# 2019
# Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US waters of the Western North Atlantic Ocean – AMAPPS II

Bubble feeding humpback whale (*Megaptera novaeangliae*). Credit: SEFSC MMPA Permit #21938.

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

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

# Contents

# 1 Overview of 2019

## 1.1 Background

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) is a comprehensive multi-agency research program in the US Atlantic Ocean, from Maine to the Florida Keys. Its aims are to assess the abundance, distribution, ecology, and behavior of marine mammals, sea turtles, and seabirds throughout the US Atlantic and to place them in an ecosystem context. This information can then provide spatially-explicit information in a format that can be used when making marine resource management decisions and will provide enhanced data to managers and other users by addressing data gaps that are needed to support conservation initiatives mandated under the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), National Environmental Policy Act (NEPA) and Migratory Bird Treaty Act (MBTA).

To conduct this work National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) has inter-agency agreements with the Bureau of Ocean Energy Management (BOEM) and the US Navy. The products of these inter-agency agreements are being developed by NMFS's Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC).

Because of the broad nature and importance of the AMAPPS work, AMAPPS has evolved beyond the above agencies into a larger collaborative program that involving researchers from a variety of domestic and international organizations. These collaborative efforts have the benefit of increasing the amount of funds and personnel for integrated field and analytical work.

This report documents the field work conducted by NMFS during 2019. Because the analyses conducted during 2019 will be presented in the final report for AMAPPS II, the current report will not present a summary of 2019 analyses.

## 1.2 Summary of 2019 Field Activities

During 2019 under AMAPPS, NMFS conducted field studies to collect cetacean, sea turtle, seal, and sea bird seasonal distribution, abundance, and biological data (Table 1.1). In addition, NMFS staff continued to analyze past and present data collected under AMAPPS I and II, resulting in journal papers (Table 1.2), web articles (Table 1.3) and meeting presentations (Table 1.4). A summary of the 2019 field projects follows, with more details in the following chapters.

During 3 April – 24 June 2019, the NEFSC and SEFSC conducted two aerial line transect abundance surveys covering Atlantic waters from Florida to Nova Scotia, from the coastline to shelf break at about the 2,000 m depth contour (Figure 1.1). The surveys using NOAA Twin Otter airplanes targeted marine mammals, sea turtles and seals. In total, the two planes completed about 20,080 km of on-effort track lines. The observers detected about 962 groups of cetaceans consisting of 4,841 individuals from 24 species or species groups (Table 1.5) and about 1,000 groups consisting of about 1,300 individual sea turtles from 5 species or species groups (Table 1.6). The most frequently detected dolphin species were common dolphins (*Delphinus delphis*) and common bottlenose dolphins (*Tursiops truncatus*). The most frequently detected large whales were humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*), and minke whales (*Balaenoptera acutorostrata*). Of interest are the

rarely seen groups of rough-toothed dolphins (*Steno bredanensis*) and white-beaked dolphins (*Lagenorhynchus albirostris*). The most frequently detected turtle species was the loggerhead turtle (*Caretta caretta*), with over 600 individuals that ranged from 24°N – 39°N on the continental shelf with large aggregations off Florida and North Carolina/Virginia. All visual line-transect data have been or will be archived in the NEFSC Oracle data base, the NOAA Fisheries InPort and submitted to the publicly available OBIS-SEAMAP website. More information is found in Chapters 2 and 3.

During 13 October 2019 – 25 January 2020, the NEFSC and SEFSC conducted two aerial line transect abundance surveys covering Atlantic waters from Florida to Nova Scotia, from the coastline to shelf break at about the 2,000 m depth contour (Figure 1.2). The surveys using NOAA Twin Otter airplanes targeted marine mammals and sea turtles. In total the two planes completed about 13,852 km of on-effort track lines. The observers detected 587 groups of cetaceans consisting of 4,584 individuals from 18 species or species groups and 504 groups consisting of 612 individual sea turtles from 6 species or species groups (Table 1.6). The most frequently detected dolphin species were common dolphins and common bottlenose dolphins. The most frequently detected large whale was fin whales. The most frequently detected turtle species was the loggerhead turtle, with about 270 individuals that ranged from 24°N – 35°N on the continental shelf with large aggregations off Florida and Georgia. All visual line-transect data have been or will be archived in the NEFSC Oracle data base, the NOAA Fisheries InPort and submitted to the publicly available OBIS-SEAMAP website. More information is found in Chapters 2 and 3.

During 18 – 23 April 2019, the National Science Foundation ship *R/V Endeavor* operated by the University of Rhode Island (URI) conducted a Rhode Island Endeavor Program (RIEP) research cruise intended to explore marine mammal distribution, in particular the North Atlantic right whale (*Eubalaena glacialis*), relative to prey layers and physical oceanography south of New England in wind energy regions. AMAPPS contributed contractor funds for one marine mammal observer and partial time for one staff member to run a Video Plankton Recorder (VPR). Due to the short time period and poor weather, no right whales were detected. However, within and adjacent to potential wind energy leases minke whales were detected and oceanographic sampling included 4 deployments of the VPR, 5 of the echosounder package, 2 CTDs (Conductivity Temperature Depth sensor), and continuous ADCP (Acoustic Dopler Current Profiler) current data were collected. Zooplankton samples were collected from 2 bongo net deployments, 1 Tucker trawl and 1 ring net. An innovative low-cost package with underwater cameras and hydrophones was developed and successfully field tested; this will be used in future studies and monitoring. All visual line-transect data have been or will be archived in the NEFSC Oracle data base and submitted to the publicly available OBIS-SEAMAP website. More information is found in Chapter 4.

During 17 – 28 August 2019, NEFSC and partners conducted a shipboard survey primarily offshore of Georges Bank to assess the ecology and distribution of deep diving cetacean species, such as beaked whales (*Ziphiidae*), pygmy/dwarf sperm whales (*Kogia* spp.), and sperm whales (*Physeter microcephalus*). This survey focused primarily on True's beaked whale (*Mesoplodon mirus*) habitat. The scientific crew included a visual observation team scanning for marine mammals and sea turtles, an additional observer or two collecting data on avian sightings, and a passive acoustic team monitoring a towed hydrophone array. Three High-Frequency Acoustic Recording Packages ("HARPs") were recovered during this cruise after a year of passive

recording along the shelf break of the US eastern seaboard. Approximately 580 km were surveyed by the marine mammal visual team; passive acoustic data were collected over an additional 570 km. CTD data were collected at 3 stations in conjunction with recovery of the HARPs. Approximately 22 beaked whale groups were sighted. Three groups of pygmy/dwarf sperm whales were sighted, including at least one mother-calf pair. An estimated 60 groups of other cetaceans were sighted. Over 2,100 seabirds from at least 31 species were detected. The hydrophone arrays were monitored for 120 hrs, yielding over 150 acoustic detections of cetacean groups, including 41 detections of beaked whale groups. All visual line-transect data have been or will be archived in the NEFSC Oracle data base and submitted to the publicly available OBIS-SEAMAP website. More information is found in Chapter 5.

To learn about turtle ecology, Coonamessett Farm Foundation in collaboration with NEFSC, instrumented 10 loggerhead turtles were with satellite tags in June 2019 on the Mid-Atlantic shelf. The NEFSC and SEFSC, together with partners, instrumented leatherback turtles with 13 towable satellite tags during May 2019 in waters off North Carolina, and with 9 satellite tags during August 2019 in waters in Cape Cod Bay, Massachusetts. To learn about turtle surfacing, foraging and diving behavior, in collaboration the NEFSC, SEFSC, Coonamessett Farm Foundation, Department of Fisheries and Oceans Canada and Loggerhead Instruments equipped 24 leatherback turtles with suction cup camera tags primarily in Massachusetts state waters. More information is found in Chapter 6.

During May, June, July, August, October and November 2019, visual detection data of primarily seabirds, but also marine mammals, turtles, and large pelagic fish were collected during 5 shipboard cruises. These included the spring, summer and fall Ecosystem Monitoring (EcoMon) cruises and an additional two on Woods Hole Oceanographic Institution (WHOI) cruises that were part of an National Science Foundation sponsored project entitled “Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications”. The cruises sampled regions from the Gulf of Maine to North Carolina (Figure 1.3). A total of 15,724 sightings of seabirds and 2,797 other marine megafauna were recorded (Table 1.7). The majority of sea bird species for each survey varied by season and region but were dominated by Shearwaters (*Puffinus* sp.), Storm-Petrels (*Oceanites* sp.), Cormorants (*Phalacrocorax* sp.), Gannets (*Morus* sp.), and Phalaropes (*Phalaropus sp.*). In general, spring was dominated by Phalaropes and Storm-Petrels, summer by Shearwaters, and fall by Shearwaters, Cormorants, and Gannets. Other species ranging from butterflies to sharks to whales and dolphins were also detected. Data are archived in the NEFSC Oracle data base and submitted to the Seabird Compendium who will also submit it to the publicly available OBIS-SEAMAP website. More information is found in Chapter 7.

**Table 1.1. General information on the 2019 field data collection projects**

| Field collection project[1] | Platform(s) [1] | Dates in 2019 | Location | Chapter |
|---|---|---|---|---|
| Spring abundance survey (NEFSC) | NOAA Twin Otter airplane | 03 Apr – 15 May | Shelf waters from Nova Scotia to New Jersey | 2 |
| Fall abundance survey (NEFSC) | NOAA Twin Otter airplane | 13 Oct – 24 Nov | Shelf waters from Nova Scotia to New Jersey | 2 |
| Spring abundance survey (SEFSC) | NOAA Twin Otter airplane | 18 May – 24 Jun | Shelf waters from New Jersey to Florida | 3 |
| Winter abundance survey (SEFSC) | NOAA Twin Otter airplane | 7 Dec 2019 – 25 Jan 2020 | Shelf waters from New Jersey to Florida | 3 |
| Rhode Island Endeavor Program survey (NEFSC) | R/V *Endeavor* | 18 – 23 Apr | South of Massachusetts on shelf break | 4 |
| Deep diving cetacean ecology (NEFSC) | R/V *Hugh R. Sharp* | 17 – 28 Aug | Georges Bank and offshore | 5 |
| Loggerhead satellite tagging (NEFSC+SEFSC) | F/V *Katy Ann* | 5 – 8 Jun | Southern Mid-Atlantic | 6 |
| Loggerhead satellite tagging (NEFSC+SEFSC) | Small boats | 13 – 23 May; 19 – 30 Aug | North Carolina; Massachusetts | 6 |
| Leatherback suction cup tagging (NEFSC+SEFSC) | Small boats | Aug – Oct | Massachusetts | 6 |
| WHOI seabird survey-RB1904 (NEFSC) | NOAA ship *Ronald H. Brown* | 12 – 24 May | South of Massachusetts on shelf | 7 |
| Ecosystem monitoring seabird survey-HB1902 (NEFSC) | NOAA ship *Henry B. Bigelow* | 22 May – 6 Jun | Nova Scotia to Virginia on shelf | 7 |
| WHOI seabird survey-TN368 (NEFSC) | R/V *Thomas G. Thompson* | 7 – 17 Jul | South of Massachusetts on shelf | 7 |
| Ecosystem monitoring seabird survey-GU1902 (NEFSC) | NOAA ship *Gordon Gunter* | 15 - 29 Aug | Maine to Virginia on shelf | 7 |
| Ecosystem monitoring seabird survey-GU1905 (NEFSC) | NOAA ship *Gordon Gunter* | 15 Oct – 1 Nov | Massachusetts to North Carolina on shelf | 7 |

[1] NEFSC = Northeast Fisheries Science Center; SEFSC = Southeast Fisheries Science Center; WHOI = Woods Hole Oceanographic Institution; NOAA = National Oceanic and Atmospheric Administration

**Table 1.2. Published manuscripts from 2019**

Chavez-Rosales S, Palka D, Garrison L, Josephson E. 2019. Environmental predictors of habitat suitability and occurrence of cetaceans in the western North Atlantic Ocean. Scientific Reports 9:5833.

Hayes SA, Josephson E, Maze-Foley K, Rosel PE. 2019. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2018. NOAA Tech Memo NMFS-NE 258; 291 p.

Palka D. in press. Cetacean abundance estimates in US northwestern Atlantic Ocean waters from summer 2016 line transect surveys. NEFSC Lab Reference report.

Sigourney DB, Chavez-Rosales S, Conn PB, Garrison L, Josephson E, Palka D. 2020. Developing and assessing a density surface model in a Bayesian hierarchical framework with a focus on uncertainty: insights from simulations and an application to fin whales (*Balaenptera physalus*). PeerJ 8:e8226.

Yang, T, Haas HL, Patel S, Smolowitz R, James MC, Williard A. 2019. Blood biochemistry and hematology of migrating loggerhead turtles (*Caretta caretta*) in the Northwest Atlantic: reference intervals and intrapopulation comparisons. Conservation Physiology 7(1).

