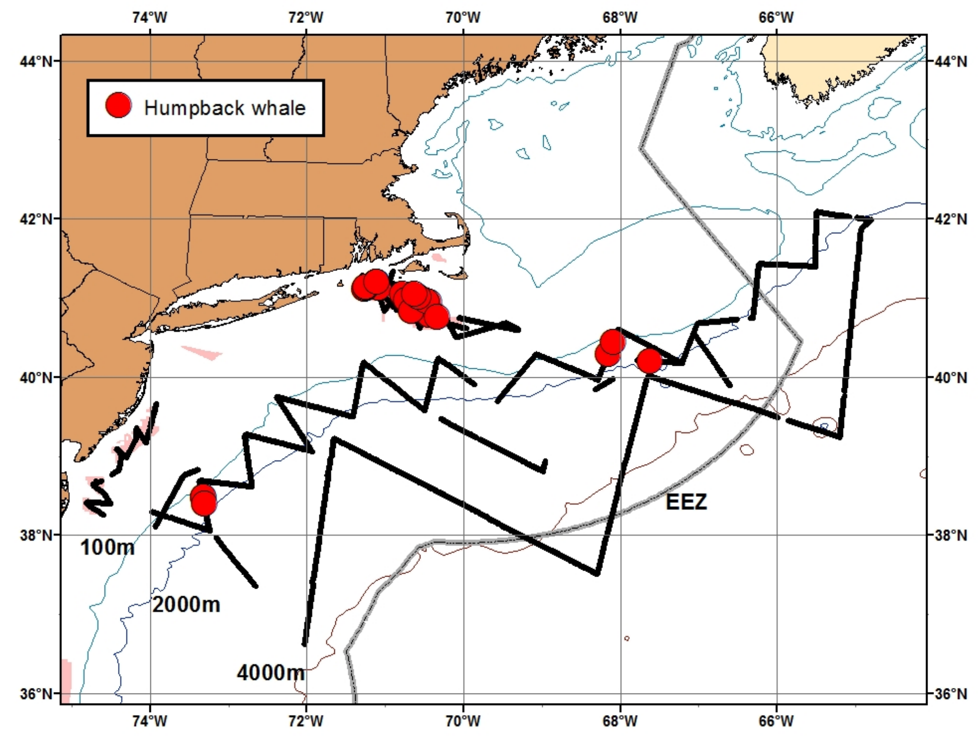


Figure B9. Location of sperm whale (*Physeter macrocephalus*; top), blue whale (*Balaenoptera musculus*), minke whale (*Balaenoptera acutorostrata*) and right whale (*Eubalaena glacialis*; bottom) sightings detected by the upper team during on-effort better conditions.

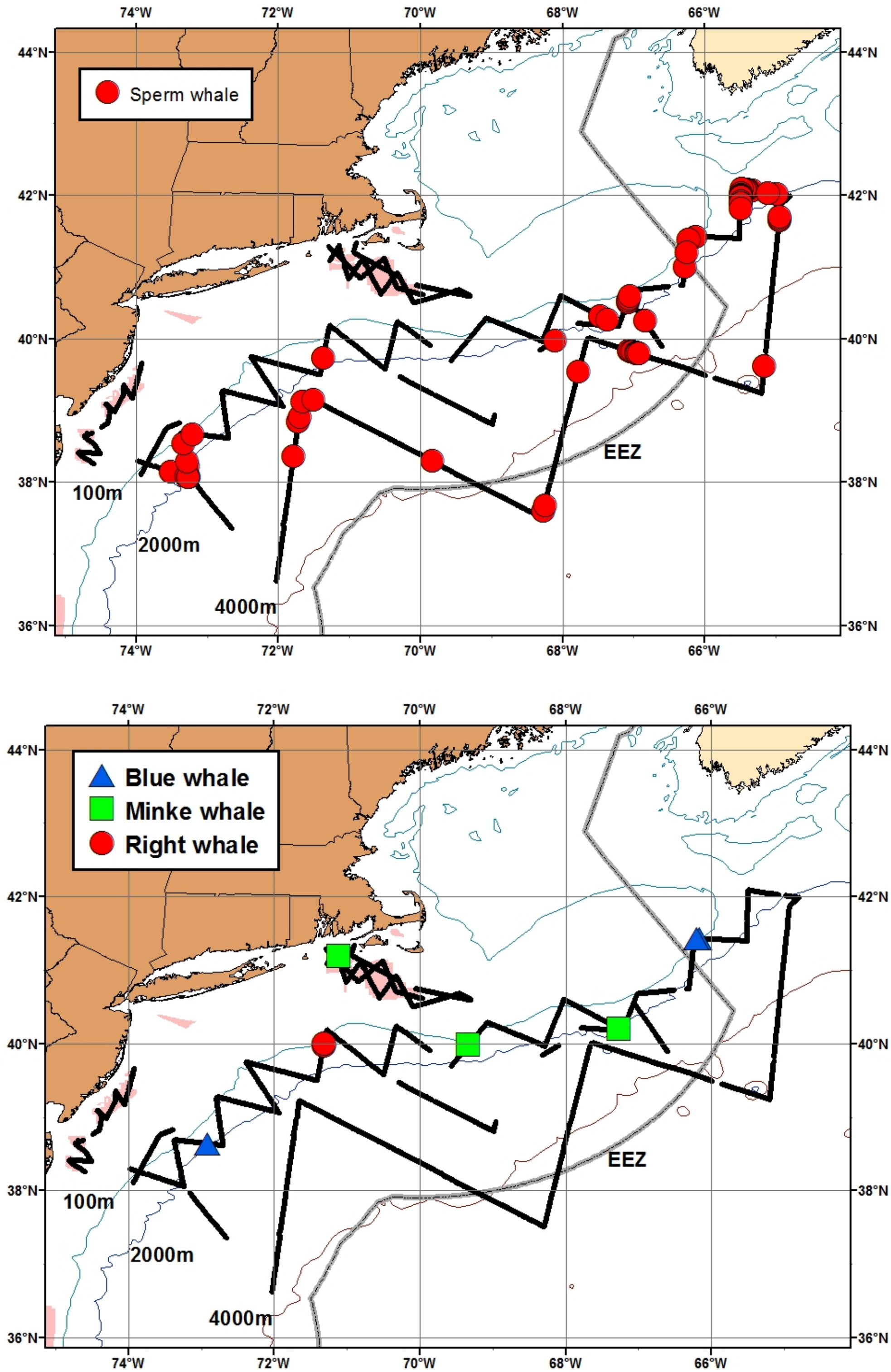


Figure B10. Location of unidentified whales (top), loggerhead turtle (*Caretta caretta*), and unidentified hardshell turtle (bottom) sightings detected by the upper team during on-effort better conditions.

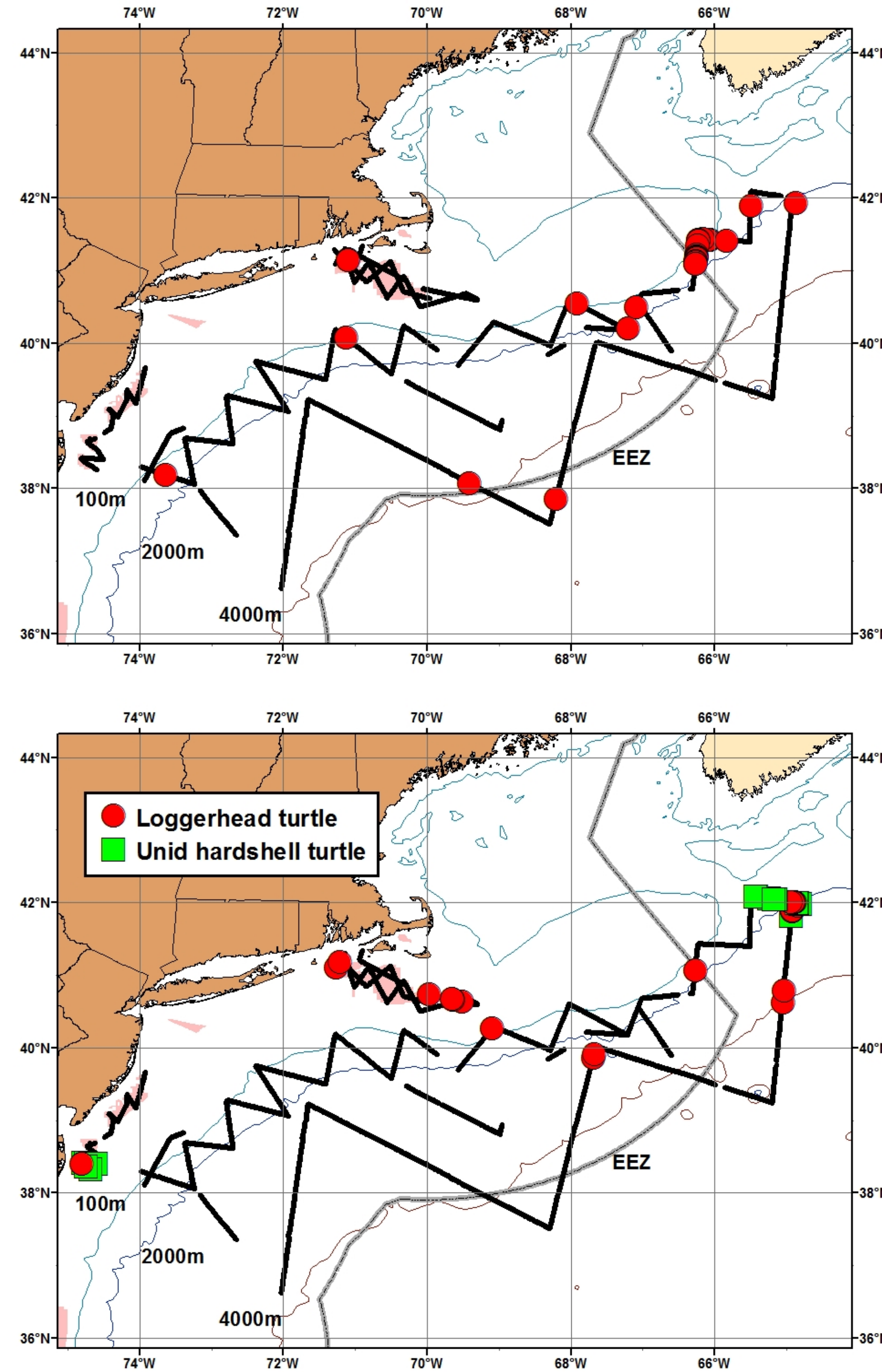


Figure B11. Location of basking sharks (*Cetorhinus maximus*), billfish spp., manta rays (Manta spp.), marlin, tuna (top), gray seals, harbor seals (*Phoca vitulina*) and unidentified seal (Pinniped; bottom) sightings detected by the upper team during on-effort better conditions.

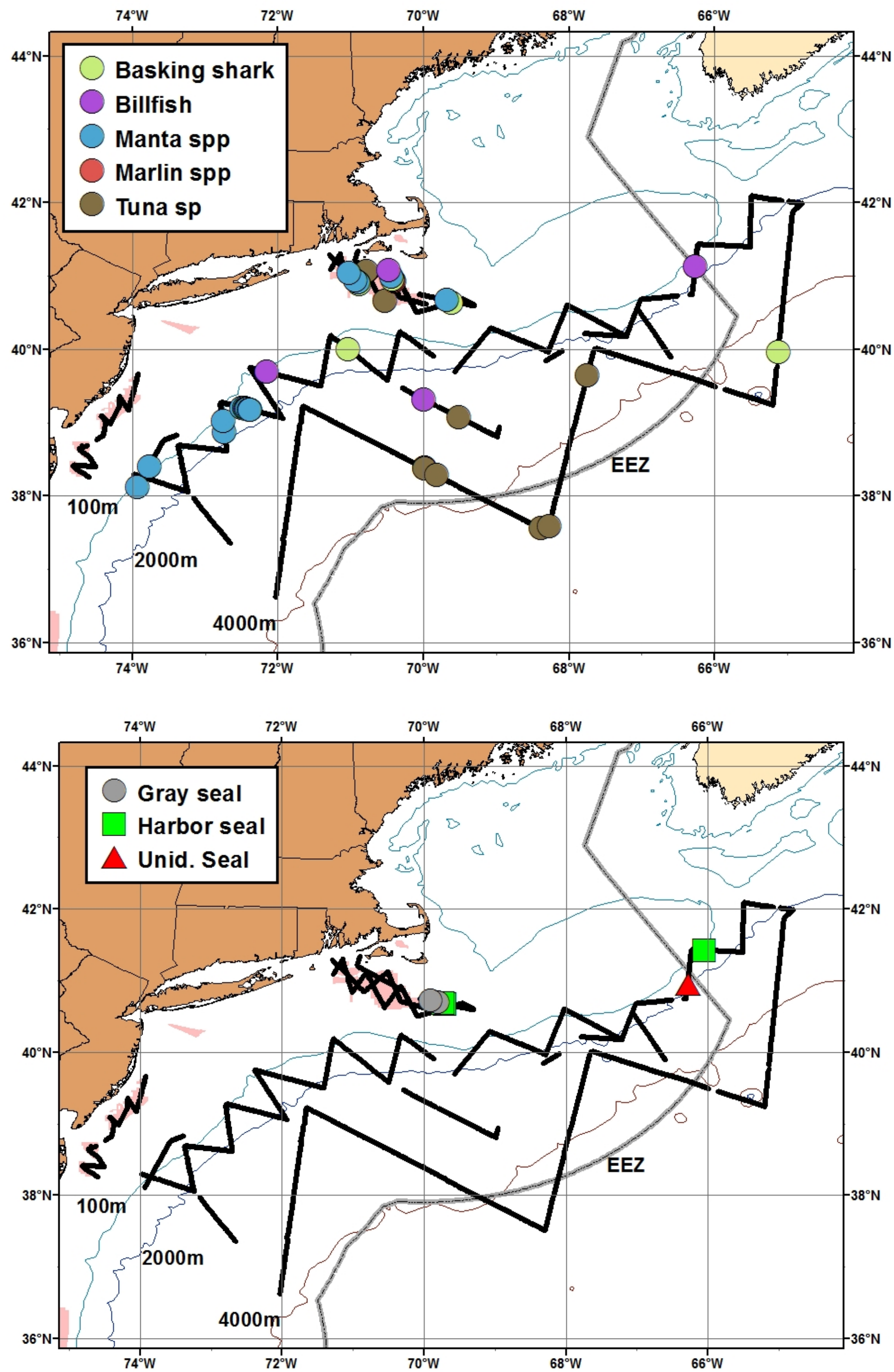


Figure B12. Locations of biopsied dolphins.

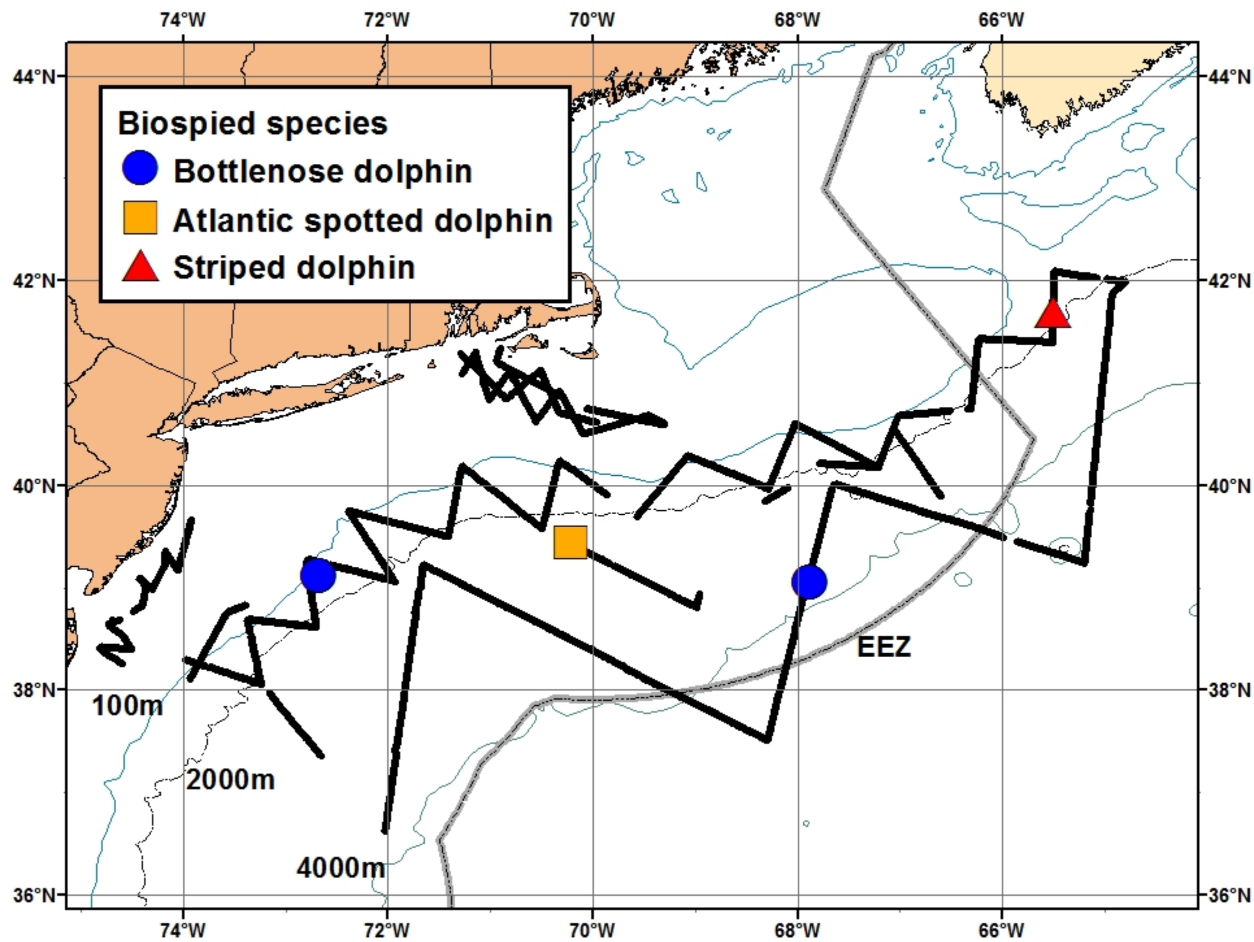


Figure B13. Black tracklines surveyed by both seabird and marine mammal/turtle observer teams. Red tracklines surveyed only by the seabird team.

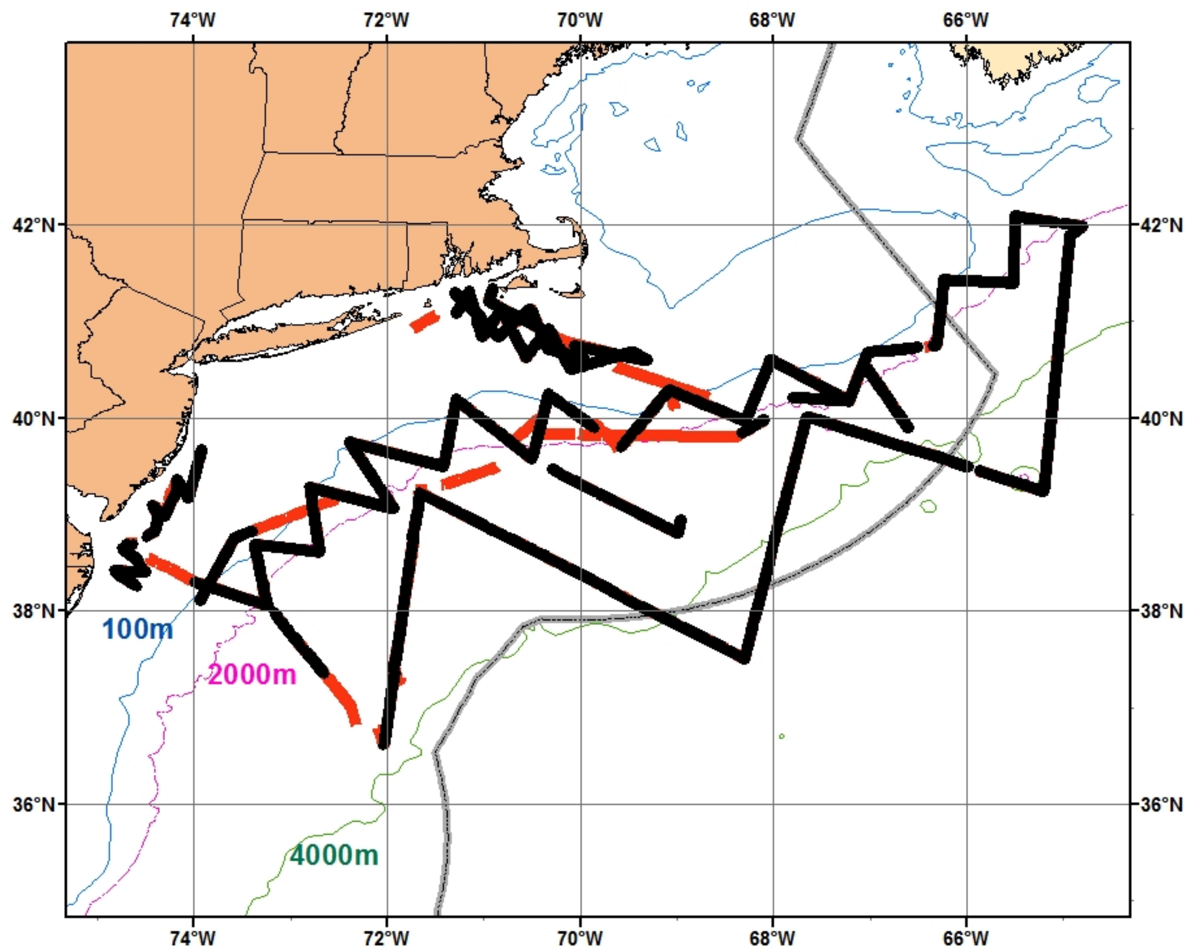
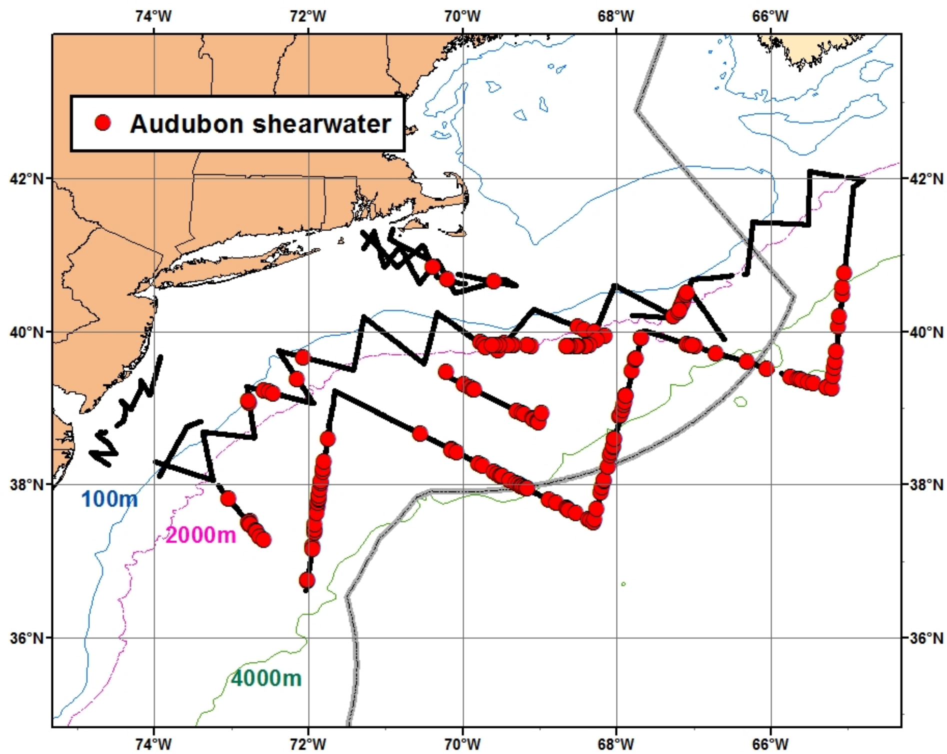


Figure B14. Location of Audubon shearwaters (*Puffinus lherminieri*; top), and Barolo (Little) shearwater (*Puffinus baroli*; bottom) sightings detected by the seabird team.



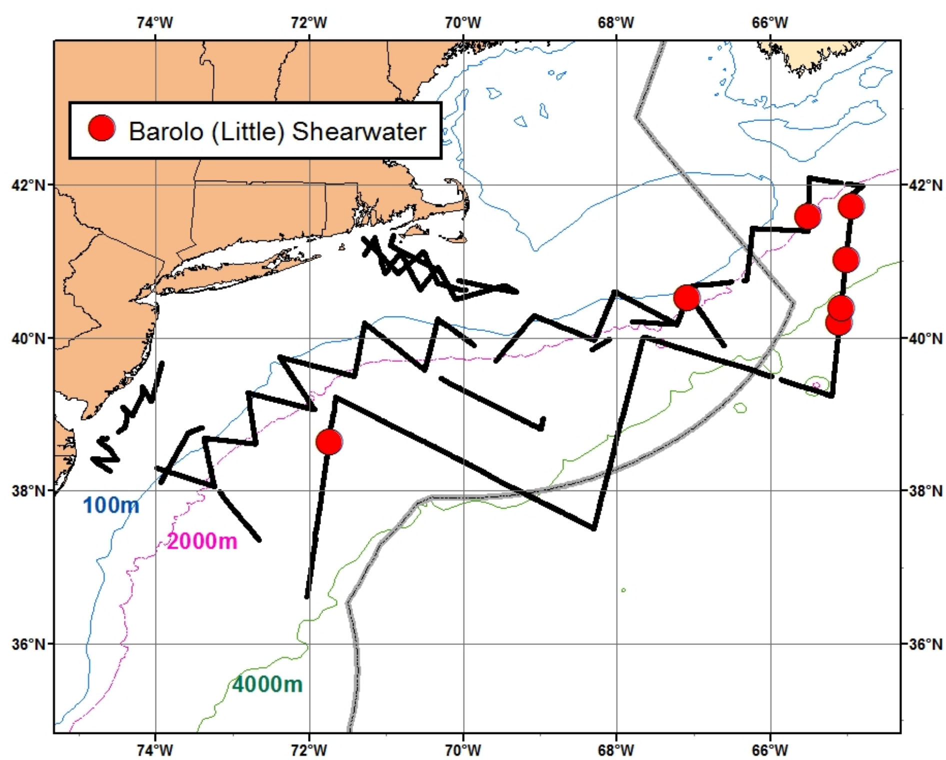
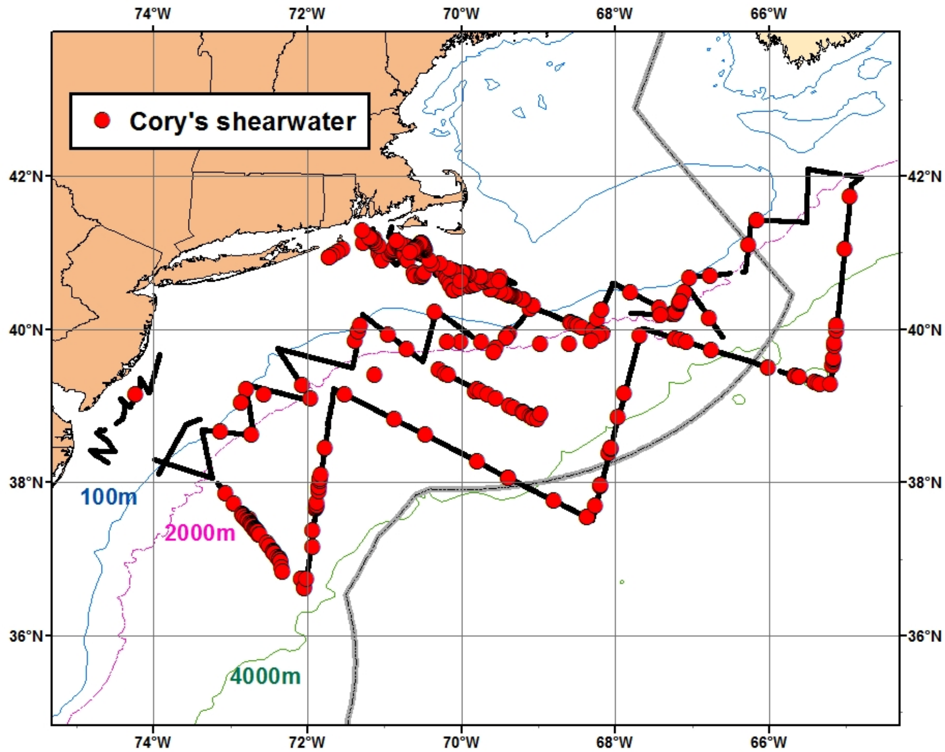


Figure B15. Location of Cory's shearwaters (*Calonectris diomedea*; top), and Great shearwater (*Puffinus gravis*; bottom) sightings detected by the seabird team.



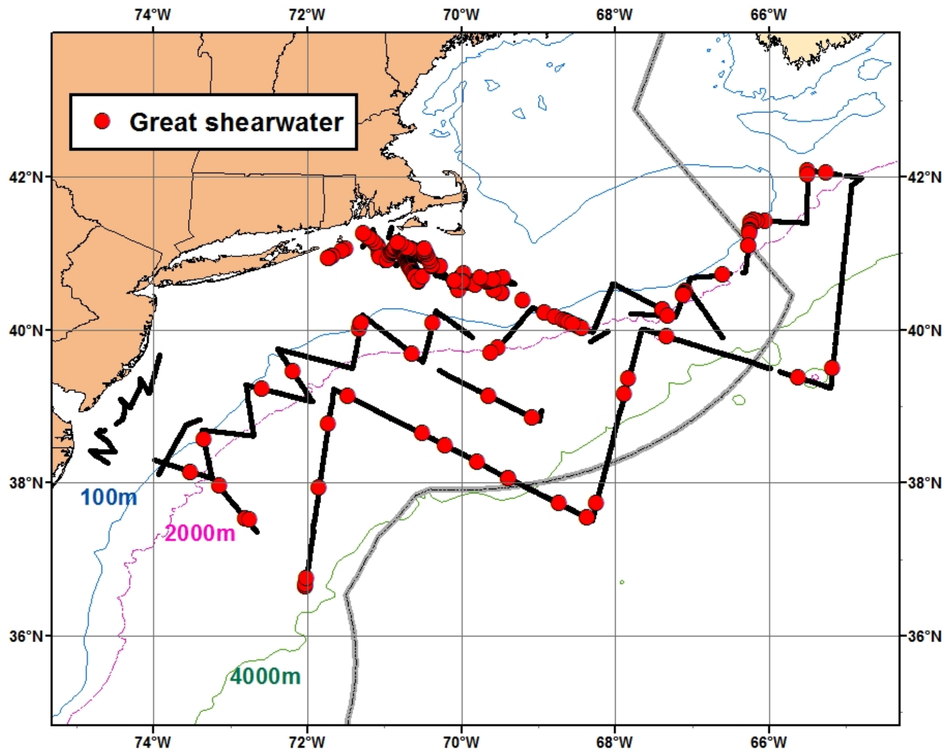
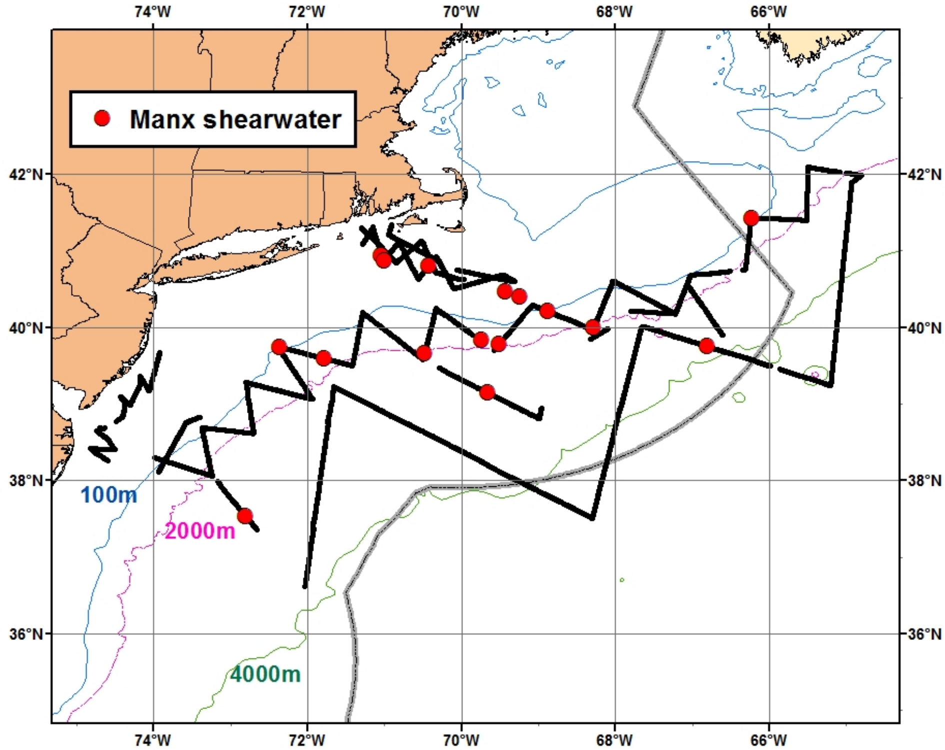


Figure B16. Location of Manx shearwaters (*Puffinus puffinus*; top), and Sooty shearwater (*Puffinus griseus*; bottom) sightings detected by the seabird team.



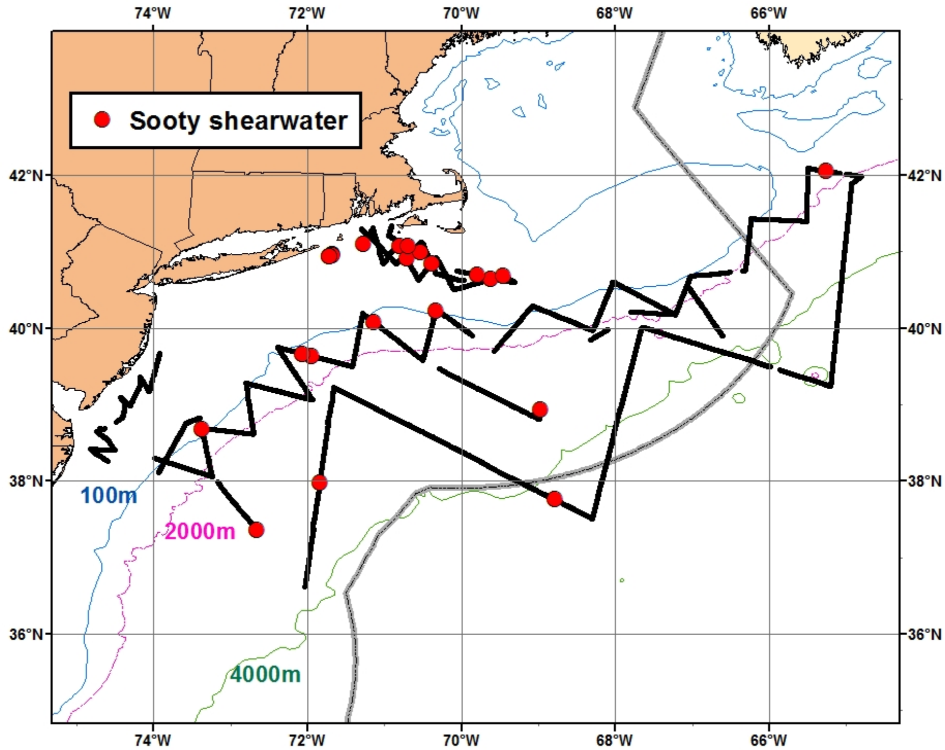
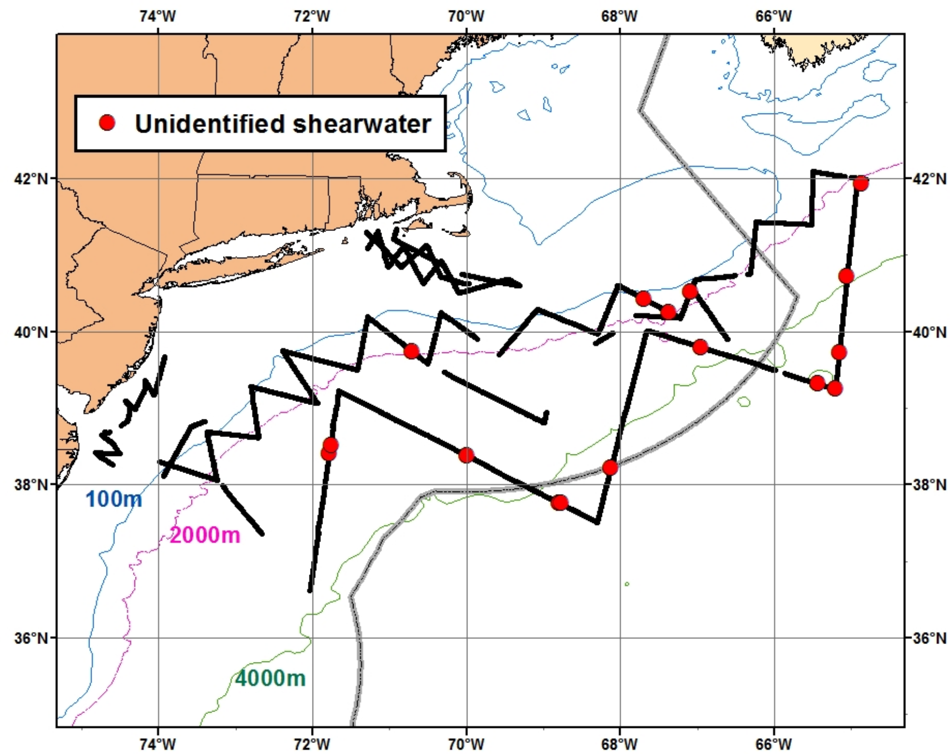


Figure B17. Location of unidentified shearwaters (*Puffinus sp.*; top), and Band-rumped storm-petrel (*Oceanodroma castro*; bottom) sightings detected by the seabird team.



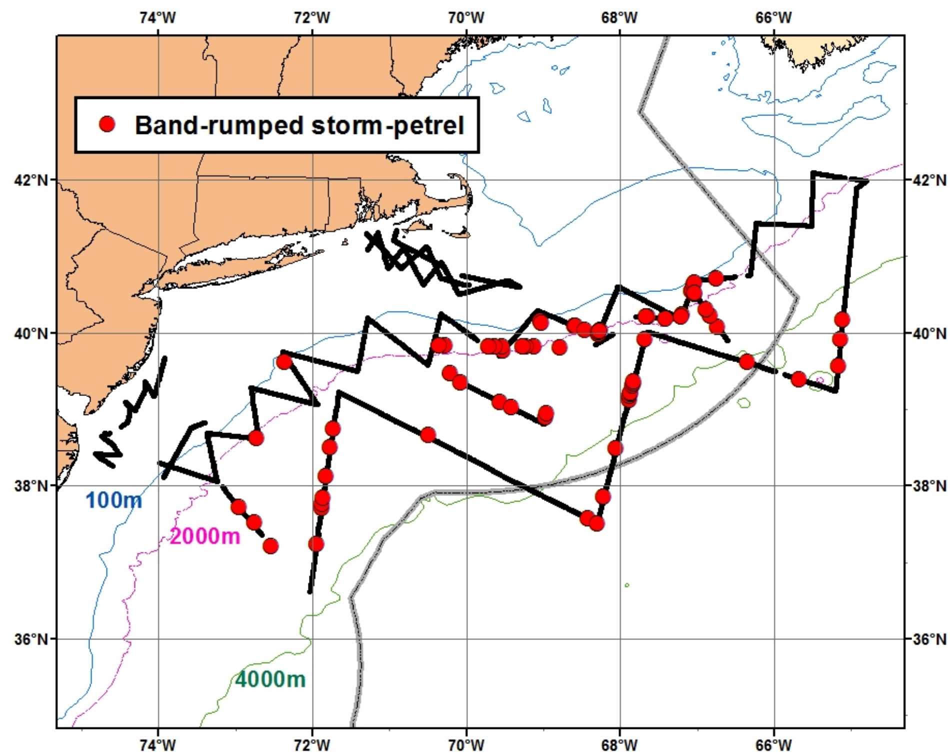
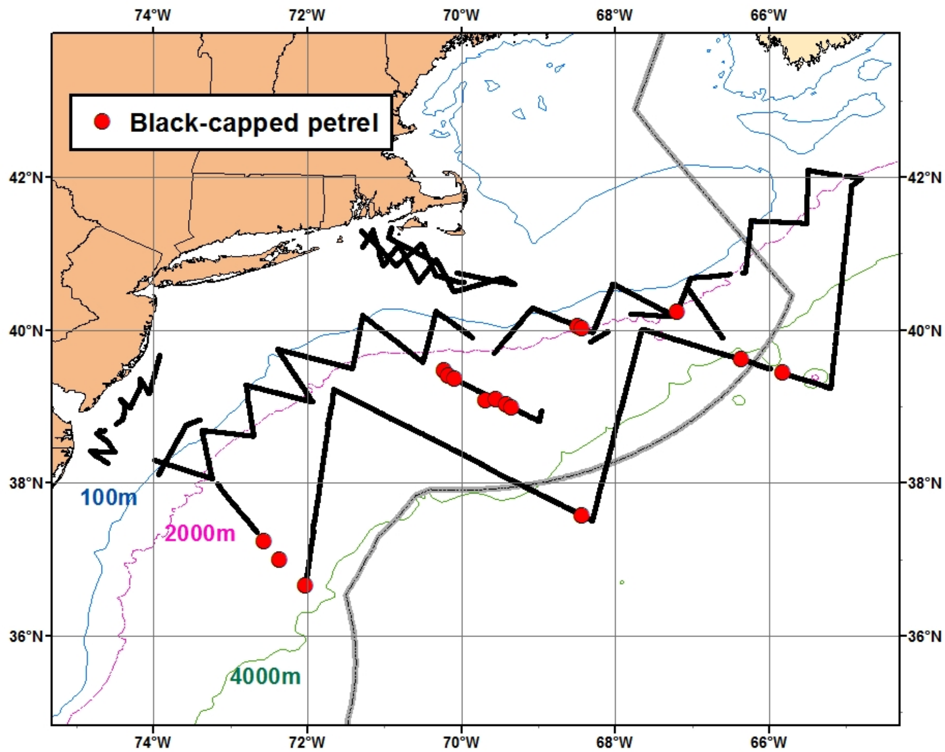


Figure B18. Location of Black-caped petrels (*Pterodroma hasitata*; top), and Leach's/Harcourt's storm-petrel (*Oceanodroma leucorhoa/castro*; bottom) sightings detected by the seabird team.



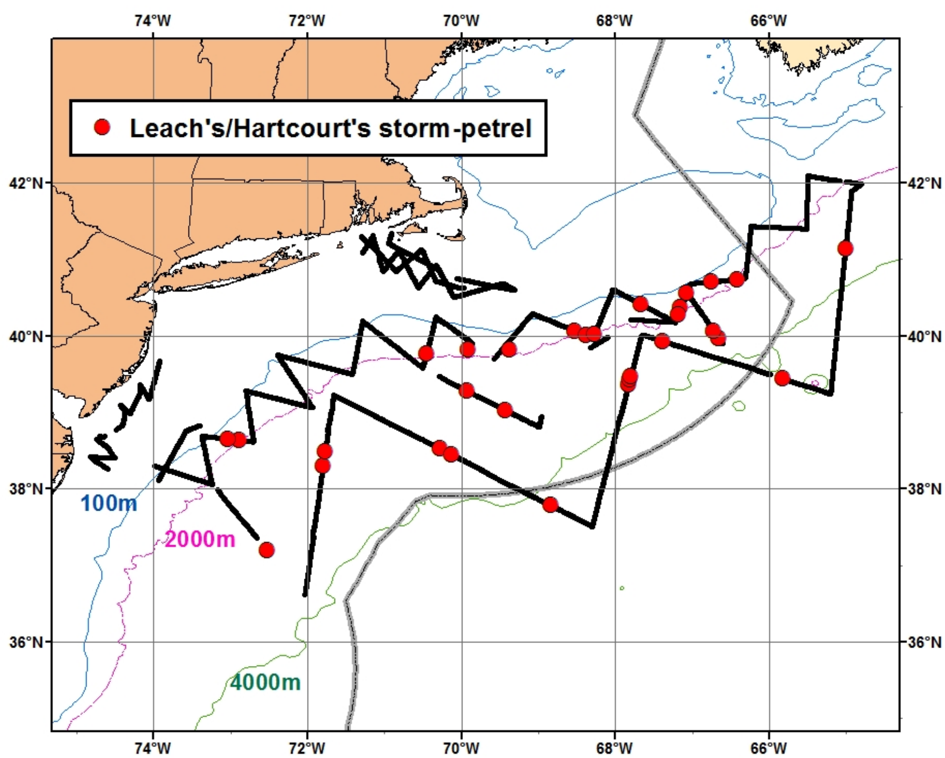


Figure B19. Location of Leach's storm-petrels (*Oceanodroma leucorhoa*; top), and Trindade petrel (*Pterodroma (heraldica) arminjoniana*; bottom) sightings detected by the seabird team.

