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

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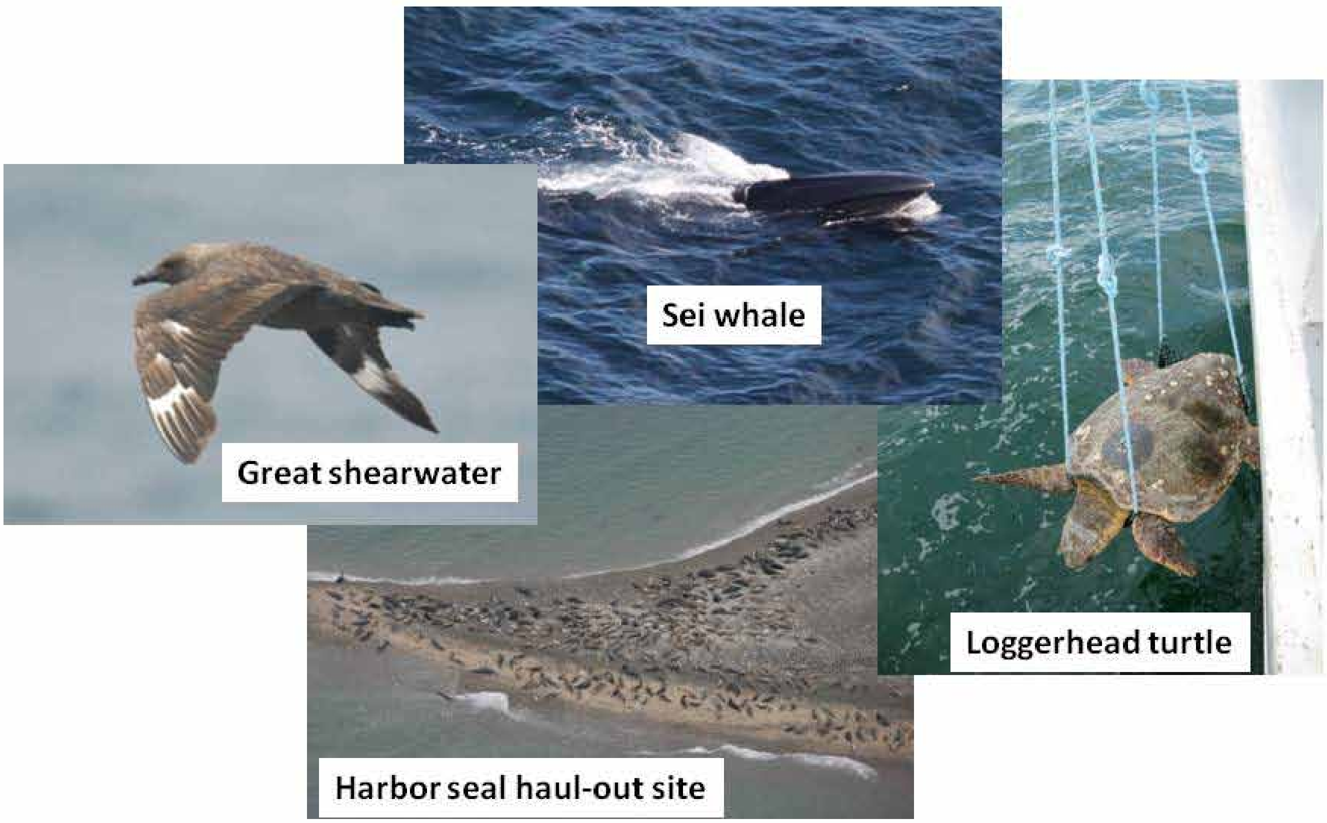

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Background

An inter-agency agreement (IA) was established between the Bureau of Ocean Energy Management (BOEM) and NOAA National Marine Fisheries Service (NOAA Fisheries Service), through which NOAA Fisheries Service will provide services to BOEM in the form of an Atlantic Marine Assessment Program for Protected Species (AMAPPS) in the US Atlantic Ocean from Maine to the Florida Keys. The NOAA Fisheries Service work will be conducted by the Northeast Fisheries Science Center (NEFSC) and the Southeast Fisheries Science Center (SEFSC).

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. It is funded by BOEM, NOAA Fisheries Service, US Fish and Wildlife Service (USFWS), and the US Navy. AMAPPS will coordinate the data collection and analysis efforts of the NOAA Fisheries Service NEFSC and SEFSC and the USFWS Division of Migratory Birds. This effort includes seasonal vessel and aerial surveys for marine mammals, sea turtles, and sea birds to quantify abundance and spatial distribution and to produce spatially explicit density distribution maps. These data will be used to support environmental assessments associated with BOEM and US Navy activities, including anticipated offshore energy exploration projects. These data will also be used to support programs that monitor risk of extinction and recovery of the species detected during the surveys, in particular the non-marine mammal species not already covered under the Marine Mammal Protection Act (MMPA).

In addition, these data will be used to improve the assessment of marine mammal stocks as required under the MMPA. The MMPA requires that stocks of marine mammal species in U.S. waters be maintained at or above their optimum sustainable population level (OSP), defined as the number of animals which results in the maximum net productivity. To meet this requirement, NOAA Fisheries Service conducts research to define stock structure, and for each stock, estimates annual human-caused mortality and potential biological removal (PBR), the maximum number of animals that may be removed from a stock due to human activities (e.g., fisheries bycatch) while allowing the stock to reach or maintain its OSP. PBR is calculated following specific criteria using the estimated abundance of the stock, its maximum net productivity rate (theoretical or estimated), and a recovery factor (Barlow *et al.*, 1995; Wade and Angliss, 1997). NOAA Fisheries Service is required to prepare an annual Stock Assessment Report (SAR) for each stock to update abundance, stock structure, maximum net productivity, human-caused mortality, PBR and status (e.g., Waring *et al.*, 2012). The surveys conducted during 2011 provide data to support updated abundance estimates for U.S. Atlantic oceanic stocks of marine mammals. These estimates were last updated from data collected during 2004.

Summary of 2011 activities

During 2011, NOAA Fisheries Service conducted the following studies that relate to the AMAPPS project (Table 1):

1) Aerial and shipboard line transect abundance surveys of U.S. Atlantic waters during the winter and summer which will result in density/abundance estimates of marine mammals, sea turtles, and sea birds that are at or above the ocean surface within the study area;

2) Loggerhead turtle satellite telemetry studies in U.S. waters which will result in dive time correction factors for the proportion of loggerhead turtles that were underwater and therefore, not available to be detected at the surface during the abundance surveys; in addition, these data provide information on loggerhead turtle habitat use, residence time, behavior, and life history;
3) Harbor seal telemetry and abundance surveys involving radio-tagging seals from Cape Cod, MA and western Penobscot Bay, ME waters and conducting aerial surveys along the Maine coast during the peak harbor seal pupping period; thus, this will result in an updated harbor seal abundance estimate and information on their spatial distribution and habitat preferences.
4) Developed a training tool to assist aerial observers to correctly identify sea turtle species in the US Atlantic and Gulf of Mexico.

During winter (February and March) 2011, the NEFSC and SEFSC conducted aerial line-transect abundance surveys using NOAA Twin Otter airplanes targeting marine mammals and sea turtles designed to cover northern Atlantic continental shelf waters, from southeastern Florida to the southern tip of Nova Scotia, Canada, from the coast line out to either the 200 m depth or 2000 m depth contours, depending on the area (Figure 1; Table 1). The NEFSC completed a survey of a study area including waters north of New Jersey during 28 January – 15 March 2011 with 4850 km of track lines. The SEFSC completed a survey of a study area included waters from North Carolina to Florida during 7 February – 13 March 2011 with 4934 km of track lines. Unfortunately, due to poor weather conditions the region between Virginia and New Jersey was not able to be surveyed. Combining both surveys, 14 species of identifiable cetaceans were detected: fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), minke whales (*B. acutorostrata*), North Atlantic right whales (*Eubalaena glacialis*), pilot (short-fin and/or long-fin) whales (*Globiciphala spp.*), sei whales (*B. borealis*), sperm whales (*Physeter macrocephalus*), Atlantic spotted dolphins (*Stenella frontalis*), bottlenose (coastal and/or offshore) dolphins (*Tursiops truncatus*), common dolphins (*Delphinus delphis*), Risso's dolphins (*Grampus griseus*), rough-toothed dolphins (*Steno bredanensis*), white-sided dolphins (*Lagenorhynchus acutus*), and harbor porpoises (*Phocoena phocoena*). Four turtle species were also detected: green turtles (*Chelonia mydas*), Kemp's ridley turtles (*Lepidochelys kempii*), leatherback turtles (*Dermochelys coriacea*), and loggerhead turtles (*Caretta caretta*). In addition, basking sharks (*Cetorhinus maximus*), sunfish (*Mola mola*), and some seals, sharks and rays were also recorded. The most common small cetacean species were bottlenose dolphins, common dolphins and white-sided dolphins; the most common large whales were sei whales and right whales; and the most common sea turtles were loggerhead turtles, including a couple loggerhead turtles in the central Gulf of Maine which is a rare sighting for the wintertime. Details on the surveys can be found in Appendices A (NEFSC) and B (SEFSC). These sightings and effort data will be archived in the NEFSC Oracle database.

During summer (June – August) 2011, the NEFSC and SEFSC conducted aerial and shipboard line-transect abundance surveys targeting marine mammals, sea turtles, and sea birds designed to cover northern Atlantic waters from Florida to Nova Scotia, Canada, from the coast line out to the U.S. exclusive economic zone; EEZ (Figure 2; Table 1). The aerial surveys targeting marine mammals and sea turtles were designed to cover northern Atlantic continental shelf waters (southeastern Florida to the southern tip of Nova Scotia, Canada, for the coast line out to either the 100 or 200 m depth contours, depending on the area). The shipboard surveys targeting marine mammals, sea turtles, and sea birds were designed to cover the deeper waters, starting from the offshore extent of the aerial surveys and ending at or slightly beyond the U.S. EEZ. On the ships, in addition to visual sighting surveys, a variety of other activities were conducted: biopsy samples were collected from cetaceans for species identifications and stock structure analyses; passive acoustic data were collected from vocalizing marine mammals using towed hydrophones and Expendable Directional Frequency Analysis and Ranging (DIFAR) sonobuoys; backscatter data of other trophic levels were collected using active acoustics, the scientific echosounder EK60 and Acoustic Current Doppler Profiler (ADCP); physical water characteristics were collected using Conductivity, Temperature and Depth profilers (CTDs) and Expendable Bathythermographic profilers (XBTs) and using the ship's continuously recording systems which samples surface waters; and plankton samples were collected using bongo nets and a visual plankton recorder (VPR). The NEFSC surveyed 11,528 km of track lines (6481 km in the aerial survey and 5047 km in the shipboard survey), while the SEFSC surveyed 13,678 km of track lines (8665 km in the aerial survey and 5013 km in the shipboard survey). Combining all of the surveys, 27 species of identifiable cetaceans were detected: Blainville's beaked whales (*Mesoplodon densirostris*), Bryde's whales (*Balaenoptera edeni*), Cuvier's beaked whales (*Ziphius cavirostris*), dwarf sperm whales (*Kogia simus*), fin whales, Gervais' beaked whales (*M. europacus*), humpback whales, killer whales (*Orcinus orca*), North Atlantic right whales, minke whales, pilot (short-fin and/or long-fin) whales, pygmy sperm whales (*K. breviceps*), sei whales, Sowerby's beaked whales (*M. bidens*), sperm whales, Atlantic spotted dolphins, bottlenose (coastal and/or offshore) dolphins, Clymene dolphins (*Stenella clymene*), common dolphins, false killer whales (*Pseudorca crassidens*), Pantropical spotted dolphins (*S. attanuata*), Risso's dolphins, rough-toothed dolphins, spinner dolphins (*S. longirostris*), striped dolphins (*S. coeruleoalba*), white-sided dolphins, and harbor porpoises. Four turtle species were positively identified: green turtles, Kemp's ridley turtles, leatherback turtles, and loggerhead turtles. In addition, 45 species of birds were detected. Plus, basking sharks, sunfish, and some seals, sharks and rays were also recorded. The most common small cetacean species detected were common dolphins, bottlenose dolphins, and striped dolphins; the most common large whales were fin whales, Cuvier's beaked whales, and minke whales; the most common sea turtles were loggerhead turtles; and the most common seabirds were Great shearwaters (*Puffinus gravis*), Wilson's storm-petrels (*Oceanites oceanicus*), Leach's storm-petrel (*Oceanodroma leucorhoa*), and Cory's shearwaters (*Calonectris diomedea*). Details on the aerial surveys can be found in Appendices A (NEFSC) and B (SEFSC). Details on the shipboard surveys can be found in Appendices C (NEFSC) and D (SEFSC). These sightings and effort data will be archived in the NEFSC Oracle database.

The NEFSC, in collaboration with Coonamessett Farm Foundation and the sea scallop industry, conducted a loggerhead turtle tagging study. During 2 – 6 June 2011, NEFSC deployed satellite tags on 15 immature loggerhead turtles in waters 40 – 80 miles off Delaware to Virginia. Coonamessett Farm Foundation deployed an additional 10 identical tags in 2011. Each of the tagged loggerhead turtles were weighed, carapace length and body depth were measured, biopsy samples for genetic analyses were collected, and blood samples were collected to analyze for testosterone levels (to identify sex) and general blood chemistry (for health assessment). As of 20 October 2011, all of the 2011 tags and three of the 2010 tags were still actively transmitting. As of 4 June 2012, fourteen tags from 2011 have been transmitting for about one year. More details can be found in Appendix E. The NEFSC and Coonamessett Farm Foundation satellite tag data are archived in the Northeast Sea Turtle Collaborative Oracle database, maintained by the NEFSC.

To estimate the abundance of harbor seals, the NEFSC developed a practical and statistically valid survey design. This design involved first tagging harbor seals, then simultaneously conducting an aerial abundance survey of seals at haul out sites with one plane and a radio tracking aerial survey with another plane to detect if the tagged seals are hauled out. The proportion of detected tagged seals would then be used to correct for the animals not at a haul out site and thus not available to be detected during the aerial abundance survey. To implement this survey design, fifteen harbor seals were tagged with VHR radio transmitters in outer Cape Cod, MA waters in early April 2011 and six in western Penobscot Bay, ME in April/May 2011. In addition, satellite tags were deployed on two of the seals from Maine. The aerial survey and radio tracking components were scheduled for the 21 – 30 May; however, survey operations were significantly curtailed by coastal fog during the time when low tides were in the middle of day (only time available to conduct an abundance survey of pupping seals on haul out sites). Consequentially, there were insufficient data collected to estimate the abundance of the harbor seals. Thus, the tagging and abundance surveys will be repeated in spring 2012. More details can be found in Appendix F. The satellite tag data from the two Maine seals are archived in the NEFSC Oracle database.

Due to the increase in the numbers of observers in aerial surveys conducted by NMFS and FWS and the difficult of correctly identified sea turtles which are relative small and are available to be seen on the surface for only short time periods, the SEFSC developed the "Guide to the aerial identification of sea turtles in the US Atlantic and Gulf of Mexico" (Goodman Hall and Belskis 2012). This document provides tips and guidance on what to look for, descriptions and photographs of species-specific key physical features that can be detected at survey altitudes, and biological information such as range maps that show the approximate previously documented distribution of each species. A draft version of this document was distributed to the NMFS and FWS aerial surveys that were conducted during 2011. The final version will be very helpful in the future.

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Table 1. General information on the NMFS projects within the 2011 AMAPPS initiative: the NMFS center principal investigator (PI), platforms used, dates, and general location where the completed research occurred.

Project	PI	Platform	Dates in 2011	Location
Winter abundance survey	NEFSC	NOAA Twin Otter aircraft	28 Jan - 15 Mar	Shelf waters north of New Jersey to Nova Scotia
	SEFSC	NOAA Twin Otter aircraft	7 Feb – 13 Mar	Shelf waters from North Carolina to Florida
Summer abundance survey	NEFSC	NOAA Twin Otter aircraft	7 - 26 Aug	Shelf waters north of North Carolina to Nova Scotia
		NOAA ship Henry B. Bigelow	2 Jun - 1 Aug	Offshore waters north of North Carolina to Massachusetts
	SEFSC	NOAA Twin Otter aircraft	6 – 29 Jul	Shelf waters from North Carolina to Florida
		NOAA ship Gordon Gunter	21 Jun - 2 Aug	Offshore waters from North Carolina to Florida
Loggerhead turtle tagging	NEFSC	F/Vs Kathy Ann and Ms. Manya	2 - 6 Jun	40 – 80 nmi off the coasts of Delaware through Virginia.
Harbor seal tagging	NEFSC	small boats	7 - 10 Apr; 24 - 29 Apr; 13 - 15 May	Cape Cod, MA and western Penobscot Bay, ME
Harbor seal abundance survey	NEFSC	NOAA Twin Otter aircraft	21 - 30 May	Maine coast
Sea turtle id guide	SEFSC	-	-	Applicable to the US Atlantic and Gulf of Mexico

Figure 1. Tracklines completed during the winter (Jan-Mar) 2011 AMAPPS aerial survey

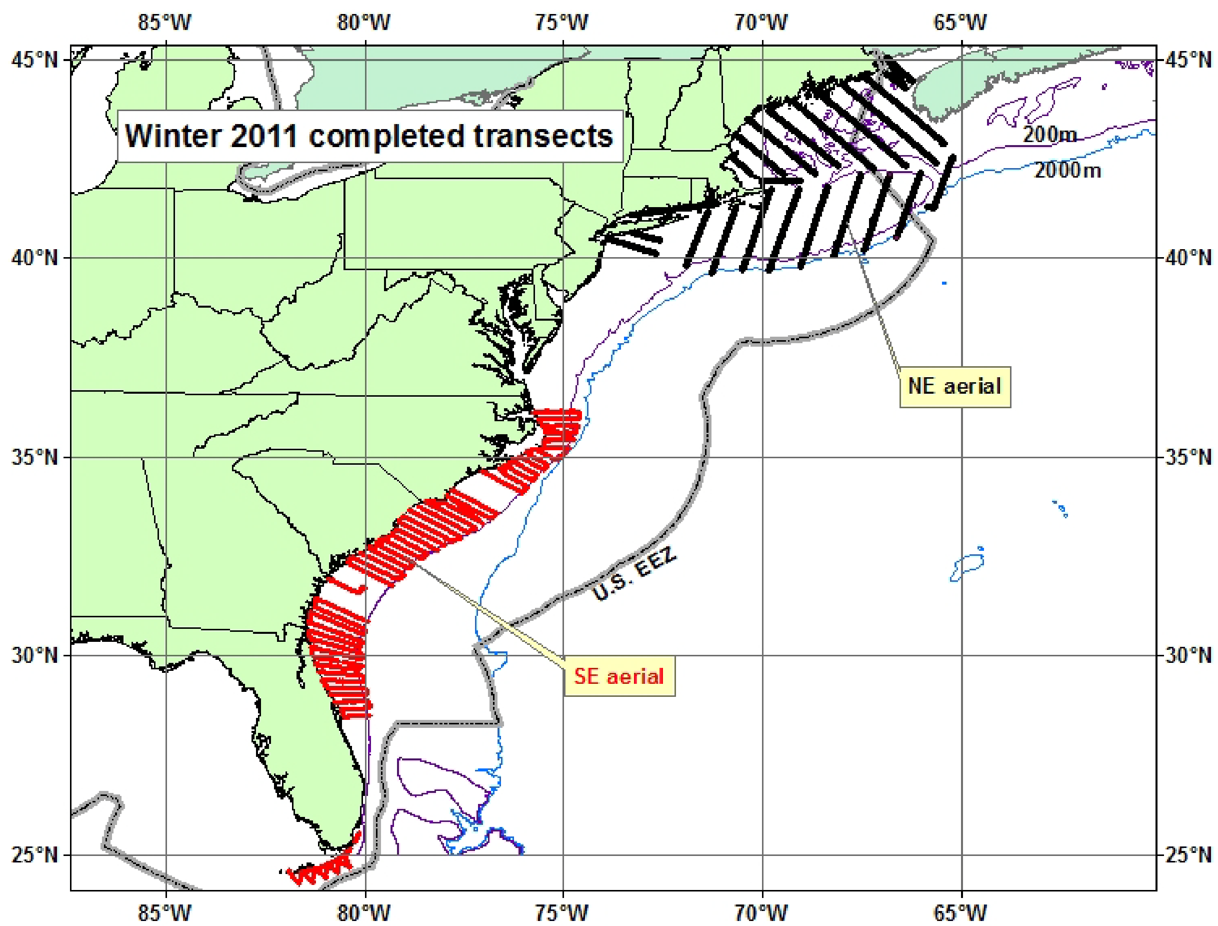
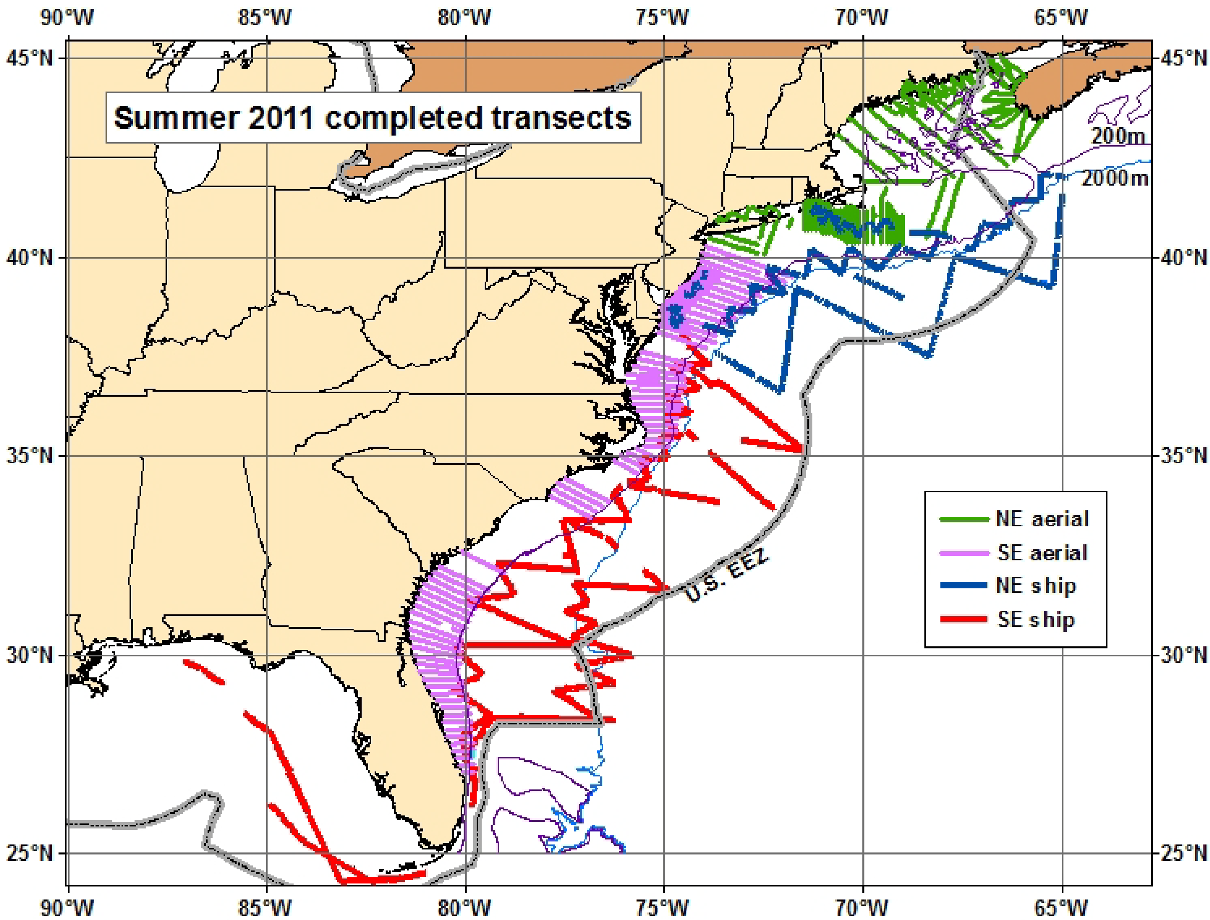


Figure 2. Tracklines completed during the summer (Jun-Aug) 2011 AMAPPS aerial and shipboard survey



Appendix A: *Northern leg of aerial abundance surveys during winter and summer 2011: Northeast Fisheries Science Center*

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Summary

During 28 January – 15 March 2011 and 7 – 26 August 2011, the Northeast Fisheries Science Center (NEFSC) conducted aerial abundance surveys targeting marine mammals and sea turtles. These surveys covered waters from New Jersey to the southern tip of Nova Scotia, Canada, and from the coast line to about the 2000 m depth contour in the winter and to the 100 m depth contour in the summer. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots). To compare data collection methods used to estimate visibility bias, the Hiby circle-back data collection method was used during the winter and the two independent team method was used in the summer. In Beaufort sea states of 4 and less, about 4850 km of on-effort track lines were surveyed in the winter survey and 5979 km in the summer survey. During winter, over 1100 individuals within 304 groups of animals were detected. The most regularly detected small cetacean species were common dolphins, white-sided dolphins and harbor porpoises; the most common large whale was the sei whale. Only a few sea turtles were detected, which is still notable since it was winter and no turtles were expected. During summer, over 1500 individuals of 10 species of identifiable cetaceans, 3 sea turtle species, 1 identifiable seal species, and three fish species were detected. The most regularly detected small cetacean species were common dolphins, harbor porpoises, and white-sided dolphins, the most common large whale was the minke whale, and the most common turtle was the leatherback turtle.

Cruise Period and Area

Winter survey

The winter survey was conducted during 28 January – 15 March 2011. The study area extended from New Jersey to the southern tip of Nova Scotia, Canada, from the coast line to about the 2000 m depth contour (Figure A1).

Summer survey

The summer survey was scheduled for 1 – 31 August 2011. Tracklines were flown during 7 – 26 August 2011. The plane was unavailable during 1 – 6 August when the 100 hour normal maintenance was conducted and the plane was unavailable during 27 – 31 August because it was re-assigned to cover emergency weather related flights in the southern U.S. The study area extended from New Jersey to the southern tip of Nova Scotia, Canada, from the coast line to about the 100 m depth contour (Figure A2).

Objectives

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

Methods

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

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

- Time animal passed perpendicular to the observer;
- Species identification;
- Best estimate of the group size;
- Angle of declination between the track line and location of the animal group when it passed abeam (measured to the nearest one degree by inclinometers or marks on the windows, where 0º is straight down);
- Cue (animal, splash, blow, footprint, birds, vessel/gear, windrows, disturbance, or other);
- Swim direction (0º indicates animal was swimming parallel to the track line in the same direction the plane was flying, 90º indicates animal was swimming perpendicular to the track line and towards the right, etc.);
- If the animal appeared to react to the plane (yes or no);
- If the animal was diving (yes or no), and;
- Comments, if any.

Other fish species were also recorded opportunistically. Species identifications were recorded to the lowest taxonomic level possible. This resulted in species specific identifications only when the observers were certain of the identification; otherwise, the group was identified to a higher level of identification (e.g., fin or sei whale, or unidentified dolphin).

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

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

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

To help correct for visibility bias, the parameter *g(0)*, the probability of detecting a group on the track line, was estimated. During the winter this was accomplished by using the Hiby circle-back method (Hiby 1999) for animals in groups of five or less animals. During the summer this was accomplished by using the two independent team method. These two methods will be compared to evaluate which method produces the least biased, most precise abundance estimates and is practically the easiest to implement.

Winter survey
Onboard, in addition to the two pilots, were four scientists (three observers and one recorder). One of the observers was searching through the back belly window, one in the forward starboard (right) bubble window and one in the forward port (left) bubble window.

The Hiby circle-back method (Hiby 1999) was used for animals that were in groups of five or less animals. This method modifies the standard single-plane line transect method by circling back and re-surveying a portion of the track line (Figure A3). The re-surveyed track lines were called "trailing" legs; sections of the track lines that initiated the circle were called "leading" legs; and sections of the track lines between the circles were called "single-plane" legs. As in the case of two teams on a ship or plane, *g(0)* can be estimated using the data collected during the leading and trailing legs, as they are comparable to data collected by two teams. The trailing legs corresponded to times when a second team was "on effort", while the leading legs corresponded to times when the primary team was "on effort" at the same time as the second team, and the single-plane legs corresponded to times when the primary team was "on effort" as a single team. Thus, *g(0)* can be estimated using data collected when both teams were "on effort", that is, using data from the trailing and leading legs.

The criterion that started a circle-back was a single small group ($\le$ 5 animals) of cetaceans or turtles that was seen within a 30 second time period. The procedure used was as follows (Figure A3):

1. Time and location of an initial sighting when it passed abeam of the plane was marked and started a 30-second timer,
2. During the 30-seconds, additional sightings were recorded as usual. If more than one additional sighting of the same species that triggered the circle was recorded during this time, then the circle-back procedure was aborted (because the density may be too high to accurately determine if a group of animals was the same group on both the leading and trailing legs of the track line).
3. At the end of the 30-seconds, if the criterion in number 2 was passed, the plane started to circle back and the observers went "off effort". The time leaving the track line was marked, which started another timer for 120 seconds.
4. During this 120 seconds, the plane circled back 180º and traveled parallel to the original track line about 0.8 nmi away, in the opposite direction, and on either side of the original track line.
5. At the end of the 120 seconds, the plane started to fly back to the track line.
6. When the plane intercepted the original track line, the time was marked, observers went back "on effort", they started searching again, and a 5-minute timer was started.
7. Sightings were then recorded as usual.
8. The circle-back procedure was not initiated again until a sighting was made after the 5-minute timer had expired. This was to insure forward progress on the track line.

Summer survey
Onboard, in addition to the two pilots, were six scientists who were divided into two teams. One team, the primary forward team, consisted of a recorder and two observers viewing through the

two forward right and left bubble windows. The other team, the independent back team, consisted of one observer viewing through the back belly window and a recorder. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

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

When both teams could not identify the species of a group that was within about 50º of the track line and there was a high chance that the group could be relocated, sighting effort was broke off, and the plane returned to the group to confirm the species identification and group size. The marine mammal and turtle data will be reviewed at a later time to identify duplicate sightings made by the two teams based upon time, location, and position relative to the trackline.

Results

Winter survey

Eight days had sufficiently good weather to conduct the survey and the plane was available. There were about 4850 km of "on-effort" track lines.

On the on-effort track lines, 1100 individual cetaceans within 238 groups were detected (Table A1). The locations of sightings seen on the on-effort winter transect legs, by species, are displayed in Figures A4 to A10, where porpoises are in Figure A4, dolphins in Figures A5 – A7, whales in Figures A8 – A9, and seals, sea turtles and other species in Figure A10. The sightings included nine species of identifiable cetaceans: minke whales, fin whales, sei whales, pilot whales, white-sided dolphins, common dolphins, Risso's dolphins, bottlenose dolphins, and harbor porpoises. In addition, loggerhead turtles, sunfish and seals were also seen. The most regularly detected small cetacean species were common dolphins, white-sided dolphins and harbor porpoises. Sei whales were the most common large whale. Only a couple turtles were detected. However, given it was winter the loggerhead turtles seen in the central portion of the Gulf of Maine are considered rare sightings.

Summer survey

Of the 31 days allocated to this project, 11 days had sufficiently good weather to conduct the survey and the plane was available. There were 6,481 km of "on-effort" track lines, of which 5979 km (92%) were surveyed in Beaufort 3 or less (Table A2).

On the on-effort track lines, 1128 individual cetaceans (435 groups) were detected by the forward team (Table A3). These comprised of 10 species of identifiable cetaceans: minke whales, fin whales, sei whales, right whales, sperm whales, humpback whales, white-sided dolphins, common dolphins, bottlenose dolphins and harbor porpoises. In addition, leatherback turtles, loggerhead turtles, green turtles, basking sharks, hammerhead sharks, sunfish and seals (either harbor or gray) were seen. The most regularly detected small cetacean species were common dolphins, harbor porpoises, and white-sided dolphins; the most common large whale was the minke whale; and the most common turtle was the leatherback turtle.

The locations of sightings seen while on the on-effort summer transects, by species, are displayed in Figures A11 to A21, where porpoises are in Figure A11, dolphins in Figures A12 – A13, whales in Figures A14 – A16, harbor or unidentified seals in Figure A17, sea turtles in Figure A18, and other species in Figures A19 – A21.

Disposition of the data

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

Permits

NEFSC was authorized to conduct these research activities during this survey under Permit No. 775-1875 issued to the NEFSC by the NMFS Office of Protected Resources. The NOAA aircraft Nwas granted diplomatic overflight clearance in Canadian airspace with the overflight clearance number 0067-US-2011-02-TC.

Literature cited

Hiby, L. 1999. The objective identification of duplicate sightings in aerial survey for porpoise. Pages 179-189 *in*: Garner *et al.* (eds). Marine Mammal Survey and Assessment Methods. Balkema, Rotterdam.

Table A1. Winter 2011 Northeast AMAPPS aerial survey: Number of groups and individuals of species detected while on-effort during the leading, trailing and single legs. Some of the groups seen in the trailing legs were also seen during the leading legs.

Species		number of groups	number of animals
Bottlenose dolphin spp.	*Tursiops truncatus*	5	74
Common dolphin	*Delphinus delphis*	10	305
Fin whale	*Balaenoptera physalus*	5	5
Harbor porpoise	*Phocoena phocoena*	92	142
Minke whale	*B. acutorostrata*	1	1
Risso's dolphin	*Grampus griseus*	24	90
Pilot whale spp.	*Globiciphala spp.*	7	8
Sei whale	*B. borealis*	9	18
Common or white-sided dolphin		4	75
Unid dolphin	*Delphinidae*	42	118
Unid whale	*Mysticeti*	12	15
White-sided dolphin	*Lagenorhynchus acutus*	27	249
Total cetaceans		**238**	**1100**
Ocean sunfish	*Mola mola*	1	1
Loggerhead turtle	*Caretta caretta*	2	2
Unid hardshell turtle	*Chelonioidea*	1	1
Unid seal	*Pinniped*	62	66
Total all species		**304**	**1170**

Table A2. Summer 2011 Northeast AMAPPS aerial survey: Lengths and percentages of on-effort track lines covered during various Beaufort sea states.

	Beaufort sea states						
	0	1	2	3	4	5	Total
Length (km)	132.4	2271.4	2069.3	1506	501.2	0.1	6480.4
Percentage	0.02	0.35	0.32	0.23	0.08	0.00	1
Cumulative %	0.02	0.37	0.69	0.92	1	1	

Table A3. Summer 2011 Northeast AMAPPS aerial survey: Number of groups and individuals of species detected by each team (back or front), while on-effort.

Species		Number of groups		Number of individuals	
		back	front	back	front
Bottlenose dolphin spp.	*Tursiops truncatus*	0	3	0	4
Common dolphin	*Delphinus delphis*	8	11	113	415
Fin whale	*Balaenoptera*	0	7	0	7
Fin/sei whales	*B. physalus or B.*	0	4	0	4
Harbor porpoise	*Phocoena phocoena*	60	129	185	375
Humpback whale	*Megaptera*	0	8	0	10
Minke whale	*B. acutorostrata*	3	18	3	18
Right whale	*Eubalaena glacialis*	0	1	0	1
Sei whale	*Balaenoptera*	1	1	1	1
Sperm whale	*Physeter*	0	2	0	2
Common or white-sided dolphin		3	2	7	20
Unid dolphin	*Delphinidae*	2	6	2	29
Unid whale	*Mysticeti*	2	8	2	8
White-sided dolphin	*Lagenorhynchus*	11	16	122	234
Total cetaceans		**90**	**216**	**435**	**1,128**
Basking shark	*Cetorhinus maximus*	24	61	27	65
Ocean sunfish	*Mola mola*	71	236	73	253
Hammerhead shark	*Sphyrnidae*	1	1	1	1
Leatherback turtle	*Dermochelys*	9	31	9	32
Loggerhead turtle	*Caretta caretta*	12	21	12	22
Green turtle	*Chelonia mydas*	0	5	0	5
Unid hardshell turtle	*Chelonioidea*	3	3	3	3
Harbor seal	*Phoca vitulina*	2	2	2	2
Unid seal	*Pinniped*	12	35	13	38
Total all species		**224**	**611**	**575**	**1,549**

Figure A1. Winter 2011 Northeast AMAPPS aerial survey: completed tracklines.

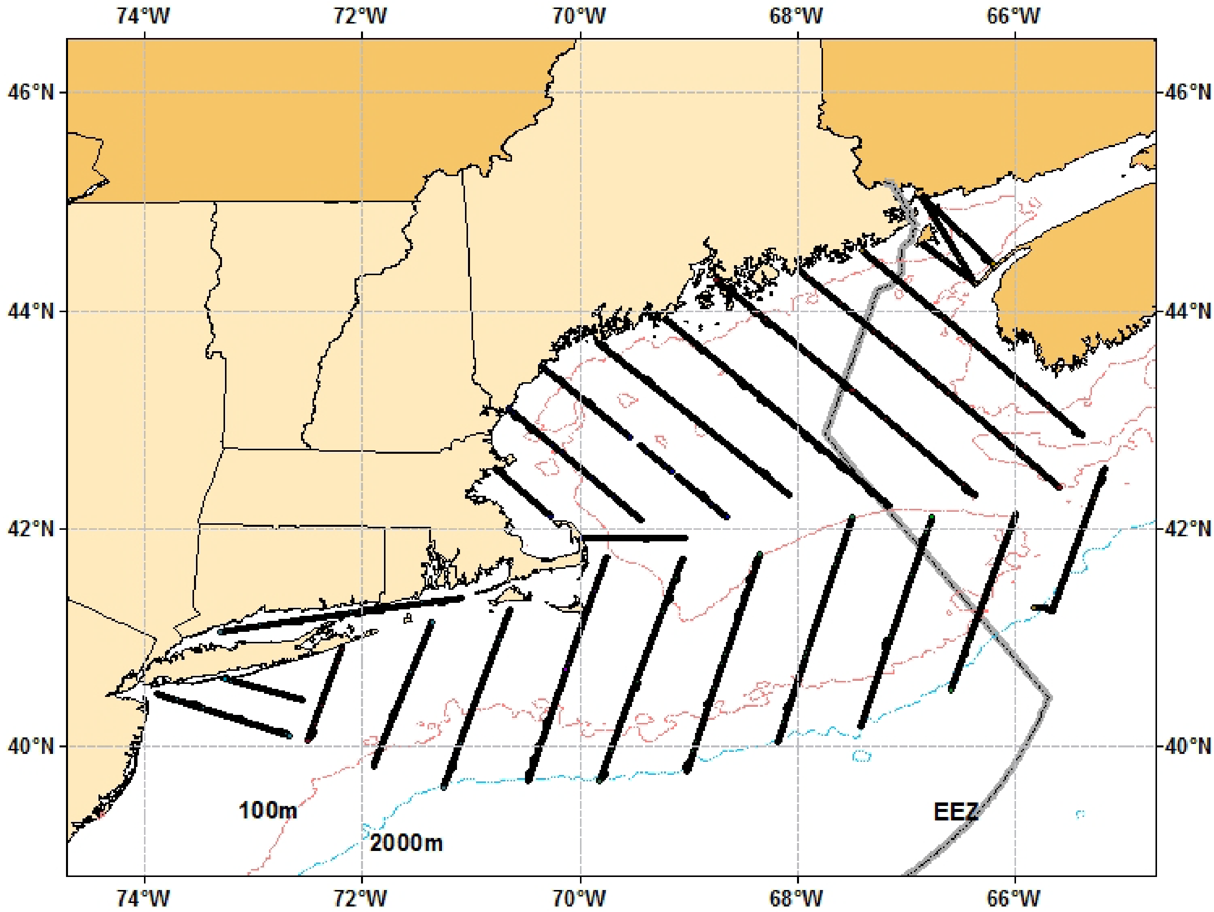


Figure A2. Summer 2011 Northeast AMAPPS aerial survey: completed tracklines. Line colors correspond to Beaufort sea state during which the flight was conducted in.

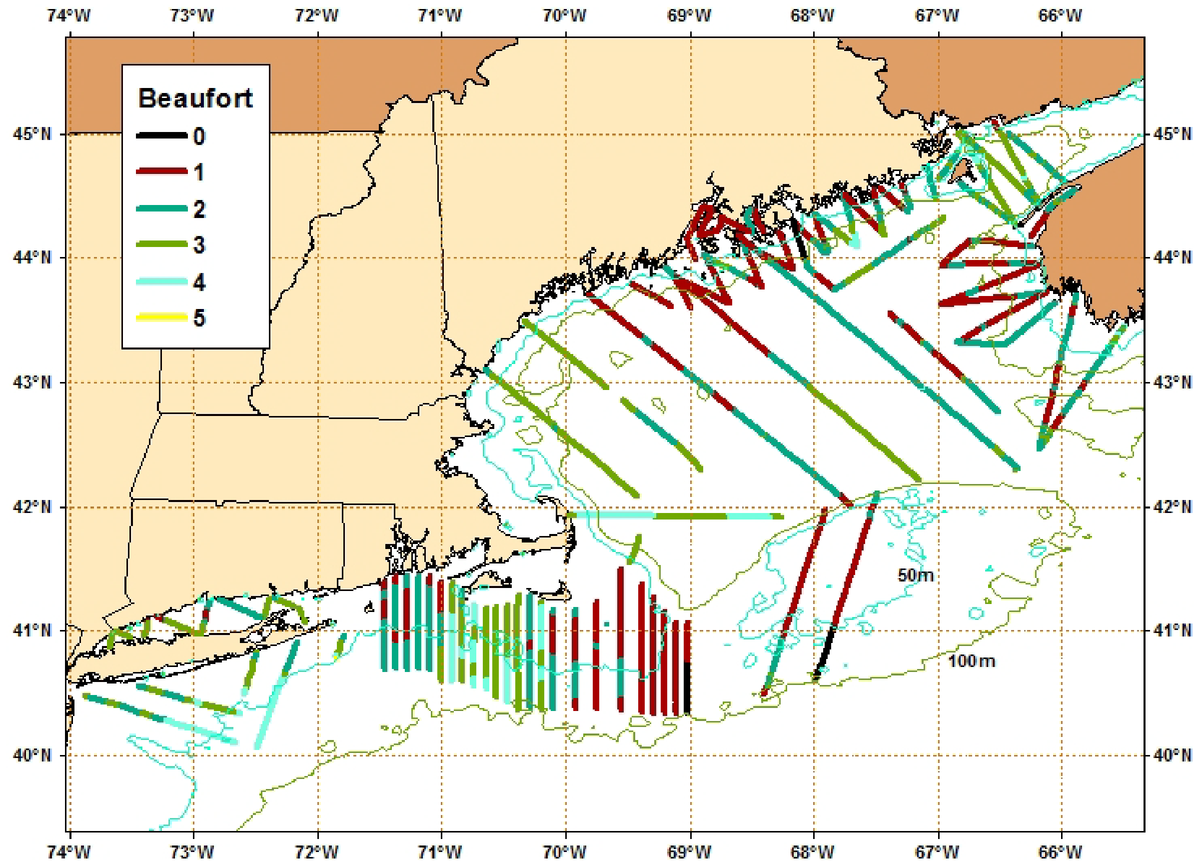


Figure A3. Diagram of how the circle-back technique was performed.

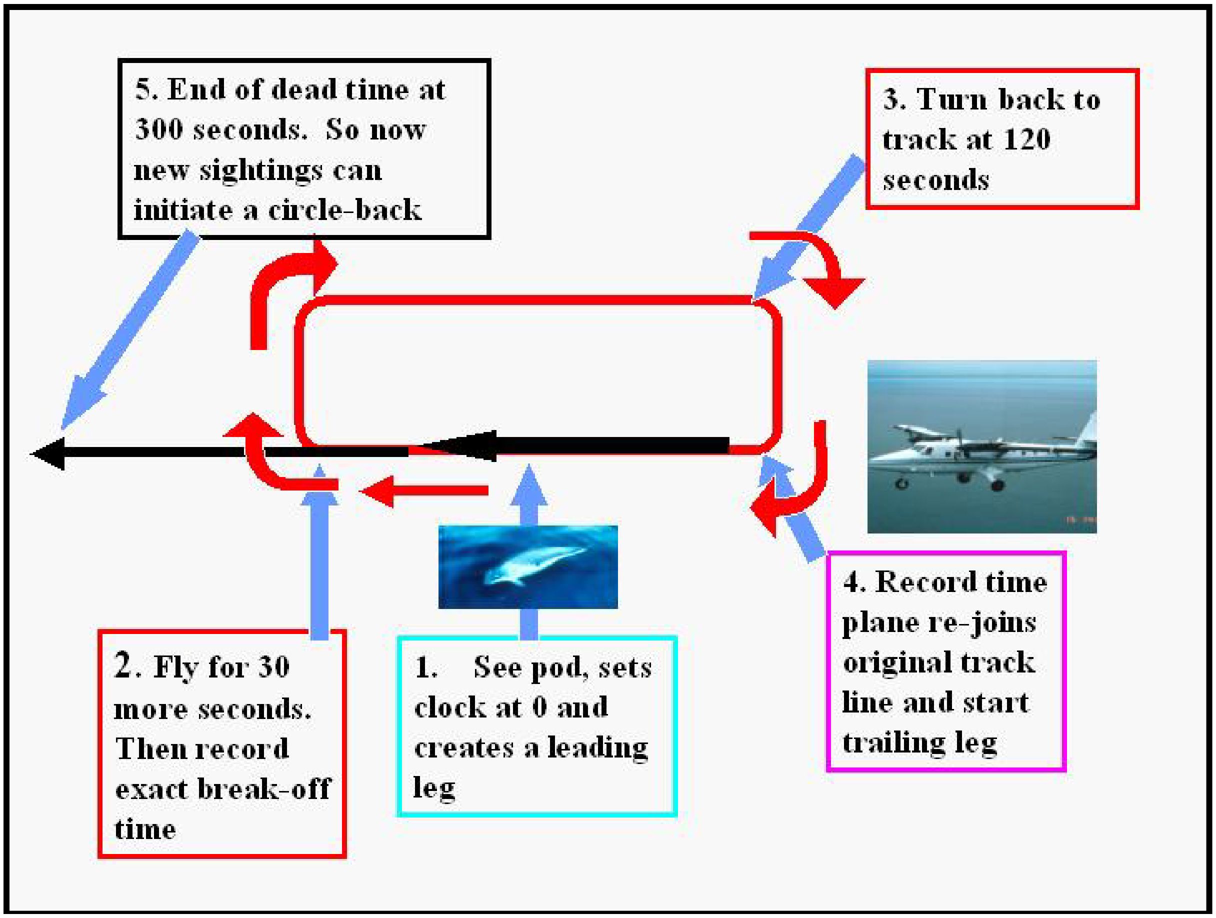


Figure A4. Winter 2011 Northeast AMAPPS aerial survey: Location of harbor porpoise sightings.

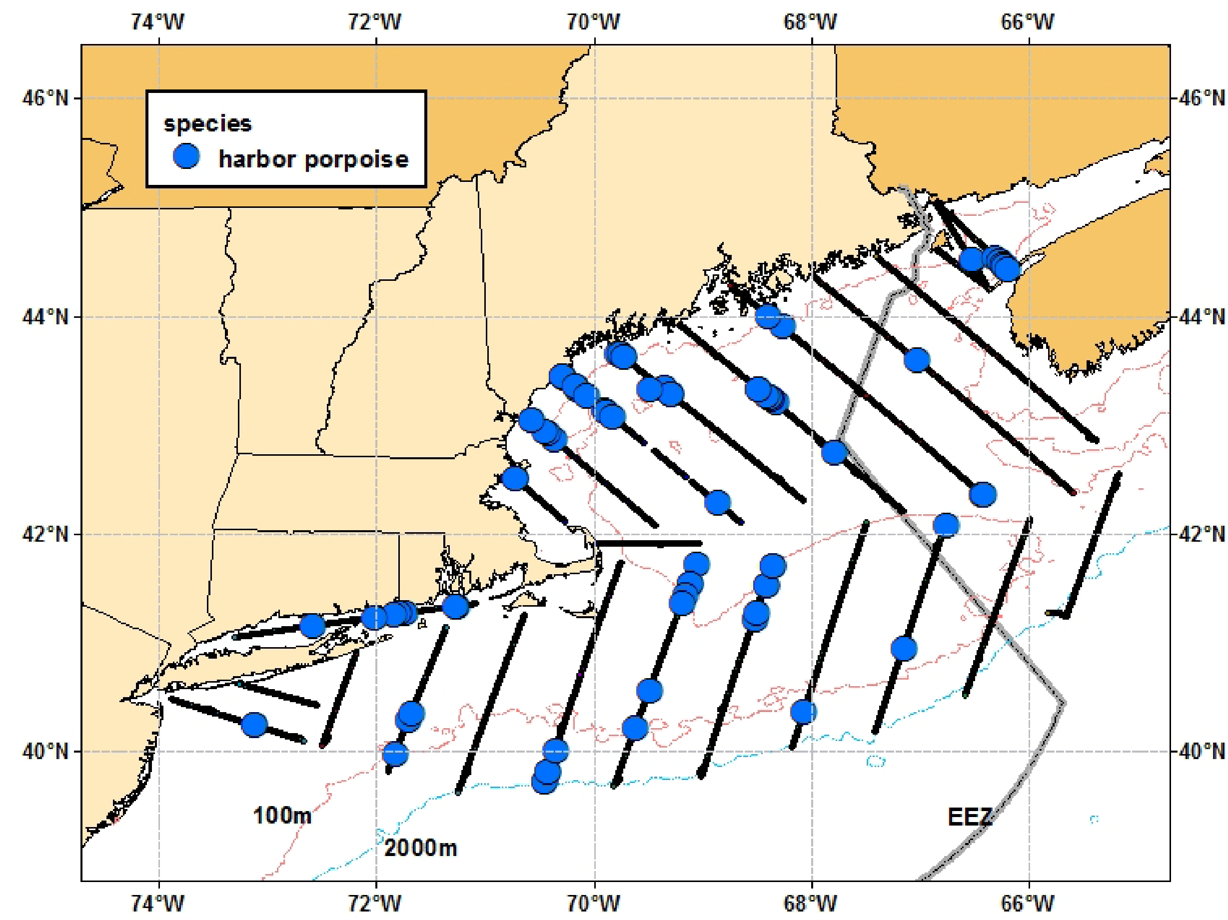


Figure A5. Winter 2011 Northeast AMAPPS aerial survey: Location of white-sided and common dolphin sightings.

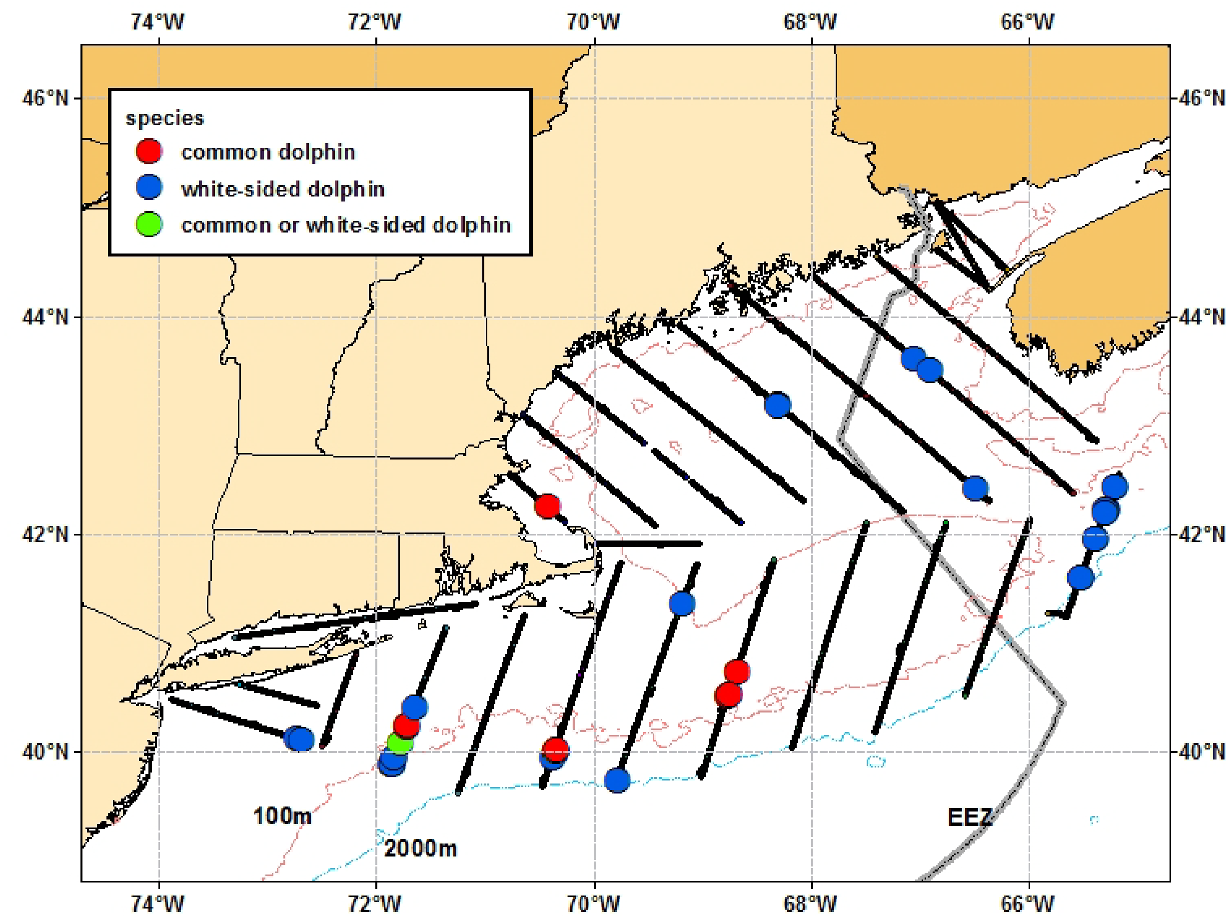


Figure A6. Winter 2011 Northeast AMAPPS aerial survey: Location of Risso's dolphin sightings.