**Table 1.3. Published web articles from 2019**

NOAA Fisheries Feature Story on AMAPPS: East Coast Marine Life Survey Renewed for Five More Years

NEFSC Highlights the AMAPPS model mapper and a rare bird seen by an AMAPPS observer on an EcoMon survey

WCAI (NPR) reports on seabirds sighted during an offshore cetacean ecology survey

NOAA Fisheries Feature Story on the successful tagging of 9 leatherback turtles in Cape Cod Bay in August 2019

NOAA Fisheries Feature Story on the record number of leatherback turtles tagged in North Carolina

**Table 1.4. Meeting presentations from 2019**

Baker CS, Baird R, Cholewiak D, Constantine R, Filatova O, Jacobsen L, Notarbarolo de Sciaria G, Oleson E, Panigada S, Schorr GS, Klink H, Steel D. Species identification of cetaceans by environmental (e)DNA metabarcoding – a new tool for surveys of the high seas. Oral presentation at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

Chavez S, Palka D, Garrison D, Sigourney DB, Josephson E. Habitat suitability as a tool to detect spatial and temporal distribution changes of marine mammals. Poster presentation at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

Cholewiak D, Allen D, Baker CS, Cerchio S, Conger L, DeAngelis A, Hickmott L, Metheny N, Pitman R, Stanistreet J, Steel D, Tremblay C, Trickey J. True's beaked whale: a cryptic species revealed. Oral presentation at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

Hyde K. Applications of ocean color and SST data in fisheries science and management. Poster presented at International Operational Satellite Oceanography Symposium, 18-20 June 2019, College Park MD.

Jech M, Lavery A, Wiebe P, Stanton T. Comparison of net catches and acoustic abundance estimates of the deep-scattering layers. Oral presentation at the ICES WGFAST meeting, 29 April - 2 May 2019, Galway, IR.

Rankin S, Sakai T, Archer E, Barlow J, Cholewiak D, DeAngelis A, Keating J, Oleson E, Simonis A, Soldevilla M. Beaker BANTER: a machine learning approach to acoustic classification of beaked whales. Poster presentation at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

Stepanuk J, Chong-Montenegro C, Ney J, Kim H, Roberts J, Halpin P, Palka D, Pabse A, McLellan W, Barco SG, Thorne L. Using prey availability and environmental covariates to forecast humpback and fin whale distributions in the Northeast United States. Oral presentation at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

VanParijs S, Davis G, Palka D. Update on AMAPPS. Oral presentation at the New York Bight Whale Monitoring Workshop, 6 June 2019, Setauket-East Setuaket, NY.

Weiss S, Cholewiak D, Baumann-Pickering S, Frasier K, Hildebrand J,Van Parijs SM. Defining shelf break soundscapes of southern Georges Bank, western North Atlantic Ocean. Poster presentation at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

**Table 1.5 Summary of cetaceans detected during the spring (3 April – 24 June 2019) and winter (13 October 2019 – 25 January 2020) abundance aerial surveys**

| Common Name | Scientific Name | Groups Spring | Groups Winter | Individuals Spring | Individuals Winter |
|---|---|---|---|---|---|
| Atlantic spotted dolphin | *Stenella frontalis* | 31 | 7 | 461 | 132 |
| Bottlenose/Spotted dolphin | *T. truncatus* or *S. frontalis* | 11 | 1 | 24 | 13 |
| Common bottlenose dolphin | *Tursiops truncatus* | 170 | 116 | 1299 | 727 |
| Common dolphin | *Delphinus delphis* | 173 | 273 | 1387 | 3020 |
| Common/white-sided dolphin | *D. delphis* or *L. acutus* | 110 | 13 | 263 | 76 |
| Cuvier's beaked whale | *Ziphius cavirostris* | 5 | 1 | 10 | 3 |
| Fin or sei whale | *B. physalus* or *borealis* | 5 | 5 | 6 | 6 |
| Fin whale | *Balaenoptera physalus* | 18 | 17 | 24 | 26 |
| Harbor porpoise | *Phocoena phocoena* | 148 | 48 | 180 | 148 |
| Humpback whale | *Megaptera novaeangliae* | 37 | 7 | 56 | 11 |
| Killer whale | *Orcinus orca* | 2 | 0 | 6 | 0 |
| Minke whale | *B. acutorostrata* | 21 | 12 | 22 | 14 |
| Pilot whales | *Globicephala sp.* | 27 | 12 | 312 | 80 |
| Pygmy/Dwarf sperm whale | *Kogia sp.* | 1 | 0 | 1 | 0 |
| Right whale | *Eubalaena glacialis* | 9 | 1 | 13 | 2 |
| Risso's dolphin | *Grampus griseus* | 29 | 9 | 274 | 21 |
| Rough-toothed dolphin | *Steno bredanensis* | 1 | 0 | 3 | 0 |
| Sei whale | *Balaenoptera borealis* | 2 | 0 | 2 | 0 |
| Sperm whale | *Physeter macrocephalus* | 1 | 1 | 2 | 2 |
| Striped dolphin | *Stenella coeruleoalba* | 1 | 0 | 70 | 0 |
| White-beaked dolphin | *Lagenorhynchus albirostris* | 1 | 0 | 6 | 0 |
| White-sided dolphin | *Lagenorhynchus acutus* | 55 | 13 | 255 | 117 |
| Unidentified dolphin | Delphinidae | 92 | 42 | 149 | 176 |
| Unidentified large whale | Mysticeti | 12 | 9 | 16 | 10 |
| Total cetaceans | | 962 | 587 | 4841 | 4584 |

**Table 1.6 Summary of turtles, seals, and fish detected during the spring (3 April – 24 June 2019) and winter (13 October 2019 – 25 January 2020) abundance aerial surveys**

| Common Name | Scientific Name | Groups Spring | Groups Winter | Individuals Spring | Individuals Winter |
|---|---|---|---|---|---|
| Green turtle | *Chelonia mydas* | 44 | 45 | 52 | 86 |
| Hawksbill turtle | *Eretmochelys imbricata* | 0 | 2 | 0 | 2 |
| Kemp's ridley turtle | *Lepidochelys kempii* | 22 | 8 | 22 | 9 |
| Leatherback turtle | *Dermochelys coriacea* | 24 | 25 | 24 | 25 |
| Loggerhead turtle | *Caretta caretta* | 544 | 234 | 615 | 270 |
| Unid hardshell turtle | - | 670 | 190 | 1054 | 220 |
| Total turtles | | 1304 | 504 | 1767 | 612 |
| | | | | | |
| Gray seal | *Halichoerus grypus* | 105 | 20 | 122 | 20 |
| Harbor seal | *Phoca vitulina* | 16 | 14 | 281 | 15 |
| Unidentified seal | *Pinnipedia* | 117 | 10 | 174 | 12 |
| Total seals | | 238 | 44 | 577 | 47 |
| | | | | | |
| Basking shark | *Cetorhinus maximus* | 136 | 9 | 194 | 9 |
| Great white shark | *Carcharodon carcharias* | 0 | 1 | 0 | 1 |
| Ocean sunfish | *Mola mola* | 64 | 93 | 68 | 102 |
| Unidentified shark | - | 18 | 11 | 18 | 11 |

**Table 1.7 Summary of 2019 strip transect seabird surveys, including birds and megafauna**

| Cruise | Program | Start Date | End Date | Number of Days | Total Sightings | Sightings in 300m Strip |
|---|---|---|---|---|---|---|
| RB1904 | Woods Hole Oceanographic Institution | 12-May | 24-May | 12 | 1,388 | 795 |
| HB1902 | Ecosystem Monitoring | 22-May | 6-Jun | 16 | 5,734 | 3,124 |
| TN368 | Woods Hole Oceanographic Institution | 7-Jul | 17-Jul | 11 | 479 | 209 |
| GU1902 | Ecosystem Monitoring | 15-Aug | 29-Aug | 15 | 4,930 | 3,101 |
| GU1905 | Ecosystem Monitoring | 15-Oct | 1-Nov | 18 | 6,597 | 3,424 |
| TOTAL | | | | 72 | 19,128 | 10,653 |

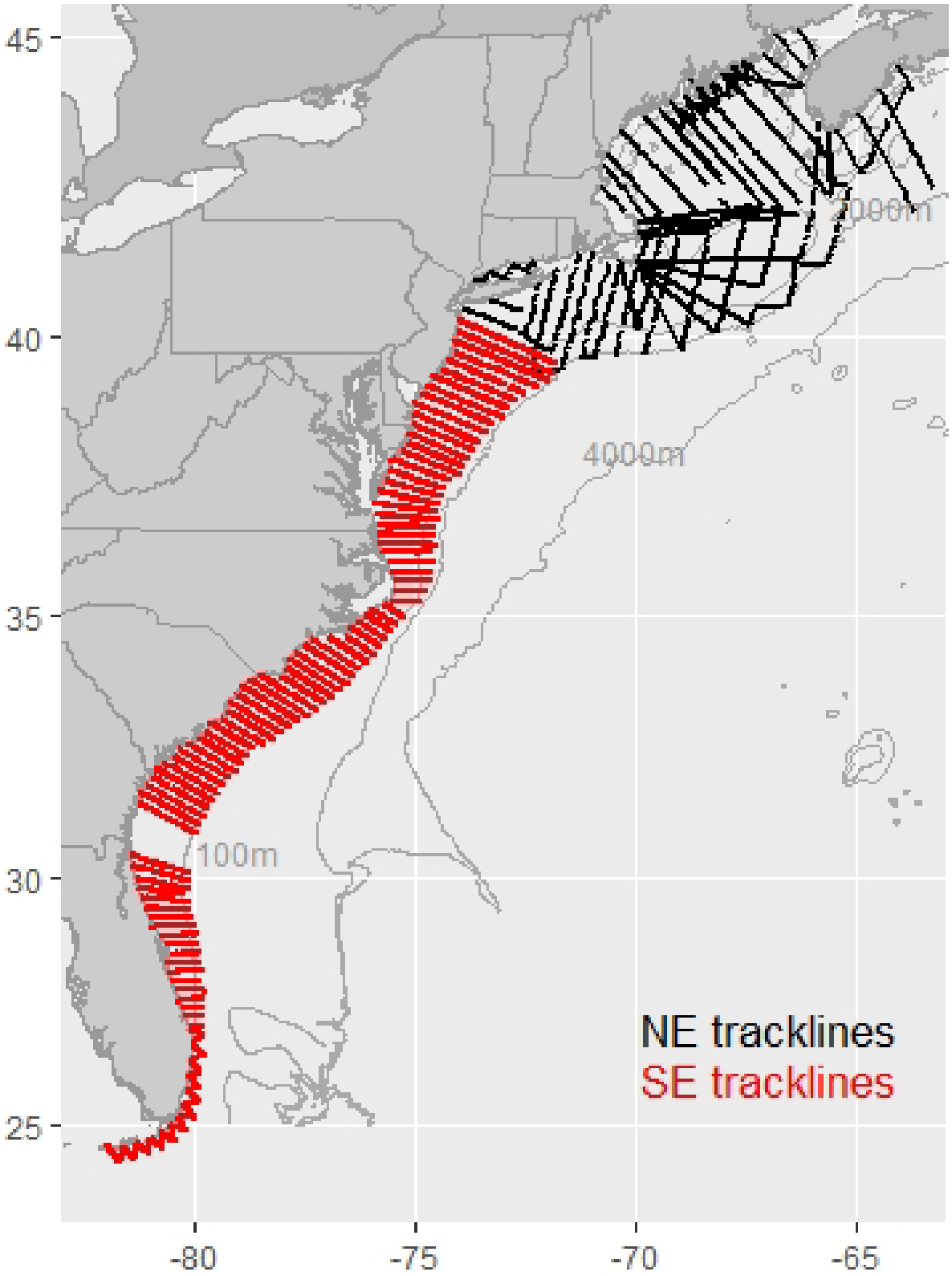


**Figure 1.1. Track lines completed during 3 April – 24 June 2019 aerial surveys conducted by the Northeast and Southeast Fisheries Science Centers**