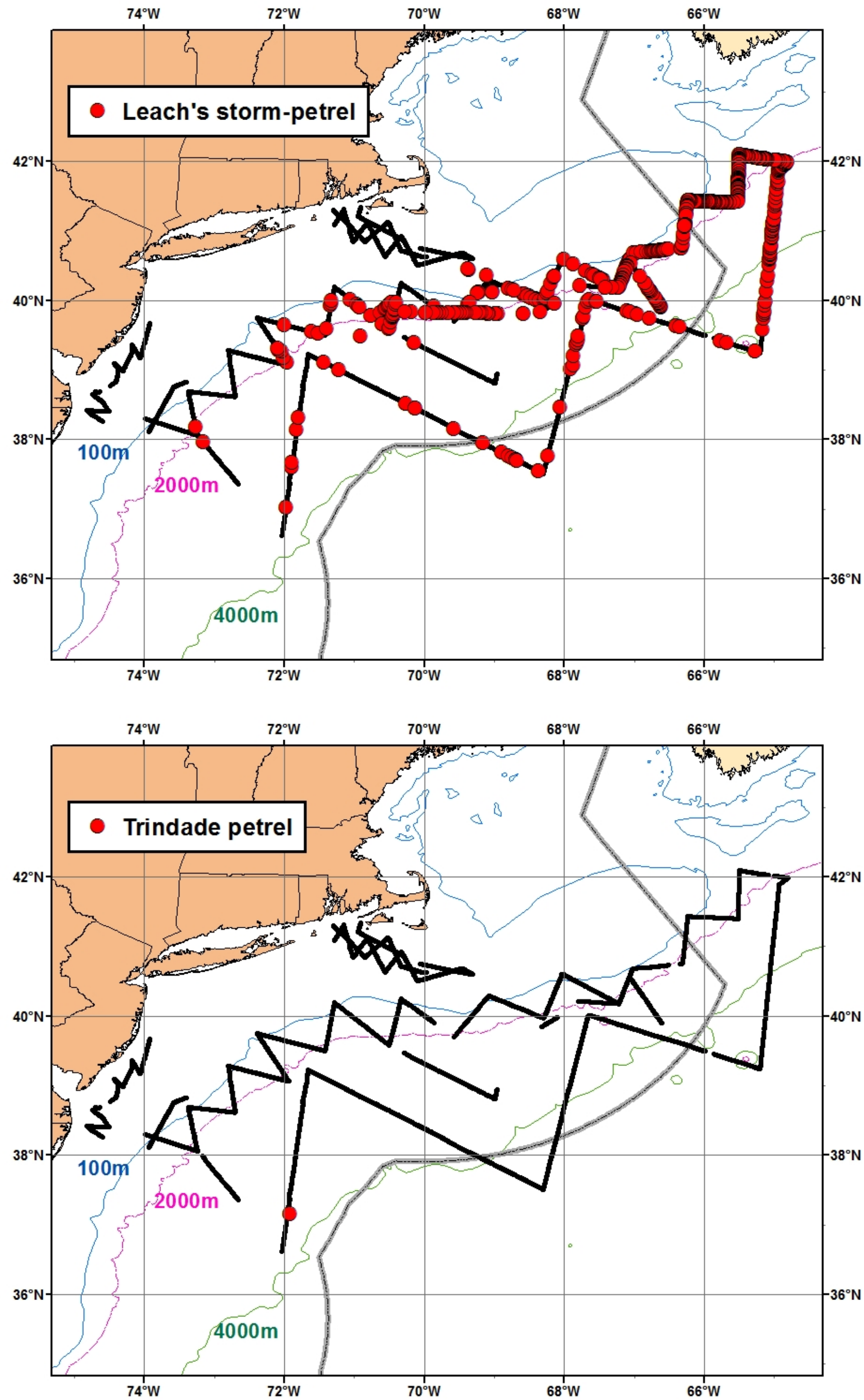
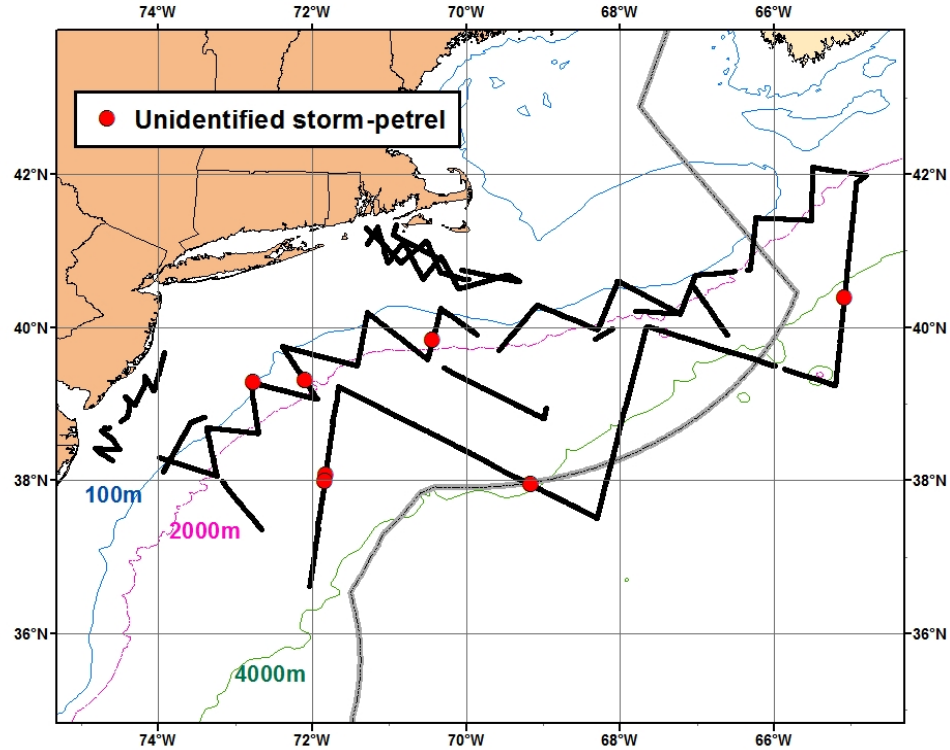


Figure B20. Location of unidentified storm-petrels (Oceanodroma sp.; top), and white-faced storm-petrel (*Pelagodroma marina*; bottom) sightings detected by the seabird team.



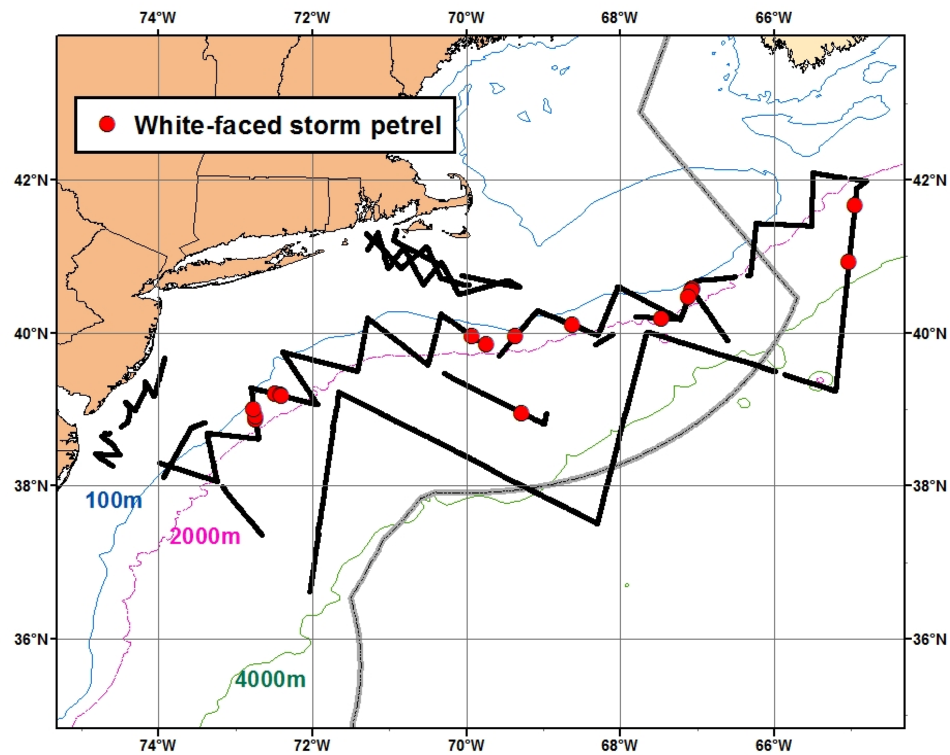


Figure B21. Location of Bridled terns (*Onychoprion anaethetus*; top), and Common tern (*Sterna hirundo*; bottom) sightings detected by the seabird team.

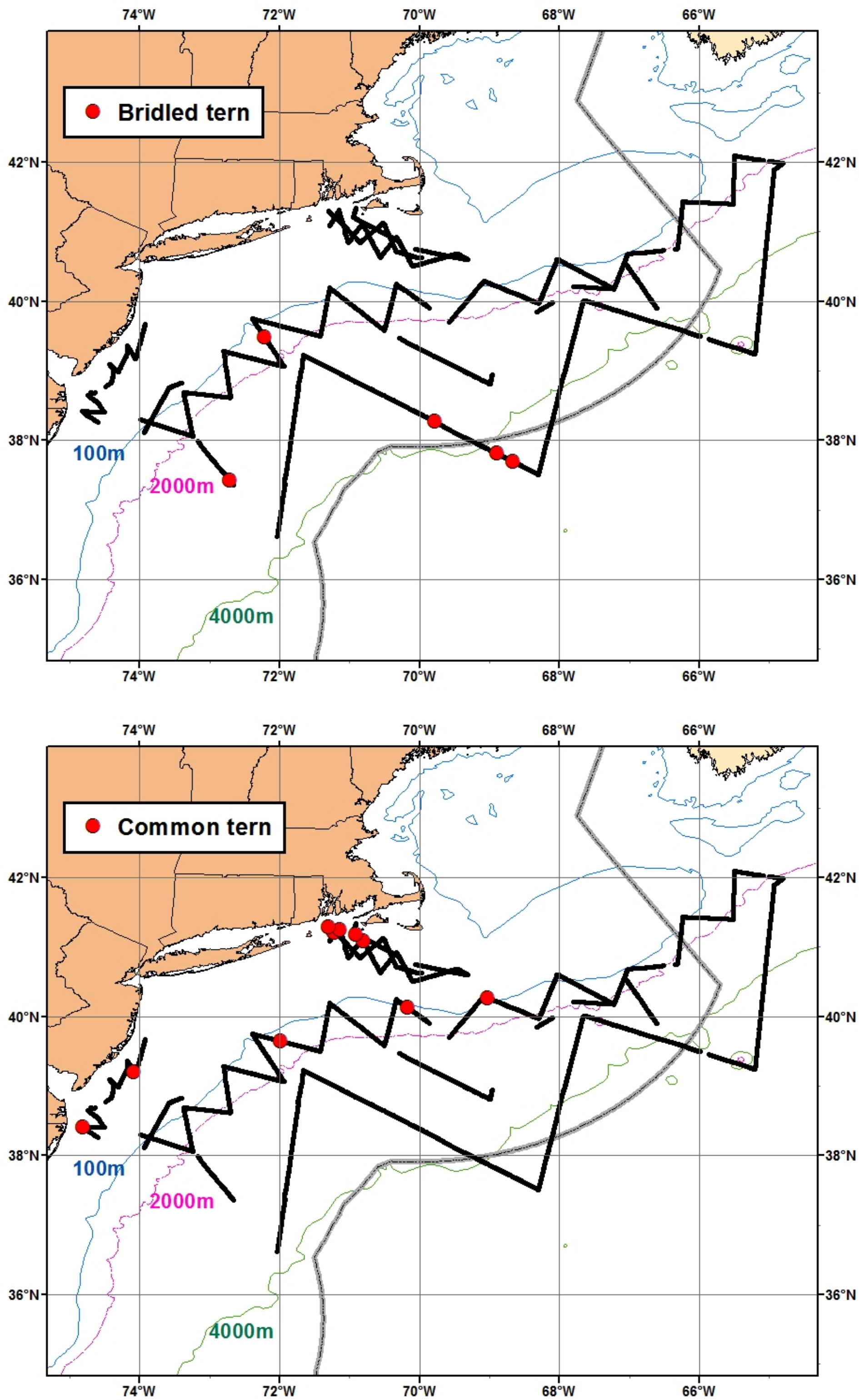
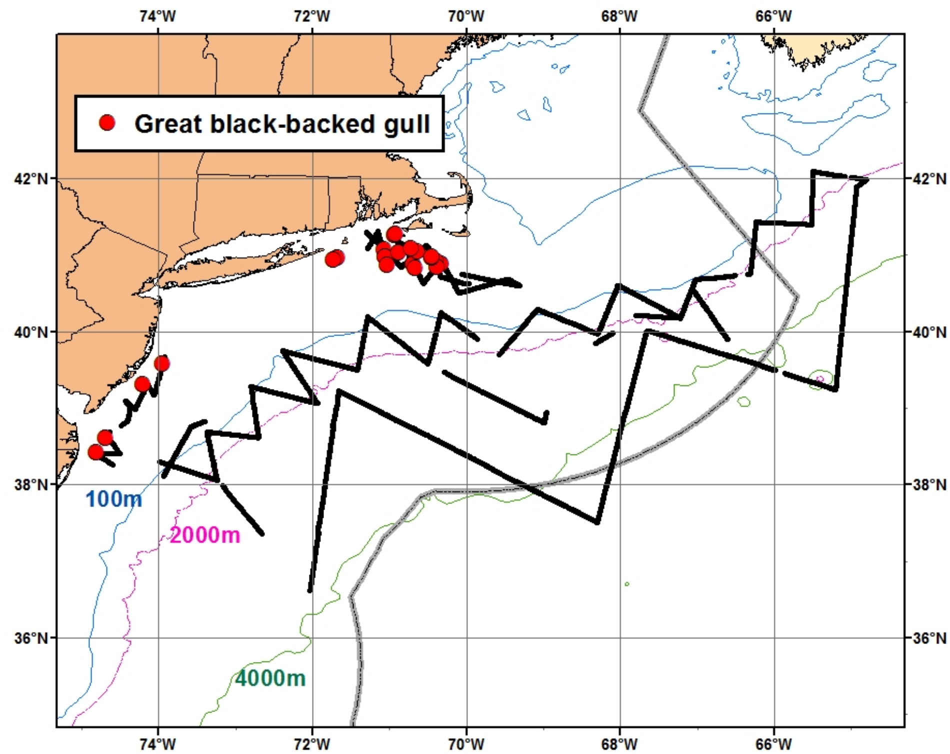


Figure B22. Location of Great black-backed gulls (*Larus marinus*; top), and Herring gull (*Larus argentatus*; bottom) sightings detected by the seabird team.



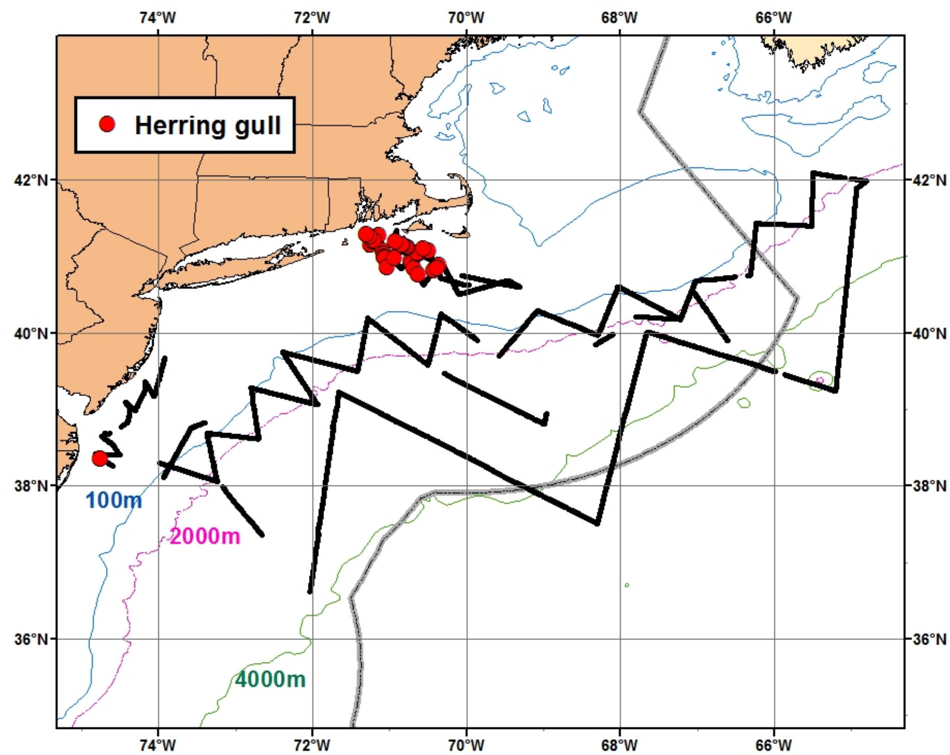
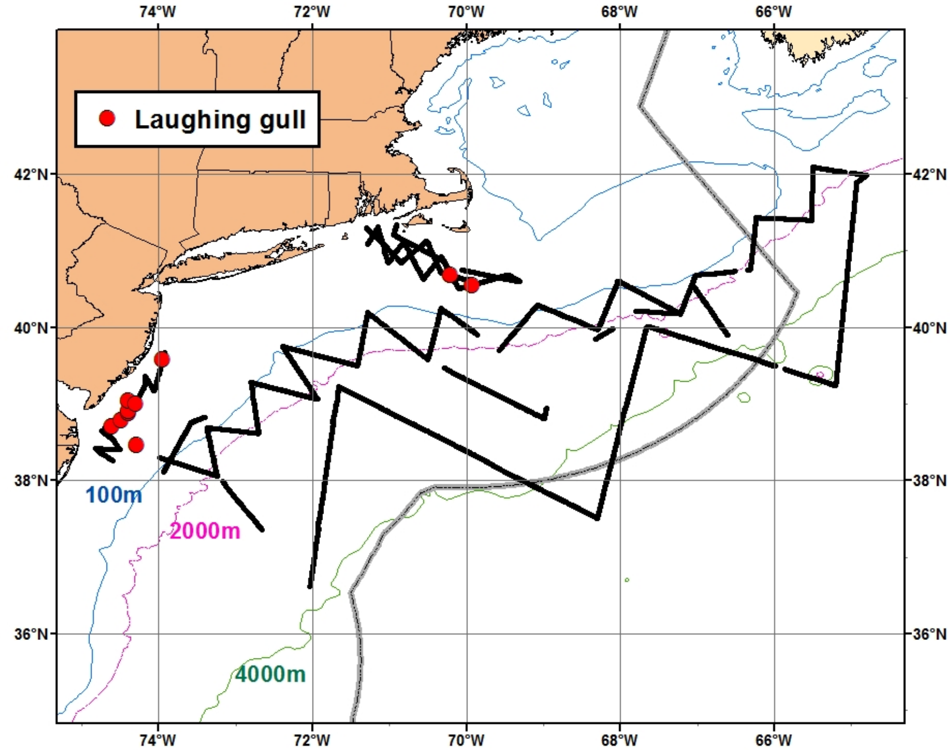


Figure B23. Location of Laughing gulls (*Leucophaeus atricilla*; top), and Parasitic jaeger (*Stercorarius parasiticus*; bottom) sightings detected by the seabird team.



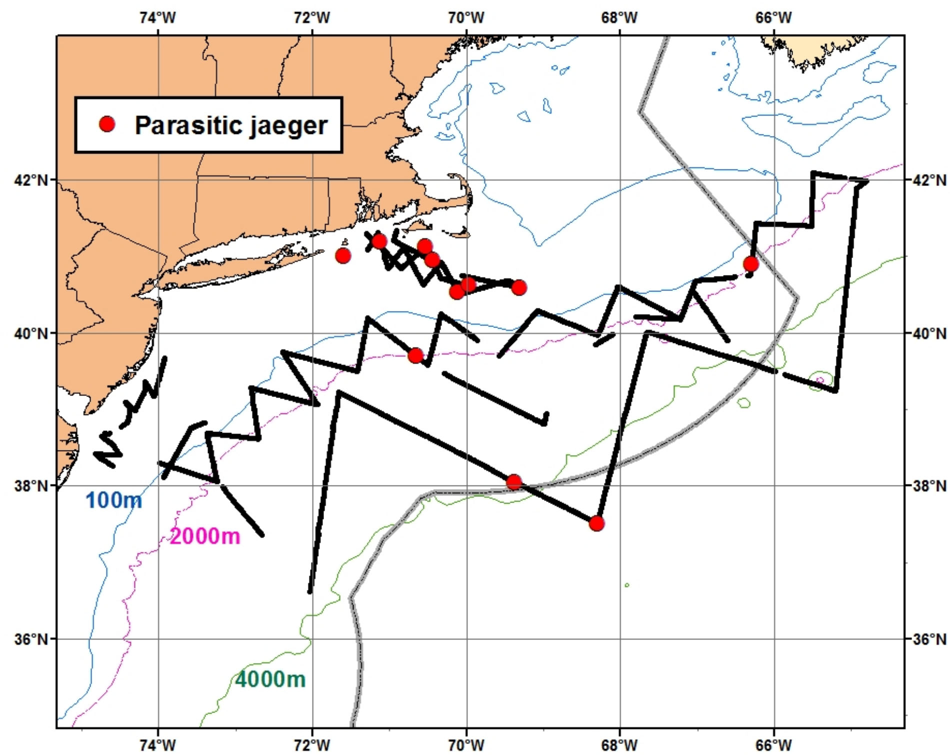
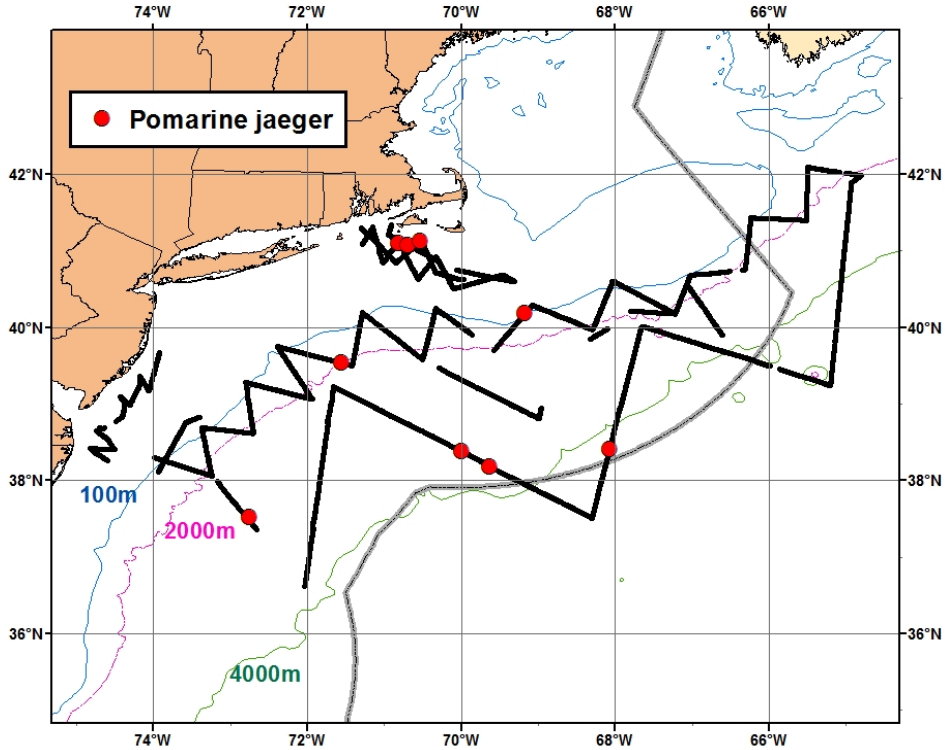


Figure B24. Location of Pomarine jaeger (*Stercorarius pomarinus*; top), and White-tailed tropicbirds (*Phaethon lepturus*; bottom) sightings detected by the seabird team.



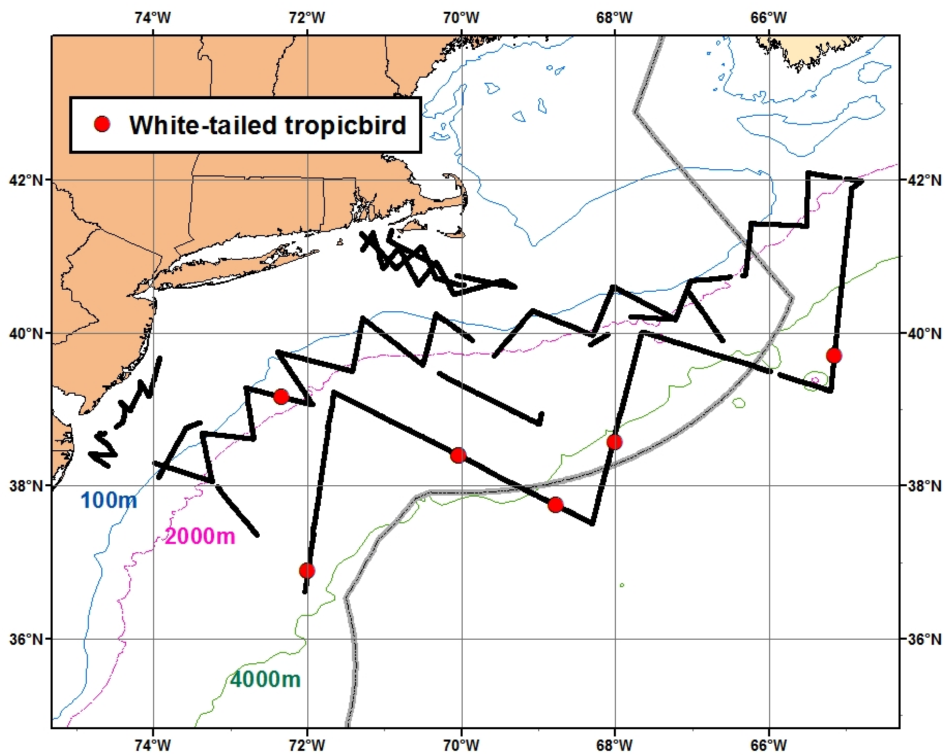


Figure B25. Acoustic recording effort and location of the *NOAA ship Henry B. Bigelow* during acoustic detections of vocally-active cetacean groups. Purple lines indicate daytime recording effort, during which time all data were reviewed in real-time. Blue lines indicate evening recording effort. Black dots indicate ship's location during acoustic events. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

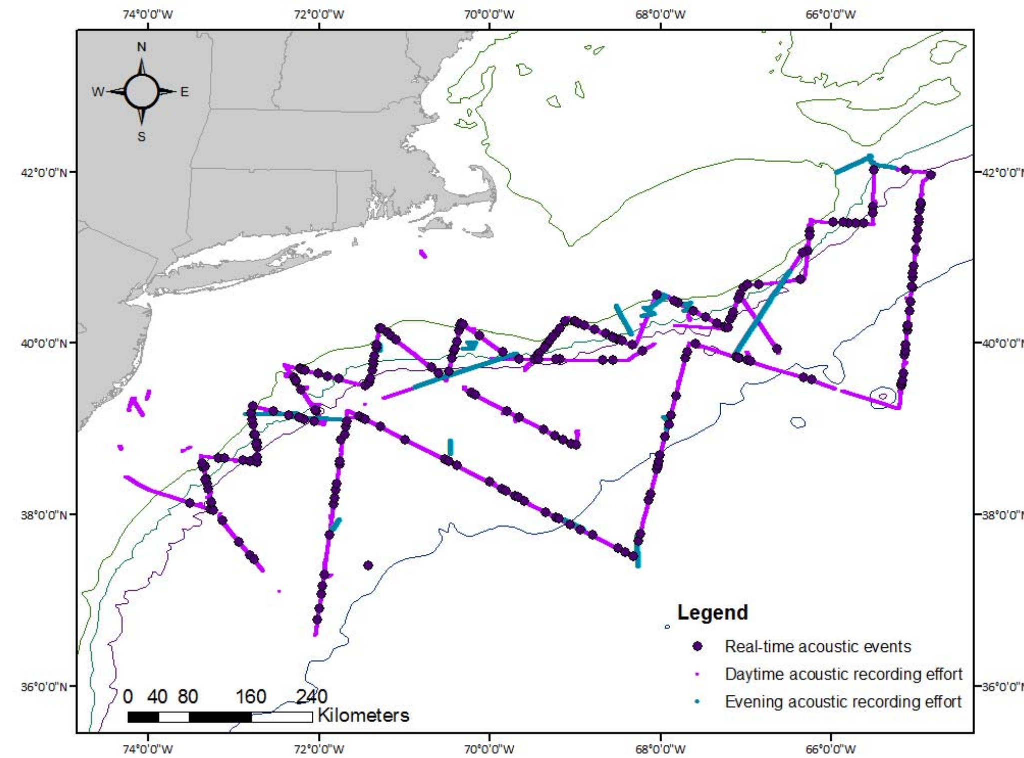


Figure B26. Acoustic detection of sperm whales. Purple lines indicate daytime recording effort; orange squares indicate the location of the *NOAA ship Henry B. Bigelow* during detections of sperm whales.

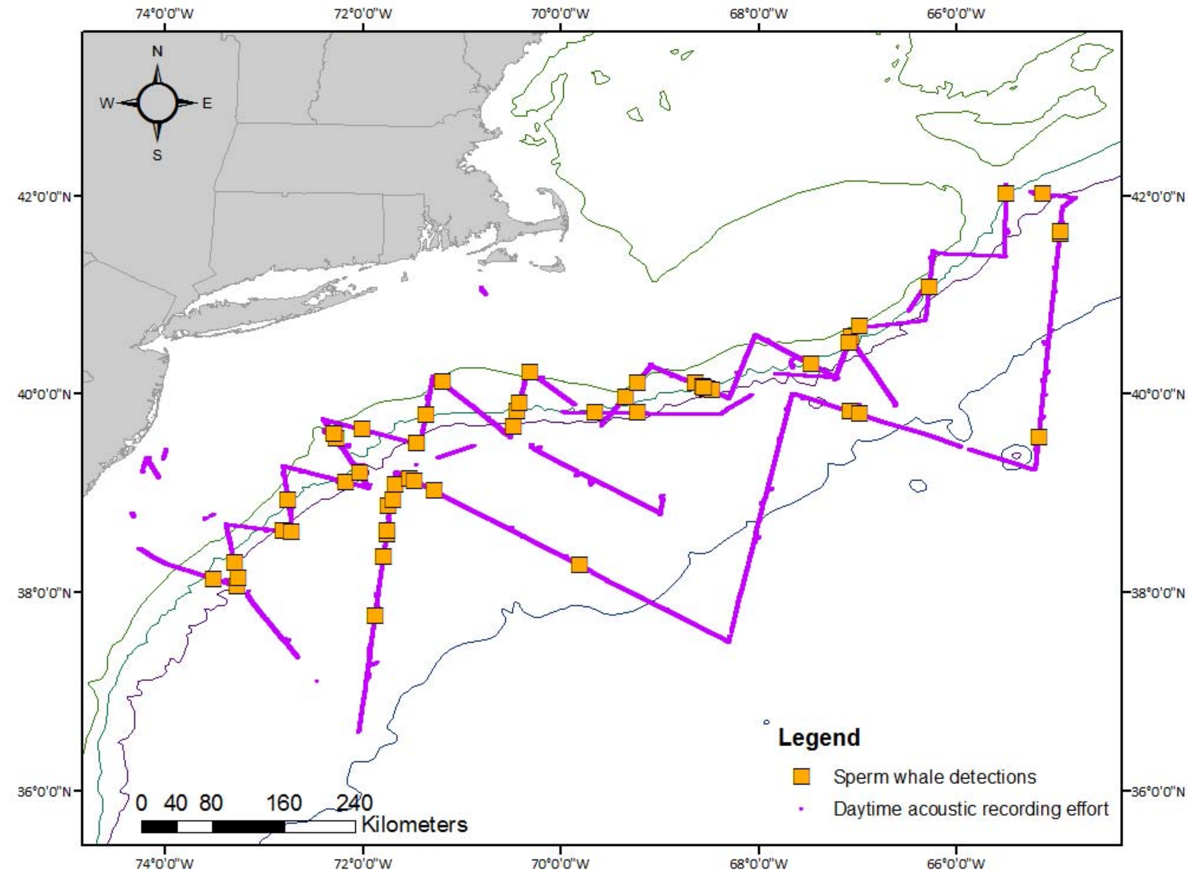


Figure B27. (Left) Photo of a marine autonomous recording unit (MARU). The yellow harness lines and white float are good points for grappling with the boat hook. The black power lines and the white burn connector (on the right side of the picture) should be avoided when attempting to retrieve it.

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

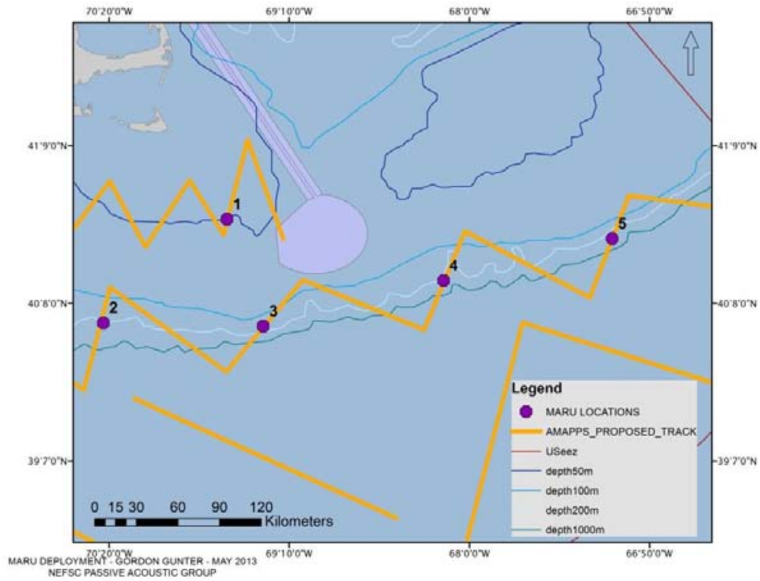


Figure B28. Overall view of the locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac's-Kidd mid-water trawls (IKMT), and the MOCNESS.

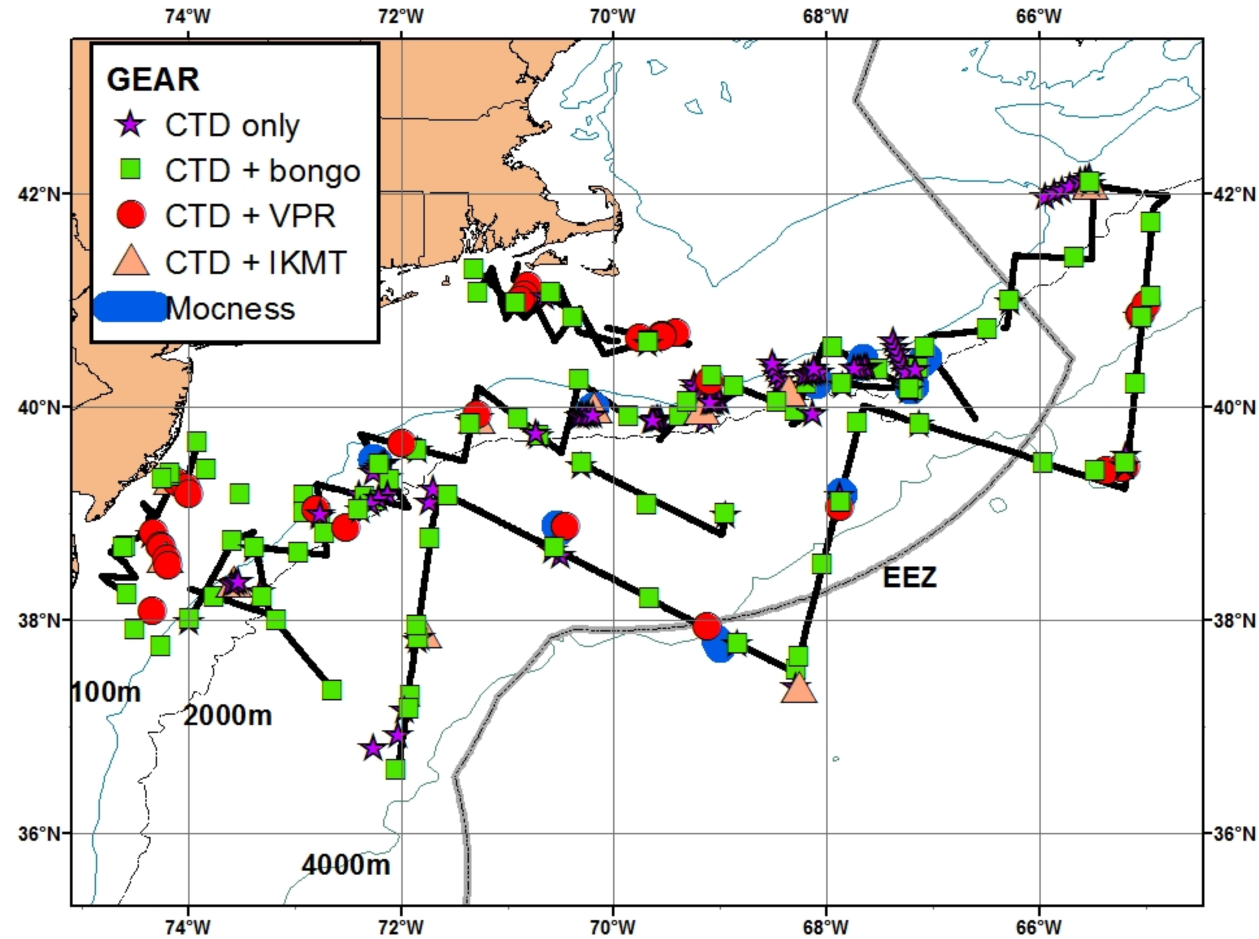
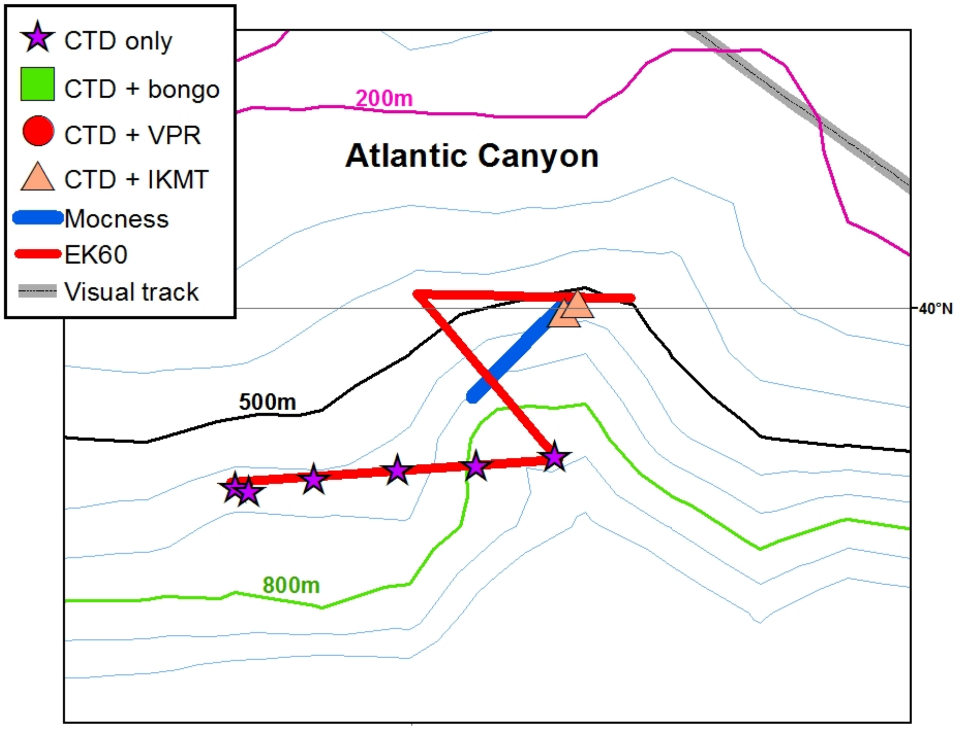


Figure B29. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near Atlantic Canyon; Bottom: near Hudson Canyon.



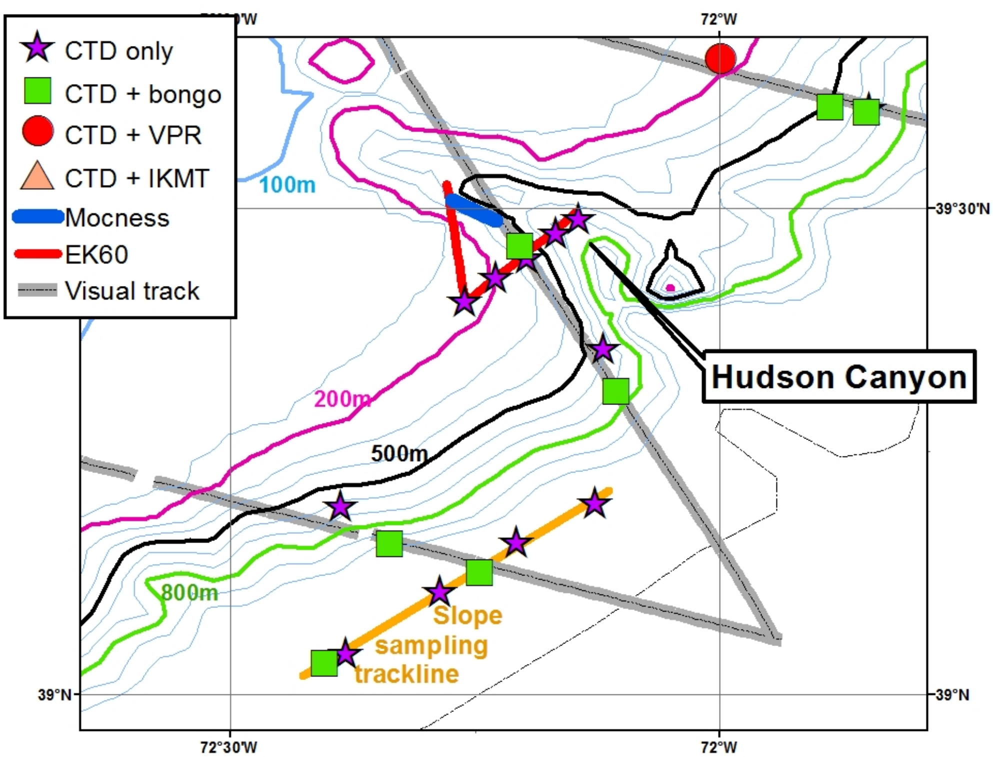
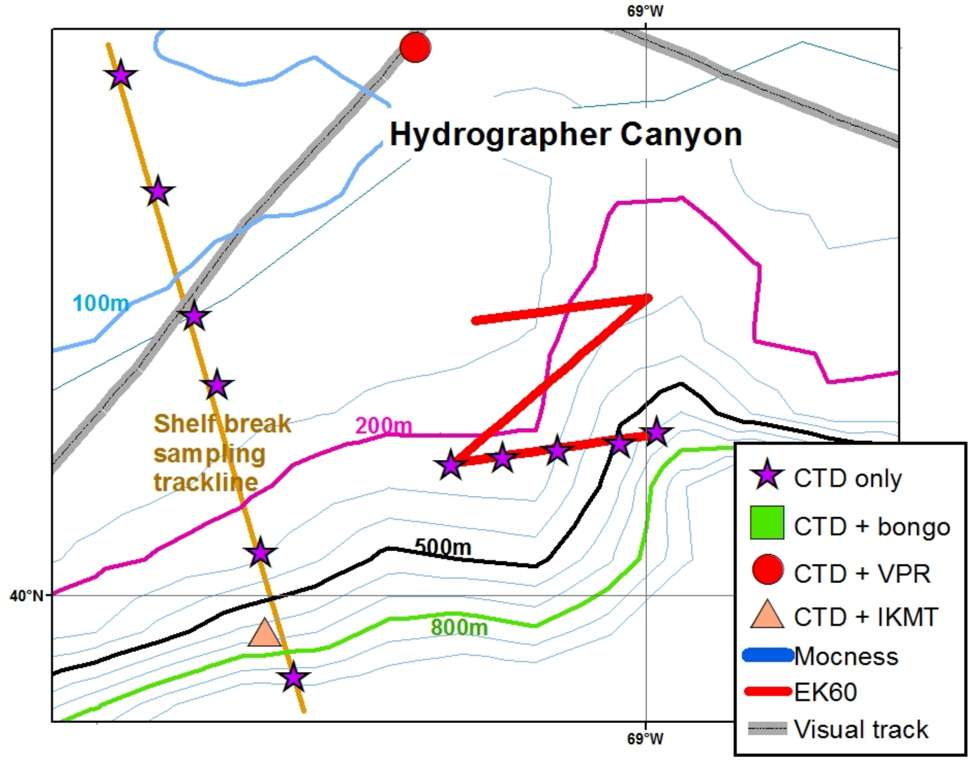


Figure B30. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near Hydrographer Canyon; Bottom: near Lydonia Canyon.



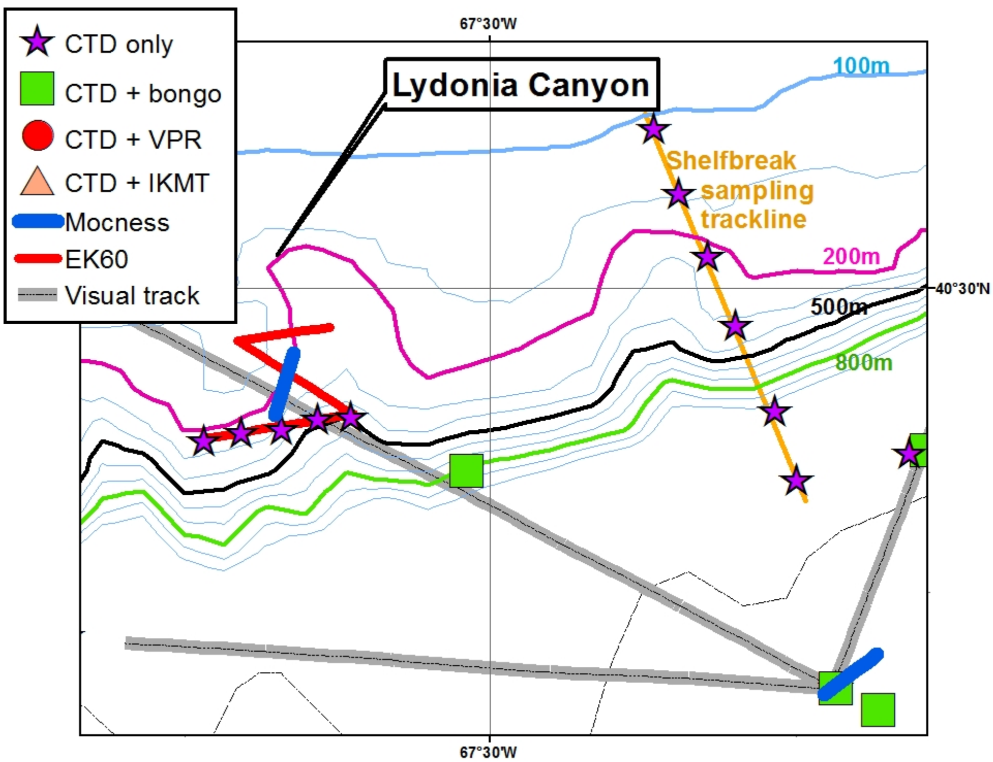
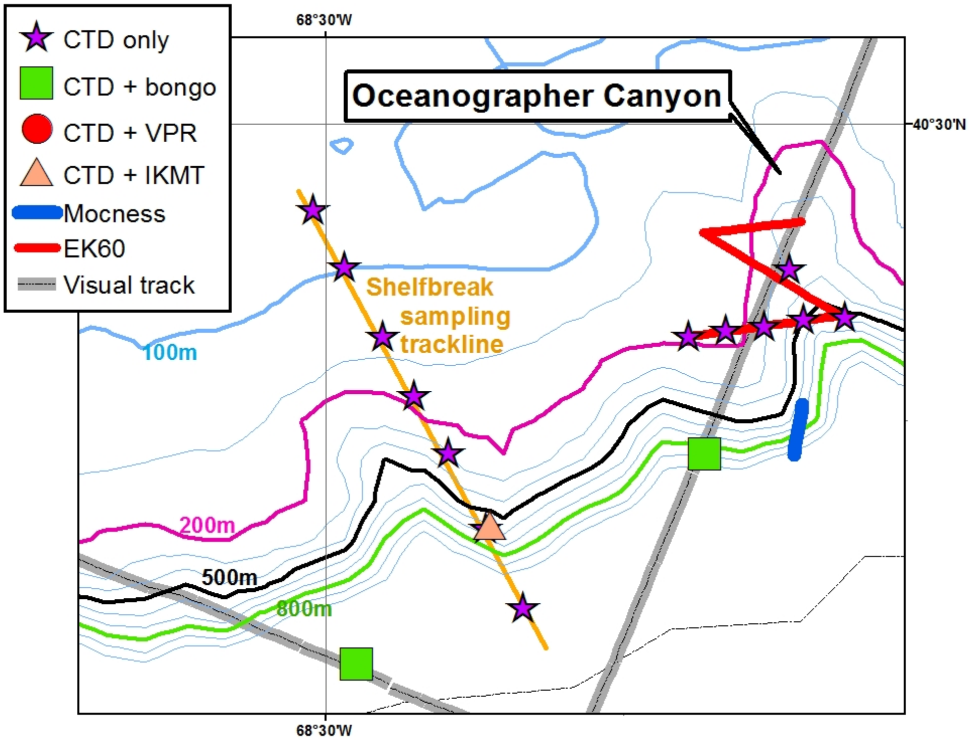


Figure B31. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near Oceanographer Canyon; Bottom: near Wilmington Canyon.