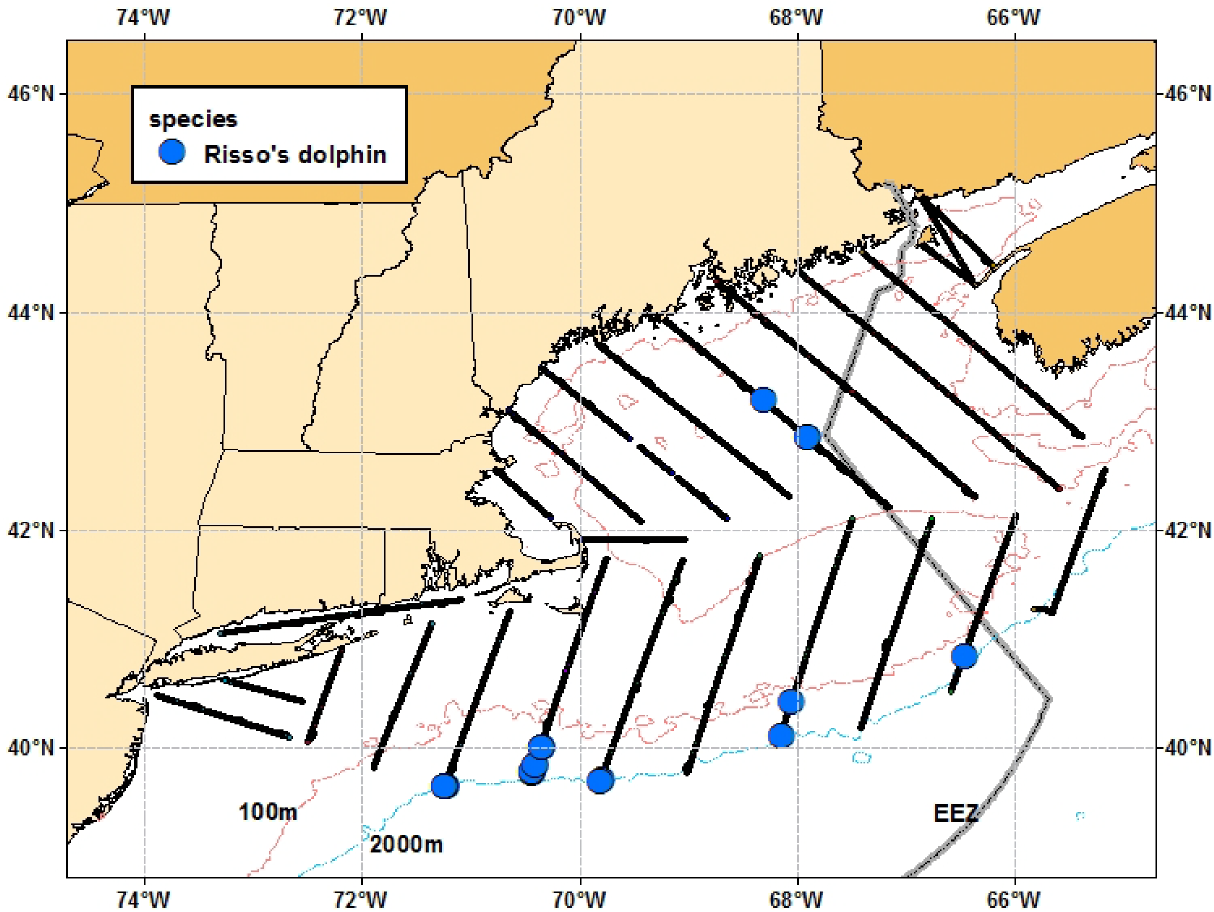


Figure A7. Winter 2011 Northeast AMAPPS aerial survey: Location of bottlenose dolphin, pilot whales (either short-finned or long-finned), and unidentified dolphin sightings.

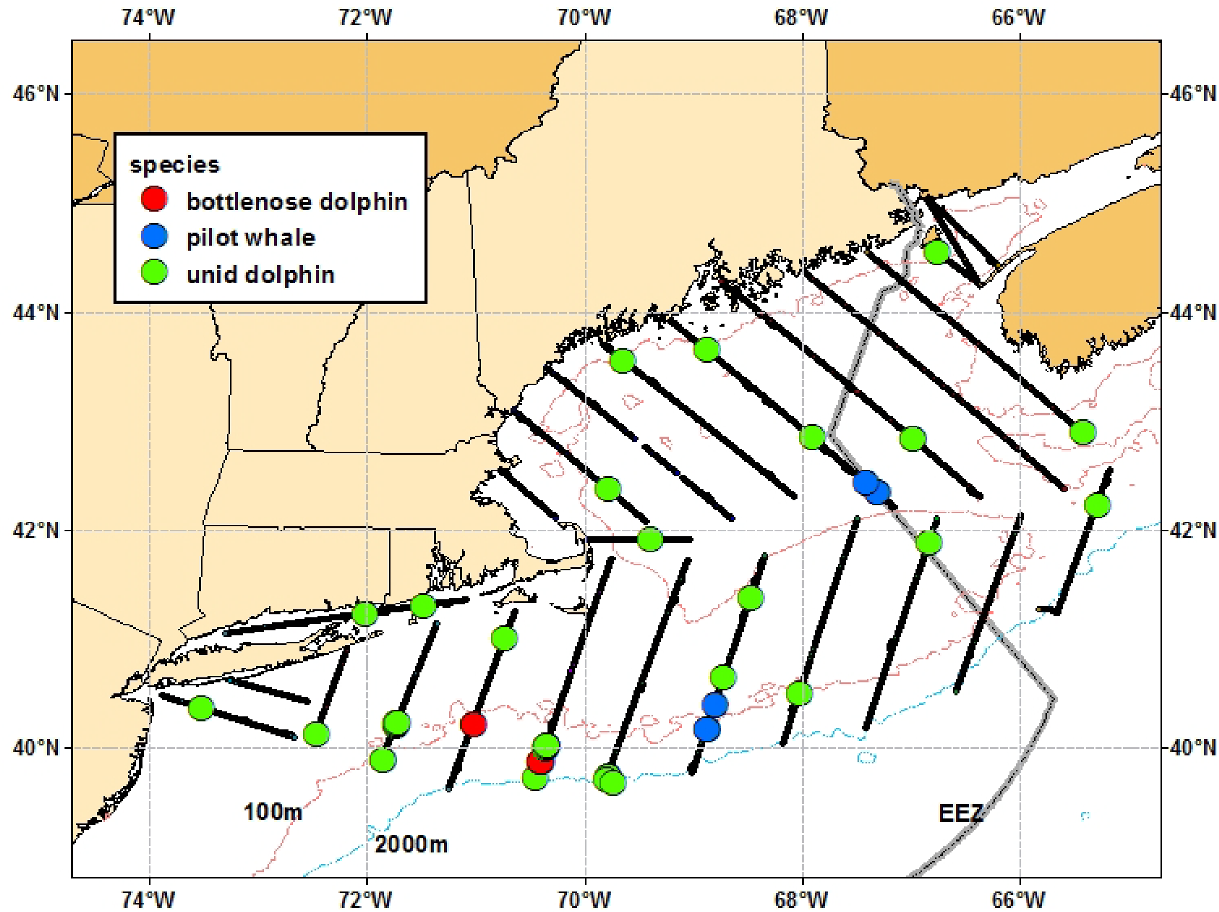


Figure A8. Winter 2011 Northeast AMAPPS aerial survey: Location of sightings of fin and sei whales.

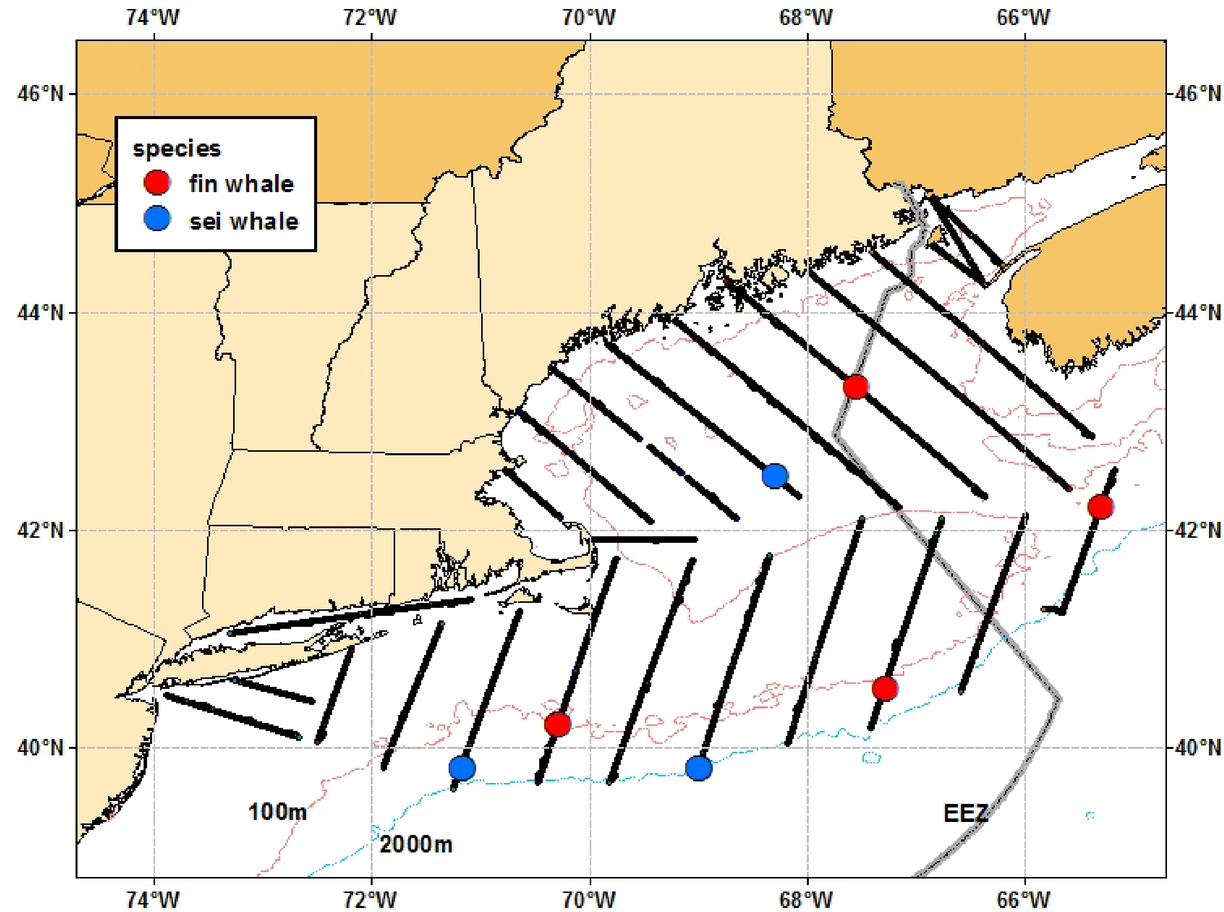


Figure A9. Winter 2011 Northeast AMAPPS aerial survey: Location of minke whale and unidentified whale sightings.

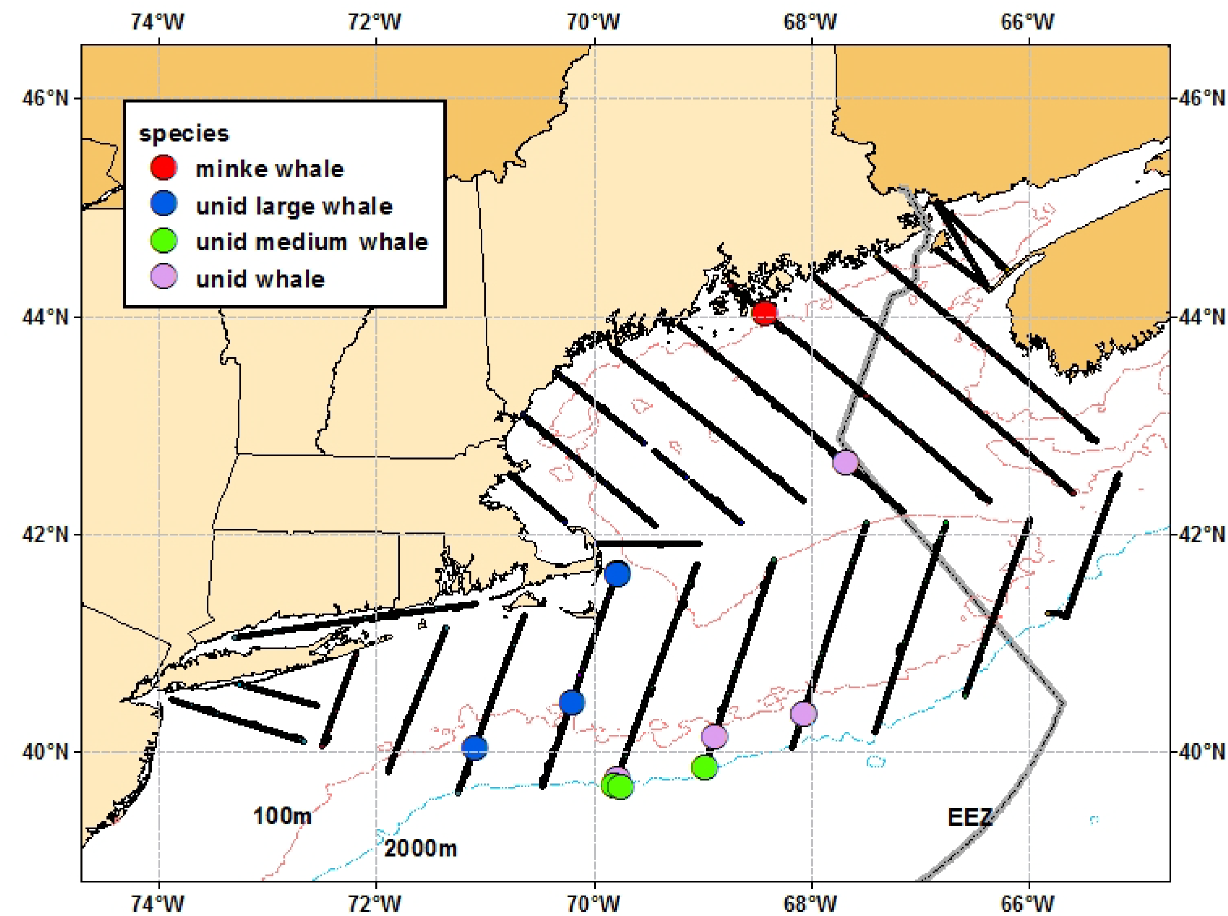


Figure A10. Winter 2011 Northeast AMAPPS aerial survey: Location of loggerhead turtle, unidentified hardshell turtle, unidentified seal, and ocean sunfish sightings.

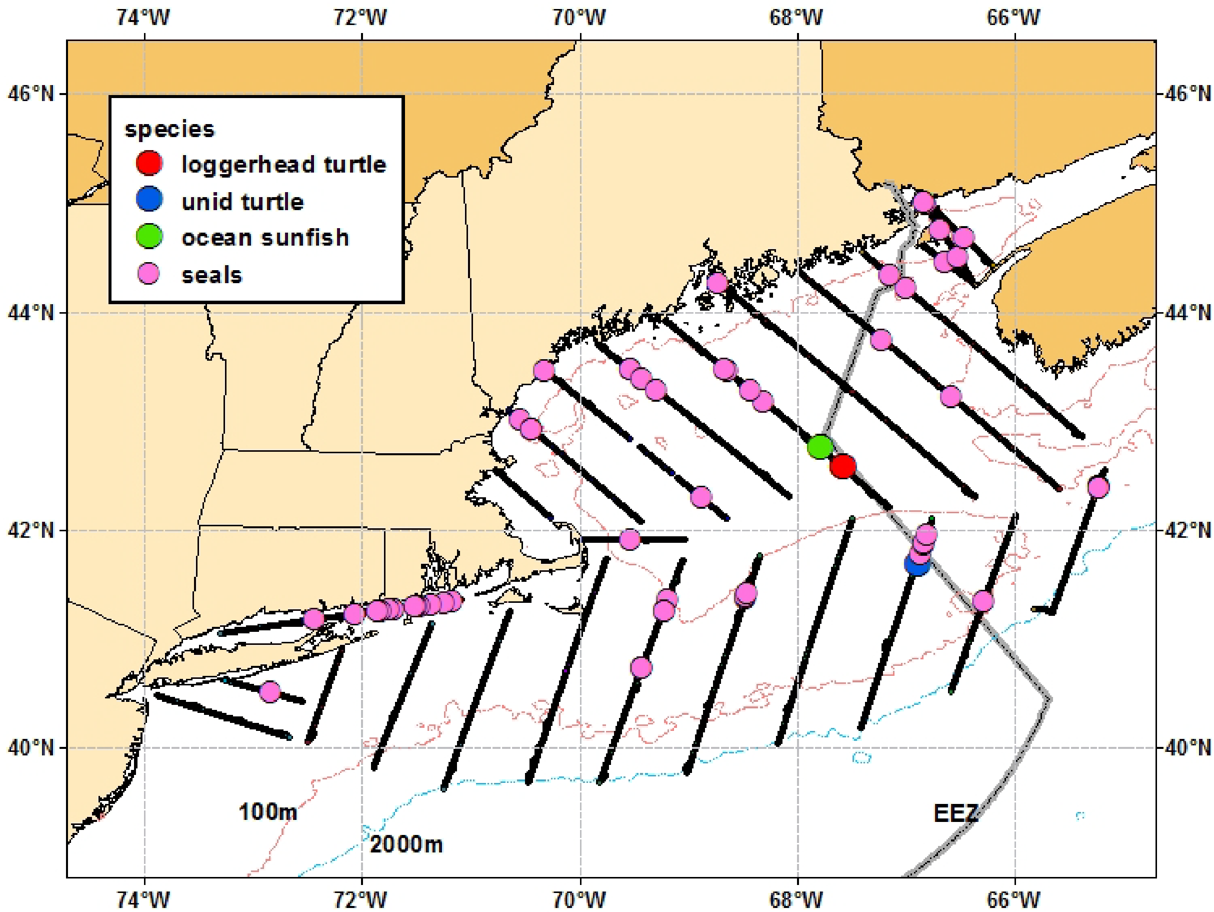


Figure A11. Summer 2011 Northeast AMAPPS aerial survey: Location of harbor porpoise sightings.

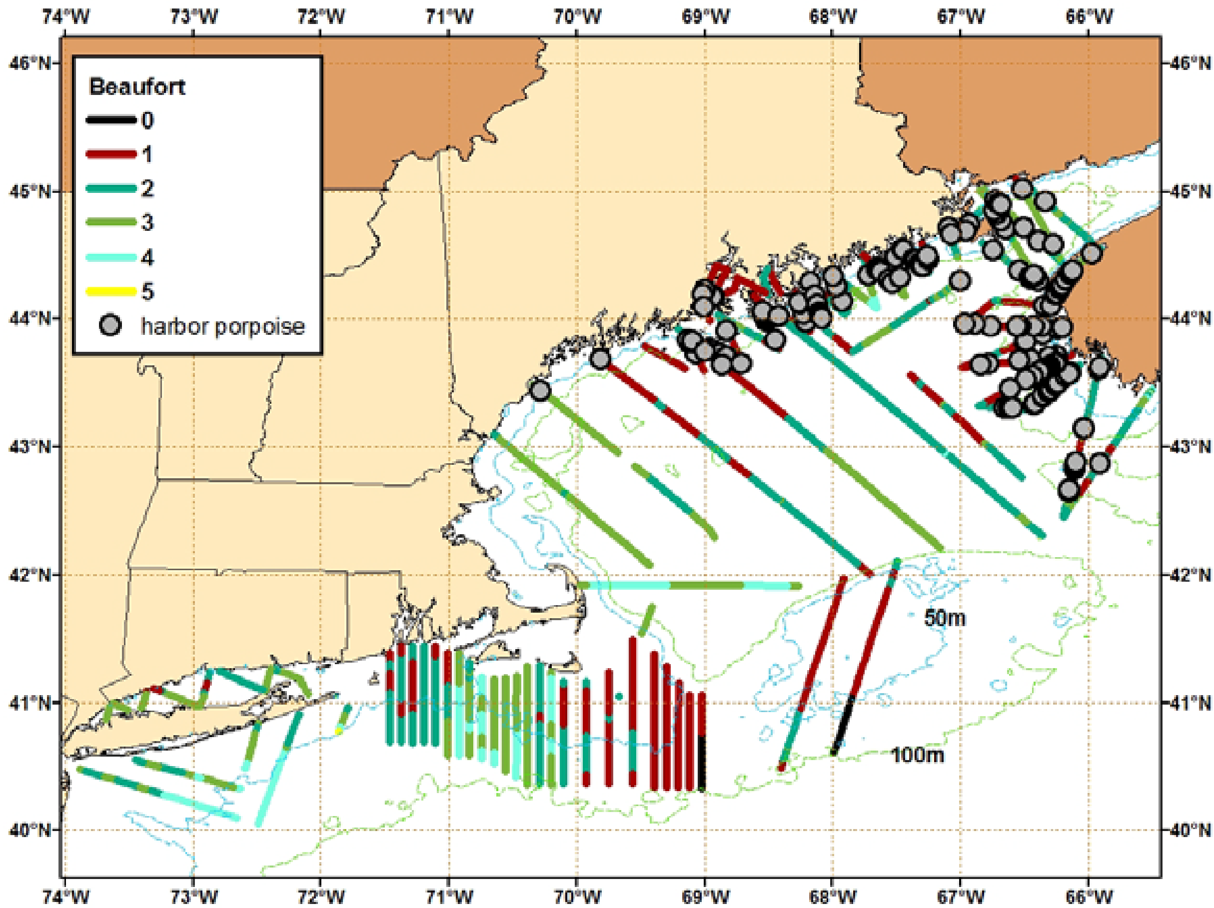


Figure A12. Summer 2011 Northeast AMAPPS aerial survey: Location of white-sided and common dolphin sightings.

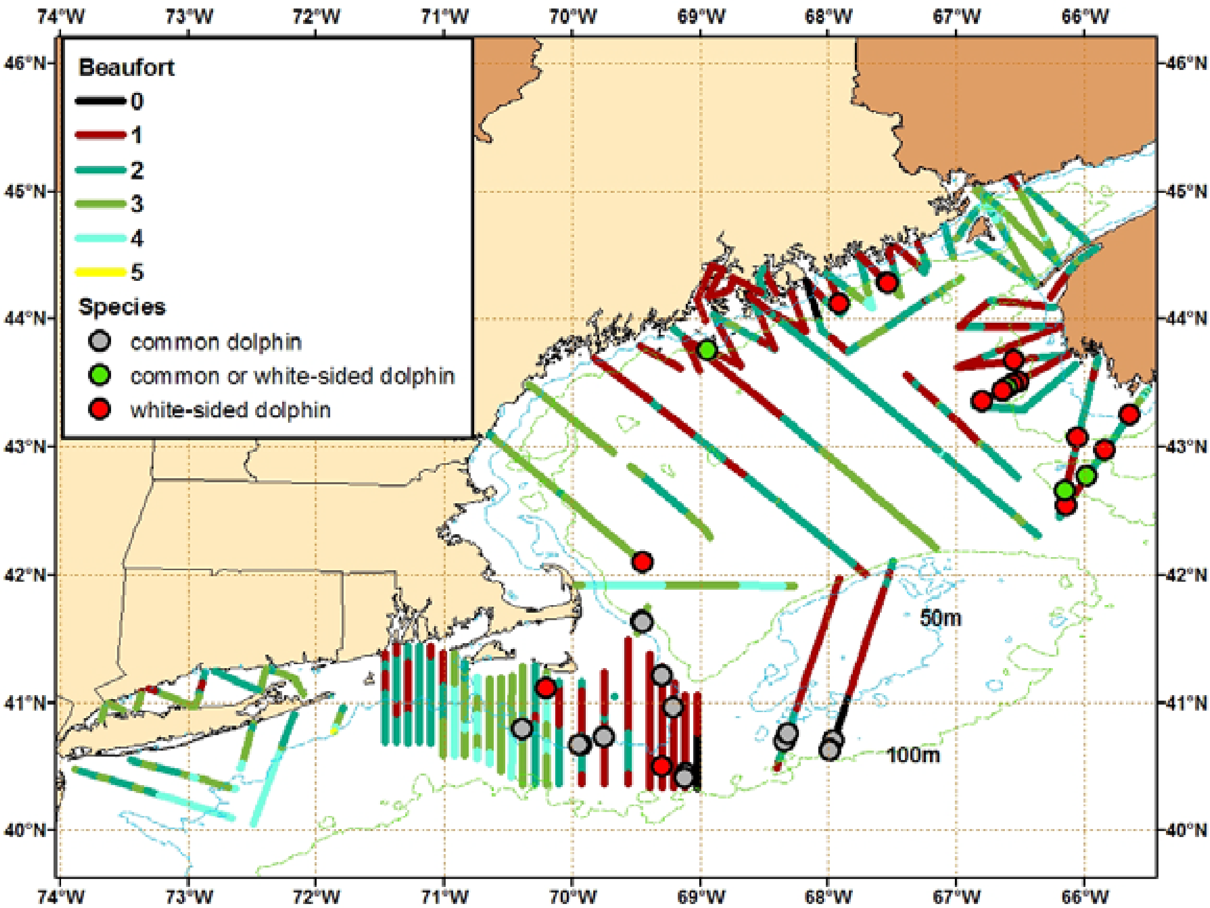


Figure A13. Summer 2011 Northeast AMAPPS aerial survey: Location of bottlenose dolphin and unidentified dolphin sightings.

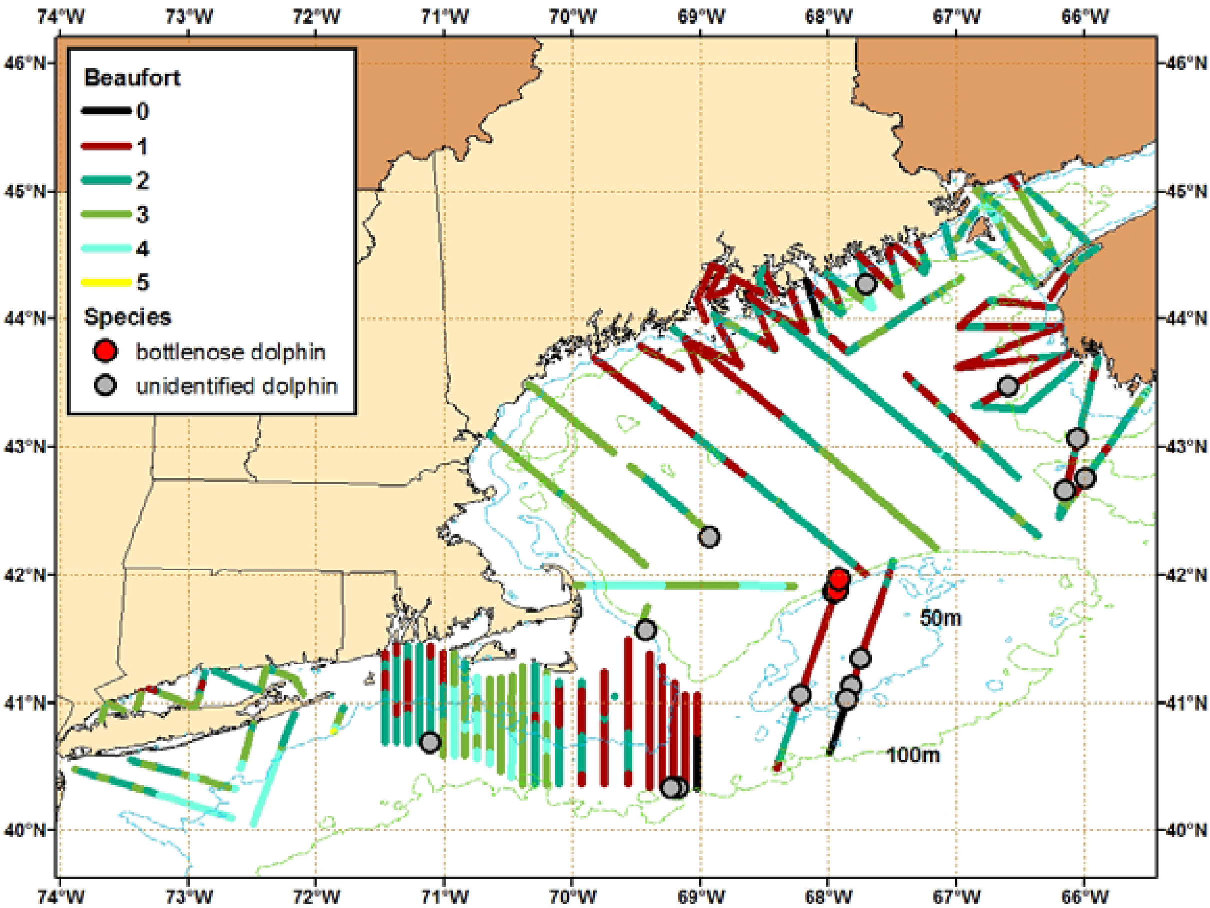


Figure A14. Summer 2011 Northeast AMAPPS aerial survey: Location of sightings of fin whales, sei whales, and whales that were either a fin or sei whale.

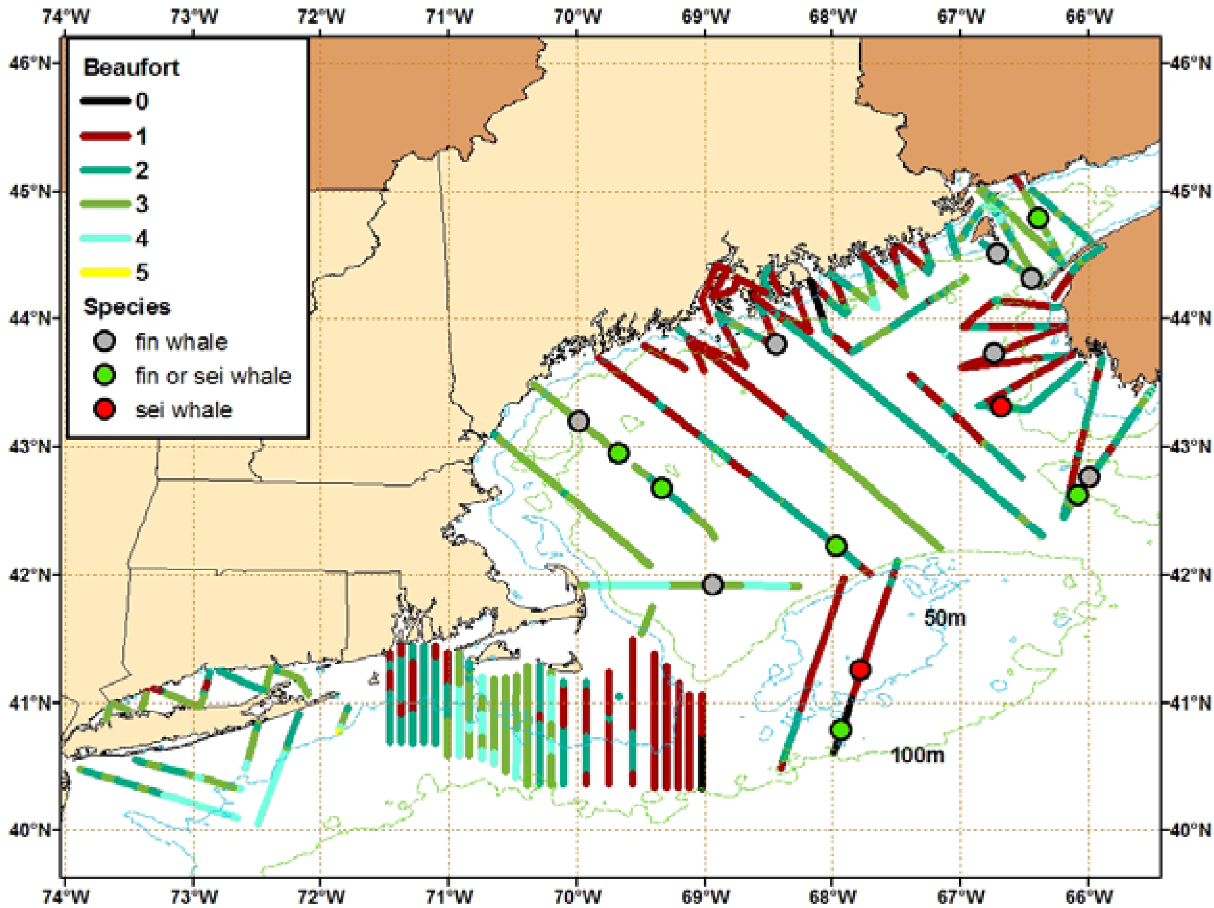


Figure A15. Summer 2011 Northeast AMAPPS aerial survey: Location of minke whale sightings.

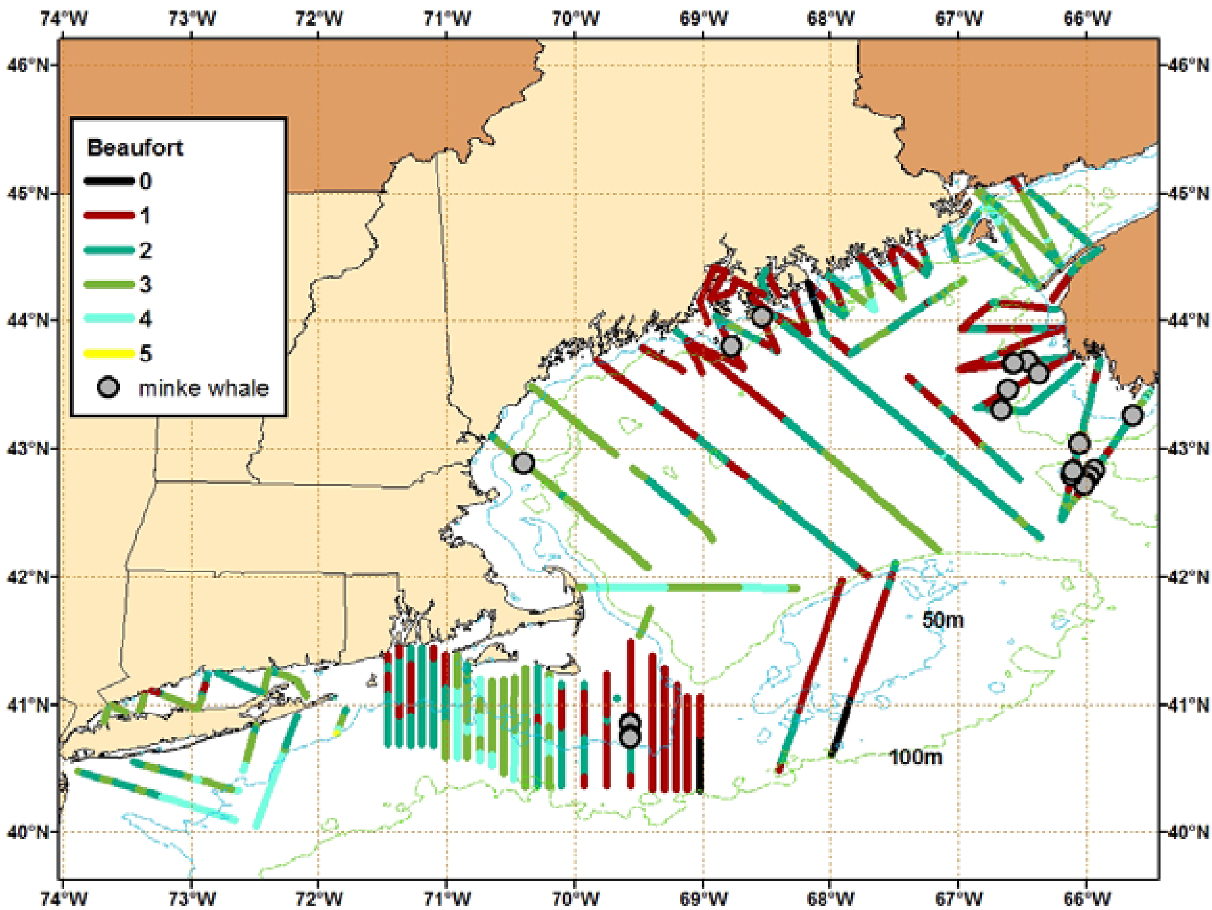


Figure A16. Summer 2011 Northeast AMAPPS aerial survey: Location of humpback whale, right whale, sperm whale, and unidentified whale sightings.

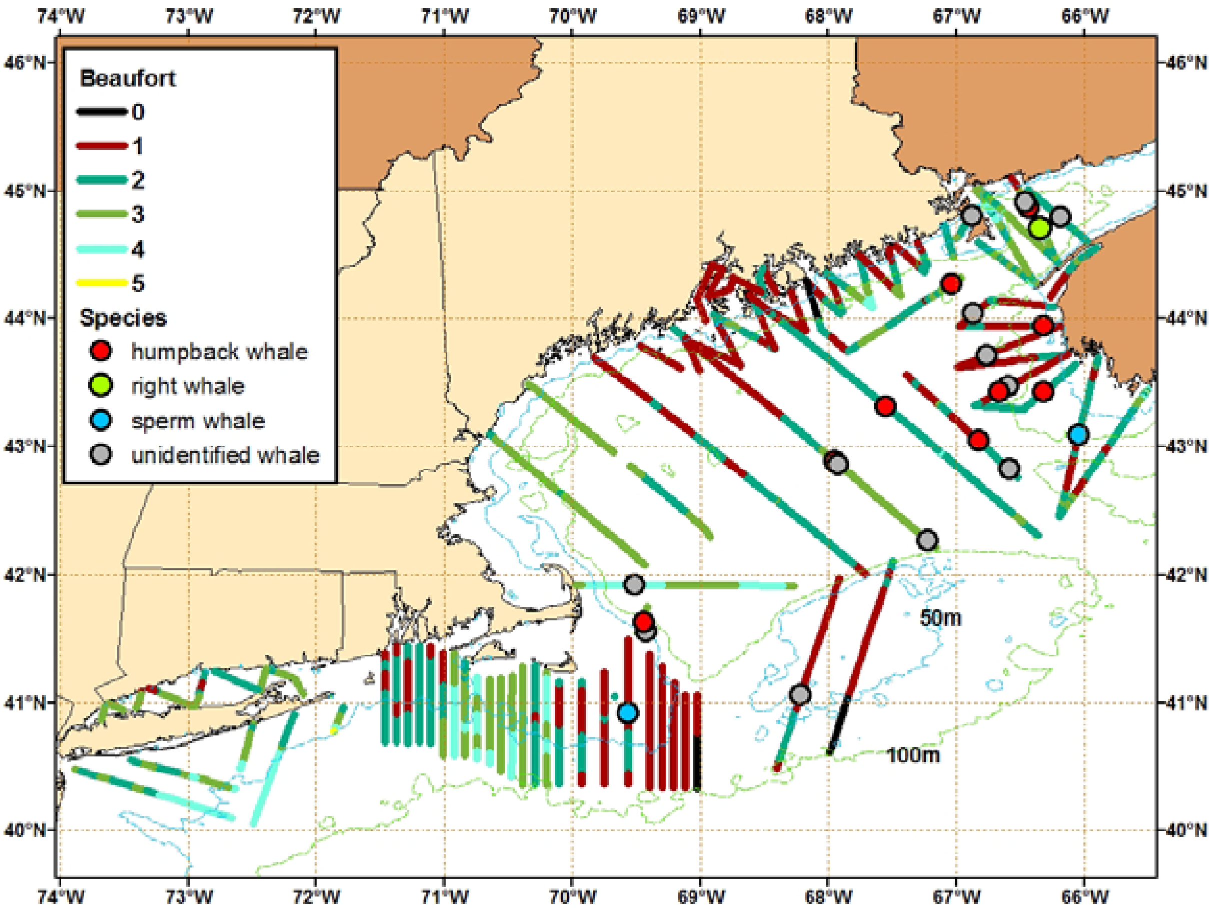


Figure A17. Summer 2011 Northeast AMAPPS aerial survey: Location of harbor seal or unidentified seal sightings.

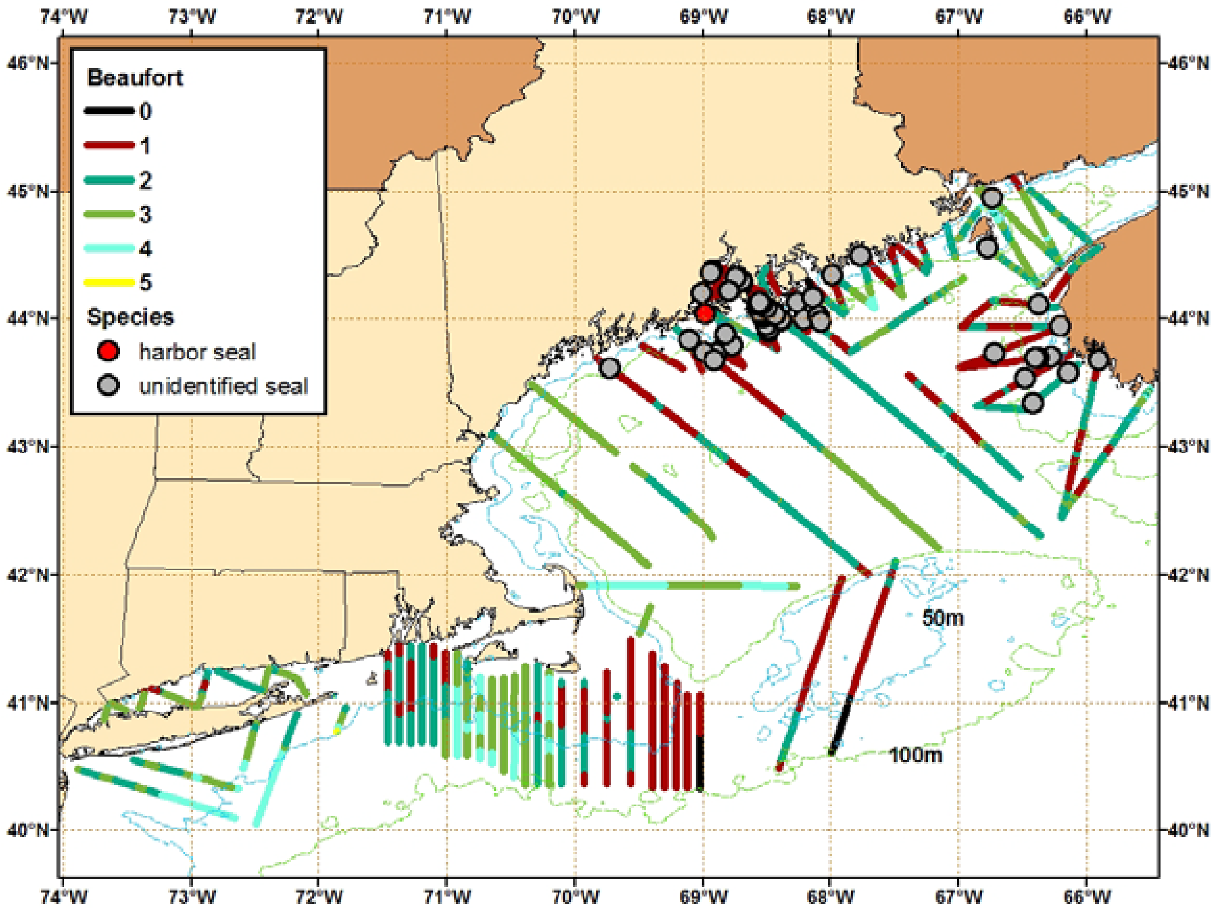


Figure A18. Summer 2011 Northeast AMAPPS aerial survey: Location of green turtle, leatherback turtle, loggerhead turtle, and unidentified hardshell turtle sightings.

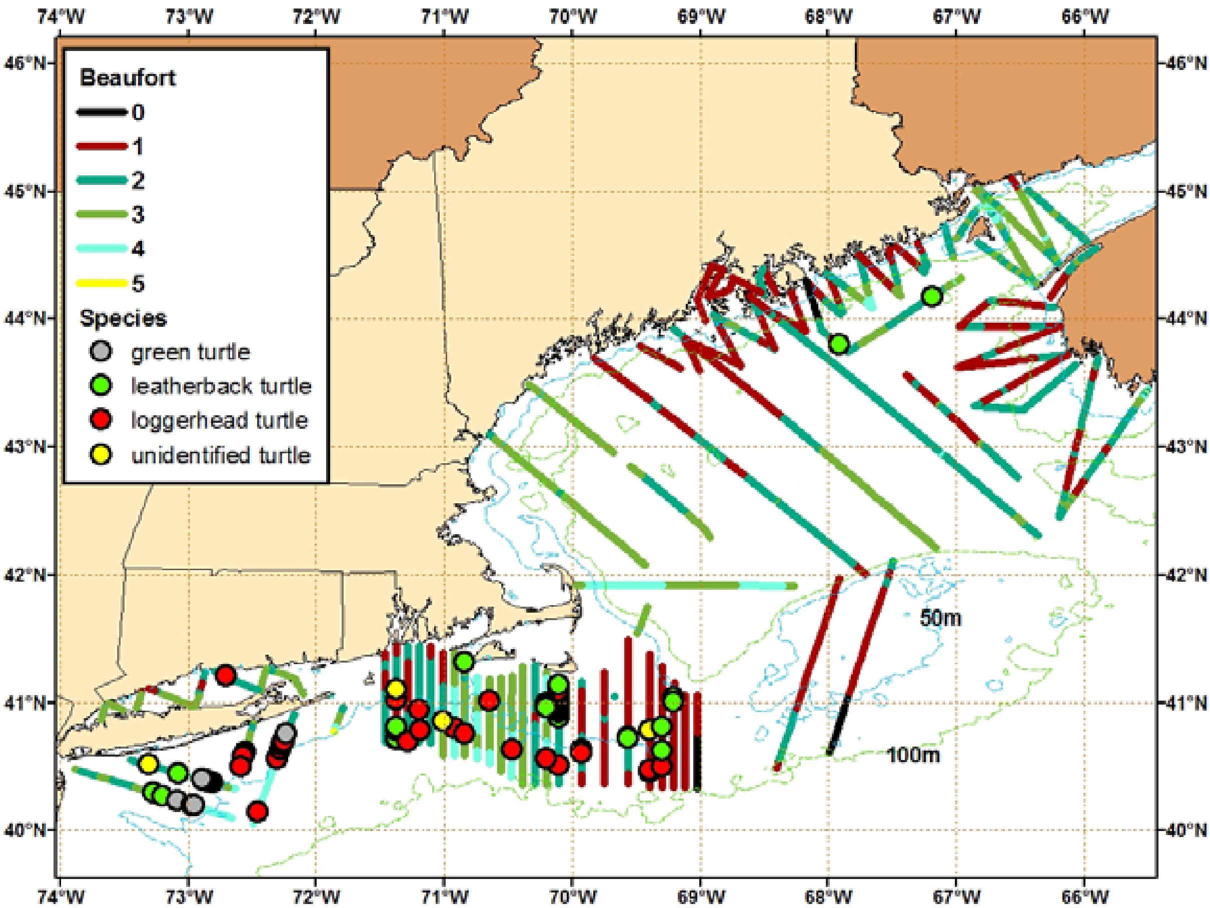


Figure A19. Summer 2011 Northeast AMAPPS aerial survey: Location of basking shark sightings.

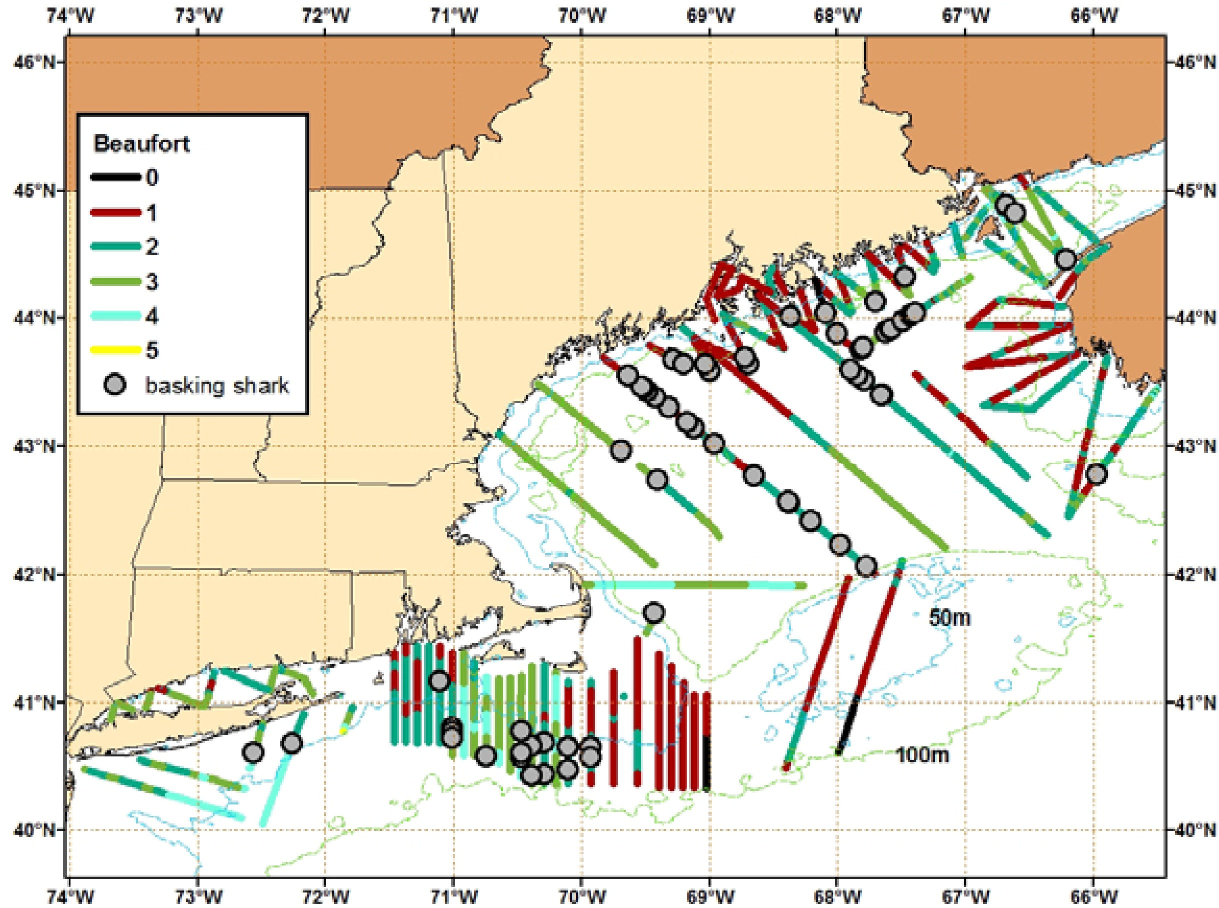


Figure A20. Summer 2011 Northeast AMAPPS aerial survey: Location of ocean sun fish sightings.

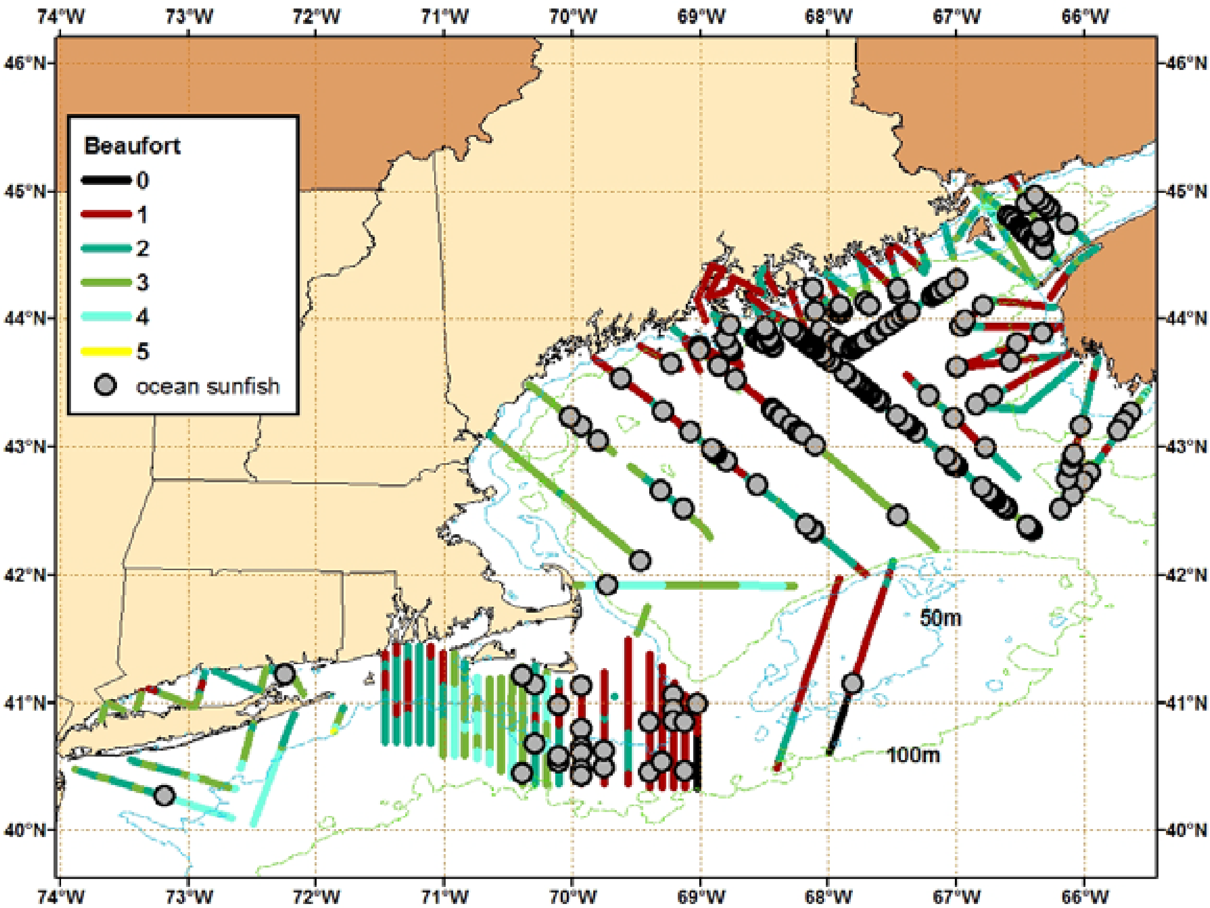
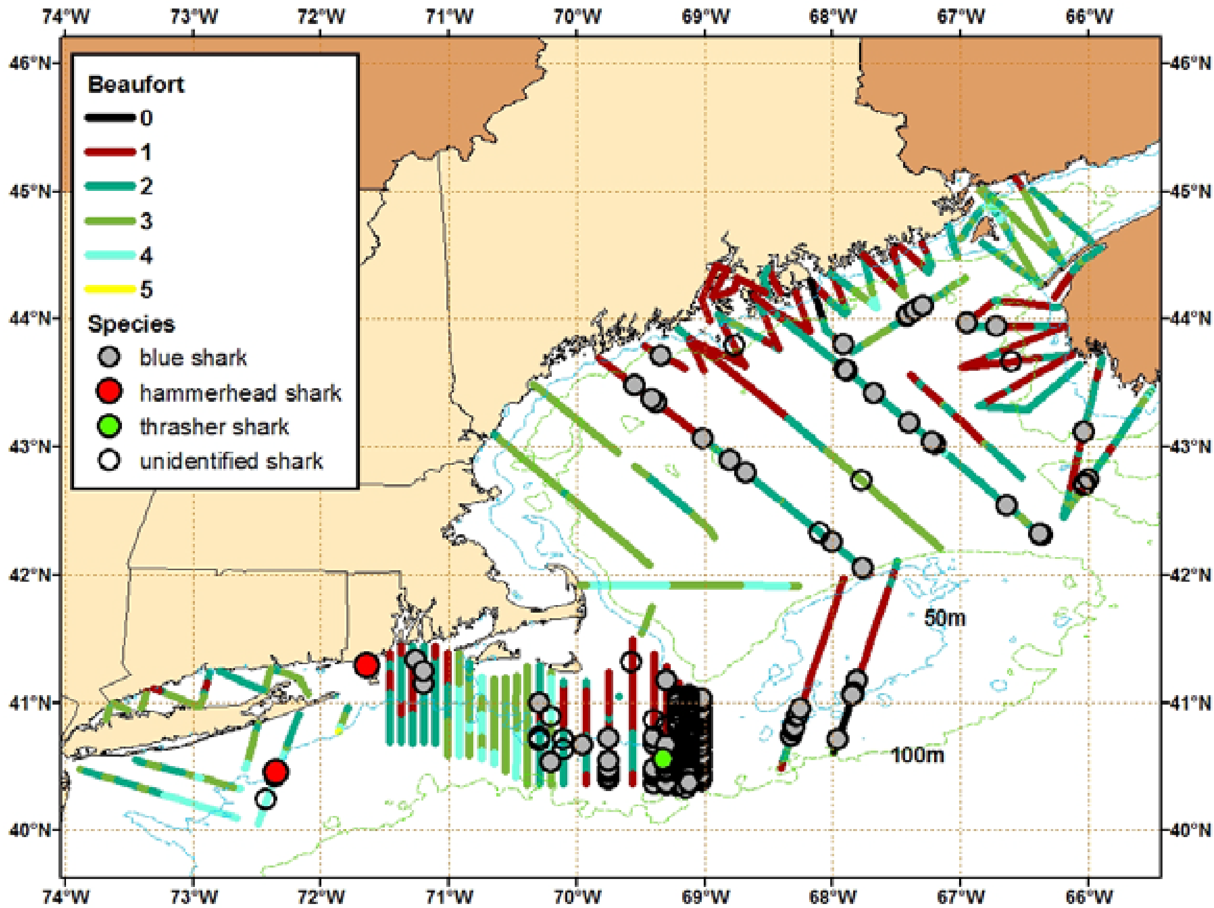


Figure A21. Summer 2011 Northeast AMAPPS aerial survey: Location of blue shark, hammerhead shark, thrasher shark and unidentified shark sightings.