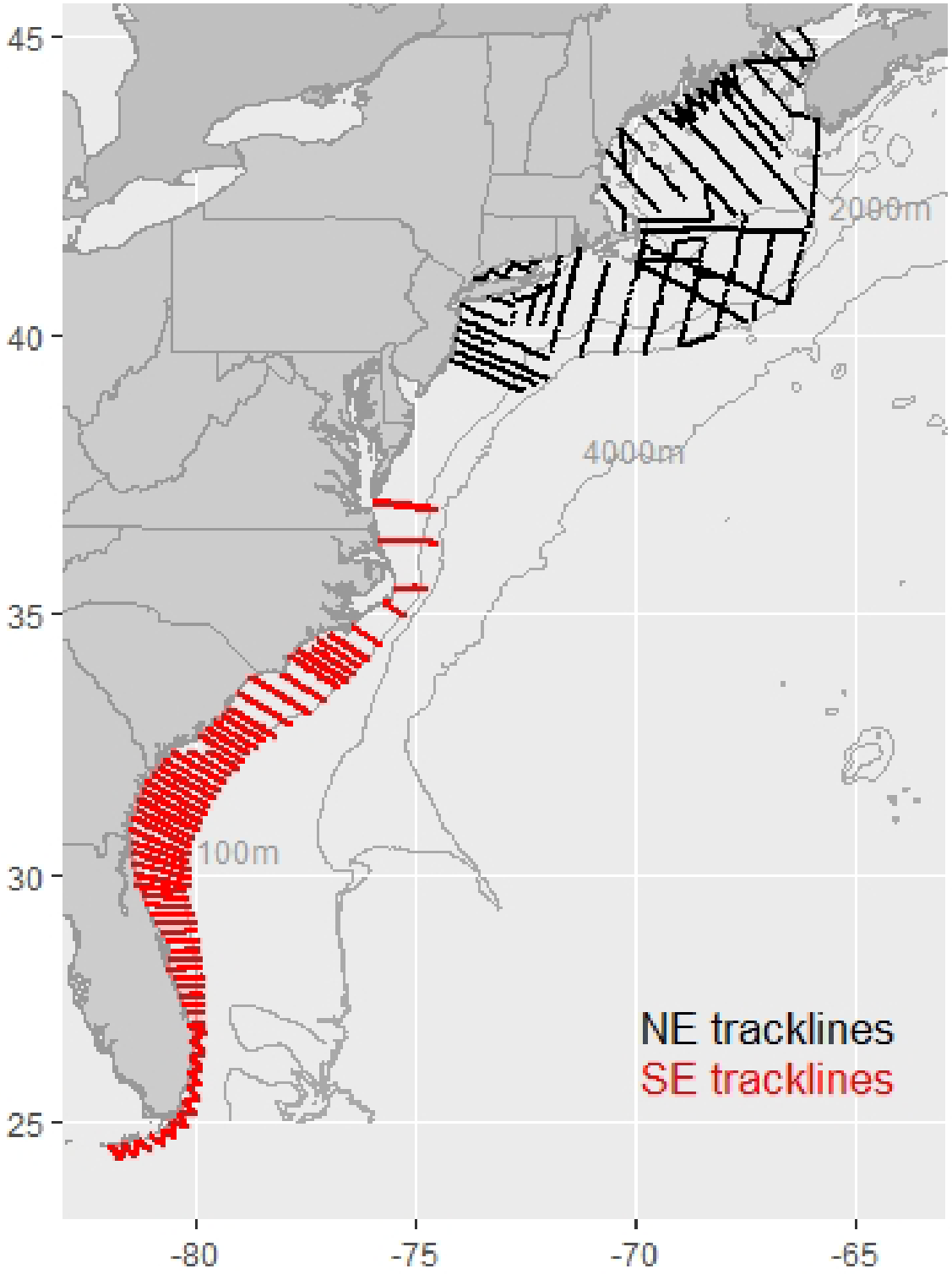


**Figure 1.2. Track lines completed during 13 October 2019 – 29 January 2020 aerial surveys conducted by the Northeast and Southeast Fisheries Science Centers**

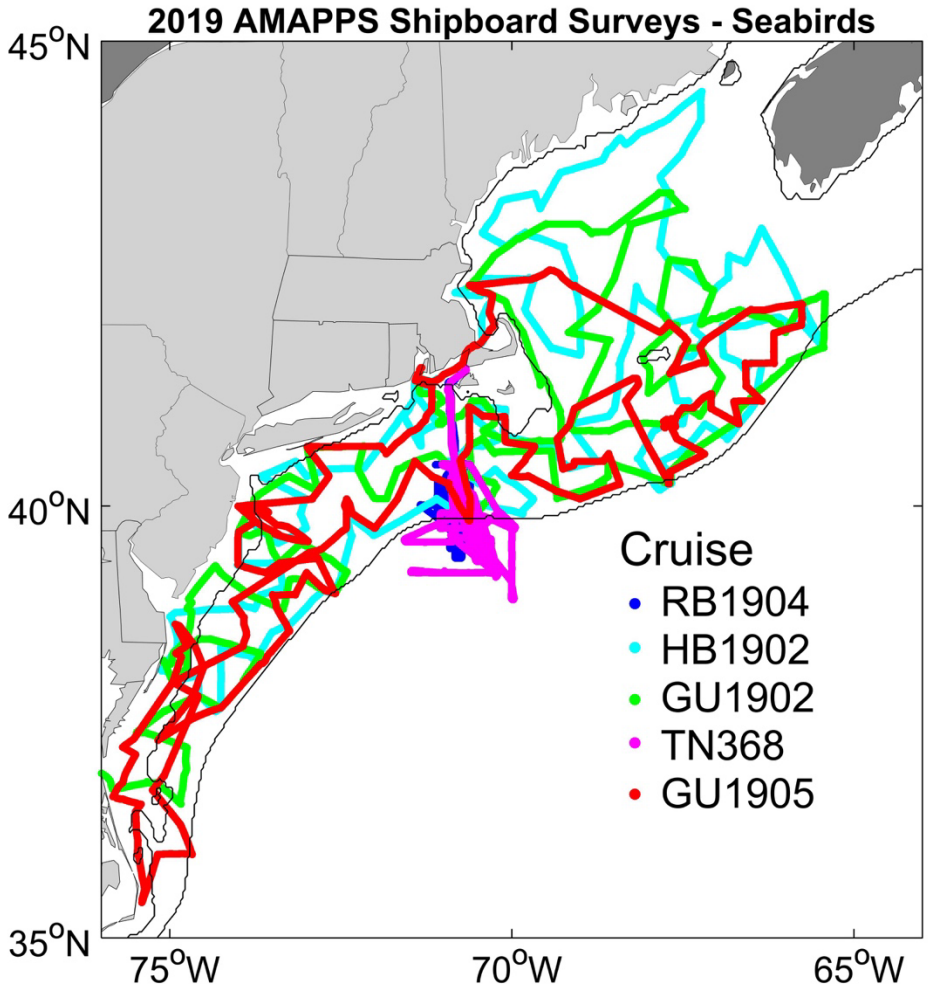


**Figure 1.3 Cruise tracks of five 2019 cruises on which seabird strip-transect surveys were conducted. Cruise designations explained in Table 1.1.**

# 2 Northern leg of two aerial abundance surveys during 2019: Northeast Fisheries Science Center

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

## 2.1 Summary

During spring (3 April – 15 May 2019) and fall (13 October – 24 November 2019), the Northeast Fisheries Science Center (NEFSC) conducted aerial abundance surveys targeting marine mammals and sea turtles. The southwestern extent of the study area was New Jersey and the northeastern extent was off of Halifax, Nova Scotia, Canada on the Scotia Shelf. The surveys covered waters from the coast line to about the 2,000 m depth contour. The Southeast Fisheries Science Center (SEFSC) flew aerial surveys after the NEFSC's survey in water south of the NEFSC study area (see Chapter 3 for more details). Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots). The two-independent team methodology was used to collect data. In the spring NEFSC survey about 10,392 km of on-effort track lines were surveyed, where 89% of this effort was in Beaufort 3 and below. In the NEFSC fall about 7,770 km of on-effort track lines were surveyed, where 85% of this effort was in Beaufort 3 and below. In the spring survey, the two teams detected 1,749 individual cetaceans from 706 groups of 19 species or species groups. In the fall survey, the two teams detected 3,744 individual cetaceans from 461 groups of 15 species or species groups. Common dolphins (*Delphinus delphis*) were the most frequently detected species. The most frequently detected large whales were humpback whales (*Megaptera novaeangliae*) in the spring and fin whales (*Balaenoptera physalus*) in the fall. In the spring only 1 loggerhead turtle (*Caretta caretta*) and 1 unidentified hardback turtle was detected. During the fall a few more turtles were detected: 4 leatherback turtles (*Dermochelys coriacea*), 7 loggerhead turtles and 1 green turtle (*Chelonia mydas*). Seals at-sea and ocean sunfish (*Mola mola*) were also commonly detected. In addition, seal haul-out sites were photographed, which will be used to define the distribution and abundance of gray seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*).

## 2.2 Objectives

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

## 2.3 Cruise Period and Area

The NEFSC surveys were conducted during 3 April – 15 May 2019 and 13 October – 24 November 2019. The study area for both surveys extended from New Jersey to the waters south of Halifax, Nova Scotia, Canada, from the coastline to about the 2,000 m depth contour (Figures 2.1 – 2.2). An associated aerial survey was conducted by the SEFSC in US waters from New Jersey and south (see Chapter 3 for more details).

The proposed track lines covered the entire region using a broad scale systematic strategy providing an overall spatial coverage. Additional flight paths that had to be flown to reach the

farther systematic track lines were also flown using normal survey data collection procedures to collect additional on-effort sightings and effort which has increased the spatial and temporal coverage of the region.

## 2.4 Methods

The aerial surveys were conducted on a DeHavilland Twin Otter DHC-6 aircraft over Atlantic Ocean waters off the east coast of the U.S. and Canada. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots), when Beaufort sea state conditions were six and below, and when there was at least 3.2 km (2 miles) of visibility. The methods used by the NEFSC (described below) are similar to that used by the SEFSC (described in Chapter 3).

When a cetacean, seal, turtle, sunfish, or basking shark (*Cetorhinus maximus*) was observed the following data were collected:

- Time animal passed perpendicular to the observer
- Species identification
- Species identification confidence level (certain, probable, not sure)
- Best estimate of the group size
- Angle of declination between the track line and location of the animal group when it passed abeam (measured to the nearest one degree by inclinometers or marks on the windows, where 0º is straight down)
- Cue (animal, splash, blow, footprint, birds, vessel/gear, windrows, disturbance, or other)
- Swim direction (0º indicates animal was swimming parallel to the track line in the same direction the plane was flying, 90º indicates animal was swimming perpendicular to the track line and towards the right, etc.)
- If the animal appeared to react to the plane (yes or no)
- If a turtle was initially detected above or below the surface
- Comments, if any

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

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

- Initials of person in the pilot seats and observation stations
- Beaufort Sea State (recorded to one decimal place)
- Water turbidity (clear, moderately clear, turbid very turbid, and unknown)
- 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)
- Subjective overall quality of viewing conditions (excellent, good, moderate, fair, and poor)

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 computerized data entry program called VOR.exe, version 8.75 originally created by Phil Lovell and Lex Hiby.

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

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

Onboard, in addition to two pilots, were a maximum of six scientists who were divided into two teams. One team, the primary forward team, consisted of a recorder and two observers viewing through the two forward right and left bubble windows. The other team, the independent back team, consisted of one observer viewing through the back belly window, one observer viewing from the right side back visa 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.

The belly window observer, who was searching straight down was limited to approximately a 30º view on both sides of the track line. The front bubble windows and back side visa 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 at the end of track lines or about every 30 – 40 minutes, scientists rotated between the observations positions. When both teams could not identify the species of a group that was within about 60º of the track line and there was a high chance that the group could be relocated or the species was thought to have been a North Atlantic right whale (*Eubalaena glacialis*), then sighting effort was broke off, and the plane returned to the group to confirm the species identification and group size. The data were reviewed after the flights to identify duplicate sightings that were made by the two teams based upon time, location, and position relative to the track line.

## 2.5 Results

The observers and pilots who collected these data are listed in Table 2.1.

During the spring survey, 15 of the 30 possible flight days had sufficiently good weather to conduct the survey (Table 2.2). One additional day had sufficiently good weather to photograph seal haul out sites but not good enough to conduct an abundance survey. The two aircrafts used in this survey were in routine maintenance for 13 days. During the on-effort portions of the flights about 10,392 km of track lines were covered, where about 89% of the track lines were surveyed in Beaufort 3 and less (Table 2.3).

During the fall survey, 13 of the 40 possible flight days had sufficiently good weather for at least part of the day to conduct the abundance survey (Table 2.2). In addition, part of 1 day (4-Nov-19) had weather sufficient to photograph seal haul out sites but not good enough to conduct an abundance survey. The aircraft was in routine maintenance for 5 days, and unscheduled maintenance for an additional 5 days (of which 3 days had weather conditions too poor to fly). Leaving 16 additional bad weather days. During the on-effort portions of the flights about 7,771 km of track lines were covered, where about 85% of the track lines were surveyed in Beaufort 3 and less (Table 2.3). An additional 286 km were flown in and around seal haul outs on days or parts of days that did not have sufficiently good weather conditions for abundance surveys or the haul out sites were close to the track lines or airports thus not impacting the abundance surveys.

On the on-effort portions of the spring track lines, 1,749 individual cetaceans from 706 groups of 19 cetacean species or species groups were detected by either the back, front or both teams (Table 2.4). In addition, 2 seal, 1 turtle, and several fish species were also identified (Table 2.5).

On the on-effort portions of the fall track lines, 3,744 individual cetaceans from 461 groups of 15 cetacean species or species groups were detected by either the back, front or both teams (Table 2.4). In addition, 2 seal, 3 turtle, and several fish species were also identified (Table 2.5).

The locations of sightings seen on the on-effort transect legs, by species, are displayed in Figures 2.2 – 2.13. In most cases each figure displays the locations of one or two species, where the spring survey results are displayed at the top panel and fall survey results are in the bottom panel. Identified dolphins and porpoises are in Figures 2.2 – 2.6, identified whales in Figures 2.6 – 2.9, and unidentified dolphins and whales in Figure 2.10. Locations of several large fish are in Figures 2.11, turtles are in Figure 2.12, and seals are in Figures 2.13.