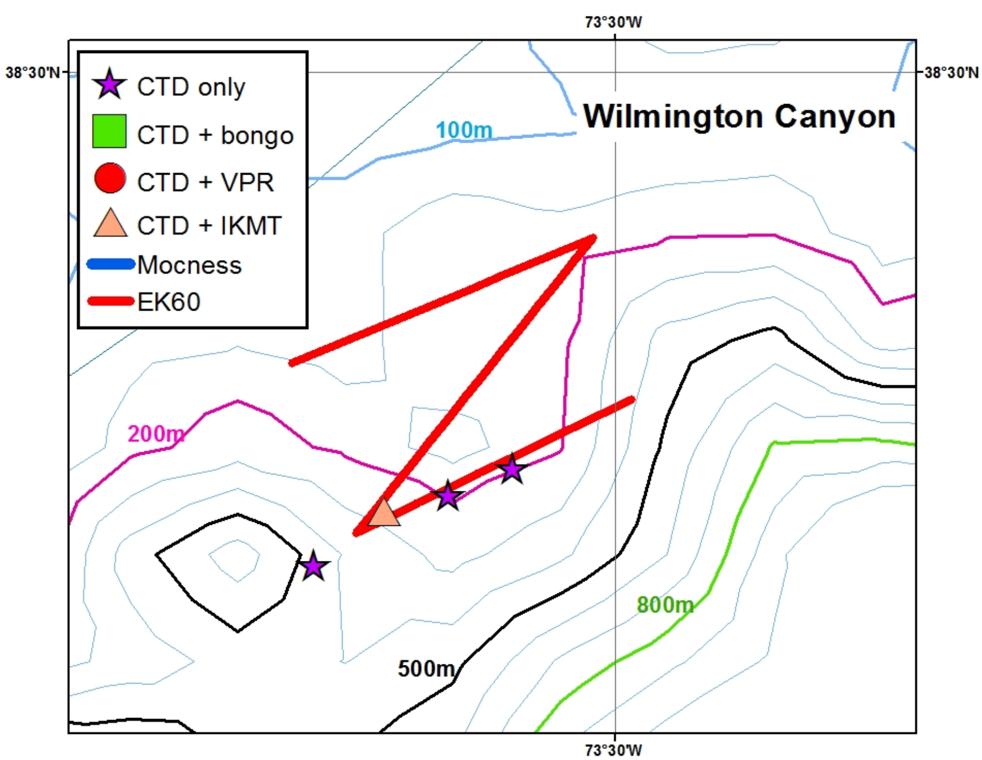


Figure B32. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT), and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Top: near the BOEM-MA stratum; Bottom: near BOEM-MidAtl stratum.

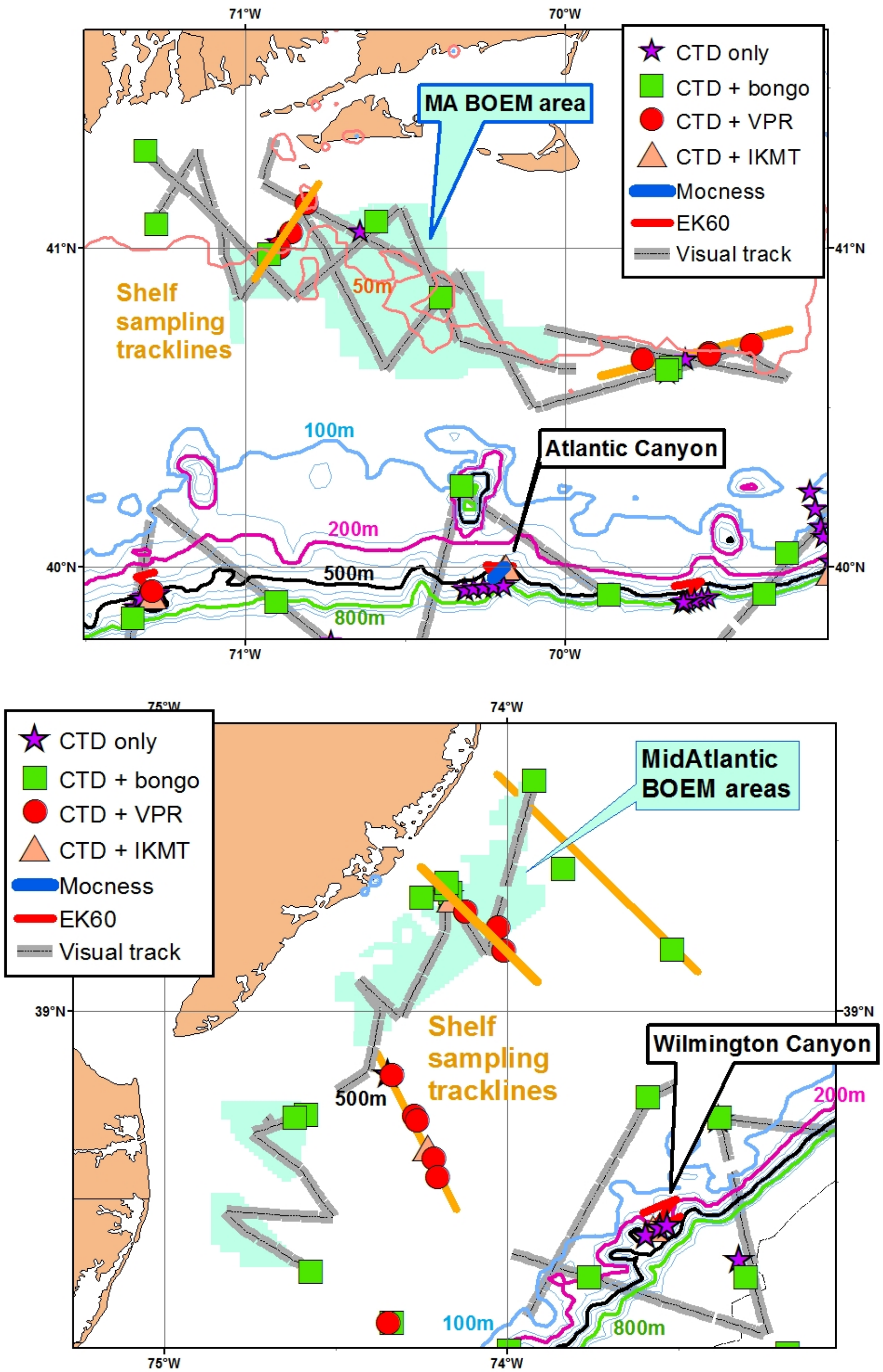


Figure B33. Locations of the deployment of CTDs, bongos, visual plankton recorders (VPR), Isaac Kidd mid-water trawls (IKMT) , and the MOCNESS relative to the track lines where the EK60 was recording at night and the visual teams were surveying at day. Near the Northeast Channel, east of Georges Bank.

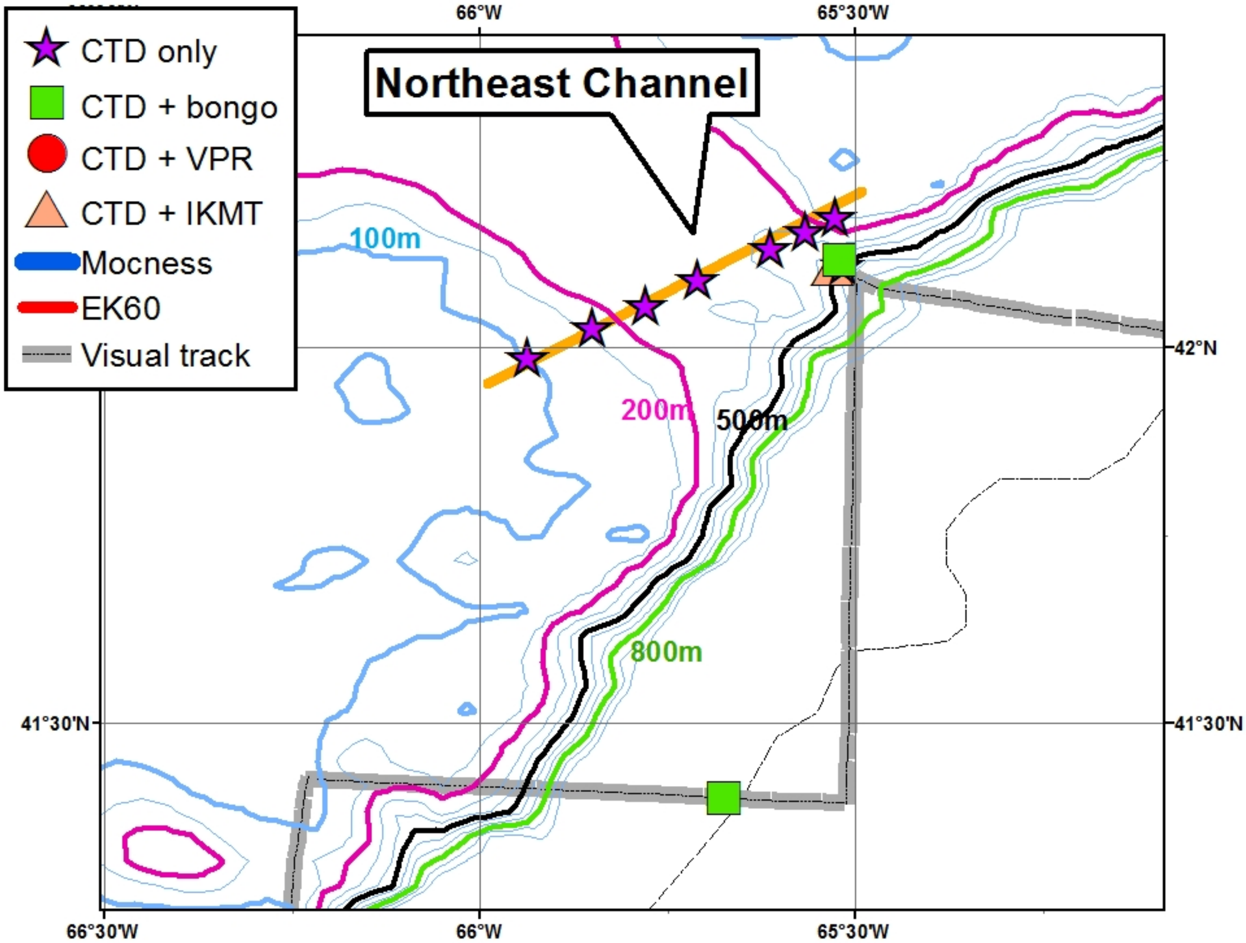


Figure B34. Raw EK60 Multi-frequency acoustic data collected along the mid-canyon transect in Wilmington Canyon showing strong scattering layers, especially at the lower (18 and 38 kHz) frequencies.

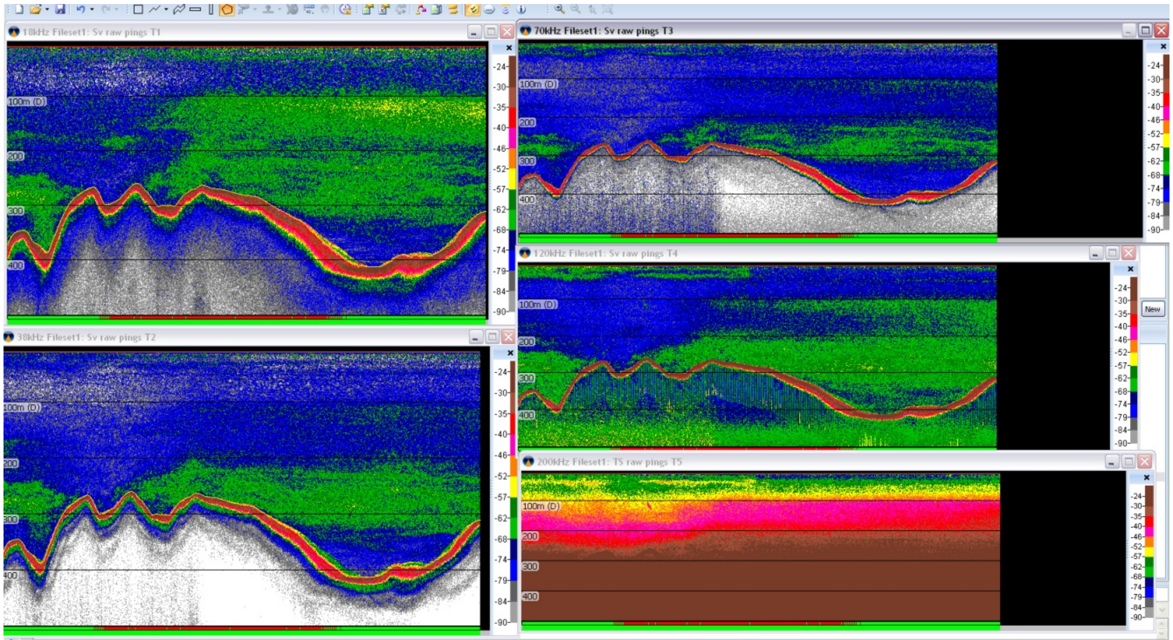


Figure B35. (a, upper panel) Processed EK60 Multi-frequency acoustic data collected along the shelfbreak transect east of Welker Canyon showing strong scattering layers at the 18kHz frequency. Processing involves removal from the raw data of unwanted returns from the seafloor, as well as removal of noise (e.g., surface bubbles, vessel noise, interference from other acoustic devices). (b, lower panel) Acoustic frequency response (i.e., backscattering vs. frequency) for the polygon denoted by 31 in the echogram of panel a. Scattering was highest at the lowest survey frequency (18 kHz), consistent with larger scatterers and/or small swimbladdered fish.

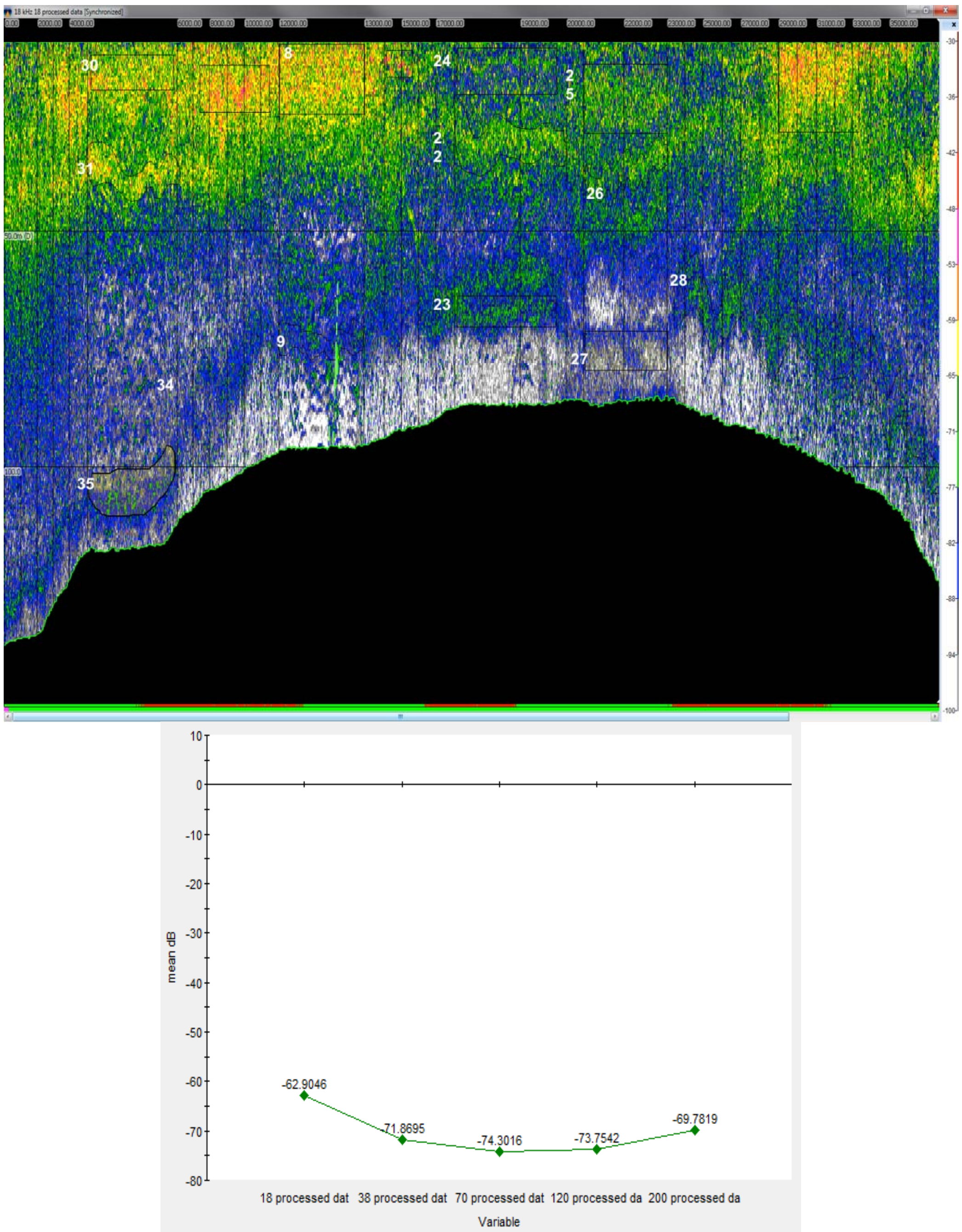


Figure B36. Euphausiids, *Thysanoessa sp*., (right) and Hyperiids, *Themisto gaudichaudii*, (left) which were commonly collected in the 1m MOCNESS and IKMT.

Figure B37. Mesopelagic fishes, (a) pearlsides and (b) myctophids, commonly collected in the 1m MOCNESS and IKMT.

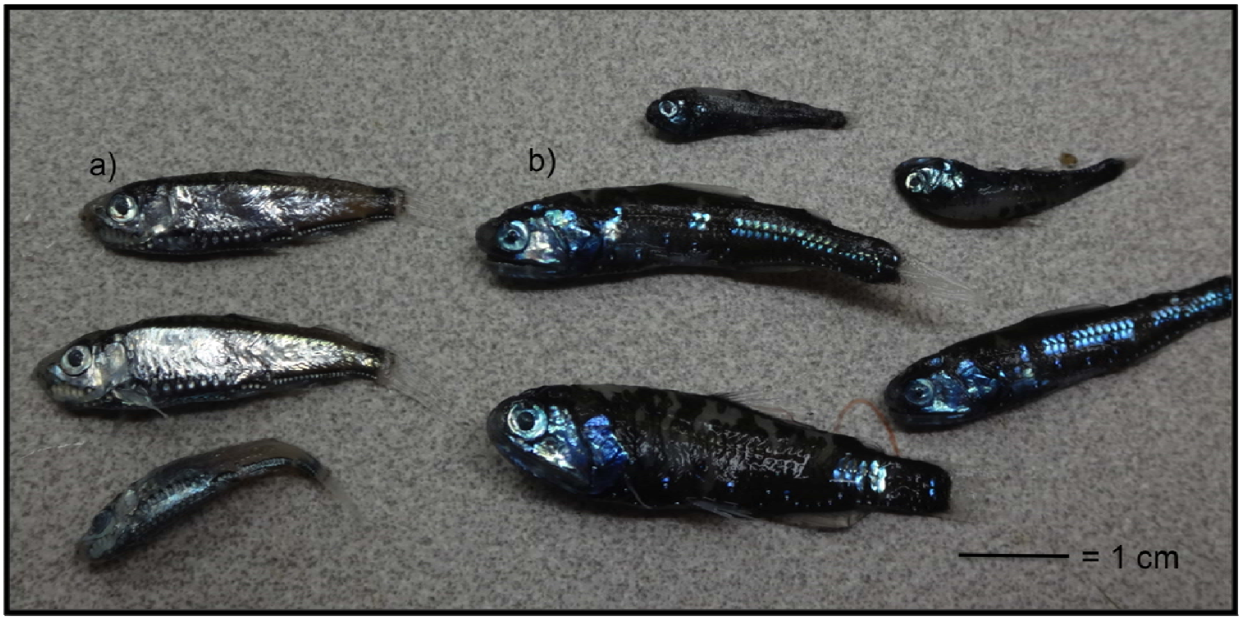


Figure B38. Typical oceanographic profile from the offshore transects characterized by high salinities and very low chlorophyll counts.

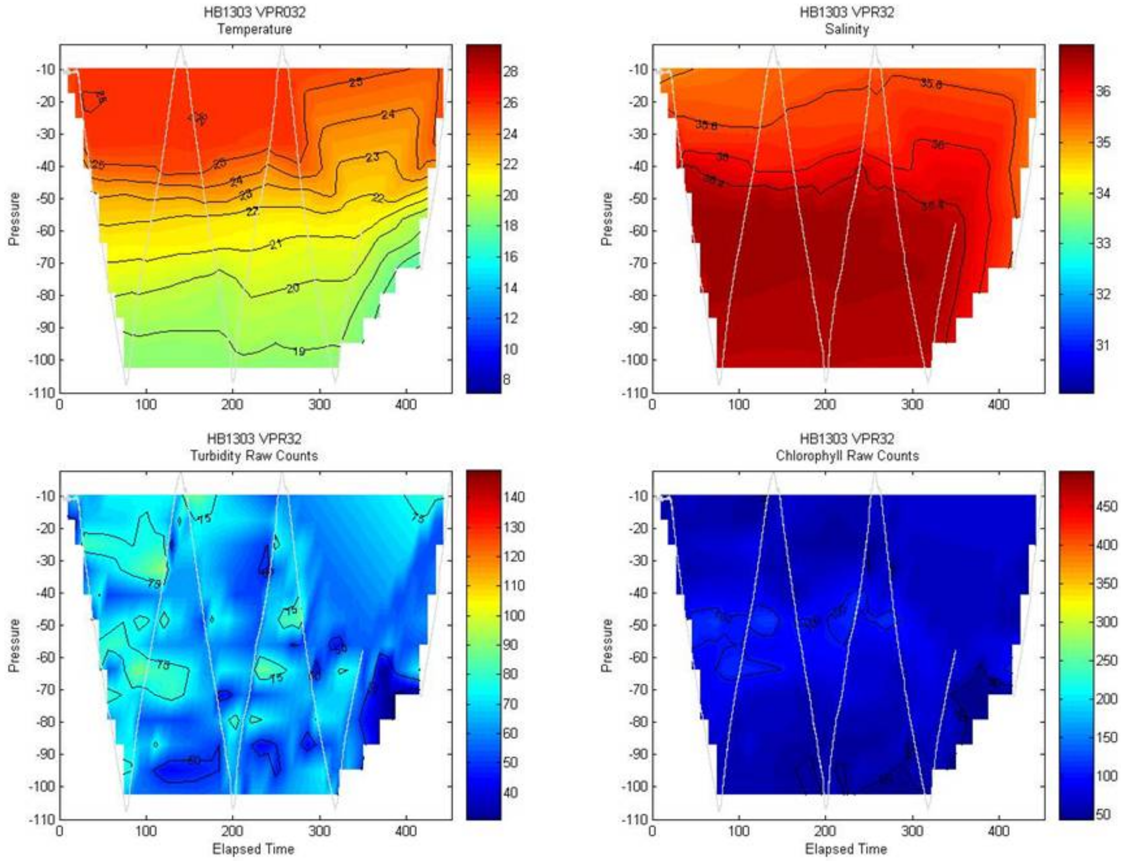


Figure B39. Gelatinous zooplankton images taken with the color VPR. From top left: leptomedusa (a), larvacean (b), siphonophore (c), dolid (d), hydromedusa (e).

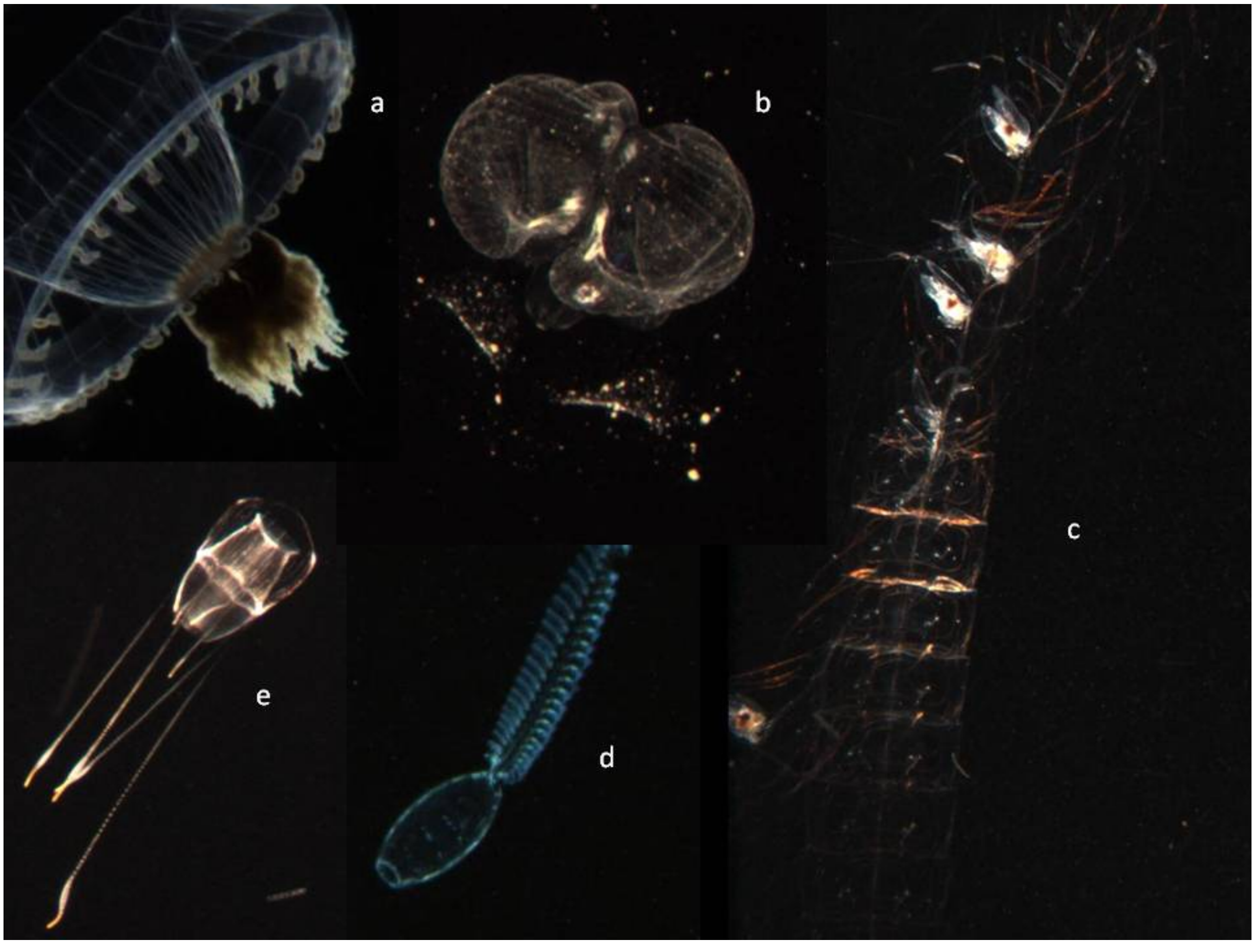


Figure B40. Salpa fusiformes was present in two forms: solitary (a) and colonial chains up to 1m in length (b).

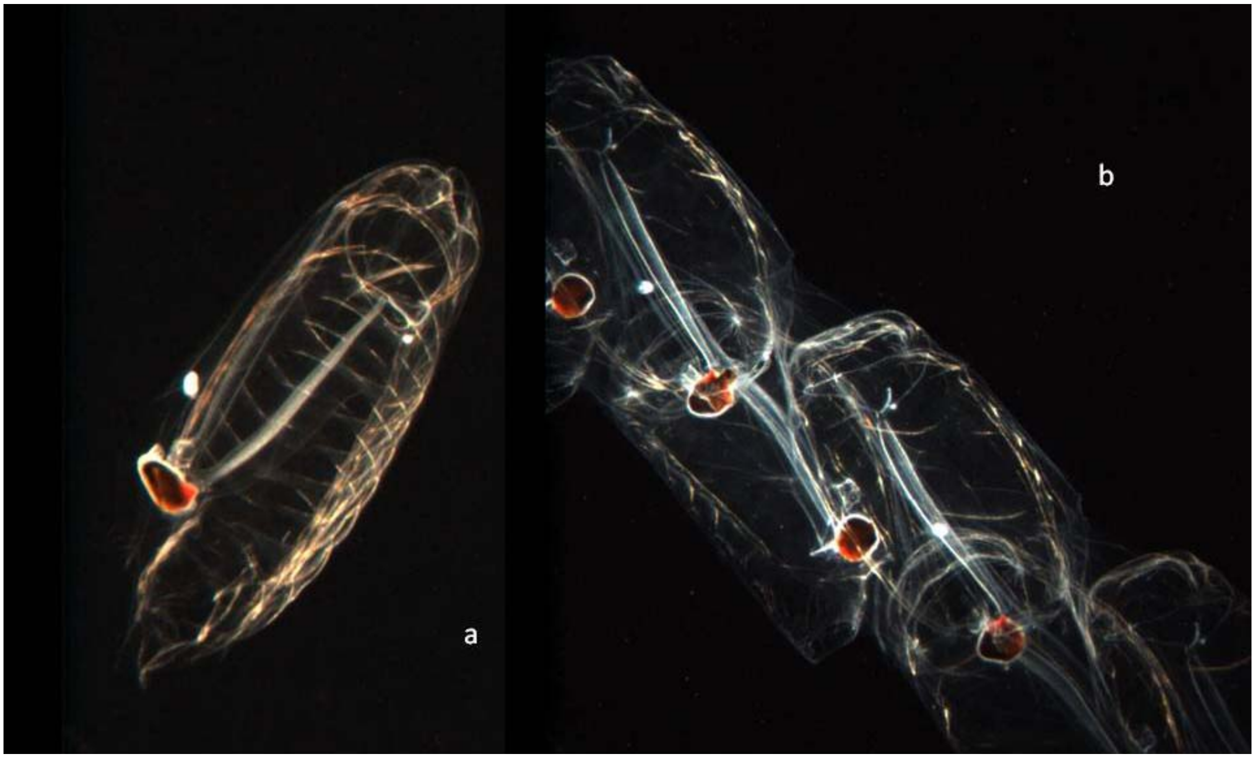


Figure B41. Typical southern NE oceanography showing a well defined thermocline with plankton and chlorophyll layers just below the thermocline.

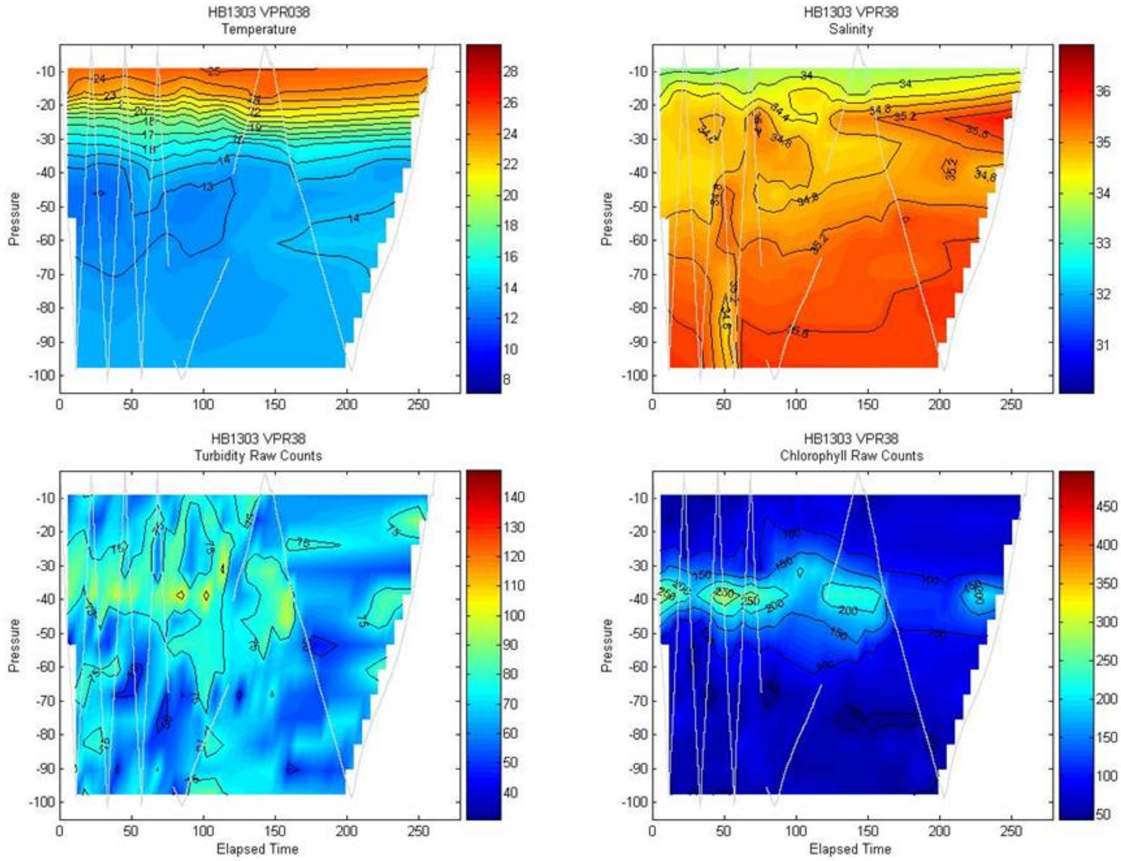


Figure B42. Oceanography offshore from the NE Channel of Georges Bank. The area shows the low chlorophyll and high salinity associated with offshore stations but has the well developed thermocline typical of the Georges Bank area.

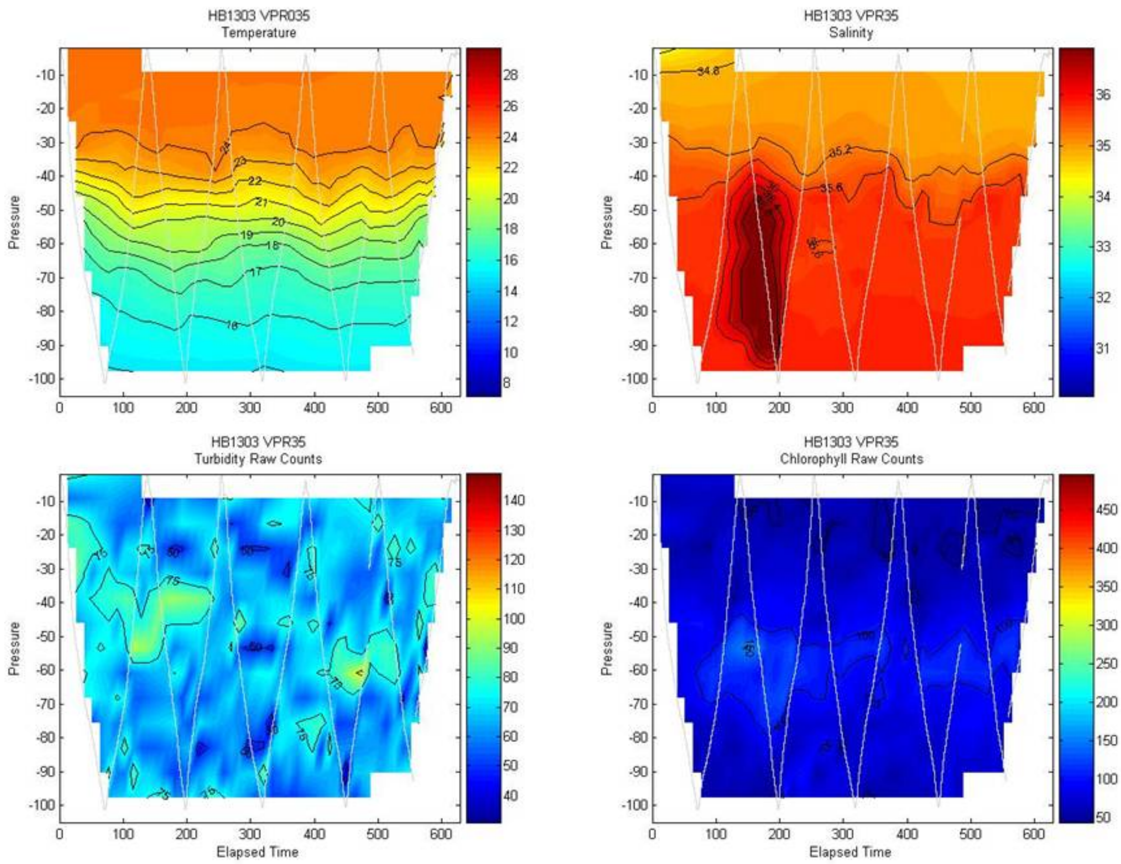


Figure B43. Oceanography on Nantucket shoals showing cooler water temperatures, moderate thermoclines, with strong layers of chlorophyll and plankton associated with the thermocline.

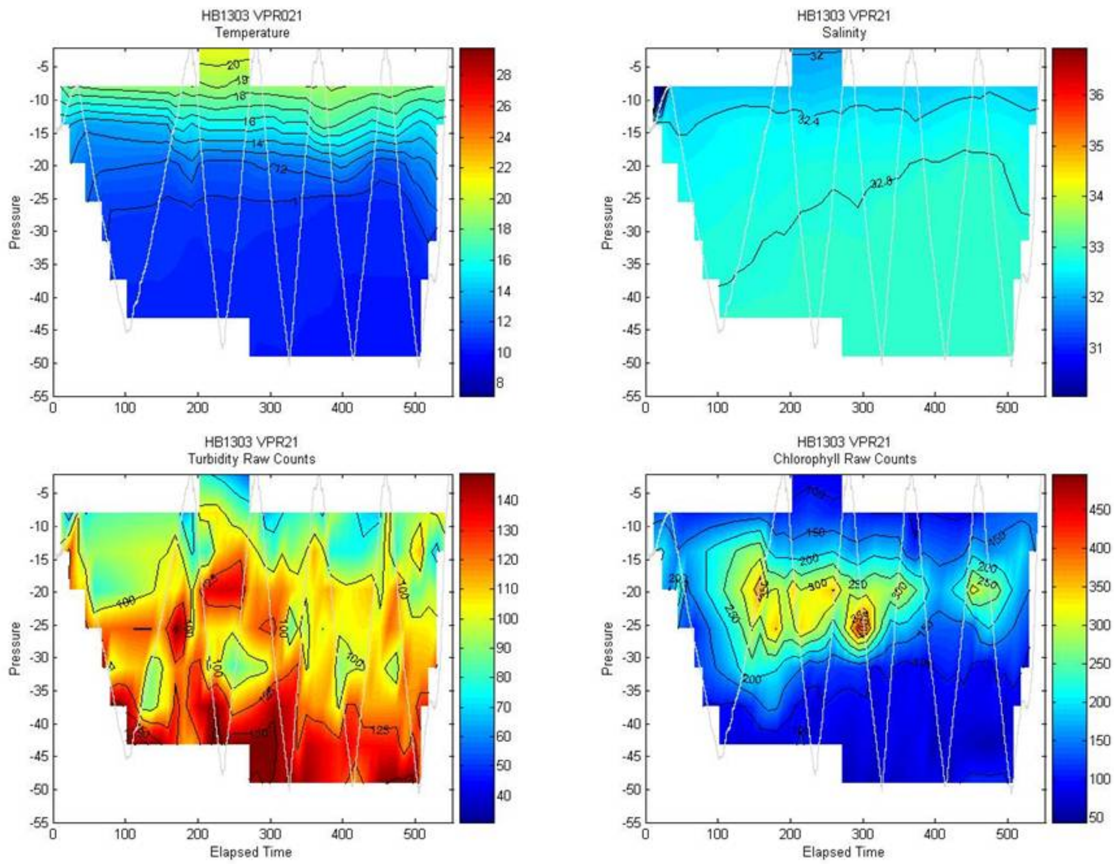
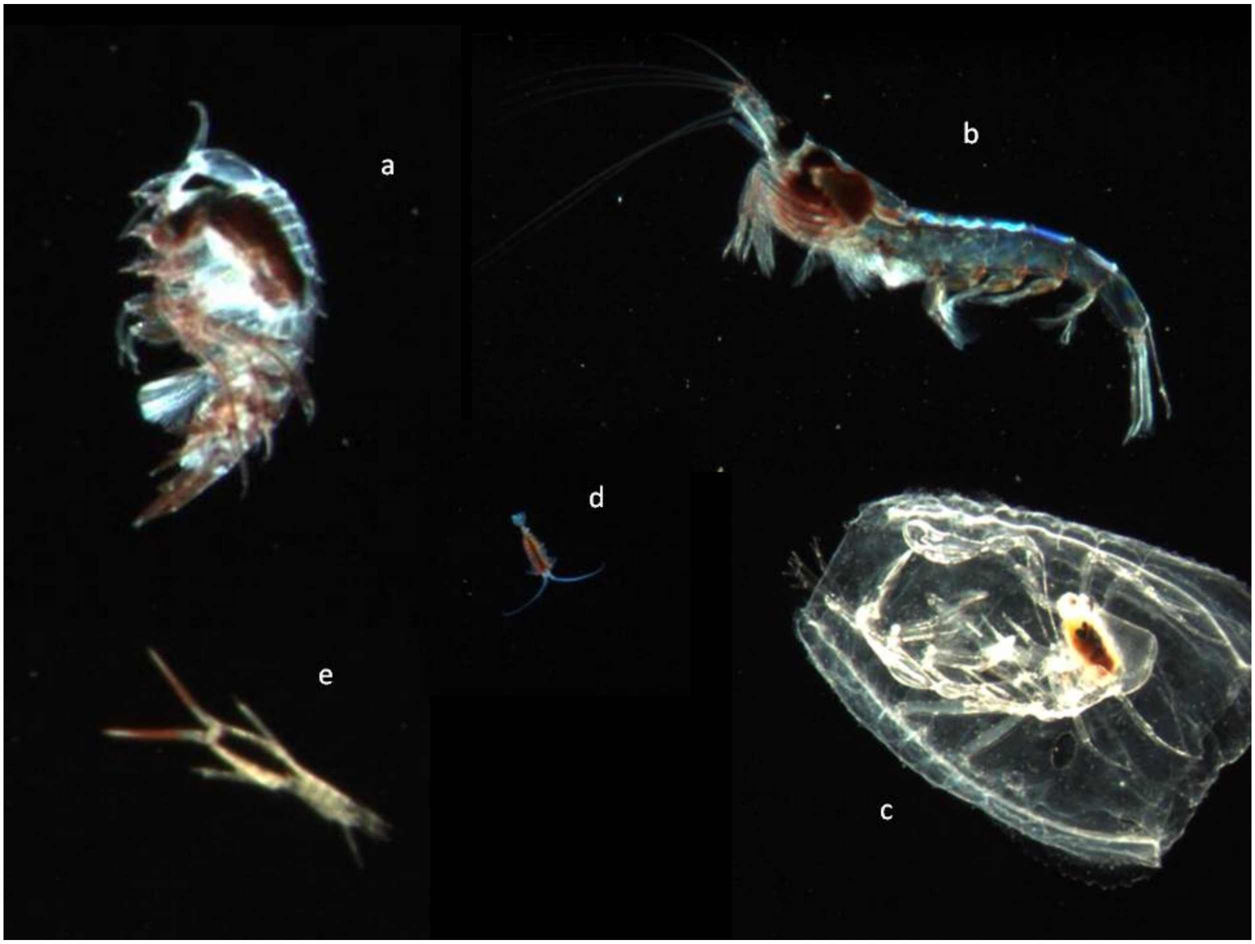


Figure B44. plankton images taken with the color VPR. From top left *Themisto gaudichaudii* (a), *Meganyctiphanes norvegica* (b), *Phoronima sp.* (c), copepod (d), gammarid amphipoda (e).



Appendix C: *Southern leg of shipboard abundance survey during summer 2013: Southeast Fisheries Science Center*

Lance P. Garrison[1], Kevin P. Barry[2], Anthony Martinez[1]

[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 conducted shipboard surveys of continental shelf and shelfbreak waters along the US East Coast from South Carolina to Virginia during 16 July – 16 September 2013. The marine mammal survey was designed for analysis using Distance sampling and a two-team (independent observer) approach to correct for perception bias in resulting abundance estimates. In addition, passive acoustic hydrophones were used to monitor vocalizing cetaceans. The sea bird survey used the standard strip transect approach for one team. In addition, cetacean biopsy samples and photographs were taken, along with hydrographic profiles at sampling stations. A total of 5,475 km of survey effort was accomplished in good to fair weather conditions. As expected, the majority of the cetacean sightings were along the shelf break. Large whale sightings included fin whales (*Balaenoptera physalus*) and sperm whales (*Physeter macrocephalus*), humpback whales (*Megaptera novaeangliae*), and one North Atlantic right whale (*Eubalaena glacialis*). A notably high concentration of beaked whale sightings occurred along a trackline offshore of North Carolina. In total, there were 547 sightings of cetaceans during this survey from at least 17 different species (not including unidentified taxa). Additional species observed included large numbers of leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) sea turtles that were observed in waters over the continental shelf north of Cape Hatteras. The passive acoustic hydrophone array was deployed and monitored for approximately 574 hours during the entire survey yielding 729 acoustic detection events. A total of 39 cetacean biopsies were collected from 5 different species. A total of 254 hydrographic profiles were collected including 227 XBT stations and 27 CTD stations. At least 56 bird species were observed and identified for a total of 2,542 individuals. The most common species observed were Cory's shearwater (*Calonectris diomedea*), Audubon shearwater (*Puffinus lherminieri*), Wilson's storm-petrel (*Oceanites oceanicus*), Black-capped storm petrel (*Pterodroma hasitata*), and Band-rumped storm petrel (*Oceanodroma castro*).

OBJECTIVES

The objectives of this survey were: 1) conduct visual line-transect surveys to estimate the abundance and spatial distribution of cetaceans in U.S. Atlantic waters; 2) conduct passive acoustic surveys simultaneous with visual surveys to provide supplemental information on cetacean abundance and spatial distribution; 3) collect tissue samples (biopsies) of certain cetaceans from the bow of the *Gordon Gunter*.; 4) collect data on distribution and abundance of seabirds; 5) collect oceanographic and environmental data including scientific echosounders (EK60) to quantify acoustic backscatter due to the presence of small fish and zooplankton; 6) collect vertical profiles of hydrographic parameters (*e.g.*, temperature, salinity, oxygen concentration) using Conductivity, Temperature, and Depth sensors (CTD) and Expendable Bathythermographs (XBT).

CRUISE PERIOD AND AREA

The survey was scheduled to be divided into three legs: 13 July – 1 August; 10 – 24 August; 28 August – 15 September 2013. The study area was waters from the coast to 200 nmi offshore from South Carolina to Virginia.

The survey was scheduled to commence on 13 July 2013. However, a mechanical issue on the ship resulted in a delayed departure, and the vessel departed Norfolk, VA at 1030 hrs on 16 July. Visual operations began on the afternoon of 16 July. On the evening of 19 July the *Gunter* had another mechanical issue forcing the ship to return back into port for dockside repairs. The vessel departed Norfolk, VA at 1200 hrs on 25 July. Visual and acoustic survey began the morning of 26 July. The vessel arrived at Norfolk, VA on 1 August at 0800 hrs for completion of the first leg.

The second leg commenced with the vessel departing at 1200 hrs on 10 August from Norfolk, VA. Visual and passive acoustic surveys were conducted through 23 August. The vessel arrived at Charleston, SC at 0800 hrs on the morning of 24 August.

The third leg commenced with the vessel departing Charleston, SC at 1400 hrs on 28 August. Visual and passive acoustic surveys were conducted through 9 September. A scheduled scientific personnel exchange was carried out on 10 September off of Virginia Beach, VA. Two scientists departed the *Gunter* and one new scientist boarded to help with the calibration of the EK 60. The EK60 calibration started on the afternoon of 10 September and was completed mid-day on 11 September. The visual and passive acoustic surveys recommenced on the afternoon of 11 September and continued along the zig-zag tracklines through 15 September.

The vessel arrived at Norfolk, VA at 0900 hrs on the morning of 16 September to complete the survey.

METHODS

Survey operations and effort are summarized in Table C1. Scientific staff is listed in Table C2.

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

Standard ship-based, line-transect survey methods for cetaceans, similar to those used previously in the Pacific Ocean, Atlantic Ocean, and Gulf of Mexico, were used (*e.g.*, Barlow, 1995; Mullin and Fulling, 2003; Fulling *et al.*, 2003). The survey employed the two-team "independent observer" methodology to improve estimates of sighting probability. This approach was similar to that used during the summer of 2004 (Garrison *et al.*, 2011).

Each team consisted of two observers, where one team was stationed on the flying bridge (height above water = 13.7 m) and the other on the bridge wings (height above water = 11.0 m). The two teams were isolated from one another to avoid "cueing" each other to the presence of marine mammals. Observers rotated through two positions (port and starboard) at 30 min intervals. A data recorder stationed on the bridge maintained communication with both teams and entered data on sightings using a computerized data entry program interfaced with a global positioning system (GPS) receiver. For each team, at least one observer with extensive experience in ship-based, line-transect methods and identification of cetaceans was present on the flying bridge and bridge wings at all times. Observers searched the horizon using 25x150 "bigeye" binoculars, scanning from their respective 90° angle up to 10° on the opposite side.