Appendix B*: Southern leg of aerial abundance surveys during winter and summer 2011: Southeast Fisheries Science Center*

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Summary
As part of the AMAPPS program, the Southeast Fisheries Science Center (SEFSC) conducted aerial surveys of continental shelf waters along the U.S. east coast from southeastern Florida to Cape May, NJ. Two surveys were conducted during 2011; a winter survey conducted during 7 February – 13 March and a summer survey conducted during 6 – 29 July. The surveys were conducted along tracklines oriented perpendicular to the shoreline that were latitudinally spaced 20 km apart. The surveys were aboard a NOAA Twin Otter aircraft at an altitude of 600 feet (183 m) and a speed of 200kph (110 knots). The surveys were designed for analysis using Distance sampling and a two-team (independent observer) approach to correct for visibility bias in resulting abundance estimates. Due to poor weather conditions, the winter survey effort was restricted primarily to waters between Cape Canaveral, FL and North Carolina. A total of 4934 km of trackline were surveyed on effort during 45.1 flight hours. Eight species of marine mammals were identified, with the majority being bottlenose dolphins (116 groups sighted totaling 848 animals). Four species of sea turtles were identified, with the majority being loggerhead turtles (230 groups totaling 270 animals). During the summer survey, 8665 km of trackline were completed between Cape May, NJ and Ft. Pierce, FL. This included "fine-scale" tracklines in waters offshore of New Jersey and Virginia. Seven species of marine mammals were identified, with the majority being bottlenose dolphins (112 groups sighted totaling 1339 animals). Four species of sea turtles were identified, with the majority being loggerhead turtles (217 groups totaling 228 animals). The data collected from these surveys will be analyzed to estimate the abundance and spatial distribution of mammals and turtles along the U.S. east coast.

Objectives
The goal of these surveys 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 200 m isobaths) from southeast Florida to Cape May, New Jersey.

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

There were two pilots and six scientists onboard the airplane. The scientists operated as two teams to implement the independent observer approach to correct for visibility bias (Laake and Borchers 2004). The forward team (Team 1) consisted of two observers stationed in bubble windows on either side of the airplane and a data recorder dedicated to these two observers. 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 in the back of the plane on one side of the aircraft observing through a large bubble window, and a dedicated data recorder. This 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 had limited visibility of the left side of the aircraft. During the summer survey, the vista window was not available, so the aft team consisted solely of a belly observer and data recorder. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

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

During on-effort periods (e.g., level flight at survey altitude and speed), observers searched visually from the trackline (0°) to approx imately 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. Data recorders indicated at the time of the sighting whether or not the group was recorded by one or both teams.

The turtle data will be reviewed to identify sightings that were detected by both teams using information on the time, location, and position relative to the trackline.

Results

Winter survey

The winter survey was conducted during 7 February – 13 March 2011, but due to weather conditions, mechanical issues, or transits between cities, survey flights could only be conducted on 11 days. A total of 45.1 flight hours were used to cover a total of 4934 km of trackline which covered 56 tracklines (Figure B1, Table B1). The average sea state during the survey was 2.8 on the Beaufort scale with the vast majority of the survey effort flown in sea states of 2 or 3 (Figure B2). However, some sections of trackline, particularly the offshore portions of the tracklines, were flown in higher sea states.

There were a total of 415 sightings of sea turtles for a total of 475 individuals detected by the forward team; this total does not include turtles only seen by the aft survey team (Table B2). Turtles were identified as loggerhead turtles, green turtles, Kemp’s ridley turtles, leatherback turtles, and unidentified hardshells. Of these, the majority of turtle sightings were loggerhead turtles (Figure B3). The highest concentration of turtle sightings occurred north of Cape Canaveral and along the Florida and Georgia coasts, with lower number of sightings further north (Figures B3 – B5).

There were a total of 161 groups of marine mammals sighted for a total of 1884 individuals (Table B3). The primary species observed was bottlenose dolphins (Figures B6 – B7). Large whales including right whales, humpback whales, and fin whales were seen in waters off northern Florida and North Carolina (Figure B8).

Fish species sighted included primarily sharks, rays, and ocean sunfish (Figure B9).

Summer survey

The summer survey was conducted during 6 July – 29 July, 2011. But due to weather conditions, mechanical issues, or transits between cities, survey flights were conducted on only 14 days. A total of 73.9 flight hours were used, and a total of 8665 km of trackline were covered on-effort along 98 tracklines including fine scale tracklines in wind energy areas offshore of New Jersey and Virginia (Figure B10, Table B4). The average sea state during the survey was 2.5 on the Beaufort scale with the vast majority of the survey effort flown in sea states of 2 or 3 (Figure B11). However, some sections of trackline, particularly the offshore portions of tracklines, were flown in higher sea states. There were gaps in survey coverage in the southern portion of the survey range due to weather conditions and limited available flight days.

A total of 457 sightings of sea turtles for a total of 476 individuals were detected by the forward team. This total does not include turtles seen by only the aft survey team (Table B5). Turtles were identified as loggerhead turtles, green turtles, Kemp's ridley turtles, leatherback turtles, and unidentified hardshells. Of these, the majority of turtle sightings were loggerhead turtles (Figure B12). The highest concentration of turtle sightings occurred north of Cape Canaveral, Florida and in areas offshore Cape Hatteras, North Carolina (Figures B12 – B14).

There were a total of 199 groups of marine mammals sighted for a total of 3174 individuals. The primary species observed was bottlenose dolphins. A diverse group of species including pilot whales, common dolphins, and fin whales were observed along the shelf break north of North Carolina (Table B6, Figures B15 – B17).

Fish species sighted included primarily sharks, rays, and sunfish (Figure B18).

Disposition of the data

All data collected during these surveys will be maintained by Dr. Lance Garrison at SEFSC in Miami, FL and are available from the NEFSC's Oracle database.

Permits

SEFSC was authorized to conduct the research activities during this survey under Permit No. 779-1633-00 issued to the SEFSC by the NMFS Office of Protected Resources. Sea turtle sightings were permitted under ESA Section 10a1a permit #1551 issued to the SEFSC.

Literature 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 B1. Winter 2011 Southeast AMAPPS aerial survey: Daily summary of survey effort and protected species sightings.

Date	Flight hours	Effort (km)	Marine mammal sightings	Turtle sightings (Team 1)	Average sea state
2/7/2011	3.4	341.3	4	44	3.2
2/8/2011	0	Weather			
2/9/2011	0	Weather			
2/10/2011	0	Weather			
2/11/2011	0	Weather			
2/12/2011	0	Weather			
2/13/2011	7.1	583.5	41	102	2.9
2/14/2011	4.4	461.9	20	53	2.9
2/15/2011	0	Weather			
2/16/2011	0	Weather			
2/17/2011	0.9	77.1	2	2	0.9
2/18/2011	5.4	680.3	18	94	2.4
2/19/2011	0	Weather			
2/20/2011	0	Weather			
2/21/2011	0	Weather			
2/22/2011	0	Weather			
2/23/2011	0	Weather			
2/24/2011	4.3	512.7	6	27	2.6
2/25/2011	0	Weather			
2/26/2011	0	Weather			
2/27/2011	2.7	358.6	10	31	2.0
2/28/2011	0	Weather			
3/1/2011	0	Weather			
3/2/2011	6.3	754.6	21	20	2.5
3/3/2011	0	Weather			
3/4/2011	0	Weather			
3/5/2011	0	Weather			
3/6/2011	0	Weather			
3/7/2011	1.4	230.6	1	14	4.5
3/8/2011	0	Weather			
3/9/2011	0	Weather			
3/10/2011	0	Weather			
3/11/2011	0	Weather			
3/12/2011	3.8	334.6	19	0	2.8
3/13/2011	5.3	598.8	19	28	3.4
Total	**45.1**	**4934.0**	**161**	**415**	**2.8**

Table B2. Winter 2011 Southeast AMAPPS aerial survey: Summary of sea turtle sightings. These include only sightings by the forward team and are therefore a minimum number of turtles sighted during the survey.

Species	Number of sightings	Number of animals
Green turtle	17	17
Unid. hardshell	140	167
Kemp's ridley	3	3
Leatherback	17	18
Loggerhead	230	270
Total	**415**	**475**

Table B3. Winter 2011 Southeast AMAPPS aerial survey: Summary of marine mammal sightings.

Species	Number of groups	Number of animals
Atlantic spotted dolphin	6	184
Bottlenose dolphin	116	848
Bottlenose/Atl spotted	4	26
Common dolphin	2	42
Fin whale	2	4
Humpback whale	3	6
North Atlantic right whale	2	7
Rough-toothed dolphin	1	38
Sperm whale	1	1
Stenella sp.	6	535
Unid. Dolphin	16	191
Unid. Odonocete	1	1
Unid. large whale	1	1
Total	**161**	**1884**

Table B4. Summer 2011 Southeast AMAPPS aerial survey: Daily summary of survey effort and protected species sightings.

Date	Flight hours	Effort (km)	Number of marine mammal sightings	Turtle sightings (Team 1)	Average sea state
7/6/2011	3.5	361	6	14	2.7
7/7/2011	0	Weather			
7/8/2011	0	Weather			
7/9/2011	6.9	827	17	53	2.2
7/10/2011	7.7	856	31	73	1.4
7/11/2011	7.3	1001	22	23	3.4
7/12/2011	0	Weather			
7/13/2011	4.0	484	13	59	1.9
7/14/2011	0	Weather			
7/15/2011	0	Weather			
7/16/2011	0	Weather			
7/17/2011	4.4	549	15	40	2.2
7/18/2011	7.2	857	17	34	3.5
7/19/2011	3.5	478	7	5	2.8
7/20/2011	0	Weather			
7/21/2011	4.7	355	1	1	3.7
7/22/2011	3.9	543	8	13	3.1
7/23/2011	5.3	635	22	25	2.7
7/24/2011	0	Weather			
7/25/2011	4.2	412	8	29	2.0
7/26/2011	0	Weather			
7/27/2011	0	Weather			
7/28/2011	7.0	806	25	56	2.3
7/29/2011	4.0	498	7	32	1.9
Total	**73.9**	**8665**	**199**	**457**	**2.5**

Table B5. Summer 2011 Southeast AMAPPS aerial survey: Summary of sea turtle sightings. These include sightings by the forward survey team and are therefore a minimum number of turtles sighted during the survey.

Species	Number of sightings	Number of animals
Green turtle	60	60
Unid. hardshell	147	154
Kemp's ridley	3	4
Leatherback	30	30
Loggerhead	217	228
Total	**457**	**476**

Table B6. Summer 2011 Southeast AMAPPS aerial survey: Summary of marine mammal sightings.

Species	Number of groups	Number of animals
Atlantic spotted dolphin	14	346
Bottlenose dolphin	112	1339
Bottlenose/Atlantic spotted	3	36
Common dolphin	5	395
Fin whale	1	1
Pilot whale spp.	23	406
Risso’s dolphin	10	93
Sperm whale	3	3
Stenella sp.	2	119
Unid baleen whale	2	3
Unid dolphin	21	427
Unid Odonocete	2	5
Unid large whale	1	1
Total	**199**	**3174**

Figure B1. Winter 2011 Southeast AMAPPS aerial survey: Completed survey tracklines.

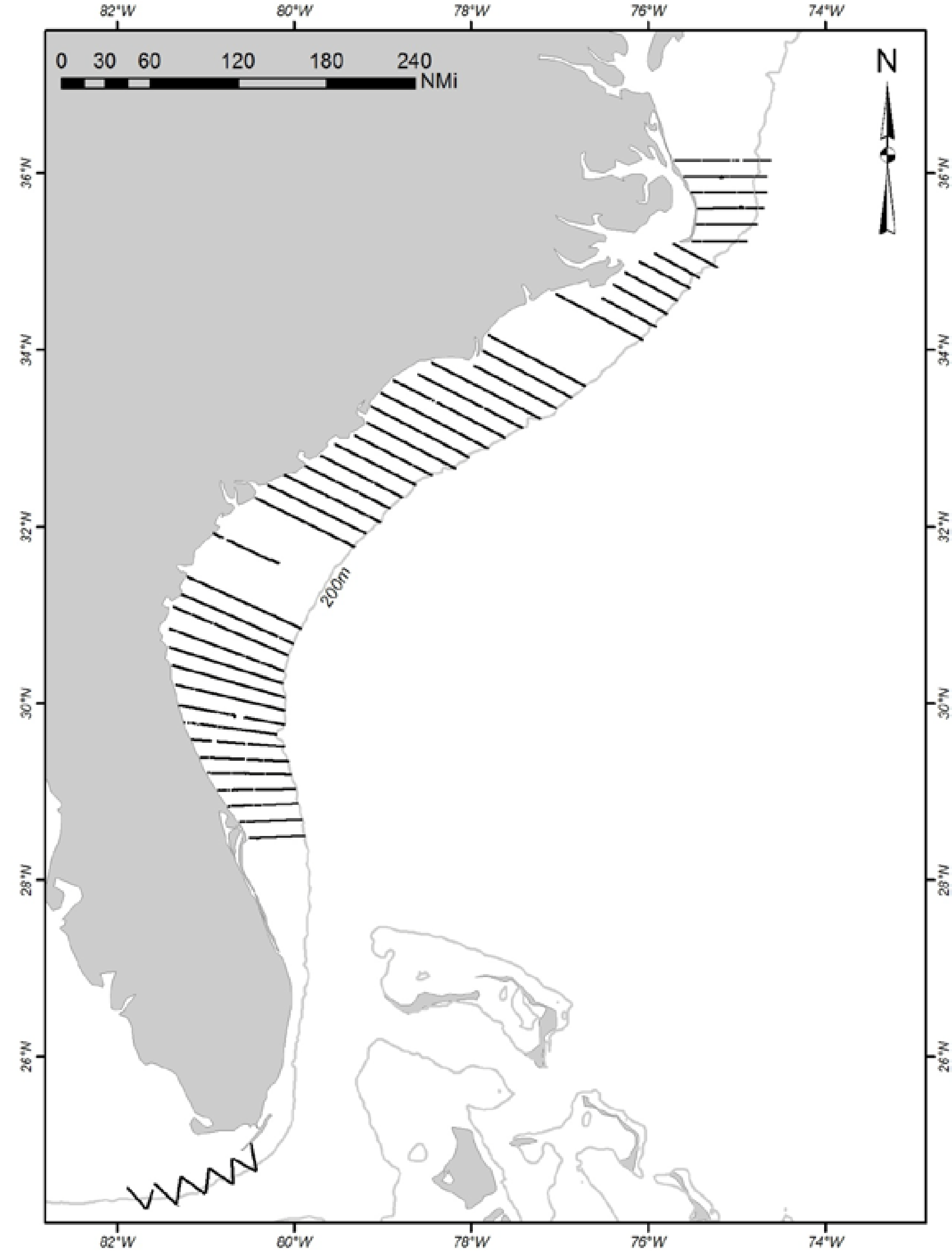


Figure B2. Winter 2011 Southeast AMAPPS aerial survey: Beaufort sea state conditions tracklines were surveyed in.

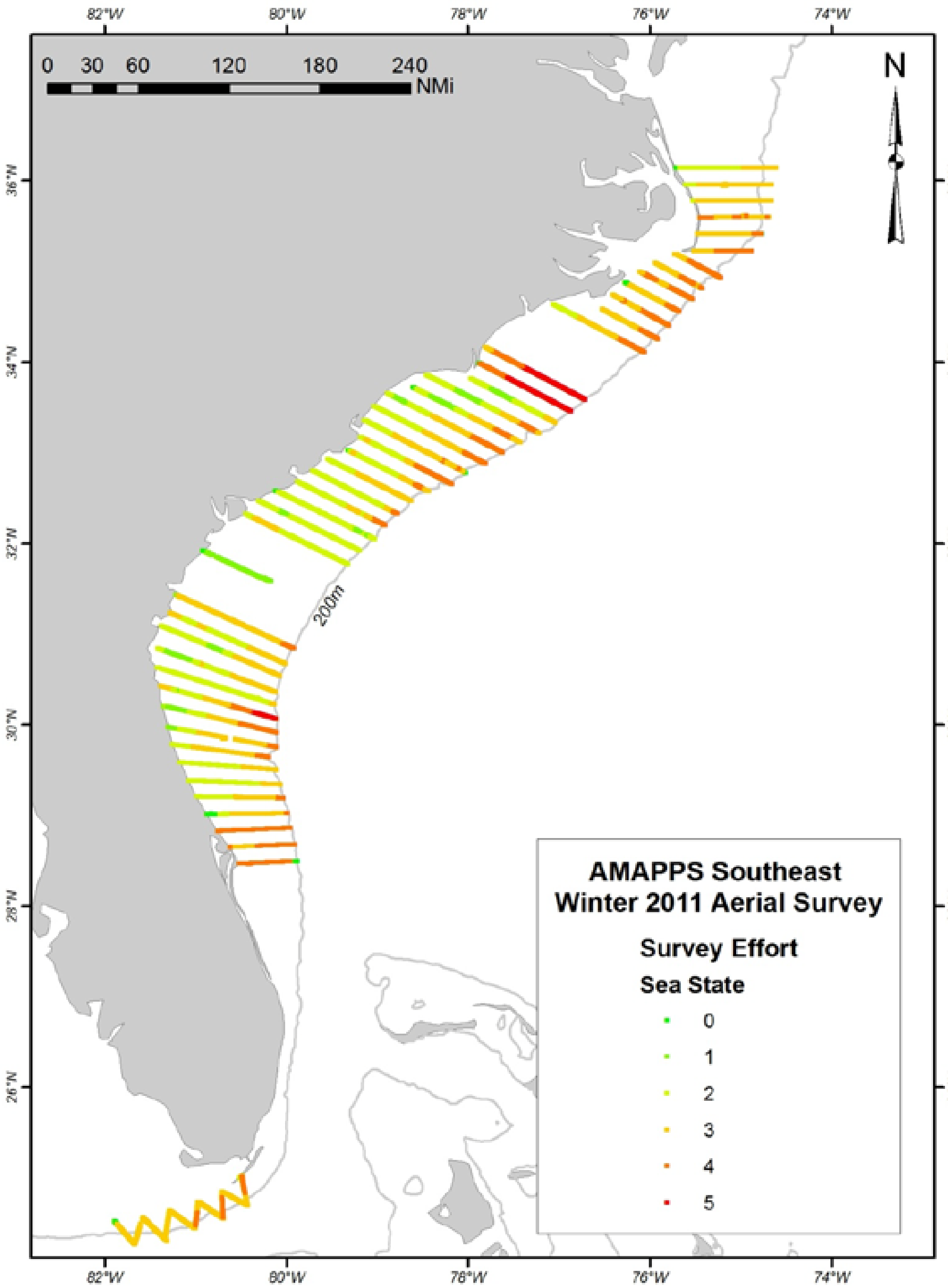


Figure B3. Winter 2011 Southeast AMAPPS aerial survey: Loggerhead turtle sightings detected by forward survey team.

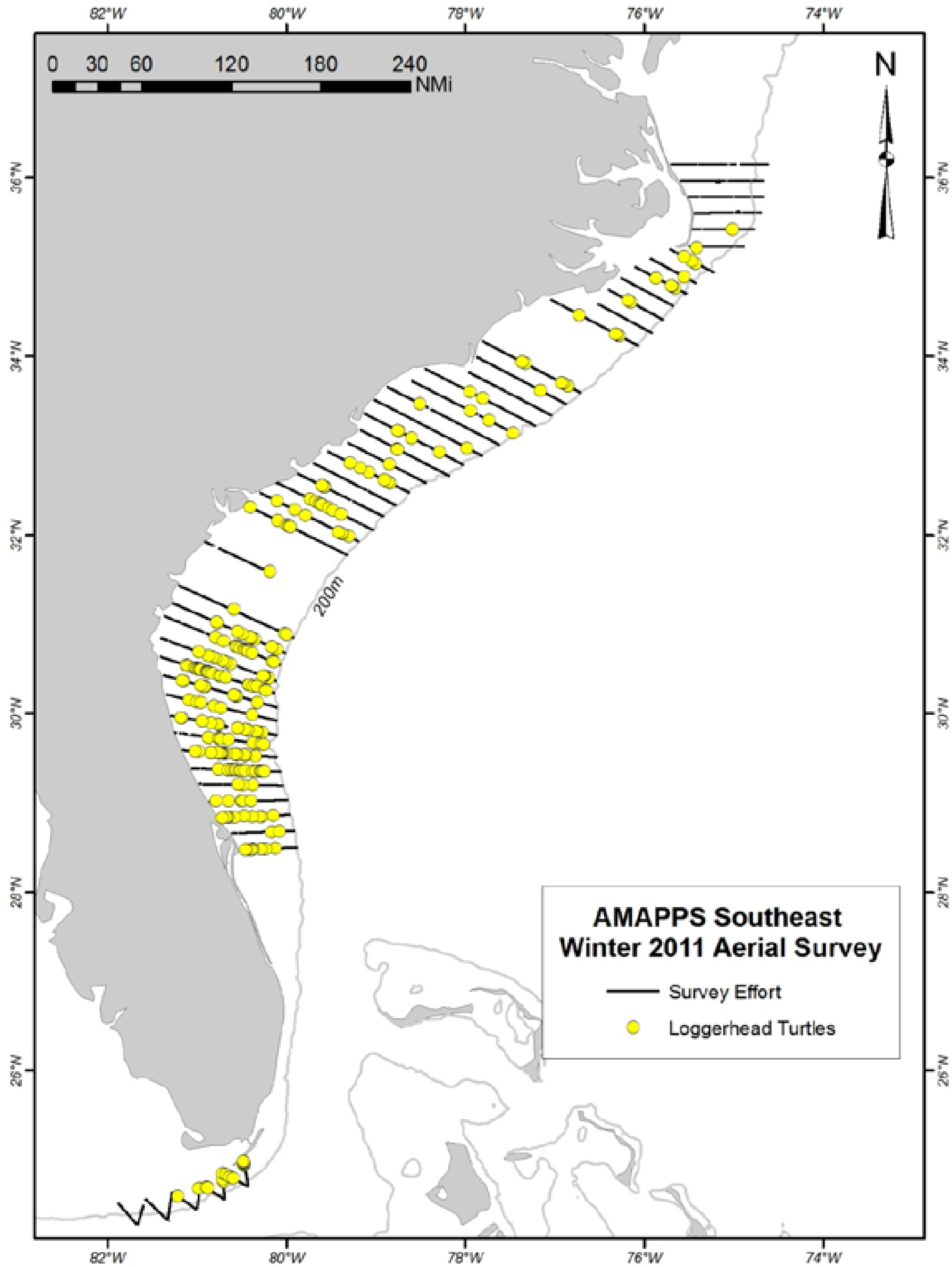


Figure B4. Winter 2011 Southeast AMAPPS aerial survey: Green turtle, Kemp's ridley turtles and unidentifed hardshell turtle sightings detected by forward survey team.

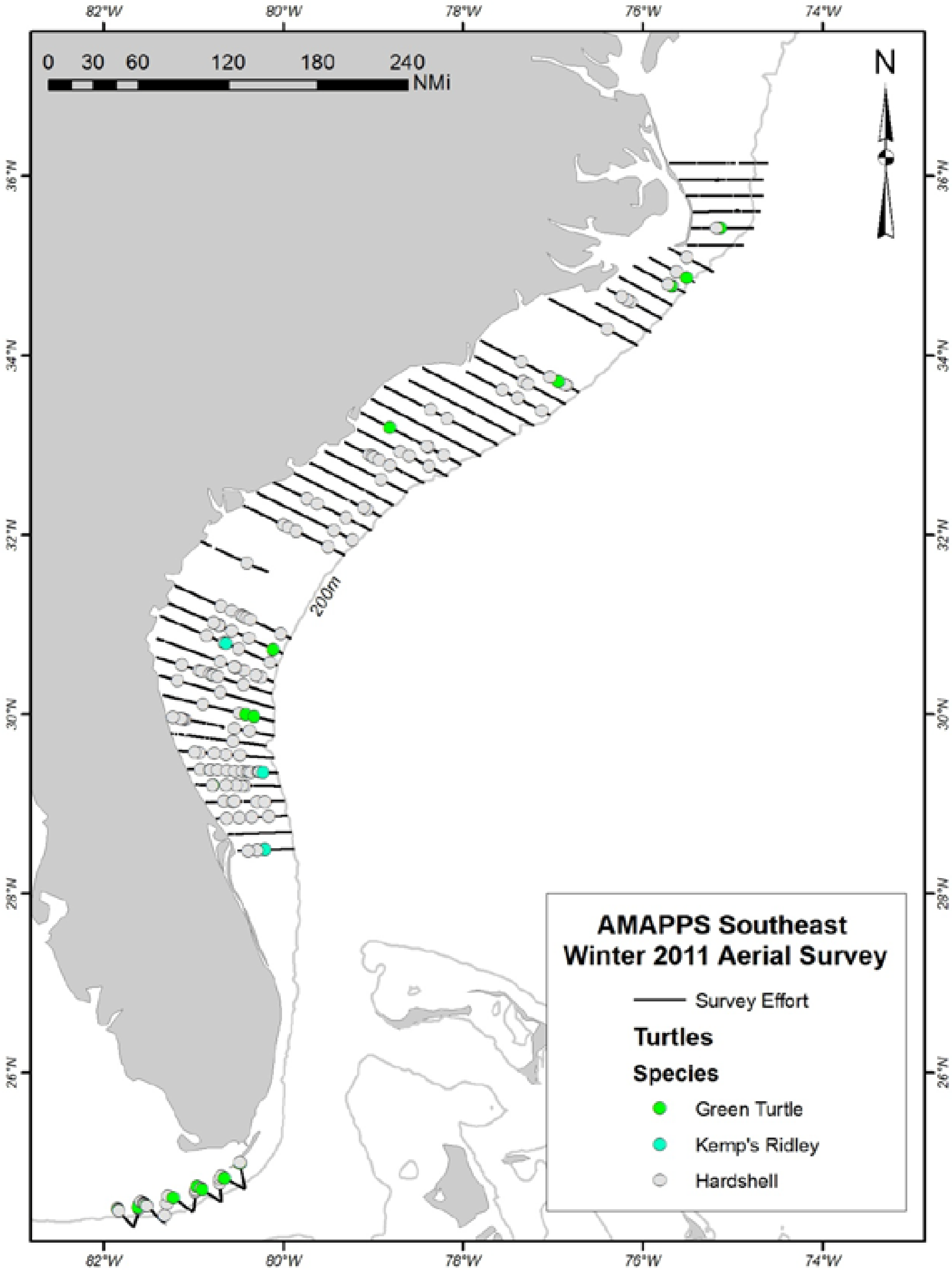


Figure B5. Winter 2011 Southeast AMAPPS aerial survey: Leatherback turtle sightings detected by forward survey team.

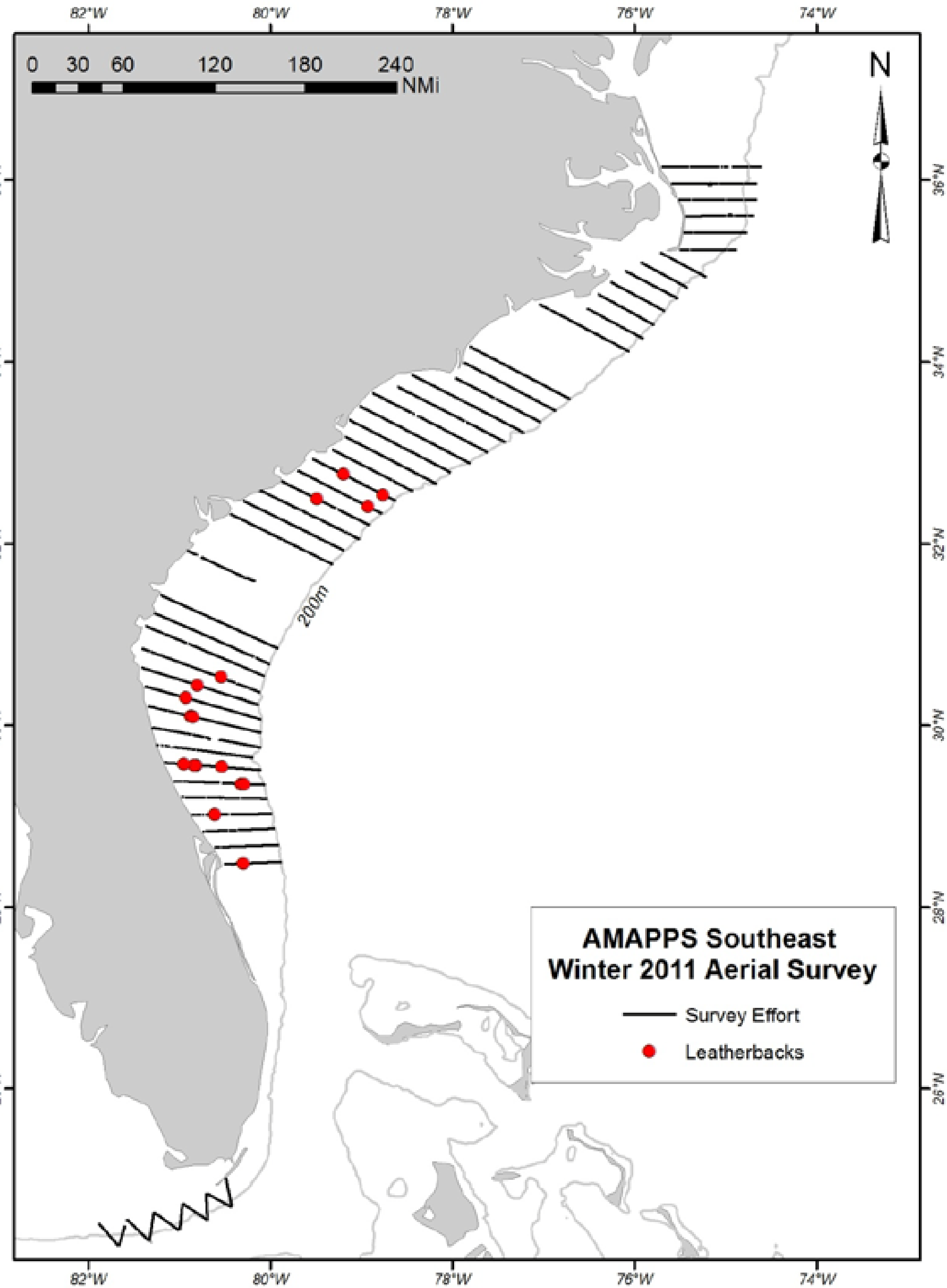


Figure B6. Winter 2011 Southeast AMAPPS aerial survey: Bottlenose dolphin sightings detected by both survey teams.

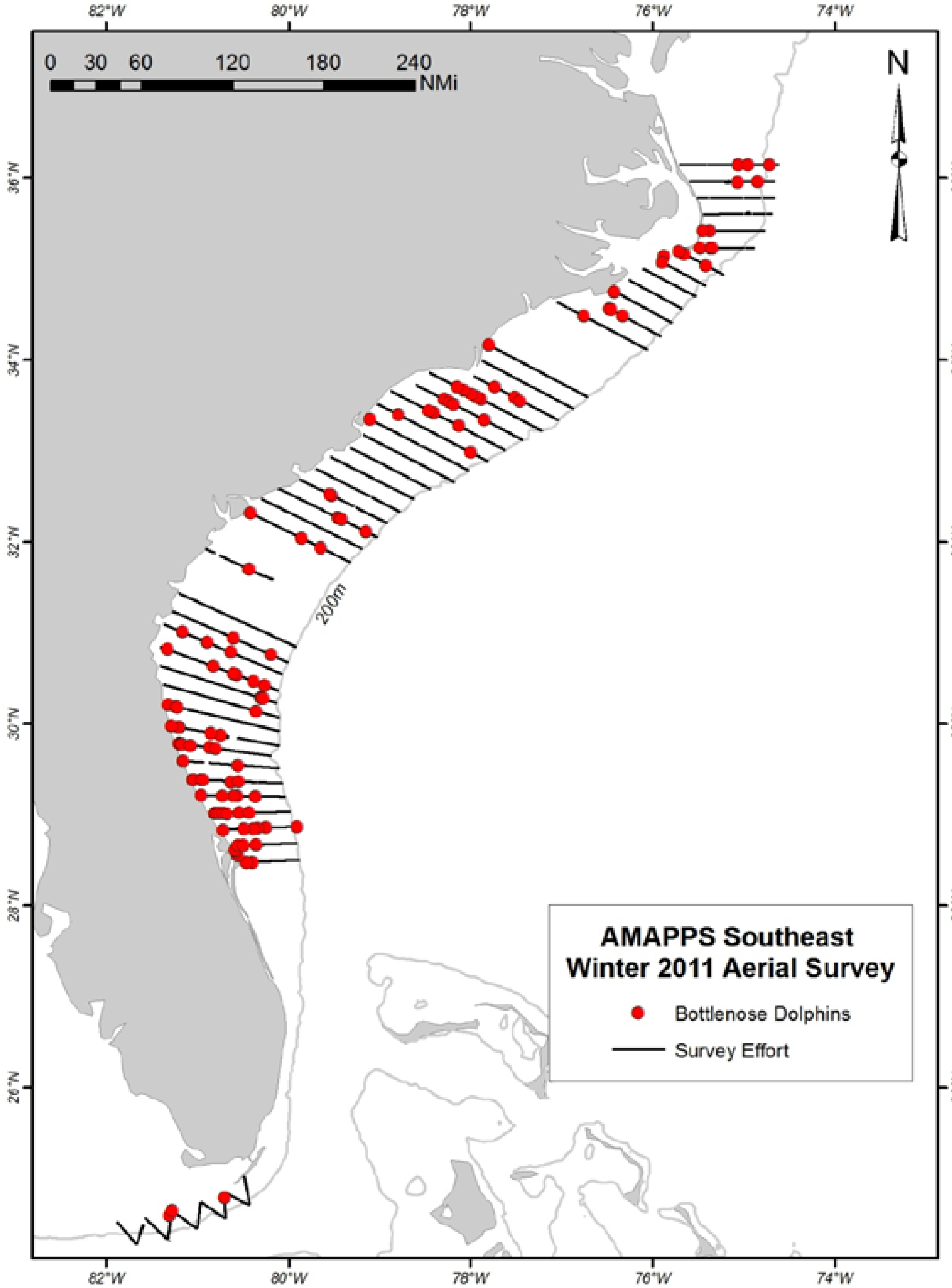


Figure B7. Winter 2011 Southeast AMAPPS aerial survey: Other dolphin sightings detected by both survey teams.

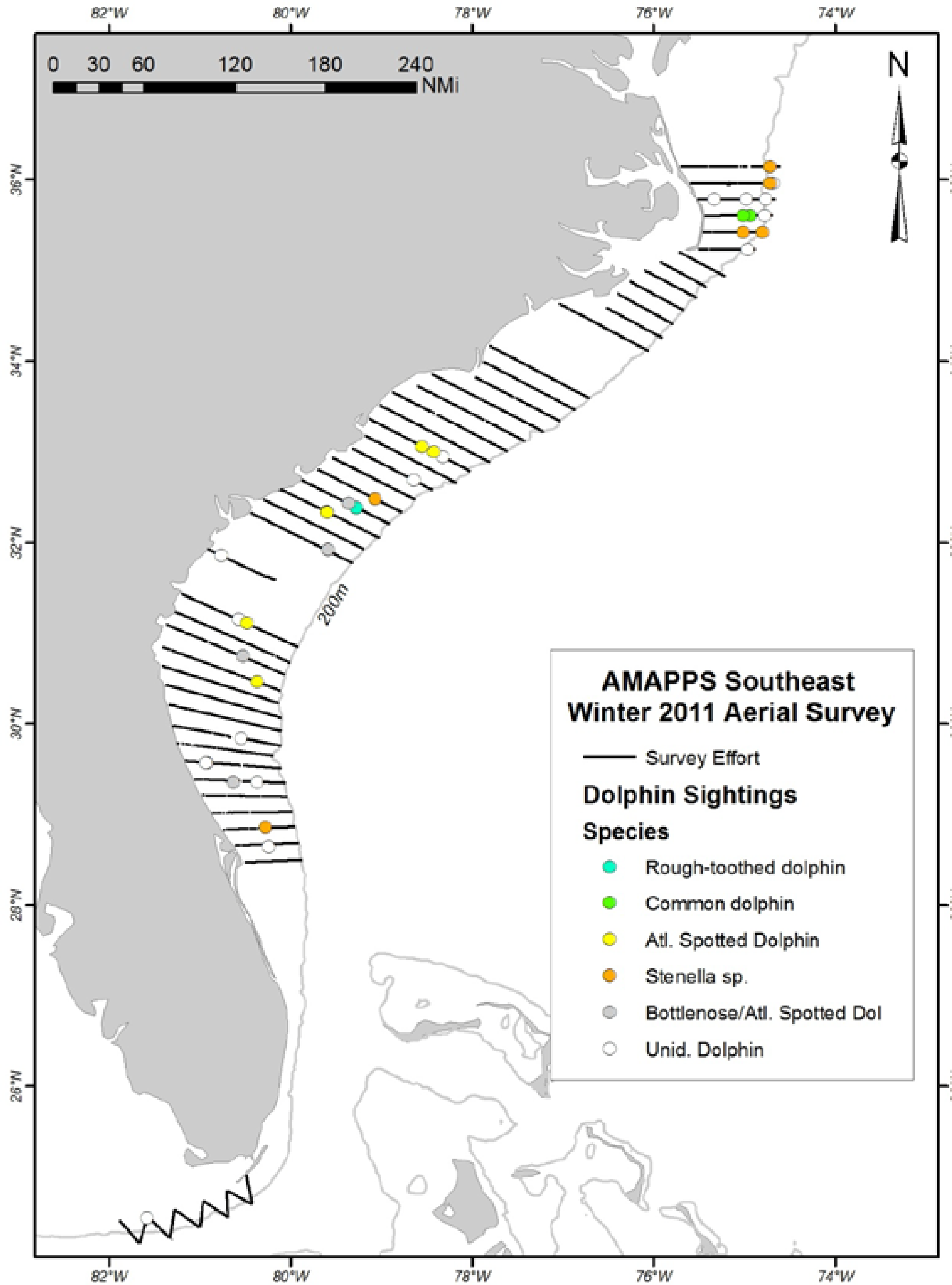


Figure B8. Winter 2011 Southeast AMAPPS aerial survey: Large whale sightings detected by both survey teams.

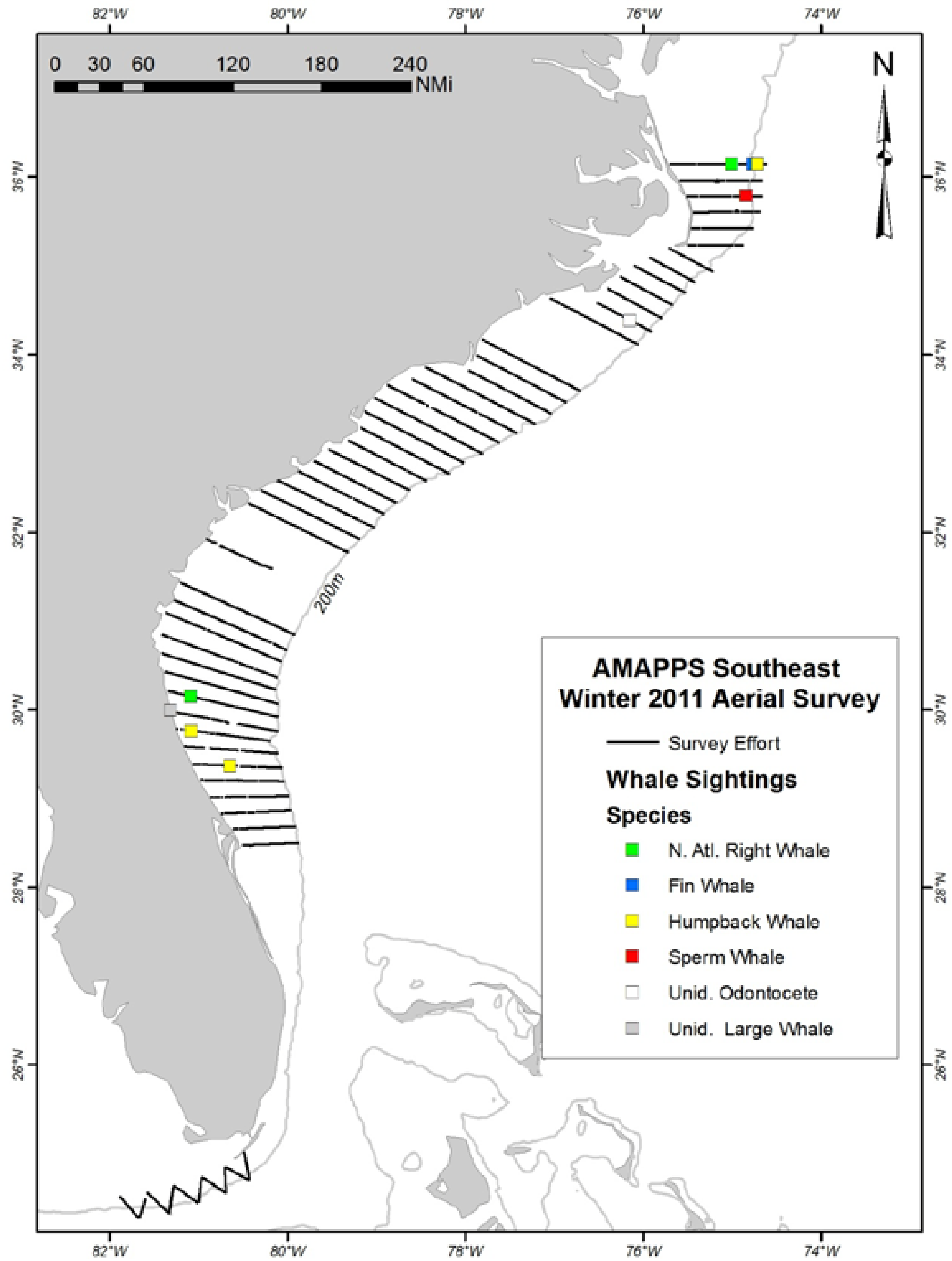


Figure B9. Winter 2011 Southeast AMAPPS aerial survey: Fish sightings detected by forward team.

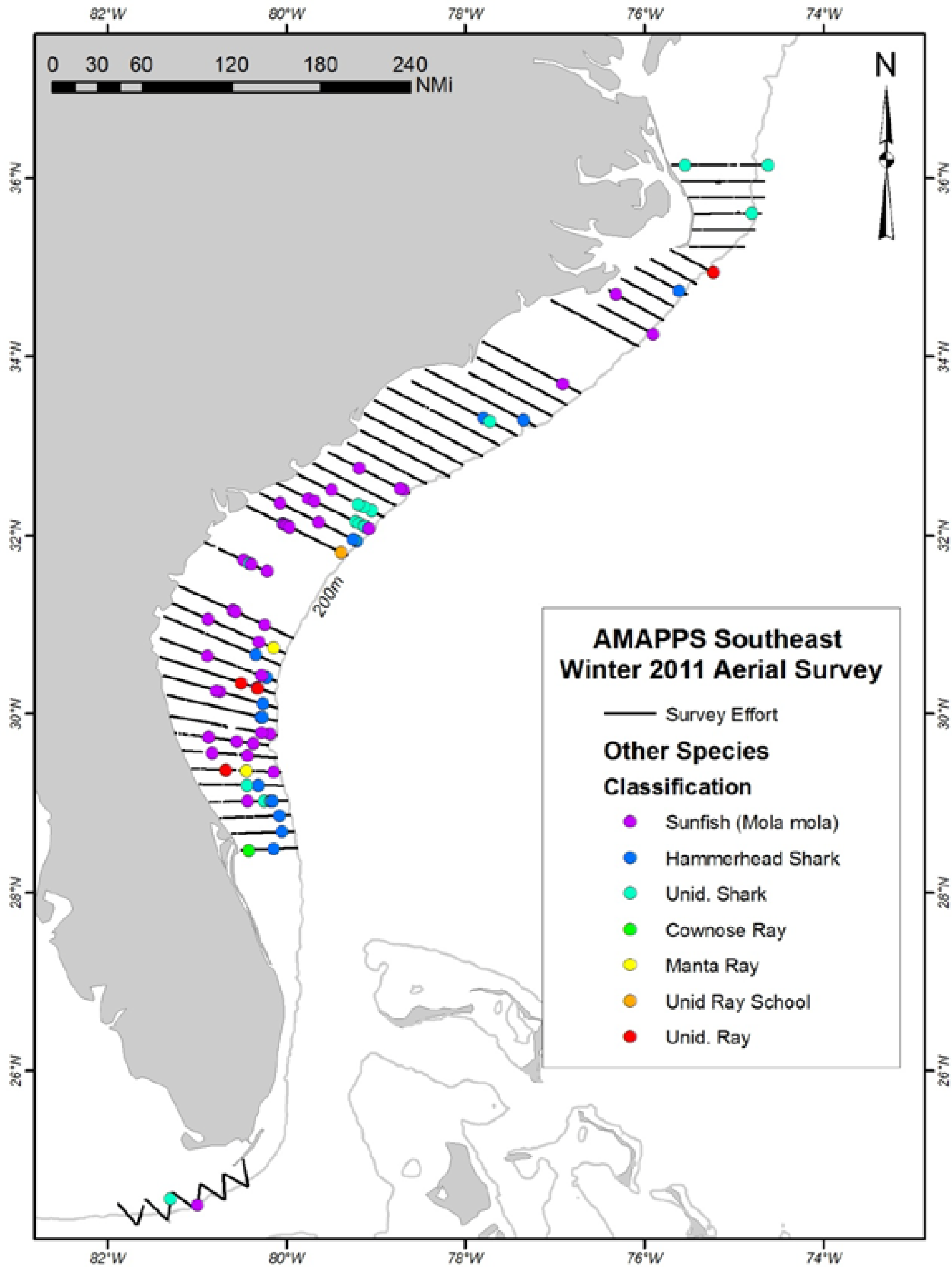


Figure B10. Summer 2011 Southeast AMAPPS aerial survey: Completed survey tracklines. 200 m depth contour depicted.

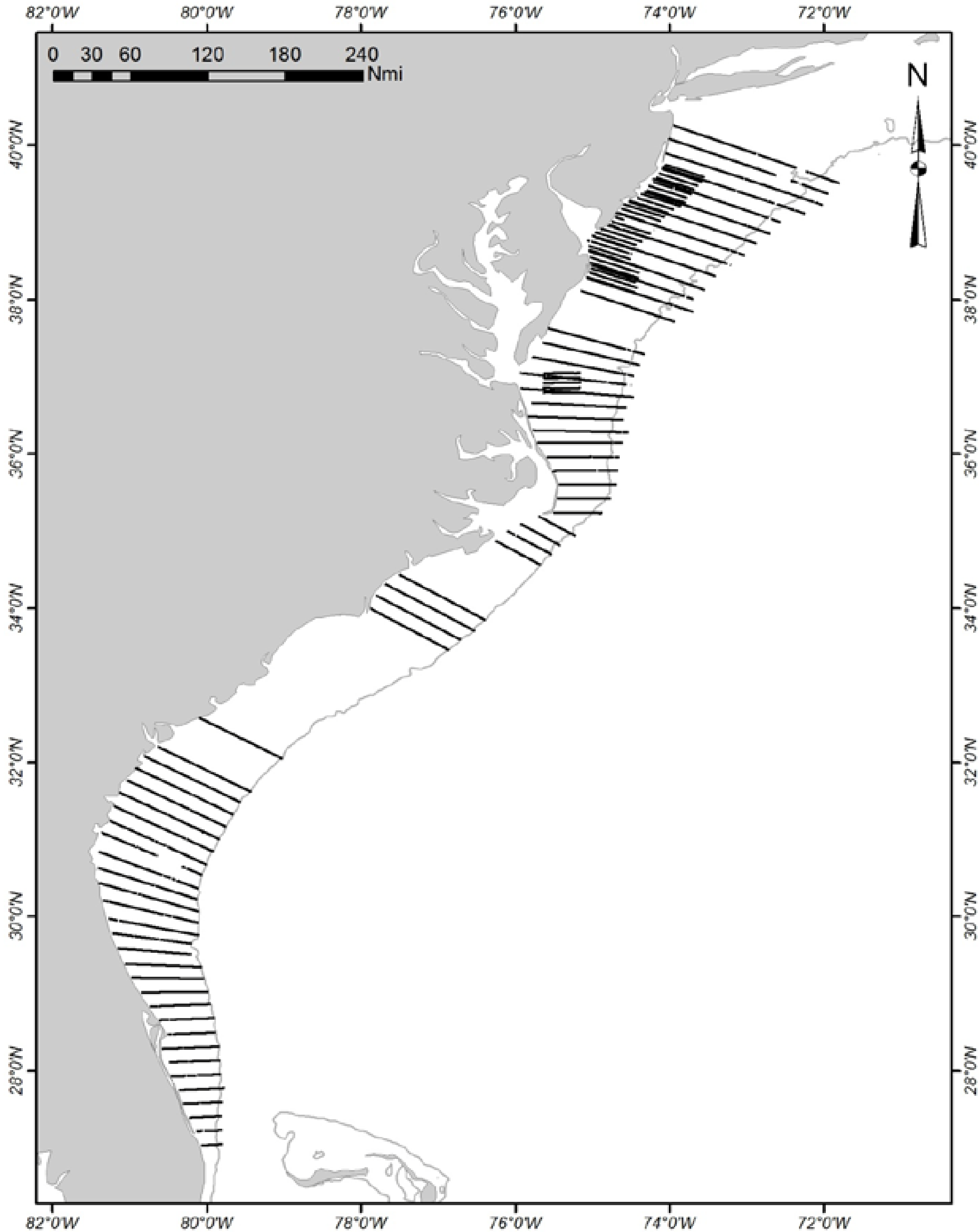


Figure B11. Summer 2011 Southeast AMAPPS aerial survey: Beaufort sea states during flights; 200 m depth contour depicted.

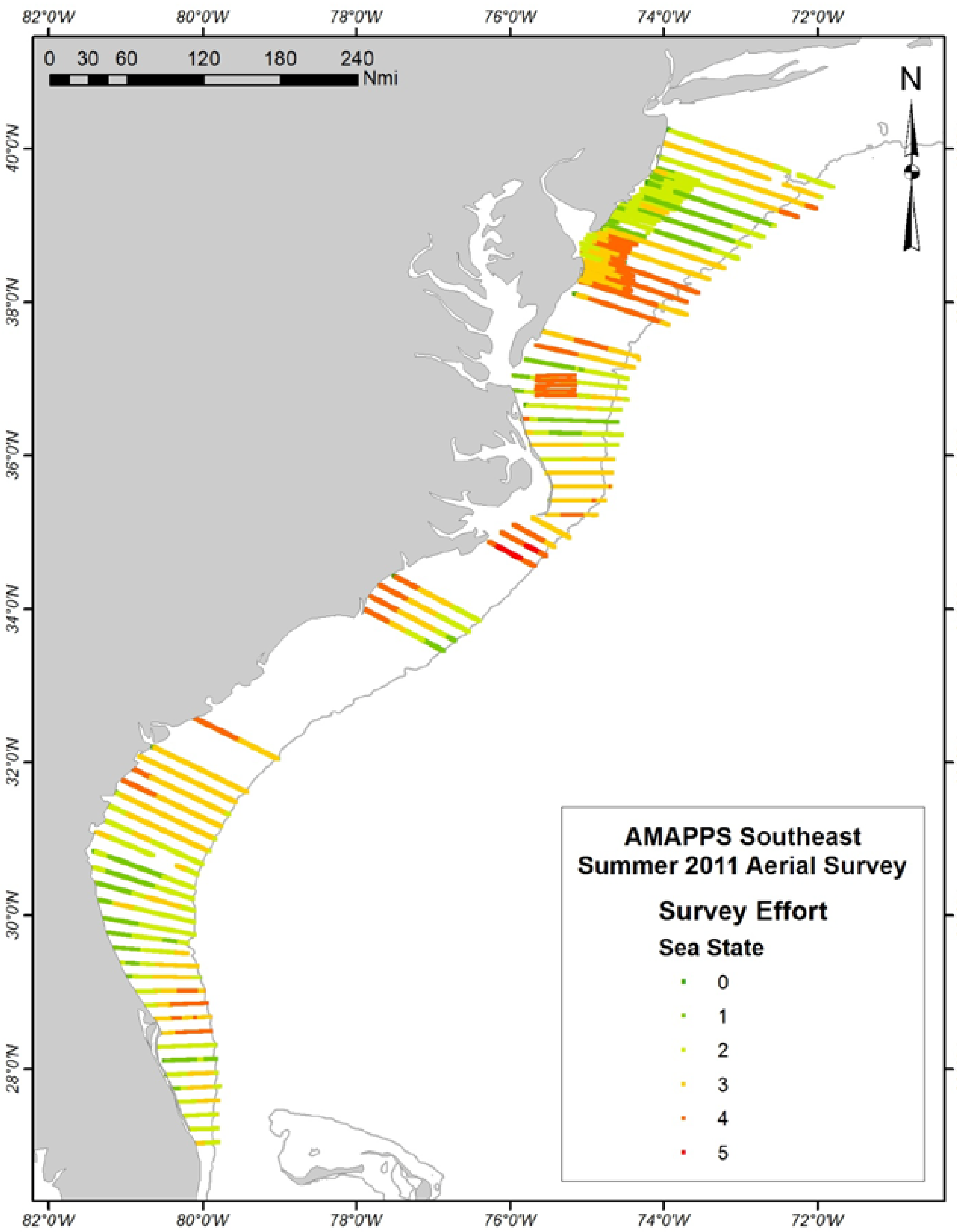


Figure B12. Summer 2011 Southeast AMAPPS aerial survey: Loggerhead turtle sightings detected by forward survey team. 200 m depth contour depicted.