In the spring, the most commonly detected species was the common dolphin (*Delphinus delphis*), which was seen everywhere from New York to Halifax, but not in the near-coastal Maine waters. White-sided dolphins (*Lagenorhynchus acutus*), humpback whales, minke whales (*Balaenoptera acutorostrata*) and ocean sunfish were also spread out through the entire study area. Harbor porpoises (*Phocoena phocoena*) were prevalent, but in contrast to their summer restricted distribution, during the spring they were spread out for Rhode Island to Halifax. Risso's dolphins (*Grampus griseus*), most of the common bottlenose dolphins (*Tursiops truncatus*) basking sharks (*Cetorhinus maximus*), pilot whales (*Globicephala* spp.), striped dolphins (*Stenella coeruleoalba*), and Cuvier's beaked whales (*Ziphiidae cavirostris*) were located in the deeper waters, particularly on the shelf break. Even most of the North Atlantic right whales were detected offshore near the 100 m depth contour.

As in the spring survey, during the fall survey, the most frequent observations were common dolphin that were seen everywhere from New Jersey to Nova Scotia, from the coastline to the 2,000 m depth contour, though again not in the near-coastal Maine waters. Harbor porpoises and white-sided dolphins were found in low densities but concentrated in the regions where common dolphins were not detected. Humpback whales, minke whales, fin whales, and ocean sunfish were spread out but mostly in waters south of Maine from the coast line to the 2,000 m depth contour. Risso's dolphins, most of the common bottlenose dolphins, basking sharks, pilot whales, sperm whales (*Physeter macrocephalus*), and Cuvier's beaked whales were located in the deeper waters, particularly on the shelf break, and in lower densities on the northern edge of Georges Bank.

During the spring survey, only two turtles were detected. One unidentified turtle was on the northern edge of Georges Bank and the loggerhead turtle was in nearly 2,000 m depth off New Jersey. During the fall survey, all the turtles were detected from Long Island Sound, NY to the southern edge of Georges Bank.

During the spring, seals were seen spread out from Long Island, NY, along Cape Cod, MA, up to the coast of Maine. Many groups were south of Cape Cod, few on Georges Bank, and few were farther offshore Nova Scotia in the Gulf of Maine. Nearly all were in waters less than 100 m depth. In the fall, seals were seen spread out from the coast of Maine to waters south of Cape Cod, where nearly all were in waters less than 100 m depth.

## 2.6 Disposition of Data

All data collected during these surveys are maintained by the Protected Species Branch at NEFSC in Woods Hole, MA and are available from the NEFSC's Oracle database. The on-effort transect data are also available on OBIS-SEAMAP.

## 2.7 Permits

NEFSC was authorized to conduct these research activities during this survey under US Permit No. 21719-01 issued to the NEFSC by the NMFS Office of Protected Resources. The NOAA aircraft was granted diplomatic overflight clearance in Canadian airspace with the Overflight Clearance number 0154-US-2019-04-TC for the spring 2019 survey and Overflight Clearance number 0515-US-2019-11-TC for the fall 2019 survey. The Species at Risk Management Division of the Canadian Fisheries and Oceans concluded a permit under SARA was not needed for the aerial surveys.

## 2.8 Acknowledgements

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

## 2.9 References Cited

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

**Table 2.1. List of observers and pilots that participated in the spring (3 April – 15 May 2019) and fall (13 October – 24 November 2019) Northeast aerial surveys**

| Observers | Affiliation | Spring | Fall |
|---|---|---|---|
| Robert DiGiovanni | Integrated Statistics, Inc, Woods Hole, MA | Y | Y |
| Corey Accardo | Integrated Statistics, Inc, Woods Hole, MA | Y | Y |
| Rachel Hardee | Integrated Statistics, Inc, Woods Hole, MA | Y | Y |
| Paul Nagelkirk | Integrated Statistics, Inc, Woods Hole, MA | Y | Y |
| Richard Holt | Integrated Statistics, Inc, Woods Hole, MA | Y | Y |
| Valentina Sherlock | Integrated Statistics, Inc, Woods Hole, MA | Y | N |
| Nicolas Metheny | Integrated Statistics, Inc, Woods Hole, MA | Y | Y |
| Debra Palka | Northeast Fisheries Science Center, Woods Hole, MA | Y | N |
| Jennifer Gatzke | NOAA West Coast Region, Moscow, ID | N | Y |
| **Pilots** | **Affiliation** | **Spring** | **Fall** |
| Rob Mitchell | NOAA Aircraft Operations Center, Tampa, FL | Y | Y |
| Bennett Singletary | NOAA Aircraft Operations Center, Tampa, FL | Y | N |
| Francisco Fuemaor | NOAA Aircraft Operations Center, Tampa, FL | Y | Y |
| Bill Carrier | NOAA Aircraft Operations Center, Tampa, FL | Y | N |
| Conor Maginn | NOAA Aircraft Operations Center, Tampa, FL | Y | N |
| Richard deTriquet | NOAA Aircraft Operations Center, Tampa, FL | Y | N |
| Casey Marwine | NOAA Aircraft Operations Center, Tampa, FL | N | Y |
| Mason Carroll | NOAA Aircraft Operations Center, Tampa, FL | N | Y |

**Table 2.2. Daily on-effort track line lengths and numbers of unique groups detected**

| Date | Track Length (km) | Marine Mammals | Seals | Turtles |
|---|---|---|---|---|
| 05-Apr-19 | 507.1 | 28 | 12 | 0 |
| 07-Apr-19 | 1,067.1 | 111 | 63 | 0 |
| 10-Apr-19 | 81.7 | 0 | 0 | 0 |
| 11-Apr-19 | 716.0 | 9 | 1 | 0 |
| 12-Apr-19 | 1,082.5 | 23 | 32 | 0 |
| 14-Apr-19 | 1,116.4 | 92 | 43 | 0 |
| 17-Apr-19 | 354.5 | 3 | 1 | 0 |
| 23-Apr-19 | 497.2 | 52 | 6 | 1 |
| 25-Apr-19 | 946.3 | 184 | 44 | 0 |
| 28-Apr-19 | 552.1 | 61 | 6 | 0 |
| 30-Apr-19 | 317.2 | 4 | 1 | 0 |
| 01-May-19 | 1,344.3 | 102 | 25 | 1 |
| 02-May-19 | 526.7 | 7 | 2 | 0 |
| 12-May-19 | 1,236.0 | 30 | 2 | 0 |
| 13-May-19 | 47.2 | 0 | 0 | 0 |
| TOTAL SPRING | 10,392.3 | 706 | 238 | 2 |
| 15-Oct-19 | 573.1 | 5 | 0 | 6 |
| 19-Oct-19 | 260.9 | 3 | 1 | 0 |
| 20-Oct-19 | 167.9 | 7 | 2 | 0 |
| 24-Oct-19 | 1,093.3 | 53 | 5 | 3 |
| 25-Oct-19 | 1,091.7 | 100 | 14 | 0 |
| 26-Oct-19 | 185.7 | 0 | 0 | 1 |
| 29-Oct-19 | 773.8 | 48 | 19 | 0 |
| 2-Nov-19 | 1,377.5 | 135 | 1 | 2 |
| 4-Nov-19 | 850.7 | 52 | 2 | 0 |
| 11-Nov-19 | 441.6 | 35 | 0 | 0 |
| 19-Nov-19 | 81.8 | 0 | 0 | 0 |
| 21-Nov-19 | 342.6 | 17 | 0 | 0 |
| 23-Nov-19 | 530.2 | 6 | 0 | 0 |
| TOTAL FALL | 7,770.8 | 461 | 44 | 12 |

**Table 2.3. Length of on-effort track lines surveyed by Beaufort sea state**

| Feature | 0 | 1 | 2 | 3 | 4 | 5 | 6 | Total |
|---|---|---|---|---|---|---|---|---|
| Spring track length (km) | 22.3 | 2,415.6 | 3,616.7 | 3,155.3 | 1,016.7 | 135.1 | 30.6 | 10,392.3 |
| Spring % total | 0.00 | 23.24 | 34.80 | 30.36 | 9.78 | 1.30 | 0.29 | 100.00 |
| Fall track length (km) | 0 | 376.1 | 3076.8 | 3145.4 | 1083.8 | 88.7 | 0 | 7,770.8 |
| Fall % total | 0.00 | 4.84 | 39.59 | 40.48 | 13.95 | 1.14 | 0 | 100.00 |

**Table 2.4. Numbers of groups (Grps) and individual (Ind) cetaceans detected on-effort during the spring and fall Northeast surveys**

| Common Name | Scientific Name | Spring Grps | Fall Grps | Spring Ind | Fall Ind |
|---|---|---|---|---|---|
| Common bottlenose dolphin | *Tursiops truncatus* | 25 | 6 | 60 | 62 |
| Common dolphin | *Delphinus delphis* | 142 | 273 | 474 | 3,020 |
| Cuvier's beaked whale | *Ziphius cavirostris* | 4 | 1 | 7 | 3 |
| Risso's dolphin | *Grampus griseus* | 18 | 9 | 95 | 21 |
| Pilot whale | Globicephala spp. | 14 | 10 | 65 | 58 |
| Striped dolphin | *Stenella coeruleoalba* | 1 | 0 | 70 | 0 |
| White-beaked dolphin | *Lagenorhynchus albirostris* | 1 | 0 | 6 | 0 |
| White-sided dolphin | *Lagenorhynchus acutus* | 55 | 13 | 255 | 117 |
| Common/white-sided dolphin | *D. delphis or L. acutus* | 110 | 13 | 263 | 76 |
| Unidentified dolphin | *Delphinidae* | 90 | 39 | 141 | 172 |
| Harbor porpoise | *Phocoena phocoena* | 148 | 48 | 180 | 148 |
| Fin whale | *Balaenoptera physalus* | 16 | 17 | 21 | 26 |
| Fin or sei whale | *B. physalus or borealis* | 5 | 5 | 6 | 6 |
| Humpback whale | *Megaptera novaeangliae* | 33 | 6 | 50 | 10 |
| Killer whale | *Orcinus orca* | 2 | 0 | 6 | 0 |
| Minke whale | *B. acutorostrata* | 19 | 11 | 19 | 13 |
| Right whale | *Eubalaena glacialis* | 9 | 0 | 13 | 0 |
| Sei whale | *Balaenoptera borealis* | 2 | 0 | 2 | 0 |
| Sperm whale | *Physeter macrocephalus* | 0 | 1 | 0 | 2 |
| Unidentified large whale | *Mysticeti* | 12 | 9 | 16 | 10 |
| TOTAL CETACEANS | | 706 | 461 | 1,749 | 3,744 |

**Table 2.5. Numbers of groups (Grps) and individual (Ind) turtle, shark and seal species detected on-effort during the spring and fall Northeast surveys**

| Common Name | Scientific Name | Spring Groups | Fall Groups | Spring Indiv | Fall Indiv |
|---|---|---|---|---|---|
| Green turtle | *Chelonia mydas* | 0 | 1 | 0 | 1 |
| Leatherback turtle | *Dermochelys coriacea* | 0 | 4 | 0 | 4 |
| Loggerhead turtle | *Caretta caretta* | 1 | 7 | 1 | 7 |
| Unid hardshell turtle | - | 1 | 0 | 1 | 0 |
| Basking shark | *Cetorhinus maximus* | 136 | 9 | 194 | 0 |
| Great white shark | *Carcharodon carcharias* | 0 | 1 | 0 | 1 |
| Ocean sunfish | *Mola mola* | 64 | 93 | 68 | 102 |
| Unidentified shark | - | 18 | 11 | 18 | 11 |
| Gray seal | *Halichoerus grypus* | 105 | 20 | 122 | 20 |
| Harbor seal | *Phoca vitulina* | 16 | 14 | 281 | 15 |
| $Unidentified seal | *Pinnipedia* | 117 | 10 | 174 | 12 |
| TOTAL ALL SPECIES | | 1,164 | 631 | 2,608 | 3,917 |