For each cetacean sighting, time, position, bearing, reticle (a measure of radial distance), species, group-size, behavior, bottom depth, sea surface temperature, and associated animals (*e.g.*, seabirds, fish) were recorded. The bearing and radial distance for groups sighted without the 25x150 powered binoculars and close to the ship were estimated by naked eye. Survey effort data were automatically recorded every minute and included the ship's position and heading, effort status, observer positions, and environmental conditions which could affect the observers' ability to sight animals (*e.g.*, Beaufort sea state, trackline glare, etc.).

Survey tracklines alternated between "Passing Mode" and "Closing Mode". In "Closing Mode", if a sighting was located within a 3.0 nm strip on either side of the ship, the ship was diverted from the trackline to approach the group to identify species and estimate group-size. In "Passing Mode", the ship was not diverted and the observers made the best possible identification of species and group size count from the distance. Cetaceans were identified to the lowest taxonomic level possible.

Survey speed was usually 18 km/hr (~10 kn) but varied with sea conditions. The effectiveness of visual line transect survey effort is severely limited during high sea state and poor visibility conditions (e.g., fog, haze or rain). Survey effort was therefore suspended during heavy seas (Beaufort sea state > 5) and rain.

PASSIVE ACOUSTIC SURVEY

Passive acoustic surveys were conducted 24 hours a day when conditions allowed, both simultaneously with visual surveys and during night and other periods when the visual survey was inactive. Passive acoustic surveys were suspended during portions of the tracklines that occurred in water depths shallower than 75 m and when passing through thunderstorms.

Passive acoustic monitoring was conducted using a towed hydrophone array deployed at approximately 300 m behind the ship and 10 m depth at standard ship speeds. A custom-built five-element mixed-frequency oil-filled hydrophone array included paired pre-amplifier and hydrophone elements capable of recording a broad range of frequencies. Sensors 1, 3, and 5 were optimized for greater detection ranges for mid-frequency recordings by using APC International 42-1021 hydrophones with custom-built pre-amplifiers. The APC 42-1021 hydrophones have a -212 dB re V/uPa sensitivity with a flat frequency response (+/- 4 dB) from 1 to 45 kHz. The corresponding pre-amplifiers provided a highpass filter with 45 dB gain above 5 kHz. Sensors 2 and 4 were optimized for recording the full bandwidth of high-frequency echolocation clicks by using Reson TC4013 hydrophones with custom-built pre-amplifiers. The TC4013 hydrophones have a -212 dB re V/uPa sensitivity with a flat frequency response (+/- 2 dB) from 5 to 160 kHz. The corresponding pre-amplifiers provide a highpass filter with 50 dB gain above 5 kHz. Data from sensors 1 and 5 were recorded through an RME Fireface UC audio interface at 16 bit 192 kHz sample rate yielding a recording range of 1-96 kHz, while data from sensors 2 and 4 were recorded through a National Instruments USB-6251 BNC sound card at 16 bit 500 kHz sample rate yielding a recording range of 1 – 250 kHz.

The Pamguard software program was used to record acoustic data and log comments to hard-disk and to obtain bearings to acoustic detections. Acoustic field technicians monitored data aurally and visually through spectrographic analysis using Ishmael software and attempted to acoustically localize active cetaceans in real-time using Ishmael's hyperbolic bearing calculator and a custom-written acoustic version of VisSurvey. The acoustic VisSurvey version is capable of receiving and plotting visual sighting information along with acoustic bearings to improve correlation of acoustic and visual detections in real-time.

BIOPSY SAMPLING

Cetacean biopsy tissue samples were collected from the bow of the NOAA ship *Gordon Gunter*. Samples were collected using a modified .22 caliber dart rifle fitted with custom designed biopsy heads that extract a small plug of tissue from the animals, usually including skin and blubber. A portion of the skin can be genetically analyzed for species identification and gender determination, as well as evaluation of population structure. Another portion of the skin can be used for stable isotopes analysis. Blubber samples can be analyzed for a variety of contaminants or to measure hormone levels. Data on each sampling attempt were recorded and included GPS location, time, date, sampler, species, body location where the dart struck, behavioral reaction, and whether or not a sample was obtained. A complete log of the biopsy data is maintained at the Pascagoula and Miami laboratories. Biopsy sampling was attempted after all pertinent group size and biological information was recorded by the visual team.

ACTIVE ACOUSTIC SAMPLING

Calibrations were conducted on the 18 kHz and 38 kHz frequencies of the scientific echosounder (EK60). Calibration is necessary to ensure that the data collected by the gear are comparable between different surveys accounting for deviations in the behavior of the transducers and receivers over time. Calibration followed standard guidelines described in the user manuals for the scientific echosounders and recommendations from the manufacturer. Briefly, a spherical standard target is suspended at a depth of approximately 15 m beneath the transducer by attaching it to three reels stationed in a triangular pattern around the vessel. This allows the position of the sphere within the transducer beam to be controlled. During the calibration, the target is moved throughout the circular beam, and the resulting strength (in dB) of the return signal from the transducer is measured. After a large number of returns are measured, a statistical model is used to correct the returns from acoustic targets for variability in the sensitivity of the receiver throughout the beam.

HYDROGRAPHIC SAMPLES

Environmental data were collected at predetermined stations using a Conductivity, Temperature and Depth (CTD) unit and expendable bathythermographs (XBT). CTD casts were submerged up to 1000 m deep and recorded vertical profiles of salinity, temperature, oxygen content, and fluorescence. XBT profiles recorded only temperature up to a depth of 750 m. CTD data were recorded on a daily basis, typically at the beginning and end of the survey day. XBT casts were made at regular intervals along the trackline throughout the cruise at stations typically spaced 15 – 20 km apart.

Constant records of environmental parameters including water temperature, salinity, and weather conditions (*e.g.*, wind speed, wind direction) were collected *in situ* via the ship's Scientific Computer System (SCS).

SEABIRD SURVEYS

Data on seabird occurrence were collected by a dedicated observer stationed on the flying bridge of the NOAA ship *Gordon Gunter*. Seabird data were collected consistent with protocols provided by the U.S. Fish and Wildlife Service to allow analysis of seabird abundance and spatial distribution. Seabird observations operated simultaneously with the marine mammal surveys throughout much of the survey. Species identifications were confirmed through photography and visual identification.

RESULTS

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

Visual cetacean surveys were conducted between 16 July and 16 September 2013. A total of 5,475 km of survey effort were accomplished. Weather conditions were good to fair throughout much of the survey, with sea states of Beaufort 2 – 3 on most survey days. Accomplished trackline and marine mammal sightings are shown in Figure C2. As expected, the majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope (Figure C2). Large whale sightings included fin whales and sperm whales, humpback whales, and one North Atlantic right whale (Figure C3; Table C3). A notably high concentration of beaked whale sightings occurred along a trackline offshore of North Carolina (Figure C3). This particular trackline also had a very high number of pygmy/dwarf sperm whale sightings (Figure C4). Pilot whale's and Risso's dolphins were the other primary small whales sighted during the survey. A variety of delphinids were encountered during the survey with the majority of sightings along the shelf-break (Figure C5).

In total, there were 547 sightings of cetaceans during this survey from at least 17 different species (not including unidentified taxa). Of the total number of sightings, 2.5% (14) were of mixed species groups.

Additional species observed included high numbers of leatherback and loggerhead sea turtles that were observed in waters over the continental shelf north of Cape Hatteras (Figure C6). Several species of sharks and *Mola mola* were also seen in this region (Figure C7). During the survey, *Sargassum* patches were recorded and characterized based upon size and shape. *Sargassum* patches were seen primarily along the shelf break and in the deeper waters of the continental slope (Figure C8).

PASSIVE ACOUSTIC SURVEY

The passive acoustic technicians monitored the signals continuously and recorded and classified cetacean sounds (e.g., echolocation clicks, whistles, etc.) along with anthropogenic noises. All acoustic data were recorded as multichannel wav files to 2 TB external SATA hard drives, resulting in 7 TB of data collected. Data on the bearing to the sounds and the sound types and intensity were recorded using Ishmael and Pamguard data collection software. The array was deployed and monitored for approximately 574 hours during the entire survey (Table C1) yielding 729 acoustic detection events.

Acoustic detections of marine mammals were made throughout the survey and were correlated with visual sightings when localization was possible. Direct identification of acoustic detections was made through visual verification of species identifications. At initial data collection, these sounds were typically broadly categorized as unidentified delphinids or sperm whale clicks (Figure C3). However, correlation with visual identifications will allow characterization of the acoustic signature of different species and these will be incorporated into classification algorithms. Acoustic data will also be used to improve estimates of sperm whale abundance.

BIOPSY SAMPLING

A total of 39 cetacean biopsies were collected from 5 different species (Table C4, Figure C10).

ACTIVE ACOUSTIC SAMPLING

Following the calibration of the EK60, active acoustic backscatter data were collected continuously throughout the cruise and stored on hard drives for archiving and later data analysis.

HYDROGRAPHIC SAMPLES

A total of 254 hydrographic profiles were collected including 227 XBT stations and 27 CTD stations (Figure C11). All data from the CTDs and the SCS are maintained at the Pascagoula Laboratory for analysis, editing, and archiving.

SEABIRD SURVEYS

At least 56 species were observed and identified for a total of 2,542 individuals recorded (Table C5, Figure C12). The most common species observed were Cory’s shearwater (*Calonectris diomedea*), Audubon shearwater (*Puffinus lherminieri*), Wilson’s storm-petrel (*Oceanites oceanicus*), Black-capped storm petrel (*Pterodroma hasitata*), and Band-rumped storm petrel (*Oceanodroma castro*).

DISPOSITION OF DATA

All data collected during GU-13-04 including visual survey data, passive acoustic data, EK60 data, SCS data, XBT and CTD data, and seabird data are archived and managed at the Southeast Fisheries Science Center, Miami, FL. Genetic samples are stored at the Southeast Marine

Mammal Molecular Genetics Laboratory in Lafayette, LA. All other samples are stored at the SEFSC in Miami, FL.

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 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 NOAA Fisheries Service, SEFSC. We would also like to thank the ship's crew and observers that were involved in collecting these data.

REFERENCES CITED
Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fishery Bulletin 93:1-14.

Barlow, J., S.L. Swartz, T.C. Eagle, and P.R. Wade. 1995. U.S. marine mammal stock assessments: Guidelines for preparation, background, and a summary of the 1995 assessments. NOAA Tech. Mem. NMFS-OPR-6. 73 p.

Fulling, G.L., K.D. Mullin, and C.W. Hubard. 2003. Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico. Fishery Bulletin 101:923-932.

Garrison, L.P., Martinez, A.M., Foley, K.M. 2011. Habitat and abundance of marine mammals in continental slope waters of the southeastern U.S. Atlantic. Journal of Cetacean Research and Management. 11:267-277.

Mullin, K.D. and G.L. Fulling. 2003. Abundance of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998. Fishery Bulletin 101:603-613.

Wade, P.R. and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Mem. NMFS-OPR-12. 93 p.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley, eds. 2010. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2009. NOAA Tech. Mem. NMFS-NE-213.

Table C1. Summary of survey effort during the July – September 2013 abundance survey on the NOAA ship *Gordon Gunter*, GU-13-04.

LEG 1 Date	Survey Event	Survey Effort (km)	Number of Sightings	Number of Biopsies	Avg. Sea State	Acoustic Recording (hrs)
16 July	Depart Norfolk, VA 1030 hrs, Visual Survey, Acoustic Testing/Setup	50.5	2	0	1.1	-
17 July	Visual Survey – Acoustic Testing/Setup	133.0	9	1	1.9	0
18 July	Visual Survey and Acoustic Survey	90.5	30	3	1.4	6.4
19 July	Visual and Acoustic Survey	151.6	10	1	4.2	10.7
20 July	Transit – Back to Norfolk Dock side repairs	-	-	-	-	3.0
21 July	Dock side repairs	-	-	-	-	-
22 July	Dock side repairs	-	-	-	-	-
23 July	Dock side repairs	-	-	-	-	-
24 July	Dock side repairs	-	-	-	-	-
25 July	Depart Norfolk, VA 1200 hrs,	-	-	-	-	-
26 July	Limited Effort - Weather	105.4	14	0	4.0	12.6
27 July	Visual and Acoustic Survey	147.5	18	0	2.3	17.9
28 July	Visual and Acoustic Survey	92.9	9	3	3.9	16.5
29 July	Visual and Acoustic Survey	135.3	23	1	2.9	19.2
30 July	Visual and Acoustic Survey	155.2	22	0	2.9	22.8
31 July	Visual and Acoustic Survey	142.7	9	1	2.7	18.9
1 August	Arrive Norfolk, VA 0900 hrs	-	0	0	-	-
Leg 1 Totals		1,204	147	8	2.7	127.9

Table C1 (cont). Summary of survey effort during the July – September 2013 abundance survey on the NOAA ship *Gordon Gunter*, GU-13-04.

LEG 2 Date	Survey Event	Survey Effort (km)	Number of Sightings	Number of Biopsies	Avg. Sea State	Acoustic Recording (hrs)
10 August	Depart Norfolk, VA 1200 hrs	13.2	1	0	2.4	0
11 August	Visual and Acoustic Survey	118.3	30	2	1.9	16.2
12 August	Visual and Acoustic Survey	209.1	7	1	3.6	20.2
13 August	Limited Effort -Weather	65.6	4	0	4.6	18.2
14 August	Limited Effort -Weather	-	8	0	-	8.8
15 August	Limited Effort -Weather	94.3	3	0	4.2	14.4
16 August	Visual and Acoustic Survey	189.6	4	0	3.5	14.5
17 August	Visual and Acoustic Survey	186.8	8	0	2.3	21.8
18 August	Visual and Acoustic Survey	204.4	3	0	3.3	22.1
19 August	Visual and Acoustic Survey	187.6	20	0	2.3	22.2
20 August	Visual and Acoustic Survey	185.3	35	1	1.5	22.2
21 August	Visual and Acoustic Survey	99.1	50	1	0.4	17.2
22 August	Visual Survey	120.4	13	1	2.4	0
23 August	Visual and Acoustic Survey	138.4	14	1	2.4	10.1
24 August	Arrive Charleston, SC 0800 hrs	-	-	-	-	-
Leg 2 Total		1,812	201	8	2.7	207.8

Table C1 (cont). Summary of survey effort during the July – September 2013 abundance survey on the NOAA ship *Gordon Gunter*, GU-13-04.

LEG 3 Date	Survey Event	Survey Effort (km)	Number of Sightings	Number of Biopsies	Avg. Sea State	Acoustic Effort (hrs)
28 August	Depart Charleston, SC 1400 hrs	35.7	4	1	3.4	5.3
29 August	Visual and Acoustic Survey	190.7	10	0	4.7	21.6
30 August	Visual and Acoustic Survey	140.2	11	1	3.9	18.4
31 August	Visual Survey	121.4	17	4	1.5	2.7
1 September	Visual and Acoustic Survey	166.8	10	2	4.1	21.5
2 September	Visual and Acoustic Survey	164.2	3	0	4.7	20.2
3 September	Visual and Acoustic Survey	184.8	6	0	4.8	16.8
4 September	Visual and Acoustic Survey	191.3	4	0	2.7	16,5
5 September	Visual and Acoustic Survey	167.8	9	0	2.4	21.0
6 September	Visual and Acoustic Survey	154.8	6	0	3.7	21.2
7 September	Limited Effort -Weather	128.2	4	0	5.0	12.7
8 September	Visual and Acoustic Survey	133.5	22	5	2.6	13.3
9 September	Visual Survey	130.2	14	6	2.7	0
10 September	Personnel Exchange, Calibrate EK60 Echosounder	0	0	0	-	0
11 September	Calibrate EK60 Echosounder, Visual and Acoustic Survey	40.7	28	1	1.0	12.1
12 September	Visual and Acoustic Survey	83.6	30	2	1.8	18.3
13 September	Visual and Acoustic Survey	155.8	5	0	4.5	19.9
14 September	Limited Effort – Weather	141.5	5	0	3.3	15.7
15 September	Visual Survey	126.9	11	0	1.8	0
16 September	Arrive Norfolk, VA 0900 hrs	-	0	0	-	-
Leg 3 Totals		2,458	199	22	3.3	257.2
Survey Total		5,475	547	39	3.0	593

Table C2. GU-13-04 (063) Cruise Participants

Name	Title	Sex	Organization	Citizenship
Leg 1 (13 July – 01 August 2013)				
Jesse Wicker	Chief Sci	M	CIMAS, Miami, FL	US
Laura Dias	Scientist	F	CIMAS, Miami, FL	Brazil
Tom Johnson	Scientist	M	AP, Pascagoula, MS	US
Melody Baran	Scientist	F	IAP, Pascagoula, MS	US
Keith Rittmaster	Scientist	M	IAP, Pascagoula, MS	US
Juan Carlos Salinas	Scientist	M	Ocean Associates	Mexico
Michelle Savoie	Scientist	F	IAP, Pascagoula, MS	US
Carol Roden	Scientist	F	IAP, Pascagoula, MS	US
Jodi Smith	Scientist	F	IAP, Pascagoula, MS	US
Emma Jugovich	Scientist	F	IAP, Pascagoula, MS	US
Melissa Soldevilla	Scientist	F	NMFS, Miami, FL	US
Paul Nagelkirk	Scientist	M	IAP, Pascagoula, MS	US
Taila Dominello	Scientist	F	Biowaves, San Diego, CA	US
Kerry Dunleavy	Scientist	F	Biowaves, San Diego, CA	US
Corey Ann Hom-Weaver	Scientist	F	Biowaves, San Diego, CA	US
Leg 2 (10August –24 August 2013)				
Jesse Wicker	Chief Sci	M	CIMAS, Miami, FL	US
Laura Dias	Scientist	F	CIMAS, Miami, FL	Brazil
Adam U	Scientist	M	NMFS, La Jolla, CA,	US
Tom Johnson	Scientist	M	IAP, Pascagoula, MS	US
Tom Ninke	Scientist	M	IAP, Pascagoula, MS	US
Melody Baran	Scientist	F	IAP, Pascagoula, MS	US
Keith Rittmaster	Scientist	M	IAP, Pascagoula, MS	US
Juan Carlos Salinas	Scientist	M	Ocean Associates	Mexico
Michelle Savoie	Scientist	F	IAP, Pascagoula, MS	US
Carol Roden	Scientist	F	IAP, Pascagoula, MS	US
Jodi Smith	Scientist	F	IAP, Pascagoula, MS	US
Paul Nagelkirk	Scientist	M	IAP, Pascagoula, MS	US
Taila Dominello	Scientist	F	Biowaves, San Diego, CA	US
Kerry Dunleavy	Scientist	F	Biowaves, San Diego, CA	US
Corey Ann Hom-Weaver	Scientist	F	Biowaves, San Diego, CA	US
Leg 3 (28 August – 16 September 2013)				
Jesse Wicker	Chief Sci	M	CIMAS, Miami, FL	US
Laura Dias	Scientist	F	CIMAS, Miami, FL	Brazil
Anthony Martinez	Scientist	M	NMFS, Miami, FL	US
Adam U	Scientist	M	NMFS, La Jolla, CA,	US
Tom Johnson	Scientist	M	IAP, Pascagoula, MS	US
Tom Ninke	Scientist	M	IAP, Pascagoula, MS	US
Melody Baran	Scientist	F	IAP, Pascagoula, MS	US
Keith Rittmaster	Scientist	M	IAP, Pascagoula, MS	US
Juan Carlos Salinas	Scientist	M	Ocean Associates	Mexico
Michelle Savoie	Scientist	F	IAP, Pascagoula, MS	US
Carol Roden	Scientist	F	IAP, Pascagoula, MS	US
Jodi Smith	Scientist	F	IAP, Pascagoula, MS	US
Paul Nagelkirk	Scientist	M	IAP, Pascagoula, MS	US
Taila Dominello	Scientist	F	Biowaves, San Diego, CA	US
Kerry Dunleavy	Scientist	F	Biowaves, San Diego, CA	US
Corey Ann Hom-Weaver	Scientist	F	Biowaves, San Diego, CA	US

Table C3. Cetacean sightings during GU-13-04.

Common name	Leg 1	Leg 2	Leg 3	Total
unid. dolphin	39	19	46	104
Bottlenose dolphin	18	23	48	89
Atlantic spotted dolphin	27	10	28	65
Sperm whale	16	21	12	49
Pygmy/Dwarf sperm whale	0	40	2	42
Pilot whales	8	7	14	29
unid. small whale	1	21	2	24
Risso's dolphin	2	6	10	18
Unid. Ziphiid	2	10	4	16
Bottlenose/Spotted dolphin	3	5	6	14
unid. large whale	10	3	0	13
Stenella sp.	3	0	9	12
Unid. Mesoplondant	0	10	2	12
unid. odontocete	1	7	1	9
Bottlenose dolphin + Pilot whales	5	0	2	7
Cuvier's beaked whale	0	2	5	7
Fin whale	3	1	2	6
Unid. Baleen Whale	4	0	0	4
Blainville's beaked whale	0	3	0	3
Dwarf sperm whale	0	3	0	3
Rough-toothed dolphin	0	0	3	3
Pantropical spotted dolphin	0	3	0	3
Striped dolphin	0	2	0	2
Pygmy sperm whale	0	2	0	2
Clymene dolphin	1	1	0	2
Fin whale + Humpback whale	1	0	0	1
Bottlenose dolphin + Fin whale	0	0	1	1
Bottlenose dolphin + Atlantic spotted dolphin	0	0	1	1
Atlantic spotted dolphin + Bottlenose dolphin	0	1	0	1
unid. Odontocete + unid. large whale	1	0	0	1
Bottlenose dolphin + Risso's dolphin	0	0	1	1
Common dolphin	1	0	0	1
Atlantic spotted dolphin + unid. Dolphin	0	0	1	1
Northern right whale	1	0	0	1
Grand Total	147	200	200	547

Table C4. **Cetacean biopsies (*n* = 39) collected during GU-13-04.**

Species	Leg 1	Leg 2	Leg 3	Total
Bottlenose dolphin	3	3	13	19
Atlantic spotted dolphin	7	2	8	17
Clymene dolphin	0	1	0	1
Pantropical Spotted dolphin	0	1	0	1
Rough-toothed dolphin	0	0	1	1
Survey Total	10	7	22	39

Table C5. Bird sightings recorded during GU-13-04.

Abbreviation	Name	Number
AMRE	American redstart	1
AUSH	Audubon shearwater	323
BARS	Barn swallow	11
BBPL	Black bellied plover	3
BCPE	Black-capped petrel	154
BEPE	Brown pelican	1
BHCO	Brown-headed cowbird	1
BLTE	Black tern	16
BRTE	Bridled tern	14
BSTP	Band-rumped storm petrel	157
BTBW	Black throated blue warbler	1
BWTE	Blue-winged teal	16
CLSW	Cliff swallow	1
CONI	Common nighthawk	2
COSH	Cory's shearwater	1113
COTE	Common tern	12
GRSH	Great shearwater	25
GRYE	Greater yellowlegs	1
LESA	Least sandpiper	5
LESP	Leach's storm-petrel	6
LETE	Least tern	1
LEYE	Lesser yellowlegs	13
LTJA	Long-tailed Jaeger	1
MASH	Manx shearwater	6
NOWA	Northern waterthrush	1
OROR	Orchard oriole	1
PASS	Passerine	2
PESA	Pectoral sandpiper	10
POJA	Pomarine jaeger	4
PRAW	Prairie warbler	1
RBTR	Red-billed tropic bird	1
RNPH	Red-necked phalarope	5
ROYT	Royal tern	20
RUTU	Ruddy turnstone	7
SATE	Sandwich tern	1
SBDO	Short-billed dowitcher	1
SEPL	Semipalmated plover	4
SESA	Semipalmated sandpiper	7

SHOR	Shorebird	7
SNEG	Snowy egret	2
SOTE	Sooty tern	29
TRPE	Herald petrel	34
UNLS	Unidentified large shearwater	1
UNPE	Unidentified petrel	1
UNSH	Unidentified shearwater	244
UNSP	Unidentified storm petrel	32
UNSS	Unidentified small shearwater	1
UNTE	Unidentified tern	14
UNTR	Unidentified tropicbird	2
WFSP	White-faced storm petrel	1
WHIM	Whimbrel	2
WILL	Willet	1
WISP	Wilson's storm petrel	198
WTTR	While-tailed tropicbird	22
YBCH	Yellow-breasted chat	1
Total		2,540

Figure C1. Tracklines showing survey effort during GU-13-04. Shaded areas are being considered for offshore wind energy development over the continental shelf off of Virginia, North Carolina, and South Carolina.

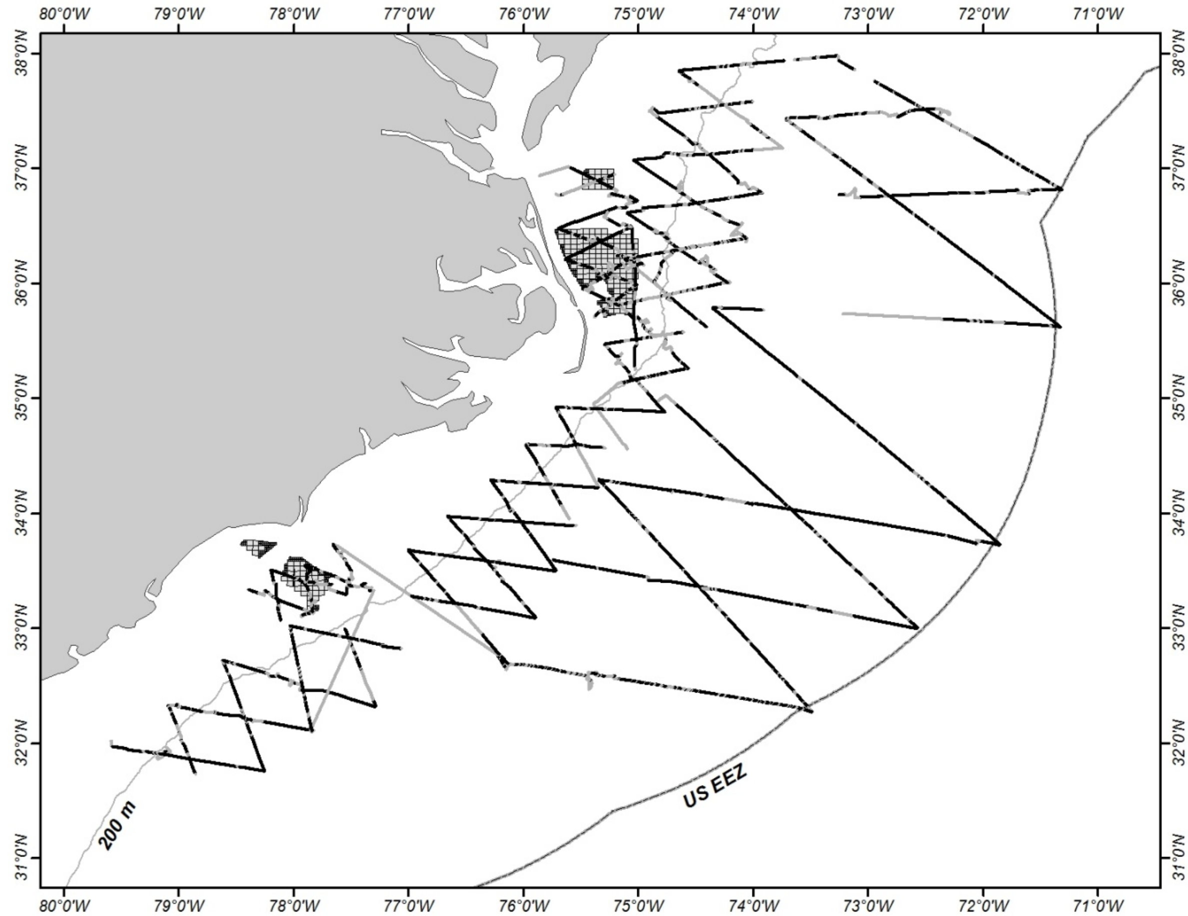


Figure C2. Locations of all marine mammal sightings during GU-13-04.

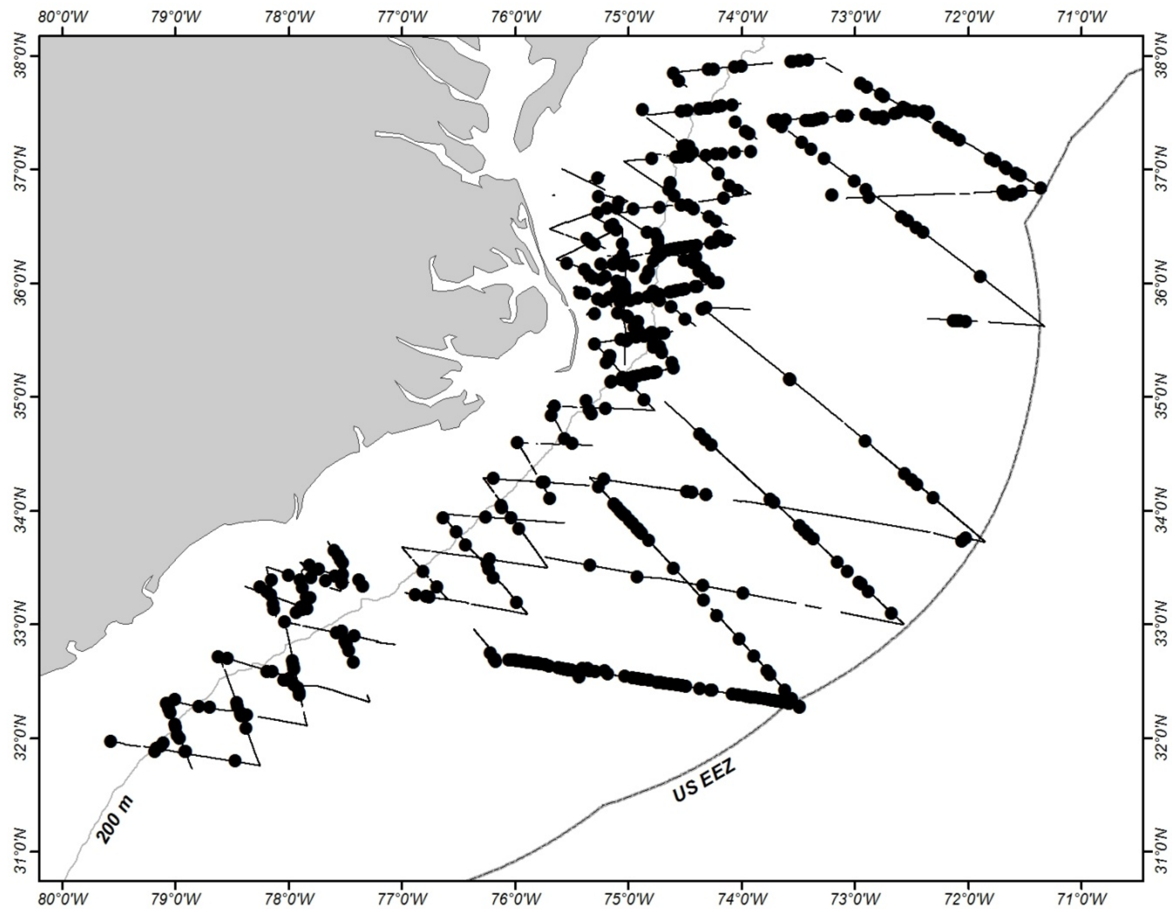


Figure C3. Locations of large whale and beaked whale sightings during GU-13-04.

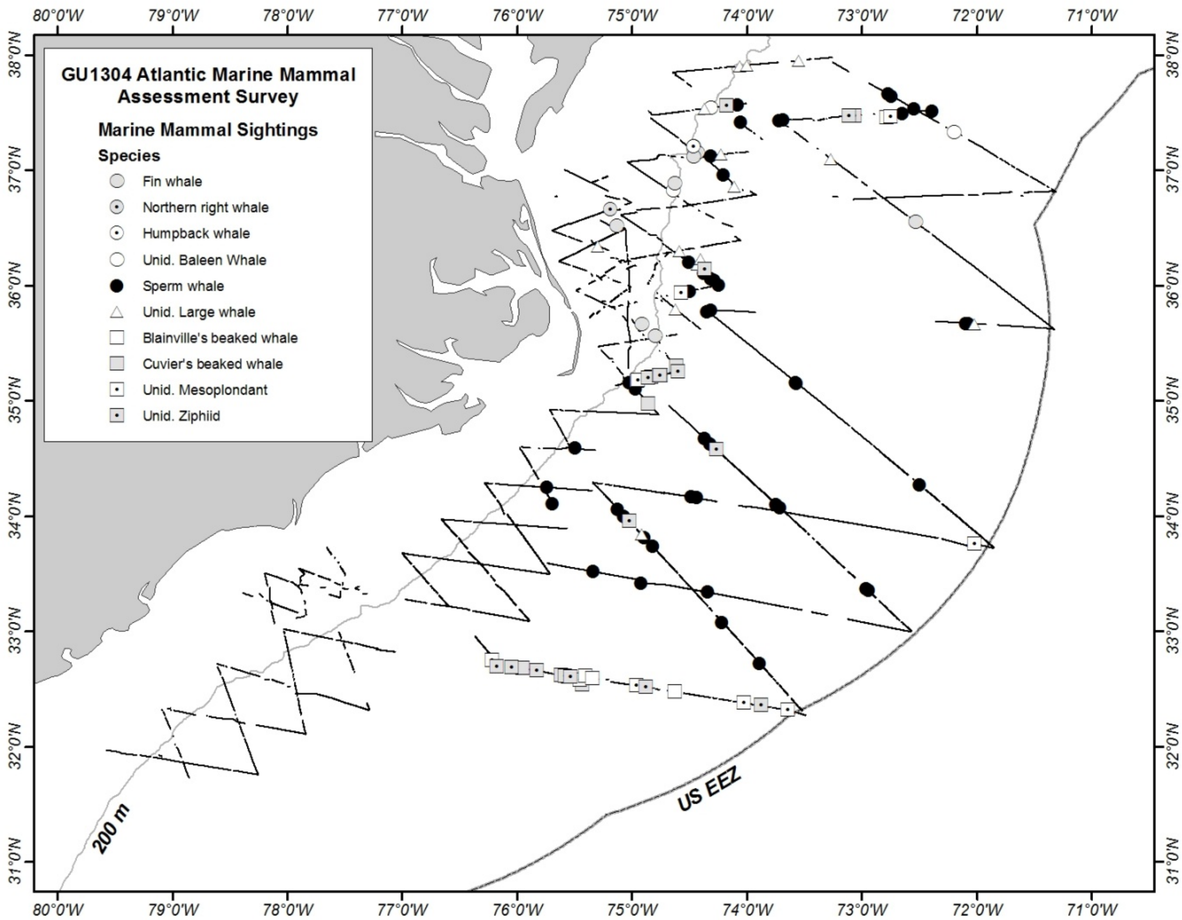


Figure C4. Locations of small whale sightings during GU-13-04.

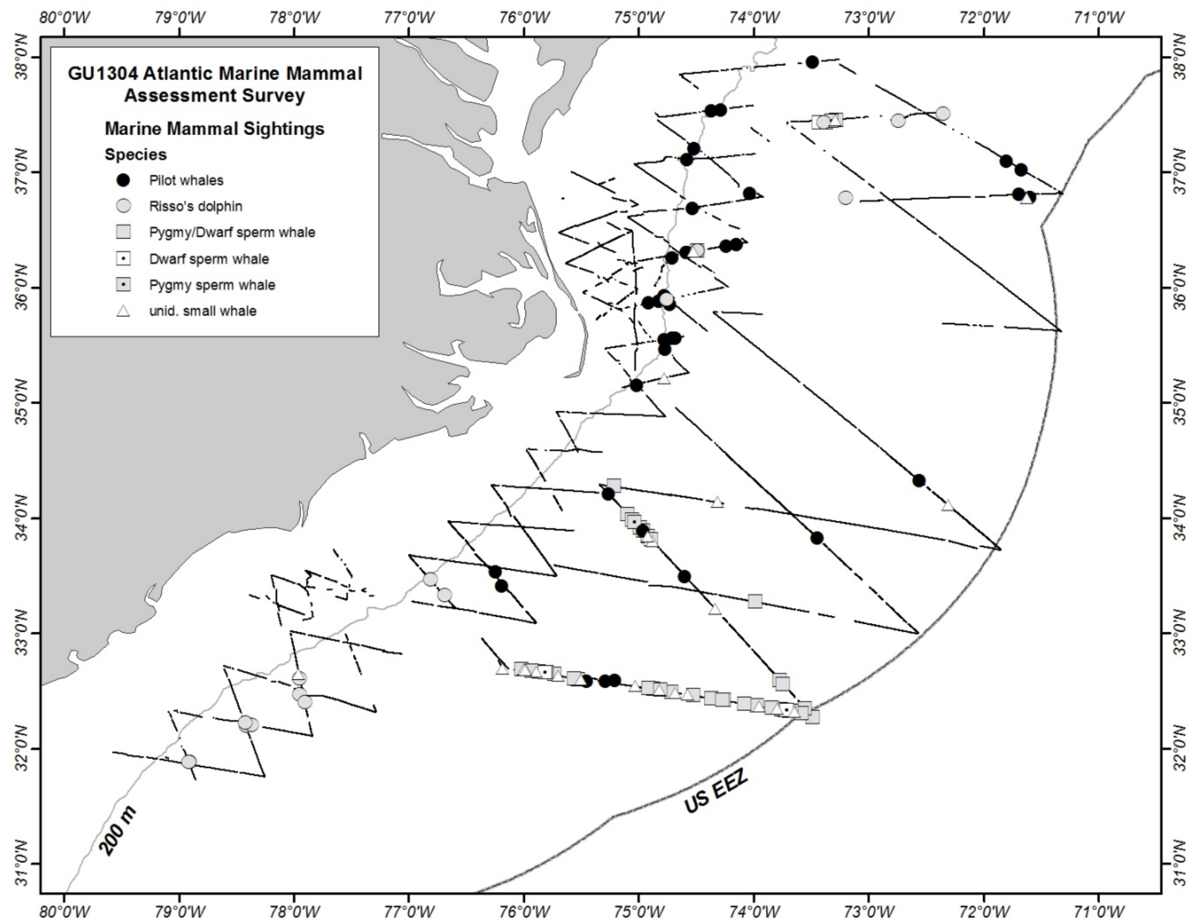


Figure C5. Locations of dolphin sightings during GU-13-04.

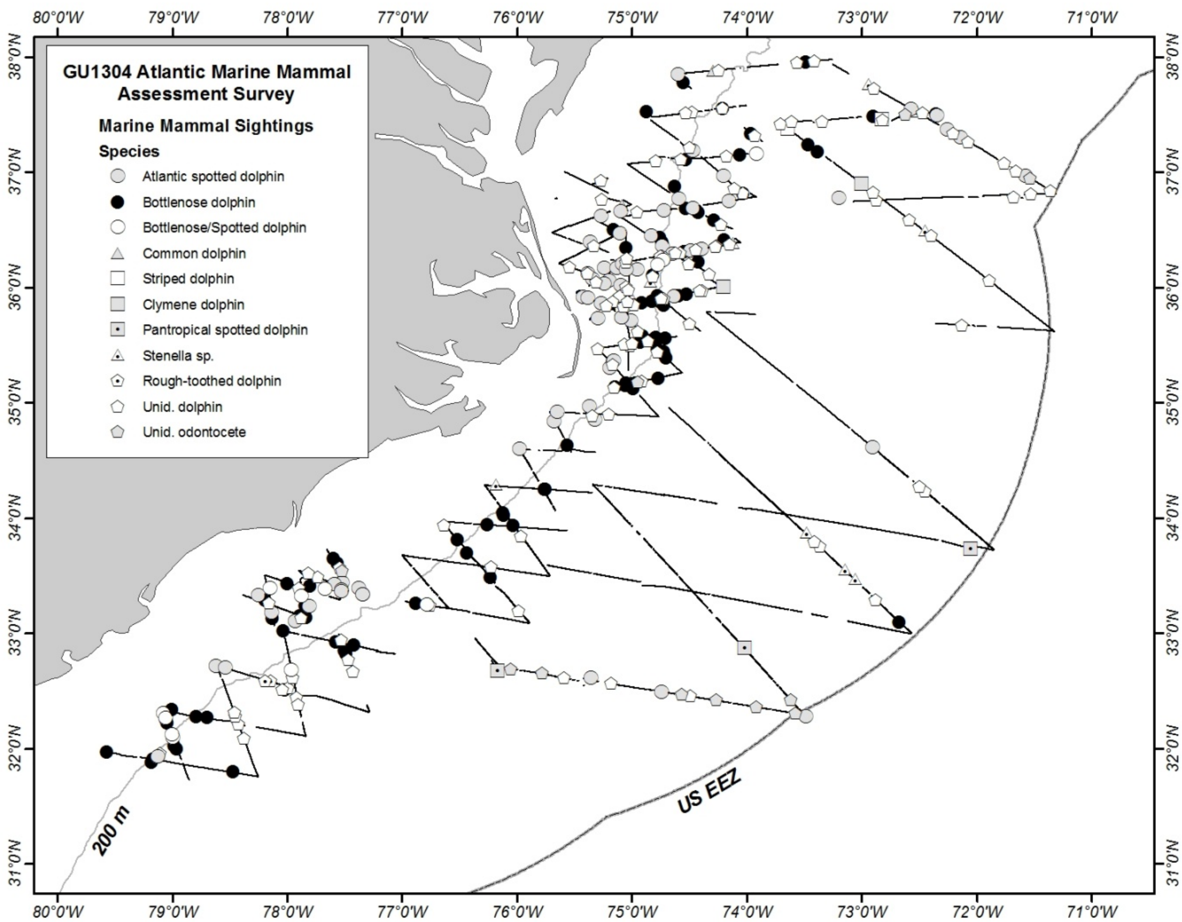


Figure C6. Location of sea turtle sightings during GU-13-04.

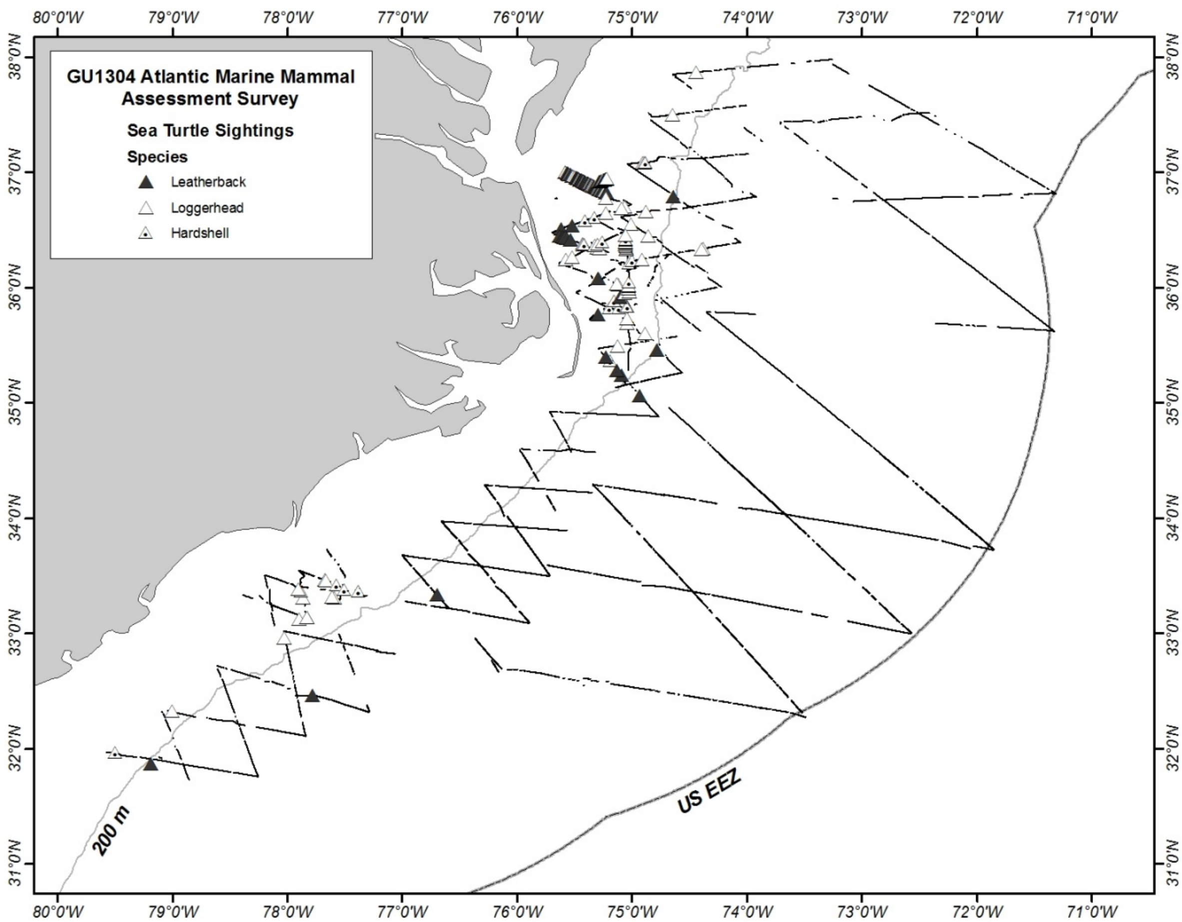


Figure C7. Fish sightings during GU-13-04.

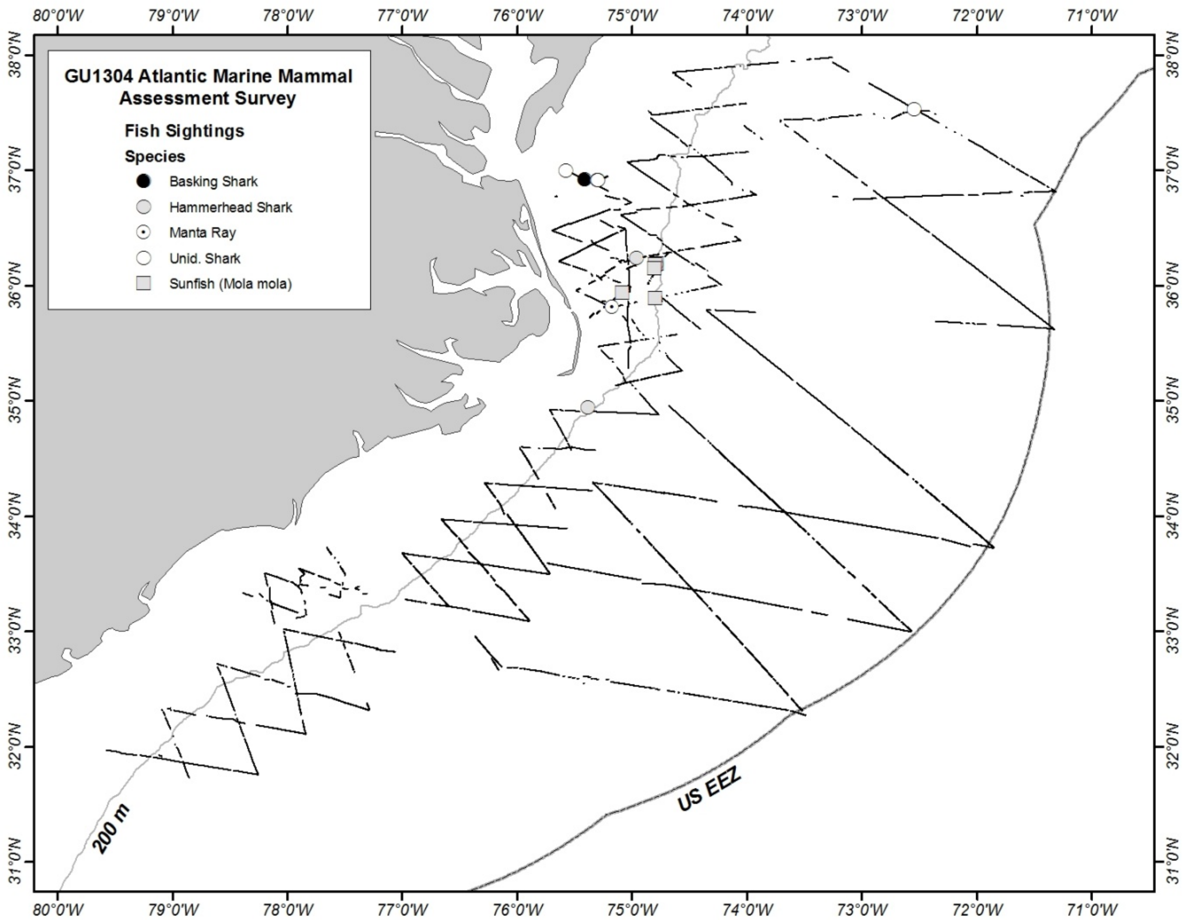


Figure C8. Location and type of *Sargassum* patches observed during GU-13-04.