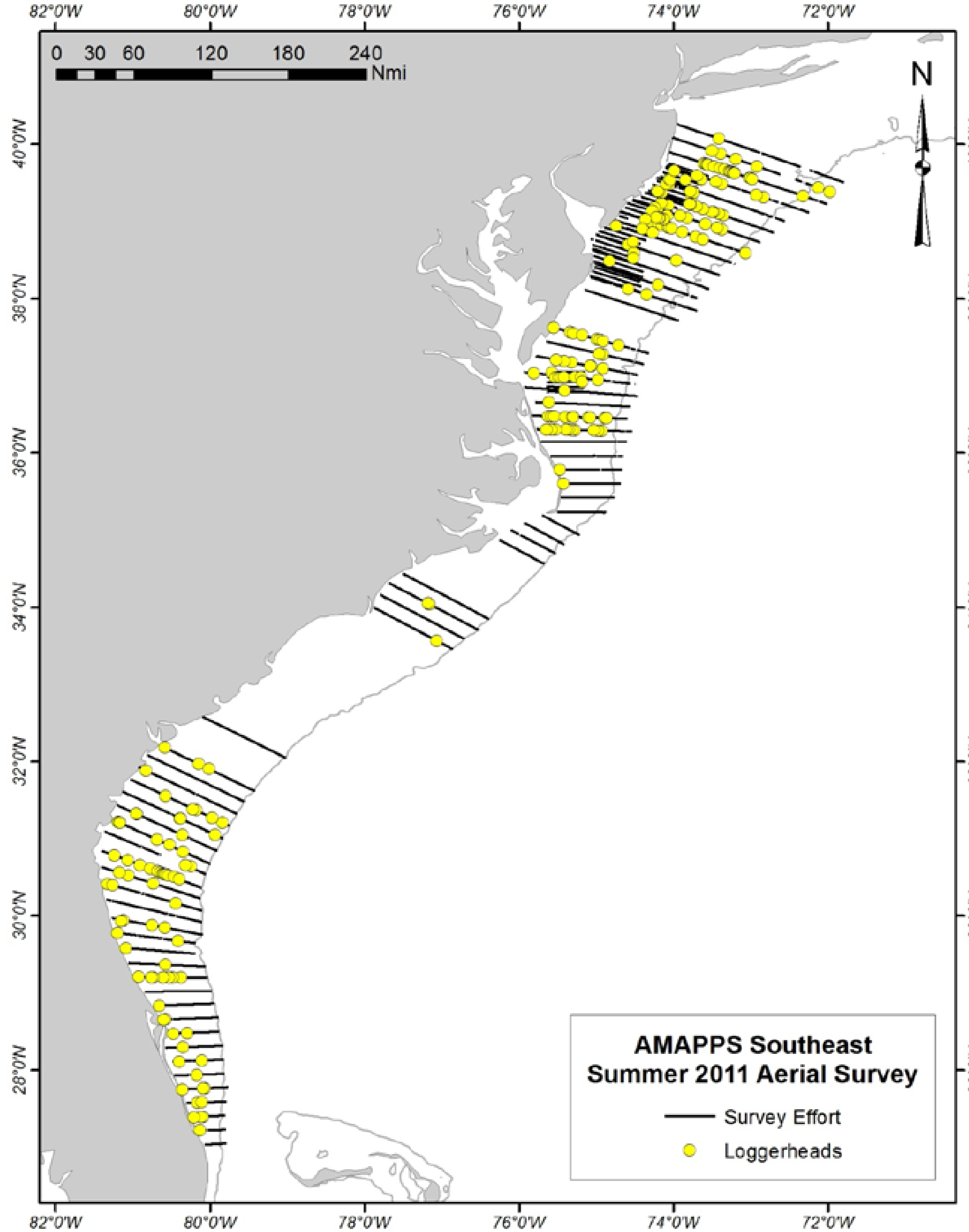


Figure B13. Summer 2011 Southeast AMAPPS aerial survey: Other hardshell turtle sightings detected by forward survey team. 200 m depth contour depicted.

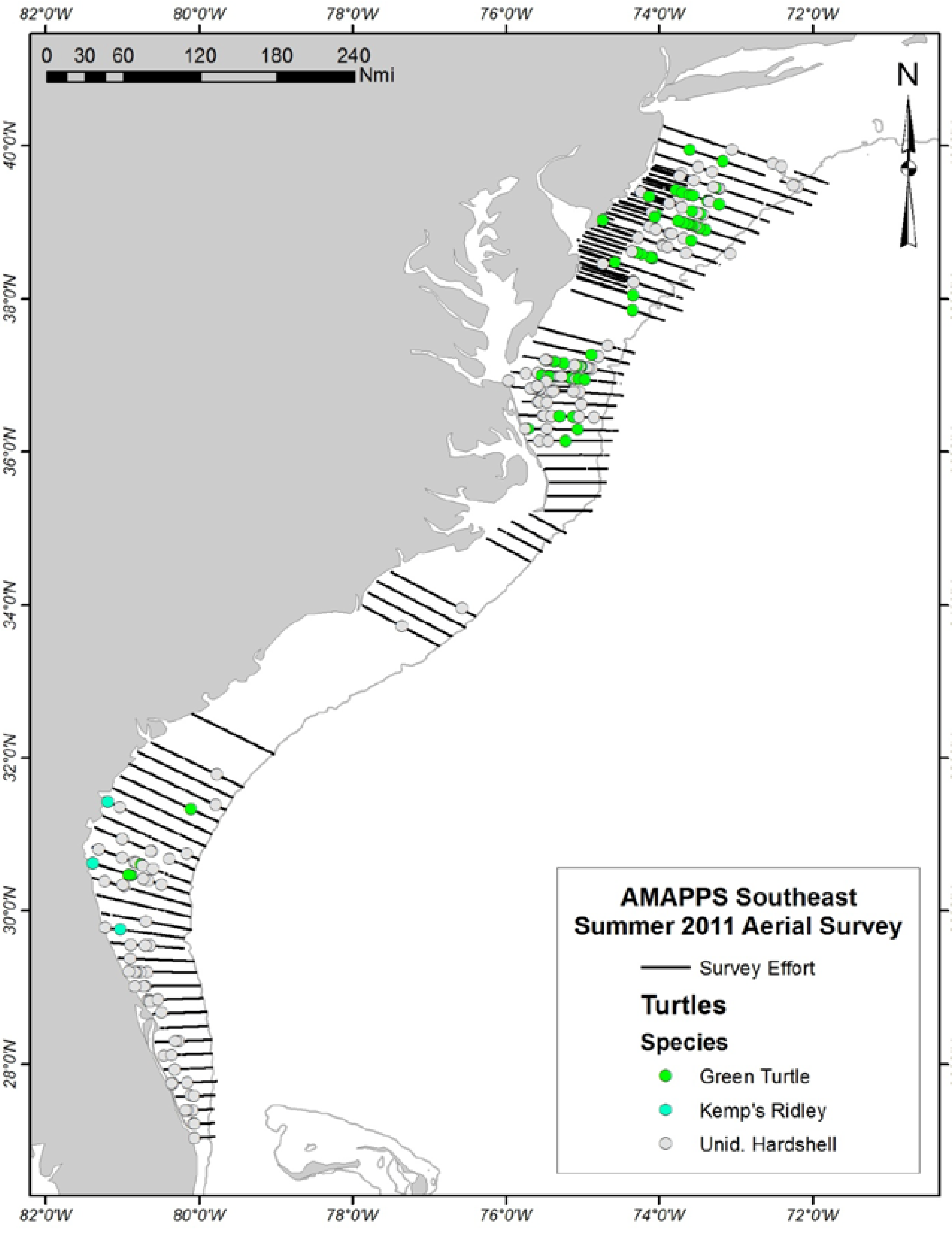


Figure B14. Summer 2011 Southeast AMAPPS aerial survey: Leatherback turtle sightings detected by forward survey team. 200 m depth contour depicted.

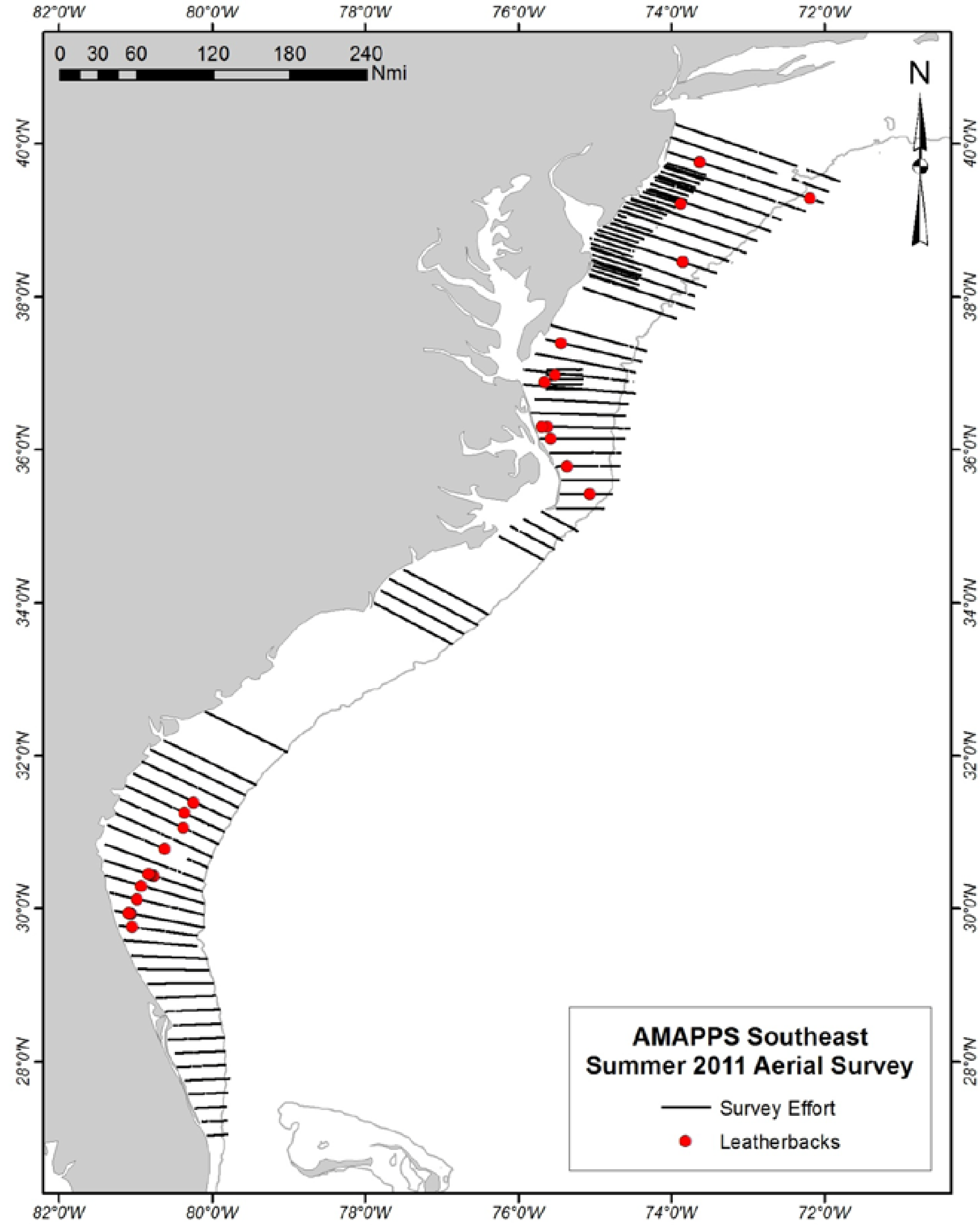


Figure B15. Summer 2011 Southeast AMAPPS aerial survey: Bottlenose dolphin sightings detected by both survey teams. 200 m depth contour depicted.

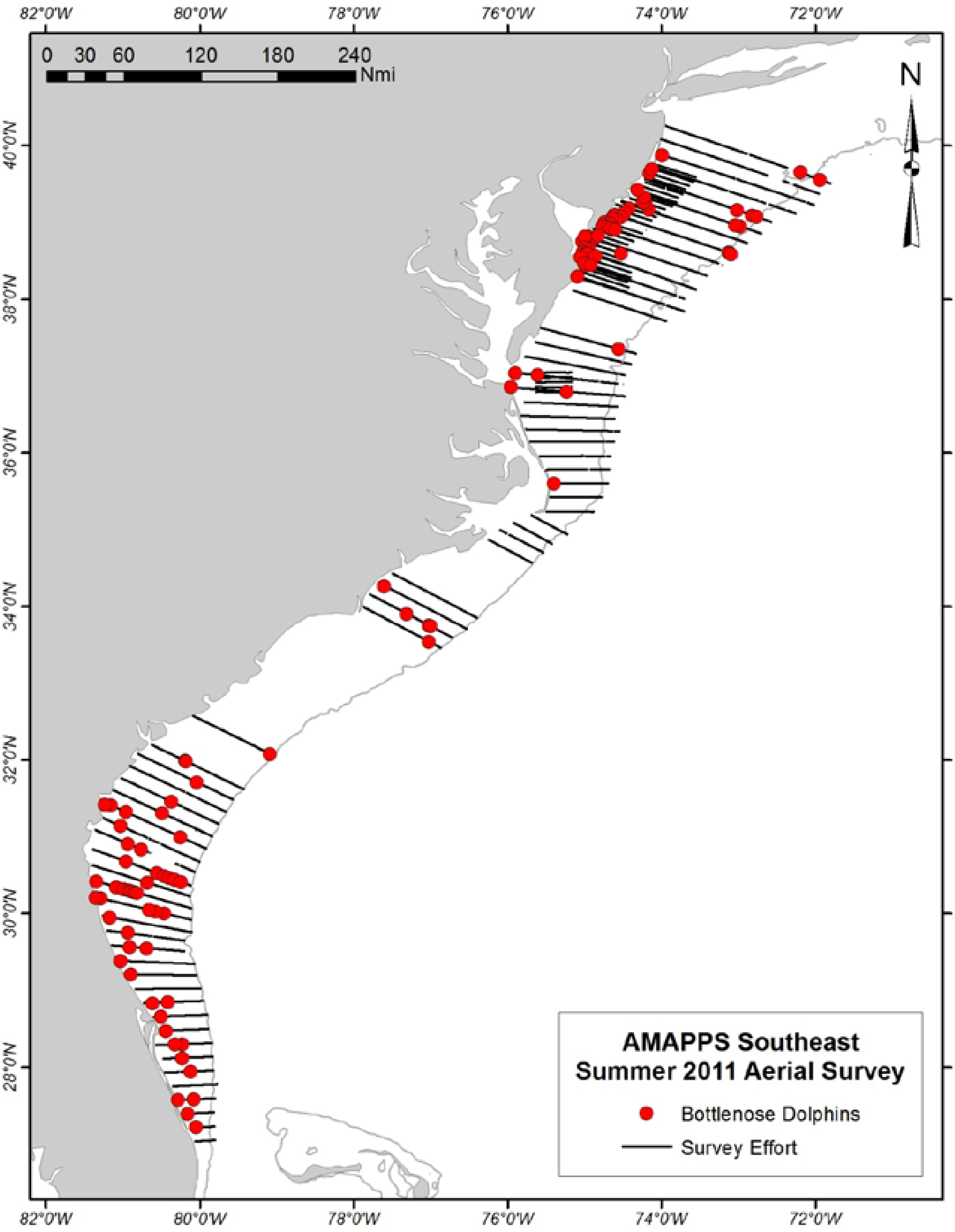


Figure B16. Summer 2011 Southeast AMAPPS aerial survey: Other dolphin sightings detected by both survey teams. 200 m depth contour depicted.

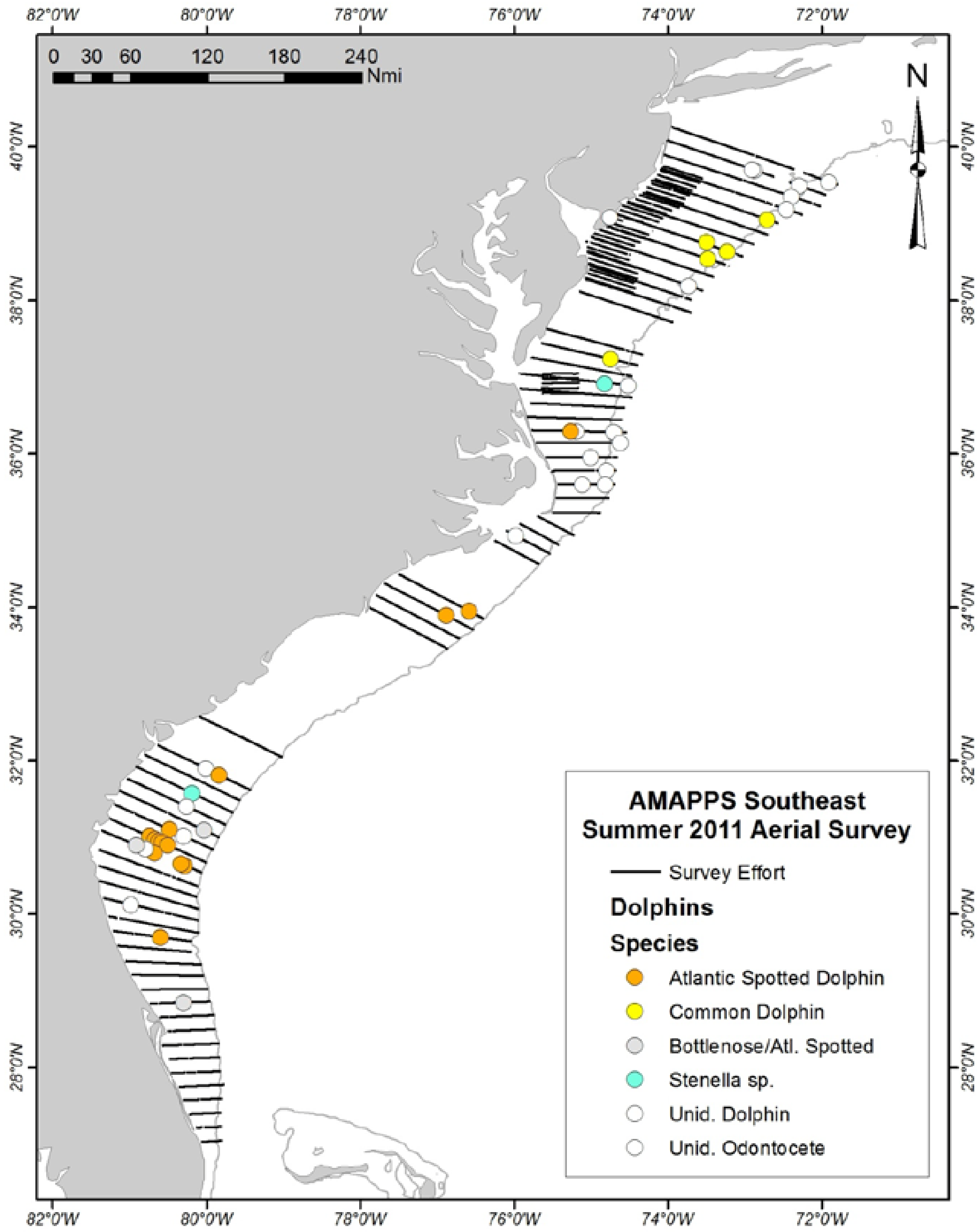


Figure B17. Summer 2011 Southeast AMAPPS aerial survey: Whale sightings detected by both survey teams. 200 m depth contour depicted.

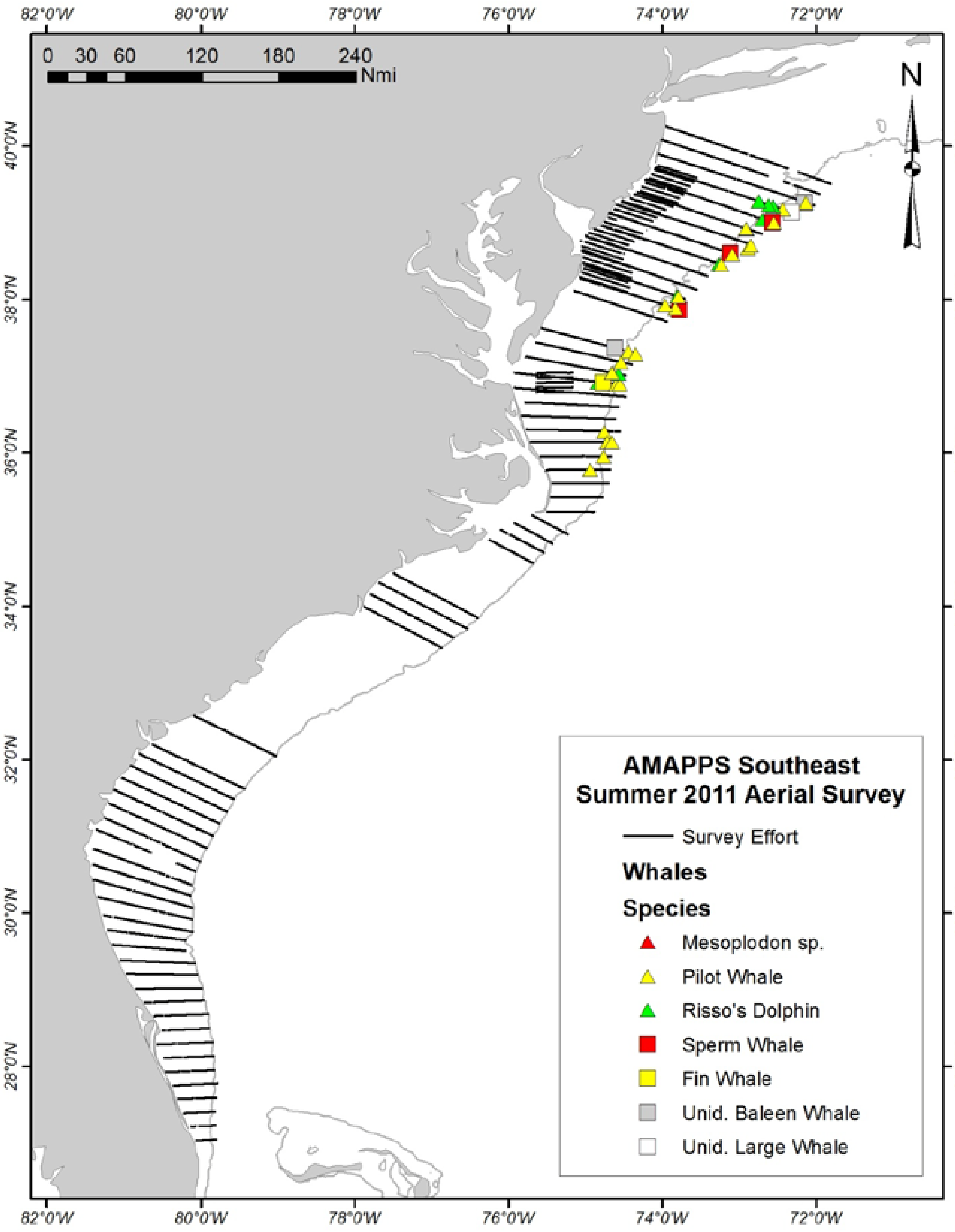
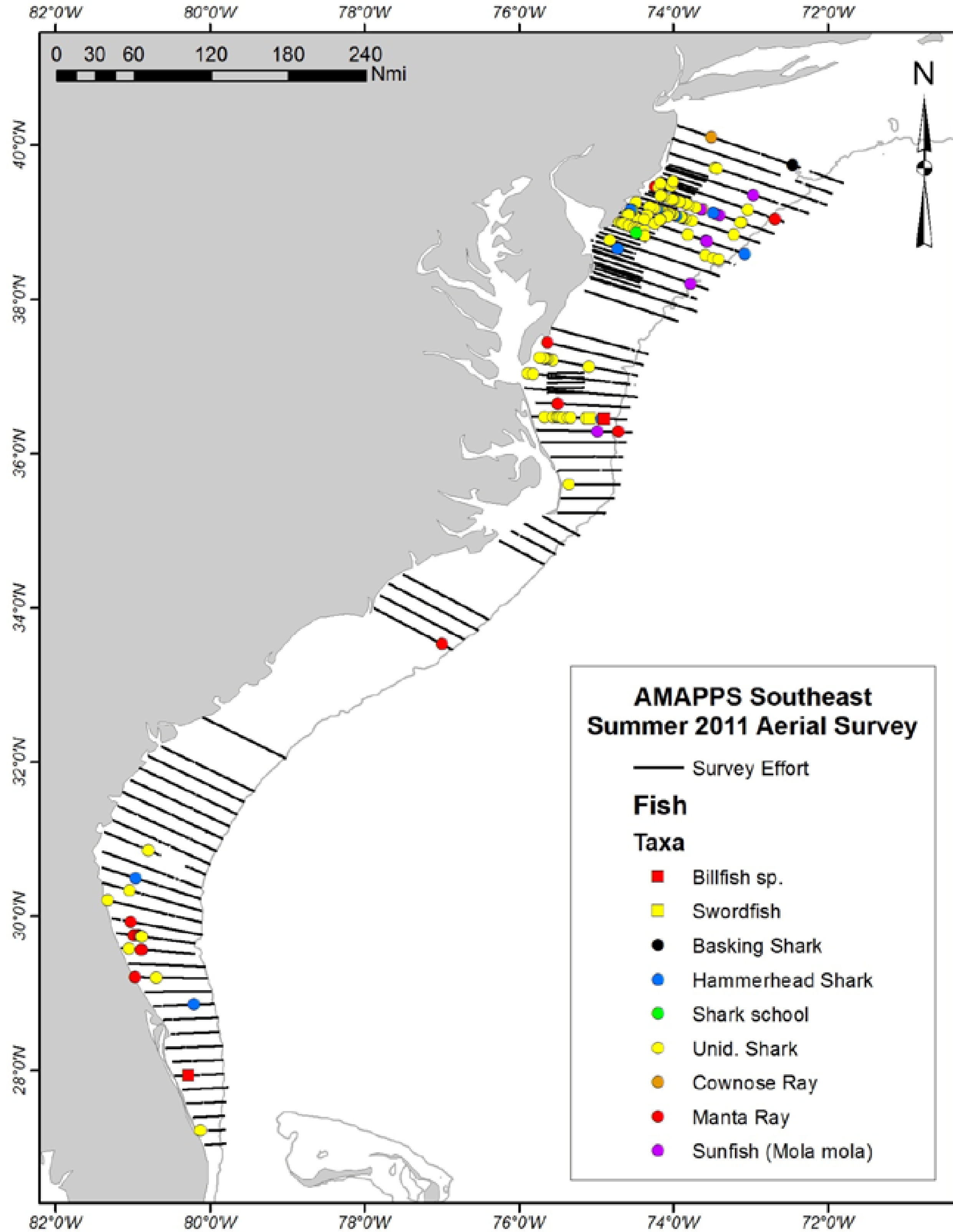


Figure B18. Summer 2011 Southeast AMAPPS aerial survey: Fish sightings detected by forward team. 200 m depth contour depicted.



Appendix C*:* *Northern leg of shipboard abundance survey during summer 2011: Northeast Fisheries Science Center*

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Summary

The Northeast Fisheries Science Center (NEFSC) conducted an abundance survey on the NOAA ship *Henry B. Bigelow* targeting marine mammals, sea turtles and sea birds during 2 June – 1 August 2011. The survey was divided into three legs, and surveyed about 5050 km of track lines in acceptable weather conditions (less than Beaufort 5 sea state conditions). The study area included waters south of Cape Cod (about 42° N latitude), north of North Carolina (about 36° N latitude), east of the southern tip of Nova Scotia (about 64° 30'W longitude), and west of the U.S. coast (about 75° W longitude). There were five teams of scientists collecting data: two teams of visual observers searching for marine mammals and sea turtles, a team of visual observers searching for sea birds, a team of acoustic observers listening for cetacean vocalizations detected by a passive acoustic array and recording fauna detected by the active acoustic scientific echosounder EK60, and a team of scientists collecting plankton data. In total, over 11,000 individuals (about 650 groups) of 21 species or species groups of cetaceans and 2 turtle species were visually or acoustically detected, and over 5000 individuals of 46 bird species were visually detected. Ten cetacean biopsies were collected. Over 311 hours of passive acoustic data were collected. In addition, 21 vertical conductivity-temperature depth (CTD) profiles, 90 hauls of double oblique bongo nets with a CTD, 81 hauls of a visual plankton recorder (VPR) with a CTD, and 44 expendable bathythermograph (XBT) profiles were deployed.

Study area and cruise period

Using the NOAA ship *Henry B. Bigelow*, this cruise, designated HB-11-03, was conducted during 2 June – 1 August 2011 and was divided into three legs: 2 – 22 June, 27 June – 15 July, and 20 July – 1 August. The only port use was Newport, RI. Participant for each leg are detailed in Table C1.

The study area (Figure C1) included waters south of Cape Cod (about 42° N latitude), north of North Carolina (about 36° N latitude), east of the southern tip of Nova Scotia (about 64° 30'W longitude), and west of the US coast (about 75° W longitude). This is waters shallower than about 4500 m and includes international waters and waters within the US and Canadian economic exclusive zones (EEZ).

This study area was divided into four spatial strata that represent different habitats (Figure C1):

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

- *Offshore*: a stratum ranging from North Carolina to the southern tip of Nova Scotia (about 36˚N – 42˚N latitude) and in waters that are offshore of the 2000 m depth contour to beyond the U.S. EEZ and the Gulf Steam's northern wall;
- *BOEM-MA*: a stratum south of Massachusetts on the continental shelf in waters that are about 30 – 60 m deep (around 41˚N latitude); and
- *BOEM-MidAtl*: a couple small areas of water off the coasts of New Jersey, Delaware and Virginia that are on the continental shelf in waters that are about 20 – 30 m deep (between 38˚N – 40˚N latitude).

Objectives

The primary objective of the survey was to collect data and samples to support the assessment of the abundance, habitats, and spatial distribution of cetaceans, sea turtles and sea birds within U.S. waters. The survey was conducted as part of the Atlantic Marine Assessment Program for Protected Species (AMAPPS). In addition, the data will improve the assessment of marine mammal stocks as required under the Marine Mammal Protection Act (MMPA). The current survey will provide data to support updated abundance estimates for U.S. Atlantic oceanic stocks of marine mammals, which were last updated from data collected during 2004.

The detailed objectives of the survey were:

1) Collect data to determine the distribution and abundance of cetaceans, sea turtles and sea birds within the study area using visual line-transect survey methods;
2) Collect vocalizations of cetaceans using passive acoustic arrays;
3) Collect data to determine the distribution and relative abundance of plankton and other trophic levels using scientific echosounders (EK60), bongo nets, and a visual plankton recorder (VPR),
4) Collect hydrographic and meteorological data using various onboard instruments and using conductivity-temperature-depth profilers (CTDs) and expendable bathythermograph profilers (XBTs) to sample the water column,
5) When possible, collect tissue samples (biopsies) and photo-identification pictures of cetaceans from the bow of the NOAA ship *Henry B. Bigelow*, and
6) Further develop data entry programs to improve the collection of visual sightings data of sea birds and marine mammals.

Methods

Visual marine mammal – turtle sightings data

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 (Laake and Borchers 2004). Surveying was conducted during good weather conditions (Beaufort four and below) while traveling at about 10 – 12 knots, as measured over the ground.

Scientific personnel formed two visual independent 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 ("bigeyes"), one on-effort observer who recorded the sightings data detected by all team members and also searched using naked eye and, and one off-effort observer who could rest. Every 30 minutes observers on each team rotated positions within the team. Observers did not rotate between teams. The composition of the teams changed every leg.

Position, date, time, ship's speed and course, water depth, surface temperature, salinity, and conductivity, along with other variables (Table C2) were obtained from the ship's Science Computer System (SCS). These data were routinely collected and recorded every second during at least the visual survey operation time periods. Sightings and visual team effort data were entered by the scientists onto hand held data entry computerized systems using a software program called VisSurv_NE which saved the data into an Access database (version 1 used on leg 1; version 2 used on legs 2 and 3; developed by L. Garrison and D. Palka) and was connected to the SCS system to automatically obtain the ship's location.

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

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

- Time sighting was initially detected, recorded to the nearest second,
- Species composition of the group,
- 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,
- 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,
- Best estimate of group size,
- Direction of swim,
- Number of calves,
- Initial sighting cue,
- Initial behavior of the group, and
- Any comments on unusual markings or behavior.

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

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

- Time of recording,
- Position of each observer, and

- Weather conditions: swell direction and height, Beaufort sea state, presence of rain or fog, amount of cloud coverage, visibility (i.e., approximate maximum distance that can be seen), and glare width and glare strength.

Seabird sightings data

From an observation station on the flying bridge, about 15.1 m above the sea surface, one to three observers conducted a visual survey dedicated for marine birds during daylight hours, approximately 0600 – 1800 with a one hour break at lunchtime. Seabird observation effort employed a modified 300 m strip and line transect methodology, where data on seabird distribution and abundance were collected by identifying and enumerating all birds seen within a 300 m arc on one side of the bow while the ship was underway. Seabird observers maintained a visual unaided eye watch of the 300 m survey zone, with frequent scans of the perimeter using hand-held binoculars for cryptic hard to detect species. Binoculars were also used to confirm identification. All birds including non-marine species, such as herons and swallows, were recorded.

Operational limits are higher for seabird surveys as compared to the above marine mammal and turtle surveys. As a result, seabird survey effort was possible in sea states above Beaufort 4, up to and including Beaufort 7. Standardized seabird data collection effort continued during "repositioning transits"—transits between waypoints that could span a few hours to all day—even though there was no corresponding visual marine mammal survey effort. The seabird observer rotation generally adhered to a two hours on, two hours off routine, but this was modified on legs 1 and 2 when frequently two observers would be on effort simultaneously.

All data were entered in real time into a laptop computer running Seebird linked to the ship's navigation system via a serial/RJ-45 cable. The Seebird software incorporates a time synchronization feature to ensure the computer clock matches the GPS clock to assist with post-processing of the seabird data with the ship's SCS data. Data on species identification, number of birds within a group, distance between the observer and the group, angle between the track line and the line of sight to the group, behavior, flight direction, flight height, age, sex and molt condition, if possible, were collected for each sighting. The sighting record received a corresponding time and GPS fix once the observer accepted the record and the software wrote it to disk. *Seebird* also added a time and location fix every 5 to 10 minutes. All data underwent a quality assurance and data integrity check each evening and was saved to disk and to an external backup dataset.

Passive acoustic data

The acoustic monitoring team consisted of 2 – 3 people who operated the system in two-hour shifts from 0600 – 1800 or later. The hydrophone array was deployed at about 0545 each morning, and was retrieved at about 1130 for the midday bongo/CTD casts and at about 1800 at the end of the survey day. The acoustic team collected the passive acoustic data during all hours when the visual team was on-effort, with the following two exceptions: 1) during Leg 1, repairs to the hydrophone array resulted in the loss of approximately 15 hours of acoustic monitoring effort; and 2) during Legs 2 and 3 the array was not deployed along coastal tracklines, where it was considered too shallow for safe deployment. On some occasions, the acoustic team also monitored when weather conditions prevented the visual team from operating.

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

At all times when the array was deployed, acoustic data were routed to a desktop computer via an external RME Fireface 400 soundcard and were recorded continuously utilizing the software package PAMGUARD (http://www.pamguard.org/home.shtml). Two-channel data were also routed to a second set of computers via an external M-Audio soundcard, sampling at 44kHz, for real-time detection and tracking of vocal animals utilizing the software packages WhalTrak and Ishmael. Whenever possible, vocally-active groups that were acoustically tracked were matched with visual detections in real-time, for assignment of unambiguous species classification. Communication was established between the acoustic team and the visual team situated on the flying bridge to facilitate this process. Acoustic detection data were manually saved to an Access database, which also included real-time GPS positions of the ship.

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

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

Biopsy sampling data

Biopsies from bow riding dolphins were obtained from the bow of the NOAA ship *Henry B. Bigelow* using cross-bows and specially designed arrows with a modified tip that extract a small plug of tissue from an animal. Skin samples will be used to determine gender and species identification, and to evaluate population structure. Blubber samples can be analyzed for a variety of contaminants. Data on each sampling attempt were recorded and included GPS location, time, date, sampler and recorder name, species, group size, body location struck, behavioral reaction, and whether or not a sample was obtained. A complete log of the biopsy data is maintained at the NEFSC Woods Hole laboratory. Biopsy skin samples were preserved in vials containing 20% dimethyl sulfoxide (DMSO).

Active acoustic data

Acoustic backscatter data used to identify zooplankton and fishes were collected from the ship's Simrad EK60 multi-frequency scientific echosounder system. These data were collected every night after marine mammal operations ended and every other day when the marine mammal teams were on-effort. The purpose of the every other day operations was to allow an investigation into the effects, if any, of active acoustics on the encounter rates or reactions of marine mammals. The EK60 system consists of five frequencies, 18 kHz, 38 kHz, 70 kHz, 120 kHz, and 200 kHz that synchronously emit pings and record returned acoustic backscatter. These five frequencies were appropriate for measuring acoustic backscatter from zooplankton and fishes. When the ship was in water depths shallower than 1000 m, a ping was emitted every 2 s. When the ship was in water depths greater than 1000 m, a ping was emitted every 5 s. Data were recorded to 3000 m depth. All five transducers were mounted on a retractable centerboard that was 6 m below the waterline when flush with the hull and 7.5 m below the waterline when the centerboard was extended to its intermediate depth position. When the EK60 system was operational, active acoustic data were continuously recorded to the ship's acoustic server. Five minutes of passive acoustic data were recorded through the 70 kHz, 120 kHz, and 200 kHz transducers most days after the passive acoustic array was brought on board. The SCS event logger system was used during the cruise to record all operational events (e.g., begin and end recordings, changes in centerboard position, and changes in ping rate). The EK60 transducers were calibrated in March 2011 before the NEFSC spring bottom trawl survey.

Hydrographic data
The ship's SCS data logger system continuously recorded oceanographic data from the ship's sensors (Table C2). In addition, a SEACAT 19 Profiler (CTD) was used to measure water column conductivity, temperature and depth. The CTD was mounted on a 322 conducting core cable allowing the operator to see a real time display of the instrument depth and water column temperature, salinity, density and sound speed on a computer monitor in the ship's Dry Lab. Once a day, if the oceanography profiles showed an area of steady salinity values, a vertical profile was created with the CTD and a Niskin bottle attached to the wire above the CTD to collect a water sample which will be used to calibrate the conductivity sensor of the CTD.

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

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

Plankton data
A 61 cm bongo plankton frame was equipped with one 333 μm and one 505 μm mesh net and a CTD mounted on the wire 1 m above the nets. 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 the time of sunset). The bongo was towed in a double oblique profile using standard MARMAP protocols. The ship's speed through the water was approximately 1.5 kts. Wire out speed was 50 m/min and wire in speed was 20 m/min. Tows were to within 5 m of the bottom or to 200 m depth, if the bottom depth exceeded 205 m. Upon retrieval, samples were rinsed from the nets using seawater and preserved in 5% formaldehyde and seawater. Samples were transported to the Narragansett, RI NEFSC lab for future identification.

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

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

Results

Scientists involved in this survey are detailed in Table C1.

Visual marine mammal – turtle sightings data

The visual marine mammal and turtle team surveyed about 5047 km in total. However, some track lines initially surveyed in poor sighting conditions (Beaufort sea states of 4 and 5) were re-surveyed at a later time in better conditions. Thus resulting in 3811 km of track lines surveyed in the best possible sighting conditions which will be used in the abundance estimation analyses (Figure C1; Table C3). About 52% of the survey transects were conducted in very good weather conditions, Beaufort sea state 2 or less (Table C3).

During the on-effort track lines, 21 species or species groups and 2 identifiable sea turtles were recorded (Table C4). Distribution maps of sighting locations of the cetaceans, turtles and sunfish are displayed in Figures C2 to C4. Note these are locations of sightings seen by both teams, where some groups of animals were seen by both teams and other groups were seen by only one of the teams. For cetaceans, the upper team detected 792 groups (11,455 individuals) and the lower team detected 609 groups (8458 individuals). For turtles, the upper team detected 14 groups (14 individuals) and the lower team detected 7 groups (7 individuals). Note some, but not all, groups of cetaceans and turtles detected by one team were also detected by the other team. One seal was detected. In addition, 18 (17) basking sharks and 41 (15) ocean sunfish were detected by the upper (and lower) teams.

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

Sea bird sightings data

Seabird survey effort was conducted on 43 days. The NOAA ship *Henry B. Bigelow's* flying bridge provided a stable platform and afforded good visibility for the seabird team. Seabird survey data were collected on every sea-day except for three days when the vessel was hove-to due to weather (Figure C5a).

While on-effort, 5148 birds were detected (Table C5; Figures C5 to C7). Nomenclature followed that reported in The Clements Checklist of Birds of the World. 6th edition, Cornell University Press 2007, with electronic updates to 2010. This survey identified 46 species of birds, in addition to five unidentified species groups (e.g., unidentified jaeger, unidentified storm-petrel). Four species comprised 86% of the total birds seen. In declining order of abundance these were: great shearwater *(Puffinus gravis)*, Wilson's storm-petrel *(Oceanites oceanicus)*, Leach's storm-petrel *(Oceandroma leucorhoa)* and Cory's shearwater *(Puffinus diomedea)*. Meanwhile, others, such as Audubon's shearwater *(Puffinus lherminieri)* and bridled tern *(Onychoprion anaethetus)*, being tropical and sub-tropical species, were closely associated with habitat type; in this case, warm Gulf Stream waters.

Extremely unusual was the sighting of a Barolo Shearwater (*Puffinus baroli*), only the second sighting for Massachusetts and very rare anywhere in the northwest Atlantic. The normal breeding range includes islands off northwest Africa (Azores, Desertas, Salvage and the Canary Islands). All other seabirds were expected although several, such as White-faced storm-petrel (*Pelagodroma marina*) and White-tailed tropicbird (*Phaethon lepturus*) are considered quite rare. However, this is probably more a reflection of a lack of observer effort in distant off-shore areas where these birds normally occur rather than actual scarcity. The sighting of an immature male Yellow-headed blackbird (*Xanthocephalus xanthocephalus*) was exceptional because the typical eastern edge of its habitat is the Great Plains (Illinois and Indiana), not the Atlantic Ocean.

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

Passive acoustic data

The acoustic team collected passive acoustic data during all hours when the visual team was on-effort, with the following two exceptions: 1) during Leg 1, repairs to the hydrophone array resulted in the loss of approximately 15 hours of acoustic monitoring effort; and 2) during Legs 2 and 3 when the tracklines were in waters considered too shallow for safe deployment. The acoustic team also monitored on some occasions when weather conditions prevented the visual team from operating. Thus, during the course of the survey, there were 40 days with acoustic monitoring effort, for a total of 311.5 hours of continuous data collection (Table C6).

Real-time monitoring resulted in the detection of 356 acoustic groups (Figures C8 and C9). Of these, approximately 37% corresponded to the visual detection of small odontocetes, including 8 species of delphinids, and 1 species of beaked whale (Table C7). In some cases, it was impossible in real-time to acoustically differentiate subgroups of animals that were visually distinguished and counted as separate sightings, resulting in the underestimate of acoustic detections as compared to visual detections.

Sperm whales were detected on 32 survey days, with a total of 87 different individuals or groups of individuals, comprising 24% of all acoustic detections (Table C8; Figure C10). At the times when many individuals were present, they were treated as one acoustic detection event for practicality of real-time tracking. Approximately 11 of these groups were detected visually; therefore approximately 87% of sperm whale detections were solely acoustic.

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

Post-processing of acoustic data will be conducted towards several main objectives. These include: 1) re-analyses of acoustic groups that may correspond to visual sightings but were not confirmed in the field, 2) implementation of acoustic detectors for beaked whales, which were not feasible to detect in real-time, with the exception of one species, 3) analyses of sperm whale data for a preliminary calculation of abundance, and 4) whistles and echolocation clicks will be extracted for instances in which high-quality recordings were collected of unambiguously-identified species, for the eventual development of automatic species classifiers.

Biopsy sampling data

A total of 10 cetacean biopsies were collected from 4 different species: striped dolphins, Atlantic spotted dolphins, rough-toothed dolphins, and pilot whales sp. (Table C9; Figure C11).

Active acoustic data

The EK60 and ADCP systems were operational every other day that the marine mammal teams were on-effort and during all nighttime operations (Table C10). Echo layers observed in the EK60 real time display, especially at night, were targeted for VPR sampling. Archived EK60 data will be analyzed via frequency differencing to determine a broad acoustic classification of middle trophic level biological data. When possible the classified sections will be checked against the bongo tows and VPR images.

Preliminary assessment of the multi-frequency data show strong scattering in the lower frequencies around shelf break areas. These scattering regions are spatially patchy and temporally ephemeral. The diel vertical plankton migration is best seen on the higher frequencies at dusk and dawn. ADCP data have been archived and will be analyzed at a later date.

Hydrographic data
A total of 21 vertical CTD profiles, 90 double oblique bongo hauls with a CTD, and 81 VPR hauls with a CTD were conducted (Table C11; Figure C12), and 44 XBTs were launched (Figure C13).

An XBT was launched directly after an evening CTD was deployed. When comparing these two temperature profiles, temperatures from the XBT probe were an average of 0.02° (SD = 0.41) greater than temperatures from CTD at the same depths (Figure C14). Temperature profiles varied across the shelf break, most noticeably along trackline 7 when the northwest wall of a warm core ring was at the shelf break (Figure C15). Surface temperatures ranged from 15 – 30°C. Bottom temperatures in deep water were approximately 5°C. Bottom temperatures in the shelf ranged between 10 – 13°C.

Oceanographic profiles varied strongly within the study area (Figures C16 – C19). Offshore profiles were strongly affected by the Gulf Stream on the southern end and a warm core ring on the northern end of the sampling area. Oceanography along the shelf slope edge tended to be cooler with 4 – 5°C thermoclines in June and warmer with 6 – 12°C thermoclines in July. Depth of the thermocline varied from 15 – 50 m with most being around 20 – 25 m. Northern stations tended to have lower temperatures and salinities than the southern Mid-Atlantic Bight stations. All shelf slope stations with a noticeable thermocline also had increased chlorophyll and turbidity in the area of the thermocline. Inshore stations showed well mixed oceanographic conditions with warm temperatures in both northern and southern stations, but lower salinities at the Nantucket shoals stations.

Plankton data
A total of 90 double oblique bongo with CTD hauls, and 81 VPR with CTD hauls were conducted (Table C11; Figure C12). In addition, for Kara Dodge special samples of 12 bags of gelatinous zooplankton of various species were frozen on Legs 1 and 2.

Plankton layers in the offshore stations associated with layers seen on the EK60 were generally Euphasiids (krill). Southern offshore stations had higher densities of krill than northern stations as well as numerous siphonophores. Mid Atlantic bight samples had extremely high densities of gelatinous zooplankton (Figure C20). At least four species of Euphausiid were noted including: *Meganyctiphanes norvegica*, *Euphausia superba* and *Nematoscelis* spp. (Figure C21). Both the adult blastozooid with juveniles and the solitary oozoid forms of the salp T*halia democratica* were imaged (Figure C22). Ctenphora of the species *Pleurobrachi a* spp., *Bolinopsis* spp. and Beroe spp. and the hydromedusae of numerous species were also detected (Figure C23). Shelf slope edge stations from along Georges Bank had low densities of ctenophores and siphonophores but no salps. These stations also had medium densities of copepods, mostly *Calanus finmarchicus*, and the Hyperiid *Themisto gaudichaudii*.

Disposition of the data
All visual and passive acoustic data collected will be maintained by the Protected Species Branch at NEFSC in Woods Hole, MA. Visual sightings data will be available from the NEFSC's Oracle database.

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

All plankton samples collected will be maintained by the Fishery Oceanography Branch at the NEFSC in Narragansett RI. Plankton samples will be sent to Poland for identification. Plankton data are currently available by request only.

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

XBT data will be maintained by Erin LaBrecque (Duke University) and Gareth Lawson (Woods Hole Oceanography Institution). EK60 data will be maintained by the NEFSC in Woods Hole, MA. XBT and EK60 data are currently available by request only.

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

Permits

NEFSC was authorized to conduct the research activities during this cruise under Permit No. 775-1875 issued to the NEFSC by the NMFS Office of Protected Resources. Canada authorized NEFSC to engage in these research activities in Atlantic Canadian waters under license number 330996.

Literature 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 C1. Scientific personnel involved in the three legs of the HB-11-03 survey. FN = Foreign National.

Personnel	Organization	Duties
Leg 1 (2-22 Jun 2011)		
Gordon Waring	NMFS, NEFSC, Woods Hole, MA	Chief Scientist, Mammal observer
Elizabeth Broughton	NMFS, NEFSC, Woods Hole, MA	Oceanographer
Allison Henry	Integrated Statistics, Woods Hole, MA	Mammal observer
Richard Holt	Integrated Statistics, Woods Hole, MA	Mammal observer
Todd Pusser	Integrated Statistics, Woods Hole, MA	Mammal observer
Kelly Slivka	Integrated Statistics, Woods Hole, MA	Mammal observer
Aija Irene Briga	Integrated Statistics, Woods Hole, MA	Mammal observer
Betty Lentell	Integrated Statistics, Woods Hole, MA	Mammal observer
Alexandra McFarland	Integrated Statistics, Woods Hole, MA	Bird observer
Michael Force (FN)	Integrated Statistics, Woods Hole, MA	Bird observer
Christopher Vogel	Integrated Statistics, Woods Hole, MA	Acoustics
Joy Stanstreet	Integrated Statistics, Woods Hole, MA	Acoustics
Robert Valtierra	Integrated Statistics, Woods Hole, MA	Acoustics
Cara Hotchkin	Pennsylvania State University, University Park, PA	Mammal observer
Leg 2 (27Jun – 15Jul)		
Allison Henry	NMFS, NEFSC, Woods Hole, MA	Chief Scientist, Mammal observer
Marjorie Rossman	NMFS, NEFSC, Woods Hole, MA	Mammal observer
Peter Duley	NMFS, NEFSC, Woods Hole, MA	Mammal observer
Elizabeth Broughton	NMFS, NEFSC, Woods Hole, MA	Oceanographer
Carol Fairfield	NMFS, SEFSC, Miami, FL	Mammal observer
Gary Friedrichsen	Integrated Statistics, Woods Hole, MA	Mammal observer
Kelly Slivka	Integrated Statistics, Woods Hole, MA	Mammal observer
Todd Pusser	Integrated Statistics, Woods Hole, MA	Mammal observer
Jennifer Gatzke	Integrated Statistics, Woods Hole, MA	Mammal observer
Michael Force (FN)	Integrated Statistics, Woods Hole, MA	Bird observer
Michael Sylvia	Integrated Statistics, Woods Hole, MA	Bird observer
Robert Valtierra	Integrated Statistics, Woods Hole, MA	Acoustics
Danielle Cholewiak	Integrated Statistics, Woods Hole, MA	Acoustics
Reuben Darlington	Sunburst Sensors LLC, Missoula, MT	Flow-through system chemist
Jeffery Gleason	Bureau of Ocean Energy Management, Regulation and Enforcement, New Orleans, LA	Bird observer

Table C1 (cont'd). Scientific personnel involved in the three legs of the HB-11-03 survey. FN = Foreign National.

Personnel	Organization	Duties
Leg 3 (20Jul – 1Aug)		
Debra Palka	NMFS, NEFSC, Woods Hole, MA	Chief Scientist, Mammal observer
Peter Duley	NMFS, NEFSC, Woods Hole, MA	Mammal observer
Elizabeth Broughton	NMFS, NEFSC, Woods Hole, MA	Oceanographer
Gary Friedrichsen	Integrated Statistics, Woods Hole, MA	Mammal observer
Kalyn MacIntyre	Integrated Statistics, Woods Hole, MA	Mammal observer
Jennifer Gatzke	Integrated Statistics, Woods Hole, MA	Mammal observer
Aija Irene Briga	Integrated Statistics, Woods Hole, MA	Mammal observer
Carol Roden	Integrated Statistics, Woods Hole, MA	Mammal observer
Michael Force (FN)	Integrated Statistics, Woods Hole, MA	Bird observer
Marie Martin (FN)	Integrated Statistics, Woods Hole, MA	Bird observer
Robert Valtierra	Integrated Statistics, Woods Hole, MA	Acoustics
Sandra Smith	Integrated Statistics, Woods Hole, MA	Acoustics
Erin LaBrecque	Duke University, NC	Oceanographer
Christopher Faist	Teacher-at-sea, Calif.	Teacher-at-sea volunteer
Deborah Epperson	Bureau of Ocean Energy Management, Regulation and Enforcement, New Orleans, LA	Mammal observer

Table C2. Science Computer System (SCS) data collected continuously every second during the visual survey time periods (0600 – 1800).

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

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

		Track line length (km) within Beaufort sea state levels						
Strata	Area (km^2)	0	1	2	3	4	5	Total
Shelf break	54,376	0	192.5	415.1	494.6	372.5	34.9	1509.6
Offshore	197,953	129.9	194.2	607.8	355.6	253.7	56.6	1597.8
BOEM-MidAtl	2,563	0	0	29.1	10.9	194.6	7.3	241.9
BOEM-MA	8,672	48.5	168.1	191.0	54.5	0	0	462.1
Total	**263,564**	**178.4**	**554.8**	**1243.0**	**915.6**	**820.8**	**98.8**	**3811.4**

Cumulative percent of total	0.05	0.19	0.52	0.76	0.97	1.00

Table C4. Number of groups and individuals of marine mammals, turtles and large fish species detected by the two marine mammal - turtle visual teams, upper and lower. Note, some, but not all, groups detected by one team were also detected by the other team.