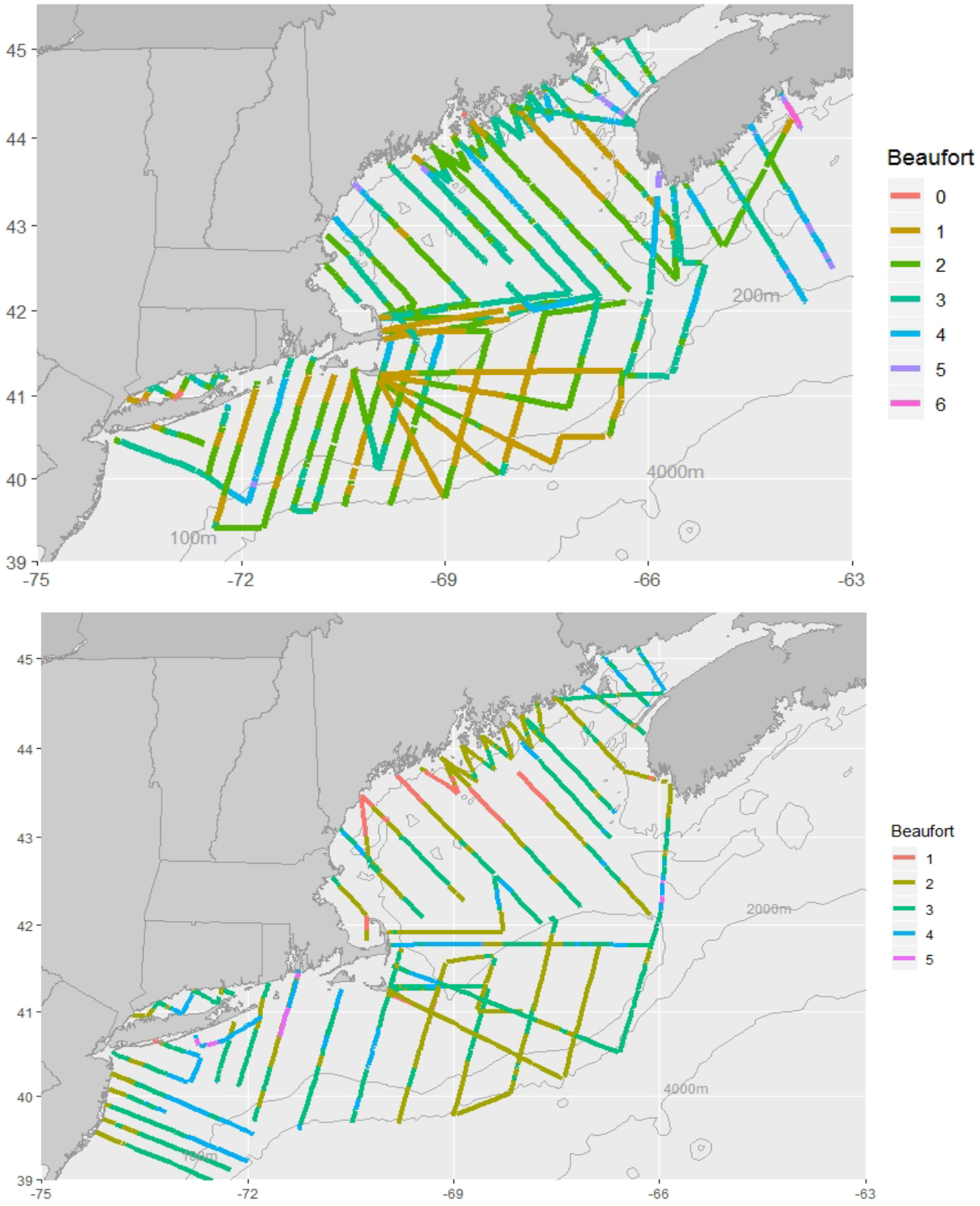


**Figure 2.1. Completed on-effort track lines by Beaufort sea state from spring (top) and fall (bottom) Northeast survey.**

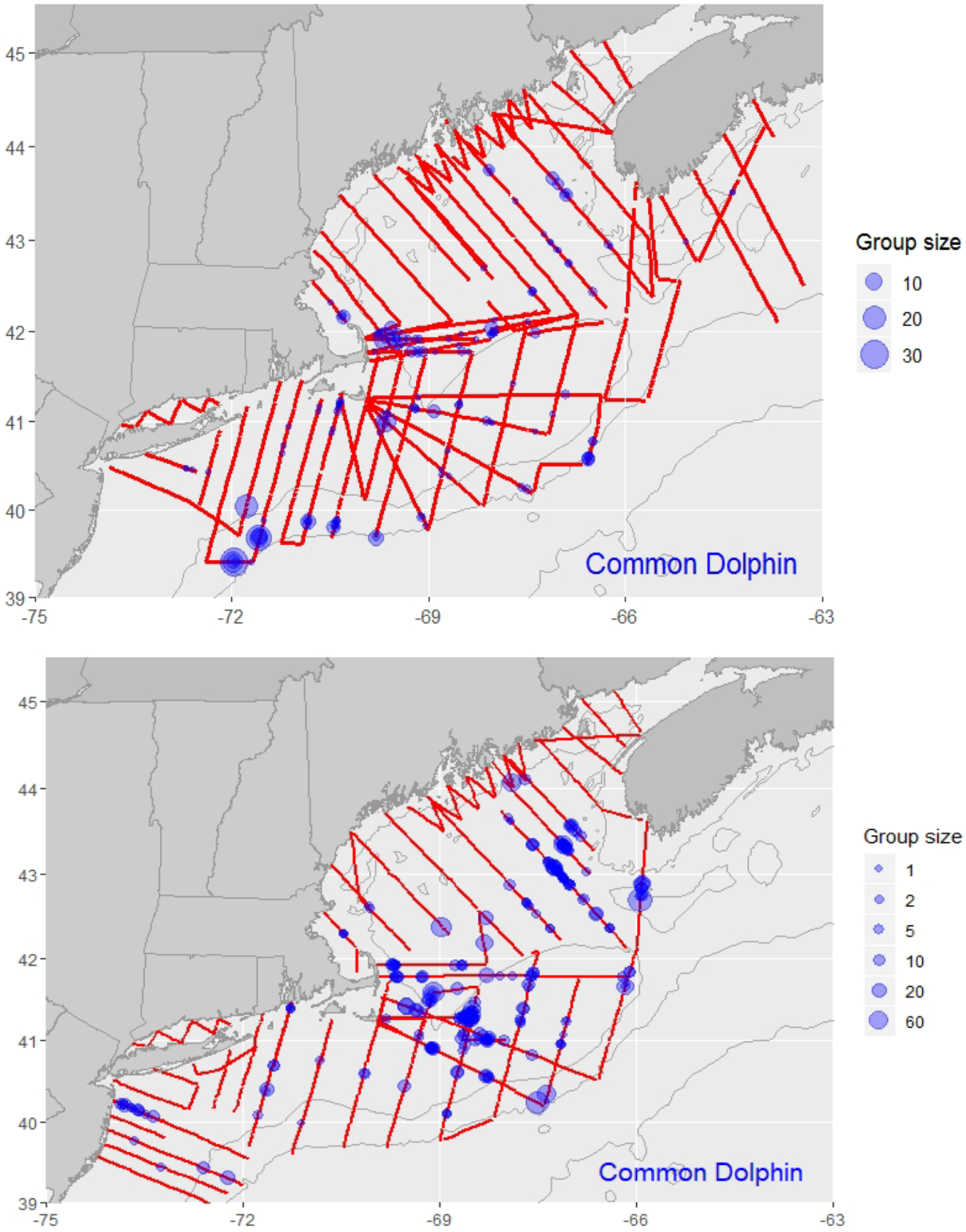


**Figure 2.2. Common dolphins (*Delphinus delphis*) from spring (top) and fall (bottom) surveys**

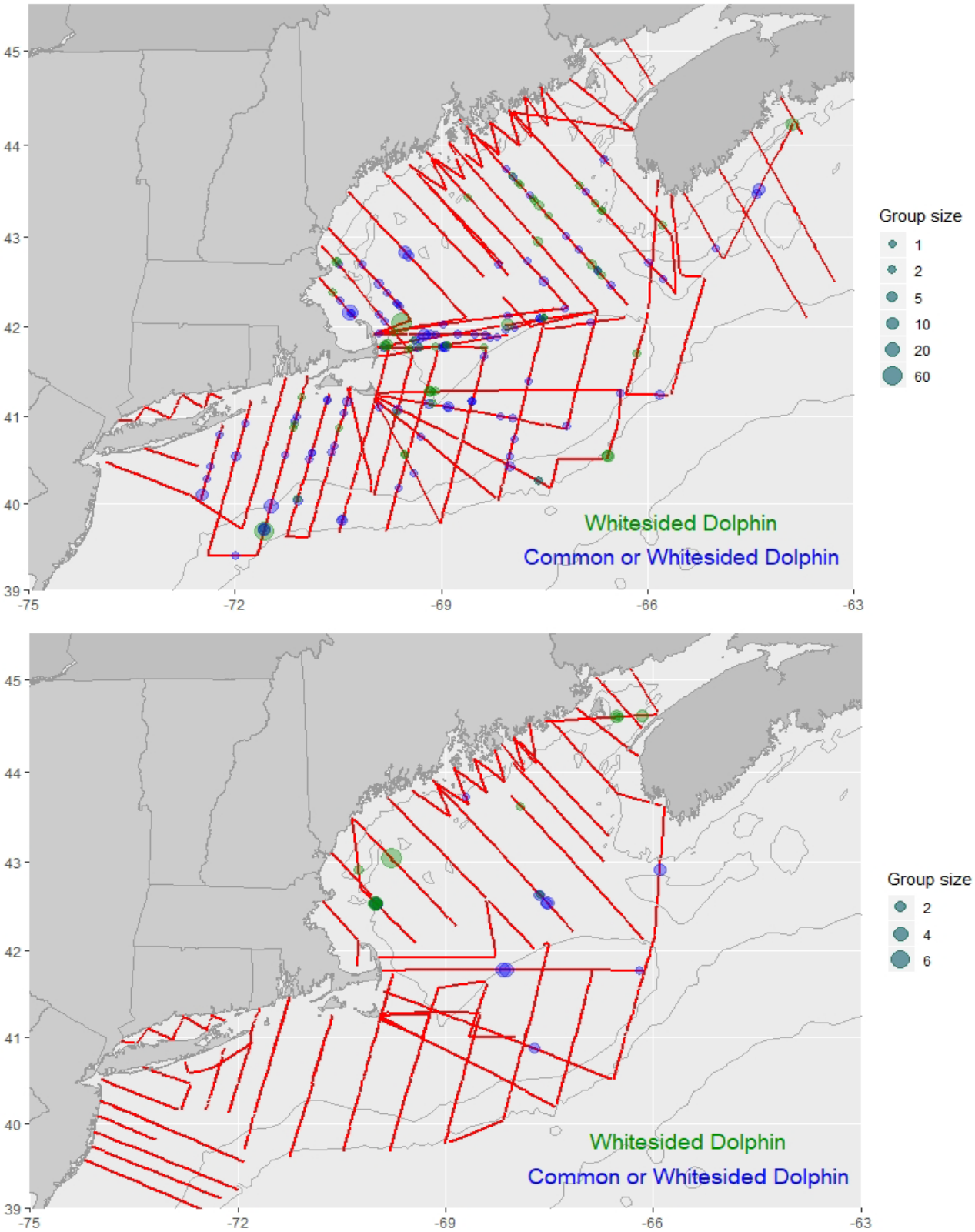


**Figure 2.3. White-sided dolphins (*Lagenorhynchus acutus*) and groups ambiguously identified as either common dolphins (*Delphinus delphis*) or white-sided dolphins from spring (top) and fall (bottom) surveys**