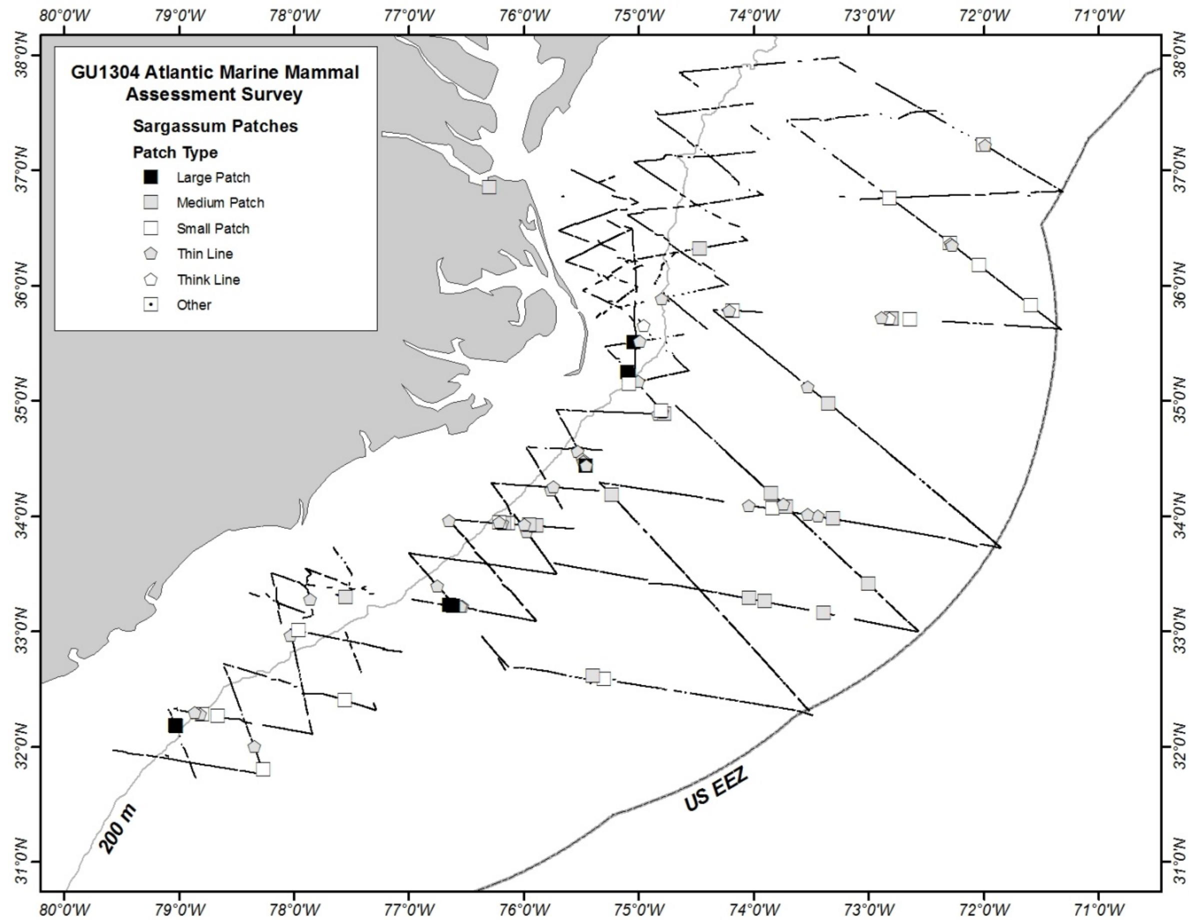


Figure C9. Passive acoustic effort and detections during GU-13-04.

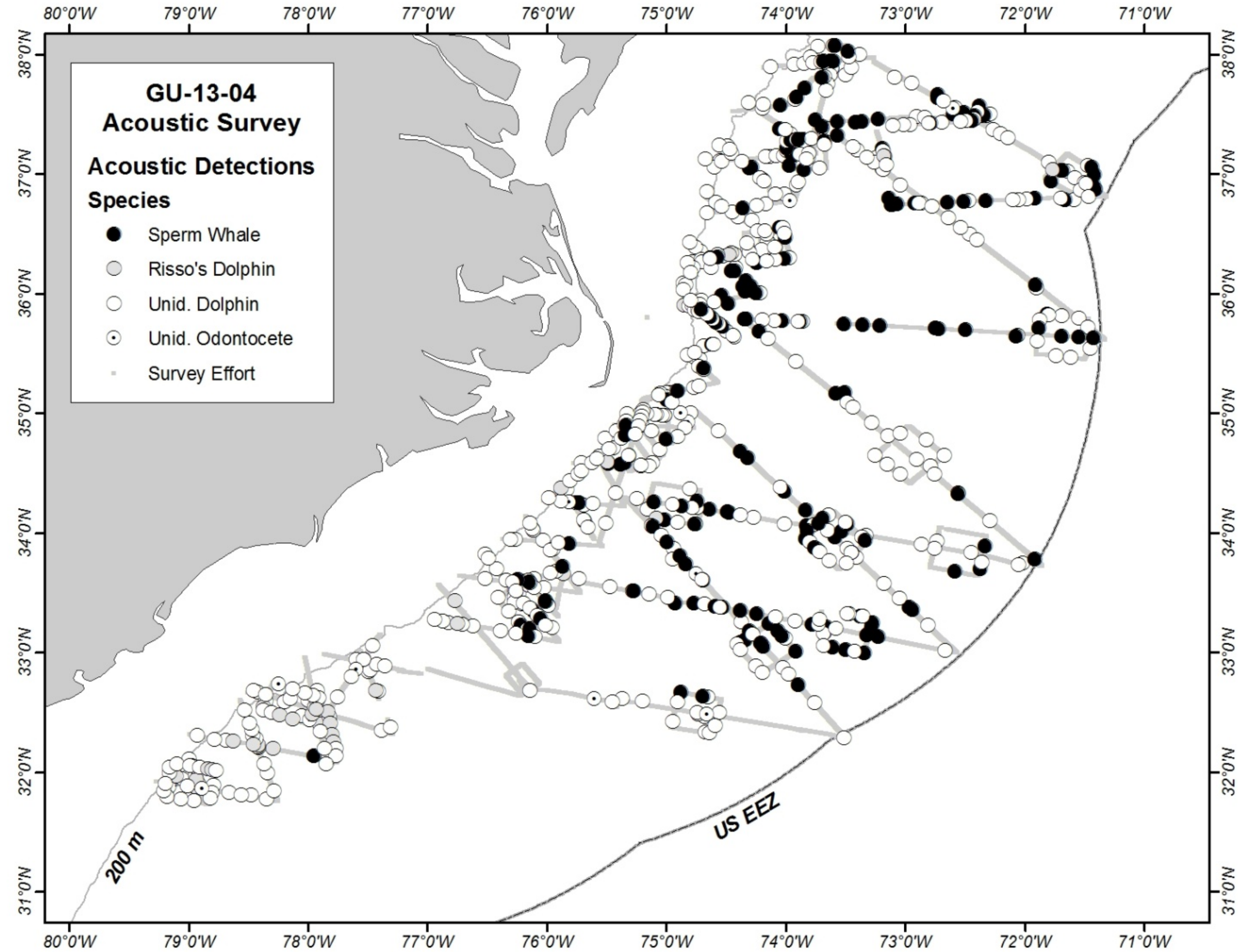


Figure C10. Locations of biopsy samples collected during GU-13-04.

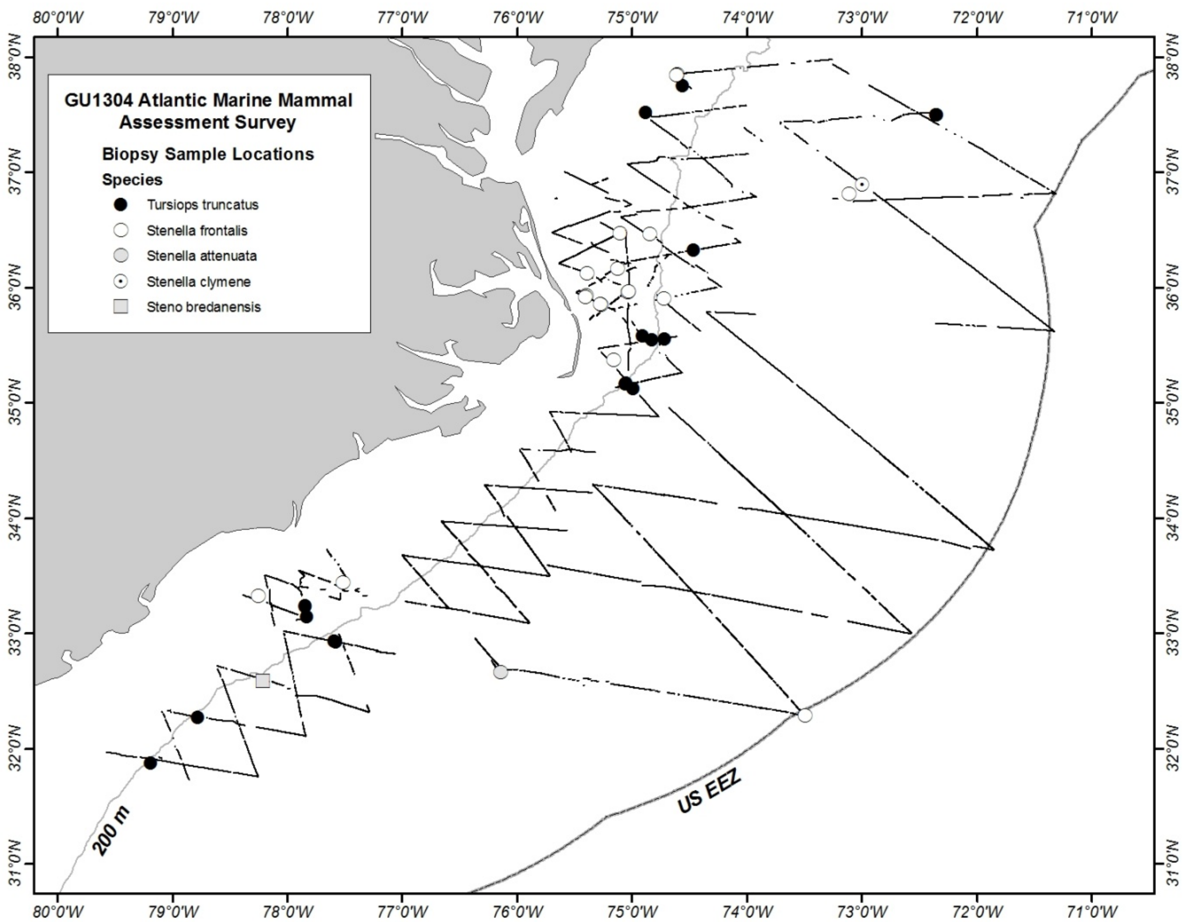


Figure C11. Locations of CTD and XBT stations during GU-13-04.

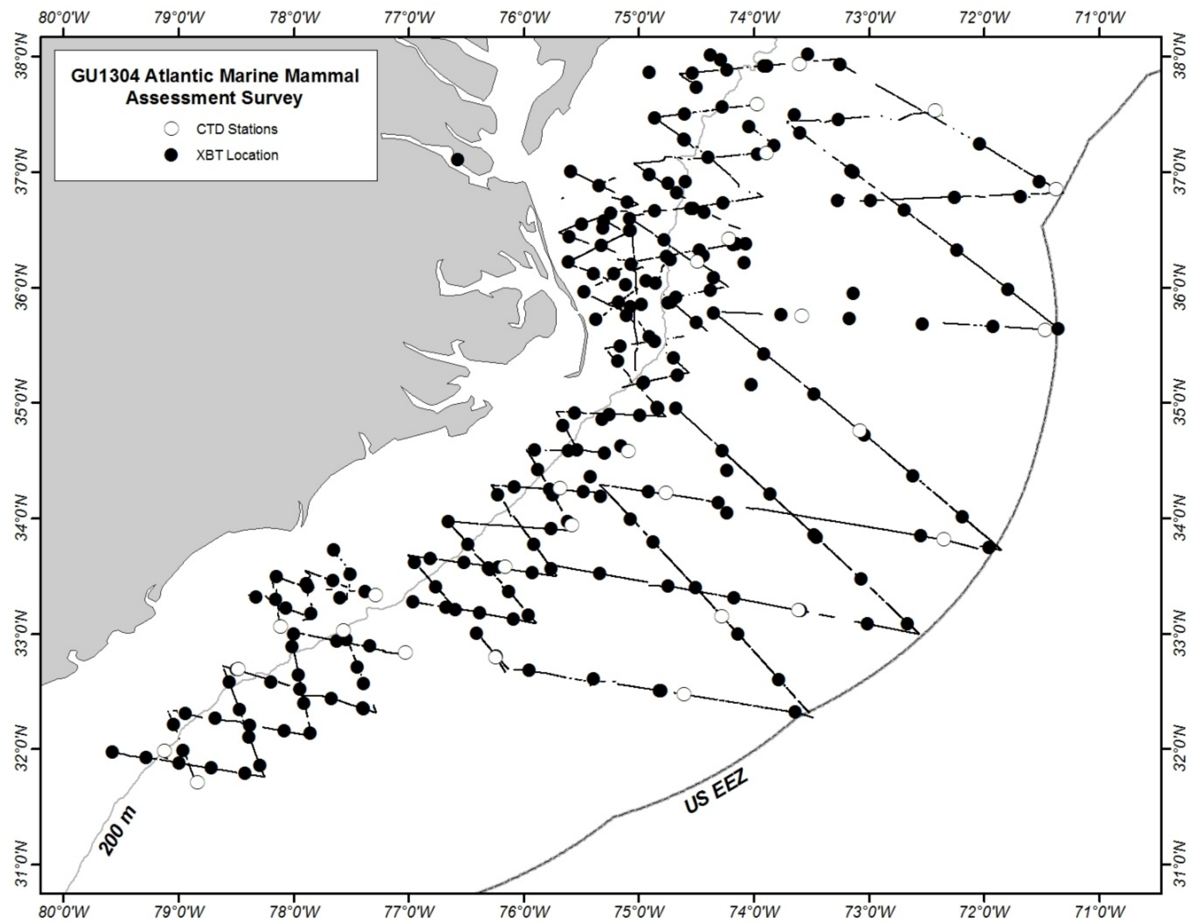
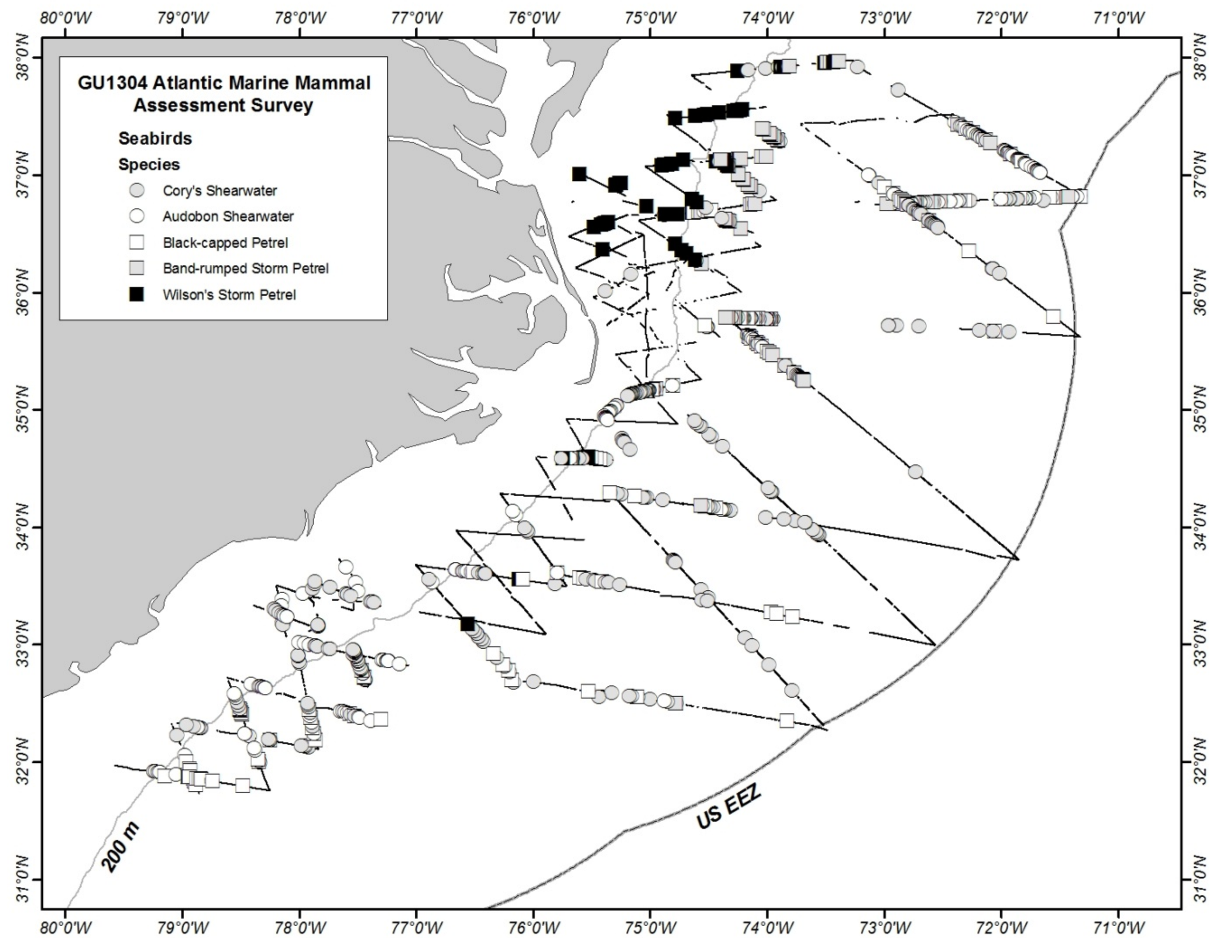


Figure C12. Locations of sightings of the most common seabird species encountered during GU-13-04.



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

Heather Haas[1], Ron Smolowitz[2], Susan Barco[3]

[1] **Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543**
[2] **Coonamessett Farm Foundation, 277 Hatchville Rd., E. Falmouth, MA 02536**
[3] **Virginia Aquarium Marine Mammal Center, 717 General Booth Blvd., Virginia Beach, Virginia 23451**

SUMMARY

The United States Mid-Atlantic region is an important foraging ground for loggerhead sea turtles (*Caretta caretta*), but relatively little is known about the turtles in this region due to complications involved with locating and capturing the immature turtles on their offshore (> 20 statute miles from the COLREGS lines) and near shore (from 2 – 20 statute miles from the COLREGs) foraging grounds. In May 2013 in partnership with AMAPPS, the Northeast Fisheries Science Center (NEFSC), Coonamessett Farm Foundation (CFF) and Virginia Aquarium & Marine Science Center (VAQ) deployed 20 satellite tags on loggerhead sea turtles captured in offshore and near shore Mid-Atlantic waters. Also in 2013, collaborative analytical work began to develop spatially and temporally explicit estimates of availability of loggerhead sea turtles.

OBJECTIVES

Because the vast majority of funding for 2013 field work was from non-AMAPPS sources, the primary objectives were to accomplish goals related to other funding sources. Through close coordination, we were also able to simultaneously address the following AMAPPS objectives: 1) collect telemetry data from loggerhead turtles in multiple years and strata; 2) begin to develop spatially and temporally explicit estimates of availability of loggerhead sea turtles.

CRUISE PERIOD AND AREA

On the evening of 20 May 2013 the F/Vs *Kathy Ann* and *Ms. Manya* (commercial scallop fishing vessels) departed from Barnegat Light, NJ for a five-day cruise with 10 scientific crew and 7 vessel crew to locate loggerheads in an area known to have overlap between large, immature and adult loggerheads and commercial fishing activity (primarily 40 – 80 statute miles offshore of Delaware through Virginia).

METHODS

The Coonamessett Farm Foundation (CFF) and Virginia Aquarium & Marine Science Center (VAQ), with the assistance of Viking Village Fisheries partnered together with the Northeast Fisheries Science Center (NEFSC) to accomplish AMAPPS goals. CFF contributed 10 satellite tags, ARGOS time, the primary vessel, crew, and several at-sea scientific staff. VAQ provided an offshore research vessel, 10 satellite tags, supplies, and one at-sea scientific staff. The VAQ contribution was partially funded with 2012 AMAPPS funds including 6 satellite tags (PTT 117169, 118902, 118902, 118903, 118904, 118905, and 11890) and associated costs including ship time, supplies, and ARGOS fees. The NEFSC used AMAPPS and NEFSC funds to provide staff and supplies.

These partnerships allowed us to pool resources to efficiently pursue shared and compatible goals. AMAPPS objectives are being met through collaborative research, and although researchers are currently sharing data, it is important to note that individual researchers retain the rights to their data. We also collaborated with the seal AMAPPS project by transferring one tag (PTT 118901) to them.

When loggerhead turtles were located, we deployed small boats (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 Sea Mammal Research Unit's (SMRU) Fastloc GPS Satellite Relay Data Loggers (SRDLs) or a Wildlife Computer SRDL to a central carapace scute of each captured turtle.

In 2013, 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 VAQ nearshore SMRU Fastloc GPS Satellite Relay Data Loggers (SRDLs) are provided in Appendix D1. This year CFF deployed 2 solar tags which theoretically are capable of transmitting more high-quality GPS locations. 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.

RESULTS

FIELD DATA

Cruise participants on the F/V *Kathy Ann* included Captain Michael Francis, Cory Karch, Thomas Walters, Ron Smolowitz, Henry Milliken, Heather Haas, Kat Goetting, Marcia Thomas, and Kathryn Sobczyk. Cruise participants on the F/V *Ms. Manya* included: Captain Peter Dolan, George West, Patrick Massimiano, Russell Baldwin, Susan Barco, Betty Lentell, Raymond Hines, and Eric Matzen.

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 January 2014 it contains about 840K uplinks, 264K ARGOS location records, 112K GPS location records, 28K temperature-depth casts, 165K dive records, and 80K summarized records of surface availability. Accumulated location information from 2010 through January 2014 from the NEC, CFF, and VAQ tags are shown in Figure D1.

ANALYTICAL PLANS

The first analytic product from the collaborative loggerhead tagging database will be a spatially and temporally explicit estimate of availability of loggerhead sea turtles to aerial surveys. Northeast data have been combined with data from the SEFSC and relevant environmental variables have been appended. Data have been shared with CREEM (Centre for Research into Ecological and Environmental Modelling at the University of St Andrews) who has been contracted by the Naval Facilities Engineering Command (NAVFAC) to lead analysis of the data.

DISPOSITION OF DATA

Data from all SMRU tags are stored in an Oracle database maintained by the NEFSC. To view the locations of the 2012 and 2013 tagged turtles see: http://www.nefsc.noaa.gov/psb/turtles/turtleTracks.html.

PERMITS

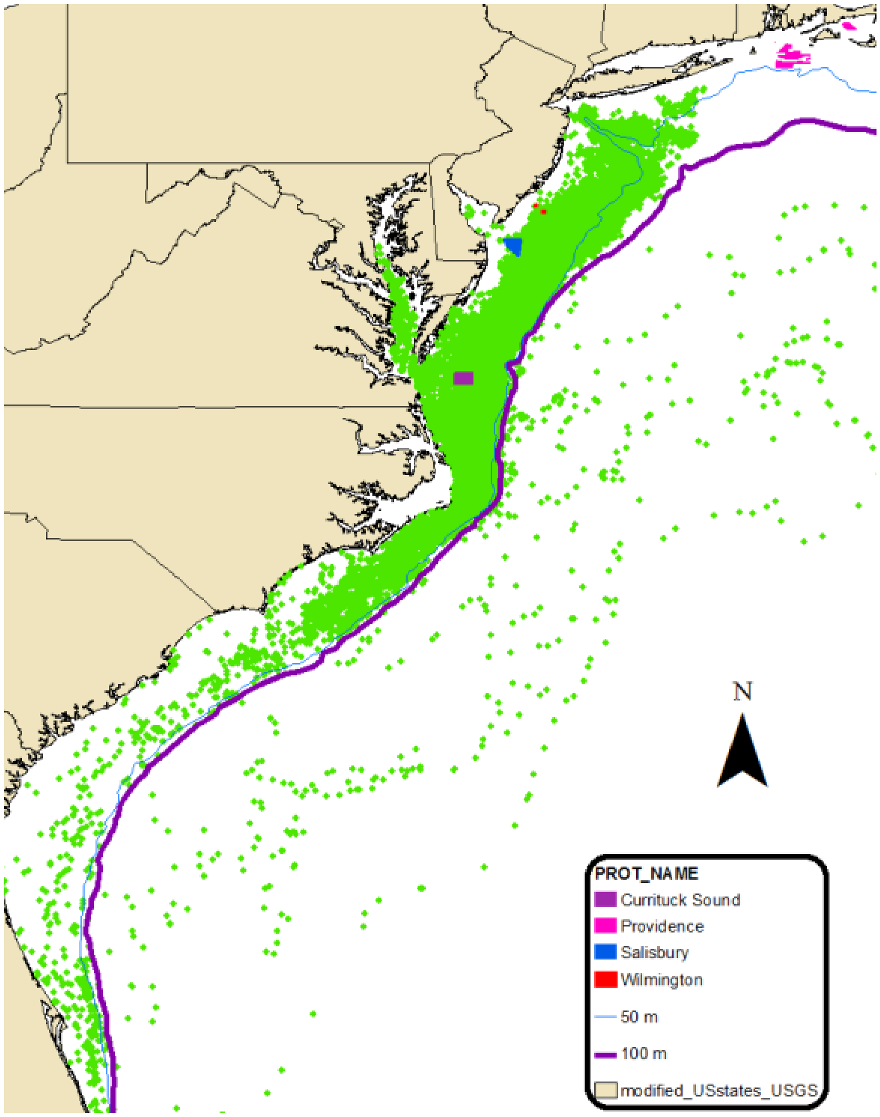
Both the VAQ and CFF primarily operated under their own ESA permits, except that the VAQ tagged one turtle (PTT 118902, CCL=58 cm) which was handled and sampled under the NEFSC permit # 16556 which allows tags to be deployed on smaller turtles.

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.

We thank James Gutowski of Viking Village Fisheries and the captains, crew and scientists on the F/Vs *Kathy Ann* and *Ms. Manya* for their expert field work; Jon O'Neil for his work managing the Oracle database; and Beth Josephson for making and maintaining an interactive webpage to show the turtle tracks.

Figure D1. Filtered locations from AMAPPS, Coonamessett Farm Foundation, and Virginia Aquarium satellite tags deployed on loggerheads since 2009. Four BOEM wind energy areas, and the 50 and 100 m depth contours are shown for reference.



Appendix D1: SMRU Tag Specifications

Software specification for FA_11A deployment Loggerhead GPS Argos)

Valid for dates in years 2011 to 2014
Transmitting via ARGOS
Page transmission sequences:
  Until day 120: 0 1 2 1 3 4 1 2 3 0 1 2 3 0 1 2 3 1 3 1
  Until day 200: 0 1 3 1 3 4 1 3 1 3 0 1 3 0 3 1 3 1 3 1
  Until day 1464: 0 1 4 1 0 1 1 0 1 1 0 1 4 1 0 1 1 0 1 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: -* off *-
  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:

50000 transmissions after 200 days
70000 transmissions after 365 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.
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: 5000 (then increase interval to 0x normal)
Cut-off date for GPS attempts: 120 days (then increase interval to 0x normal)
Discard results with fewer than 5 satellites
Processing timeout: 30 secs
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: 63.8889 days if interval is 20 mins): 4600 = 18400 bytes
No Spot CTD's

TOTAL 20800 bytes (of about 21000 available)

MAIN BUFFERS (in 8 or 24 Mb Flash):
Dive in groups of 2 (208.333 days @ 10mins/dive): 15000 x 96 bytes = 1440000 bytes
No 'deep' dives
Haulout: 1000 x 16 bytes = 16000 bytes
6-hour summaries in groups of 1 (500 days): 2000 x 52 bytes = 104000 bytes
6-hour Depth & Temperature histograms in groups of 1 (500 days): 2000 x 24 bytes = 48000 bytes
No timelines
No cruises
No diving periods
No spot depths
No emergence records
No Duration histograms
No Max depth histograms
CTD casts (333.333 days): 2000 x 60 bytes = 120000 bytes
GPS fixes (variable: 70.8333 days if interval is 20 mins): 5100 x 120 bytes = 612000 bytes
No spot CTD's

TOTAL 2285 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)
Sell-by range: 7 days 6 hours
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 14 days 23 hours)
Sell-by range: 15 days
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 14 days 23 hours)
Sell-by range: 15 days
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)
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)
Sell-by range: 21 days
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)
Sell-by range: 2 days 21 hours
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:

Wettest (min wet/dry): raw 7 bits in units of 2 (range: 0 to 254)
Driest (max wet/dry): raw 8 bits in units of 1 (range: 0 to 255)
GPS zero satellites: wraparound 11 bits in units of 1 (range: 0 to 2047)
GPS 1-4 satellites: wraparound 10 bits in units of 1 (range: 0 to 1023)
GPS 5 or more satellites: wraparound 12 bits in units of 1 (range: 0 to 4095)
GPS reboots: wraparound 2 bits in units of 1 (range: 0 to 3)
-----------[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 192 days @ 1 sec= 16588800
tx as raw 24 bits in units of 1 (range: 0 to 1.67772e+07)
(recommended sell-by 191 days 23 hours)
Sell-by range: 190 days
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)
-----------[192 bits: 11 - 202]

DIAGNOSTICS in format 2:

Tag time (mm:ss): raw 11 bits in units of 2 secs (range: 0 to 4094 secs)
GPS zero satellites: wraparound 11 bits in units of 1 (range: 0 to 2047)
GPS 1-4 satellites: wraparound 10 bits in units of 1 (range: 0 to 1023)
GPS 5 or more satellites: wraparound 12 bits in units of 1 (range: 0 to 4095)
-----------[44 bits: 203 - 246]

Available bits used exactly
=== 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 7 hours)
Sell-by range: 7 days
CTD cast number: -- not transmitted --

Min pressure: -- not transmitted --
Max pressure: raw 8 bits in units of 1 dbar (range: 2 to 257 dbar)
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 oxy: -- not transmitted --
Max oxy: -- 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)
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)
Sell-by range: 21 days
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)
Current temperature: raw 16 bits in units of 0.001 (range: 0 to 65.535 = -5 to 60.535 °C in steps of 0.001 °C)
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)

-----------[234 bits: 11 - 244]

UNUSED

-----------[2 bits: 245 - 246]

=== End of page 5 ===

Appendix E: *Gray seal live capture, biological sampling, and electronic tagging in Chatham Harbor, June 2013: Northeast Fisheries Science Center*

Gordon T. Waring[1], Elizabeth Josephson,[2] Robert A. DiGiovanni Jr[3], and Jerry Moxley[4]

[1] Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2] Integrated Statistics, Inc, 172 Shearwater Way, Falmouth, MA 02540
[3] Riverhead Foundation for Marine Research and Preservation, 467 East Main St., Riverhead, NY 11901
[4] Duke University, Marine Geospatial Ecology Lab, 135 Duke Marine Lab Rd., Beaufort, NC

SUMMARY
As part of the AMAPSS program, a multi-agency team conducted the first non-pup gray seal (*Halichoerus grypus grypus*) live capture, tagging, and biological sampling in U.S. waters. This was conducted at Chatham Harbor, MA from 13 – 17 June 2013, which coincided with the end of the annual molt. Twenty-seven seals were captured, of which six escaped, five were intentionally released, fifteen were sampled, and one accidentally drowned in the capture net. A suite of biological measurements and samples (e.g., weight, lengths, girth, blood, hair, skin, blubber, tooth, whisker, and mucous swabs) were collected, as feasible, from the fifteen seals for various studies including: health assessment, diet, disease, age, and genetics. Numbered and labeled green Destron Feering[1] Goat Ear Tags were attached to the hind flippers of each seal. Nine good condition animals were selected for the following electronic tagging: Seven Sea Mammal Research Unit[1] (SMRU) GPS Cell Phone (GPS) Tags, one SMRU GPS Satellite Relay Data Logger (SRDL), and one Wildlife Computers[1] Smart Position or Temperature Transmitting (Spot) Tag. For several months the tagged animals remained within or adjacent to the capture region. One of the cell phone tagged seals died from a fatal shark bite and stranded in Chatham Harbor in early August. The remaining seals exhibited longer distance excursions to offshore waters, including one to Sable Island, and others used haul-out sites in eastern Nantucket Sound in late autumn, prior to the start of the December-February pupping and breeding period. At the end of December 2013 the SRDL was the first that ceased transmitting, presumably the first tag to be shed as opposed to the animal dying at sea. Two cell phone tags were still transmitting data in mid-March 2014 (J. Moxley, pers. comm., Duke University, 27 March 2014). Data processing is ongoing.

OBJECTIVES
The goals of this project were to:

1) Determine the feasibility of capturing, safely sedating, sampling and tagging non-pup gray seals on Cape Cod;
2) Successfully, tag and track animals over an extended time period to improve our knowledge and understanding of gray seal ecology in New England waters;
3) Expand external collaboration with universities, stranding responders, and government organizations, and identify journal publications.

---

[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.

METHODS

SITE SELECTION, TIMING, INCIDENT ACTION PLAN

Site selection and timing of the June 13-17 gray seal capture operations in Chatham Harbor were based on prior NEFSC experience capturing harbor seals off the dominant tidal sand bar, good daylight low tide cycle, expected completion date of the annual molt, and small boat operational logistics. A critical component for implementing the project was developing an Incident Action Plan (IAP) that fulfilled the requirements of collaborating organizations. For example, the IAP defined the capture, handling, monitoring, and sampling protocols, and lead personnel for the components (e.g., boat operators, staffing and assignments, and capture, disentanglement, sampling, tagging, sedation, etc protocols).

CAPTURE, SAMPLING AND TAGGING

Gray seal capture operations followed protocols used in prior NEFSC harbor seal efforts (Gilbert *et al.* 2005; Waring *et al.* 2006), which are similar to procedures followed in other regions (Jeffries *et al.* 1993; Withrow and Loughlin 1997; M. Hammill, pers. comm., Department of Fisheries and Oceans, Mont-Joli, Quebec, Canada). Seals were primarily captured by setting a nylon twine research gillnet (100 x 7.4 m) off southeastern end of the dominant tidal sand bar in Chatham Harbor, and secondarily by making circle sets around small groups of seals in shallow waters between the central sand bar and North Beach (Figure E1). Seals typically flee into the water at the approach of the set boat, and the goal was to entangle some seals in the net. Once entangled, researchers pulled the net onto the sand bar where seals were transferred and secured in pole nets (Figure E2). Once all seals were secured they were transferred by boat to the designated handling site (e.g., North Beach). Secured seals were weighted, transferred to a shade tent, and kept cool by using buckets of water. The net weight (i.e., without the tare weight) was used to estimate the volume of sedative required to sedate a seal for safe handling, sampling and tagging (Sharp *et al.*, in prep.). The intramuscular dose 100mg/mL tiletamine-zolazepam (TZ) in a 1:1 ratio (Telazol ®, Fort Dodge Animal Health, Fort Dodge, IA ranged from 0.58-0.8 mg/kg (0.70 mg/kg average) (Sharp *et al.*, in prep.). Following, sedation the full sampling and tagging protocol for most seals included: external examination, incisor tooth extraction, morphometrics, sex, age class, ultrasound, blood draw, blubber core biopsy, whisker and hair clipping, mucous swabs, electronic and flipper tagging, which provide skin samples. Animals were also fitted with a heart monitor and physiological parameters for each seal were recorded every five min after arrival at the work site and were comprised of: heart rate (per min, evaluated per auscultation when possible or per observation of apex beat when restrained in the net, respiration rate (per two-min), mucous membrane color (as feasible), rectal temperature and airway patency. The complete sampling protocol, however was not conducted for each animal due to logistics, animal activity level, or presence of preexisting entanglement wounds. The cell phone and satellite tags were attached to the head pelage using 5-min epoxy (Fedak *et al.* 1983). Numbered and labeled flipper tags (Destron Fearing Goat Tags) were attached to one hind flipper of each seal. At completion of sampling, seals were left undisturbed and monitored until they fully recovered from sedation. At this stage, the seals left alone and they entered the water on their own volition.

RESULTS

Scientists from 15 difference organizations participated in this project (Table E1).

CAPTURE, HANDLING, AND SAMPLING

Of the twenty-seven seals that were captured, six escaped, five were released prior to handling, and sixteen were retained for sampling, of which, 9 (6 female, 3 male) were selected for electronic tagging (Table E2). However, one of the sixteen seals accidently drowned in the net and was transferred to Woods Hole for necropsy. Tissue samples (e.g., tooth, blood, skin, hair, blubber, mucous membranes) were collected for multiple research requests as well as for archival, but the full suite of samples were not collected from each seal based on sample size requests and/or animal condition. For example, a blubber biopsy core was not taken from an animal that appeared to be stressed.

TRACKING

Cell phone data from the seven GPS tagged seals are being processed at Duke University (J. Moxley, pers. comm.). Since July, monthly updates for each animal were distributed to the June 2013 seal team. Monthly data, however, may not include all individuals, as some will be at-sea or not hauled out in areas lacking cell coverage. PSB has monitored the movements of the SRDL and SPOT tagged seals. In the beginning of January and February 2014, respectively transmissions from the SRDL and SPOT tags ceased, and by mid-February only four of the GPS tagged seals were still transmitting. The latter four tags are expected to be shed during the molt.
The following summary is based on data from all tags. From July to early September 2013, most animals remained near Chatham Harbor, including some excursions to the adjacent Monomoy National Wildlife Refuge (MNWR) (Figures E3 and E4), One animal traveled north to the tip of Cape Cod, another appeared to have made a round trip to Noman's Land (Figure E4). The apparent site fidelity to Chatham was still evident by 20 September 2013 (Figure E5), but one animal relocated to Muskeget Island. In addition, in early August 2013 one animal was found dead in Chatham, MA with a shark attack as the cause of death. From mid-June to early October 2013, the two adult female (Table E1) satellite tagged animals exhibited movement patters similar to the GPS tagged seals (Figure E6). Through the end of October 2013 five GPS tagged seals remained in coastal waters along the Cape, with three of the animals moving north of Chatham (Figure E7). From late October to 20 November, 2013 all GPS individuals began moving into new areas, including waters south of Martha's Vineyard and into the Great South Channel (Figure E8). The use of these waters increased from late November to mid-December 2013 (Figure E9). Similarly, the two satellite tagged seals move into Nantucket Sound, including use of Muskeget Island and waters south of Nantucket during the early October to 29 December 2013 period (Figure E10). Mid-December also marks the start of the two-month pupping season on Muskeget Island (Wood *et al.* 2002). From mid December 2013 to early January 2014 two adult GPS tagged females moved directly to Muskeget Island and remained there for the monthly reporting period. Two adult males continued offshore trips to the Great South Channel, a third spent the entire period on Nomans Land Island (Figure E11). The fourth male traveled to Sable Island, Nova Scotia and back. The SDLR and SPOT tagged seals, respectively stopped transmitting on 8 January and 11 February 2014. In both cases this occurred after each female

spent 15 days on Muskeget Island, presumably for pupping, nursing and breeding. Habitat use by the SDLR tagged animal were similar to the prior summary period – (Figures E10 and E12). Whereas, the SPOT tagged seal used both offshore waters SE of Nantucket and also made an excursion to Nomans Land (Figure X=E12). Between 25 January 2014 and 21 February 2014, two animals were making extended trips offshore while the other two remained in coastal waters (Figure E13). The time period 18 February – 7 March 2014 included five tagged animals, but tag#12397 stopped transmitting after 20 February 2014. The four remaining tagged animals were making extended trips offshore (Figure E14). In March 2014, two of the four tags transmitted during the first ten days, and then stopped transmitting. The second two tags transmitted in mid March 2014 (18th and 23rd), and also then stopped transmitting.

DISCUSSION

The success of the first non-pup gray seal live capture, biological sampling, and electronic tagging in U.S. waters was clearly demonstrated which shows 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.

The use of chemical sedation to safely handle, collect tissue samples, and tag wild caught phocid seals, and to rescue animals that respond negatively to sedation has received wide attention (Haulena and Gulland 2001; Haulena and Heath 2001; Kuhn 2006; Reichmuth *et al.* 2007; Wheatley *et al.* 2006). The physiological response to sedation by animals in this project, and successful rescue of one seal from prolonged apnea will be reported in "The effects of tiletamine/zolazepam sedation in healthy wild gray seals (*Halichoerus grypus*)," Sharp *et al*. (in progress).

Preliminary analysis of the electronic tagging data provided new insight on the ecology of gray seals occupying Cape Cod waters. The data suggest strong site fidelity to Cape Cod waters from summer through late autumn, then movement into Nantucket Sound and adjacent waters, with some trips to offshore waters east/southeast of Nantucket during the pupping/breeding period (about mid-December to early February). Subsequently, some animals were making extended excursions to offshore waters, including one animal that make a round-trip to Sable Island, Nova Scotia. Gray seal movements between Sable Island to Cape Cod waters have previously been documented by Sable Island marked seals (e.g., brands, electronic tags) and genetics (Wood *et al.* 2002; Wood LaFond 2009; Wood *et al.* 2011; Rough 1995; NMFS unpublished data). Interestingly, the tagged seals did not move into more northern Gulf of Maine waters, including hauling out at pupping colonies along the mid-coast and Downeast Maine. This may reflect site fidelity to natal pupping sites or linked to other unknown ecological factors. But, it supports the need to expand live capture and electronic tagging sites in New England waters.

Based on the tag data, the two satellite tagged adult females seals (Table E1) spent approximately 15 days on Muskeget Island between the 3rd week in December 2013 to early January 2014, presumably for pupping, then dispersed. Seals #150 and #152, respectively moved to waters off Chatham and southeast of Nantucket where their transmissions ended. The causes of transmission loss for these two seals and several of the cell phone tags prior to the presumed start of the annual molt are unknown. However, based on visual observations of breeding behavior of non-tagged seals, it is feasible that the tags were loosened from the pelage prior to departed the beach.

Analysis of the GPS cell phone tags (Duke) and GPS satellite tag (NEFSC) is underway. One aspect of the analysis is a comparison of the data sets obtained by the two types of GPS to assist NEFSC in evaluating which tag or combination of tags to use in future work. Further, this study also identified the need for a multi-year capture/sample/tagging at multiple sites in New England waters.

DISPOSITION OF THE DATA

Electronic versions of the capture and samplings logs and GPS satellite tag are archived at NEFSC. Tracks of the NEFSC GPS satellite tag are posted at: http://www.nefsc.noaa.gov/psb/seals/GraySealCapture2013.html. Data and tracks for the Wheelock College satellite tag "Gracie" is posted at http://whale.wheelock.edu/whalenet-stuff/stop_cover.html. Data and tracks for the GPS cell phone tags are archived at Duke, contact: Jerry Moxley (jhm15@duke.edu).

PERMITS

NEFSC was authorized to conduct seal research activities during the study under Permit No. 17670 issued to the NEFSC by the NMFS Office of Protected Resources. NEFSC was also issued a National Park Service (NPS) Special Use Permit #CACO-2013-SCI-0015 to conduct the research activities on Cape Cod National Seashore Property - (i.e., capture - tagging work).

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through two Interagency Agreements for the AMAPPS project. We would like to thank the NMFS National Marine Mammal Health and Stranding Response Program for providing biological sampling supplies and Cape Cod National Seashore for providing a boat and personnel to assist with capture and animal monitoring, and public outreach.

REFERENCES CITED

Fedak, M., S. . Anderson, and M. . Curry 1983. Attachment of a radio tag to the fur of seals. J. Zool. Lond. 200:298–300.

Gilbert, J. R., G. T. Waring, K. M. Wynne, and N. Guldager 2005. Changes in abundance of harbor seals in Maine, 1981-2001. Mar. Mammal Sci. 21(3):519–535.

Haulena, M., and F. M. Gulland 2001. Use of medetomidine-zolazepam-tiletamine with and without atipamezole reversal to immobilize captive California sea lions. J. Wildl. Dis. 37(3):566.

Haulena, M., and R. B. Heath 2001. Marine mammal anesthesia, In: L.A. Dierauf and F.M.D. Gulland, eds. Marine Mammal Medicine. 2nd edition., pp. 655–688, CRC Press, Boca Raton, FL.

Jeffries, S., R. Brown, and J. Harvey 1993. Techniques for capturing, handling and marking harbor seals. Aquat. Mamm. 19:21–21.

Kuhn, C. E. 2006. Measuring at sea feeding to understand the foraging behavior of pinnipeds.

Reichmuth, C., J. Mulsow, J. J. Finneran, D. S. Houser, and A. Y. Supin 2007. Measurement and response characteristics of auditory brainstem responses in pinnipeds. Aquat. Mamm. 33(1):132.

Rough, V. 1995. Seals in Nantucket Sound, Massachusetts, winter and spring, 1994, Report to the Marine Mammal Commission. Contract T10155615.

Sharp, S. M. et al. In progress. The effects of tiletamine/zolazepam sedation in healthy wild gray seals (*Halichoerus grypus*).

Waring, G. T., J. R. Gilbert, J. Loftin, and N. Cabana 2006. Short-term movements of radio-tagged harbor seals in New England. Northeast. Nat. 13(1):1–14.

Wheatley, K. E., C. J. Bradshaw, R. G. Harcourt, L. S. Davis, and M. A. Hindell 2006. Chemical immobilization of adult female Weddell seals with tiletamine and zolazepam: effects of age, condition and stage of lactation. BMC Vet. Res. 2(1):8.

Withrow, D. E., and T. R. Loughlin 1997. A correction factor estimate for the proportion of harbor seals missed on sand bar haulouts during molt census surveys in 1996 near Cordova, Alaska. AFSC Process. Rep 97-10 Alsk. Fish Sci Cent Seattle WA Marine Mammal Protection Act and Endangered Species Act Implementation Program 1996:157–172.

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.

Wood, S. A., T. R. Frasier, B. A. McLeod, J. R. Gilbert, B. N. White, W. D. Bowen, M. O. Hammill, G. T. Waring, and S. Brault 2011. The genetics of recolonization: an analysis of the stock structure of grey seals (*Halichoerus grypus*) in the northwest Atlantic. Can. J. Zool. 89:490–497.

Wood, S., S. Brault, and J. Gilbert 2002. Aerial survey of grey seals in the Northeastern United States. Grey seals in the North Atlantic and Baltic. NAMMCO Sci. Publ. 6:117–121.

Table E1. Participants in the June 2013 gray seal live capture, sampling, and tagging project.

Name	Affiliation
Ashley Barratclough	Woods Hole Oceanographic Institution, Bio. Dept.
Holly Bayley	National Park Service, Cape Cod National Seashore
Andrea Bogomolni	University of Connecticut & Woods Hole Oceanographic Institution
Genevieve Davis	Integrated Statistics Inc, Woods Hole, MA
Robert DiGiovanni	Riverhead Foundation for Marine Research and Preservation
Lynda Doughty	Marine Mammals of Maine
Kim Durham	Riverhead Foundation for Marine Research and Preservation
Dana Flippini	National Park Service, Cape Cod National Seashore
Jean-Francois Gosselin	Department of Fisheries and Oceans, IML Mont-Joli, Quebec
Mike Hammill	Department of Fisheries and Oceans, IML Mont-Joli, Quebec
CT Harry	International Fund for Animal Welfare
David Johnston	Duke University
Beth Josephson	Integrated Statistics Inc, Woods Hole, MA
Betty Lentell	Woods Hole Oceanographic Institution, Biol. Dept.
Michael Moore	Woods Hole Oceanographic Institution, Bio. Dept
Jerry Moxley	Duke University
Misty Niemeyer	International Fund for Animal Welfare
Richard Pace	NOAA/NMFS/Northeast Fisheries Science Center
Mike Polito	Woods Hole Oceanographic Institution, Biology Dept.
Belinda Rubinstein	Bridgewater State University
Lisa Sette	Provincetown Center for Coastal Studies
Brian Sharp	International Fund for Animal Welfare
Sarah Sharp	International Fund for Animal Welfare
Ashley Simpson	University of New England
Gordon T. Waring	NOAA/NMFS/Northeast Fisheries Science Center
Fred Wenze1	NOAA/NMFS/Northeast Fisheries Science Center
Kenady Wilson	Duke University

Table E2. Summary of the June 2013 gray seal captures in Chatham Harbor.