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

Table C5. Number of individual birds detected within the 300 m strip and the IUCN status (2011.2)

Species		Num of indiv	IUCN status
Northern fulmar	*Fulmarus glacialis*	3	Least Concern
Herald (Trindade) petrel	*Pterodroma (heraldica)*	15	Vulnerable
Fea's petrel	*Pterodroma feae*	2	Near Threatened
Black-capped petrel	*Pterodroma hasitata*	33	Endangered
Cory's shearwater	*Calonectris diomedea*	518	Least Concern
Great shearwater	*Puffinus gravis*	1991	Least Concern
Sooty shearwater	*Puffinus griseus*	156	Near Threatened
Manx shearwater	*Puffinus puffinus*	55	Least Concern
Barolo shearwater	*Puffinus baroli*	1	Unclassified
Audubon's shearwater	*Puffinus lherminieri*	147	Least Concern
unidentified shearwater	*Puffinus sp.*	41	not applicable
Wilson's storm-petrel	*Oceanites oceanicus*	1182	Least Concern
White-faced storm-petrel	*Pelagodroma marina*	2	Least Concern
Leach's storm-petrel	*Oceanodroma leucorhoa*	749	Least Concern
Band-rumped storm-petrel	*Oceanodroma castro*	64	Least Concern
Leach's/Band-rumped storm-petrel	*Oceanodroma leucorhoa/castro*	1	not applicable
unidentified storm-petrel	*Oceanodroma sp.*	8	not applicable
White-tailed tropicbird	*Phaethon lepturus*	5	Least Concern
Northern gannet	*Morus bassanus*	3	Least Concern
Double-crested cormorant	*Phalacrocorax auritus*	5	Least Concern
Yellow-crowned night-heron	*Nyctanassa violacea*	1	Least Concern
Red phalarope	*Phalaropus fulicarius*	10	Least Concern
unidentified shorebird	*Sp. sp.*	7	not applicable
Bonaparte's gull	*Chroicocephalus philadelphia*	1	Least Concern
Laughing gull	*Leucophaeus atricilla*	24	Least Concern
Herring gull	*Larus argentatus*	5	Least Concern
Great black-backed gull	*Larus marinus*	5	Least Concern
Sooty tern	*Onychoprion fuscatus*	1	Least Concern
Bridled tern	*Onychoprion anaethetus*	5	Least Concern
Common tern	*Sterna hirundo*	13	Least Concern
Arctic tern	*Sterna paradisaea*	1	Least Concern
Royal tern	*Thalasseus maximus*	2	Least Concern
Sandwich tern	*Thalasseus sandvicensis*	1	Least Concern
Great skua	*Stercorarius skua*	1	Least Concern
South polar skua	*Stercorarius maccormicki*	16	Least Concern
unidentified skua	*Stercorarius sp.*	3	not applicable
Pomarine jaeger	*Stercorarius pomarinus*	13	Least Concern
Parasitic jaeger	*Stercorarius parasiticus*	8	Least Concern
Long-tailed jaeger	*Stercorarius longicaudus*	13	Least Concern
unidentified jaeger	*Stercorarius sp.*	1	not applicable
Dovekie	*Alle alle*	14	Least Concern

Table C5 (cont'd). Number of individual birds detected within the 300 m strip and their IUCN status (2011.2)

Species		Num of individuals	IUCN status
Atlantic puffin	*Fratercula arctica*	1	Least Concern
Rock pigeon	*Columba livia*	1	Least Concern
Tree swallow	*Tachycineta bicolor*	1	Least Concern
Barn swallow	*Hirundo rustica*	10	Least Concern
Yellow warbler	*Dendroica petechia*	3	Least Concern
Blackpoll warbler	*Dendroica striata*	1	Least Concern
Common yellowthroat	*Geothlypis trichas*	1	Least Concern
Chipping sparrow	*Spizella passerina*	1	Least Concern
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	1	Least Concern
Brown-headed cowbird	*Molothrus ater*	2	Least Concern
Total		**5148**	

Table C6. Summary of acoustic monitoring effort during the survey.

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

Table C7. Summary of acoustic detections during the HB-11-03 survey. Species were assigned to acoustic detections when real-time tracking confirmed the correspondence of acoustic detections with visual sightings. Note that in some cases, acoustic detections include multiple individuals (in the case of sperm whales) or multiple subgroups (in the case of delphinids). “Unknown species” include both groups for which no visual data exist, as well as groups which could not be definitively linked to visual sightings in real-time.

Common name	Leg 1	Leg 2	Leg 3	**Total**
Bottlenose dolphin	11	8	1	**20**
Common dolphin	12	8	6	**26**
Striped dolphin	5	15	3	**23**
Atlantic spotted dolphin	2	15	3	**20**
Risso's dolphin	3	3	3	**9**
Rough-toothed dolphin	1	2		**3**
Pilot whale	2	5	5	**12**
Clymene's dolphin	1			**1**
Mixed species groups	3	9	3	**15**
Sperm whale	45	27	15	**87**
Sowerby's beaked whale		2		**2**
Unknown species	53	53	32	**138**
Total	**138**	**147**	**71**	**356**

Table C8. Summary of acoustic detections of sperm whales during the HB-11-03 survey. Note that detections may include individuals or groups of individuals; in areas where many individuals were detected, they were included into one acoustic detection.

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

Table C9. Time, location and reaction of all biopsy misses and hits from HB-11-03.

Date	Species	Latitude	Longitude	Misses	Hits	Reaction
1-Jul-11	Striped dolphin *(Stenella coeruleoalba)*	38.25	-69.76	1		low
2-Jul-11		39.11	-67.89		1	moderate
10-Jul-11		37.52	-73.58	1		low
10-Jul-11		37.39	-73.36		1	low
13-Jul-11		38.14	-71.82	1		none
13-Jul-11		38.49	-71.77	4		low
13-Jul-11		38.58	-72.49	1		low
	Total striped dolphin			8	2	
1-Jul-11	Atlantic spotted dolphin (*Stenella frontalis*)	38.26	-69.78	1		low
1-Jul-11		38.17	-69.60		1	low
1-Jul-11		38.17	-69.60	1		low
1-Jul-11		37.77	-68.82	1		low
2-Jul-11		38.07	-68.16	2		low
6-Jul-11		39.61	-70.55		1	low
11-Jul-11		37.78	-71.87		1	low
13-Jul-11		38.54	-71.76		1	low
26-Jul-11		39.59	-65.16	2	1	low
	Total Atlantic spotted dolphin			7	5	
11-Jul-11	*Steno bredanensis*	36.78	-72.34		1	none
	Total rough-toothed dolphin			0	1	
5-Jul-11	Pilot whale sp. (*Globicephala* sp.)	41.39	-66.06	1		none
5-Jul-11		41.39	-66.06		1	none
5-Jul-11		41.39	-66.06		1	none
	Total pilot whale sp.			1	2	
	Grand total			**16**	**10**	

Table C10. Start and end times of EK60 and ADCP data collection.

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

Table C11. The number of oceanographic and plankton sampling on each leg during HB-11-03.

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

Figure C1. Location of track lines surveyed during the 2 June – 1 August 2011 shipboard abundance survey on the NOAA ship *Henry B. Bigelow*, HB-11-03.

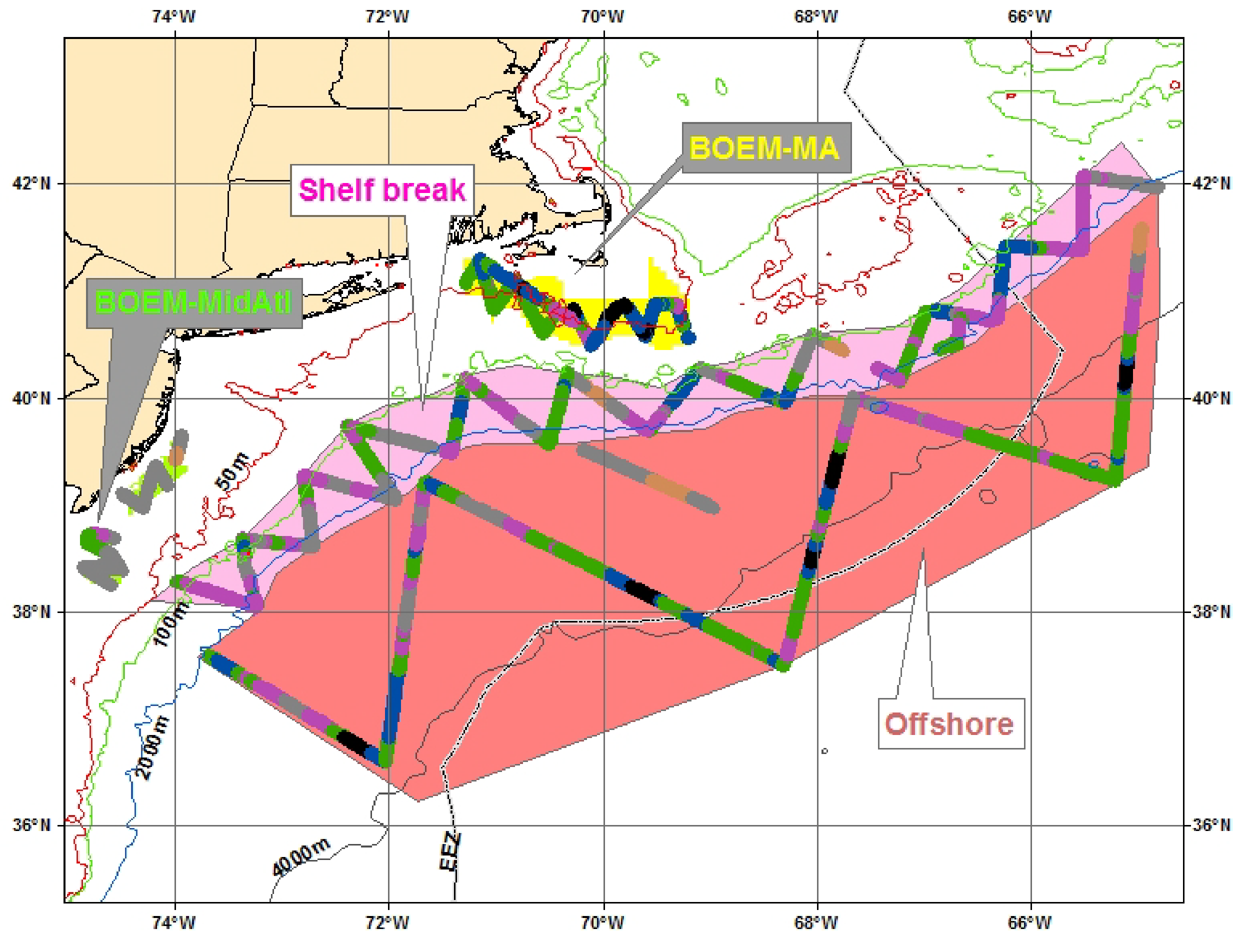


Figure C2. Distribution of the following species: A. Atlantic spotted dolphins; B. Bottlenose dolphins; C. Common dolphins; D. Risso's dolphins; E. Striped dolphins; F. Pilot whales.

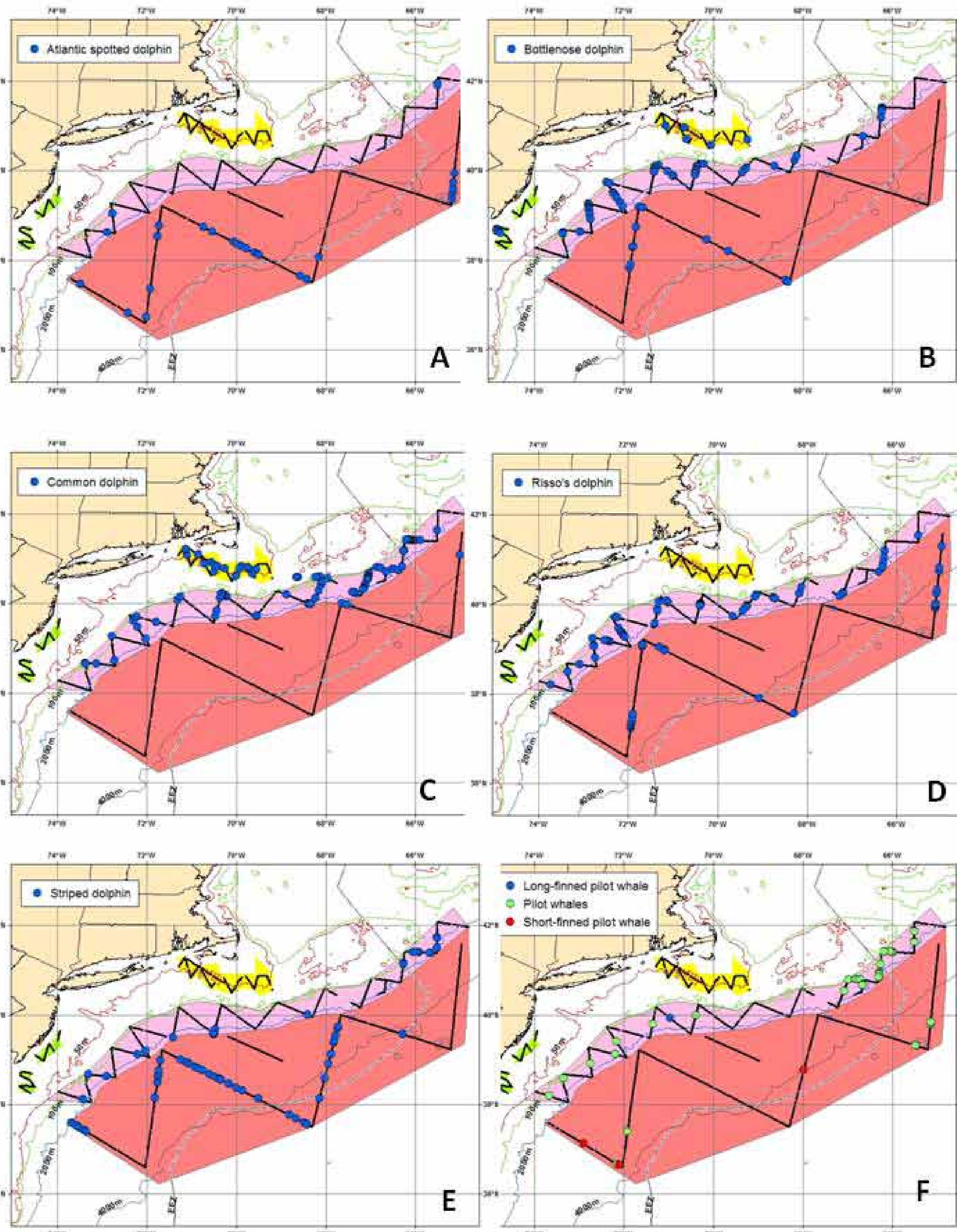


Figure C3. Distribution of the following species: A. Cuvier's beaked whales; B. Gervais', Sowerby's and unidentifed beaked whales; C. Humpback whales; D. Dwarf sperm and pygmy sperm whales; E. Fin and sei whales; F. Minke whales, killer whales, and harbor porpoise.

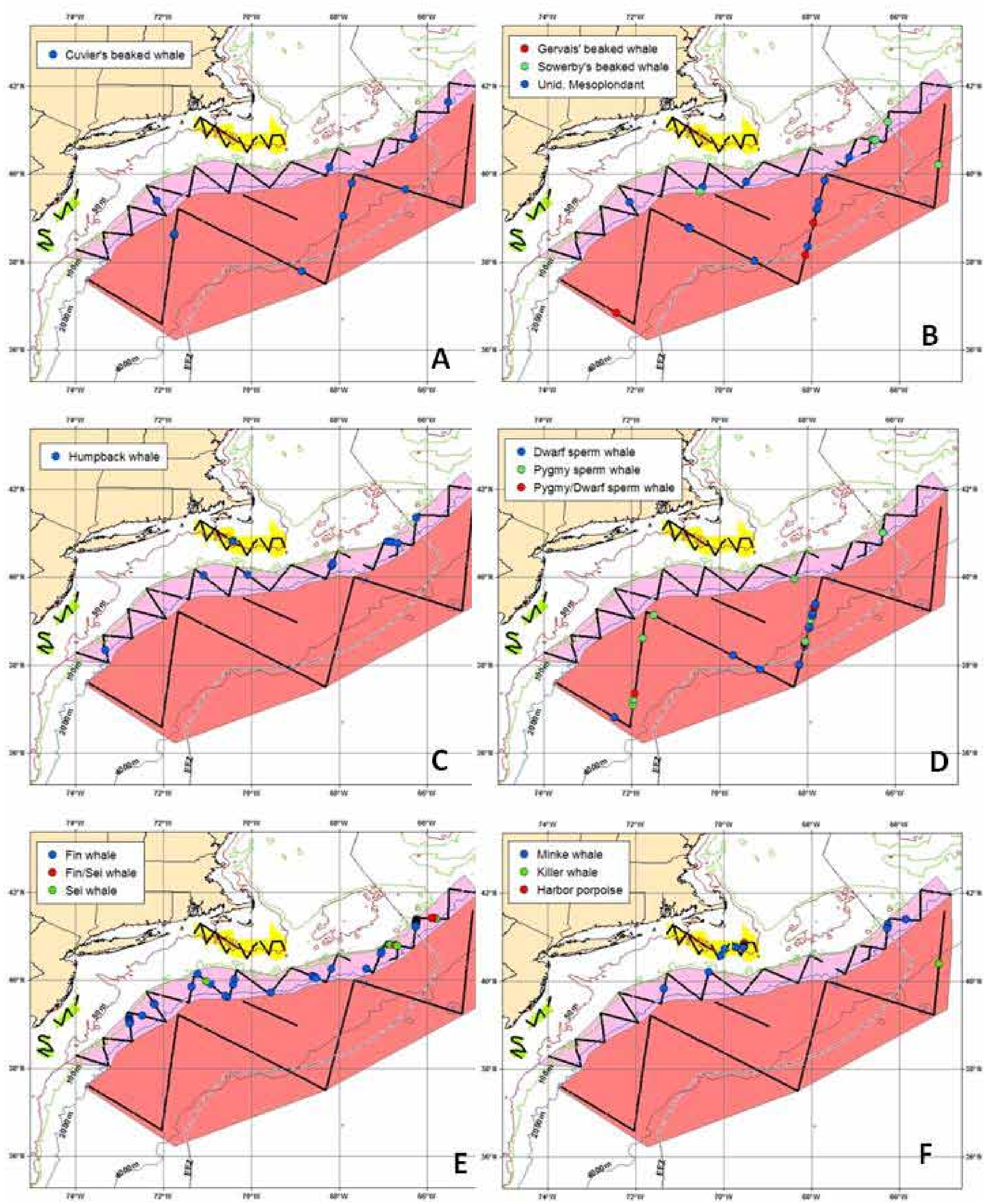


Figure C4. Distribution of the following species: A. Rough-toothed dolphins and sperm whales; B. Leatherback, loggerhead and unidentified hardshell turtles; C. Basking sharks; D. Ocean sunfishs.

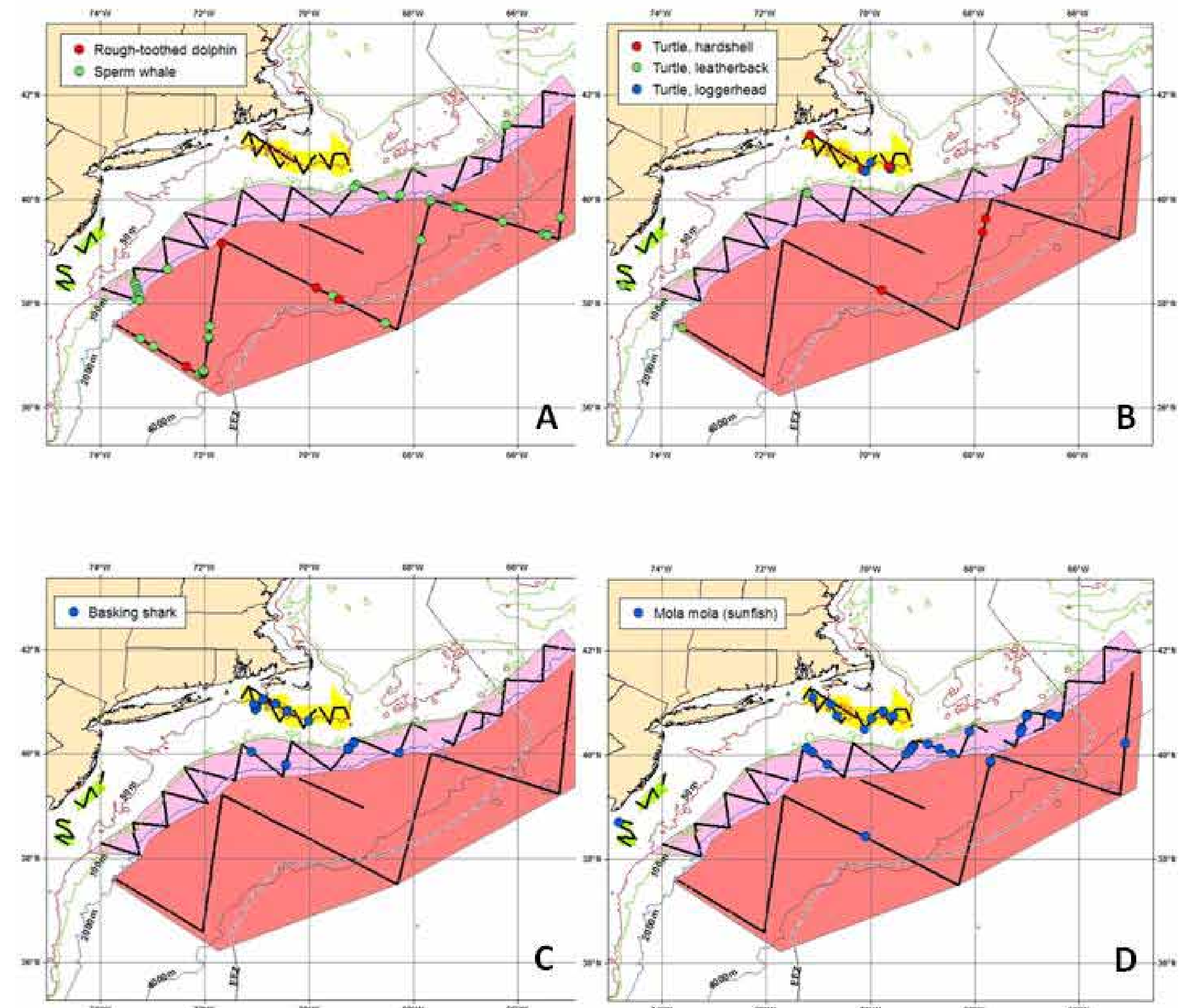


Figure C5. A. On-effort track lines surveyed for sea birds. Distribution of the following species: B. Audubon shearwaters; C. Band-rumped storm petrels; D. Black-capped petrels; E. Common terns; F. Cory's shearwaters.

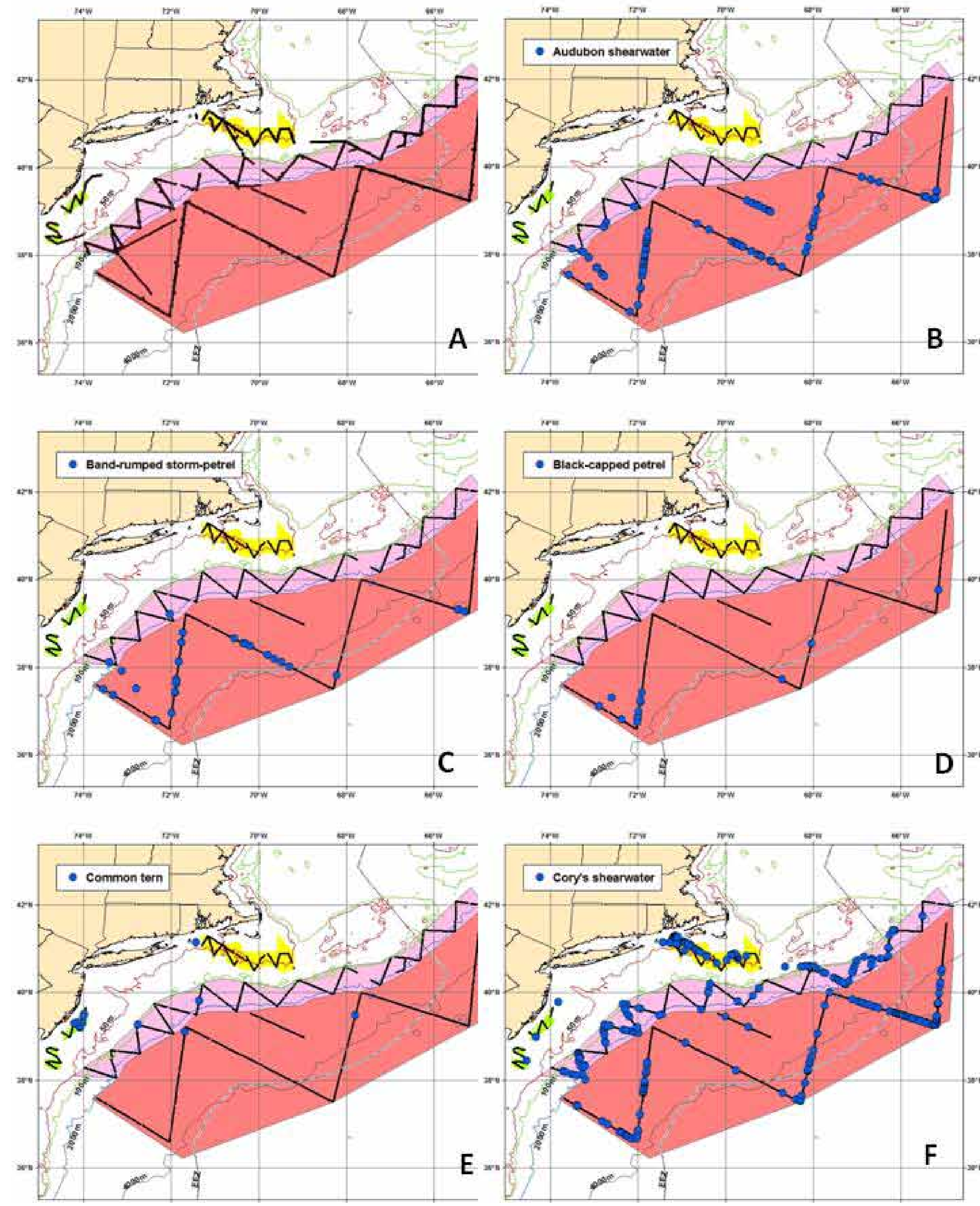


Figure C6. Distribution of the following species: A. Dovekies; B. Greater shearwaters; C. Laughing gulls; D. Leach's storm petrels; E. Long-tailed jaegers; F. Manx shearwaters.

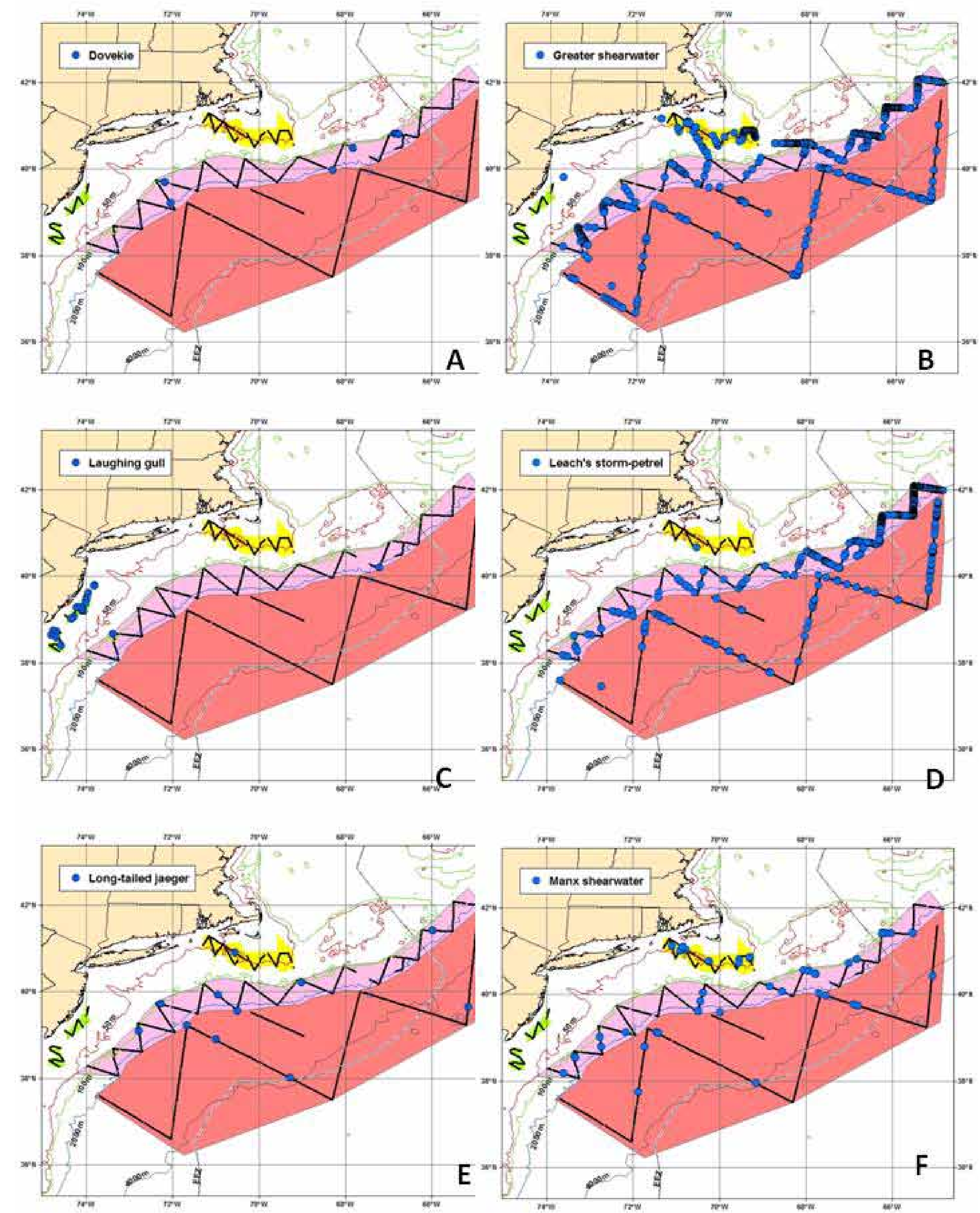


Figure C7. Distribution of the following species: A. Bonaparte's gulls, great black-backed gulls and herring gulls; B. Arctic terns, Atlantic puffins, Fea's petrels, Trindade petrels, unidentified storm-petrels, and white-faced storm petrels; C. Bridled terns, double-crested cormorants, Exocoetus sp., Great skuas, Northern fulmars, Northern gannets, Pomarine jaegers, and red phalaropes; D. Arctic terns, royal terns, sandwich terns, sooty terns; E. Sooty shearwaters; F. Wilson's storm petrels.

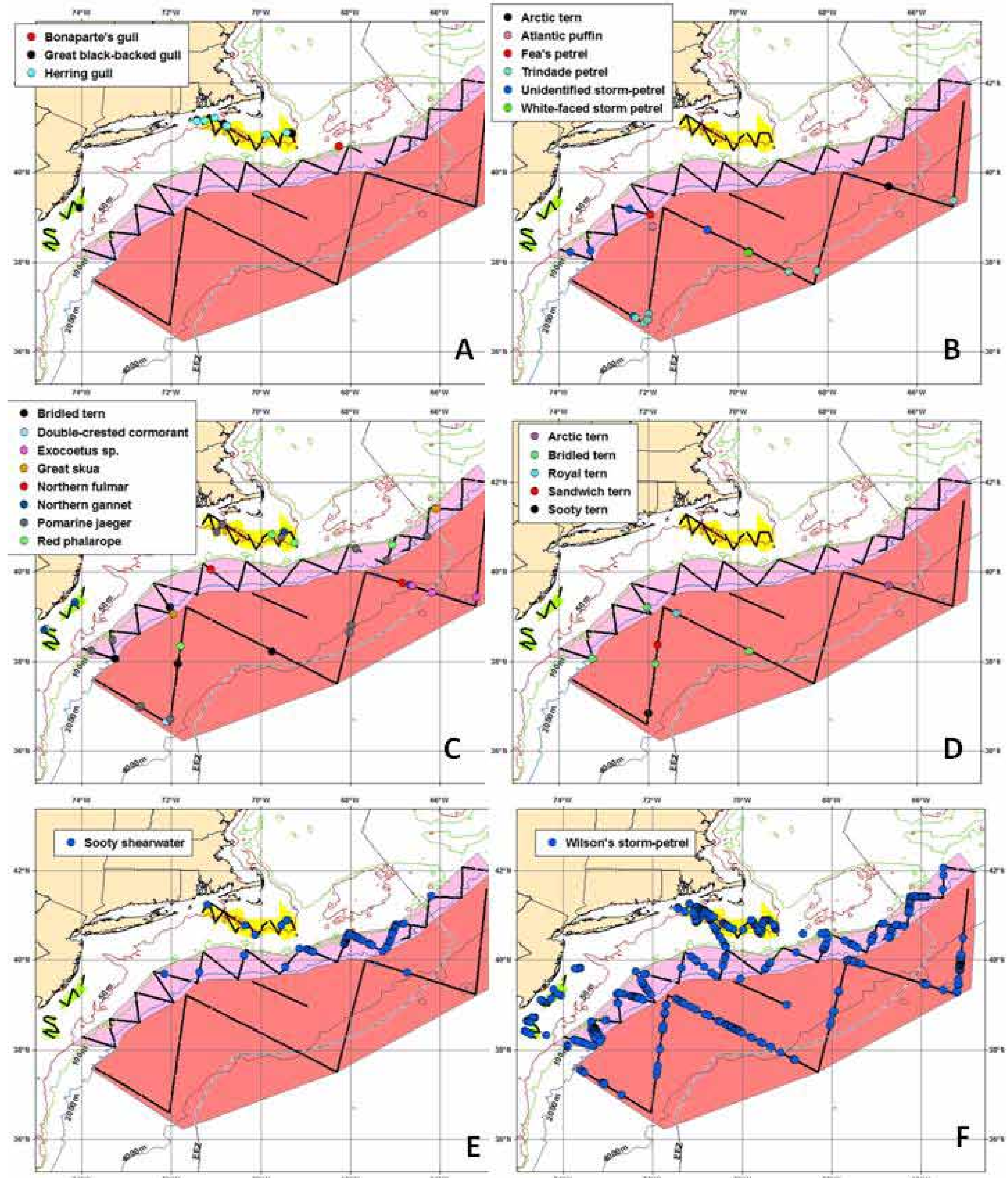


Figure C8. Location of the NOAA ship *Henry B. Bigelow* during acoustic detections of vocally-active cetacean groups. Yellow lines indicate survey track lines; dots indicate acoustic detection events where each leg is a different color. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

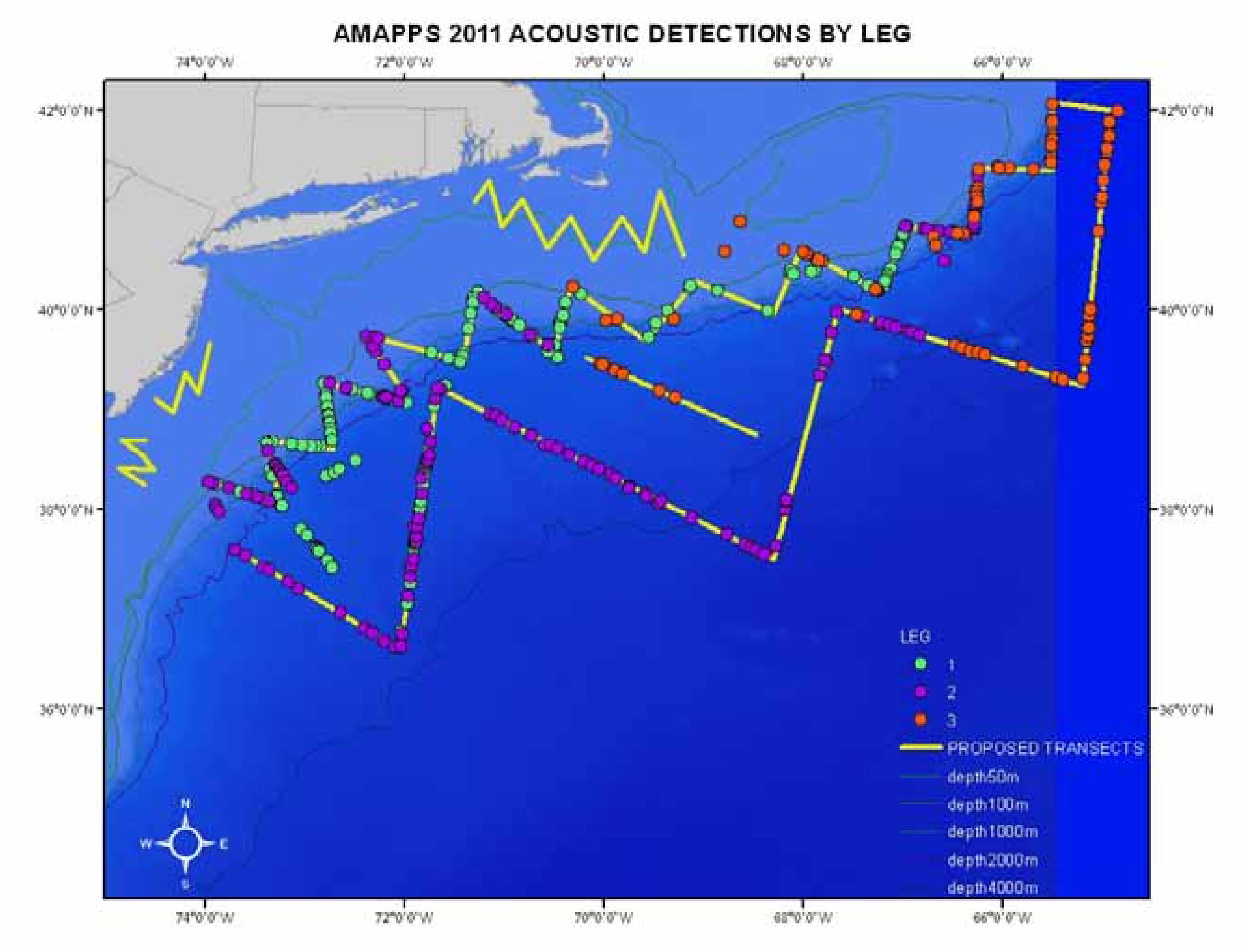


Figure C9. Location of the NOAA ship *Henry B. Bigelow* during acoustic detection of vocally-active cetacean groups. Yellow lines indicate survey track lines; other symbols represent acoustic detection events. Groups for which species identity was confirmed visually are indicated by distinct colors. The species code "MIX" indicates groups in which more than one species was present. The species code "UNID" indicates groups for which species identification was not possible at the time of data collection. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

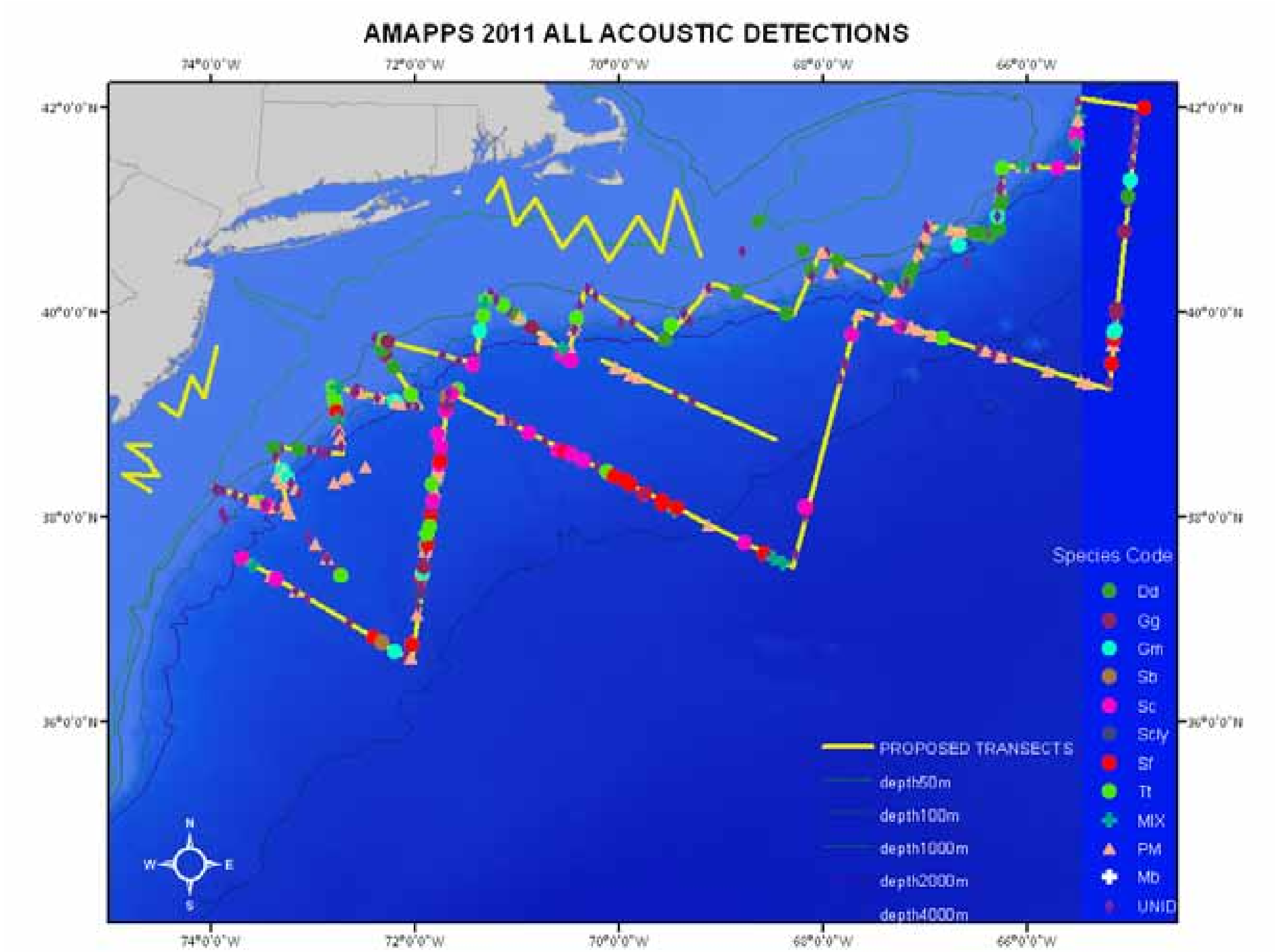


Figure C10. Location of the NOAA ship *Henry B. Bigelow* during acoustic detections of sperm whale individuals or groups of individuals. Yellow lines indicate survey track lines, orange dots indicate sperm whale acoustic detection events. Inshore tracklines were considered too shallow for deployment of acoustic equipment; therefore, acoustic monitoring was not conducted in those areas.

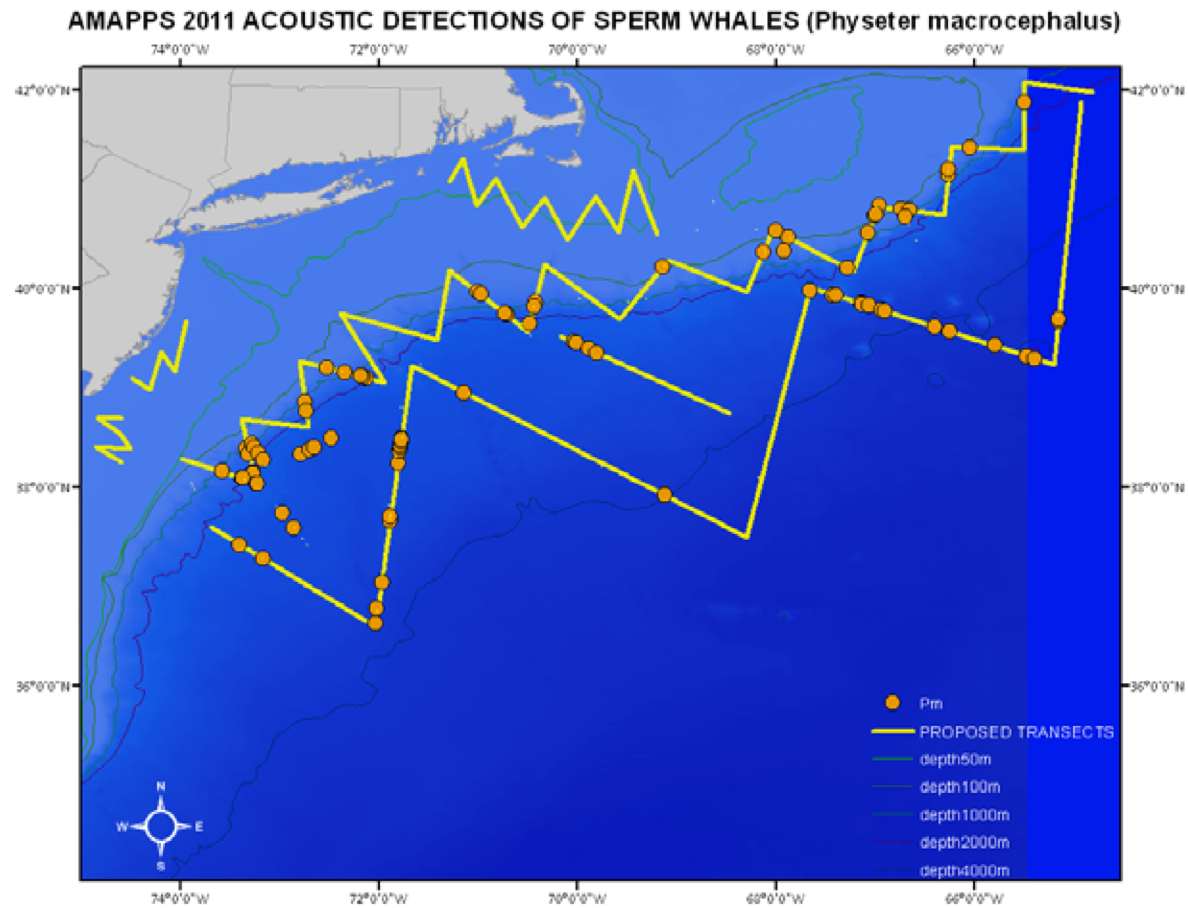


Figure C11. Location of cetacean biopsies collected during HB-11-03.

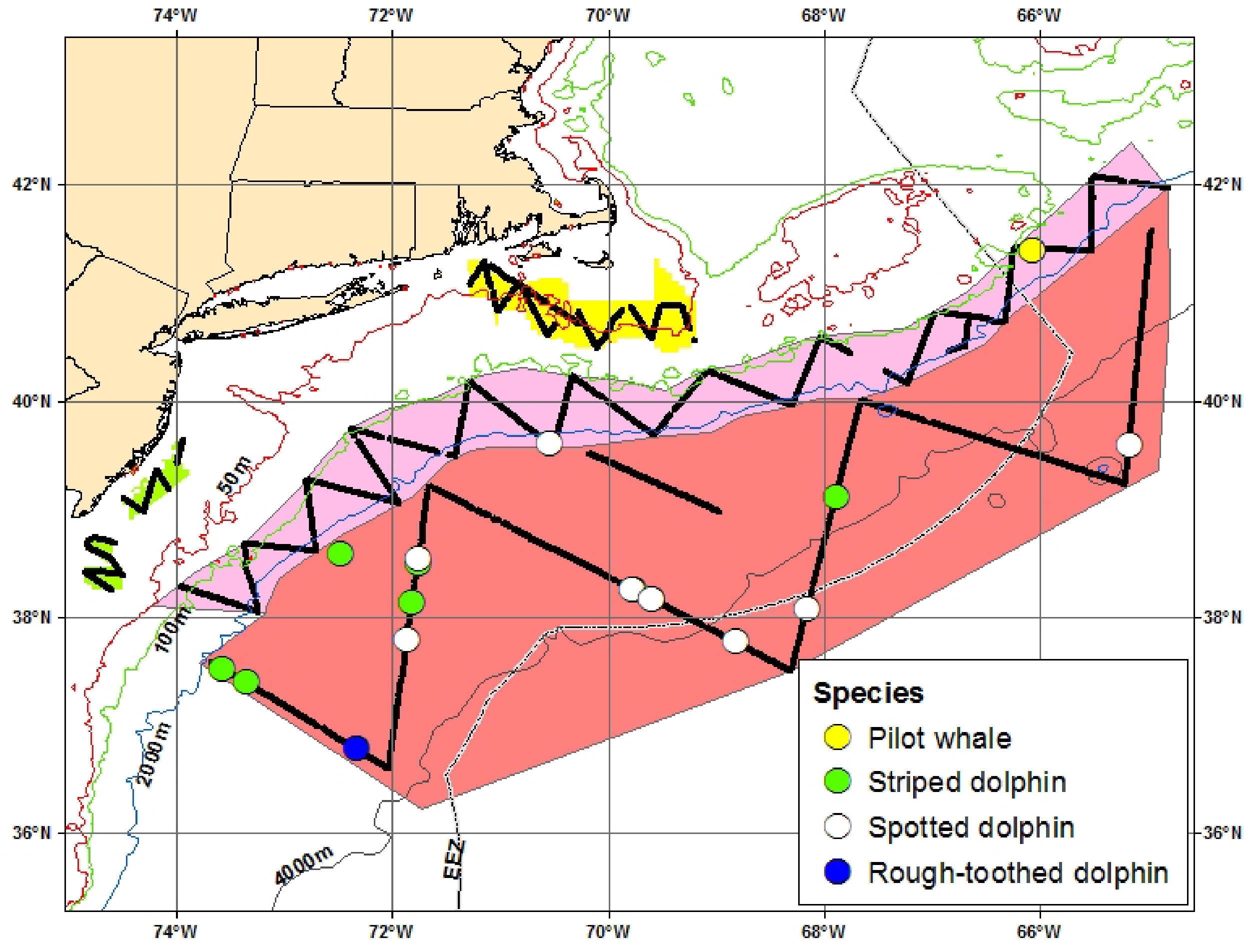


Figure C12. Location of the bongo, VPR and CTD sampling stations (colored dots) and actual track lines (line).

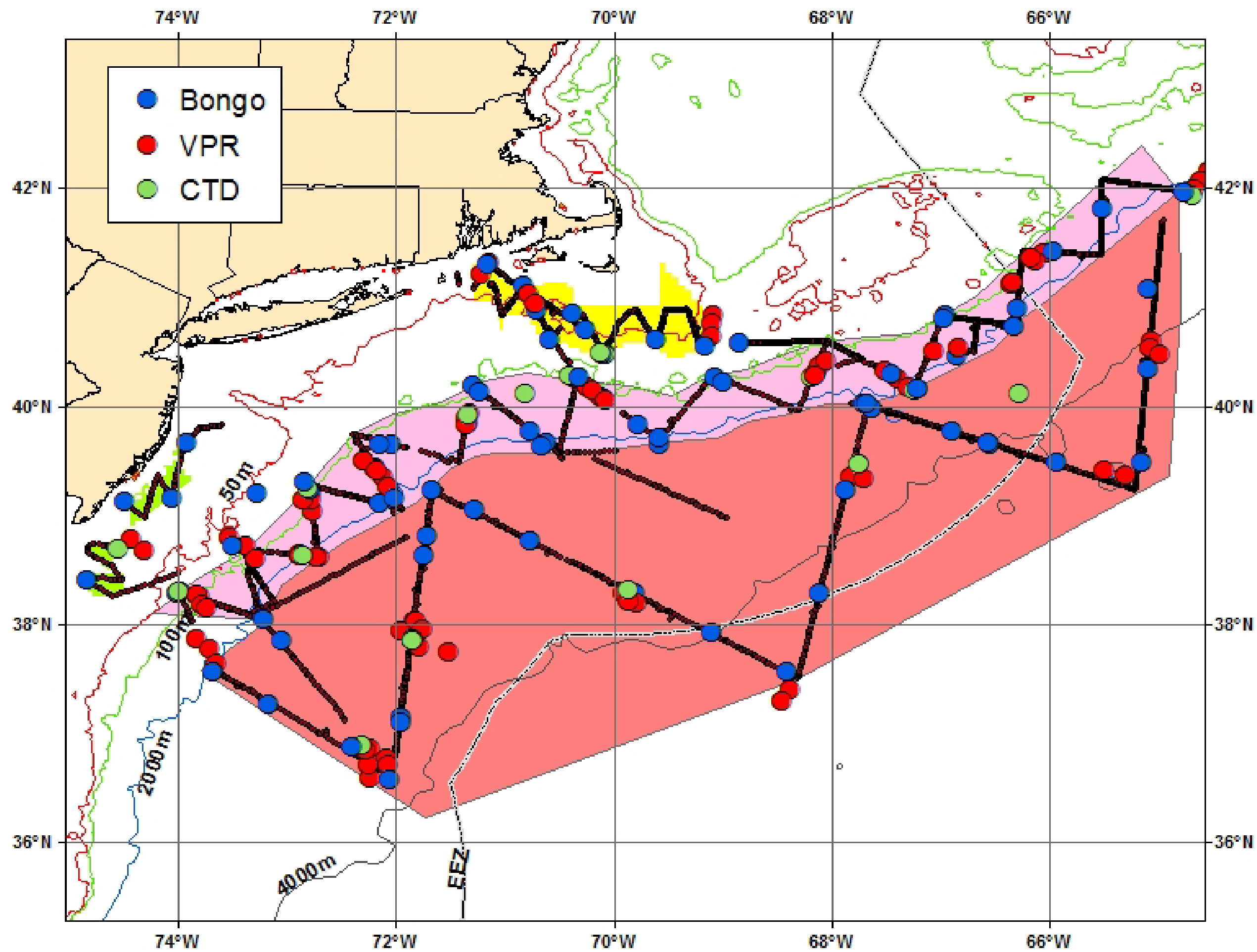


Figure C13. Location of XBT launches (dots) relative to the proposed track lines (lines).

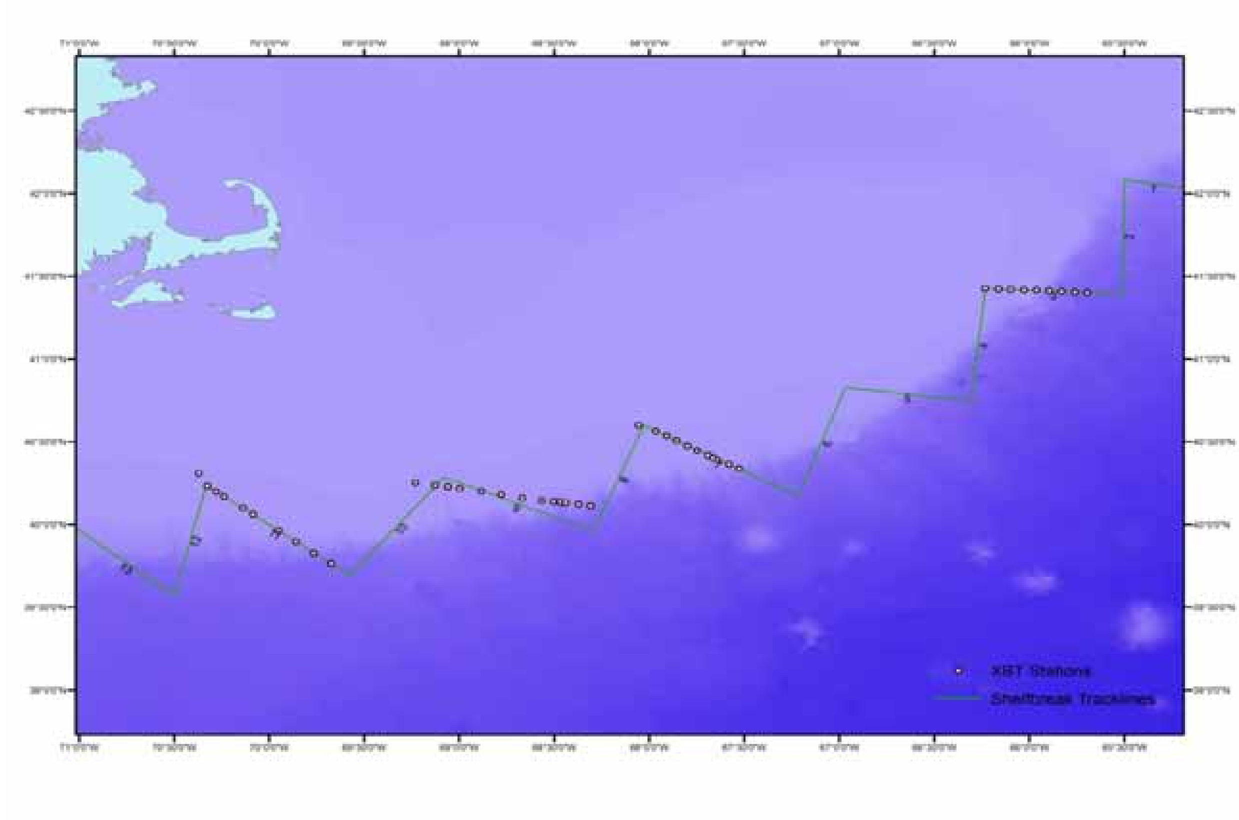


Figure C14. Comparison of XBT temperature data to CTD upcast temperature data.