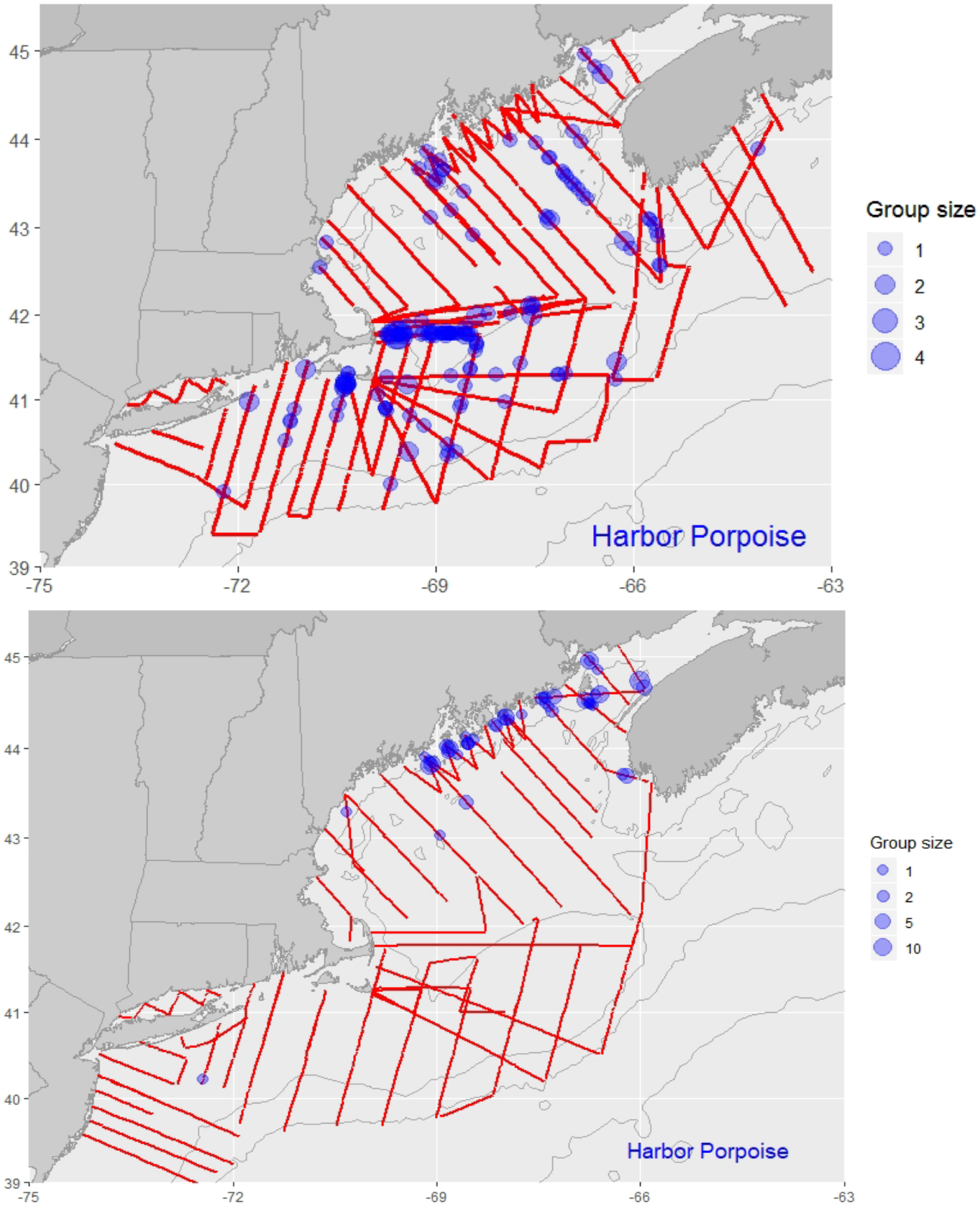


**Figure 2.4. Harbor porpoises (*Phocoena phocoena*) from spring (top) and fall (bottom) surveys**

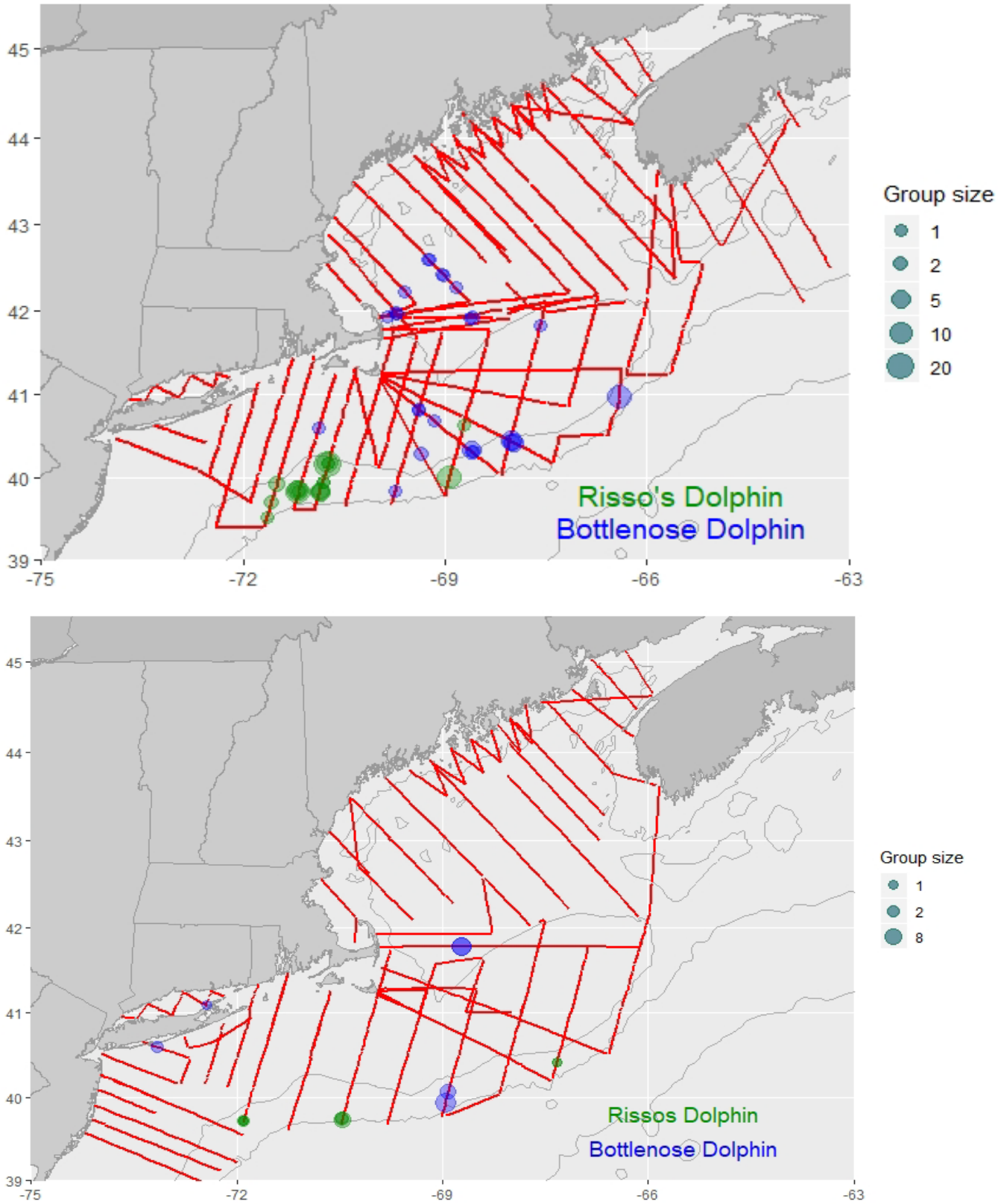


**Figure 2.5. Risso's dolphins (*Grampus griseus*) and common bottlenose dolphins (*Tursiops truncatus*) and from spring (top) and fall (bottom) surveys**

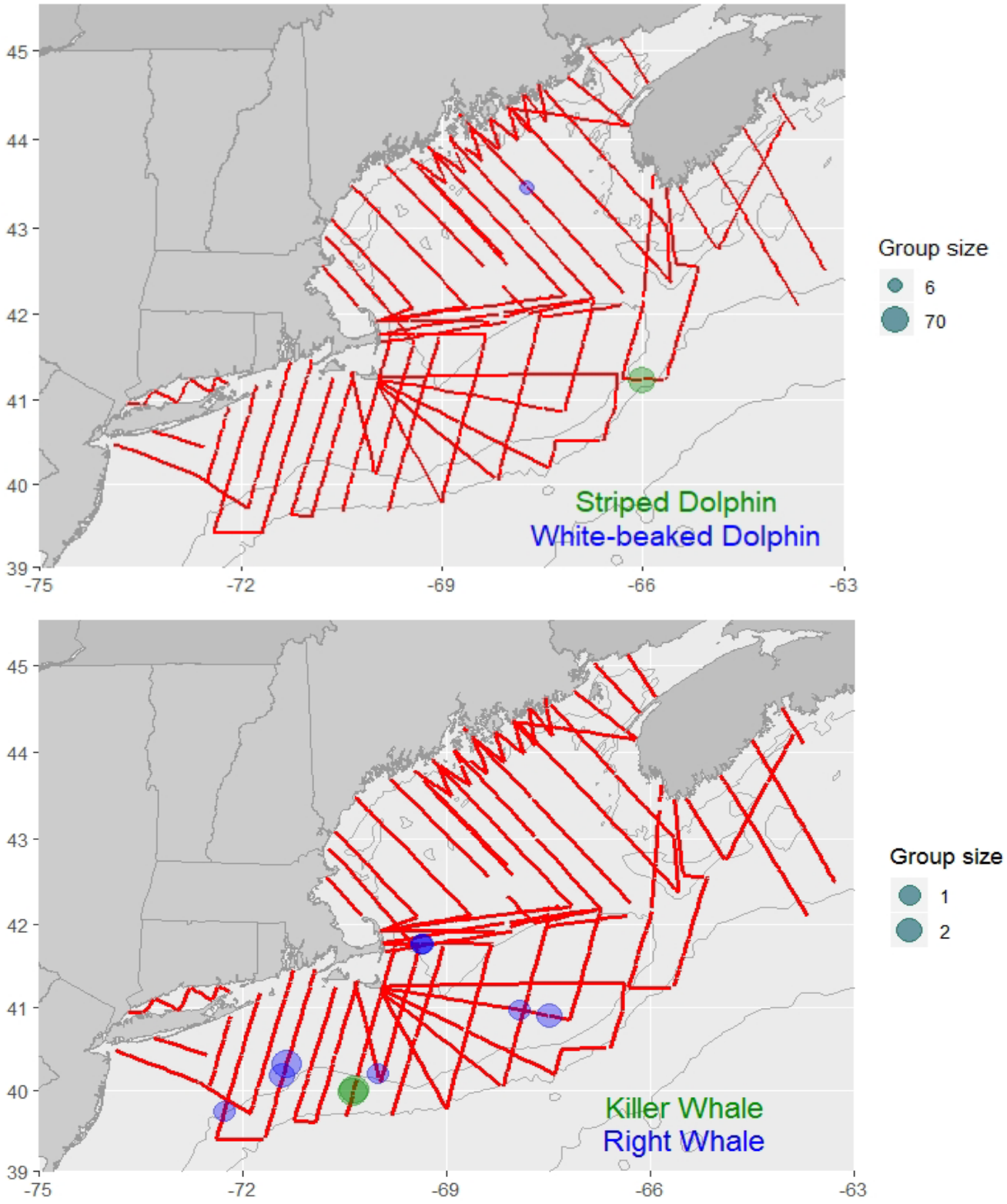


**Figure 2.6. Striped dolphins (*Stenella coeruleoalba*), white-beaked dolphins (*Lagenorhynchus albirostris*), killer whales (*Orcinus orca*) and North Atlantic right whales (*Eubalaena glacialis*) from spring survey**

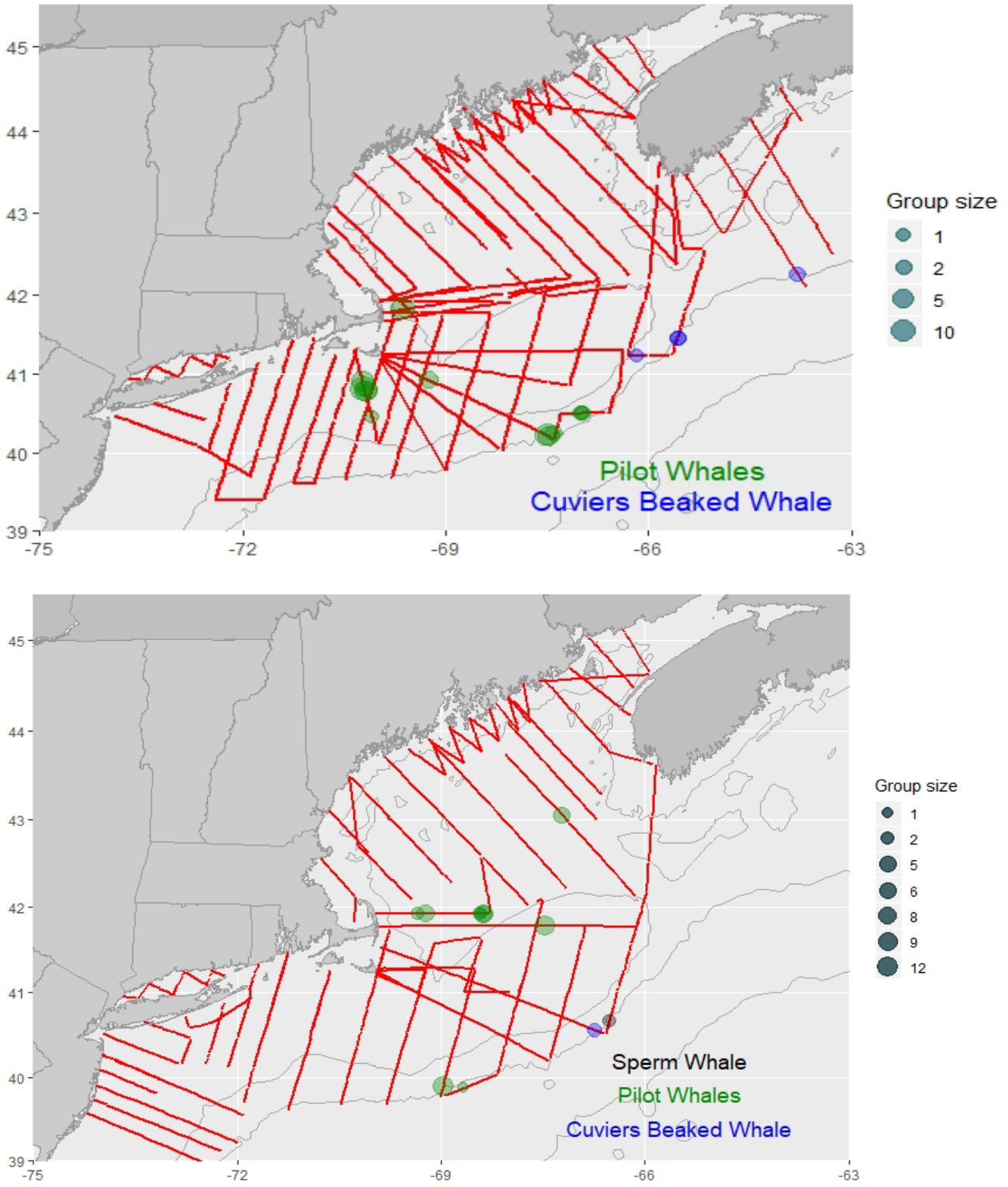


**Figure 2.7. Sperm whales (*Physeter macrocephalus*), pilot whales (Globicephala spp.), and Cuvier's beaked whales (*Ziphius cavirostris*) from spring (top) and fall (bottom) surveys**