Animal ID #	Electronic Tag ID	Date	Time from capture to release (h:mm)	Time from sedation to release (h:mm)	Age Class	Age	Sex	Weight (kg)	Std Length (cm)	Axillary Girth (cm)	Dorsal Axillary Fat (cm)	Lateral Axillary Fat (cm)	TZ Dose (mg/kg)	Level of Sedation	Comments
141	C 12652	13-Jun-13	1:23	0:33	ult	11	F	168.5	181.2	145	3.03	3.38	0.65	Moderate	
142	C 12646	13-Jun-13	0:53	0:36	Juvenile	3	M	72	156.3	104	1	1.47	0.7	Light	tooth difficult to read
143	-	13-Jun-13	1:15	0:45	Adult	5	M	126	N/A	130	2.49	3.06	0.8	Moribund	resusitated with breathing tube
144	-	15-Jun-13	1:48	-	SubAdult	NA	F	114.5	185	126	0.89	1.05	-	-	existing entanglement removed; toothless
145	C 12654	15-Jun-13	1:35	0:36	Adult	7	M	160.5	197	144	1.53	1.95	0.58	Moderate	
146	C 12709	15-Jun-13	2:05	0:32	Adult	12	F	142	172	135	1.96	2.62	0.63	Light	tooth difficult to read
147	C 12373	15-Jun-13	3:10	0:32	Adult	4	F	112.5	157	122	2.93	3.1	0.8	Moderate	
148	C 12658	15-Jun-13	2:34	0:31	Adult	6	F	119.5	152	135	2.69	3.84	0.75	Moderate	
149	C 12397	16-Jun-13	1:37	0:32	Adult	4	M	172	175.2	141	2.38	2.17	0.58	Deep	
150	S 118901	16-Jun-13	2:12	0:28	Adult	7	F	141	163.2	137	2.67	2.83	0.71	Moderate	existing wound; SDLR tag
151	-	16-Jun-13	2:32	0:21	Adult	NA	F	102.5	N/A	N/A	2.84	2.84	0.68	Light	did not respond sufficiently to sedation; toothless
152	S 39382	16-Jun-13	2:47	0:30	Adult	10	F	128.5	165.4	139	N/A	N/A	0.78	Moderate	SPOT Tag
153	-	16-Jun-13	-		Adult		F	158	178	140	3.7	2.2			capture mortality
154	-	17-Jun-13	0:46		Adult		F	185	171	N/A	N/A	N/A			
155		17-Jun-13	1:17		Juvenile		F	79.5		N/A	N/A	N/A			
156	-	17-Jun-13	1:49		Adult		F	143	177	137.4	N/A	N/A			existing entanglement removed

Figure E1. Chatham Harbor showing central sandbar and North Beach.

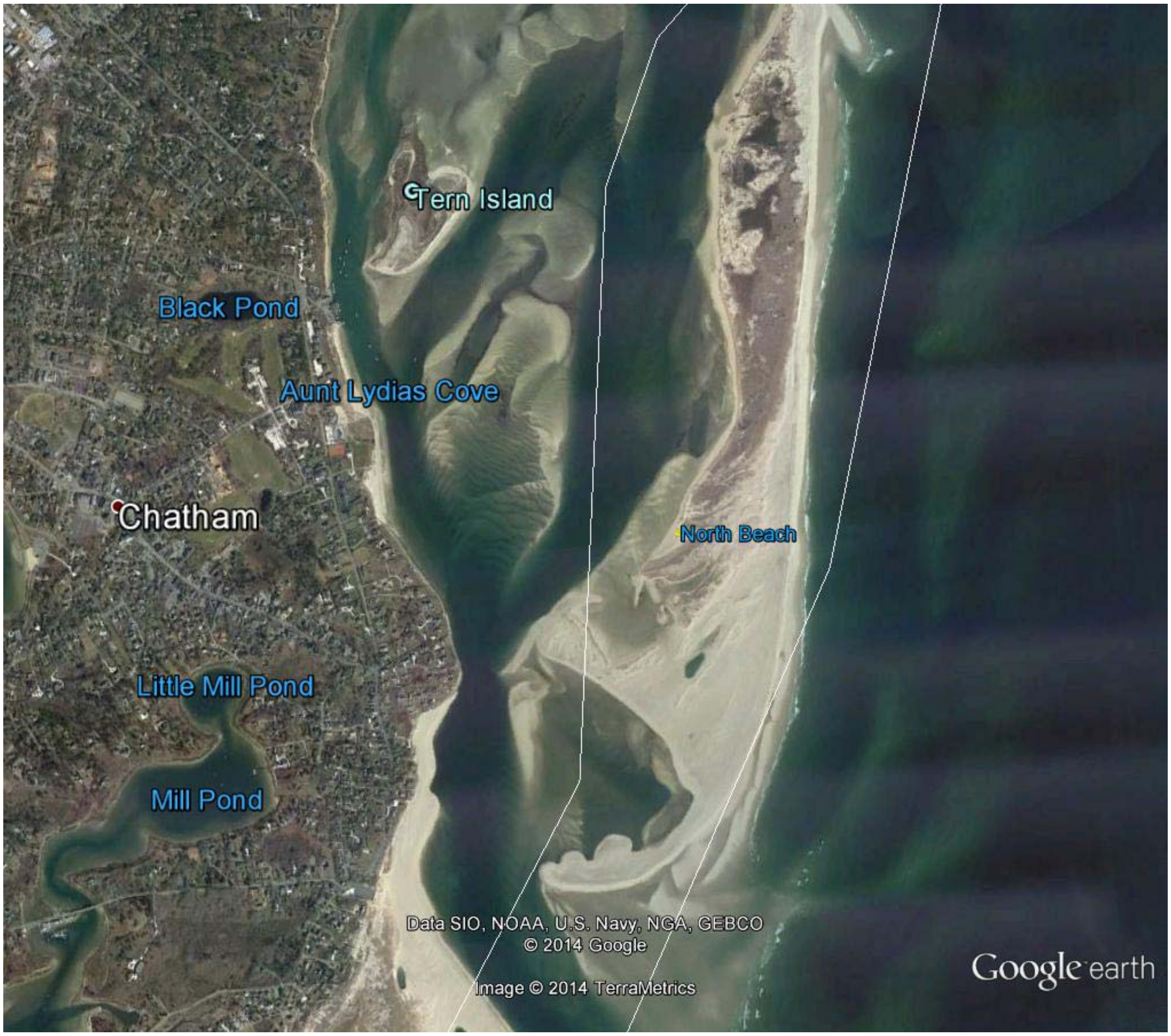


Figure E2. Gray seal restrained in pole net being weighted. Photo credit: Genevieve Davis, NEFSC.

Figure E3. The distribution of seven GPS tagged gray seal individuals between 11 July 2013 and 29 July 2013. Individuals have remained close to Chatham Harbor, with one exception of a single trip to the tip of the Cape Cod. Image credit for all GPS tagged seal maps: Map by J. Moxley, Duke.

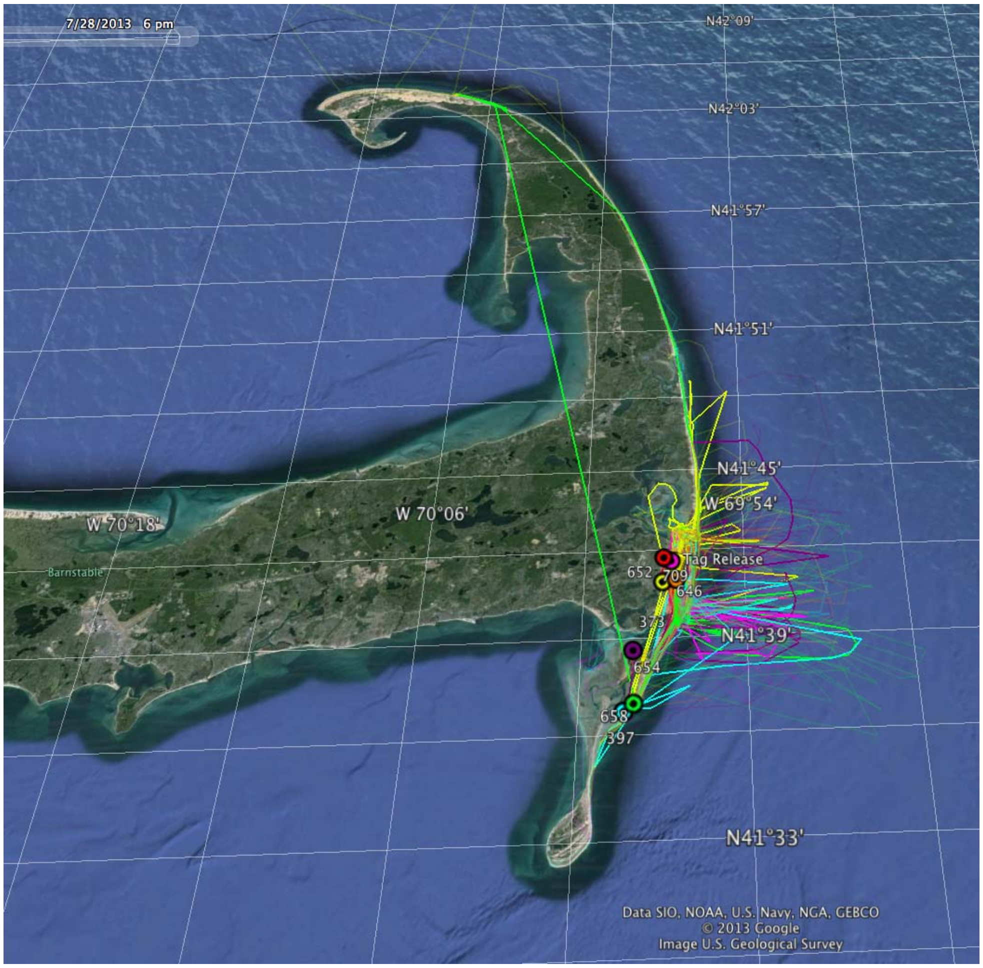


Figure E4. The distribution of seven GPS tagged gray seal individuals between 29 July 2013 and 5 September 2013. Most individuals remained around Chatham harbor with the notable exception of two tags. The malfunctioning tag #12646 captured coarse movements between Monomoy, Nomans Land, and some point offshore. Additionally, tag #12373 movement from North Beach, where it was found stranded and dead, to the IFAW offices in Barnstable. Map by J. Moxley, Duke.

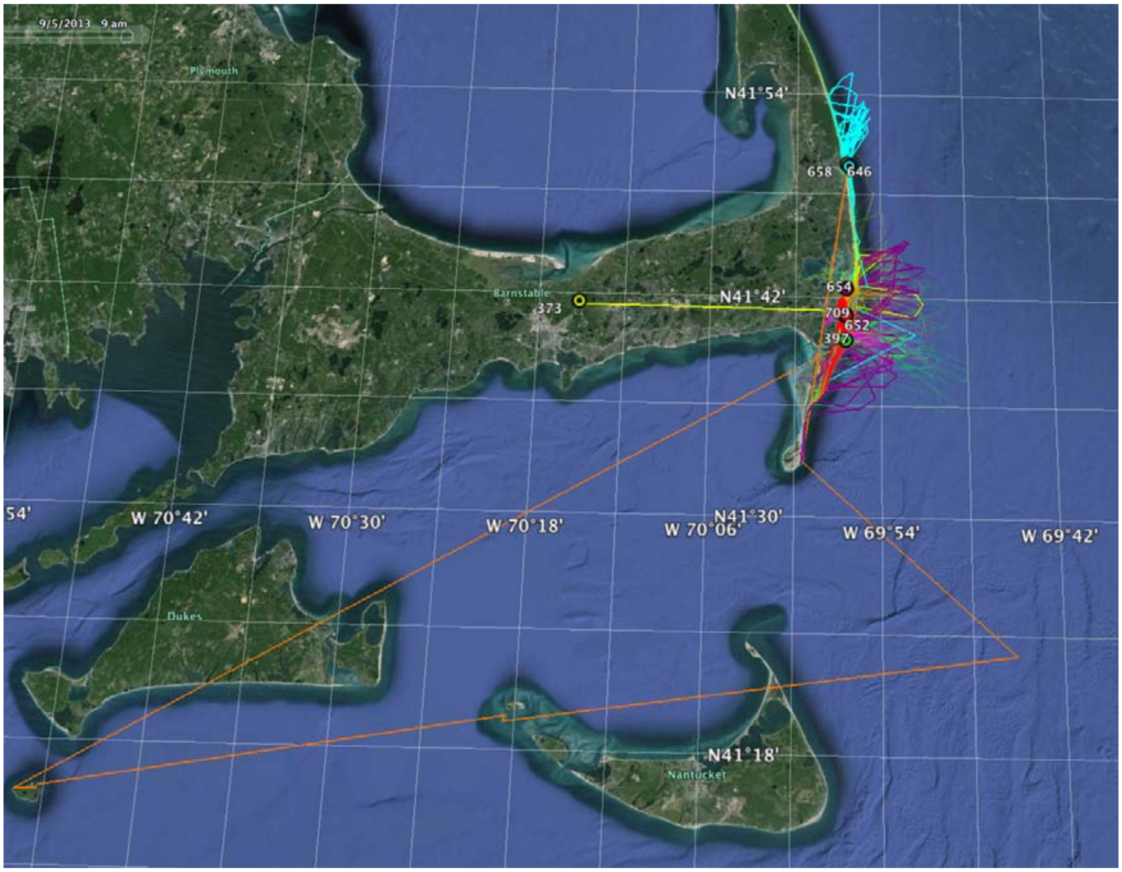


Figure E5. The distribution of six GPS tagged gray seal individuals between 6 September 2013 and 20 September 2013. Individuals largely remained around Chatham Harbor, though one animal relocated to Muskeget Island and another traveled further north along the Cape by Truro. Map by J. Moxley, Duke.

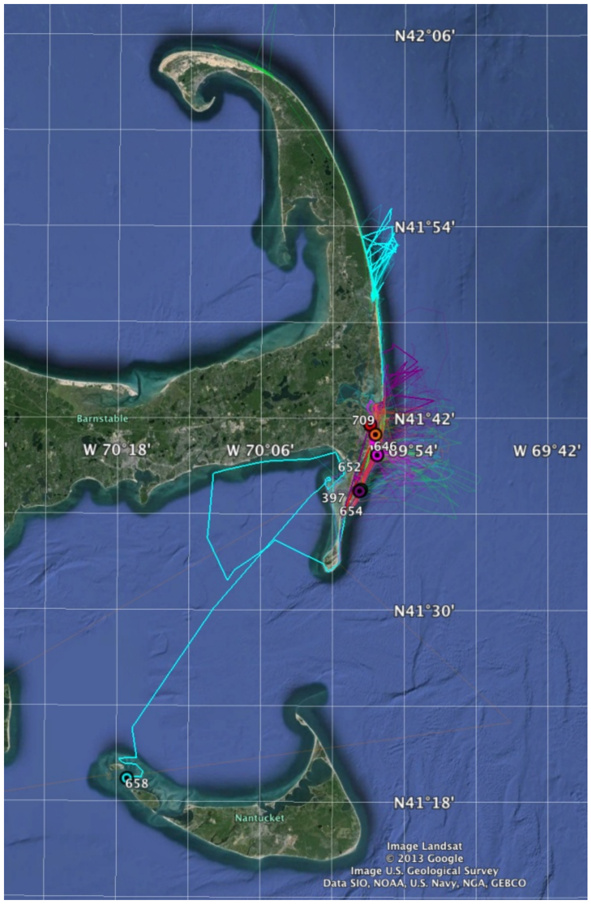


Figure E6. Movements of the two satellite tagged seals between late June and early October, white=SPOT tag & yellow= GPS SRDL tag.

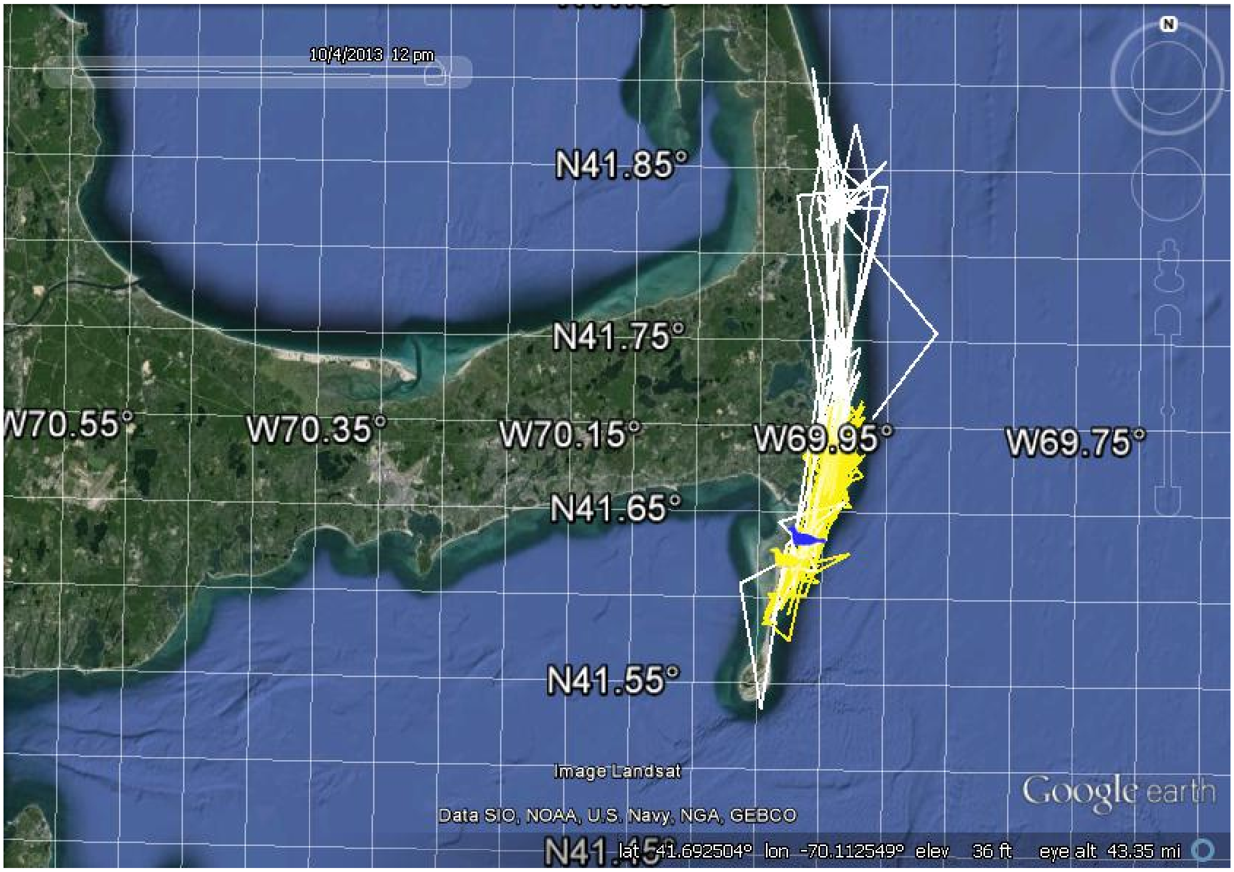


Figure E7. Distribution of five GPS tagged gray seal individuals between 9 October 2013 and 27 October 2013. All animals remained near the coast for this period, but three tagged animals have relocated north along the seashore. Map by J. Moxley, Duke.

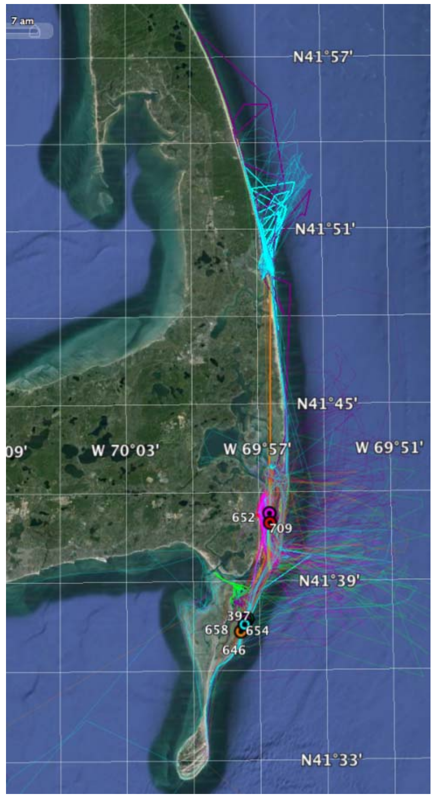


Figure E8. Movements of GPS tagged animals between 27 October and 20 November 2013. Since late October nearly all individuals began moving into new areas, including waters south of Martha's Vineyard and into the Great South Channel. Map by J. Moxley, Duke.

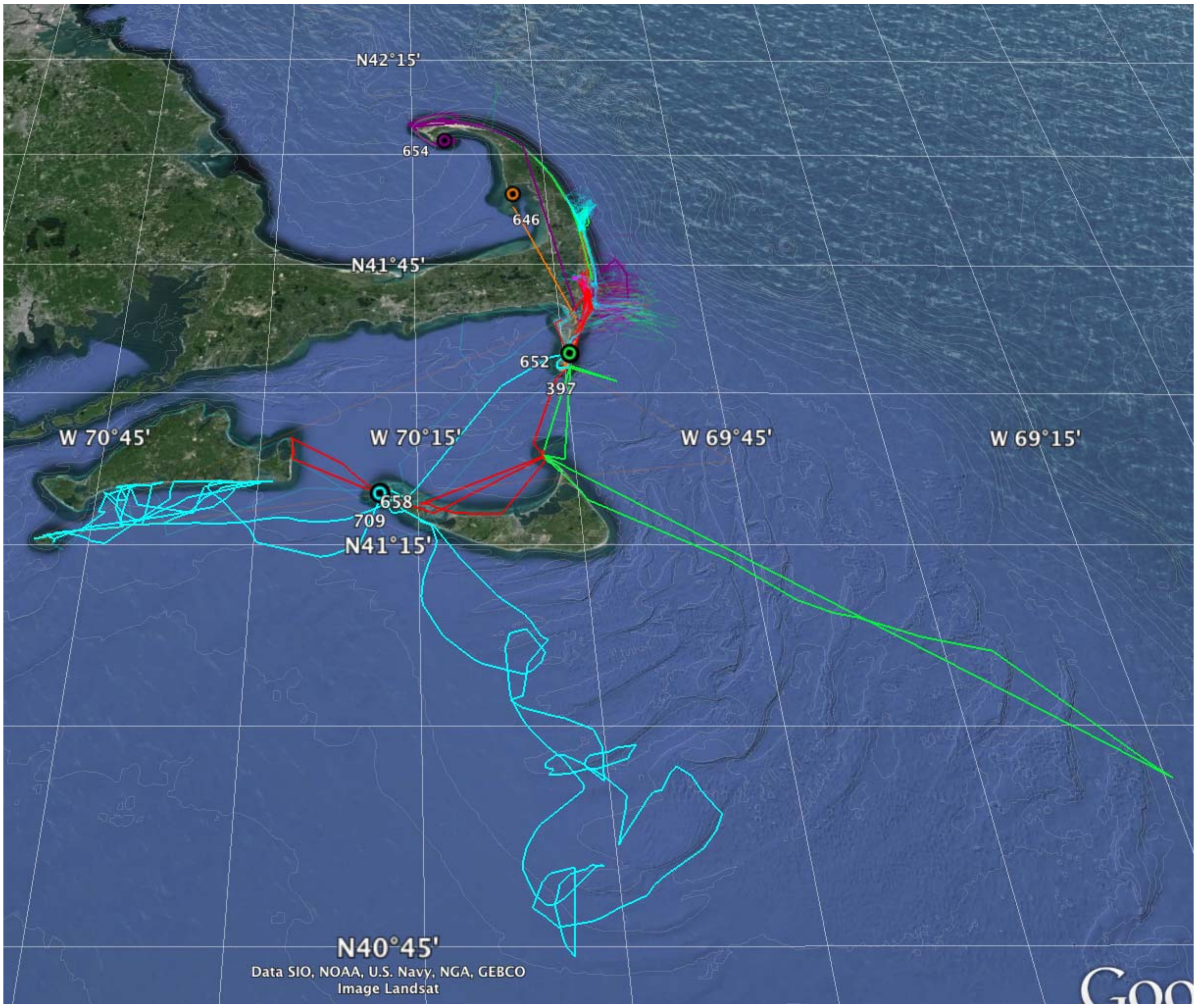


Figure E9. The distribution of six GPS tagged gray seal individuals between 21 November 2013 and December 12, 2013. Tagged animals have increased their use of both the Great South Channel and Cape Cod Bay during the tagging period. Map by J. Moxley, Duke.

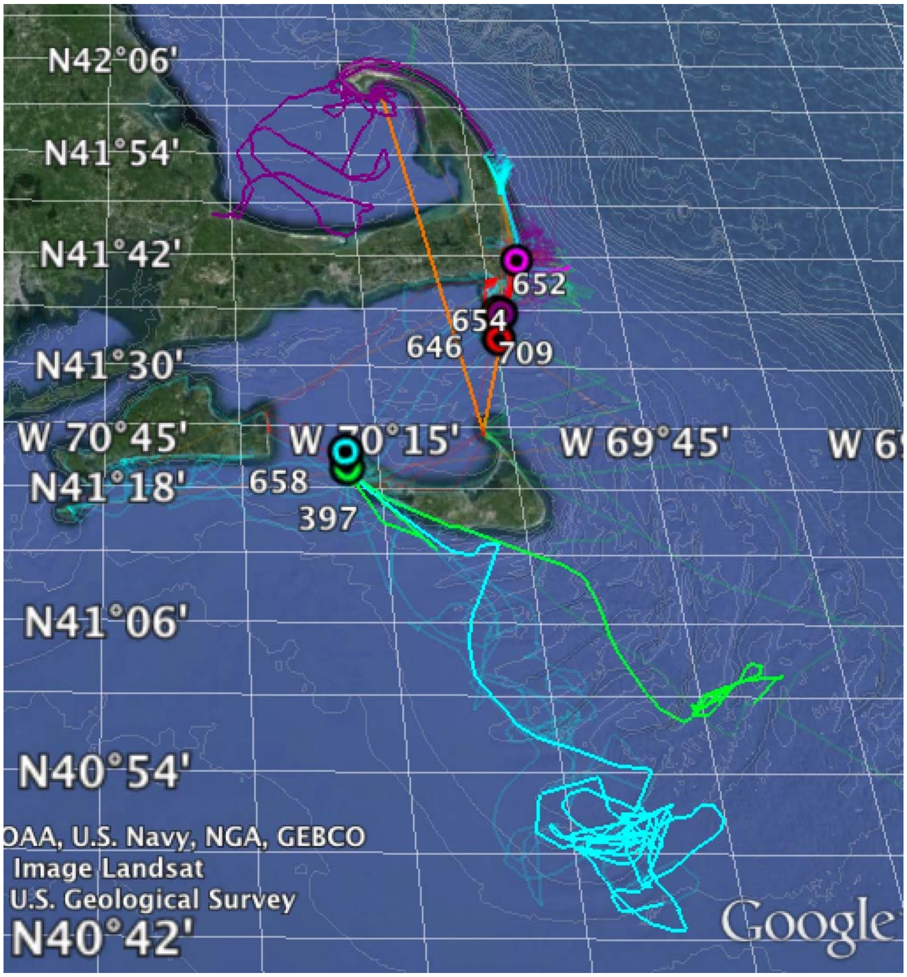


Figure E10. Movements of the two satellite tagged seals between early October though the end of 2013, white=SPOT tag and yellow= GPS SRDL tag.

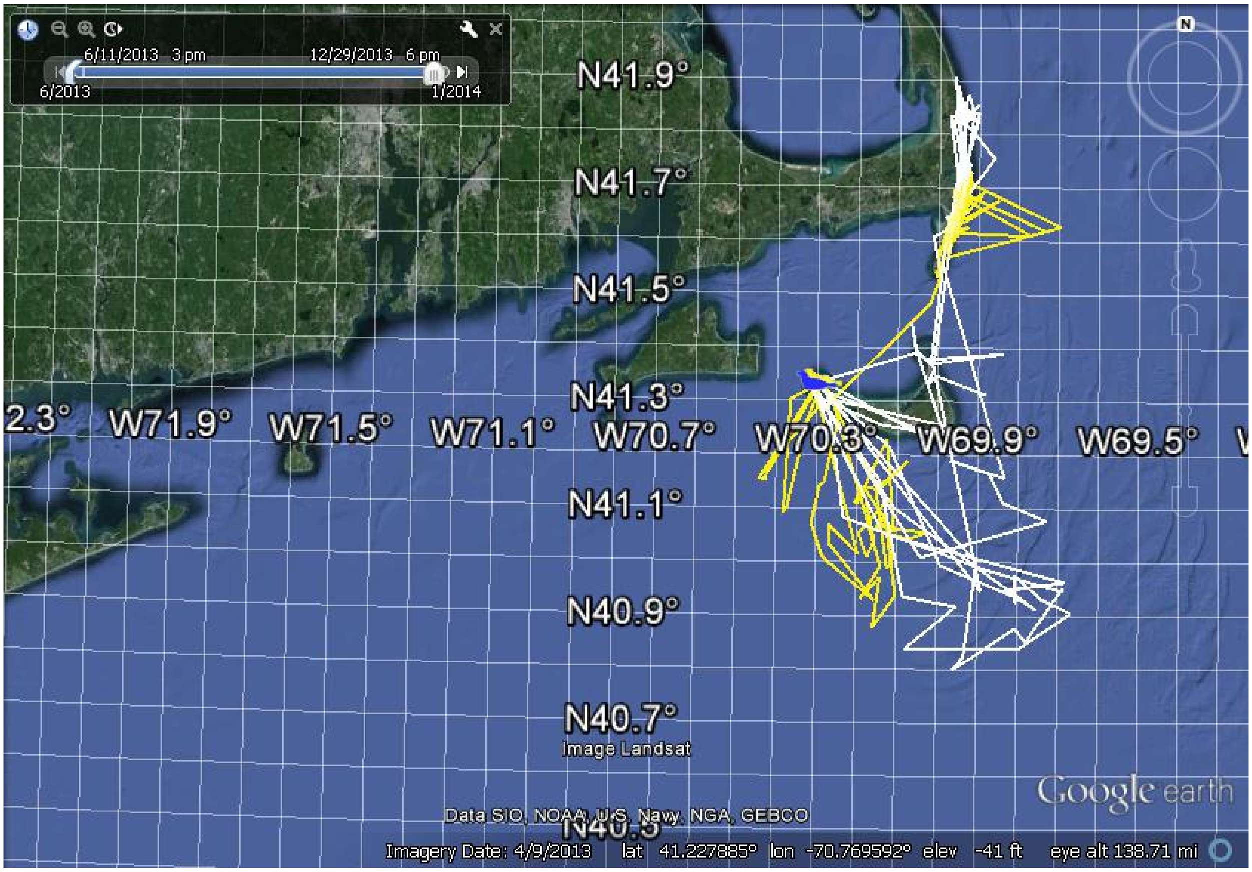


Figure E11. The distribution of five GPS tagged gray seal individuals between 13 December 2013 and 10 January 2014. Animals are beginning to diversify their spatial habitats as shown by the variation in centers of activity. Map by J. Moxley, Duke.

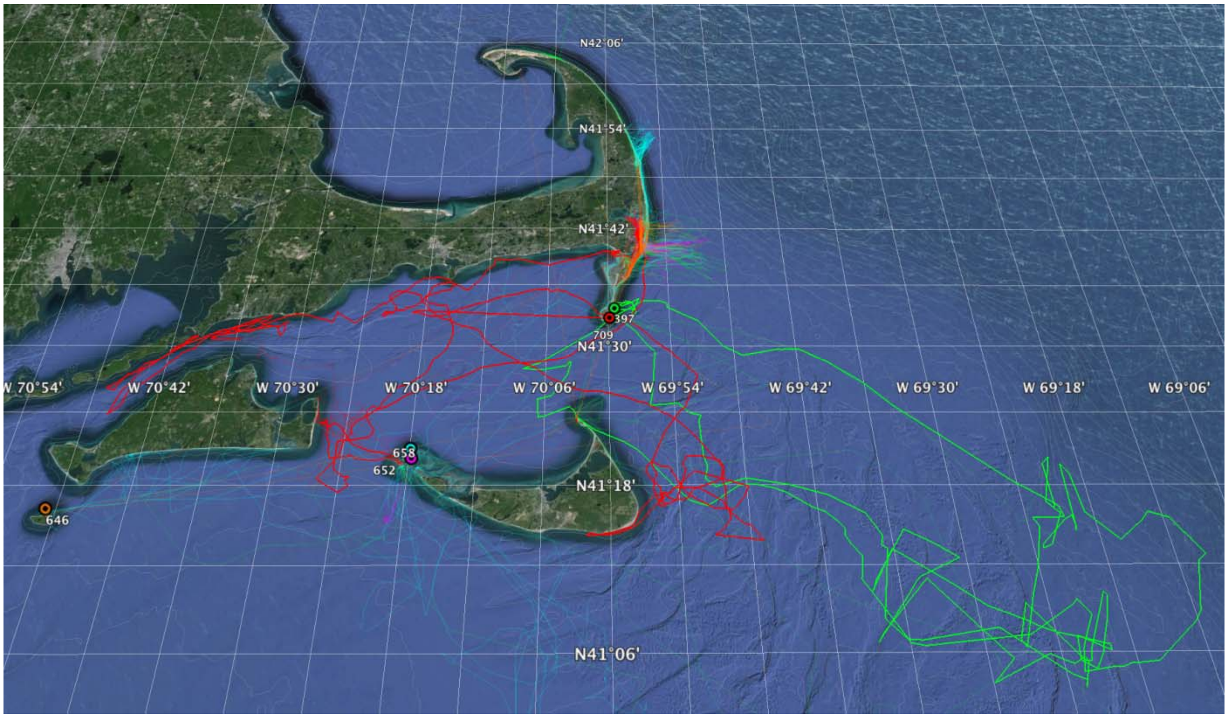


Figure E12. Movements of the two satellite tagged seals in early 2014. The GPS SRDL tag (yellow) and SPOT tag (white), respectively, stopped transmitting on 8 January and 11 February 2014.

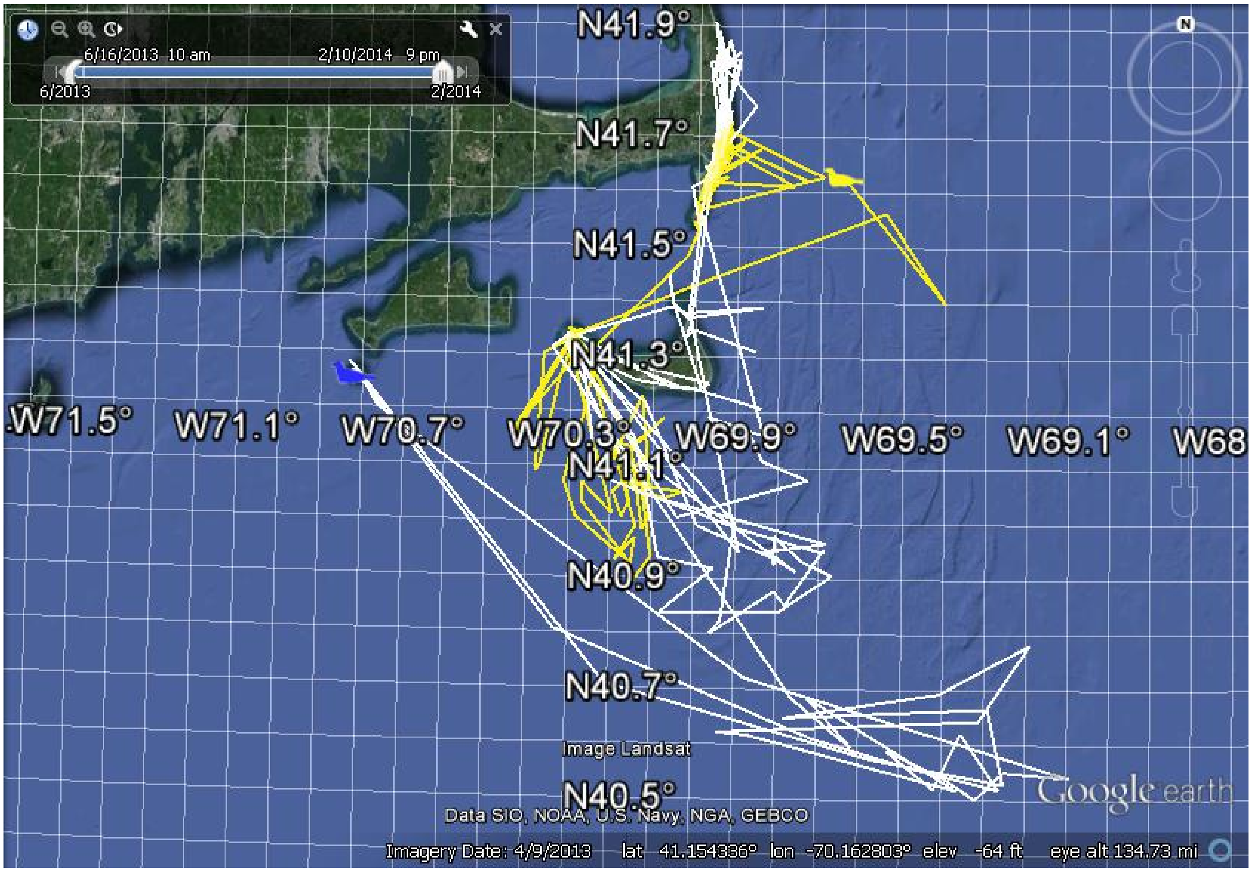


Figure E13. The distribution of four GPS tagged gray seal individuals between 25 January 2014 and 21 February 2014. Two animals were consistently moving offshore, while the other animals remain coastal. Map by J. Moxley, Duke.

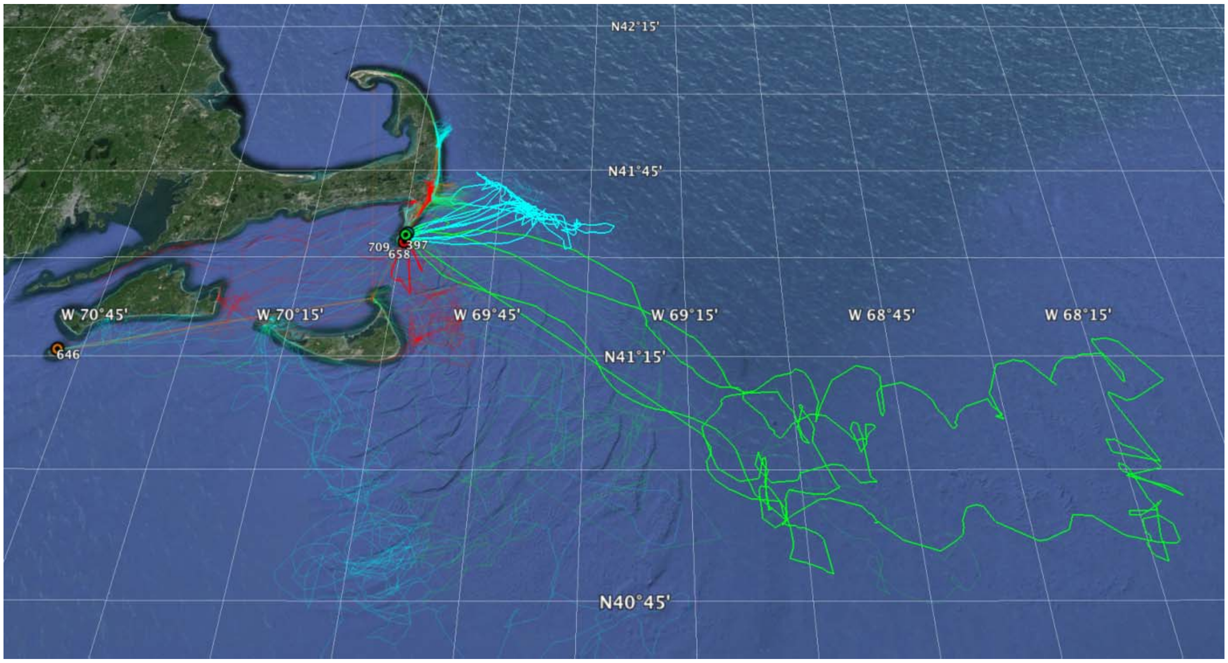
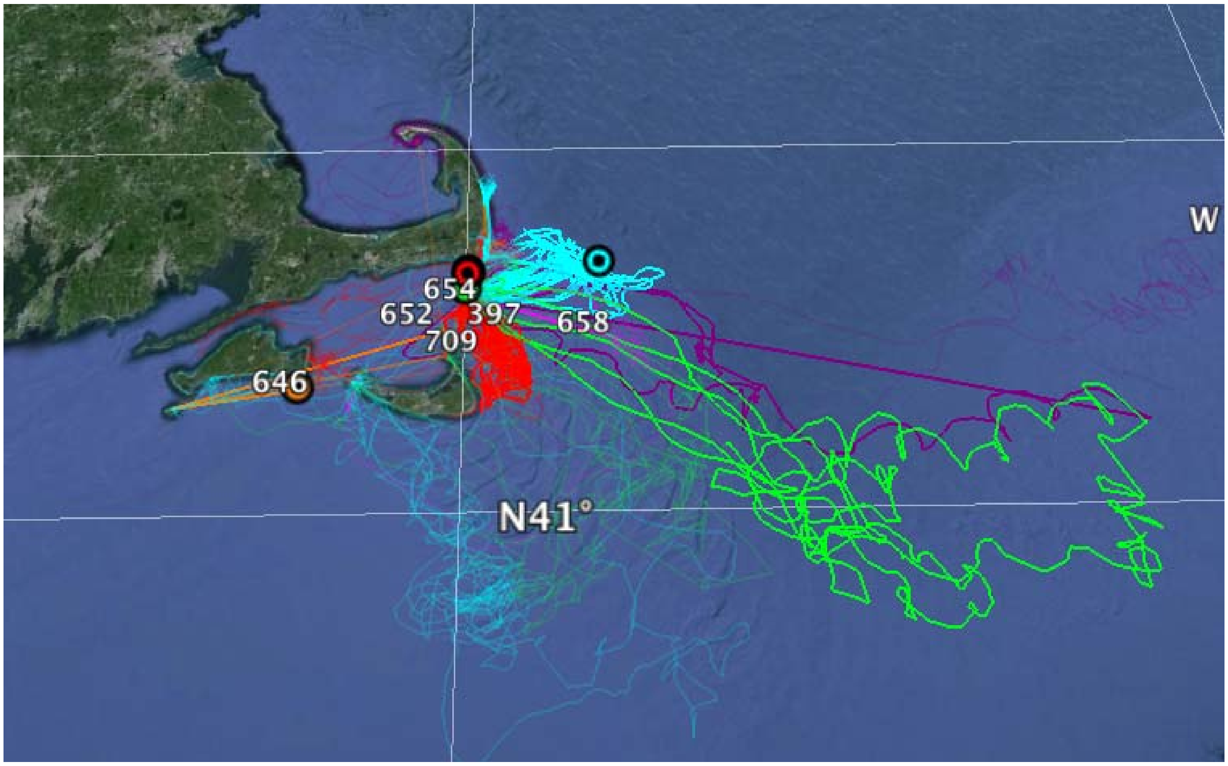


Figure E14. The distribution of five GPS tagged gray seal individuals between 18 February 2014 and 7 March 2014 (tag #12397 stopped transmitting on 20 February 2014). Animals were making extended trips offshore and spending less time hauled-out, as indicated by infrequent data transmissions. One animal returned after not being resighted for more than 45 days, but the entire track record did not transmit during its brief stay ashore. Map by J. Moxley, Duke.



Appendix F*: Progress on developing density models and maps: Northeast and Southeast Fisheries Science Centers*

Doug Sigourney[1]
Lance Garrison[2]
Debra Palka[3]

[1] Integrated Statistics, Inc., 172 Shearwater Way, Falmouth, MA 02540
[2] Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149
[3] Northeast Fisheries Science Center, 166 Water St., Woods Hole MA 02536

SUMMARY

To model the spatial/temporal distribution of marine mammals and sea turtles, we started exploring three frameworks that use different types of models: generalized linear and additive models (GLM/GAM), Bayesian hierarchical models, and nonparametric multiplicative regression 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 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. During 2013, only pilot study type results were available for a few species: fin whales using the Bayesian hierarchical framework, bottlenose dolphins using the generalized linear framework, and common dolphins using the nonparametric multiplicative regression framework. An additional person has been hired during 2014 and the plan is to complete at least two of these frameworks and apply them to as many species as the data and time allow. The efforts planned for 2014 include standardizing approaches for defining survey effort across survey platforms, establishing common variables for characterizing survey conditions (e.g., sea state, glare, visibility) across surveys, basing analyses in a common spatial framework, and standardizing the environmental variables used as predictors in the models. Based upon this common data structure, models will be developed for priority species using multiple approaches.

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 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.

Previously published examples of applying this method includes using linear regression to model cetacean habitats on the Scotian shelf (Hooker *et al.* 1999) using Poisson regression to model cetacean encounter rates in the Mediterranean to the physiographic habitats variables of depth and slope (Caňadas et al. 2002), and using generalized additive regression to model cetacean density in the Californian Current to satellite and ocean circulation modeled variables (Becker *et al.* 2012).

During 2013, this framework was explored using bottlenose dolphin data collected from the Southeast aerial surveys (summer 2010, winter 2011, summer 2011, spring 2012, fall 2012, and winter 2013). The first step in the modeling process is to fit models for the probability of detection for each sighted group. In this case, the independent observer method was used employing the data collected from two independent teams deployed on the aircraft. This approach estimates the probability of detection of groups available to both survey teams (i.e., perception bias) based upon a logistic regression of sighting probability as a function of perpendicular distance, observation team, sea state, glare, and the interaction between observer and distance (Laake and Borchers, 2004). For the bottlenose dolphin models here, there was no effort to correct for the probability of animals being on the surface and hence available to both teams, and thus the resulting density estimates are negatively biased. However, within this framework, it is straight-forward to develop an estimate of the probability of an animal being at the surface based upon tag-telemetry data and thereby correct this bias. This approach will be particularly important for sea turtles or deep-diving marine mammals. The number of animals corrected for detection probability on a particular line segment or in a spatial grid cell then becomes the response variable in a generalized linear model (GLM) or generalized additive model (GAM) of the species-environment relationship.

In the case of the bottlenose dolphin analysis, the explanatory variables in the GLM included sea surface temperature, surface chlorophyll, and bottom depth. In addition, an offset term is included in the model to account for the effects of effort, and additional spatial location terms (e.g., latitude and longitude) were included. These are modeled within a log-linear approach that can have a variety of potential error structures appropriate for modeling count data (e.g., Poisson, Negative Binomial, Quasi-Poisson, or zero-inflated models). The data suggested that the best model was a zero-inflated model that combined a binomial (logistic model) predicting frequency of zeros and a negative-binomial model to predict the density conditional on non-zero values. In this case, a GLM was appropriate; however GAM models may also be implemented within this framework if needed as they provide a greater degree of flexibility in fitting complex species-environment relationships. Finally, these models were used to predict the abundance of 10x10 km cells given the monthly 10 year climatological averages for each cell (an example is in Figure F1).

These maps should be considered preliminary examples demonstrating the concept and steps involved in data analysis, model fitting, and mapping. Some of the issues that will be dealt with in 2014 include:

- Defining a standardized grid as the basic unit;
- Standardizing the development of the environmental variables;
- Obtaining more environmental variables;
- Predicting on more current environmental data, not overall 10 year climatological averages. This will allow temporal trends to be explored;
- Integrating in the ability to account for availability bias by using the methods developed in Laake et al. 1997; and
- Developing the bootstrap approach to estimate variance.