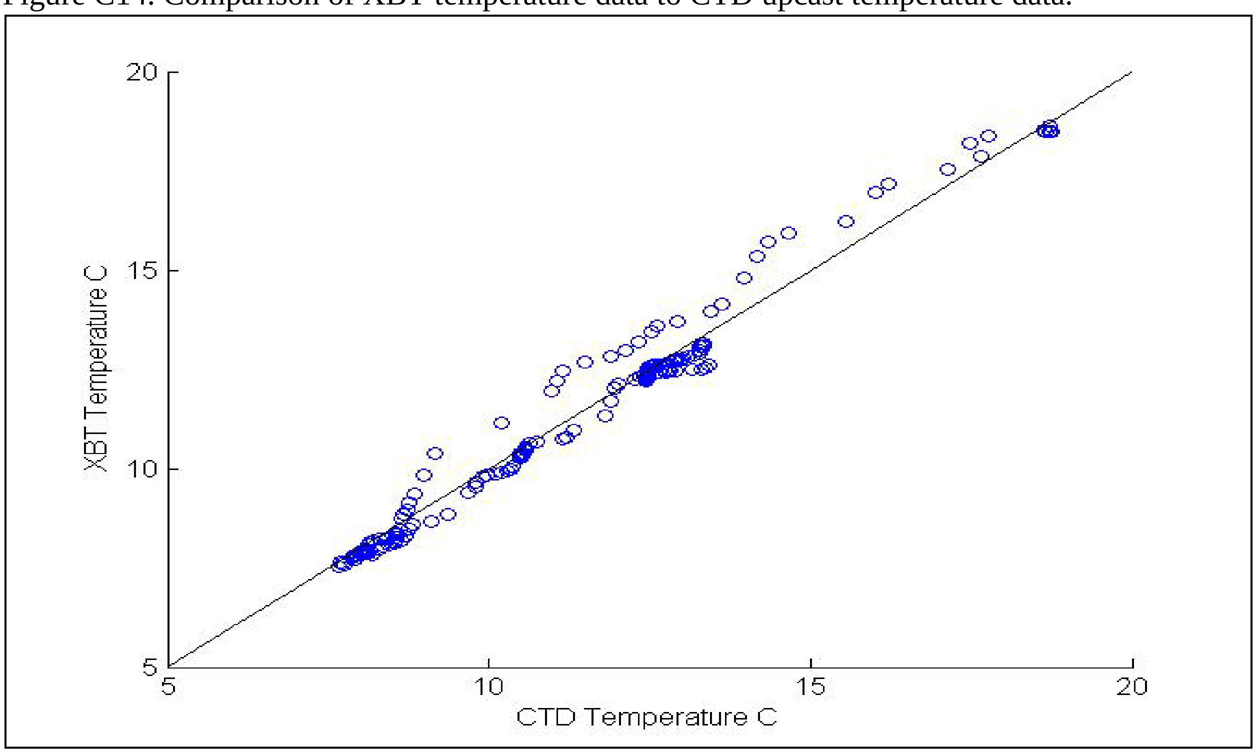


Figure C15. XBT temperature profiles along trackline 7.

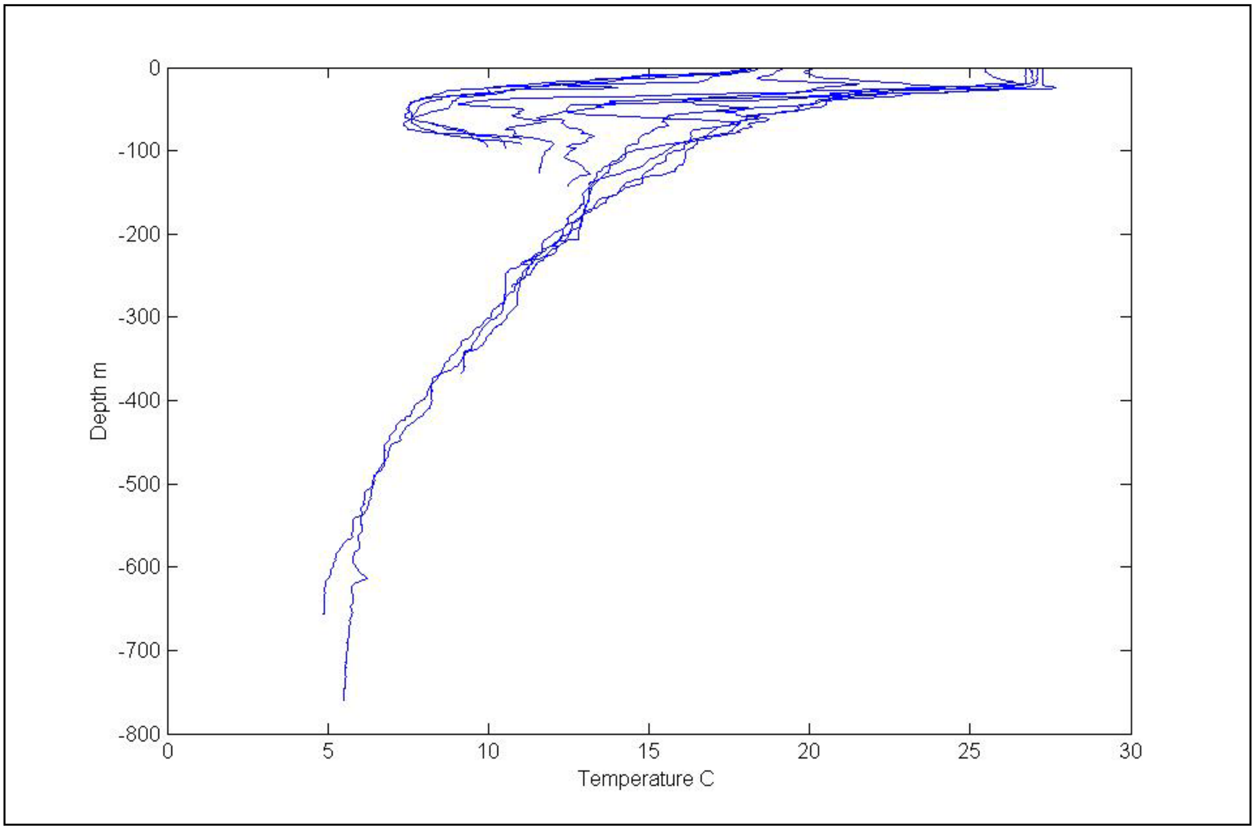


Figure C16. Oceanographic features typical of water along the shelf slope front on the southern flank of Georges Bank.

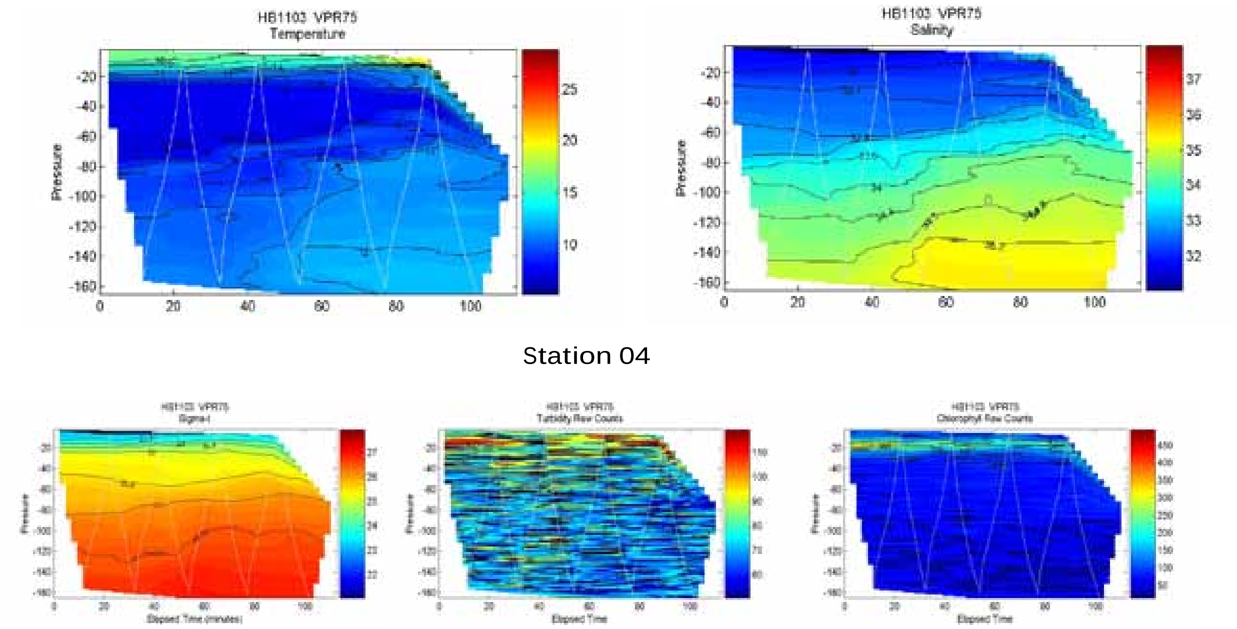


Figure C17. Oceanographic conditions typical of waters along the shelf slope front in the Mid-Atlantic Bight.

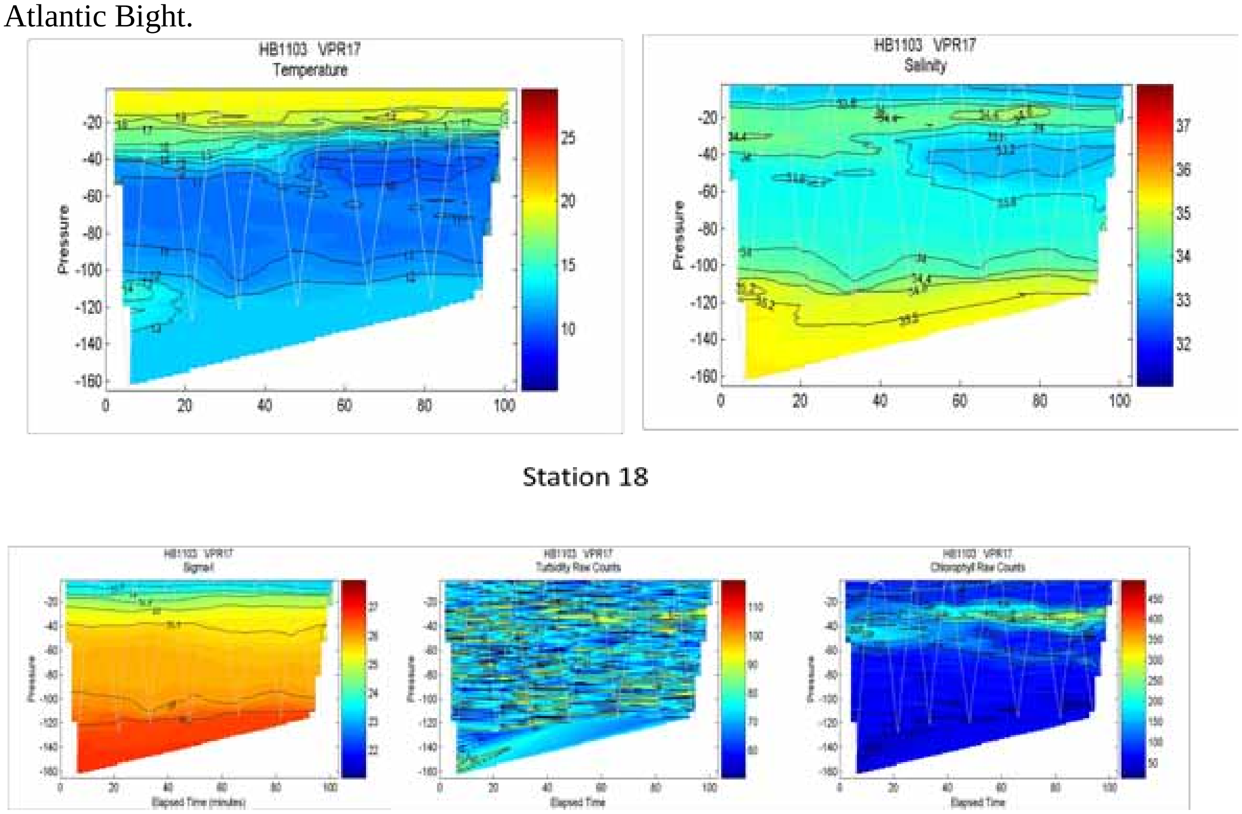


Figure C18. Oceanographic conditions typical of the offshore transects in areas not influenced by the Gulf Stream.

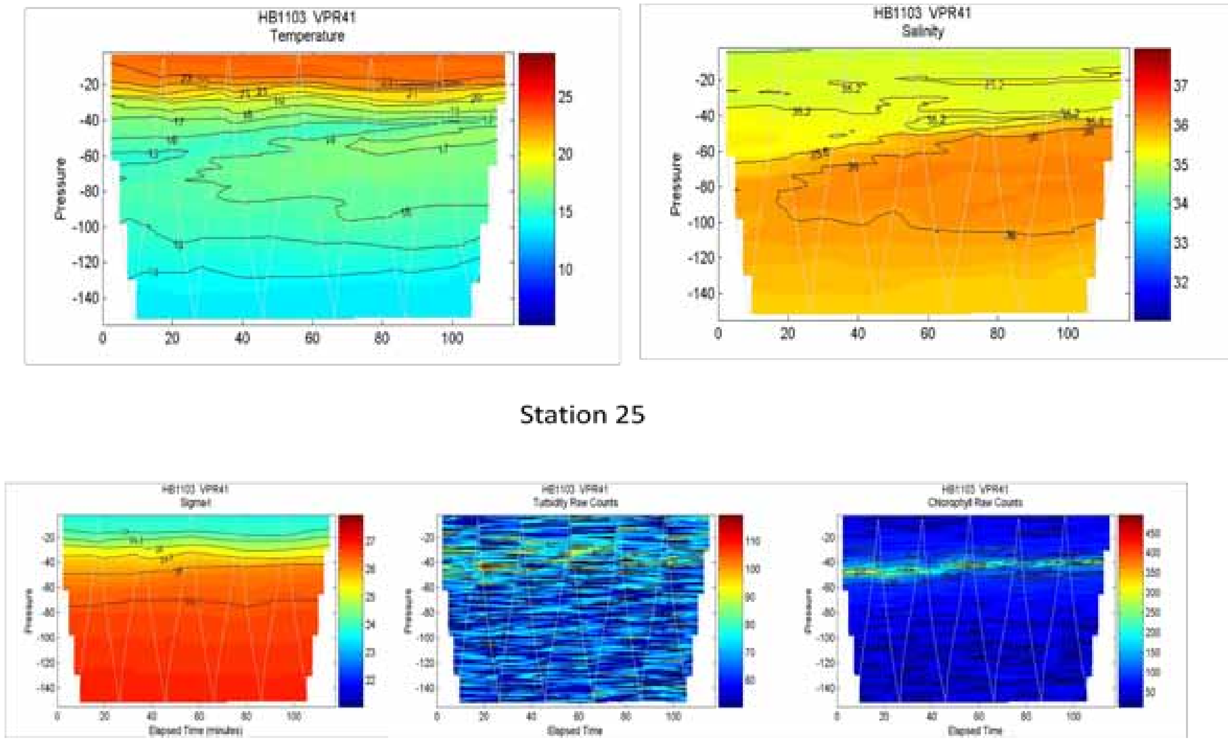


Figure C19. Oceanographic conditions typical of offshore transects in the Gulf Stream (south near waypoint 28) or the July warm core ring (north near Bear Sea Mount).

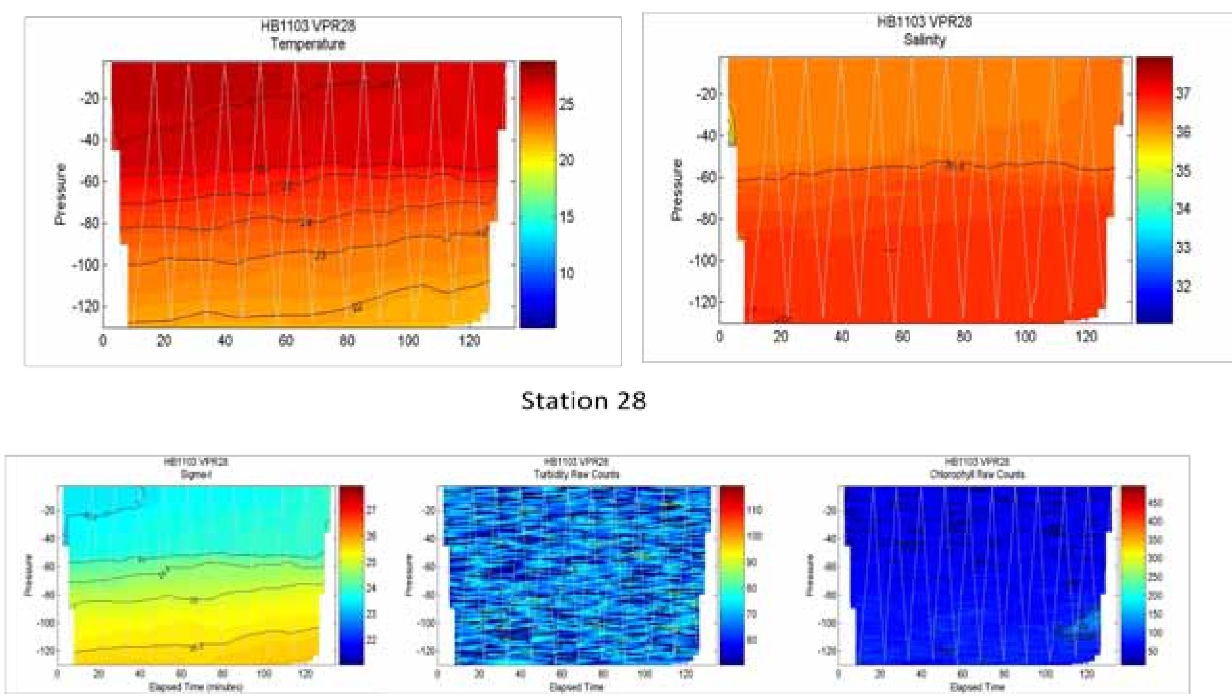


Figure C20. Gelatinous zooplankton VPR images. From top left: *Pleurobrachia pileus, Bolinopsis* sp, anthomedusa, leptomedusa, scaphozoa (true jellyfish) and *Beroe* sp.

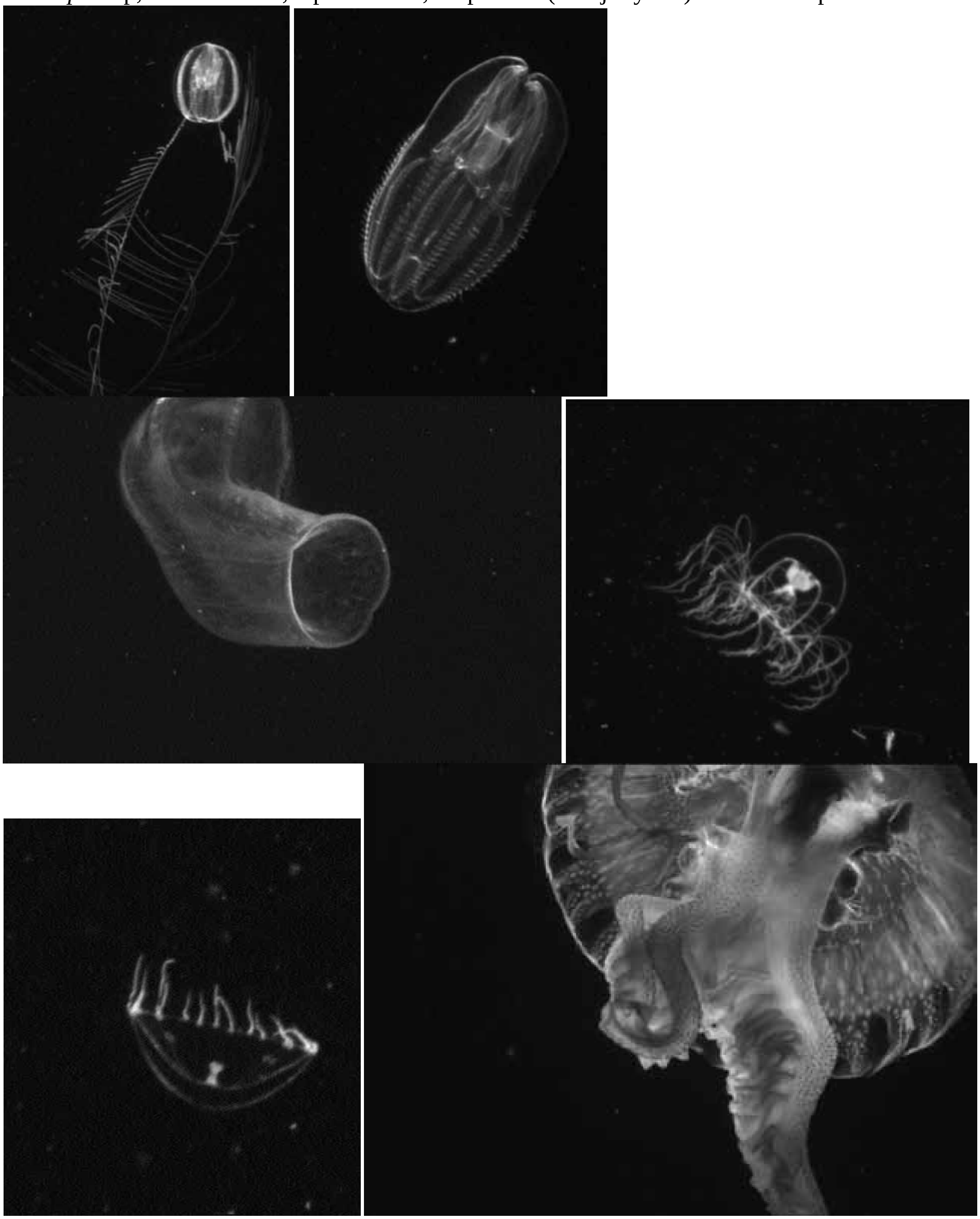


Figure C21. Crustaceans detected in the VPR images. From top left: Euphasiid, probably *Meganytiphanes norvegica*, gravid euphausiid, *Themisto gaudichaudi*, *gammaridea*

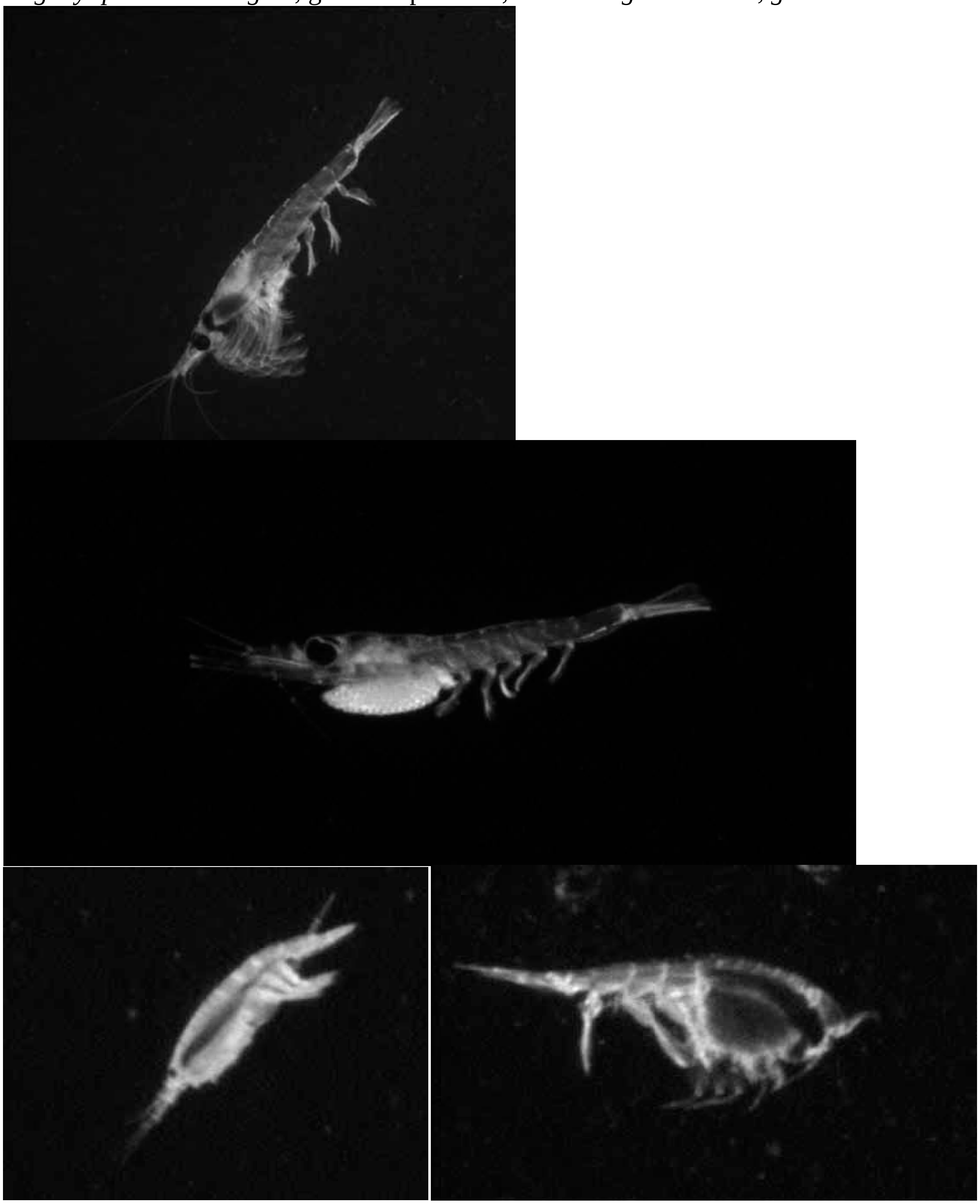


Figure C22. Other VPR images. From top left: larval fish, *Cerianthus* sp.,*Limacina* sp.,*Clione limacina*, *Tomopterus* sp.,phytoplankton.

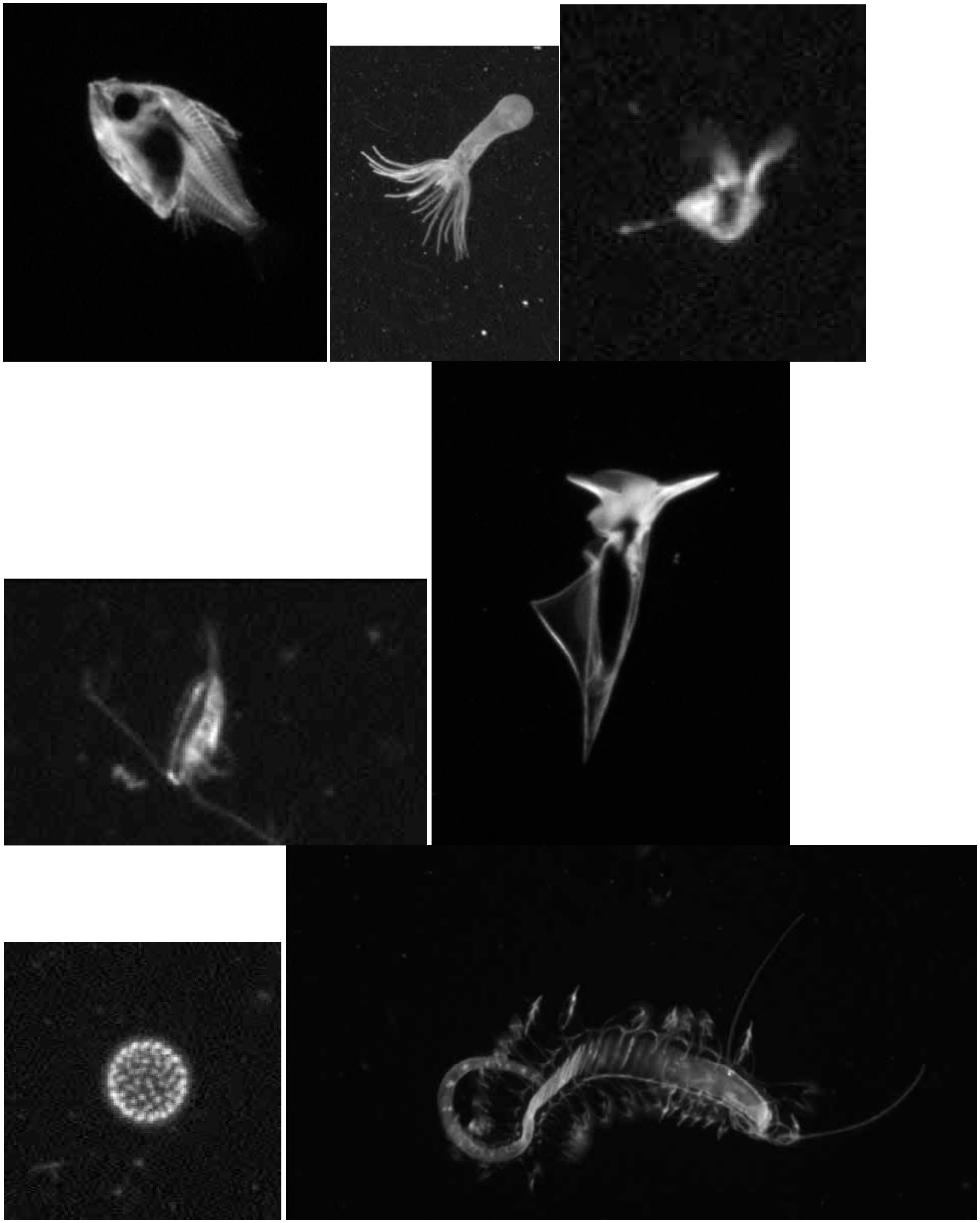
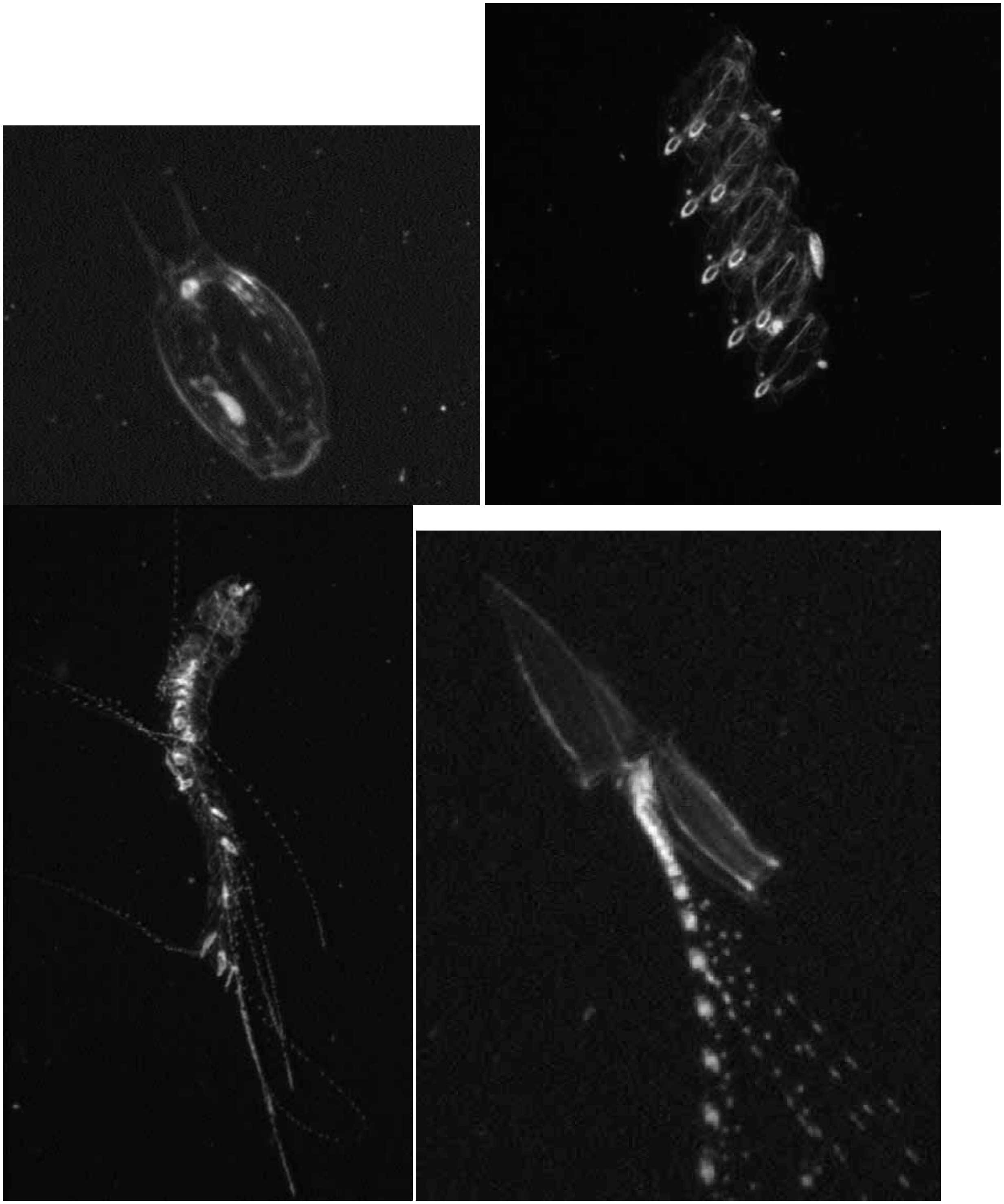


Figure C23. top row: *Thalia democratica* adult and colony of juveniles. Bottom row: two species of siphonophora.



Appendix D: *Southern leg of shipboard abundance survey during summer 2011: Southeast Fisheries Science Center*

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Summary
The Southeast Fisheries Science Center (SEFSC) conducted an abundance survey on the NOAA ship *Gordon Gunter* targeting marine mammals and sea birds during 21 June – 2 August 2011. The study area included waters between central Florida and the Maryland/Delaware border and included shelf-break and inner continental slope waters within the U.S. EEZ. There were two independent teams of visual observers searching for marine mammals in an independent observer configuration to correct abundance estimates for visibility bias. In addition, a dedicated visual observer was employed to collect data on seabird occurrence and abundance. Passive acoustic monitoring for cetaceans was conducted throughout the survey using a high-frequency towed array and deploying sonobuoys. In addition, environmental data were collected using active acoustic EK60 scientific echosounders and collected from hydrographic profiles using vertical conductivity-temperature depth (CTD) and expendable bathythermograph (XBT) profilers. A total of 5013 km of survey effort were accomplished. During this survey 332 groups of cetacean sightings of 22 species or species groups were visually or acoustically detected, and 1135 groups of birds of 42 species or species groups were detected. Nearly 600 hours of passive acoustic effort was recorded. In addition, 50 cetacean biopsies were collected and environmental data were collected in 302 XBT and 67 CTD profiles.

Study area and cruise period
NOAA ship *Gordon Gunter* departed Pascagoula, Mississippi, on 21 June 2011 to conduct a cetacean survey in waters off the southeast Atlantic coast of the U.S. and returned to Pascagoula at the end of the survey on 2 August 2011. The survey, designated GU-11-02, was conducted along “zig-zag” tracklines between central Florida and the Maryland/Delaware border and included shelf-break and inner continental slope waters within the U.S. EEZ. A small portion of the survey effort was conducted along the outer margin of the Blake Plateau at the border between U.S. and Bahamian waters. Finally, two days of effort were expended during the return transit in the eastern Gulf of Mexico (Figure D1).

The vessel departed Pascagoula, MS at 1400 hrs on 17 June to begin the transit to the Atlantic Ocean. On 18 June, the vessel remained largely stationary in deep waters of the Gulf of Mexico to accomplish calibration of the EK60 scientific echosounders. The vessel then continued its transit to the Atlantic. Visual and passive acoustic surveys were conducted during these transit days for both training and to shake-down the equipment. Combined visual and passive acoustic surveys began in earnest on 24 June off the coast of Florida. The survey continued along zig-zag tracklines through 7 July. The vessel arrived at Norfolk, VA on 8 July at 0800 hrs to complete the first leg.

The second leg commenced with the vessel departing at 1200 hrs on 12 July. Visual and passive acoustic surveys were conducted through 27 July. After transit through the Straits of Florida, additional visual and acoustic surveys were conducted in the eastern Gulf of Mexico. A small boat was deployed on 31 July and 1 August to collect biopsy samples from Bryde's whales encountered along the shelf-break off of the Florida coast. The vessel arrived at Pascagoula, MS at 0800 hrs on the morning of 2 August.

Survey operations and effort are summarized in Table D1. Participants are detailed in Table D2.

Objectives

The primary objective of the survey was to collect data and samples to support the assessment of the abundance, habitats, and spatial distribution of cetaceans within U.S. waters. The survey was conducted as part of the Atlantic Marine Assessment Program for Protected Species (AMAPPS). In addition, the data will improve the assessment of marine mammal stocks as required under the Marine Mammal Protection Act (MMPA). The current survey will provide data to support updated abundance estimates for U.S. Atlantic oceanic stocks of marine mammals, which were last updated from data collected during 2004.

Specifically the objectives 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 select cetaceans from the bow of the NOAA ship *Gordon Gunter*.
4) Collect data on distribution and abundance of sea birds.
5) Collect oceanographic and environmental data including from scientific echosounders (EK60) to quantify acoustic backscatter due to small fish and zooplankton.
6) Collect vertical profiles of hydrographic parameters (e.g., temperature, salinity, oxygen concentration) using conductivity-temperature-depth profilers (CTDs) and expendable bathythermograph profilers (XBTs).

Methods and results

Visual cetacean sightings data

Visual cetacean surveys were conducted 19 June – 1 August 2011. Standard ship-based, line-transect survey methods for cetaceans, similar to those used 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 "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).

The two observer teams were stationed on the flying bridge (height above water = 13.7 m) and 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. Both teams consisted of four observers rotating through two observation positions at 30 min intervals. A recorder position stationed on the bridge maintained communication with both teams and recorded data on sightings by each team using a computerized data entry program interfaced with a global positioning system (GPS) receiver. For each team, at least one observer experienced in ship-based, line-transect methods and identification of cetaceans was present on the flying bridge or bridge wings at all times. The left and right side observers searched to the horizon in the arc from 10° right and left of the ship's bow to the left and right beams (90°), respectively, using 25x150 powered "bigeye" binoculars.

For each cetacean sighting, time, position, bearing and reticle (a measure of radial distance) of the sighting, species identification, 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 bigeye binoculars and close to the ship were estimated. Survey effort data were automatically recorded every two minutes 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.). Typically, if a sighting was within a three nmi 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. Cetaceans were identified to the lowest taxonomic level possible.

Survey speed was usually 18 km/hr (~10 knots) 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, rain). Survey effort was therefore suspended during heavy seas (sea state > 6) and rain.

A total of 5013 km of survey effort were accomplished during the survey. Weather conditions were good to fair throughout much of the survey, with sea states of Beaufort 3 – 4 on most survey days. Accomplished trackline and marine mammal sightings are shown in Figure D2. As expected, the majority of sightings occurred along the continental shelf break with generally lower sighting rates over the continental slope (Figure D2). Large whale sightings included fin whales and sperm whales in Atlantic waters (Figure D3). A notably high concentration of beaked whale sightings occurred along a trackline offshore of North Carolina (Figure D3). This particular trackline also had a very high number of pygmy/dwarf sperm whale sightings (Figure D4). Pilot whales 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 D5). During the return transit, visual and passive acoustic survey effort was conducted in the eastern Gulf of Mexico. Two groups of Bryde's whales were encountered, and a small boat was deployed to collect biopsy samples. In total, there were 322 sightings of cetaceans during this survey from at least 18 different taxa (Table D3).

Seabird sightings data

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.

At least 37 species were observed and identified for a total of 1135 sightings recorded (Table D4, Figure D6). The most common species observed were Cory's shearwater, Great shearwater, Wilson's storm-petrel and Black-capped petrel (*Pterodroma hasitata*). There were a number of sightings of rare species or species that previously had not been recorded in these waters.

Passive acoustic data

Passive acoustic surveys were conducted either simultaneously with visual surveys or during night and other periods when the visual survey was inactive. Passive acoustic monitoring was conducted using either a towed hydrophone array or through the deployment of sonobuoys. The six-element oil-filled hydrophone array included paired pre-amplifier and hydrophone elements capable of recording a broad range of frequencies. The HS150 hydrophones (Sonar Research and Development) have a -204 dB re V/uPa sensitivity with a flat frequency response (+/- 3dB) from 1 to 180 kHz except for a 3 dB peak at 150 kHz (between 140-160 kHz). Custom-built pre-amplifiers provided a bandpass filter with 40 dB gain between 1 kHz and either 100 or 200 kHz for 4 and 2 array elements, respectively. The array was towed at approximately 275 m behind the ship and 18 m depth at standard ship speeds. Data from four of the six elements were recorded through a Mark of the Unicorn (MOTU) 896 digital mixer at 24 bit 192 kHz sample rate yielding a recording range of 1 – 96 kHz, while the remaining two channels were recorded through a National Instruments sound card at 16 bit 300 kHz sample rate yielding a recording range of 1 – 150 kHz.

Expendable Directional Frequency Analysis and Ranging (DIFAR) sonobuoys were also deployed primarily to aid in the detection, localization, and recording of baleen whales. These units float near the surface for up to eight hours after deployment, and acoustic signals are transmitted back to the vessel by radio. Sonobuoys were recorded through a Sound Blaster Extigy soundcard at 16 bit 48kHz sample rate and had a 10 – 7500 Hz recording bandwidth. Model AN/SSQ-53E DIFAR sonobuoys were deployed at regular intervals along the trackline while visual survey effort was underway on selected segments of trackline. DIFAR sonobuoys transmit acoustic signals with multiplexed magnetic bearing information to the ship via a VHF carrier frequency. The signals from the sonobuoys were received aboard the ship by a VHF antenna connected to an ICOM R100 radio with a flat frequency response from 10 Hz – 20 kHz (customized and calibrated by Greeneridge Sciences). The signal was amplified at the antenna using an ARS P150VDG preamplifier, and further boosted at the radio with a Winegard AP8275 UHF/VHF preamplifier. The average range of reception to the sonobuoy with this system was 15 – 20 km. Sonobuoy signals were recorded continuously at a sample rate of 96 kHz using a Sound Blaster Extigy USB sound card, controlled by the Logger program. Running spectrograms of these signals were monitored by the acoustician on duty using the software Ishmael and with headphones. The 7.5 kHz reference tone transmitted with the DIFAR signal was filtered out for the listening purposes using a Mackie amplifier/mixer with two chained tuneable notch filters centered at 8 kHz (-30 dB/oct combined) and two additional 12 kHz low-pass filters (-30 dB/oct combined).

The IFAW software suite, including RainbowClick, Whistle Detector, and Logger, was used to record acoustic data and comments to hard-disk and to obtain bearings to acoustic detections. All acoustic data were recorded as single or multichannel wav files to 2 TB external SATA hard drives, resulting in 9 TB of data collected. Acoustic field technicians monitored data aurally and visually through spectrographic analysis using Ishmael software and attempted to localize acoustically active cetaceans in real-time using Ishmael’s hyperbolic bearing calculator and WhaleTrak.

For both the towed array and the sonobuoys, acoustic technicians monitored the signals continuously and recorded and classified cetacean sounds (e.g., echolocation clicks, whistles, etc.) along with anthropogenic noises. Data on the bearing to the sounds and the sound types and intensity were recorded using the Logger data collection software. The array was deployed and monitored for a total of approximately 594 hours during the survey (Table D1).

Acoustic detections of marine mammals were made throughout the survey and were linked with visual sightings. 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 D7). However, 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 data

Cetacean biopsy tissue samples were collected from the bow of the NOAA ship *Gordon Gunter* or from a 7 m RHIB boat (*R3*) deployed from the NOAA ship *Gordon Gunter*. Skin samples from biopsies are genetically analyzed for gender determination, evaluation of population structure, and species identification. Blubber samples can be analyzed for a variety of contaminants. 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. Data on each sampling attempt were recorded and included GPS location, time, date, sampler and recorder name, species, body location 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. Biopsy skin samples were preserved in vials containing 20% dimethyl sulfoxide (DMSO).

A total of 50 cetacean biopsies were collected from seven different species (Table D5, Figure D8).

Active acoustic data

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 EK60 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 was 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 allowed the position of the sphere within the transducer beam to be controlled. During the calibration, the target was moved throughout the circular beam, and the resulting strength (in dB) of the return signal from the transducer was measured. After a large number of returns were measured, a statistical model was used to correct the returns from acoustic targets for variability in the sensitivity of the receiver throughout the beam.

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

Hydrographic data

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). In addition to these data, hydrographic data were collected at pre-determined stations using a Conductivity Temperature Depth (CTD) profiler units and expendable bathythermographs (XBTs). CTD casts were made down to 500 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 casts were made 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.

A total of 369 hydrographic profiles were collected including 302 XBT stations and 67 CTD stations (Figure D9).

Data and sample disposition

All data collected during GU-11-02 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. Backup copies of the passive acoustic data and recordings are maintained at Scripps Institution of Oceanography (Dr. John Hildebrand). Genetic samples are stored at the Southeast Marine Mammal Molecular Genetics Laboratory in Lafayette, LA.
All data from the CTDs and the SCS are maintained at the Pascagoula Laboratory for analysis, editing, and archiving.

Permits

SEFSC was authorized to conduct the research activities during this cruise under Permit No. 779-1633-00 issued to the SEFSC by the NMFS Office of Protected Resources. Sea turtle sightings were permitted under ESA Section 10a1a permit #1551 issued to the SEFSC.

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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.

Table D1. Summary of survey effort during GU-11-02.

Leg 1 date	Survey event	Survey effort (km)	Number of sightings	Number of biopsies	Avg. sea state	Acoustic effort (hrs)
17 June	Depart Pascagoula, MS 1400 hrs	-	-	-	-	-
18 June	Calibrate EK60 Echosounder	-	-	-	-	-
19 June	Transit – Survey SE Gulf	58	7	0	2.5	-
20 June	Transit – Survey Florida Straits, Personnel Exchange	52	1	0	2.3	-
21 June	Transit – Survey Florida East Coast	192	15	0	2.0	-
22 June	Visual Survey – Acoustic Testing/Setup	181	4	1	3.2	-
23 June	Visual Survey – Acoustic Testing/Setup	158	2	0	3.5	-
24 June	Visual and Acoustic Survey	164	4	0	3.9	20.6
25 June	Visual and Acoustic Survey	143	0	0	3.4	21.8
26 June	Visual and Acoustic Survey	136	3	0	4.2	21.8
27 June	Visual and Acoustic Survey	184	5	0	4.2	22.5
28 June	Visual and Acoustic Survey	136	3	0	4.2	22.0
29 June	Visual and Acoustic Survey	152	3	0	4.1	12.9
30 June	Visual and Acoustic Survey	126	5	2	3.2	21.5
1 July	Visual and Acoustic Survey	158	18	3	1.7	16.7
2 July	Visual and Acoustic Survey	169	46	2	1.3	22.0
3 July	Visual and Acoustic Survey	194	19	0	2.9	22.9
4 July	Limited Effort – Weather	-	2	0	5.0	20.7
5 July	Visual and Acoustic Survey	183	0	0	4.2	21.2
6 July	Visual and Acoustic Survey	149	2	0	4.4	22.0
7 July	Visual and Acoustic Survey	99	15	0	3.7	19.8
8 July	Arrive Norfolk, VA 0900 hrs	-	0	0	-	-
Leg 1 total		**2637**	**154**	**8**	**-**	**288.4**

Table D1 (cont'd) Summary of survey effort during GU-11-02.

Leg 2 date	Survey event	Survey effort (km)	Number of sightings	Number of biopsies	Avg. sea state	Acoustic effort (hrs)
12 July	Depart Norfolk, VA 1300 hrs	-	-	-	-	-
13 July	Visual and Acoustic Survey	63	26	8	2.0	9.6
14 July	Limited Effort - Weather	13	6	-	5.0	22.3
15 July	Visual and Acoustic Survey	119	23	3	4.2	16.3
16 July	Visual and Acoustic Survey	122	15	2	3.9	18.7
17 July	Visual and Acoustic Survey	153	7	2	3.5	20.3
18 July	Visual and Acoustic Survey	157	3	2	4.5	15.3
19 July	Visual and Acoustic Survey	192	4	0	3.7	22.5
20 July	Visual and Acoustic Survey	160	9	3	3.5	18.8
21 July	Visual and Acoustic Survey	76	13	3	3.8	19.2
22 July	Visual and Acoustic Survey	174	7	0	4.2	21.3
23 July	Visual and Acoustic Survey	209	0	0	2.9	22.7
24 July	Visual and Acoustic Survey	106	8	3	2.5	13.5
25 July	Visual and Acoustic Survey	148	10	2	3.5	20.0
26 July	Visual and Acoustic Survey	132	4	3	4.0	19.3
27 July	Visual Survey	97	9	2	3.0	-
28 July	Transit – Crew Exchange	-	-	-	-	11.9
29 July	Visual and Acoustic Survey – Florida Straits	131	7	1	4.0	10.8
30 July	Visual and Acoustic Survey – Gulf of Mexico	191	2	3	3.1	13.5
31 July	Visual and Acoustic Survey – Gulf of Mexico	58	12	3	2.3	13.5
1 August	Visual and Acoustic Survey – Gulf of Mexico	70	12	2	2.6	9.1
2 August	Arrive Pascagoula, MS 0800 hrs	-	-	-	-	-
Leg 2 total		**2,375**	**178**	**42**	**-**	**305.6**
Survey total		**5,013**	**332**	**50**	**-**	**594.0**

Table D2. Cruise Participants of GU-11-02.

Name	Title	Sex	Organization	Citizenship
Leg 1 (17 June – 08 July)				
Jesse Wicker	FPC	M	CIMAS, Miami, FL	US
Keith Mullin	Chief Scientist	M	NMFS, Pascagoula, MS	US
Laura Dias	Scientist	F	CIMAS, Miami, FL	Brazil
Bridget Watts	Scientist	F	IAP, Pascagoula, MS	US
Cheryl Cross	Scientist	F	IAP, Pascagoula, MS	US
Adam U	Scientist	M	NMFS, La Jolla, CA	US
Paula Olson	Scientist	F	IAP, Pascagoula, MS	US
Tom Johnson	Scientist	M	IAP, Pascagoula, MS	US
Kait Frasier	Scientist	F	SCRIPPS, La Jolla, CA	US
Tom Ninke	Scientist	M	IAP, Pascagoula, MS	US
Melody Baran	Scientist	F	IAP, Pascagoula, MS	US
Kelly Cunningham	Scientist	F	IAP, Pascagoula, MS	US
Keith Rittmaster	Scientist	M	IAP, Pascagoula, MS	US
Lauren Roche	Scientist	F	SCRIPPS, La Jolla, CA	US
Juan Carlos Salinas	Scientist	M	Ocean Associates	Mexico
Leg 2 (12 July – 02 August)				
Jesse Wicker	FPC	M	CIMAS, Miami, FL	US
Keith Mullin	Chief Scientist	M	NMFS, Pascagoula, MS	US
Bridget Watts	Scientist	F	IAP, Pascagoula, MS	US
Cheryl Cross	Scientist	F	IAP, Pascagoula, MS	US
Adam U	Scientist	M	NMFS, La Jolla, CA,	US
Paula Olson	Scientist	F	IAP, Pascagoula, MS	US
Tom Johnson	Scientist	M	IAP, Pascagoula, MS	US
Kait Frasier	Scientist	F	SCRIPPS, La Jolla, CA	US
Tom Ninke	Scientist	M	IAP, Pascagoula, MS	US
Melody Baran	Scientist	F	IAP, Pascagoula, MS	US
Kelly Cunningham	Scientist	F	IAP, Pascagoula, MS	US
Keith Rittmaster	Scientist	M	IAP, Pascagoula, MS	US
Hannah Bassett	Scientist	F	SCRIPPS, La Jolla, CA	US
Aimee Deveau	Scientist	F	University of Miami	US
Juan Carlos Salinas	Scientist	M	Ocean Associates	Mexico

Table D3. Cetacean sightings during GU-11-02.

Common name	Species	Leg 1	Leg 2	**Total**
Atlantic spotted dolphin	*Stenella frontalis*	7	22	**29**
Blainville's beaked whale	*Mesoplodon densirostris*	1	0	**1**
Bottlenose dolphin	*Tursiops truncatus*	9	60	**69**
Bottlenose/Spotted dolphin	*T. truncatus/S. frontalis*	0	2	**2**
Bryde's whale	*Balaenoptera edeni*	0	4	**4**
Clymene dolphin	*Stenella clymene*	1	0	**1**
Common dolphin	*Delphinus delphi*	0	2	**2**
Cuvier's beaked whale	*Ziphius cavirostris*	2	0	**2**
False killer whale	*Pseudorca crassidens*	1	0	**1**
Fin whale	*Balaenoptera physalus*	0	3	**3**
Melon-headed/Pygmy killer whale	*Peponocephala/Feresa*	1	0	**1**
Pantropical spotted dolphin	*Stenella attenuata*	2	1	**3**
Pilot whales	*Globicephala sp.*	8	26	**34**
Pygmy/Dwarf sperm whale	*Kogia sima/breviceps*	17	0	**17**
Risso's dolphin	*Grampus griseus*	9	10	**19**
Rough-toothed dolphin	*Steno bredanensis*	1	0	**1**
Sperm whale	*Physeter macrocephalus*	9	14	**23**
Spinner dolphin	*Stenella longirostris*	1	0	**1**
Stenella sp.	*Stenella sp.*	3	1	**4**
Striped dolphin	*Stenella coeruleoalba*	1	4	**5**
Unid dolphin		24	19	**43**
Unid large whale		0	4	**4**
Unid mesoplondant	*Mesoplodon sp.*	12	1	**13**
Unid. odontocetes		17	2	**19**
Unid small whale		16	2	**18**
Unid ziphiid		12	0	**12**
Total		**154**	**178**	**332**

Table D4. Number of bird sightings recorded during GU-11-02.