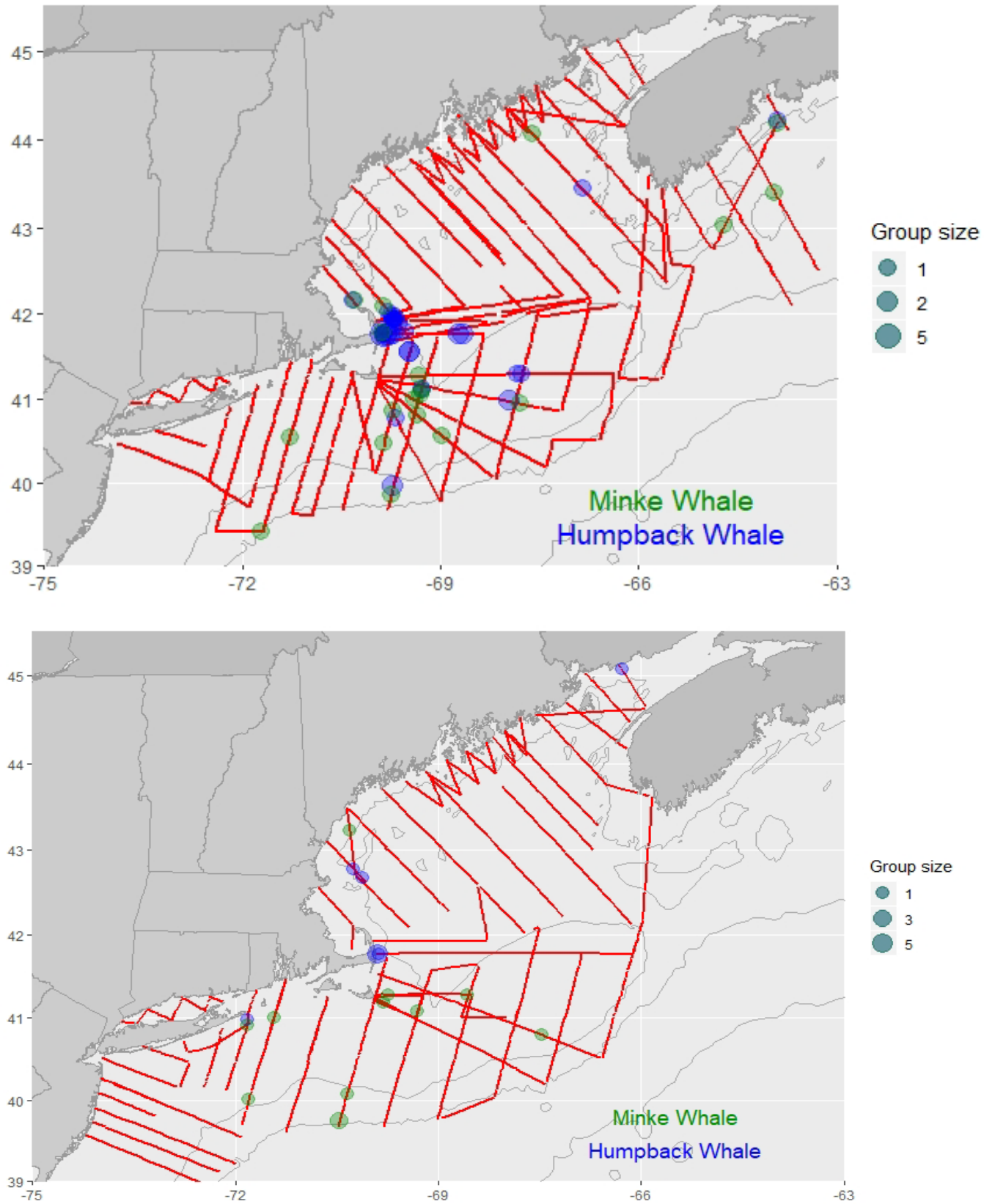


**Figure 2.8. Humpback whales (*Megaptera novaeangliae*) and minke whales (*Balaenoptera acutorostrata*) from spring (top) and fall (bottom) surveys**

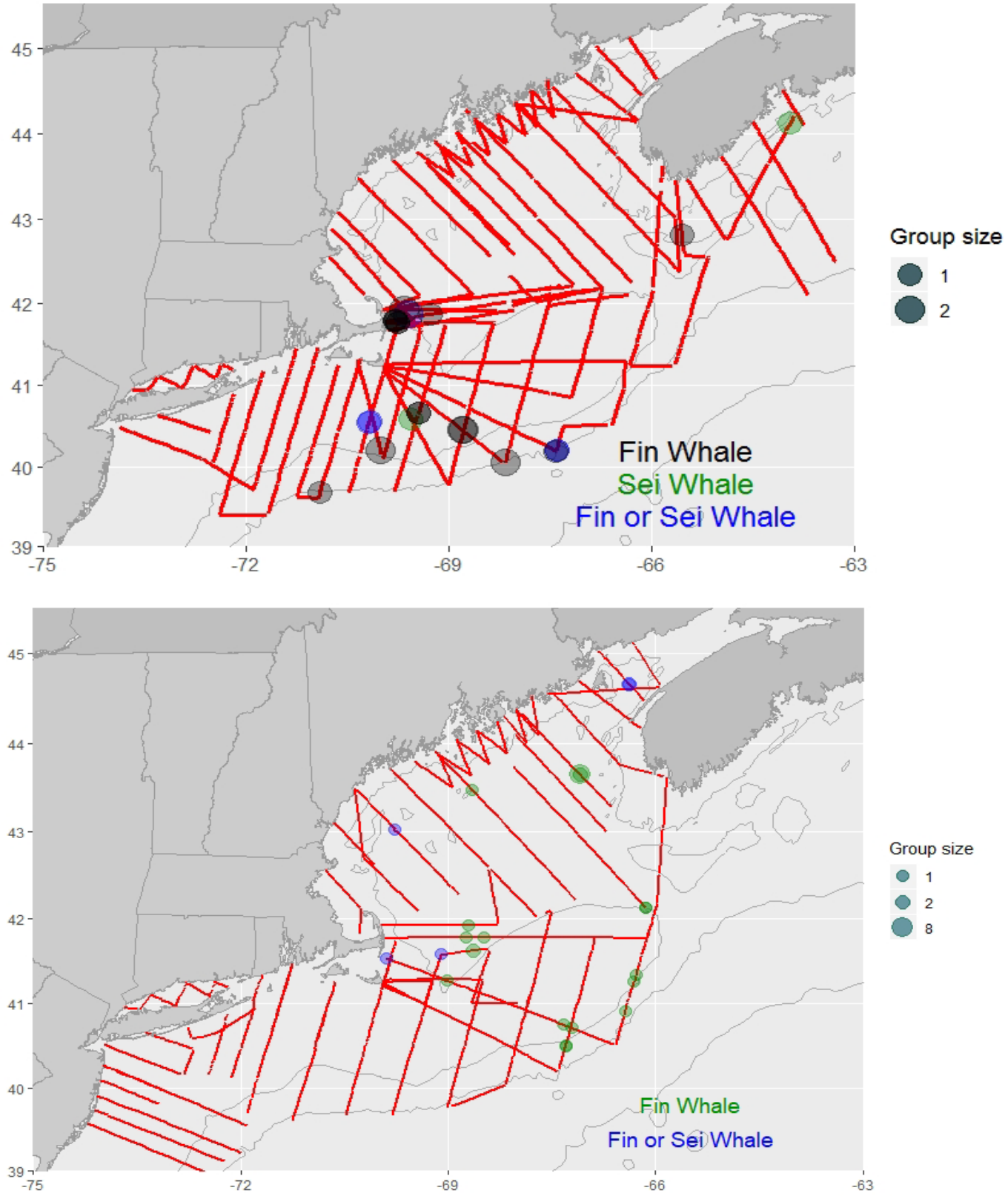


**Figure 2.9. Fin whales (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*), and groups ambiguously identified as either fin or sei whales from spring (top) and fall (bottom) surveys**