BAYESIAN HIERARCHICAL FRAMEWORK

This modeling framework offers advantages over traditional approaches to modeling species abundance because the hierarchical approach isolates the biological/ecological dynamic (state) process from the observational process (describes the probability of observing the individuals given the true density and detection process involved in a line-transect survey), yet fits the parameters in a single step. In comparison to the GAM approach above, the Bayesian hierarchical framework combines steps (1) and (2) above. An important benefit is the underlying biological state model can be used to make predictions about future values of the state variable (e.g., animal density) without requiring information about the future values of the observation process (e.g., detection process). Also because of the way Bayesian methods are analyzed estimating summaries of uncertainty via credible intervals is straightforward and is derived directly from the posterior estimators. In the case of marine mammals, recent Bayesian hierarchical methods have combined traditional distance sampling approaches with generalized linear models relating density to habitat variables (Conn *et al.* 2012; Moore and Barlow 2011).

USING VISUAL LINE TRANSECT DATA

After Conn and Moore kindly provided their computer code (Conn *et al.* 2012; Moore and Barlow 2011) to us, we started by making minor modifications to the code to adapt to our data formats and objectives. After applying simulated and real data to these methods we decided the methods were not adequate to achieve all of our objectives. Thus, we started developing our own hierarchical Bayesian model for dual observer line-transect data expanding upon the concepts from these two papers. The Moore and Barlow (2011) method only uses single observer data and therefore does not estimate *g(0)*, the detection probability on the trackline. The Conn *et al.* (2012) approach (R program Hierarchical DS) more closely achieves our objectives because it employs the dual observer data to estimate *g(0).* However, because it uses a reversible jump Markov Chain Monte Carlo (RJMCMC) algorithm to estimate both observation parameters and habitat parameters in a Bayesian hierarchical framework it is slow to converge, particularly with large datasets. We tested this method on simulated data and found that it is also susceptible to low sample sizes, which could be a problem for some of our data.

Our own hierarchical Bayesian model for dual observer line-transect data is similar to Hierarchical DS however we do not implement a RJMCMC algorithm to estimate parameters.

We wrote our model using the freely available JAGS software. JAGS implements Gibbs sampling to derive marginal probability distributions for a user specified model. We tested our model on simulated data and compared our model to the single observer model. We found our model was capable of converging relatively quickly on large datasets and accurately estimated density-habitat relationships under a range of scenarios and accurately estimating *g(0)*. As a trial with real data, we applied this model to summer shipboard data of fin whales from the 2011 AMAPPS survey, exploring only sea surface temperature and bottom depth as environmental variables. Using this approach, we found evidence of a nonlinear relationship between fin whale density and sea surface temperature (Figure F2). There was also some evidence of a relationship between depth and fin whale density. Results from this modeling exercise will be critical in making spatially explicit forecast of marine mammals distributions based on habitat characteristics.

Additional work to be done in 2014 includes:

- Defining a standardized grid as the basic unit;
- Standardizing the development of the environmental variables;
- Obtaining more environmental variables;
- Integrating data from aerial surveys into our modeling framework. Ultimately, we will combine data types from both survey platforms to inform model parameters and make robust predictions of species-specific density-habitat relationships;
- Exploring the use of generalized additive models (GAMs) in the habitat portion of the Bayesian hierarchical modeling framework. At the moment the habitat modeling biological state process portion in the framework are using linear models;
- Exploring the use of zero-inflated habitat models;
- Integrating in the ability to account for availability bias by using the methods developed in Laake et al. 1997;
- Accounting for spatial autocorrelation;
- Exploring different methods of model selection and modeling averaging. Model averaging allows inference from a number of models that are weighted by their posterior probability. We are looking into the use of Deviance Information criterion (DIC) to weight the support of several models and then using the posterior weights to derive model averaged predictions of future spatial distributions (see Moore and Barlow (2011) for an example);

<u>USING VISUAL AND PASSIVE ACOUSTIC DATA</u>

In addition to our work on visual line transect data we are also exploring methods to incorporate information from passive acoustics into our models. 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. In addition, it may help us more accurately model density-habitat relationships of cryptic species such as sperm whales and beaked whales that spend considerable time below the surface.

To model the data on acoustics, we have started to explore Hidden Markov models (HMMs). An HMM model uses a sequence of events to infer the current state of the object and estimates transition in states. We will use the sequence of clicking sounds and our estimates of spatial location to infer the probability that an animal is above or below the surface. We will use a general distance sampling framework to estimate detection and combine this information with visual surveys to estimate overall density within a specified area. We have begun to look at data collected on sperm whales as a test case for this modeling approach.

NONPARAMETERIC MULTIPLICATIVE REGRESSION FRAMEWORK

Like the above two frameworks nonparametric multiplicative regression (NPMR) methods can be used to describe the relationship between a response variable (for example, density of a species within a grid cell) and one or more habitat variables. This modeled relationship could then be used to help narrow down the variables to be used in the above two frameworks or could result directly into a spatially-temporally explicit density map. The advantage of the NPMR method is it uses local multiplicative nonlinear smoothing regression functions so that complex interactions can be modeled and it does not extrapolate outside the data, that is, it does not create a model for combinations of the habitat variables that were not encountered. NPMR has most commonly been used with non-cetacean species, such as modeling the habitat relationships of lake macroinvertebrates (Free *et al.* 2009) and bird species (Grundel and Pavlovic 2007), but has also been used to map the distribution of cetaceans in the western North Pacific (Konishi *et al.* 2009).

To explore this method the 2011 and 2012 Northeast AMAPPS aerial survey data for white-sided, common and bottlenose dolphins were used; while the habitat variables explored were bottom depth and bottom slope. Similar to the regression framework above, the first step was to analyze the two team data within the software DISTANCE to estimate the dolphin density within a grid cell, corrected for *g(0)* and covariates that could define the detection function. Then the computer package HyperNiche was used to develop the nonparametric multiplicative regression model between the dolphin density and habitat variables (Figure F3). If this model was chosen from a complete sweep of potentially biologically important habitat variables, then a predicted spatial-temporal density map could then be created.

REFERENCES CITED

Becker EA, Foley DG, Forney KA, Barlow J, Redfern JV and Gentemann CL. 2012. Forecasting cetacean abundance patterns to enhance management decisions. Endang Species Res 16:97-112.

Caňadas A, Sagaminaga R and García-Tiscar S. 2002. Cetacean distribution related with depth and slope in Mediterranean waters off southern Spain. Deep-Sea Res I 49:2053-2073.

Conn, P.B., J.L. Laake and D.S. Johnson. 2012. A hierarchical modeling framework for multiple observer transect surveys. *PLOS One* 7: e42294.

Free G, Solimini AG, Rossaro B, Marziali L, Giacchini R, Paracchini B, Ghiani M, Vaccaro S, Gawlik BM, Fresner R, Santner G, Schonhuber M and Cardoso AC. 2009. Modelling lake macroinvertebrate species in a shallow sublittoral: relative roles of habitat, lake morphology, aquatic chemistry and sediment composition. Hydrobiologia 633:123-136.

Grundel R and Pavlovic NB. 2007. Response of bird species density to habitat structure and fire history along a Midwestern open-forest gradient. The Condor 109 (4): 734-749.

Hooker SK, Whitehead H and Gowans S. 1999. Marine protected area design and the spatial and temporal distribution of cetaceans in a submarine canyon. Conserv Biol 13:592-602.

Konishi K, Kiwada H, Matsuoka K, Hakamada T and Tamura T. 2009. Density prediction modeling and mapping of common minke, sei and Bryde's whales distribution in the western North Pacific using JARPN II (2000-2007) data set. Available at http://www.icrwhale.org/pdf/SC-J09-JR19.pdf.

Laake, J.L. and D.L. Borchers 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.

McCune, B. 2006. Non-parametric habitat models with automatic interactions. Journal of Vegetation Science 17: 819-830.

Moore, J.E. and J. Barlow. 2011. Bayesian state-space model of fin whale abundance trends from a 1991–2008 time series of line-transect surveys in the California Current. *Journal of Applied Ecology* 48: 1195-1205.

Figure F1. Preliminary spatial-temporal density maps of bottlenose dolphins using Generalized Additive Models and AMAPPS aerial survey data collected during 2010-2013.

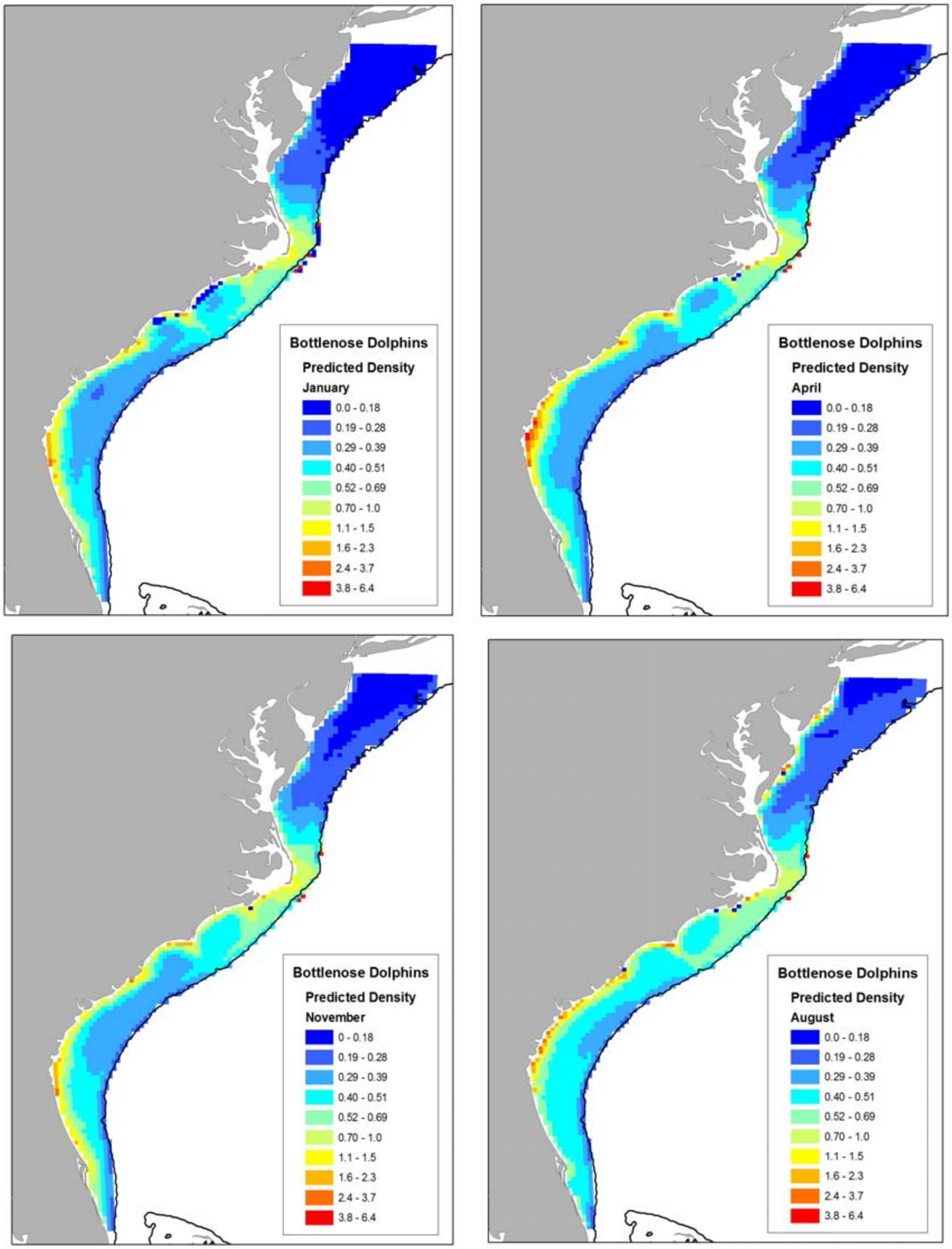


Figure F2. Examples of posterior distributions of environmental factors as related to the density of fin whales. Since the posterior distribution of salinity (A) is centered around 0 (on the x axis), there is not a significant relationship with fin whale density. In contrast, the posterior distributions of the linear (C) and quadratic terms (D) of sea surface temperature (SST and SST2, respectively) are significantly related to fin whale density because they are not centered on zero. Depth (B) appears to be more weakly related to fin whale density.

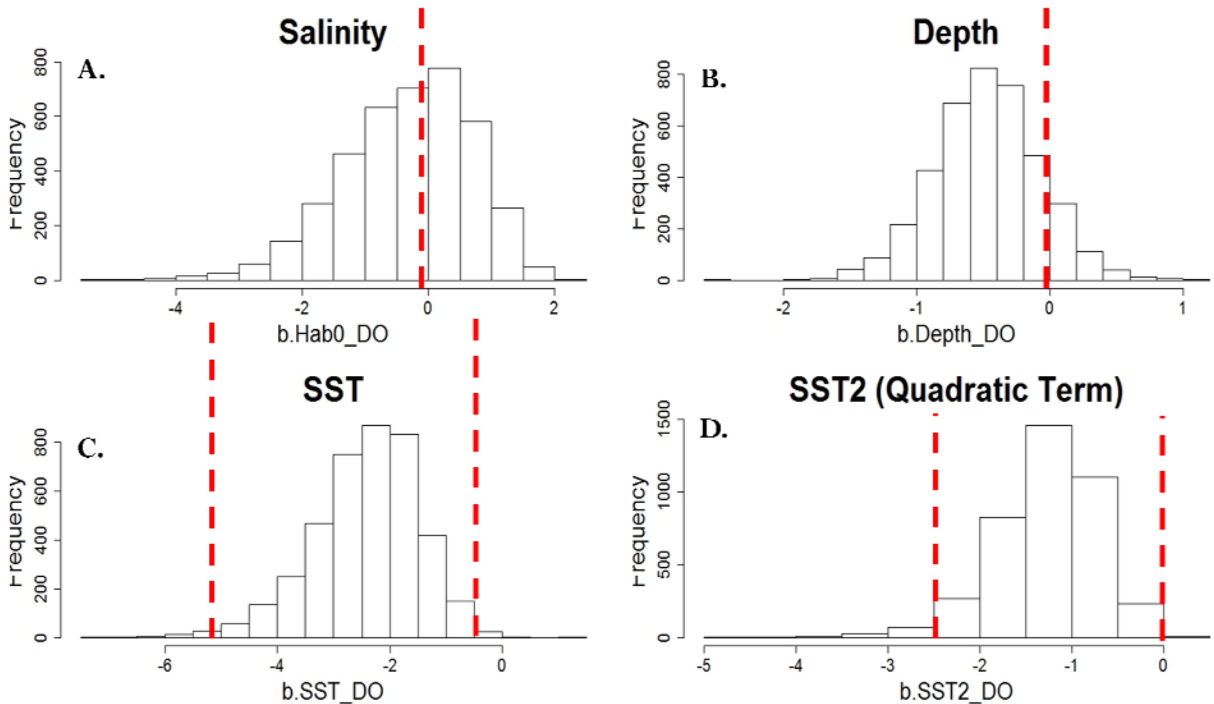


Figure F3. Example of a nonparametric multiplicative regression model of the abundance of white-sided dolphins. The gray area is not included in the model because this combination of habitat variables was not realistic in this case. The black areas are modeled low density regions while the red areas are higher density regions of the habitat variables.

Appendix G: *Progress on passive acoustic data analyses: Northeast Fisheries Science Center*

Danielle Cholewiak

Integrated Statistics, Inc., 172 Shearwater Way, Falmouth, MA 02540

SUMMARY

The goal of the AMAPPS-related work conducted by the Northeast Fisheries Science Center's passive acoustic team 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 when visual surveys are not conducted. There are currently four primary analyses involving towed array and bottom-mounted recorder data collected during the northeast 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 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; and (4) documenting the offshore spring/summer occurrence of baleen whales in the Great South Channel and Georges Bank regions to supplement visual sighting data. In addition, collaboration with colleagues at the Southeast Fisheries Science Center is ongoing to analyze echolocation clicks from Risso's dolphins (*Grampus griseus*) and to develop automated echolocation classifiers for this species and to determine whether there is geographic variation in the acoustic characteristics. Finally, in collaboration with scientists from the Scripps Institution of Oceanography and the other NOAA Science Centers, an acoustic database is continuing to be developed to house processed data analyses in a format that will be standardized across Centers. AMAPPS data will be included in this database.

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 even more reliably sighted species cannot be detected visually at night or when conditions are poor. Data collected from acoustic studies provide important new insights, 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 group at the Northeast Fisheries Science Center 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 this project are:

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 acoustic data took place using a variety of software packages. Automated detection and tracking of sperm whales (*Physeter macrocephalus*) were conducted using Pamguard (version 1.12.05 Beta, Gillespie et al. 2008). 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. Echolocation clicks for beaked whales and Risso's dolphin (*Grampus griseus*) were extracted using the package Triton (version 1.6, Scripps Institution of Oceanography) and custom-written Matlab code. 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

Acoustic analysis projects during 2013 focused on four main topics, utilizing both towed hydrophone array and archival bottom-mounted recorder data collected during 2011 – 2013.

<u>ACOUSTIC ABUNDANCE ESTIMATES OF SPERM WHALES</u>

Sperm whale analyses conducted in 2013 were two-fold. First, the AMAPPS 2011 survey data were compiled to calculate preliminary acoustic abundance estimates for this species. 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 (Figure G1). The software package DISTANCE was used to estimate sperm whale abundance for this single survey. Over 400 sperm whales were detected in the 2011 survey (Table G1), resulting in a preliminary abundance estimation of 3,439 individuals (CV = 0.34) for this region. Data are currently being verified to finalize the acoustic abundance estimate.

All acoustic data from the 2013 northeast AMAPPS shipboard survey have been reviewed for the presence of sperm whales. Similarly to the 2011 dataset, sperm whale echolocation clicks were identified using specialized detectors in the software package Pamguard. Approximately 360 sperm whales were detected over the 28 survey days with towed array data collection. Two-dimensional localization analyses are being conducted; once these analyses are complete, abundance estimates will be calculated using both the AMAPPS 2011 and 2013 datasets. Real-time detections of sperm whales from the 2013 survey are shown in Figure G2.

These data are currently being prepared for a manuscript describing the acoustic abundance estimate for sperm whales in the northeastern U.S. EEZ.

ACOUSTIC DETECTION OF BEAKED WHALES

Analyses conducted in 2012 to characterize the echolocation signals of Sowerby's beaked whales from recordings collected during the AMAPPS 2011 shipboard survey were published in the Journal of the Acoustical Society of America in 2013 (Cholewiak *et al.* 2013).

Analyses in 2013 focused on quantifying the acoustic detection rate for all beaked whale species from the northeast AMAPPS 2011 and 2013 shipboard survey data, identifying species where possible, and comparing these data to the visual detection data. These analyses are being conducted through a two-stage process using the software platform Triton (Scripps Institution of Oceanography). Echolocation clicks are extracted from the entire dataset using automated click detectors; these are then subject to specific classifiers that extract likely beaked whale events. Simultaneously, long-term spectral averages (LTSAs) are calculated over each day of data, and allow for close examination of any acoustic events of interest. Analyses are in process; once complete, abundance estimates will be calculated if possible, and acoustic detections will be compared to visual sightings.

DELPHINID WHISTLE AND ECOLOCATION CLASSIFICATION

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, twenty-eight encounters from the AMAPPS 2011 shipboard survey data were extracted to provide over 1200 whistles to Dr. Oswald for development of an Atlantic species-specific version of ROCCA (Table G1).

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*). We are currently testing the performance of ROCCA using data collected during the AMAPPS 2013 shipboard survey. All visual sightings have been 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.). Twenty-four separate encounters met these criteria (Table G2), and analyses are underway to extract and classify individual whistles from each of these groups. Results will be used to improve future versions of ROCCA, and further evaluation will involve testing classification success rates of mixed species groups.

Collaboration also continued with colleagues at other NOAA Science Centers and the Scripps Institution of Oceanography to continue work on acoustic classification of dolphins using echolocation clicks, focusing on Risso's dolphins. Data from the 2013 AMAPPS survey were reviewed to identify and extract visually-confirmed encounters with Risso's dolphins. Similarly to the procedures for selecting whistles for the ROCCA tests, a series of criteria were established to select appropriate encounters with Risso's dolphins (including: distance of <3 km to the survey vessel and >3 km from any other delphinid group). Eight encounters over six days met these criteria and were extracted and contributed to collaborators for analysis.

BALEEN WHALE CALL CLASSSIFICATION AND NORTH ATLANTIC RIGHT WHALE SPRING/SUMMER PRESENCE IN THE GREAT SOUTH CHANNEL AND GEORGES BANK REGIONS

Bottom-mounted recorders (MARUs) were deployed around the Great South Channel and Georges Bank regions from March – June 2012 and May – July/August 2013 (Figure G2). Six of ten recorders were successfully recovered in 2012; four of five recorders were recovered in 2013. Recording duration varied by site, but approximately 2045 hours/site were recorded in 2012 and 1938 hours/site in 2013.

The LFDCS, an automated acoustic detector developed by Mark Baumgartner at WHOI, was used to evaluate the presence of baleen whale species at these sites. Evaluation of the detector's performance for these datasets was initiated in 2013, with initial focus on "up-calls" produced by North Atlantic right whales. A subset of the detector output was systematically reviewed from each year, totaling 313 hr for 2012 and 314 hr for 2013. From these data, a logistic regression was generated to determine an appropriate calling threshold for assuming right whale presence. These results indicated that a detection rate of 21 or more calls/hr indicated right whale presence with an 80% confidence level. Because right whales also often call at lower rates, all hours with at least 10 or more "up-call" detections were manually reviewed. Right whale up-calls were detected on 3 sites in 2012 and 4 sites in 2013 (Table G3). This analysis is currently in process for determining the presence of sei, fin, and blue whales.

DISPOSITION OF DATA

Acoustic data are stored on-site at the Northeast Fisheries Science Center. In 2012, representatives of all of the NOAA Science Centers and colleagues at Scripps Institution of Oceanography participated in the development of an acoustic database system. When completed, this database will allow for standardized archival of acoustic analysis products, including those from the AMAPPS surveys.

ACKNOWLEDGEMENTS

The Bureau of Ocean Energy Management (BOEM) and the US Navy through Interagency Agreements for the AMAPPS project provided the funds for the 2013 summer acoustic data collection and partially funded the 2013 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 2013 visual observers, and the NEFSC Large Whale team for assistance in data collection. We would also like to thank NOAA Hollings Scholar Julianne Gurnée for assistance in analyses of the sperm whale data.

REFERENCES CITED

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

Baumgartner M, Fratantoni D, Hurst T, Brown M, Cole T, Van Pajis S, 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., Clark, C. W., and Lammers, M. O. 2012. Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise. Biological Conservation **147**, 115–122.

Cholewiak, D., Baumann-Pickering, S., Van Parijs, S. M. 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 Robbins, M. 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, Gordon J, McHugh R, Mclaren D, Mellinger D, Redmond P. 2008. PAMGUARD: semiautomated, open source software for real-time acoustic detection and localisation of cetaceans. Proc Inst Acoust 30(5).

Marques T, Thomas L, Ward J, DiMarzio J, 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., Stafford, K. M., Mellinger, D. Berchok, C., Wiig, Ø., Kovacs, K. M., Lydersen, C. 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 G1. Detection and localization results for acoustic encounters with sperm whales in the towed array dataset from the NEFSC AMAPPS 2011 shipboard survey. The data from localized individuals were used in abundance analyses. A number of individuals could not be localized due to a variety of factors (e.g., surfacing shortly after detection, distance from ship, detection event while ship was not on trackline, etc.).

Number of sperm whales detected	415
Number of sperm whales localized	288
Average perpendicular distance (m)	1699
Minimum distance (m)	96
Maximum distance (m)	8788

Table G2. Species and number of encounters selected from NEFSC AMAPPS 2013 shipboard data for testing of the Atlantic ROCCA classifier.

Species name	Common name	Discrete encounters
Globicephala spp.	Pilot whale	1
Grampus griseus	Risso's dolphin	3
Delphinus delphis	Common dolphin	4
Stenella frontalis	Atlantic spotted dolphin	4
Tursiops truncatus	Bottlenose dolphin	4
Stenella coeruleoalba	Striped dolphin	3
Stenella clymene	Clymene dolphin	1
Stenella species	Unidentified S*tenella*	3
TOTAL		23

Table G3. Number of days with right whale "up-calls" detected by the LFDCS on bottom-mounted recorder data from Georges Bank and the Great South Channel in 2012 and 2013. Site numbers correspond to locations on map in Figure G3.

Year	Site Number	Number of days with detections
2012	1	73
	2	43
	4	15
	5	0
	9	0
	10	0
	Total	131
2013	1	15
	2	13
	3	2
	4	5
	Total	35

Figure G 1. Acoustic detections of sperm whales from the AMAPPS 2011 survey included in the preliminary abundance analyses. Blue lines indicate survey track lines where the hydrophone array was deployed (with the exception of the nearshore lines); pink dots indicate acoustic locations of sperm whale individuals or groups.

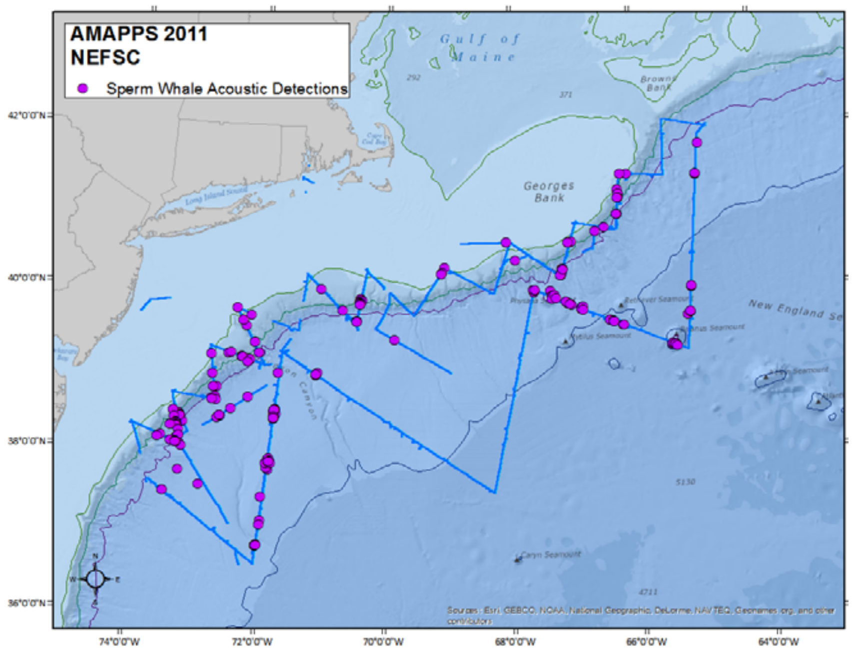


Figure G 2. Acoustic detections of sperm whales from the AMAPPS 2013 survey as detected in real-time. Pink lines indicate daytime survey track lines where the hydrophone array was deployed (with the exception of the nearshore lines); orange squares indicate the position of the ship when sperm whale individuals or groups were acoustically detected.

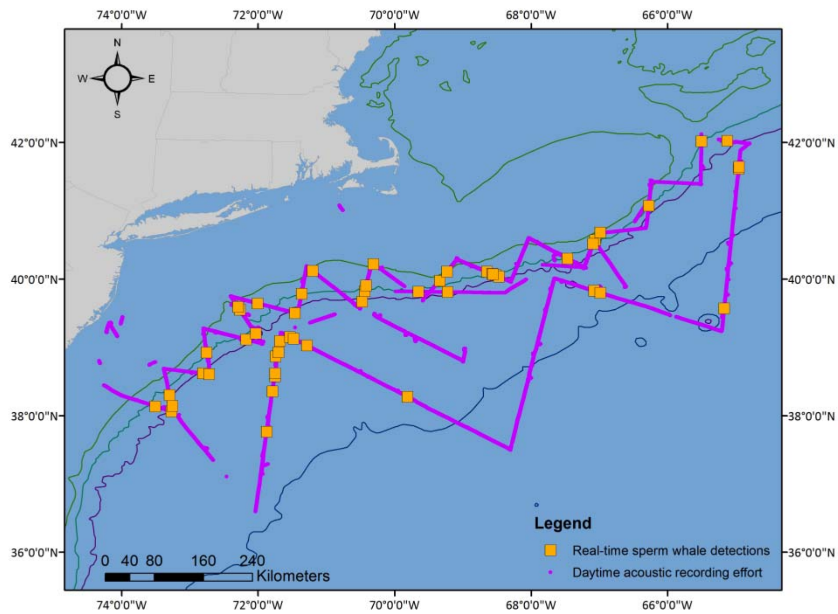
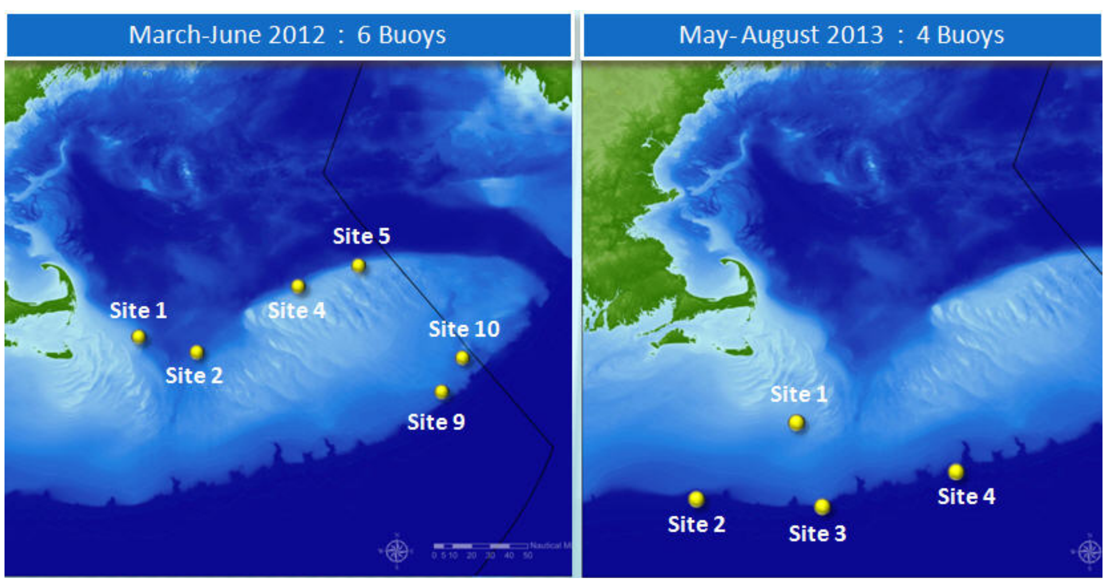


Figure G 3. Map showing locations of the marine autonomous recording units (MARU) along Great South Channel and Georges Bank in 2012 and 2013 that were successfully recovered. MARUs were deployed from March – June in 2012, and from May – July/August 2013. MARUs at several sites were not recovered; those sites are not depicted in the figure below.



Appendix H: Progress on analyses of active acoustic, hydrographic and plankton data: Northeast Fisheries Science Center

Elisabeth Broughton[1]
Erin LaBrecque[2]

[1]**Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543**
[2]**Duke Marine Lab, 135 Duke Marine Lab Rd, Beaufort, NC 28516**

SUMMARY
To understand how environmental habitat characteristics can influence the distribution and density of the marine mammals, sea turtles and sea birds, and to attempt to discriminate between the changes in cetacean populations due to natural environmental variability versus changes due to anthropogenic impacts, it is useful to have an understanding of what physical and biological characteristics are currently associated with the density and distribution of marine mammals, sea turtles and sea birds. The objective of this project is to document the relationships between the physical and biological characteristics of the water column relative to distribution patterns of marine mammals, sea turtles and sea birds. Hydrographic data, active acoustic backscatter data and plankton data were collected during the 2010, 2011, 2013, and 2014 AMAPPS Northeast Fisheries Science Center (NEFSC) surveys to map the lower trophic levels and oceanographic conditions of the study area. Data from 2011 have been used to develop the processing procedures for the data collected in the other years. During 2013, the 2011 active acoustic backscatter data and plankton data as detected from the visual plankton recorder (VPR) were processed. In addition, some of the net samples were enumerated. This is a cooperative project, where data collection was funded by the AMAPPS funds, data processing and analyses of the hydrographic and plankton data were conducted and funded by the NEFSC, and data processing and analyses of the hydrographic and active acoustic data were conducted by a Ph.D. student at Duke University funded through the WHOI-Duke Fellowship in Marine Conservation, the Oak Foundation and the Nancy Foster Scholarship Program.

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. Currently other projects within the AMAPPS initiative (Appendix F) are developing 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 (e.g., sea surface temperature and surface chlorophyll). However, these efforts do not explicitly account for biological processes that may be more directly driving the target species' distributions; that is, explaining why the target species is at that particular spot in time (Palacios *et al.* 2013). To investigate this, the objective of this project is to compare the distribution and density patterns of marine mammals, sea turtles and sea birds with the patterns of other trophic levels in addition to the patterns of the physical environment.

METHODS
On the Northeast Fisheries Science Center's (NEFSC) shipboard 2010 and 2011 surveys physical and biological water characteristics, distributions and densities of various trophic levels were

documented using temperature and depth profilers (CTD), the Simrad EK60 acoustic backscatter, a Video Plankton Recorder (VPR), and bongo tow nets (NEFSC & SEFSC 2011; 2012; 2013). In 2011 Sippican T-7 Expendable Bathythermographs (XBT) probes were also launched to record temperature profiles during four shelf break crossings. In 2013 the 1 m Multiple Opening Closing Net Environmental Sensing System (MOCNESS) and Isaacs-Kidd midwater trawl (IKMT) were added to quantify larger mesoplankton (see Appendix B in this report for more details).

In general, after collecting the physical and biological data, the first step involves processing and mapping the physical oceanographic data associate with the biological samples. The next step is to identify and quantify the biological samples collected by the nets (bongos, MOCNESS and IKMT), and VPR and to identify and quantify the potential biological organisms detected by the acoustic backscatter from the EK60. Then these can be compared to validate the acoustic backscatter data. Finally, the distribution patterns of all of these physical and biological data can be compared to the distribution patterns of the marine mammals, sea turtles, and sea birds.

XBT DATA

Sippican T-7 XBT probes were launched on the third leg of the 2011 survey to record temperature profiles during four shelf break crossings. The XBT records the temperature and depth of the water that the XBT travels through. On 21 July 2011, an XBT was launched during a day-time CTD station and the temperature data were compared to the calibrated up-cast temperature data from the CTD for comparison.

EK60 HYDRO-ACOUSTIC DATA

During the 2010 – 2013 shipboard surveys, the Simrad EK60 multi-frequency echosounder system was operational every night after marine mammal operations ended and during the daytime every other day when the marine mammal teams were on-effort. The EK60 system consisted of five frequencies (18, 38, 70, 120, and 200 kHz) that synchronously emitted pings and recorded returned acoustic backscatter. The organisms found in the active acoustic back scatter data which are generally in the 2 mm – 5 cm size range correspond to the middle and lower level trophic taxa.

To start with, the shipboard 2011 NEFSC EK60 active acoustics data were processed by implementing algorithms to clean the 5-frequency data in Echoview. Cruise specific algorithms automated bottom line detection over steep topography, removed spike noise from the ACDP and ship's fathometers, and removed background noise. These algorithms have been turned into templates and so during 2014 they will be used to process EK60 hydro-acoustic data from the other AMAPPS surveys.

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 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. 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. These approximations will be compared to the EK60 acoustic data and MOCNESS data collected during the 2013 survey. Until further analysis can be done to assess the validity of the acoustic classifications, the catagories are: fish-like, euphausiid-like/large micronekton, copepod-like/small micronekton, U-shaped, and other.

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. A second SEACAT 19+ CTD profiler was mounted above the V-fin and connected to the 322 conducting core cable to provide real time data on gear depth and oceanographic conditions. Tows were conducted at 3 – 4 kn speed through the water to minimize image frame overlap. Two types of tows were conducted: single depth tows to target and identify clear layers of backscattering seen on the 120 and 200 kHz EK60 frequencies, and vertical up-and-down tows (tow-yos) where the VPR traveled through multiple depths of the water column, which represented either multiple layers of organisms (multiple layers on the EK60) or no distinct layer as seen on the EK60. The VPR was also used to quickly survey the plankton in an area before deciding to deploy the larger plankton samplers.

Upon retrieval, the data were downloaded to specialized image processing computers. In focus plankton regions of interest (plankton ROIs) were extracted from each image frame using Autodeck programming from Seascan. Profiles of temperature, salinity, density, raw chlorophyll and raw turbidity values were created for each vertical tow using MATLAB. Plankton ROIs were processed to remove air bubbles and duplicate images.

During 2013, the plankton ROIs from the 2011 survey were identified to general taxonomic grouping using a modified version of Visual Plankton developed by Cabell Davis of the Woods Hole Oceanographic Institution. During 2014 data from the other surveys (2009, 2013, and 2014) will be processed.

BONGO DATA

Plankton and hydrographic sampling was conducted by making double oblique tows using the 61-cm bongo sampler and a Seabird CTD. 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 kn. Plankton sampling gear consisted of a 61-centimeter diameter aluminum bongo frame with one 333 µm and one 505 µm mesh net. Standard ECOMON sampling protocols were employed. 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).

The first processing step is to ship the preserved samples to the Polish Sorting Center for processing. After the samples have been enumerated to species or species group, they can be used to investigations to relate the distribution and density of plankton to the distribution and density of marine mammals, turtles and sea birds.

MOCNESS DATA (2013 ONLY)

Additional plankton sampling was conducted with a 1m MOCNESS equipped with 9, 333 µm nets targeting larger plankton towed at 1-1.5 kn to maintain close to a 45º net angle. The MOCNESS system was also equipped with a color VPR and strobes, thought to increase the catchability of euphausiids and mesopelagic fish such as myctophiids. The 1m MOCNESS was deployed in the canyon and cross shelf transect areas to further quantify backscatter data seen 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 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.

The first processing step is to ship the preserved samples to the Polish Sorting Center for processing. After the samples have been enumerated to species or species group, they can be used to investigations to relate the distribution and density of plankton to the distribution and density of marine mammals, turtles and sea birds.

IKMT DATA (2013 ONLY)

Larger plankton in the canyon and cross shelf transect areas was also sampled using an IKMT with a ¼ inch mesh net and 1mm mesh cod end. The IKMT was deployed 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 (~350m). While the IKMT only provides depth integrated samples it can be towed at speeds up to 3.5 kn so can be more successful at capturing mesopelagic fish than the 1m MOCNESS.

The first processing step is to ship the preserved samples to the Polish Sorting Center for processing. After the samples have been enumerated to species or species group, they can be used to investigations to relate the distribution and density of plankton to the distribution and density of marine mammals, turtles and sea birds.

RESULTS

XBT DATA

The XBT data were determined to be accurate because the mean difference between the XBT data and the co-located and calibrated CTD up-cast was 0.023^{o}C (CTD – XBT) with a standard deviation of 0.42 (Figure H1). Analysis of the XBT data (Figure H2) shows the thermal structure of the four shelf break track lines sampled (Figure H3). Only the on-effort marine mammal observer section of trackline 11 with a marine mammal sighting was gridded because of temporal sampling discrepancies between the northwester and southeastern parts of trackline 11.

EK60 HYDRO-ACOUSTIC DATA

Of all of the ship's track lines which had an operational EK60 (Figure H4), thirteen track lines were chosen that crossed the shelf break, had detected marine mammals, and had the EK60 operational (Figure H5). Temporal patterns will be able to be investigated because some of these track lines were surveyed twice during the same season in the same year (Table H1). For this analysis, the EK60 tracklines were named according to continuous acoustic data collection, not marine mammal survey tracklines.

As an example of the processing, the EK60 data along the first two tracklines of the cruise displayed as 3D heat maps of volumetric backscatter (Sv; in dB) show the biological patches around the shelfbreak and at the canyons (Figures H6 – H7). Re-displaying these data on line plots, it can be seen that there is greater intensity of scattering (more yellows and reds) in the 18 kHz than the 200 kHz at the shelfbreak (Figures H8 – H9). It is commonly thought that these types of patches would be in the vicinity of the shelf break front because of the properties of the jets associated with the front, though these biological patches are deeper than the climatological position of the shelf break front for these locations.

The next step of the processing was to select acoustic ROIs based on intensity of scatterings at 18 and 200 kHz (centroids shown in Figures H8 – H9 as asterisks). Of the 19 acoustic legs processed, there were 13 – 63 acoustic ROIs per leg where most were classified as fish-like or copepod/small micronekton-like (Table H2), and the average depths ranges were about 33 – 259 m for fish-like acoustic ROIs and about 39 – 330 m for copepod/small micronekton-like acoustic ROIs (Table H3). Acoustic ROIs categorized with a "?" represented areas where the general shape of the frequency response curve matched one of the scattering models but did not conclusively fit the curve.

Two manuscripts describing the distribution of acoustic ROIs in relation to hydrographic properties and sighting of marine mammals in the shelf break region will be submitted to peer-reviewed journals by the end of 2014.

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 (Figure H10). Data from the fluorometer and turbidity sensors represent relative intensities. In general tracklines that were 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 plots (from 2011-2014 data) and plankton data spreadsheets (from 2011 data) which can be interpolated in both time and/or depth bins from the v-fin VPR sensors are now available on request.

Seacat 19+ data from the first upcast of each haul (from the 2011 and 2013 data) have been posted to the oceanography branch website.

Oceanographic data from the single depth hauls from the 2011 survey have also been processed and plotted to visualize small scale variations in oceanographic conditions at a distinct depth (Figure H11). Data and plots from the v-fin VPR sensors (from 2011 data) are now available on request. Data spreadsheets have had surface data and outliers removed and can be interpolated in both time and/or depth bins.

VPR plankton ROIs (extracted images) have been used to create several classification data bases based on 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 the computer program Visual Plankton to create generic plankton classifiers to run on the unidentified plankton ROIs from each individual VPR haul. Future work involves continuing to expand the image collection and creating classifiers specific to regions, acoustic signals, or time of year.

2011 VPR image data have had all duplicate images removed and have had plankton ROIs identified using the generic classifiers into 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….

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, plankton densities by number and area. Data can now be interpolated in both time and/or depth bins allowing for a wide variety of visualizations (Figures H12 – H13).

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

Future research will interpolate VPR data into bins which match the EK60 processing and 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 consideration if the acoustic signal is affected by the type of plankton present and the size limitations of each frequency. Observations from the 2011 – 2014 cruises have suggested that small, insubstantial plankton like marine snow, phytoplankton, or small hydromedusa may not be seen by the 200 kHz frequency.

NET PLANKTON DATA

The bongo samples from 2011 and 2013 were shipped to the Polish Sorting Center for processing. The zooplankton from the nets with 333µm 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 were identified to the lowest taxonomic level possible, enumerated and a subset was measured (SL). Completed data have been loaded into the NMFS oracle plankton database.

The MOCNESS and 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 (SL), and 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.

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 Northeast Fisheries Science Center. In addition, the data processing and analyses of the hydrographic and hydro-acoustic data 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

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

Northeast Fisheries Science Center (NEFSC), Southeast Fisheries Science Center (SEFSC). 2012. 2011 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/read/protspp/mainpage/AMAPPS/docs/NMFS_AMAPPS_2011_annual_report_final_BOEM.pdf

Northeast Fisheries Science Center (NEFSC), Southeast Fisheries Science Center (SEFSC). 2013. 2012 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 http://www.nefsc.noaa.gov/read/protspp/mainpage/AMAPPS/docs/NMFS_AMAPPS_2012_annual_report_FINAL.pdf

Palacios, D.M., Baumgartner, M.F., Laidre, K.L. and Gregr, E.J. 2013. Beyond correlation: integrating environmentally and behaviourally mediated processes in models of marine mammals distributions. *Endangered Species Research* 22: 191-203.

Table H1. EK60 tracklines and spatial duplicates.

Acoustic Trackline	Duplicate line		Acoustic Trackline	Duplicate line
Leg 1 Ln01			Leg 2 Ln01	Leg 1 Ln13
Leg 1 Ln02	Leg 3 LnXBT 11		Leg 2 Ln02	Leg 1 Ln05
Leg 1 Ln03			Leg 2 Ln03	Leg 1 Ln04
Leg 1 Ln04	Leg 2 Ln03		Leg 3 Ln06	
Leg 1 Ln05	Leg 2 Ln02		Leg 3 LnXBT03	
Leg 1 Ln11	Leg 3 XBT07		Leg 3 LnXBT07	Leg 1 Ln11
Leg 1 Ln13	Leg 2 Ln01		Leg 3 LnXBT11	Leg 1 Ln02
Leg 1 Ln14				
Leg 1 Ln15				
Leg 1 Ln16	Leg 1 Ln19			
Leg 1 Ln19	Leg 1 Ln16			

Table H2. Preliminary summary of the number of acoustic regions of interest (Acoustic ROIs) by category per acoustic trackline. Asterisks (*) indicates spatially duplicated trackline.

		Acoustic ROIs								
		"Fish-like"		"Euphausiid-like"		"Copepods-like"		"The U"		
Acoustic Trackline	Location (MAB or GB)	Fish	Fish ?	Euphausiid/ Large micronekton	Eu ?	Copepods/ Small micronekton	Co ?	U	Unknown	Total by trackline
Leg 1 Ln01	MAB	18	3	3	4	1	--	--	7	36
Leg 1 Ln02*	MAB	12	5	2	3	9	--	2	12	45
Leg 1 Ln03	MAB	1	1	--	--	10	7	--	4	23
Leg 1 Ln04*	MAB	7	6	1	3	1	3	3	10	34
Leg 1Ln05*	MAB	3	2	1	4	3	3	5	3	24
Leg 1 Ln11*	GB	5	11	--	--	12	3	1	24	56
Leg 1 Ln13*	MAB	3	3	4	10	13	2	3	2	40
Leg 1 Ln14	MAB	6	4	--	3	9	--	--	4	26
Leg 1 Ln15	MAB	13	1	2	1	2	--	--	3	22
Leg 1 Ln16*	MAB	9	3	3	2	3	--	--	6	26
Leg 1 Ln19*	MAB	11	--	--	--	--	--	--	2	13
Leg 2 Ln01*	MAB	1	5	1	--	32	4	2	1	46
Leg 2 Ln02*	MAB	7	3	--	2	28	6	11	6	63
Leg 2 Ln03*	MAB	5	--	--	1	1	6	--	3	16
Leg 3 Ln05	GB	8	--	1	--	19	3	1	4	36
Leg 3 Ln06	GB	10	--	7	--	26	1	--	3	47
Leg 3 LnXBT03	GB	20	9	--	1	9	2	1	--	42
Leg 3 LnXBT07*	GB	8	3	--	1	7	7	6	6	38
Leg 3 LnXBT11*	MAB	1	1	--	--	4	7	1	5	19
	Total by AROI	148	60	25	35	189	54	36	105	

Table H3. Preliminary summary of the depth range and average depth in meters of acoustic regions of interest (acoustic ROIs) by category per acoustic trackline. Minimum depth – maximum depth (average depth). Asterisks (*) indicates spatially duplicated trackline.