Species	Number of sightings
Arctic tern	1
Audubon shearwater	106
Band-rumped storm-petrel	33
Black tern	1
Black-capped petrel	146
Bridled tern	15
Brown bobby	2
Brown noddy	4
Cattle egret	1
Common tern	1
Cory’s shearwater	272
Fea's petrel	2
Great shearwater	180
Green heron	1
Herald petrel	18
Laughing gull	2
Leach’s storm-petrel	22
Least sandpiper	1
Least tern	5
Little blue heron	2
Long-tailed jaeger	1
Magnificent frigatebird	4
Manx shearwater	8
Masked booby	2
Parasitic jaeger	1
Passerine (Land bird)	6
Pomarine jaeger	8
Red-billed tropicbird	3
Royal tern	4
Shorebird	4
Snowy egret	1
Sooty shearwater	2
Sooty tern	48
South polar skua	3
Unidentified petrel	2
Unidentified shearwater	13
Unidentified skua	1
Unidentified storm-petrel	12
Unidentified tern	7
White-tailed tropicbird	33
Wilson’s storm-petrel	152
Yellow-crowned night heron	5
Total	**1135**

Table D5. Cetacean biopsies (*n* = 50) collected during GU-11-02.

Species	Leg 1	Leg 2	**Total**
Bottlenose dolphin	3	22	**25**
Atlantic spotted dolphin	3	11	**14**
Bryde's whale	0	4	**4**
Common dolphin	0	1	**1**
False killer whale	1	0	**1**
Rough-toothed dolphin	1	0	**1**
Striped dolphin	0	4	**4**
Total	**8**	**42**	**50**

Figure D1. Survey effort during 21 June – 2 August 2011 on the NOAA ship *Gordon Gunter* cruise number GU-11-02.

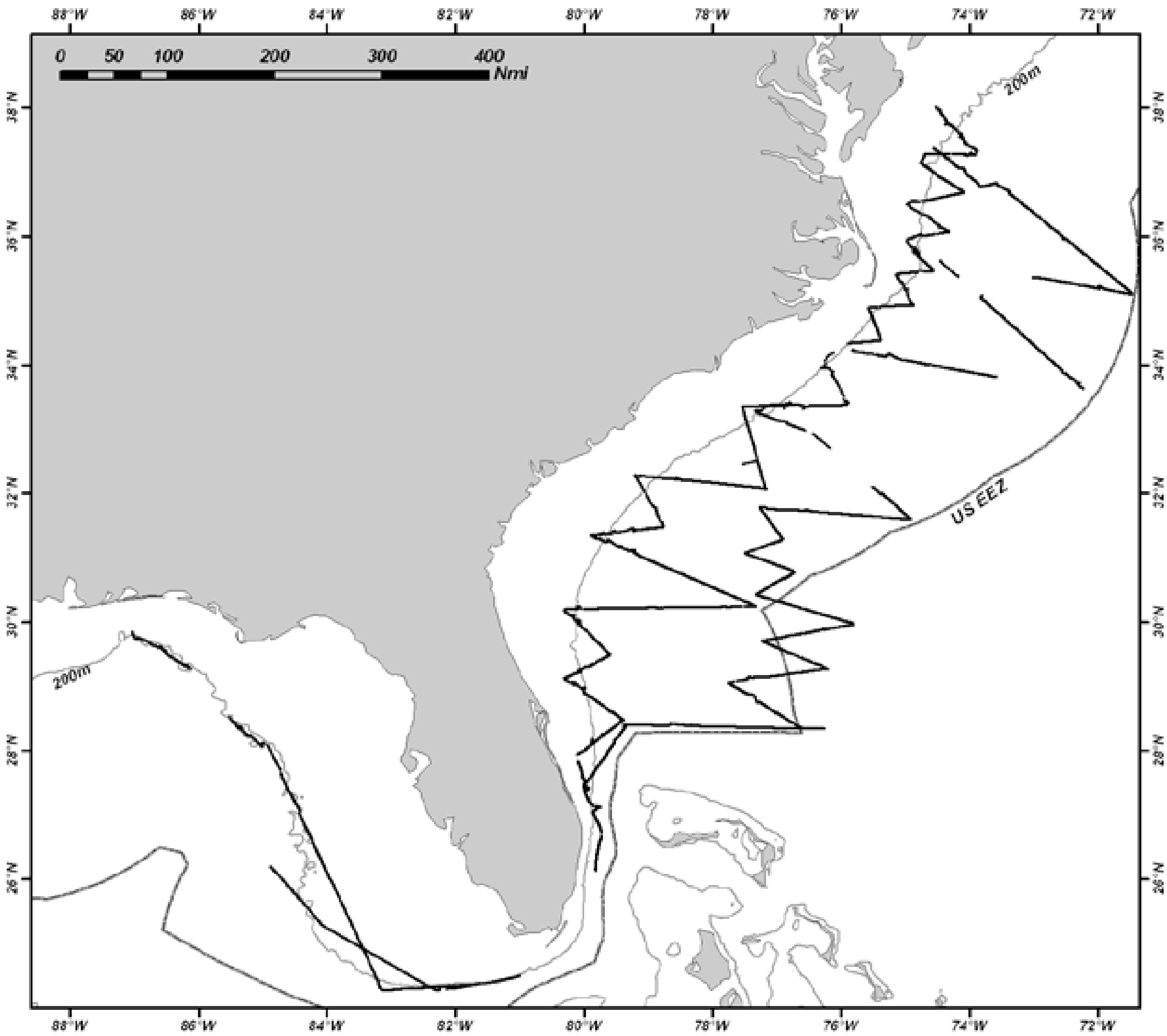


Figure D2. Locations of all marine mammal sightings during GU-11-02.

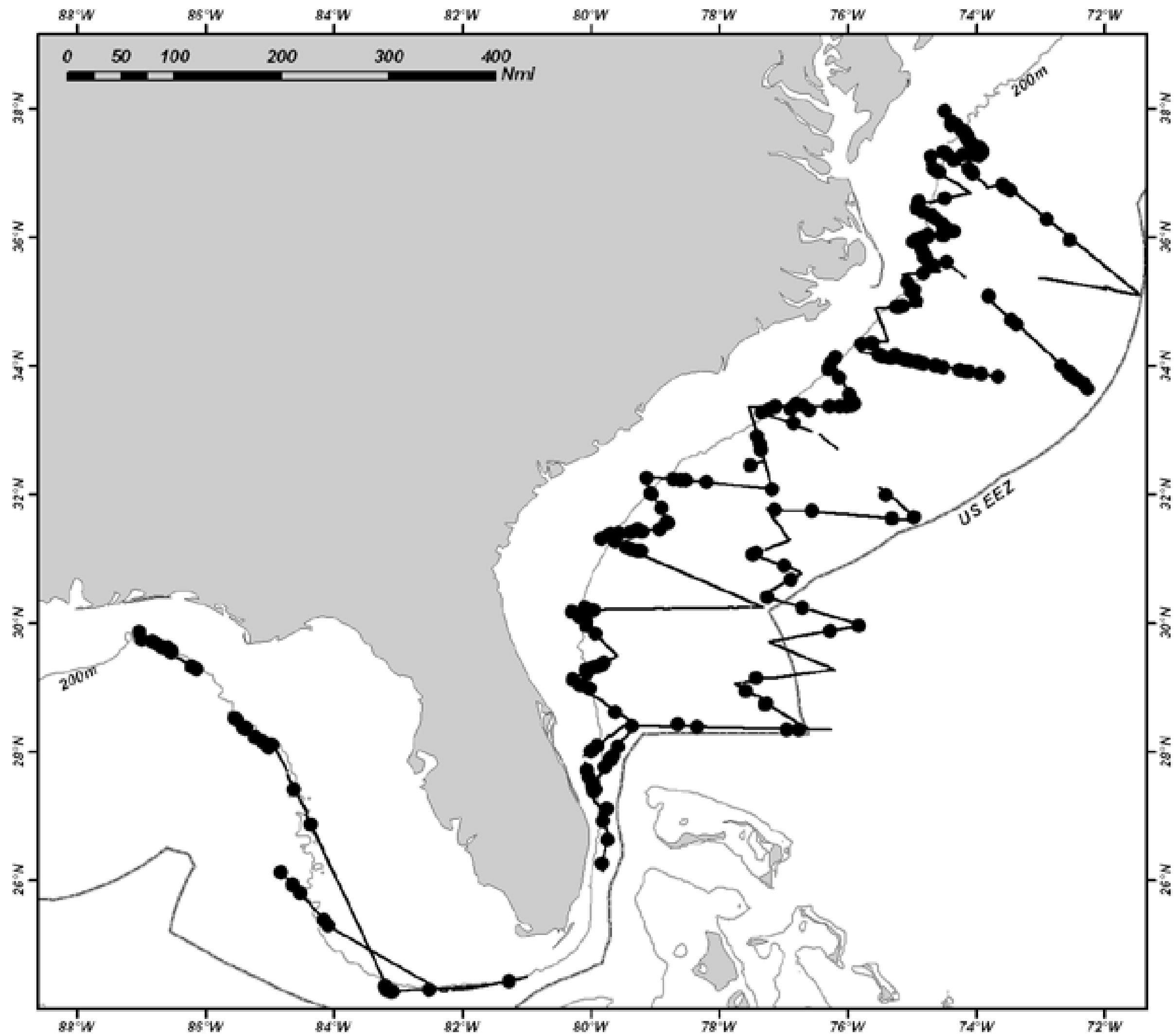


Figure D3. Locations of large whale and beaked whale sightings during GU-11-02.

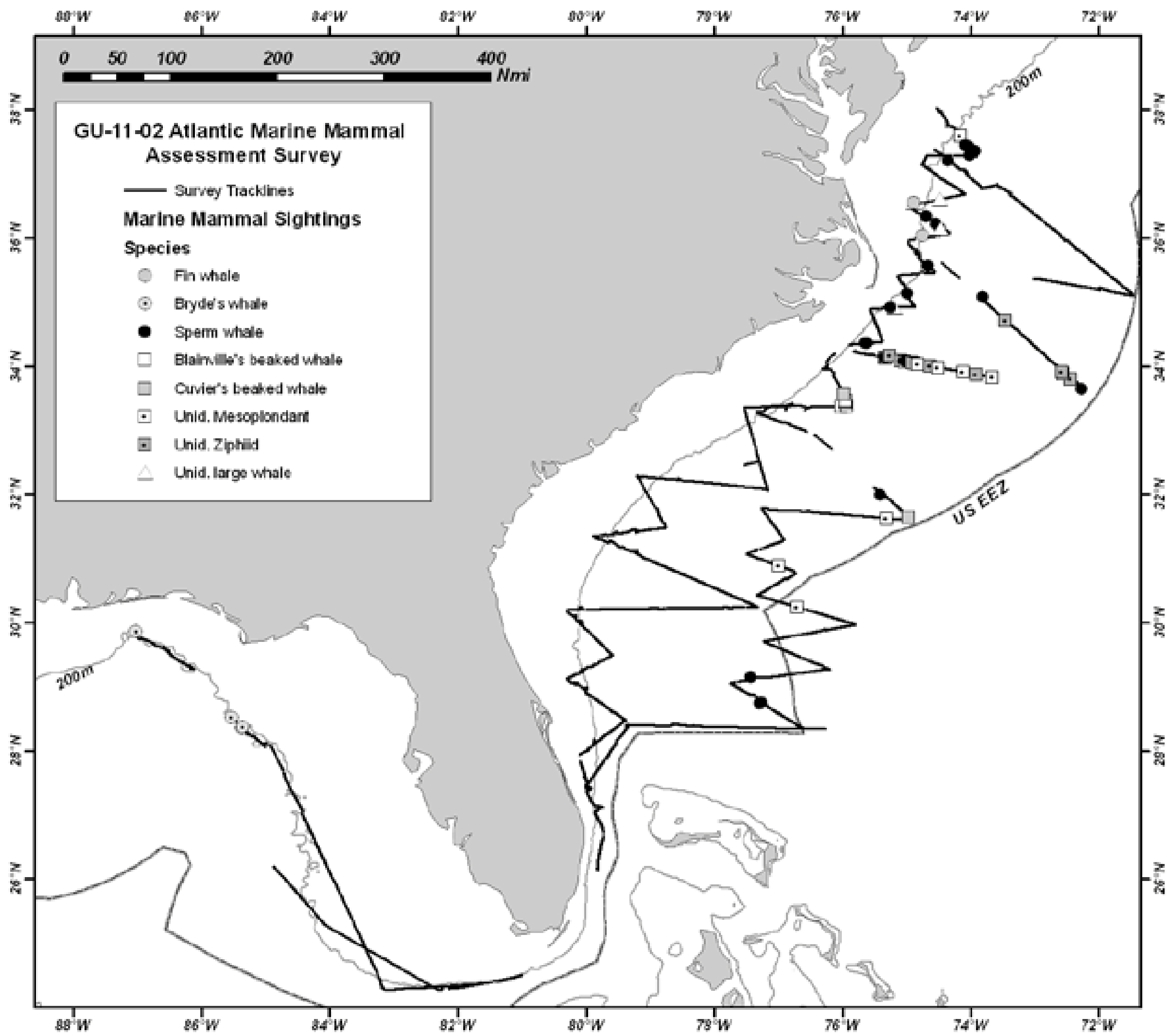


Figure D4. Locations of small whale sightings during GU-11-02.

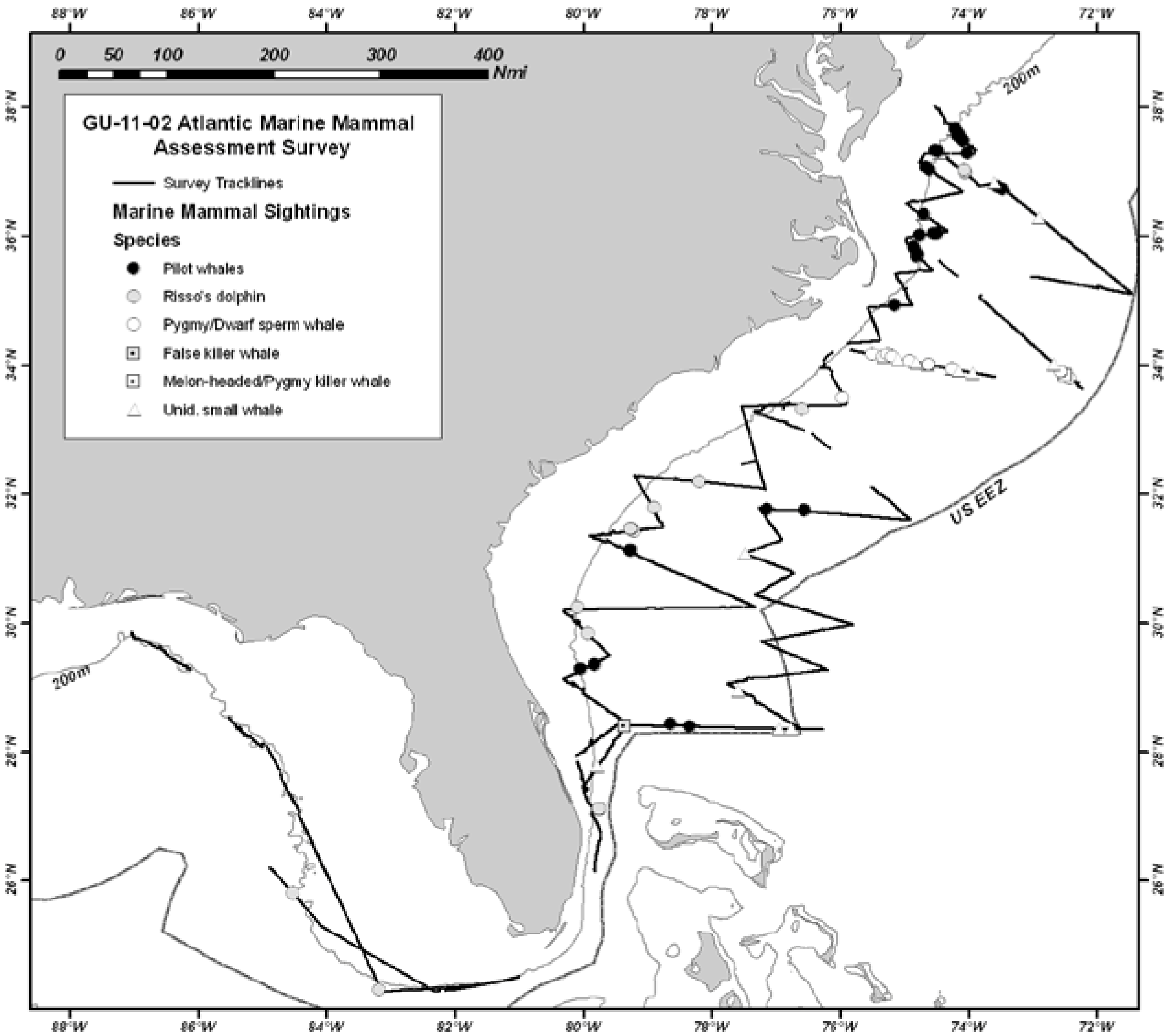


Figure D5. Locations of dolphin sightings during GU-11-02.

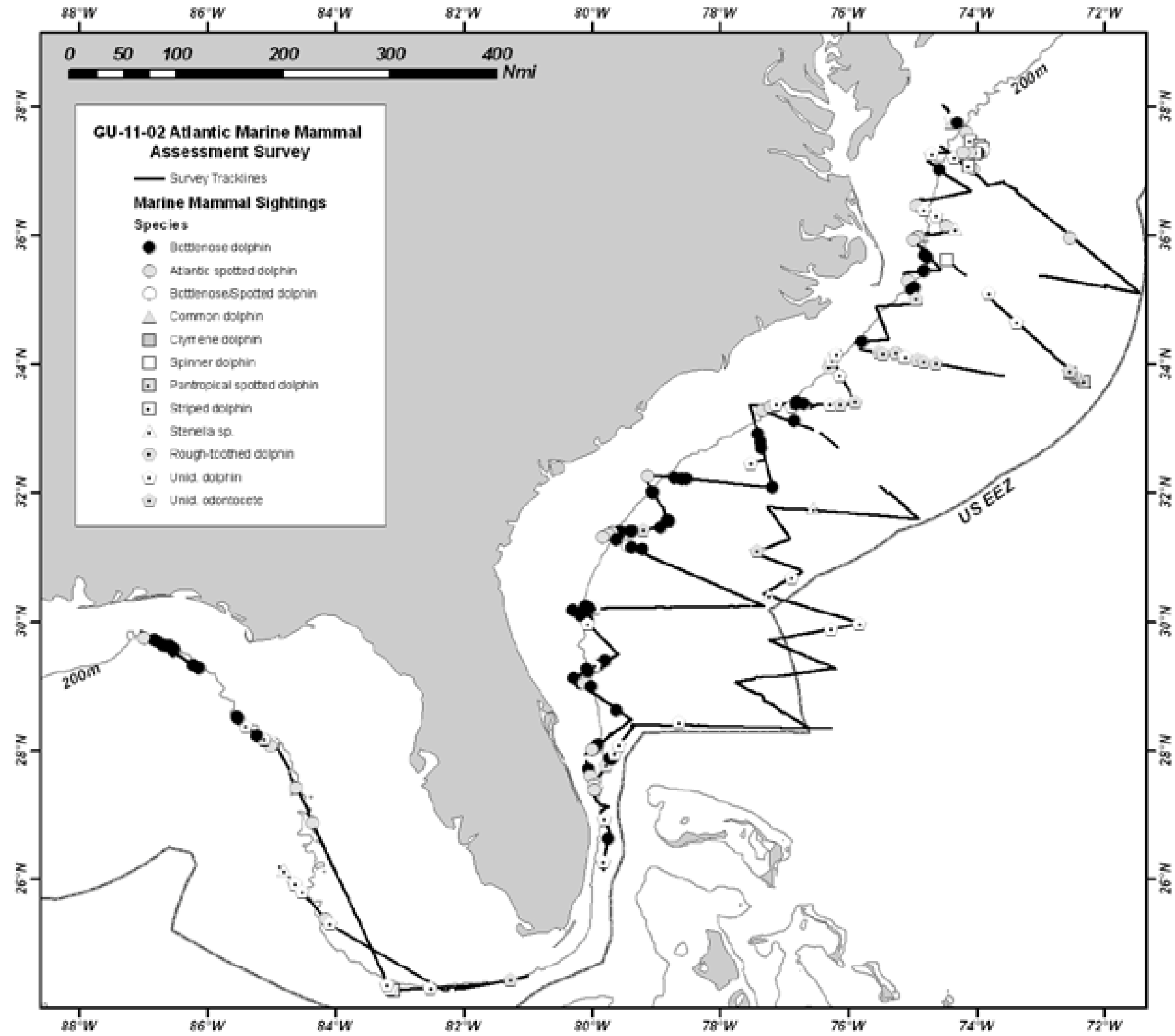


Figure D6. Locations of sightings of the most common seabird species encountered during GU-11-02.

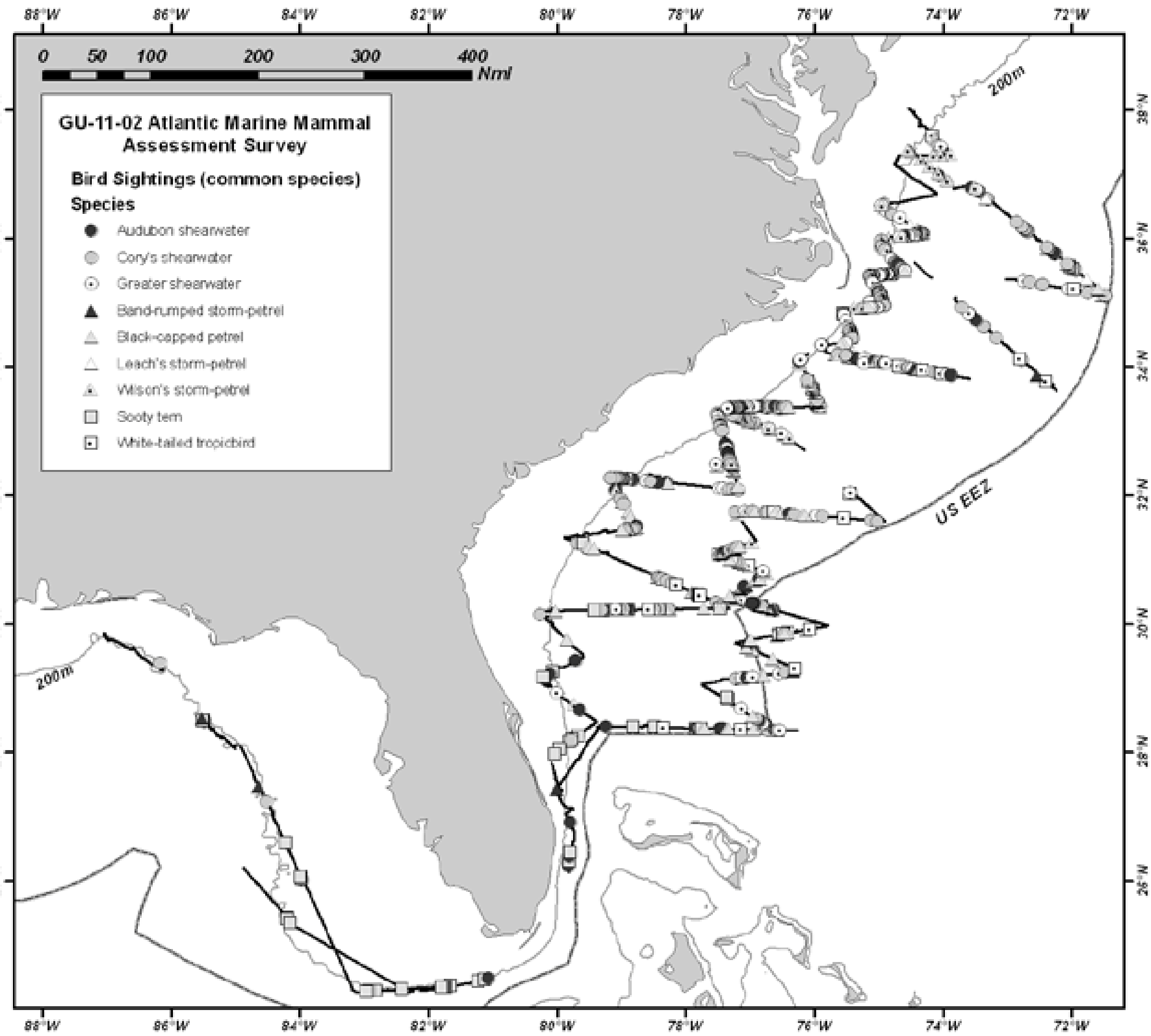


Figure D7. Passive acoustic effort and detections during GU-11-02.

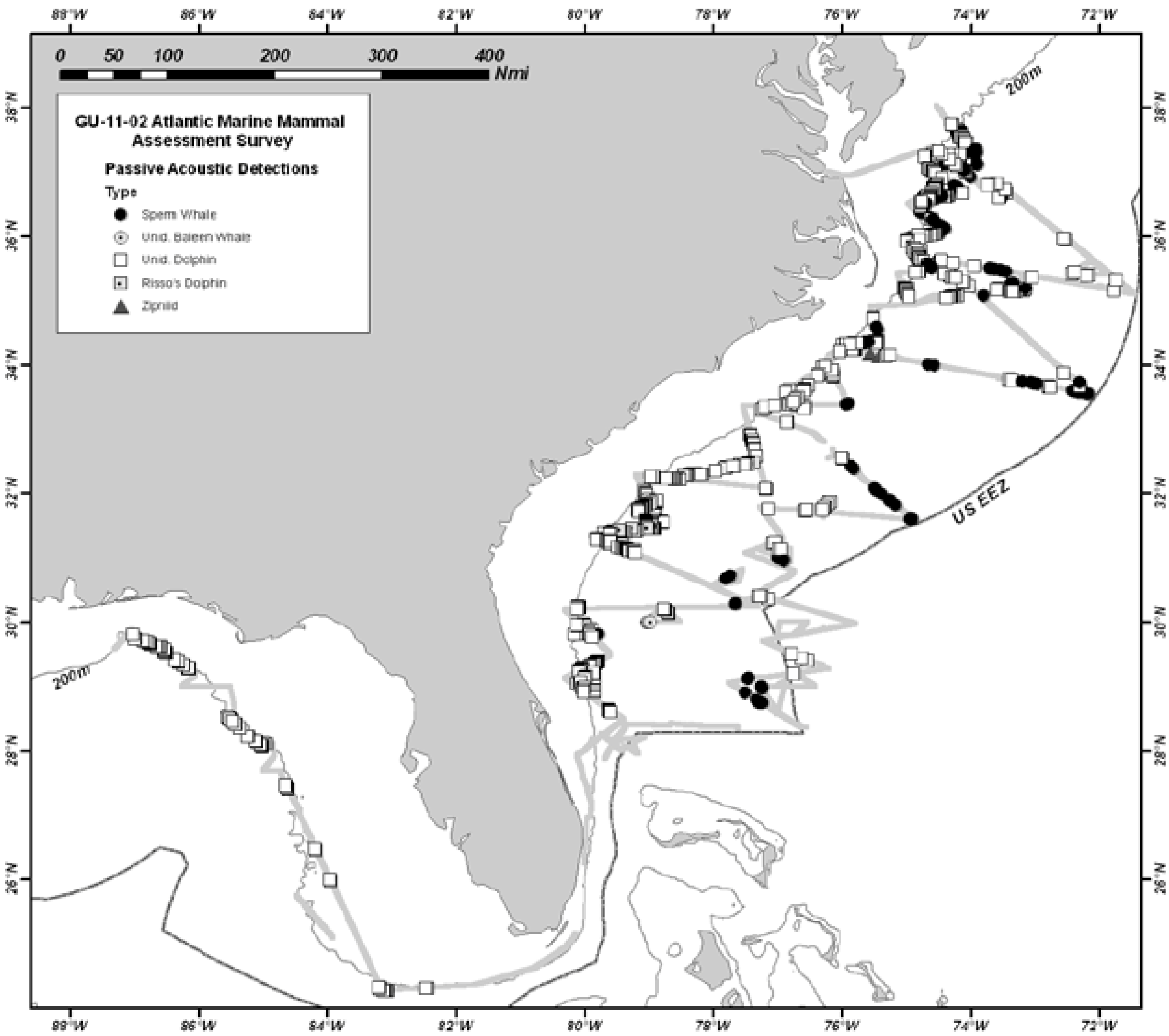


Figure D8. Locations of biopsy samples collected during GU-11-02.

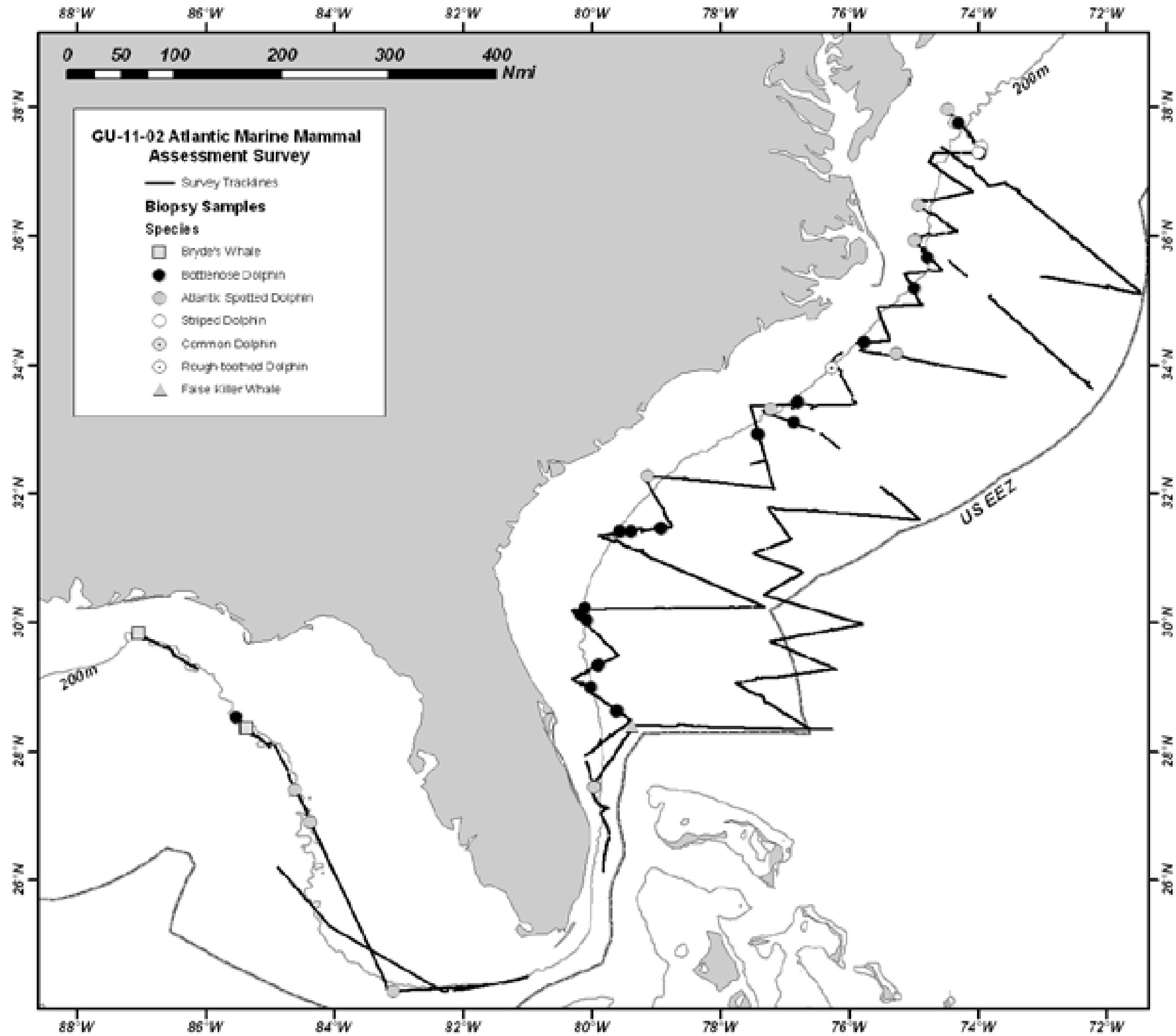
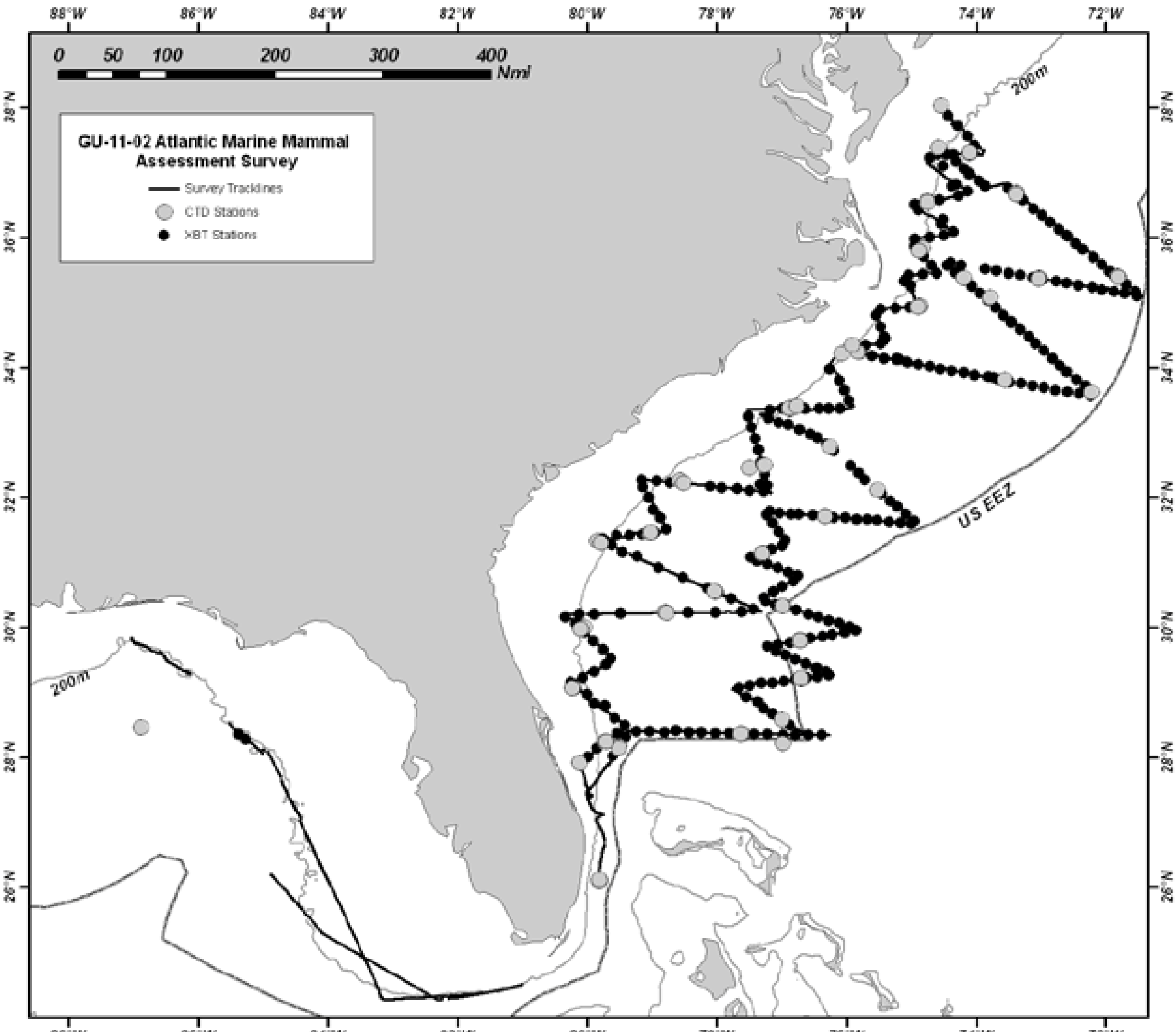


Figure D9. Locations of CTD and XBT stations during GU-11-02.



Appendix E*: Northern Sea Turtle Tagging Project: Northeast Fishery Science Center*

NEFSC
[1]**Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543**

Summary
As part of the Atlantic Marine Assessment Program for Protected Species (AMMAPS) program, a multi-agency team conducted loggerhead turtle live capture, tagging, and biological sampling in Mid-Atlantic waters. The Coonamessett Farm Foundation (with the assistance of Viking Village Fisheries) provided the vessels, crew, and several at-sea scientific personnel. In early June 2011 the *F/Vs Kathy Ann* and *Ms. Manya* (commercial scallop fishing vessels) departed from Barnegat Light, New Jersey with 10 scientific crew and 7 vessel crew to locate large, immature loggerhead turtles in an area where the loggerhead turtles overlap with commercial fishing activity (primarily 40 – 80 nmi offshore of Delaware through Virginia). During 2 – 6 Jun 2011, 15 immature loggerhead turtles (63 – 93 cm curved carapace length (CCL)) were captured and satellite-tagged. Epoxy was used to attach Sea Mammal Research Unit's (SMRU) Fastloc GPS Satellite Relay Data Loggers (SRDLs) to a central carapace scute of each captured turtle. Then the loggerhead turtles were measured, weighed, photographed, flipper and PIT tagged, biopsied, and blood was sampled. The detailed GPS location, temperature, and dive data are stored in a Northeast Fisheries Science Center (NEFSC) Oracle database.

Background
One of the goals of the AMAPPS initiative is to develop models and associated tools to provide seasonal, spatially-explicit density estimates of marine mammals, sea turtles, and seabirds in the western North Atlantic Ocean. The aerial and shipboard line-transect abundance data collected in other projects within AMAPPS result in density estimates of animals at or above the ocean surface. The project described here collects data that will be used to develop corrections for availability bias in the loggerhead turtle surface density estimates. From here on, the abbreviated term loggerheads will be used instead of loggerhead turtle. The corrections will be developed using dive and surface times collected from tags attached to the loggerheads.

The U.S. Mid-Atlantic region is an important foraging ground for loggerheads. But due to the difficulties in locating and capturing these immature turtles on their offshore foraging grounds, relatively little is known about the large, immature loggerheads that occupy the offshore Mid-Atlantic region. To start filling in these knowledge gaps, the dive/surface data collected in this project will also provide information on loggerheads habitat use, residence time, behavior, and life history.

To capture inter-annual variability and obtain sufficient sample sizes, data collection for this project will occur over multiple years. In summer 2010, the NEFSC and Southeast Fisheries Science Center (SEFSC) deployed some satellite tags on immature loggerheads located in waters off New Jersey to Florida. During 2011 additional tags were deployed on loggerheads captured in offshore Mid-Atlantic waters.

Methods

The NEFSC partnered with Coonamessett Farm Foundation (with the assistance of Viking Village Fisheries), who provided vessels, crew, and at-sea scientific personnel. This partnership allowed us to sample loggerheads in their offshore Mid-Atlantic foraging grounds. In 2011 Coonamessett Farm Foundation provided two commercial fishing vessels (compared to one vessel in 2010). In 2011Coonamessett Farm Foundation also deployed 10 identical tags and has allowed the satellite transferred data to be uploaded into a Northeast Sea Turtle Collaborative sea turtle tagging Oracle database, maintained by the NEFSC.

In early June 2011 the *F/Vs Kathy Ann* and *Ms. Manya* (commercial scallop fishing vessels) departed from Barnegat Light, NJ with 10 scientific crew (Table E1) and 7 vessel crew to locate immature loggerheads in an area where large, immature loggerheads are known to overlap with commercial fishing activities (primarily 40 – 80 miles offshore of Delaware through Virginia). When loggerheads were located, small boats (14 ft) were deployed to capture them using a large dipnet. All captured loggerheads were transferred to the *F/V Kathy Ann* for biological sampling. Epoxy was used to attach Sea Mammal Research Unit's (SMRU) Fastloc GPS Satellite Relay Data Loggers (SRDLs) to a central carapace scute of each captured turtle.

Collaborations in 2011 allowed a greatly increased sample size. The SEFSC named the NEFSC under their permit to increase sampling in this project. NEFSC also collaborated with the National Marine Life Center and the Virginia Aquarium and Marine Science Center to be able to collect blood. In 2011 the sampling procedures was the same as in 2010 (measured the curved carapace length (CCL) and width of captured loggerheads, photographed, flipper and PIT tagged, and took biopsy samples for genetic analysis). Plus in 2011, the body weight and depth were measured, biopsy samples were taken for stable isotope analysis, and blood samples were taken to be analyzed for testosterone levels (to identify sex) and general blood chemistry (for health assessment).

The satellite tags were programmed to transmit every day, though local conditions prevent some transmissions. Specifications for the SMRU Fastloc GPS Satellite Relay Data Loggers (SRDLs) are provided in Appendix E1. The Fastloc GPS supplies highly accurate locations. The tag also uses precision wet/dry, pressure, and temperature sensors to form individual dive (maximum depth, shape, time at depth, etc.) records along with temperature profiles and binned summary records. In 2011 new variables were added to the satellite telemetry data so that the average duration of a surfacing bout and average duration of a diving bout could be determined. The SMRU tag stores information in its memory and then relays an unbiased sample of detailed individual dive records and summary records.

Results

During 2 – 6 Jun 2011, 15 immature loggerheads (63 – 93 cm CCL) were captured and satellite-tagged, primarily offshore of Delaware through Virginia (Table E2).

As of 20 October 2011 three of the tags from 2010 and all of the tags from 2011 were still actively transmitting (Figure E1), according to the www.seaturtle.org website. As of 4 June 2012, fourteen tags from 2011 have been transmitting for about one year.

The satellite-relayed data are currently stored in two ways. Location data are downloaded daily to the publically-accessible website (http://www.seaturtle.org/tracking/?project_id=537). Figure E1 shows the composite www.seaturtle.org map of our tags for the entire study period. The detailed GPS location, temperature, and dive data are downloaded daily to a password-protected SMRU website and uploaded weekly to a NEFSC Oracle database. By combining the data from 2010 and 2011 along with the data from Coonamessett Farm Foundation, as of 20 October 2011, the Oracle database stores over 65K locations, 45K individual dive profiles, and 15K six-hour summaries of depth use.

Disposition of the data

All data collected during this project will be maintained by the Protected Species Branch at NEFSC in Woods Hole, MA.

Permits

NEFSC was authorized to conduct sea turtle research activities during this project under Permit Nos. 1551 and 1576 issued by the NMFS Office of Protected Resources.

Acknowledgements

This research is part of a collaborative effort to learn more about sea turtles in Northeastern US regional waters. The funds for the tags and biological sampling came from Bureau of Ocean Energy Management (BOEM). Considerable staff time was provided by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC). Funds for vessel time, crew, and some tags were supplied by the Coonamessett Farm Foundation, working with the sea scallop industry through their research set aside program.

Substantial contributions were made by staff of the Southeast Fisheries Science Center (SEFSC), staff of the Virginia Aquarium & Marine Science Center, (Virginia Beach, VA), Robert DiGiovanni of the Riverhead Foundation for Marine Research and Preservation (Riverhead, NY), and Dr. Roger Williams of the National Marine Life Center. We owe very special thanks to our Coonamessett Farm Foundation collaborators and to the owners, managers, and crew of the *F/Vs Kathy Ann* and *Ms. Manya*.

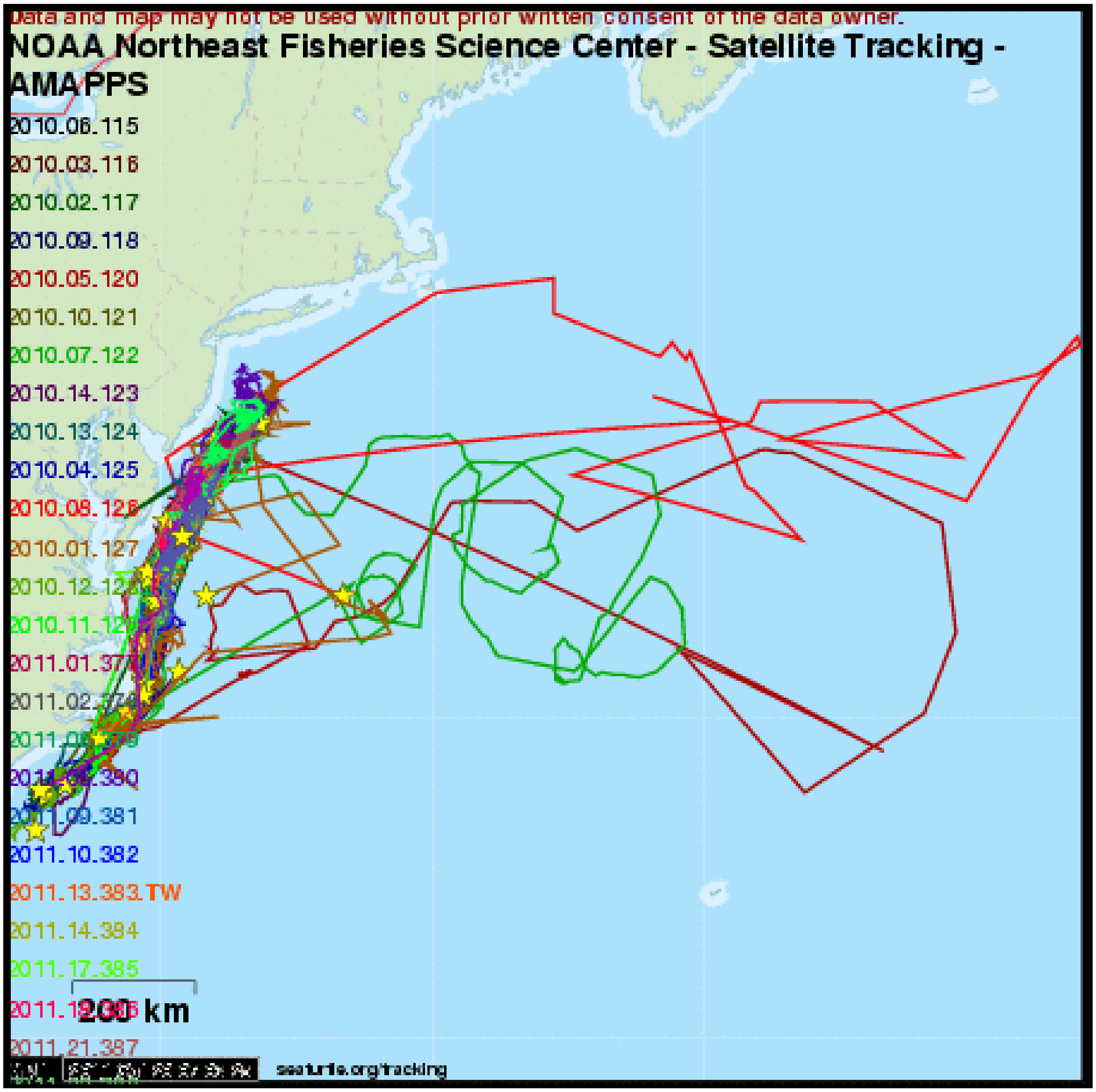
Table E1. Scientific crew on the June 2011 loggerhead turtle tagging cruise.

Name	Affiliation
Shannon Davis	Virginia Aquarium & Marine Science Center
Heather Haas	NOAA/NMFS/NEFSC/PSB
Raymond Hines	Coonamessett Farm Foundation
Eric Matzen	Integrated Statistics
Henry Milliken	NOAA/NMFS/NEFSC/PSB
Kimberly Murray	NOAA/NMFS/NEFSC/PSB
Richard Pace	NOAA/NMFS/NEFSC/PSB
Ron Smolowitz	Coonamessett Farm Foundation
Melissa Warden	Integrated Statistics
Matthew Weeks	Coonamessett Farm Foundation

Table E2. Location, date and curved carapace length (CCL), measured in cm, of loggerhead turtles tagged in waters off of Delaware to New Jersey.

Date	Latitude	Longitude	CCL (cm)
6/2/2011	38.71	-74.14	74.0
6/2/2011	38.65	-74.10	69.0
6/2/2011	38.65	74.00	80.7
6/2/2011	38.62	-73.97	87.3
6/3/2011	38.04	-74.61	67.5
6/3/2011	37.98	-74.64	80.0
6/3/2011	37.99	-74.63	83.5
6/3/2011	37.99	-74.62	79.2
6/3/2011	37.99	-74.62	79.5
6/3/2011	37.98	-74.61	89.0
6/3/2011	37.97	-74.58	72.0
6/4/2011	37.76	-74.71	90.0
6/4/2011	37.73	-74.71	93.0
6/4/2011	37.72	-74.72	82.5
6/4/2011	37.71	-74.73	76.0
6/6/2011	37.95	-74.68	73.0
6/6/2011	37.97	-74.72	63.0
6/6/2011	38.00	-74.74	79.0
6/6/2011	37.97	-74.73	83.0
6/6/2011	37.97	-74.73	73.5
6/6/2011	37.95	-74.72	73.0
6/6/2011	37.95	-74.71	93.0
6/6/2011	37.94	-74.70	77.0
6/6/2011	37.94	-74.70	77.6
6/6/2011	37.92	-74.70	87.5

Figure E1. Locations of 2010 and 2011 tagged loggerhead turtles, as displayed by seaturtle.org on 20 October 2011.



Annex E1: SMRU Tag Specifications

```
Software specification for FA_10A deployment
 (Loggerhead GPS Argos)


Valid for dates in years 2010 to 2013

 Transmitting via ARGOS
Page transmission sequences:

        Until day  120:  0 1 2 3 4 2 3 0 2 3 using 1 PTT numbers

        Until day  200:  0 1 3 3 4 3 3 0 3 3 using 1 PTT numbers

        Until day 1464:  0 1 0 4 0 1 0 1 0 1 using 1 PTT numbers


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
  7000 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
A cruise begins if there has been no dive for 15 mins
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.
        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 2 (15 days): 30  = 120 bytes
No Timelines
Cruises: 30 = 120 bytes
No Diving periods
No Spot depths
No Emergence records
No Dive duration histograms
```

No Max depth histograms
6-hour Temperature-at-depth histograms in groups of 2 (15 days): 30 = 120 bytes
CTD casts (8.33333 days): 50 = 200 bytes
GPS fixes (variable: 70.8333 days if interval is 20 mins): 5100 = 20400 bytes
No Spot CTD's

TOTAL 22680 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 76 bytes = 1140000 bytes
No 'deep' dives
Haulout: 1000 x 16 bytes = 16000 bytes
6-hour summaries in groups of 2 (500 days): 1000 x 48 bytes = 48000 bytes
6-hour berniegrams in groups of 2 (500 days): 1000 x 40 bytes = 40000 bytes
No timelines
Cruise: 2000 x 16 bytes = 32000 bytes
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 1960 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 @ 20 secs= 32400
                tx as raw 15 bits in units of 1  (range: 0 to 32767 )
                (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:  Lookup with 64 bins: <20,20-30,30-40,40-50,50-60,60-
80,80-100,100-120,120-140,140-160,160-180,180-240,240-300,300-360,360-
420,420-480,480-600,600-720,720-840,840-960,960-1080,1080-1200,1200-
1320,1320-1440,1440-1560,1560-1680,1680-1800,1800-2100,2100-2400,2400-
2700,2700-3000,3000-3300,3300-3600,3600-3900,3900-4200,4200-4500,4500-
4800,4800-5100,5100-5400,5400-5700,5700-6000,6000-6300,6300-6600,6600-
6900,6900-7200,7200-7800,7800-8400,8400-9000,9000-9600,9600-10200,10200-
10800,10800-12000,12000-13200,13200-14400,14400-16200,16200-18000,18000-
19800,19800-21600,21600-28800,28800-36000,36000-43200,43200-54000,54000-
64800, >64800 in units of 1 s (range: 0 to 64800 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 9 bits in units of 1.95695 permille
(range: 0 to 1000 permille)
                 Speed profile:  -- not transmitted --
                Residual:  -- not transmitted --
                Calculation time:  -- not transmitted --
         Surface duration:  odlog 2/4 in units of 4 s (range: 0 to 942 s)
                cf. cruise starts after 15 mins (900 secs)
         Dive area:  raw 9 bits in units of 1.95695 permille (range: 0 to 1000
permille)
        -----------[209 bits: 11 - 219]

        CRUISE group in format 0:
         Number of records:  raw 1 bits in units of 1  (range: 0 to 1 )
         Cruise number:  wraparound 6 bits in units of 1  (range: 0 to 63 )
         Start time:  -- not transmitted --
         End time:  max 5 days 12 hours @ 2 mins= 3960
               tx as raw 12 bits in units of 1  (range: 0 to 4095 )
               (recommended sell-by 5 days 11 hours)
         Sell-by range:  5 days 4 hours
         Duration:  odlog 2/6 in units of 90 s (range: 0 to 85995 s)
               cf. Max duration is 1 day
         Speed:  -- not transmitted --
         Reason for end:  -- not transmitted --
        -----------[27 bits: 220 - 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 2
        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 6 bits in units of 15.873 permille (range: 0 to
1000 permille)
         Dive time:  raw 6 bits in units of 15.873 permille (range: 0 to 1000
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:  Lookup with 64 bins: <20,20-30,30-40,40-
50,50-60,60-80,80-100,100-120,120-140,140-160,160-180,180-240,240-300,300-
360,360-420,420-480,480-600,600-720,720-840,840-960,960-1080,1080-1200,1200-
1320,1320-1440,1440-1560,1560-1680,1680-1800,1800-2100,2100-2400,2400-
2700,2700-3000,3000-3300,3300-3600,3600-3900,3900-4200,4200-4500,4500-
4800,4800-5100,5100-5400,5400-5700,5700-6000,6000-6300,6300-6600,6600-
6900,6900-7200,7200-7800,7800-8400,8400-9000,9000-9600,9600-10200,10200-
10800,10800-12000,12000-13200,13200-14400,14400-16200,16200-18000,18000-
19800,19800-21600,21600-28800,28800-36000,36000-43200,43200-54000,54000-
64800, >64800 in units of 1 s (range: 0 to 64800 s)
                SD dive duration:  Lookup with 64 bins: <20,20-30,30-40,40-
50,50-60,60-80,80-100,100-120,120-140,140-160,160-180,180-240,240-300,300-
360,360-420,420-480,480-600,600-720,720-840,840-960,960-1080,1080-1200,1200-
```

```
1320,1320-1440,1440-1560,1560-1680,1680-1800,1800-2100,2100-2400,2400-
2700,2700-3000,3000-3300,3300-3600,3600-3900,3900-4200,4200-4500,4500-
4800,4800-5100,5100-5400,5400-5700,5700-6000,6000-6300,6300-6600,6600-
6900,6900-7200,7200-7800,7800-8400,8400-9000,9000-9600,9600-10200,10200-
10800,10800-12000,12000-13200,13200-14400,14400-16200,16200-18000,18000-
19800,19800-21600,21600-28800,28800-36000,36000-43200,43200-54000,54000-
64800, >64800 in units of 1 s (range: 0 to 64800 s)
                Max dive duration:  Lookup with 64 bins: <20,20-30,30-40,40-
50,50-60,60-80,80-100,100-120,120-140,140-160,160-180,180-240,240-300,300-
360,360-420,420-480,480-600,600-720,720-840,840-960,960-1080,1080-1200,1200-
1320,1320-1440,1440-1560,1560-1680,1680-1800,1800-2100,2100-2400,2400-
2700,2700-3000,3000-3300,3300-3600,3600-3900,3900-4200,4200-4500,4500-
4800,4800-5100,5100-5400,5400-5700,5700-6000,6000-6300,6300-6600,6600-
6900,6900-7200,7200-7800,7800-8400,8400-9000,9000-9600,9600-10200,10200-
10800,10800-12000,12000-13200,13200-14400,14400-16200,16200-18000,18000-
19800,19800-21600,21600-28800,28800-36000,36000-43200,43200-54000,54000-
64800, >64800 in units of 1 s (range: 0 to 64800 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 speed in dive:  -- not transmitted --
                Number of dives:  -- not transmitted --
         Avg SST:  -- not transmitted --
        -----------[115 bits: 11 - 125]

        TEMPERATURE-AT-DEPTH histogram group in format 0:

        Histogram with 5 depth bins:
        Transmitted in groups of 2
        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:  odlog 3/4 in units of 0.25 permille (range: 0 to
1003.88 permille)
                Surface temperature:  -- not transmitted --
                Surface usage (< 1 m):  odlog 3/4 in units of 0.25 permille
(range: 0 to 1003.88 permille)
                5 depth bins:
                 Depth band temperature:  -- not transmitted --
                 Usage of depths 1 to 2 m:  odlog 3/4 in units of 0.25
permille (range: 0 to 1003.88 permille)
```

```
                 Usage of depths 2 to 3 m:  odlog 3/4 in units of 0.25
permille (range: 0 to 1003.88 permille)
                 Usage of depths 3 to 4 m:  odlog 3/4 in units of 0.25
permille (range: 0 to 1003.88 permille)
                 Usage of depths 4 to 5 m:  odlog 3/4 in units of 0.25
permille (range: 0 to 1003.88 permille)
                 Usage of depths 5 to 2999 m:  raw 7 bits in units of 7.87402
permille (range: 0 to 1000 permille)
        -----------[105 bits: 126 - 230]

        DIAGNOSTICS in format 0:

         TX number:  wraparound 14 bits in units of 5  (range: 0 to 81915 )
         Number of resets:  wraparound 2 bits in units of 1  (range: 0 to 3 )
        -----------[16 bits: 231 - 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 7 bits in units of 2  (range: 0 to 254 )
         GPS zero satellites:  wraparound 11 bits in units of 1  (range: 0 to
2047 )
         GPS 1-4 satellites:  wraparound 11 bits in units of 1  (range: 0 to
2047 )
```

```
         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 96 days @ 1 sec= 8294400
                tx as raw 23 bits in units of 1  (range: 0 to 8.38861e+06 )
                (recommended sell-by 95 days 23 hours)
         Sell-by range:  95 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 )
        -----------[191 bits: 11 - 201]

        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 11 bits in units of 1  (range: 0 to
2047 )
         GPS 5 or more satellites:  wraparound 12 bits in units of 1  (range:
0 to 4095 )
        -----------[45 bits: 202 - 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 @ 20 secs= 32400
                tx as raw 15 bits in units of 1  (range: 0 to 32767 )
                (recommended sell-by 7 days 11 hours)
         Sell-by range:  7 days 6 hours
         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 --
        -----------[191 bits: 11 - 201]

        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:  -- not transmitted --
         End time:  max 5 days 12 hours @ 2 mins= 3960
                tx as raw 12 bits in units of 1  (range: 0 to 4095 )
                (recommended sell-by 5 days 11 hours)
         Sell-by range:  5 days 4 hours
         Duration:  odlog 2/6 in units of 90 s (range: 0 to 85995 s)
                cf. Max duration is 1 day
         Reason for end:  -- not transmitted --
         Contiguous:  -- not transmitted --
        -----------[26 bits: 202 - 227]

        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 7 bits in units of 2  (range: 0 to 254 )
        -----------[19 bits: 228 - 246]

        Available bits used exactly
=== End of page 4 ===
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Appendix F*:* *Harbor seal abundance survey: Northeast Fisheries Science Center*

Gordon T. Waring[1], James R. Gilbert[2]

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[2]Department of Wildlife Ecology, University of Maine, 5755 Nutting Hall, Orono, ME 04469

Summary
As part of the AMMAPS program, a multi-agency team conducted harbor seal (*Phoca vitulina*) live capture, tagging, and biological sampling in Cape Cod waters and western Penobscot Bay, and then during the peak pupping period conducted aerial surveys along the Maine coast. Fifteen harbor seals were captured in outer Cape Cod waters in early April and six in western Penobscot Bay in April/May. Fourteen of the Cape Cod seals were radio and flipper tagged and one animal was also satellite tagged. However, this satellite tagged seal died prior to release. Six seals captured in Maine were radio and flipper tagged, two animals also received satellite tags and another individual seal received a sonic tag. The aerial survey and radio tracking component was scheduled for the period 21 – 30 May 2011 using a NOAA Twin Otter airplane. Survey operations were significantly curtailed by coastal fog; thus flights were only conducted on 22, 25 and 29 May. The 22 May flight from Cape Elizabeth to Eastport was designed to located radio tagged seals, and only four seals were detected, but tag codes were missing. The 25 and 29 May flights were a combined photographic and radio tracking survey of several bay units. The flight on the 25 May was incomplete due to missing several seal haul-out ledges within the sampling units and flight curtailment for re-fueling. The 29 May flight was aborted due to fog shortly after take-off.

Objectives
The goals of this project were to:

1) Develop a statistically robust harbor seal aerial abundance survey design based on bay units that were delineated in a 2001 survey (Gilbert *et al.* 2005);
2) Conduct harbor seal live capture and tagging (VHF, satellite, sonic) in Chatham Harbor, MA, Cape Cod Bay, MA, and western Penobscot Bay, ME;
3) Conduct aerial photographic surveys and VHF radio tracking along the Maine coast during peak pupping period; and
4) Write a report suitable for publication in a peer review journal.

Methods
Survey design
The survey design was intended to estimate the number of harbor seals in Maine with a minimum variance. The design was to take into consideration the following: resources for capturing a sufficient number of individuals to develop a haul-out behavior model is not feasible; aircrafts for multiple replicate counts are not available; and the time window for counts during the pupping season (i.e., late May to early June) is no more than eight days which is one tidal cycle with low tide between 0900 and 1800. The design also needed to minimize aircraft time

for safety considerations; the less time spent "on the wing", the less risk to the pilots and observers. In addition, the design assumed that photographic seal counts on haul-out sites were collected at 750 ft altitude by circling and photographing ledges and islands with seals.

Capture, sampling and tagging

Harbor seal capture operations followed protocols used in prior NEFSC efforts (Gilbert *et al.* 2005; Waring *et al.* 2006), which are similar to procedures followed in other regions (Jefferies *et al.* 1993 and Withrow and Loughlin 1997). Seals were captured by setting a nylon twine research gillnet (100 x 7.4 m) off specific haul-out locations (i.e., sand bars and beaches in Chatham Harbor, MA, or tidal ledges in western Penobscot Bay, ME) during low tide periods (Waring *et al.* 2006). 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 in assisting boats brought the seals aboard their boats and guided them into hoop nets. Once all seals were secured in hoop nets, they were moved to the designated handling site (e.g., beach or boat). The full sampling and tagging protocol included: external examination, weight, morphometrics, sex, age class, ultrasound, blood draw, flipper tagging (flipper punch tissue is the genetic sample), and attaching VHF coded transmitters (Lotek model RMMT-4). However, the complete sampling protocol was not conducted for each animal due to logistics and animal activity level. Satellite tags (Wildlife Computers Splash MK10) and acoustic tags (Vemco V9) were also available for selected seals. All electronic tags were attached to the pelage using 5-minute epoxy (Fedak *et al.* 1983). Numbered and labeled flipper tags (Destron Fearing Sheep and Goat) were attached to one hind flipper of each seal.

Aerial survey and radio tracking

The usual protocol for conducting simultaneous harbor seal photographic survey and radio tracking operations involves two independent aircraft and survey teams (Gilbert *et al.* 2005; Ries *et al.* 1998; Huber *et al.* 2001; Jefferies *et al.* 2003). However, due to mechanical problems only one of the two scheduled NOAA Twin Otters was available. Lotek Yagii antennas mounted to the struts of the aircraft were cabled to a Lotek Receiver (Model SRX400) to locate the VHF tag seals.

Results

Participants in this project are listed in Table F1.

Survey design

The survey design that was developed involved a harbor seal abundance estimate based on sample counts of segments of the coast (bay units) that are corrected for the fractions of seals not available to be counted within each bay unit. This involved first, before the pupping season, capturing and tagging a sample of the seal population. Then during the pupping season, photographing a sample of the haul-out sites and simultaneous determining which of the tagged seals are on haul-out sites. More details are provided below and in Appendix F1. The survey design was peer reviewed by NMFS pinniped researchers at the National Marine Mammal Laboratory, Seattle, WA.

Capture, tagging, sampling

Harbor seal capture operations were conducted on Cape Cod, MA (Chatham Harbor and Jeremy Point) during 7 – 10 April 2011 (Figure F1; Table F2). Twenty-three harbor seals and two gray seals (*Halichoerus grypus*) were captured. The gray seals were disentangled and released immediately. Nine of the twenty-three harbor seals escaped from the capture net, and one animal died on the beach subsequent to biological sampling and tagging. This seal was transported to the Woods Hole Oceanographic Institution for necropsy by Michael Moore, DVM.

Fifteen harbor seals (11 males and 4 females) were flipper tagged and various samples were collected (Table F3). VHF transmitters were attached to only 14 seals. One female seal showed signs of stress, based on her respiration rate; therefore she was released prior to attaching a VHF tag.

Capture work in western Penobscot Bay, ME were conducted during 24 – 29 April 2011 and 13 – 15 May 2011 (Figure F1; Table F2). Twelve harbor seals including three pups were captured. All pups, including a mother/new born pup pair, were immediately released at the capture site and monitored to ensure reunion with their mothers. Two non-pups escaped during retrieval from the capture net. The six remaining seals (3 males and 3 females) were tagged with flipper tags and VHF transmitters. In addition, two males also received satellite tags, and a third male also received a Vemco V9 acoustic (69 kHz) tag.

The two satellite tagged seals were captured and released on 27 April at Mouse Island, ME (44.12N, 68.57W) (Figure F1). From the time of release to 9 May, both satellite seals only made short excursions in western Penobscot Bay. On 9 May one seal moved out of Penobscot Bay and traveled westward to Manomet, MA (~41.55N, 70.32W). The second seal remained in the western Penobscot Bay, around Rockland. On 24 May, one seal remained off Manomet and the second moved back to Mouse Island. By 28 May both seals were again around Mouse Island.

The Vemco tagged seal was never detected by the NOAA/NEFSC acoustic network within Penobscot Bay, or on NOAA/NMFS listening devices mounted on the Gulf of Maine Observing System (GoMOOS) buoys.

Radio tracking and aerial survey

Radio tracking was scheduled to begin on 21 May, but was delayed to 22 May due to weather conditions. On 22 May, the NOAA Twin Otter airplane conducted a single straight-line transect along the coast of Maine (Cape Elizabeth to Eastport) to ascertain the number and distribution of VHF tagged seals (Figure F1). On the return transect, the aircraft made some zig-zag transects over several bay units in mid-coast Maine, prior to returning to the airport at Rockland, ME. Four tags were detected, but the codes were not identified (i.e., 151.280 Cxxx). On 25 May the first joint photographic/radio tracking survey was conducted. The sampling units were: Machias Bay, the Outer Islands, Pumpkin Island, and part of Casco Bay. Five radio tags were detected, but the receiver only recorded one code. The tag (100.700 C1) was originally attached to a male seal in Chatham and was later detected in Western Penobscot Bay (Table F3). On the 29th, the survey team attempted to complete the rest of Casco Bay, Boothbay area and Muscongus Bay. However, fog precluded completing any of the areas. During May 23, 24 and 26 the aircraft was grounded due to fog.

Disposition of the data

All data collected during this project will be maintained by the Protected Species Branch at NEFSC in Woods Hole, MA.

Permits

NEFSC was authorized to conduct seal research activities during the study under Permit No. 775-1875 issued to the NEFSC by the NMFS Office of Protected Resources. NEFSC was also issued a National Park Service (NPS) Special Use Permit #CACO-2011-SCI-0003 to conduct the research activities on Cape Cod National Seashore Property - (i.e., capture - tagging work).

Acknowledgements

We would like to give a special thanks the Riverhead Foundation for Marine Research and Preservation (Riverhead, NY) who provided two Wildlife Computers Splash MK10 satellite tags and Argos time ($9,000) and to the International Fund for Animal Welfare (Yarmouth, MA) who provided a Carolina skiff (~20 ft) and staff for field operations in Chatham and Jeremy Point, MA.

Table F1. Participants in the seal tagging and abundance project.

Name	Affilation
Andrea Bogomolni	University of Connecticut & Woods Hole Oceanographic Institution
Robert DiGiovanni	Riverhead Foundation for Research and Preservation
Lynda Doughty	Maine Department of Marine Resources
Peter Duley	NOAA/NMFS/Northeast Fisheries Science Center
Kim Durham	Riverhead Foundation for Research and Preservation
Mendy Garron	NOAA/NMFS Northeast Regional Office
Jen Gatzke	Integrated Statistics Inc, Woods Hole, MA
James R. Gilbert	University of Maine, Dept. Wildlife Ecology
Bill Greer	Integrated Statistics Inc, Woods Hole, MA
Lanni Hall	NOAA/NMFS Northeast Regional Office
Beth Josephson	Integrated Statistics Inc, Woods Hole, MA
Keith Matassa	University of New England
Eric Matzen	Integrated Statistics Inc, Woods Hole, MA
Michael Moore	Woods Hole Oceanographic Institution, Biology Dept. & IFAW
Richard Pace	NOAA/NMFS/Northeast Fisheries Science Center
Katie Pugliares	New England Aquarium
Belinda Rubinstein	Northeastern University
Lisa Sette	Center for Coastal Studies
Mike Simpkins	NOAA/NMFS/Northeast Fisheries Science Center
Kelly Slivka	Integrated Statistics Inc, Woods Hole, MA
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Table F2. Harbor seal live capture attempt events log for 2011 field season.

Date (ddmmyyyy)	Time	Location	LAT (dd/mm)	LONG (dd/mm)	Set #	Seals 0 =No 1= Yes	# other species	# Pv Taken	# Caught	# Escap	# Sampled	SI/Mort. 0 = No 1 = Yes	Notes
07042011	9:50	Chatham Hbr.	41.31	70.40	1	1	50 Hg	250	0	0	0	0	
07042011	10:30	Chatham Hbr.	41.31	70.40	2	1	0	50	0	0	0	0	
07042011	11:10	Chatham Hbr.	41.31	70.40	3	1	0	50	0	0	0	0	
07042011	12:45	Chatham Hbr.	41.31	70.40	4	1	0	50	0	0	0	0	
07042011	13:40	Chatham Hbr.	41.31	70.40	5	1	0	25	2	0	2	1	
08042011	9:05	Jeremy Pt.	41.52	70.04	1	1	25 Hg	200	0	0	0	1	1 Hg caught and released @0915
08042011	10:18	Jeremy Pt.	41.52	70.04	2	1	1 Hg	3	1	0	1	0	1 Hg caught and released @1030
08042011	11:20	Jeremy Pt.	41.52	70.04	3	1	0	3	1	1	0	0	escaped during disentanglment
08042011	12:06	Jeremy Pt.	41.52	70.04	4	1	0	4	1	0	1	0	
08042011	13:40	Jeremy Pt.	41.52	70.04	5	1	0	3	0	0	0	0	
09042011	11:14	Chatham Hbr.	41.31	70.40	1	1	NA	200	1	0	1	0	
09042011	13:05	Chatham Hbr.	41.31	70.40	2	1	NA	15	2	0	2	0	
09042011	14:46	Chatham Hbr.	41.31	70.40	3	0	NA	15	0	0	0	0	
10042011	9:36	Chatham Hbr.	41.31	70.40	1	1	NA	100	5	4	1	0	
10042011	10:41	Chatham Hbr.	41.31	70.40	2	1	NA	100-150	8	3	5	0	
10042011	13:32	Chatham Hbr.	41.31	70.40	3	1	NA	NA	2	1	1	0	

Date (ddmmyyyy)	Time	Location	LAT (dd/mm)	LONG (dd/mm)	Set #	Seals 0 =No 1= Yes	# other species	# Pv Taken	# Caught	# Escap	# Sampled	SI/Mort. 0 = No 1 = Yes	Notes
10042011	14:42	Chatham Hbr.	41.31	70.40	-1	1	1 Hg	0			NA	0	not a set, just flushed seals
10042011	14:28	Chatham Hbr.	41.31	70.40	4	1	NA	0	1	0	1	0	
24042011	10:20	PB S. of Clam	44.00	69.04	1	1	0	30	0	0	0	0	
24042011	11:30	PB Clam	44.00	69.04	2	1	0	50	0	0	0	0	
24042011	12:40	PB Clam	44.00	69.04	3	1	0	20	0	0	0	0	
24042011	13:30	PB Clam	44.00	69.04	4	1	0	3	0	0	0	0	
24042011	14:15	PB Dix I.	44.00	69.04	5	1	0	15	0	0	0	0	
24042011	15:00	PB Dix I.	44.00	69.04	6	1	0	5	0	0	0	0	
24042011	16:00	PB Two Bush I	43.58	69.04	-1	1	20 Hg						not a set, just flushed seals
25042011	10:15	PB Mark I.	44.11	68.59	1	1	0	30	0	0	0	0	
25042011	11:20	PB E. Goose I.	44.11	68.59	2	1	1 Hg	50	0	0	0	0	
25042011	12:00	PB E. Goose I.	44.11	68.59	3	1	0	5	0	0	0	0	
25042011	13:40	PB Goose I.	44.11	68.59	4	1	0	30	0	0	0	0	
25042011	14:20	PB Mouse I.	44.11	68.59	5	1	0	30	1	0	1	0	
25042011	15:40	PB E. Goose I.	44.11	68.59	6	1	0	5	0	0	0	0	
26042011	12:15	PB Mouse I.	44.12	68.57	1	1	0	50	0	0	0	0	
26042011	13:00	PB Mouse I.	44.12	68.57	2	1	0	10	0	0	0	0	
26042011	14:20	PB SE Lime I.	44.13	68.57	3	1	0	10	0	0	0	0	
26042011	15:50	PB E. Goose I.	44.11	68.59	4	1	0	25	0	0	0	0	
27042011	11:30	PB Mark I.	44.10	68.58	-1	1	0	40	0	0	0	0	not a set, just flushed seals
27042011	12:04	PB Mouse I.	44.12	68.57	1	1	0	10	0	0	0	0	

Date (ddmmyyyy)	Time	Location	LAT (dd/mm)	LONG (dd/mm)	Set #	Seals 0 =No 1= Yes	# other species	# Pv Taken	# Caught	# Escap	# Sampled	SI/Mort. 0 = No 1 = Yes	Notes
27042011	12:41	PB SE Lime I.	44.13	68.57	-1	1	0	8	0	0	0	0	not a set, just flushed seals
27042011	13:05	PB Mouse I.	44.12	68.57	2	1	0	30	0	0	0	0	
27042011	14:05	PB Mouse I.	44.12	68.57	3	1	0	7	2	0	2	0	
29042011	12:30	PB Goose I.	44.11	68.59	1	1	0	18	0	0	0	0	
29042011	13:50	PB Mouse I.	44.11	68.59	2	1	0	60	1	0	1	0	
29042011	15:50	PB E. Goose I.	44.11	68.59	3	1	0	30	0	0	0	0	
29042011	16:50	PB Mouse I.	44.11	68.59	4	1	0	11	0	0	0	0	
13052011	11:33	PB W. Goose I.	44.11	68.57	1			60	0	0	0	0	All sets included pups (n=1-5)
13052011	12:15	PB W. Goose I.	44.11	68.57	2			4	0	0	0	0	
13052011	13:06	PB Goose I.	44.11	68.57	3			18	1	0	1	0	
13052011	13:53	PB Goose I.	44.11	68.57	4			6	0	0	0	0	
13052011	14:35	PB Mouse I.	44.12	68.56	5			50	1P	0	0	0	
13052011	15:33	PB Mouse I.	44.12	68.56	6			10	2(1P)	0	0	0	
14052011	12:07	PB Hewett I	43.59	69.04	1			22	0	0	0	0	Pups harassed by most sets.
14052011	12:59	PB Hewett I	43.59	69.04	2			15	0	0	0	0	
14052011	13:23	PB Dix I.	44.00	69.05	3			9	0	0	0	0	
14052011	14:35	PB Dix I.	44.00	69.04	4			25	1	0	1	0	
14052011	15:51	PB NW Flag I	43.59	69.05	5			25	0	0	0	0	
14052011	16:46	PB Dix I.	44.00	69.04	6			9	0	0	0	0	
15052011	12:10	PB Mouse I.	44.11	68.59	1			30	0	0	0	0	
15052011	13:25	PB N. of Lime I.	44.13	68.57	2			12	0	0	0	0	

Date (ddmmyyyy)	Time	Location	LAT (dd/mm)	LONG (dd/mm)	Set #	Seals 0 =No 1= Yes	# other species	# Pv Taken	# Caught	# Escap	# Sampled	SI/Mort. 0 = No 1 = Yes	Notes
15052011	14:00	PB Goose I.	44.11	68.57	3			30	1	1			
15052011	14:50	PB Goose I.	44.11	68.57	4			30	0	0	0	0	
15052011	15:00	PB Goose I.	44.11	68.57	5			10	1	1			
15052011	15:20	PB Goose I.	44.11	68.57	6			7	0	0	0	0	
15052011	16:00	PB Mouse I.	44.11	68.59	7			15	0	0	0	0	
15052011	16:30	PB S. Mouse I.	44.12	68.56	8			40	1P	0	0	0	pup released
Total											21		

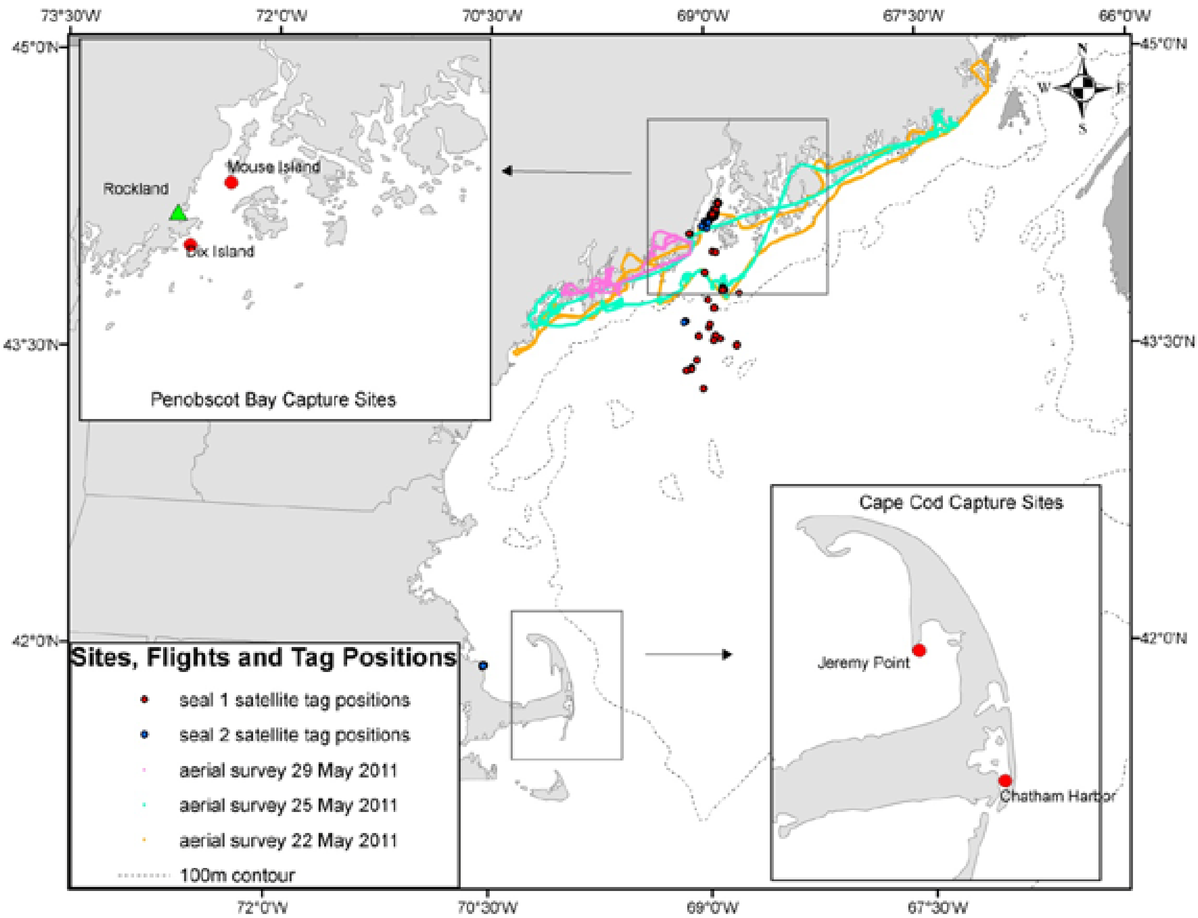
PB = Penobscot Bay
Pv = *Phoca vitulina* = harbor seal
Hg = *Halichoerus grypus* = gray seal
NA = Not available
P = pup
SI/Mort = serious injury or mortality

Figure F3. Harbor seal (Pv) biological sampling and tagging log for 2011 season. More information of each animal is available on request.

Location	Date	Flipper tag number	Color	Time tagged	Radio tag freq.	Code	Species	Sex	Condition	Released 1=Yes / 0=No	Total radio tagged	Satellite tagged
Chatham Harbor	4/7/2011	1	Orange		151.280	1	Pv	M	Alive/ Died	0	0	N
Chatham Harbor	4/7/2011	2	Orange		150.700	7	Pv	M	Alive	1	1	N
Jeremy Pt.	4/8/2011	4	Orange		150.700	5	Pv	F	Alive	1	1	N
Jeremy Pt.	4/8/2011	6	Orange		150.700	4	Pv	F	Alive	1	1	N
Chatham Harbor	4/9/2011	3	Orange		151.280	3	Pv	M	Alive	1	1	N
Chatham Harbor	4/9/2011	5	Orange		NA	NA	Pv	F	Alive	1	0	N
Chatham Harbor	4/9/2011	8	Orange		150.700	8	Pv	M	Alive	1	1	N
Chatham Harbor	4/10/2011	7	Orange		151.280	10	Pv	M	Alive	1	1	N
Chatham Harbor	4/10/2011	9	Orange		151.280	12	Pv	M	Alive	1	1	N
Chatham Harbor	4/10/2011	10	Orange		150.700	10	Pv	M	Alive	1	1	N
Chatham Harbor	4/10/2011	12	Orange		150.700	6	Pv	F	Alive	1	1	N
Chatham Harbor	4/10/2011	14	Orange		150.700	1	Pv	M	Alive	1	1	N
Chatham Harbor	4/10/2011	15	Orange		151.280	16	Pv	M	Alive	1	1	N
Chatham Harbor	4/10/2011	16	Orange		150.700	9	Pv	M	Alive	1	1	N
Chatham Harbor	4/10/2011	18	Orange		150.700	2	Pv	M	Alive	1	1	N
Shinnecock Bay, NY[1]	4/16/2011	870	Yellow		151.280	9	Pv	M	Alive	1	1	N
Shinnecock Bay, NY[1]	4/23/2011	862	Yellow		151.280	18	Pv	F	Alive	1	1	N
PB Mouse Island, ME	4/25/2011	17	Orange		151.280	14	Pv	F	Alive	1	1	N
PB Mouse Island, ME	4/27/2011	11	Orange		151.280	4	Pv	M	Alive	1	1	Y
PB Mouse Island, ME	4/27/2011	13	Orange		151.280	6	Pv	M	Alive	1	1	Y
PB Mouse Island, ME	4/29/2011	19	Orange		151.280	2	Pv	M	Alive	1	1	Y
PB Goose Island, ME	5/13/2011	21	Orange		151.280	20	Pv	F	Alive	1	1	N
PB Dix Island, ME	5/14/2011	22	Orange		151.280	11	Pv	F	Alive	1	1	N

[1] Rehabilitated seals
NA = not available

Figure F1. Harbor seal capture/tagging locations, aerial survey track lines, and locations of two satellite tagged animals from spring 2011 study.



ANNEX F1

Aerial Survey Design Proposal for 2011
New England Harbor Seal Abundance Survey

BY

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and

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The National Marine Fisheries Service (NOAA Fisheries) is charged under the Marine Mammal Protection Act of 1972 to periodically assess the population number of each stock of each marine mammal species. The harbor seal (*Phoca vitulina*) is one of the species that is easier to count when individuals are on land to rest, give birth to pups, and molt. Previous assessments have either been in the pupping season (Everiftt and Braham 1980, Thompson *et al.* 1997, Huber *et al.* 2001, Jemison and Kelly 2001, Jeffries *et al*. 2003, Brown *et al.* 2005, Gilbert *et al.* 2005) or during the molting season (Thompson and Harwood 1990, Mathews and Kelly 1996, Frost *et al.* 1999, Jemison and Kelly 2001, Boveng *et al.* 2003, Small *et al*. 2003).

Because not all seals are on land when counted, assessments of population size must necessarily include a correction for the number of seals not available to be observed, if the goal is to derive an accurate total population estimate. The information needed to estimate this correction factor is derived from radio telemetry or satellite data which indicates the fraction of individuals on land at particular times (Eberhardt *et al.* 1979, Huber *et al.* 2001, Boveng *et al.* 2003, Gilbert *et al.* 2005).

There have been two approaches to developing a correction factor. One procedure involves obtaining an average fraction of the population out during the assessment period and applying that to the average of replicate survey counts (Boveng *et al.* 2003). This approach requires replicate counts of seal numbers. With this procedure, the correction is sometimes applied to counts even in other years. The advantage of this approach is that capture and radio-tagging effort is required only for one season. The fraction of seals out of the water can be modeled to take into account co-factors such as time of low tide, weather, etc.

The approach we have used in the Northeast has been to correct the count for each individual day with a correction factor for that day. This correction factor is less precise because it is using a single day's radio telemetry information; however the counts of seals do not need to be replicated. We have not had sufficient funds to develop a model of seal haul-out behavior. In 2001, a complete count of seals on land was combined with the correction factor for each day's survey (Gilbert *et al.* 2005).

The design proposed in this manuscript takes into consideration that resources for capturing a sufficient number of individuals to develop a haul-out behavior model is not feasible; that aircraft for multiple replicate counts are not available; and the time window for counts during the pupping season is no more than eight days (one tide cycle with low tide between 0900 and 1800). The proposed design also minimizes aircraft time for safety considerations; the less time spent "on the wing", the less risk to the pilots and observers. The counts are conducted at 750 ft by circling ledges and islands with seals.

This is a design to estimate the number of harbor seals in Maine with a minimum variance. Sample haul-out counts in June would be preceded by radio-tagging harbor seals in March and April to have sufficient numbers of tagged seals for a precise estimate of a daily correction factor. The estimate is based on sample counts of segments of the coast that are corrected for the fractions of seals not available to be counted. Sample counts would be made in late May and early June.

Lessons learned from previous work

In 2001, we found that not all adults were in the area during early counts (May 15 – 20) and most pups were not yet born. The 2001 estimates were based on counts between May 27 and June 4. We attempted to obtain replicate counts of the entire coast during this period, but were not successful. It requires five days of four-hour flights to cover the entire coast with one replicate with an experienced crew; it requires more time with a crew that does not have experience.

Skinner (2006) provides additional insight about the timing of pupping. He found that the median date of pupping was May 23 or 24. He also observed that the number of lone pups observed began to increase markedly after about June 8. Because some of the pictures taken were not sharply in focus and it is difficult to judge if lone seals are pups, counts after June 8 would often classify lone pups as adult or sub-adult seals.

One of the issues some of the reviewers had with the 2001 field effort was that we did not have a sufficient number of adult female seals radio-tagged and we made the assumption that nursing pups would be in the water the same amount of time as the adults. Skinner (2006:81-82) found that the pups spend considerable time in water; the correction factor for pups would have been 2.54 – which is not significantly different from the correction factor of 2.38 used in the 2001 survey.

Capture and tagging

The radio-tagging of harbor seals to estimate the fraction of seals in the water will be conducted the same as in 2001, with a field effort in March on Cape Cod and a second field effort in late April in Maine. If necessary to obtain a sufficient sample size, another field effort could be completed in early May in Maine.

In 2001, our first capture effort was our most successful in that we netted more than 20 seals; however, lack of organization and an incoming tide limited us to one successfully tagged seal. The others released likely included female seals.

Dates of the aerial survey

The aerial survey effort should be between May 25 and June 5 along the coast of Maine (Figure FAnnex1). A year should be selected when low tide is near mid-day on about May 30. In 2010, the mid-day low tide is on May 28.

Estimator

The Hanson – Horvitz Estimator (pp. 51-53, 192-194 in (Thompson 2002), *Sampling, Second Edition* was selected because the sample units would be of unequal size. The survey area will be separated into sectors that are geographically distinct. Each of the sectors would be a potential sample and would be selected proportionally to its size, where sampling is with replacement.

Each sample would be selected with probability proportional to the size of the number of seals seen in that area as a fraction of the total seal number in 2001.

The estimator proposed is a Hansen-Horwitz estimator combined with an estimated correction factor. The sampling procedure is to draw sample units with probability proportional to size with replacement. In this case a sample unit is a sector of the coast that has a set of ledges and islands where seals are found. The probability of selecting a sector is proportional to the relative number of seals in the sector in 2001.

Let:

d = day number, d = 1, k
i = sector number; i = 1, n
p_i = probability of sector i being selected as a sample

f_d = fraction of radio-tagged seals located on day d; $\left(1/f_d\right)$ is the correction factor
C_{id} = count of seals in sector i on day d
$T_{id} = C_{id}/f_d p_i$ = estimate of total coastal population based on count in sector i
$V(f_d) = \frac{f_d(1-f_d)}{m}$; where m is the number of radio-tagged seals.
$V\left(1/f_d\right) = \frac{V(f_d)}{(f_d)^4}$

For each day, one calculates the average of the daily observed population estimates (C_d) and its variance.

$$C_d = \left(\frac{1}{n_d}\sum\frac{C_{id}}{p_i}\right)$$

$$T_d = \left(\frac{1}{f_d}\right)C_d$$

If there were no correction factor, then the variance of the observed population estimate for a day would be:

$$V(C_d) = \frac{1}{n_d(n_d-1)}\sum\left(\frac{C_{id}}{p_i} - C_d\right)^2$$

Because f_d is estimated, its variance needs to be incorporated into the variance estimate for T_d:

$$V(T_d) = \left(\frac{1}{f_d}\right)^2 (V(C_d)) + (C_d)^2\left(V\left(\frac{1}{f_d}\right)\right)$$

The total population estimate is:

$$T = \frac{1}{k}\sum_{d=1}^{k} T_d$$

with variance:

$$V(T) = \sum_{d=1}^{k} V(T_d)$$

Sample selection

Sector boundaries are defined so as each could be counted in 20 – 40 minutes. A set of flight lines from 2001 was segmented to define the boundaries. In the second set of surveys flown in 2001 by JRG a total of 15.5 h were spent on survey in 5 days of flying (approximately 22 h total) to cover the entire coast. Based on this procedure, a frame of 30 sectors was defined for the survey (Table FAnnex1, Figures FAnnex2 a, b). One sector, number 14 in Eastern Bay, took about 50 minutes to survey in 2001, but there was no logical place to partition the flight line.

Several sectors could be surveyed in the same day of flying. The entire set of sectors would be selected prior to the survey effort, and then grouped by day to increase efficiency. If 3.0 h per day were to be spent counting, we could anticipate 4 – 6 sectors completed each day.

The probabilities of selecting sectors would be proportional to the numbers of seals observed in the sectors in 2001 surveys. Thus, if a sector had 5% of the total number of seals in 2001, it would have a 5% chance of being selected each time a random number was drawn. Sampling would be with replacement.

The proposed estimation methodology is more precise when the fraction of seals in each sector is consistent from year to year. To evaluate this, we examined previous survey data from 1981, 1986, 1993, 1997 and 2001. The sample areas for this exercise (Table FAnnex1) were those previously used to describe data(Gilbert *et al.* 2005) . We used the radio telemetry data from 2001 to develop corrections for the previous years, based on the time of low tide. We then examined variability of the fractions from year to year.

One area, BOSHB, near Boothbay Harbor and Sheepscot River, was quite inconsistent from year to year (Figure FAnnex2a). Inspection revealed that this inconsistency was due to highly variable numbers from year to year being observed on Pumpkin Island and Ledges and Sequin Island. If we eliminated these sites, then we achieved much greater consistency (Figure FAnnex2b). We propose that these sites be separately counted, corrected and added into the estimate derived from the Hansen-Horvitz estimator.

To evaluate the effectiveness of the Hansen-Horvitz estimator, we used data from 1997 to determine the probability of sample areas to be selected. The data used for this were counts from 1997, corrected for numbers missed based on the correction factor for 2001 for a particular time of low tide. We caution that the corrected number for 1997 should not be quoted; we only corrected the 1997 results to determine the probability of sample areas being selected. The probability of a sample being selected was then calculated as the fraction of the total corrected 1997 estimate that was in the sample.

For each sample selected, we used the corrected 2001 estimated number of seals in that sample area. We tested to evaluate precision of the estimate using 9, 12, and 15 samples (corresponding to 3, 4 and 5 days of flying). For each sample size, we replicated the sampling 1000 times (Figure FAnnex3). The standard deviations of the estimates decreased as sample size increased, as one would expect (Figure FAnnex5).

Because we sampled with replacement, there were often samples that were drawn twice and even three times. If a sample is drawn more than once, it is counted only once, but is included in the calculation each time it is drawn. Thus, if we had a goal of a sample size of nine, we would physically have to count an average of 7.2 samples (Figure CAnnex4). With a sample size of 12, we would count an average of 8.9 samples; and with a sample size of 15, we would count an average of 10.3 samples. Therefore we suggest that we plan on three days of sampling; drawing a sample size of 15 units.

Procedures

The aerial survey would require two aircraft. One would search each day for the radio-tagged seals while the other would count selected sample sectors. The aircraft conducting the search for radio-tagged seals would need to have an external VHF antenna mounted (requiring FAA approval). It could fly at 2000 ft altitude and could be any of several aircraft models.

The aircraft conducting the aerial surveys would operate at 600 ft altitude and would be circling ledges with seals so that they could be photographed. A single-engine, high-wing aircraft or a Cessna 337 could be used to accomplish this task. Photographs would be digital images taken at high resolution using a SLR camera with an image-stabilizing 300-mm lens. Extra camera batteries and photo storage would be required for each flight – in 2001 up to 700 images were taken in one flight. A WASS GPS would be required for each aircraft that recorded position and altitude at intervals. The positions and times would be downloaded each day to a computer. It would be desirable to have the GPS connected to a small laptop computer with navigation software on board each aircraft.

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Table FAnnex1. Potential sample units and their probabilities of being sampled.

Area		Probability
Blue Hill Bay - Isle au Haut	BHBIH	0.0409
Blue Hill Bay - Merchants Row	BHBMR	0.0898
Blue Hill Bay- Swan's Island	BHBSI	0.0467
Blue Hill Bay - Upper	BHBUP	0.0527
Boothbay Region	BOSHB	0.1117
Casco Bay	CASB	0.0580
Casco Bay	CASBU	0.0083
Cape Elizabeth South	CELPT	0.0454
Cobscook Bay	COBSB	0.0064
Eastern Bay	EB	0.0525
Englishman Bay	ENGB	0.0106
Frenchman's Bay	FB	0.0285
Machias Bay	MACHB	0.0336
Mount Desert Isl.	MDI	0.0196
Muscongus Bay	MUSCB	0.0817
Outer Islands	OUTIS	0.0272
Penosbscot Bay- Eastern	PBEA	0.0706
Penosbscot Bay- Muscle Channel	PBMC	0.0462
Penosbscot Bay- Midwest	PBMW	0.0398
Penosbscot Bay- Upper	PBUP	0.0110
Penosbscot Bay- Vinal Haven	PBVL	0.0270
Plesant, Narguagus, & Denny Bay	PNDB	0.0471
Western Bay	WB	0.0448

Figure FAnnex1. Locations of the bays along the coast of Maine that were used to subdivide the 2001 seal survey area. The 100-m isobaths is indicated in the Gulf of Maine.

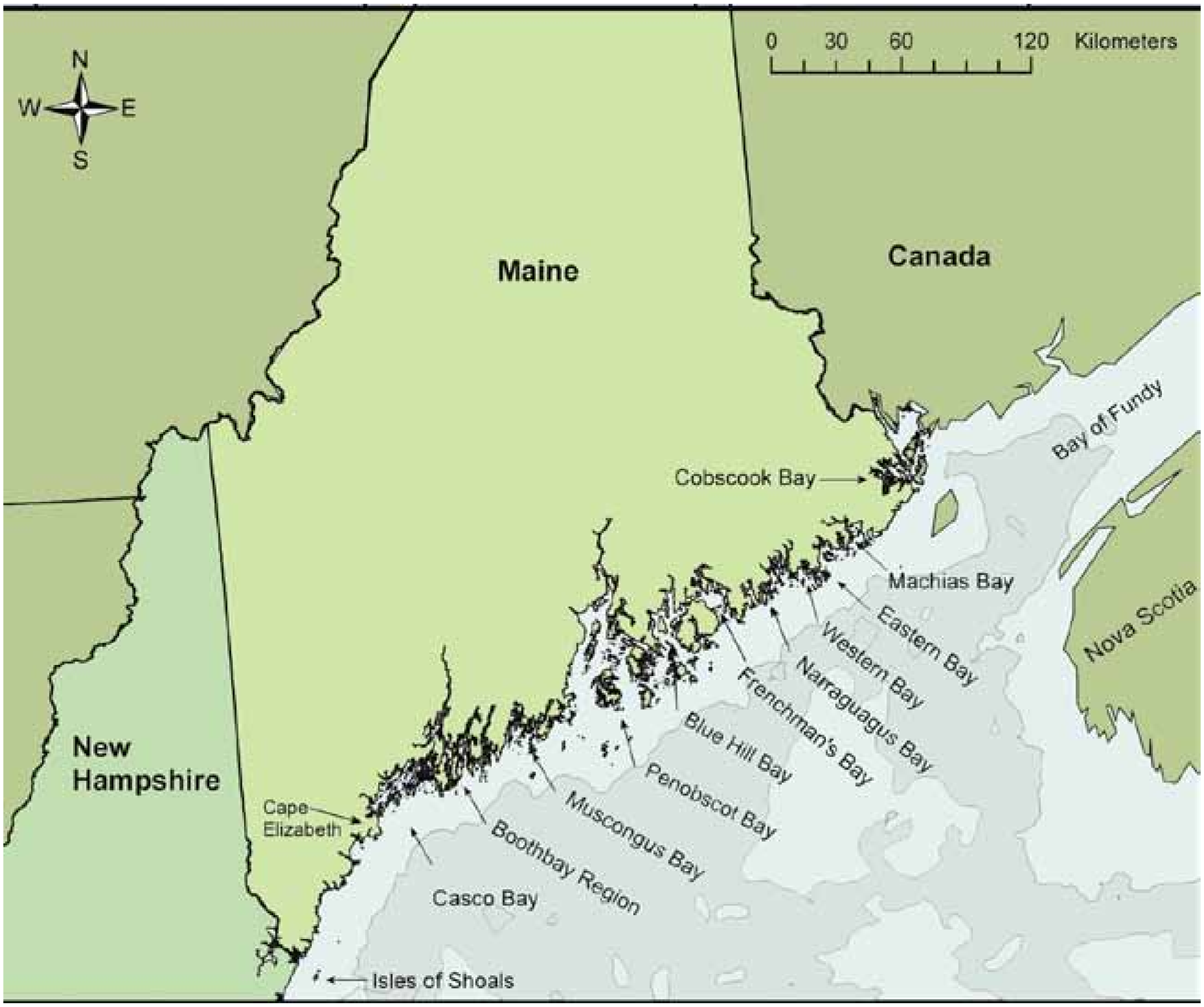

Figure FAnnex2a,b. (a) Fraction of seals in all areas. (b) Fraction of seals in most areas is more consistent when counts at Sequin Island and Pumpkin Island and Ledges are considered separately. Note that the vertical scales are different in a and b.

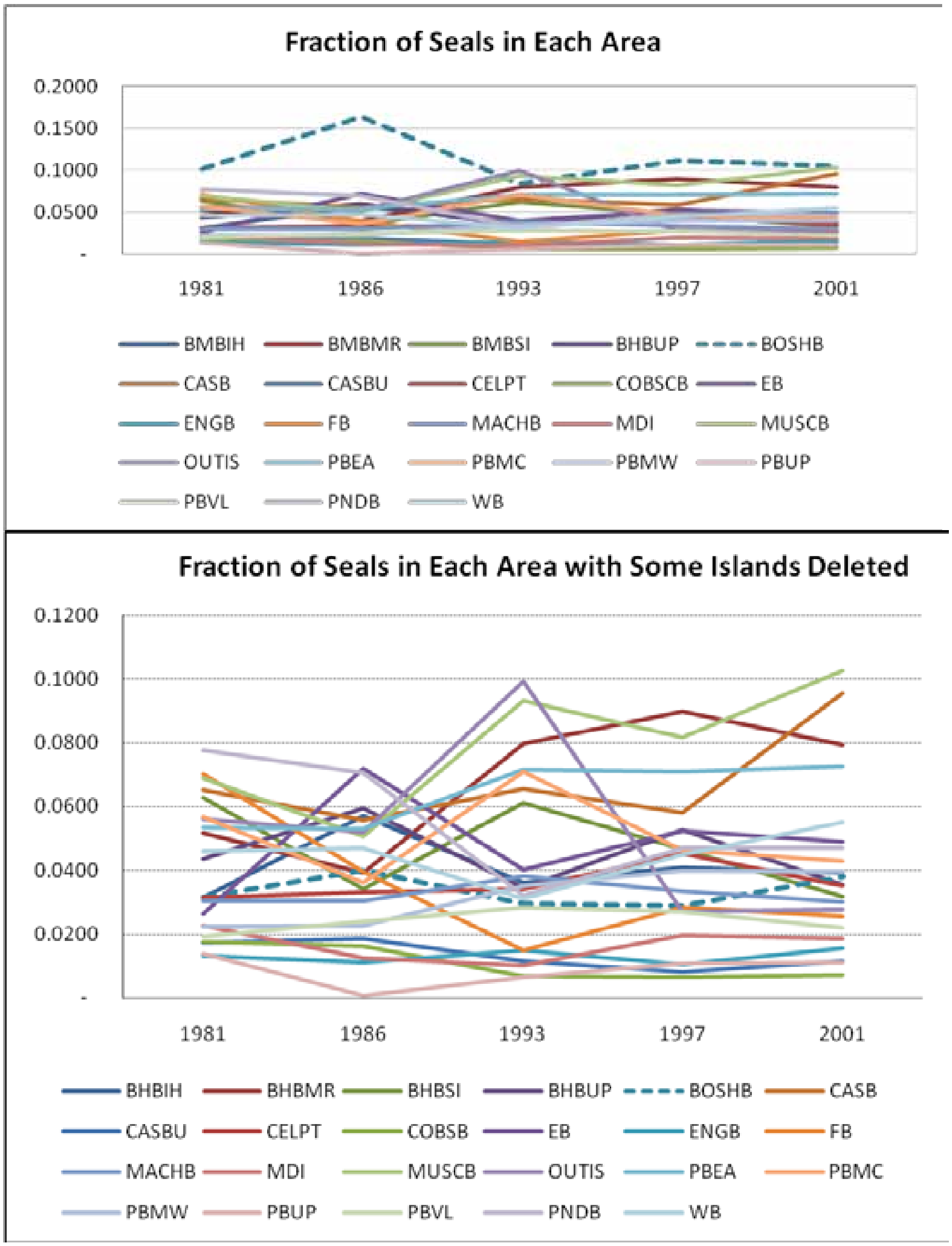

Figure CAnnex3. Distribution of 1000 replicates of estimates of population size in 2001 with samples of size 9, size 12, and size 15. The actual number in 2001 (excluding islands mentioned) was 95,274.

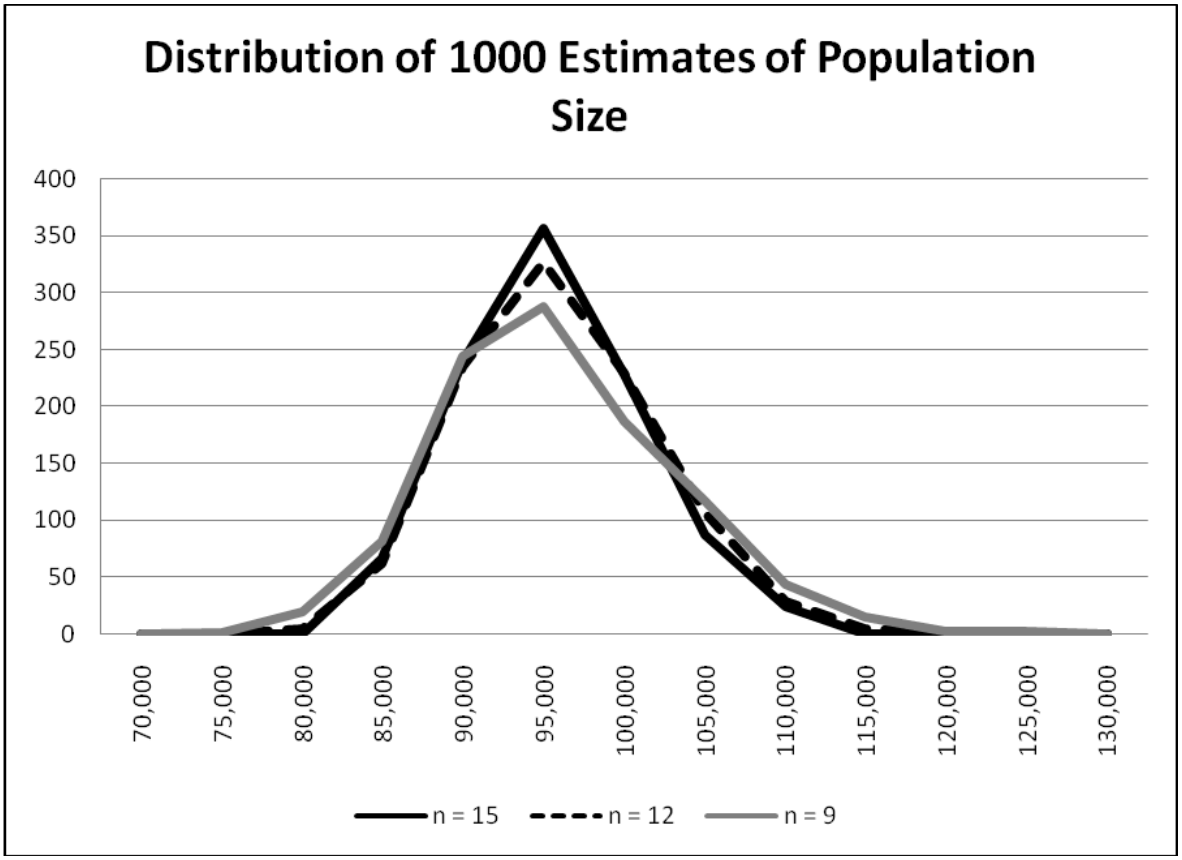

Figure CAnnex4. Distribution of the standard deviations of 1000 estimates with sample sizes of 9, 12, and 15.

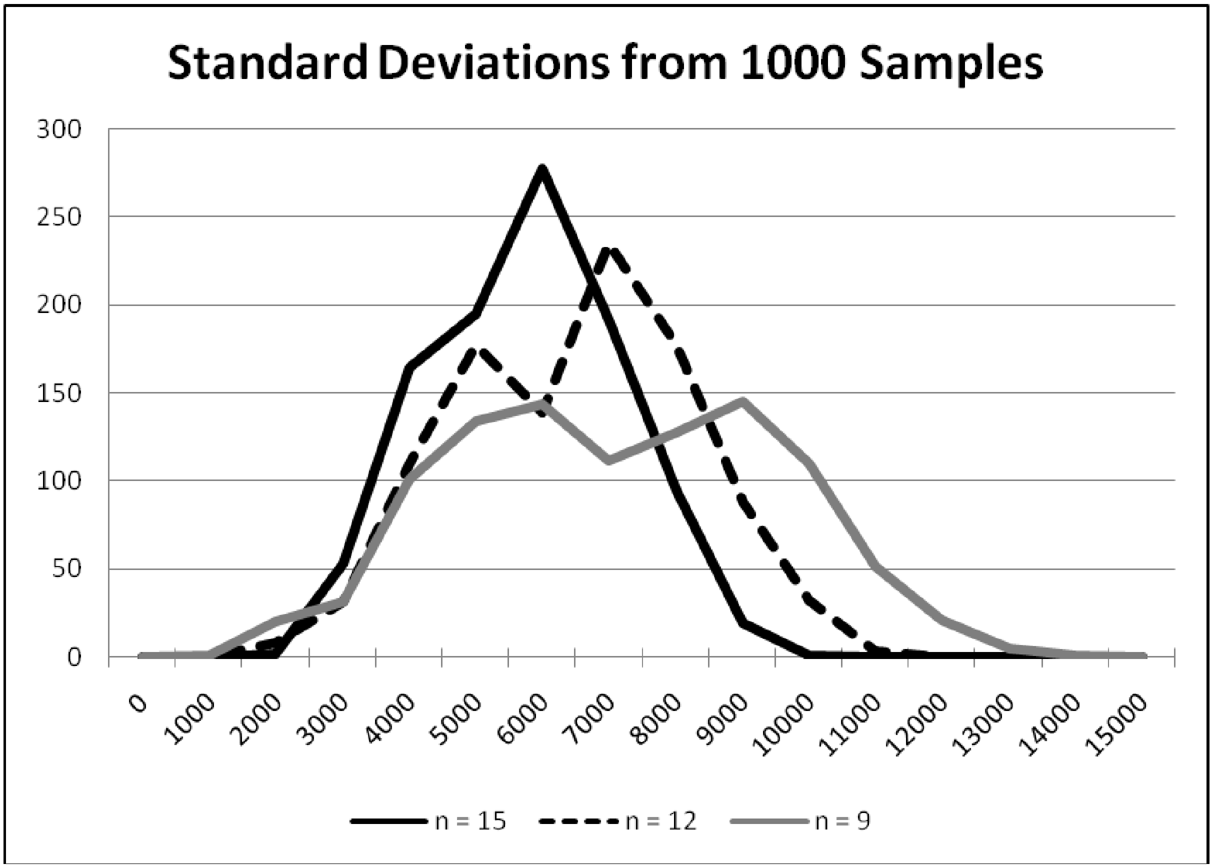

Figure CAnnex5. Distribution of the number of unique sample units selected in 1000 replicates with sample sizes of 9, 12, and 15. The average numbers of unique sample units were 7.2, 8.9, and 10.3. There were 23 sample units from which to choose.