		Acoustic ROIs							
		"Fish-like"		"Euphausiid-like"		"Copepods-like"		"The U"	
Acoustic Trackline	Location (MAB or GB)	Fish	Fish ?	Euphausiid/ Large micronekton	Eu ?	Copepods/ Small micronekton	Co ?	U	Unknown
Leg 1 Ln01	MAB	29 - 370 (206)	55 - 304 (138)	46 - 316 (147)	56 - 321 (188)	39	--	--	27 - 451 (95)
Leg 1 Ln02*	MAB	57 - 374 (237)	16 - 190 (77)	248 - 267 (258)	171 - 269 (235)	238 - 304 (267)	--	23 - 39 (31)	18 - 283 (133)
Leg 1 Ln03	MAB	161	106	--	--	35 - 255 (207)	43 - 212 (169)	--	152 - 338 (243)
Leg 1 Ln04*	MAB	42 - 390 (259)	41 - 300 (199)	149	121 - 338 (257)	253	31 - 307 (123)	174 - 287 (228)	30 - 305 (120)
Leg 1Ln05*	MAB	35 - 201 (93)	17 - 192 (104)	105	86 - 193 (126)	87 - 239 (143)	31 - 266 (181)	28 - 237 (110)	29 - 35 (32)
Leg 1 Ln11*	GB	55 - 148 (105)	16 - 184 (120)	--	--	56 - 305 (164)	55 - 288 (169)	199	19 - 245 (92)
Leg 1 Ln13*	MAB	216 - 240 (232)	18 - 335 (228)	101 - 406 (283)	58 - 186 (107)	202 - 349 (273)	93 - 186 (139)	33 - 37 (36)	57 - 297 (177)
Leg 1 Ln14	MAB	16 - 390 (141)	24 - 377 (193)	--	124 - 154 (137)	54 - 208 (209)	--	--	51 - 78 (66)
Leg 1 Ln15	MAB	24 - 267 (130)	331	351 - 368 (359)	204	309 - 351 (330)	--	--	37 - 432 (184)
Leg 1 Ln16*	MAB	11 - 154 (38)	57 - 434 (219)	206 - 354 (256)	183 - 246 (214)	223 - 320 (272)	--	--	40 - 442 (252)
Leg 1 Ln19*	MAB	16 - 331 (75)	--	--	--	--	--	--	285 - 420 (352)
Leg 2 Ln01*	MAB	376	15 - 327 (107)	135	--	43 - 249 (150)	55 - 174 (128)	26	17
Leg 2 Ln02*	MAB	36 - 381 (191)	45 - 187 (130)	--	110 - 181 (145)	52 - 346 (214)	51 - 244 (113)	48 - 297 (169)	42 - 178 (91)
Leg 2 Ln03*	MAB	12 -77 (33)	--	--	60	94	41 - 88 (65)	--	25 - 114 (81)
Leg 3 Ln05	GB	15 - 111 (46)	--	41	--	63 - 246 (127)	81 - 89 (86)	95	23 - 90 (64)
Leg 3 Ln06	GB	15 - 250 (81)	--	89 - 223 (138)	--	84 - 332 (204)	158	--	103 - 278 (187)
Leg 3 LnXBT03	GB	18 - 330 (207)	50 - 335 (190)	--	59	24 - 215 (118)	78	173	--
Leg 3 LnXBT07*	GB	20 - 69 (43)	14 - 129 (71)	--	16	74 - 128 (94)	71 - 468 (248)	71 - 380 (200)	12 - 105 (65)
Leg 3 LnXBT11*	MAB	42	30	--	--	242 - 289 (273)	33 - 267 (144)	191	33 - 268 (105)

Figure H1. Comparison of calibrated CTD temperatures (up-cast) and XBT temperatures from the same station along a 1:1 line. Average difference between sensors is 0.0227°C.

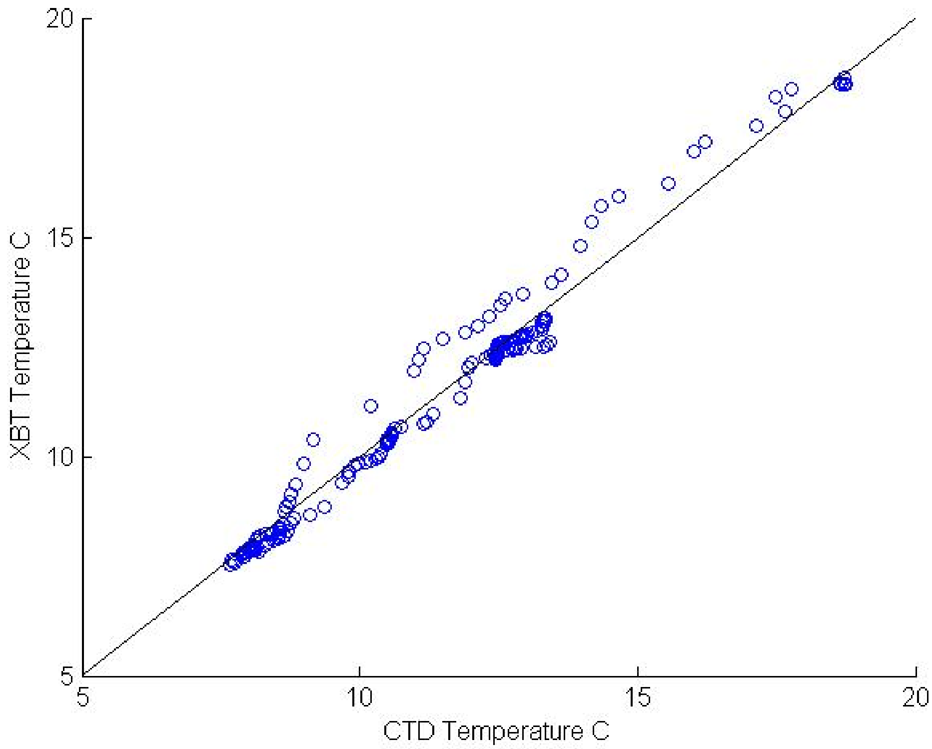


Figure H2. Temperture (^{o}C) sections. The position of each XBT station is marked with an asterisk (*). A: results from transect line 3; b: Line 7; c: night transit; d: Line 11. Line 11 was sampled on two separate days. Because mammal observer effort was limited on the northwestern part of the line due to poor visibility, only XBT data collected on the southeastern part of the line was compared to mammal observations.

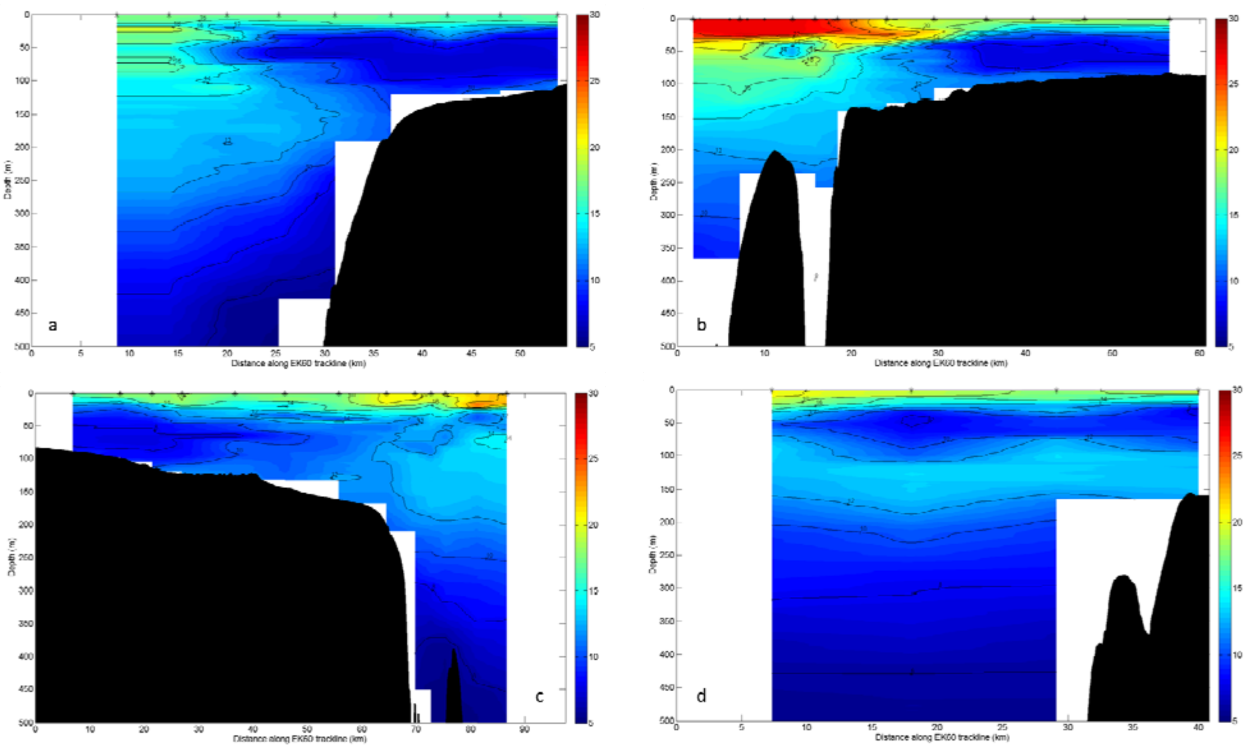


Figure H3. Location of XBT launches per trackline number. The line through line 11 indicates the section analyzed.

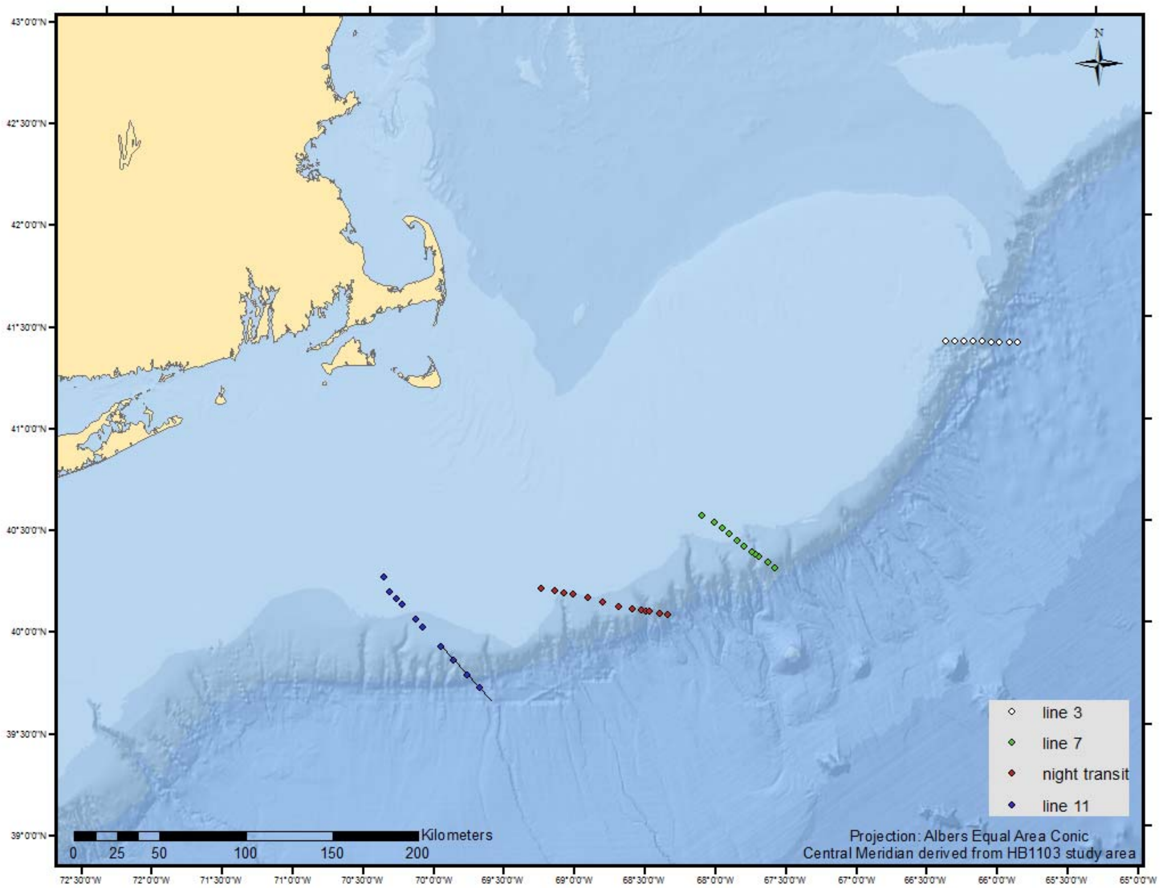


Figure H4. EK60 tracklines. The EK60 was operational every other day of marine mammal on-effort time and operational during all nighttimes.

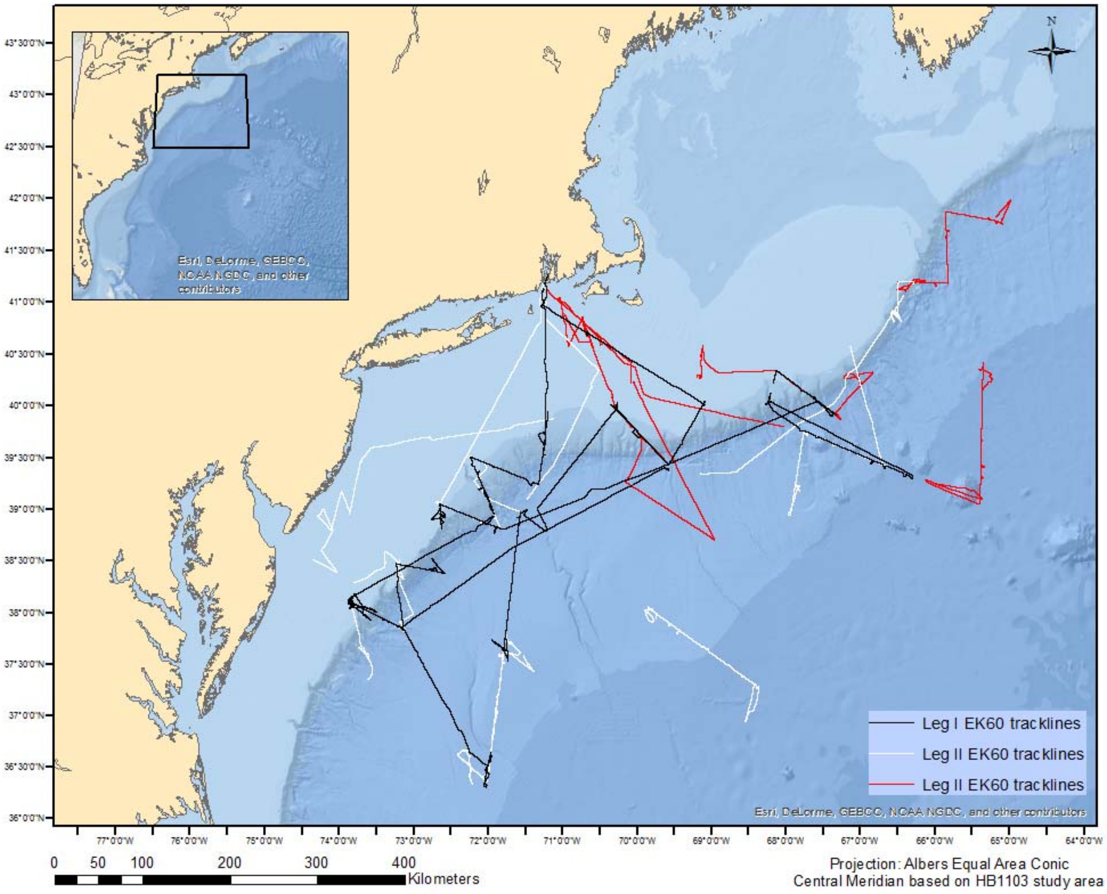


Figure H5. Analyzed EK60 shelf break tracklines. All tracklines have at least one marine mammal sighting. Trackline numbers are based on EK60 lines, not marine mammal tracklines. Tracklines with two or more numbers are spatial duplicates.

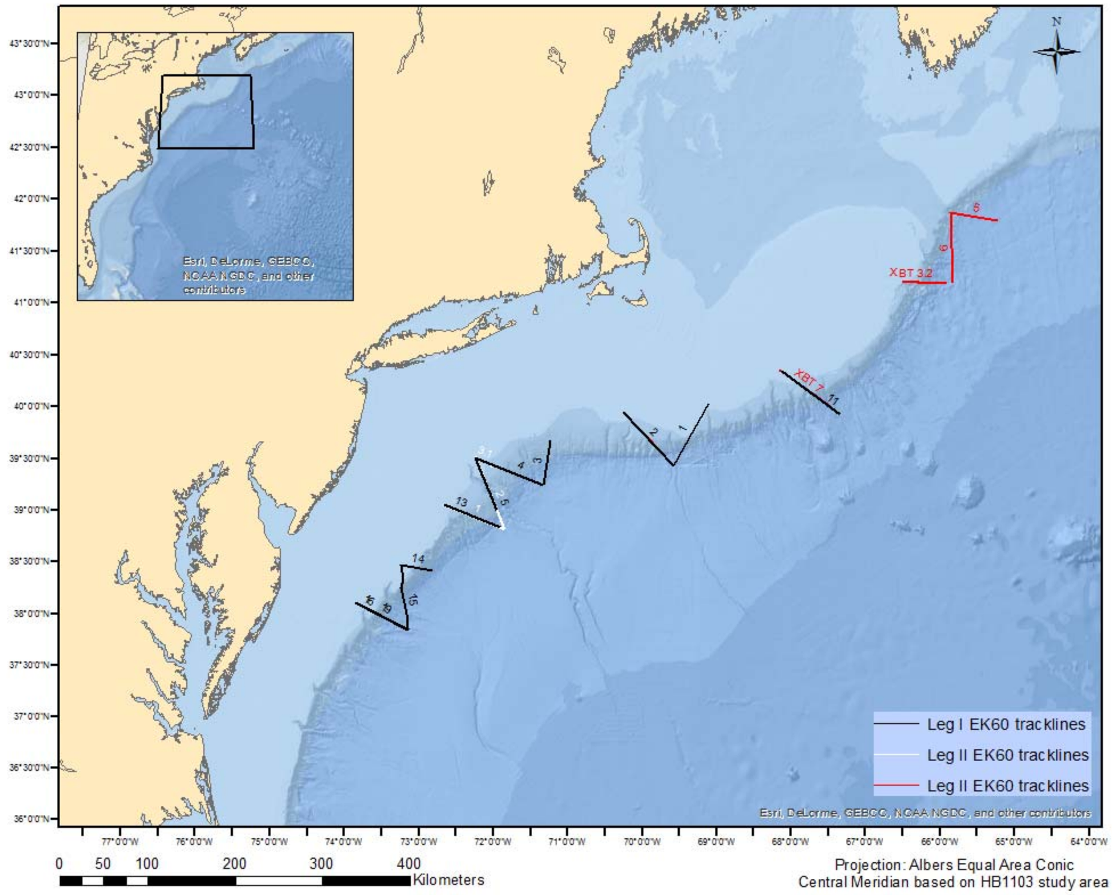


Figure H6. Acoustic trackline Leg 1 Ln01 and Leg 1 Ln02. The x axis is longitude; y axis is latitude; z axis is depth (m). Color shows intensity of volumetric backscatter (Sv) in dB at 18 kHz. The ship's trackline is depicted as the black lines at 0 and 500 meters depth. Symbols along the trackline at 0 meters depth are marine mammal sightings. Backscatter with greater intensity are red to orange, less intense backscatter are green to blue.

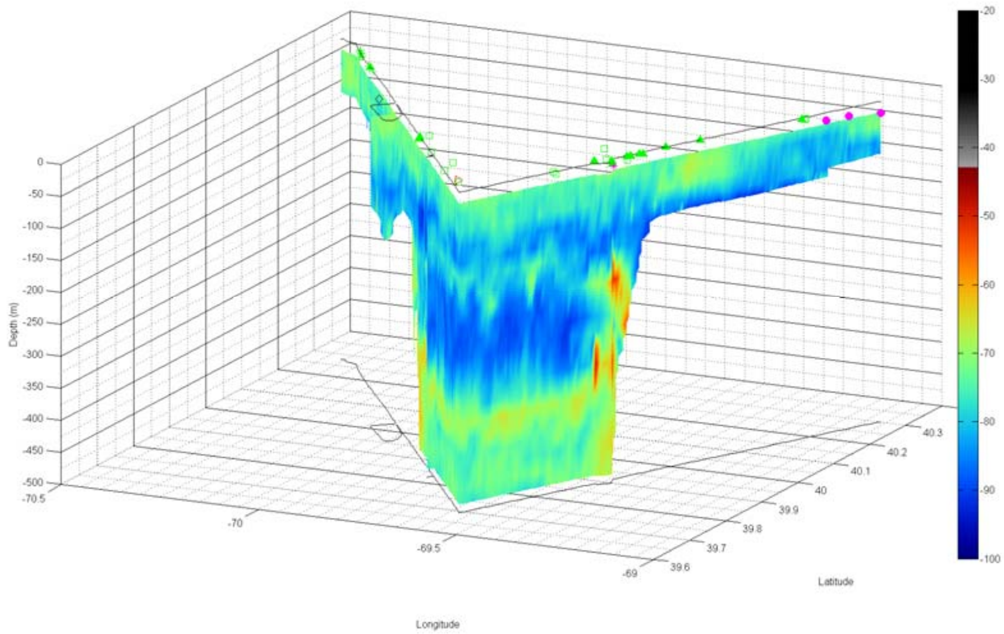


Figure H7. Acoustic trackline Leg 1 Ln01 and Leg 1 Ln02. The x axis is longitude; y axis is latitude; z axis is depth (m). Color shows intensity of volumetric backscatter (Sv) in dB at 200 kHz. The ship's trackline is depicted as the black lines at 0 and 500 meters depth. Symbols along the trackline at 0 meters depth are marine mammal sightings. Backscatter with greater intensity are red to orange, less intense backscatter are green to blue.

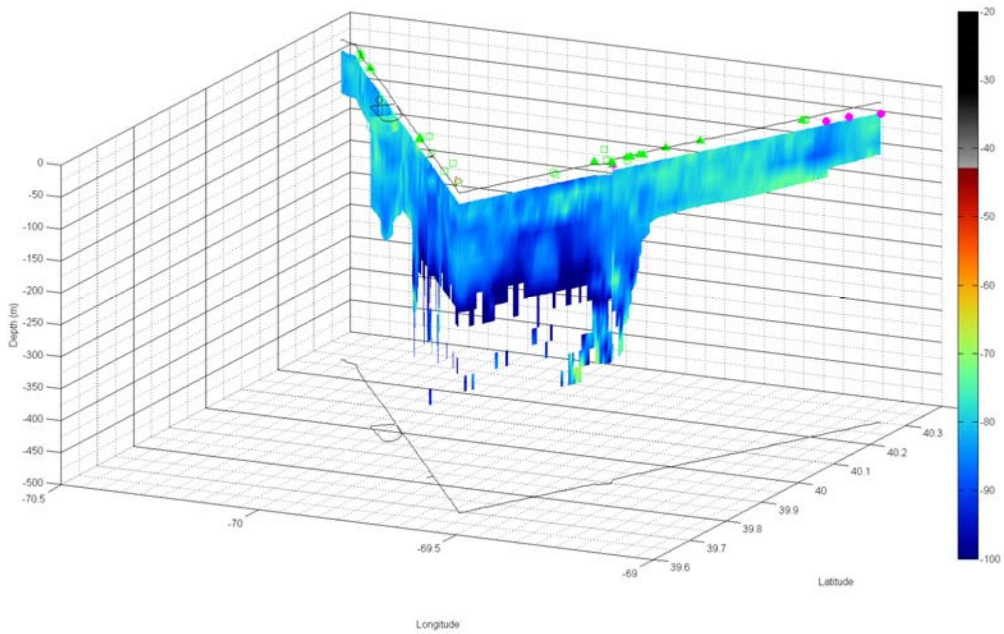


Figure H8. Acoustic trackline Leg 1 Ln01 as straight line transect. The x axis is distance along track (km); y axis is depth (m). Color shows intensity of volumetric backscatter (Sv) in dB at 18 kHz. Sybols along the trackline at 0 meters depth are marine mammal sightings. Asterisks (*) are centroids of acoustic areas of interest.

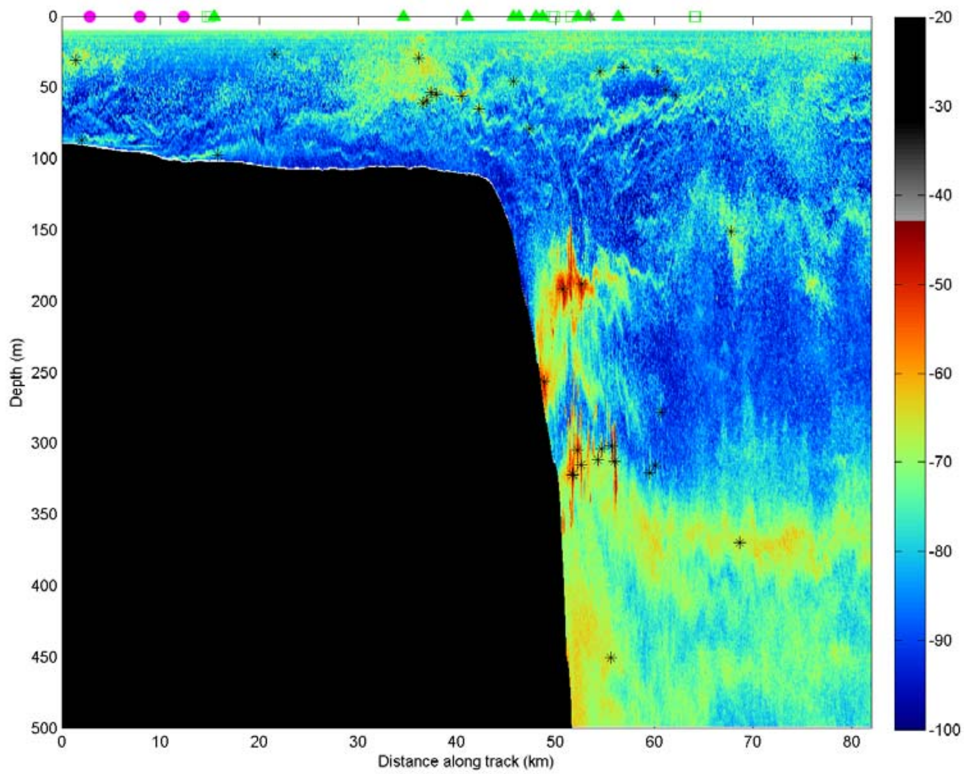


Figure H9. Acoustic trackline Leg 1 Ln01 as straight line transect. The x axis is distance along track (km); y axis is depth (m). Color shows intensity of volumetric backscatter (Sv) in dB at 200 kHz. Symbols along the trackline at 0 meters depth are marine mammal sightings. Asterisks (*) are centroids of acoustic areas of interest.

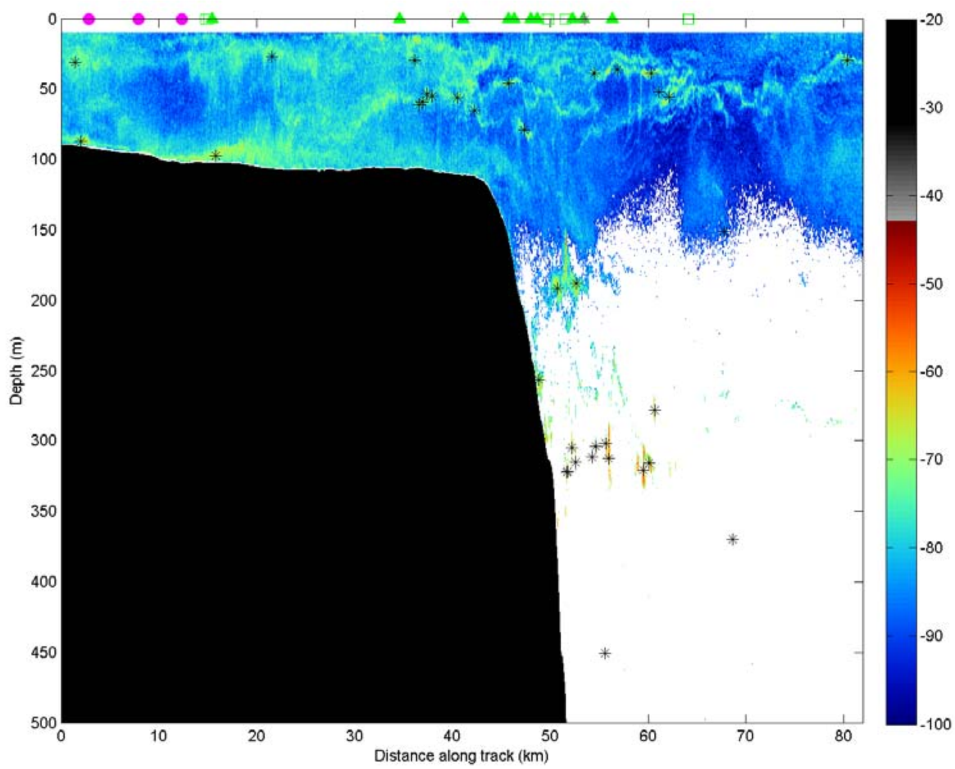


Figure H10. Examples of four different types of temperature and salinity plots for a vertical VPR haul.

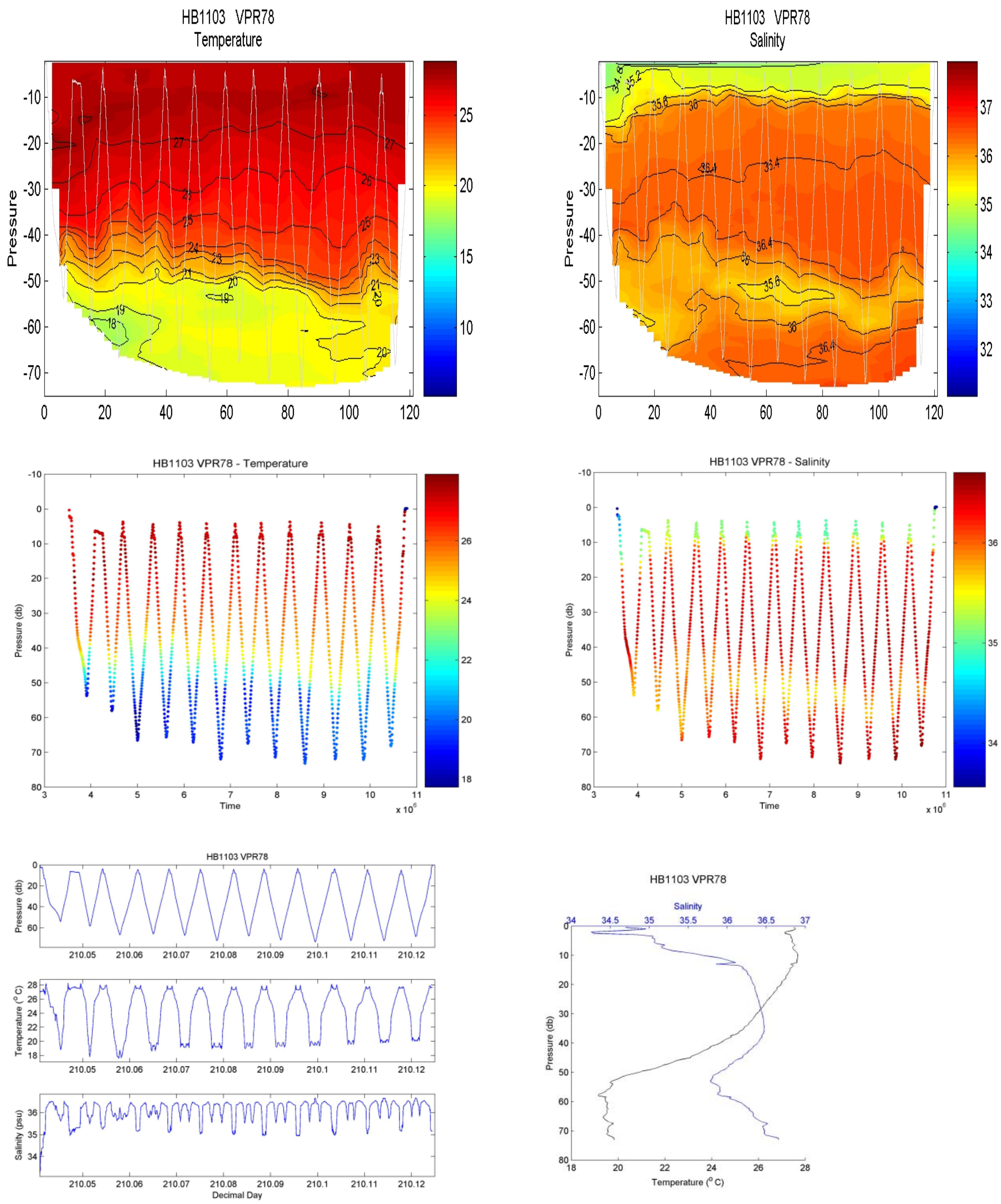


Figure H11. Sample oceanographic data plots for a single depth VPR haul.

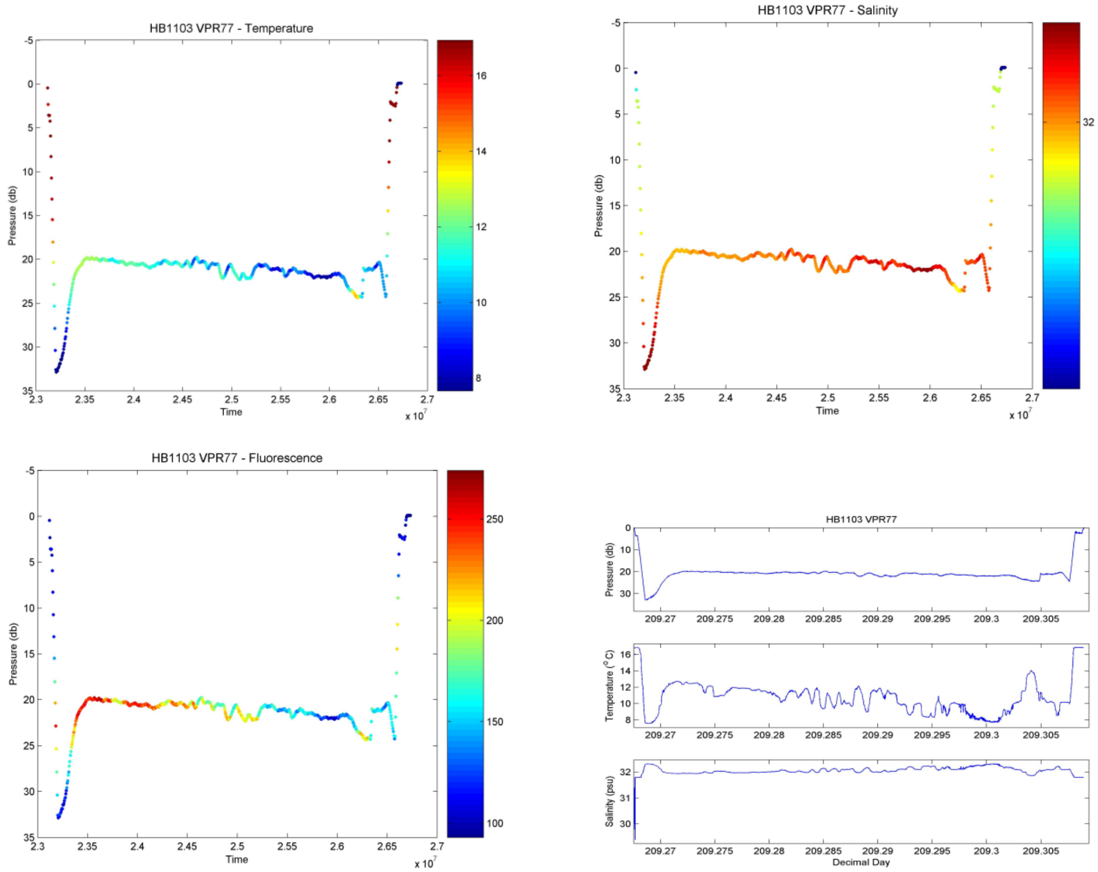
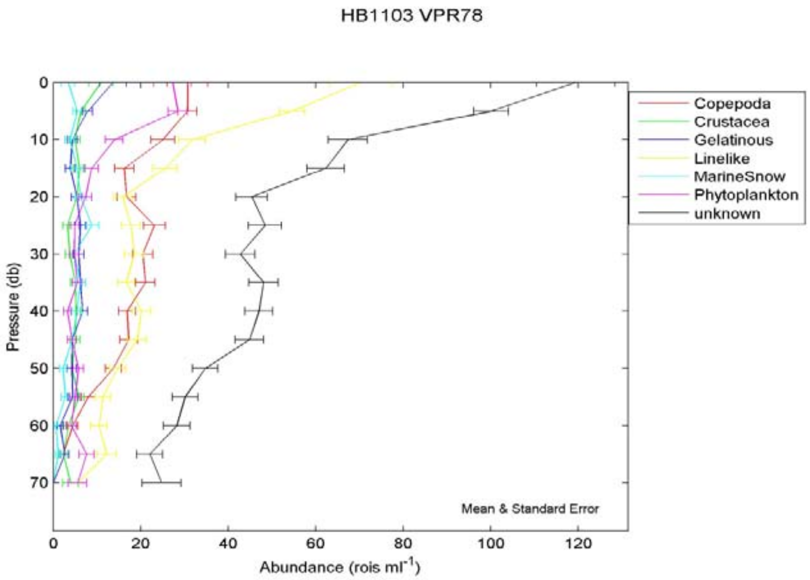
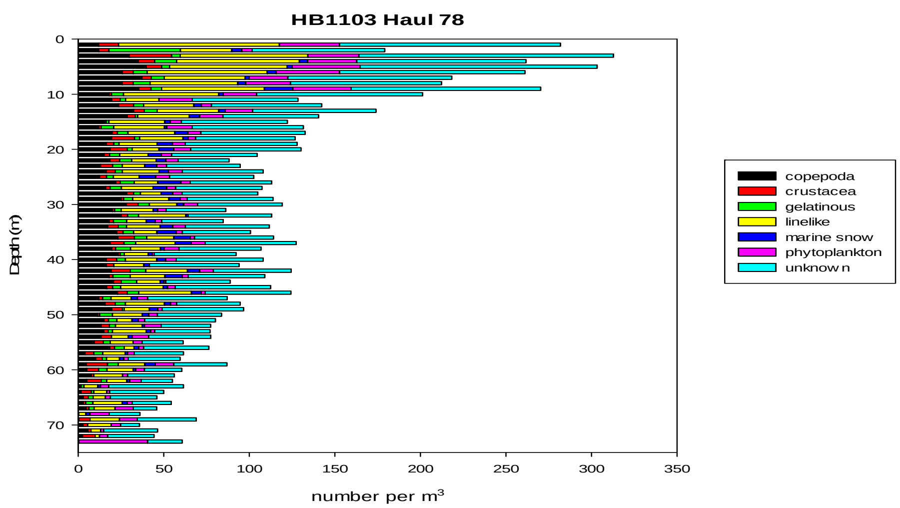


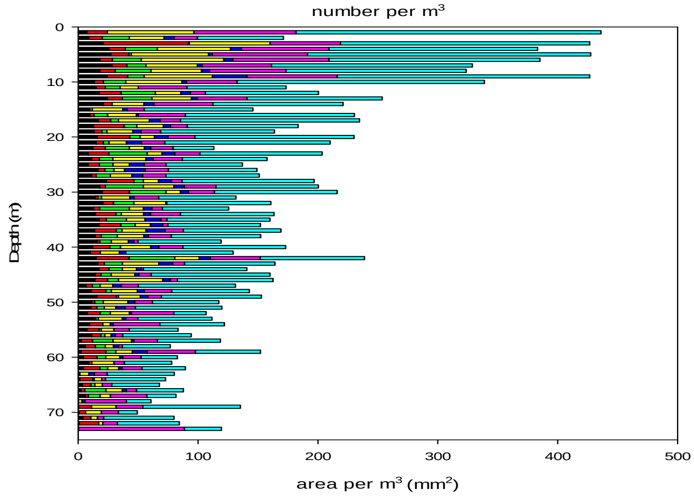
Figure H12. Mean plankton concentrations visualized in 10m (A) and 1m depth bins (B). Plankton area in 1m depth bins (C).



A

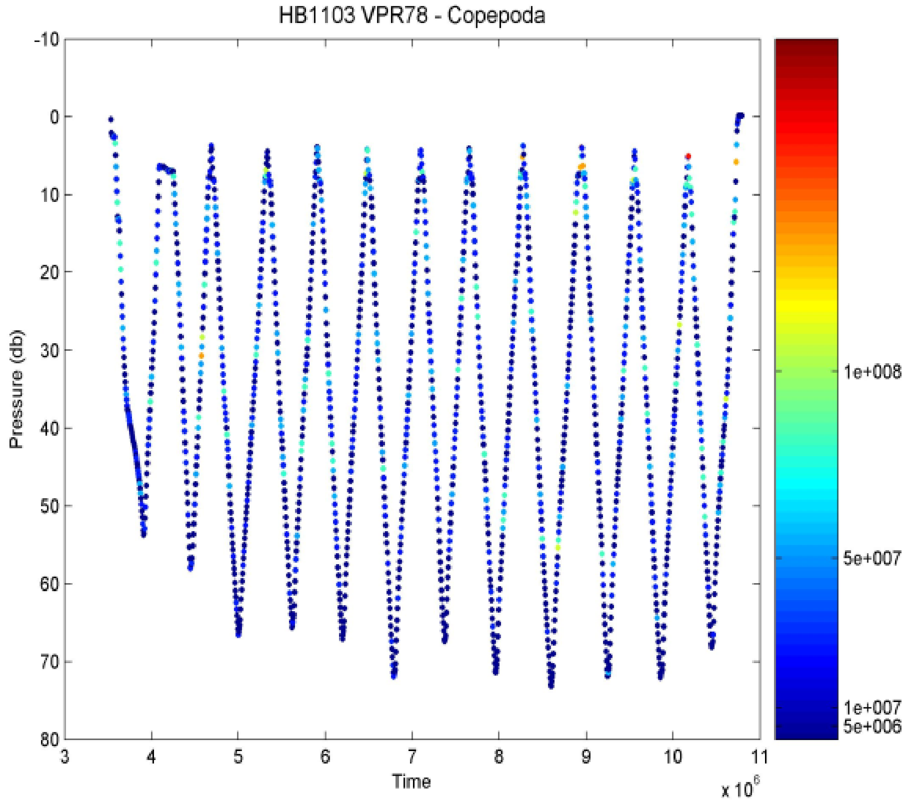


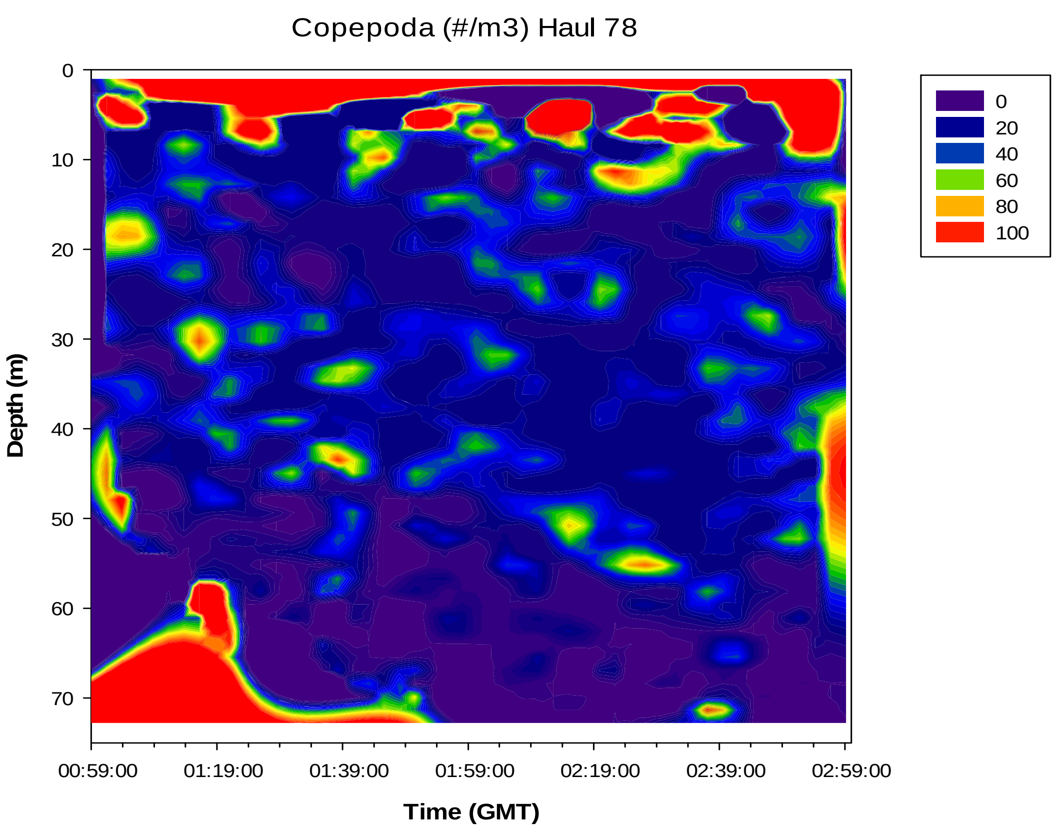
B



C

Figure H13. Plankton concentrations plotted by time and depth.





Appendix I: *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]
Christopher Orphanides[2]

[1]Integrated Statistics, Inc, 172 Shearwater Way, Falmouth, MA 02540
[2]Northeast Fisheries Science Center, 28 Tarzwell Dr., Narragansett, RI 02882

SUMMARY
To achieve the AMAPPS objective of quantifying abundance and spatial distribution, a database is needed to store the collected data. The NEFSC had already created an Oracle database for some of the past NEFSC line-transect abundance surveys. During 2013, this database was expanded to include the NEFSC and SEFSC strip-transect shipboard seabird data, new AMAPPS shipboard and aerial marine mammal and sea turtle data were entered, and new tag data from loggerhead turtles and seals were entered. In addition, environmental data collected by the ship (stored in another Oracle database) were linked to the AMAPPS abundance survey database to obtain the time-specific values of the environmental variables associated with an AMAPPS survey event. Also, the ability to download the Oracle data was also improved to display maps of the sightings, tracklines and tag tracks and to output the data so it can be analyzed by the density models.

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 needs to be developed to store the data collected.

2013 ACTIVITIES
The NEFSC had already created an Oracle database for some of the past NEFSC line-transect abundance surveys. During 2012, this database was expanded to be more flexible to incorporate data from disparate sources and in varying formats. In 2013 the major activities included:

1. Exploring the incorporation of ocean model data, where R scripts were developed to extract HYCOM ocean model rasters of temperatures at various depths to be associated with the AMAPPS point event data.
2. Developing a wiki site to improve communication and data sharing among AMAPPS team, and
3. Adding more data into the Oracle database.

At the end of 2013 the following components were in the database:

1) GPS trackline tables created for NE and SE surveys
    a) NE populated with data from:

i) Pre-AMAPPS aerial surveys: 2002, 2004, 2006, 2007, and 2008

ii) AMAPPS aerial surveys: Summer 2010, Winter 2011, Summer 2011, Fall 2012, Spring 2012

b) SE populated with data from AMAPPS aerial surveys: Summer 2010, Summer 2011, Fall 2012, Spring 2012, Winter 2013

2) Mammal and turtle sightings tables created for NE and SE surveys

a) Populated with data from: AJ9801, AJ9802, AL0108, AL0205, CH9005, CH9103, DE0007, DE0108, DE0207, DE0307, DE0410, DE0411, DE0509, DE0510, DE0612, DE1203, DE1205, DE9808, DE9908, GU1102, GU1301, HB1103, HB1203, ORII1999, SEair0412, SEair2011s, TO1995, TO1998, TO1999, TO2002, TO2004, TO2006, TO2007, TO2008, TO2010, TONEfall2012, TONEspring2012, EN395

3) Mammal and turtle effort tables created for NE and SE surveys

a) Shipboard effort tables populated with data from: EN395, GU1301, HB0709, HB1103

b) Aerial effort tables populated with data from: TO1995, TO1998, TO1999, TO2002, TO2004, TO2006, TO2007, TO2008, TO2010, TONEfall2012, TONEspring2012

4) Bird data tables created

a) Sightings from EN395 (2004), HB0709, HB1103, HB1303, GU1102

b) Effort from EN395 (2004), HB0709, HB1103, HB1303, GU1102

c) Bird data from HB0709, HB1103, and GU1102 submitted to Seabird Consortium

5) Environmental variable tables linked to GPS tracklines created, population with data initiated using custom IDL-based programs and tools, MGET where the primary sources include various NOAA, satellite and ocean model databases

a) Depth

b) Slope

c) Rugosity

d) Distance to Coastline

e) Sea surface temperature (SST)

f) Chlorophyll

ACKNOWLEDGEMENTS
The databases were originally developed and funded by the NEFSC. During 2013 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.