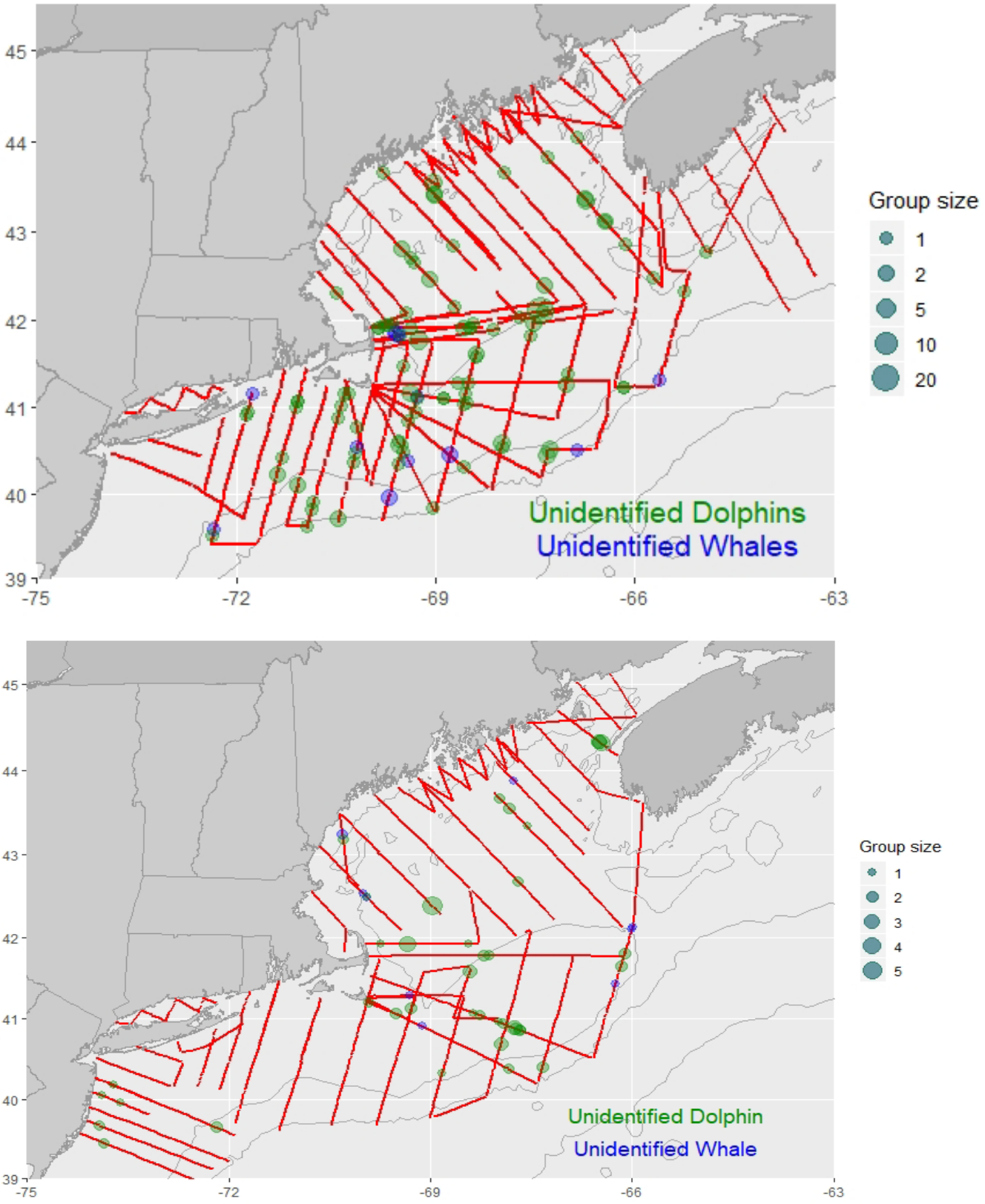


**Figure 2.10. Unidentified dolphins and whales from spring (top) and fall (bottom) surveys**

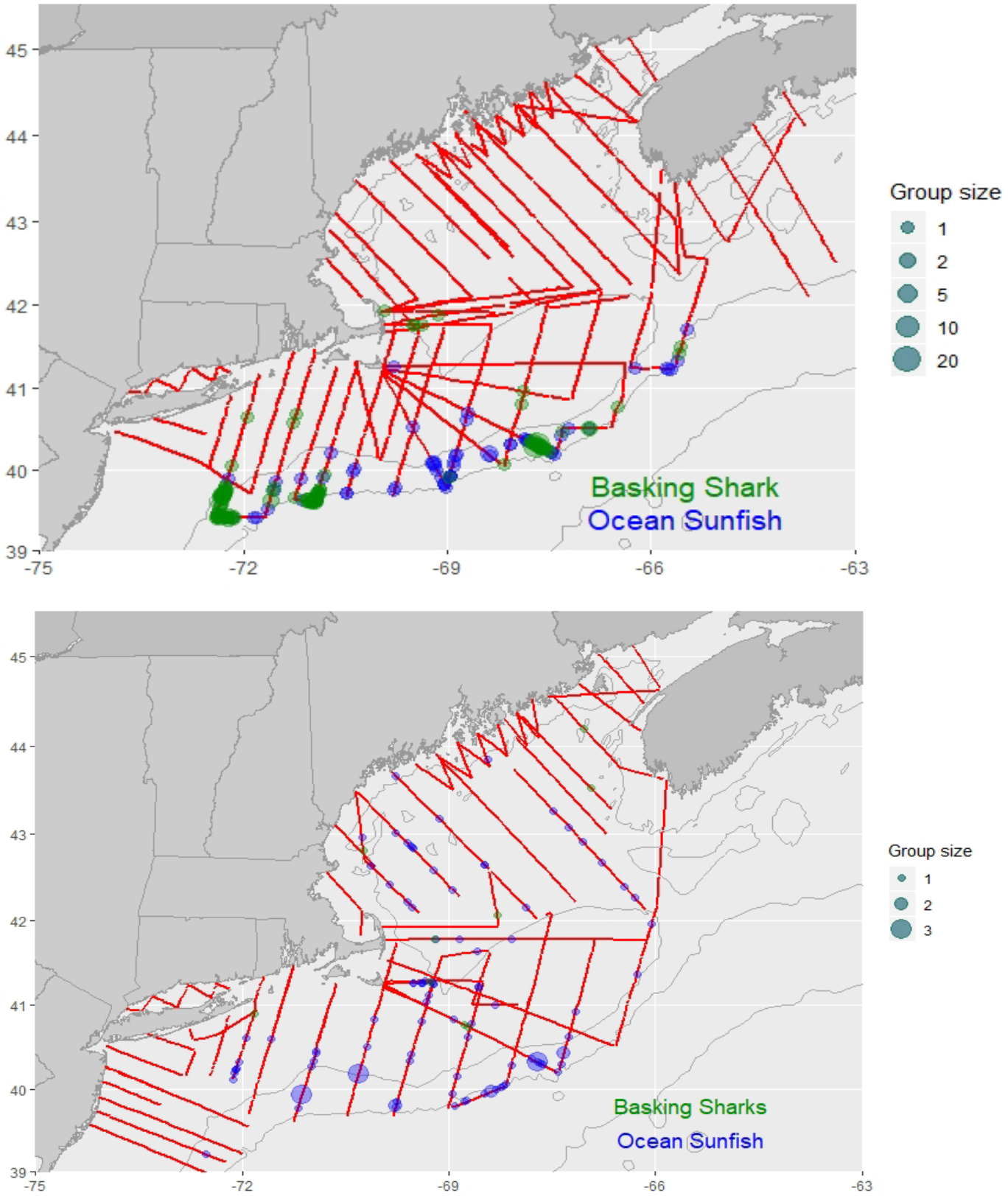


**Figure 2.11. Basking sharks (*Cetorhinus maximus*) and ocean sunfishes (*Mola mola*) from spring (top) and fall (bottom) surveys**

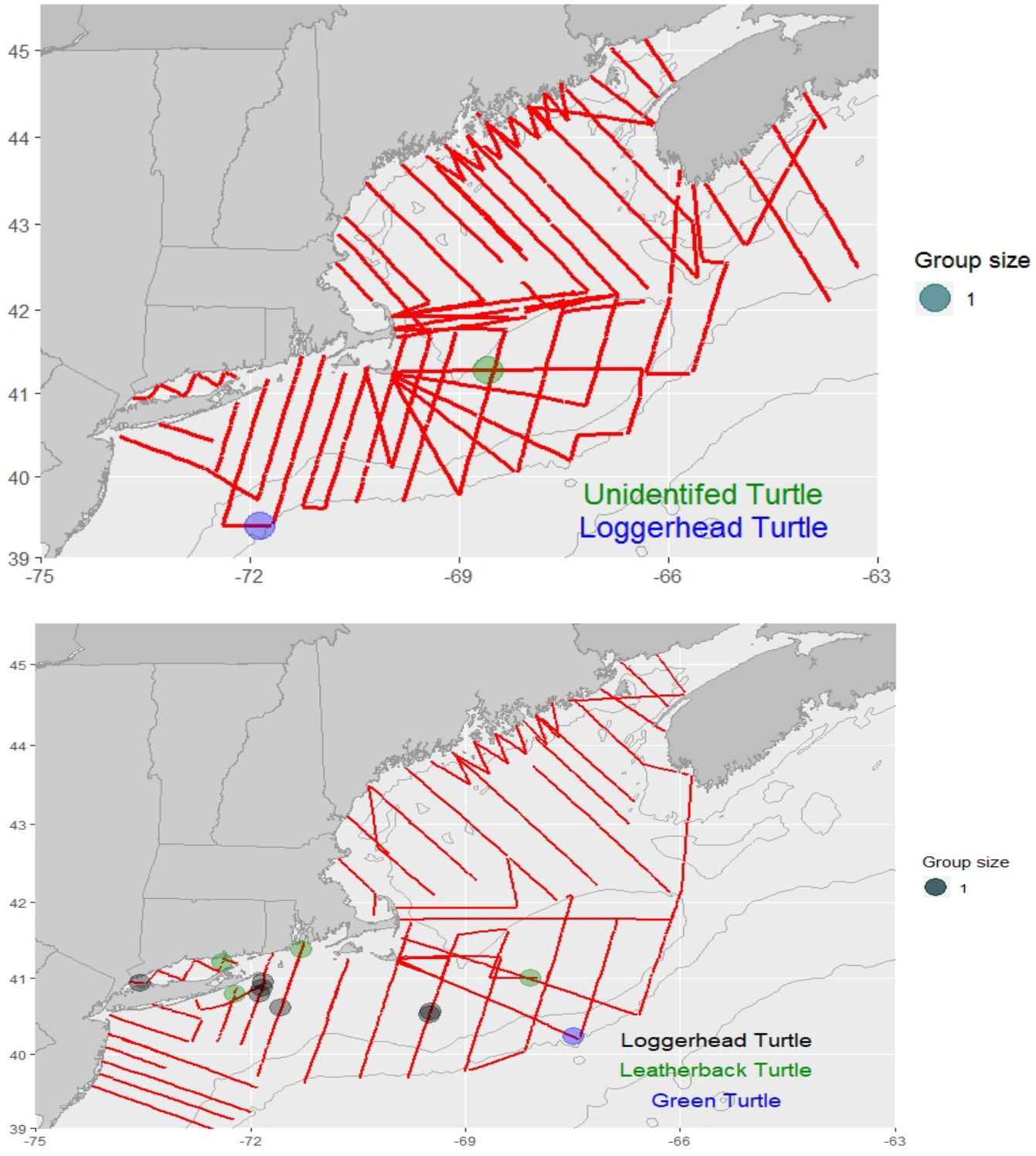


**Figure 2.12. Loggerhead turtles (*Caretta caretta*), leatherback turtles (*Dermochelys coriacea*), green turtles (*Chelonia mydas*) and unidentified hardshell turtles from spring (top) and fall (bottom) surveys**

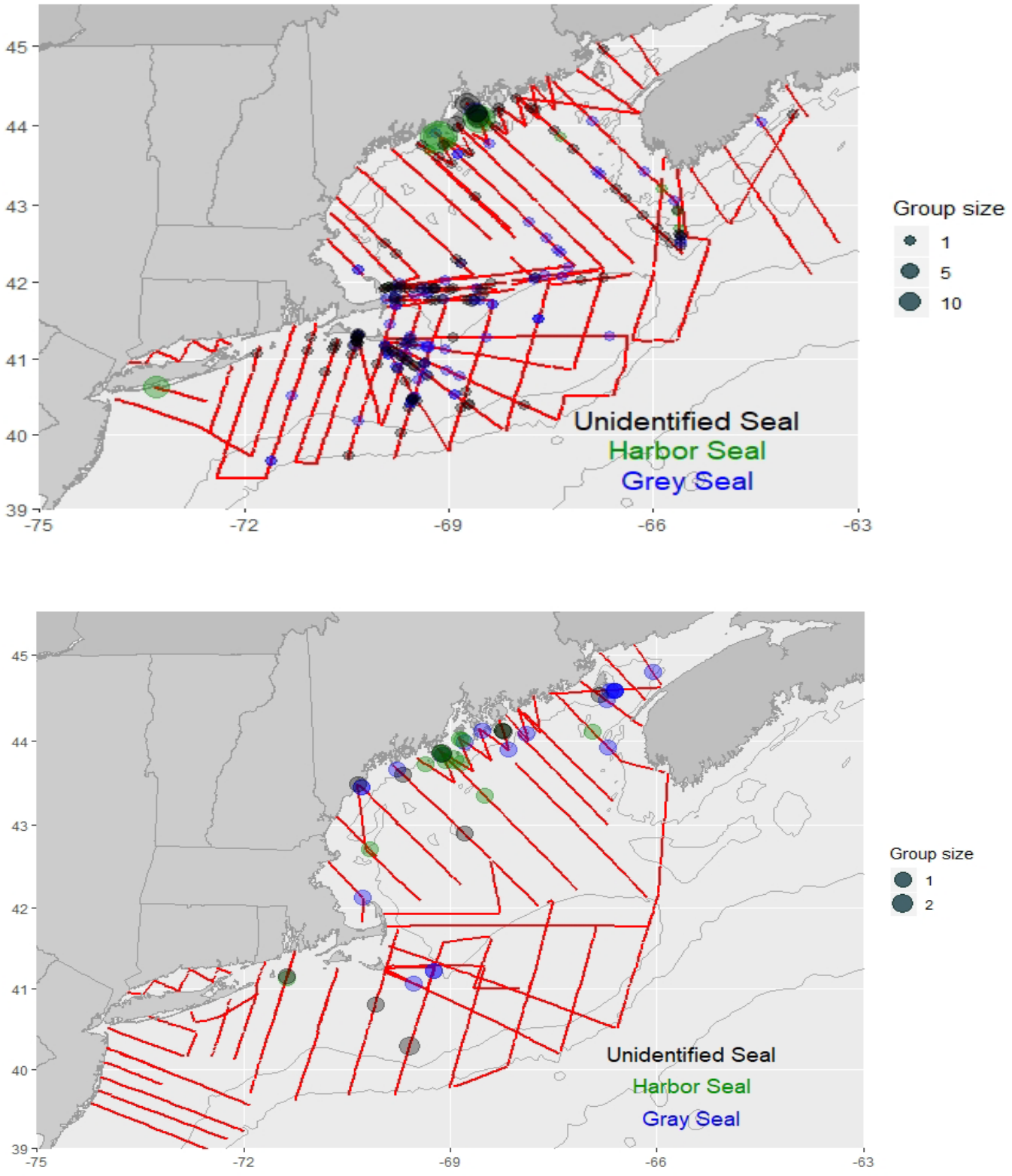


**Figure 2.13. Gray seals (*Halichoerus grypus*), harbor seals (*Phoca vitulina*) and unidentified seals detected at sea from spring (top) and fall (bottom) surveys**

# 3 Southern leg of two aerial abundance surveys during 2019: Southeast Fisheries Science Center

**Laura Aichinger Dias[1, 3], Kevin Barry[2], Lance P. Garrison[1]**
[1]Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami FL 33149
[2]Southeast Fisheries Science Center, 3209 Frederic St., Pascagoula, MS 39567
[3]Cooperative Institute for Marine and Atmospheric Studies, 4600 Rickenbacker Causeway, Miami FL 33149

## 3.1 Summary

As part of the AMAPPS program, the Southeast Fisheries Science Center conducted two aerial surveys on the continental shelf waters of the US east coast, from New Jersey to the Florida Keys. The surveys were conducted during spring (18 May – 24 June 2019) and winter (7 December 2019 – 25 January 2020) aboard a NOAA Twin Otter aircraft at an altitude of 600 ft (183 m) and a speed of 110 knots. Survey tracklines were oriented perpendicular to the shoreline and latitudinally spaced 20 km apart. The main goal of these surveys were to assess the distribution and abundance of marine mammals and sea turtles along the US east coast. The surveys were designed for analysis using Distance sampling and a two-team (independent observer) approach to correct for perception bias in resulting abundance estimates. During the spring 2019 survey, a total of 9,688 km of tracklines were surveyed on-effort and included 256 marine mammal sightings of 12 identified species. Fifty-seven percent of all spring 2019 sightings were common bottlenose dolphins (*Tursiops truncatus*), followed by Atlantic spotted dolphins (*Stenella frontalis*) and common dolphins (*Delphinus delphis*), with 12% each. Sea turtles totaled 1,302 sightings of 4 species and 1,765 individuals; unidentified hardshell turtles comprised 52% of all sightings. During the winter 2019/20 survey, a total of 6,082 km of tracklines were surveyed on-effort. Marine mammals accounted for 126 sightings of 6 identified species and 2 unidentified taxa, totaling 840 individuals. Eighty seven percent of all sightings were of common bottlenose dolphins. Sea turtles totaled 492 sightings of 5 species and 1 unidentified taxa, all including 600 individuals; loggerhead turtles (*Caretta caretta*) comprised 46% of all turtle sightings.

## 3.2 Objectives

The goal of these surveys were 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 (up to the ~200 m isobath) of the eastern USA.

## 3.3 Cruise Period and Area

The spring survey was conducted during 18 May – 24 June 2019. The winter survey was conducted during 7 Dec 2019 – 25 Jan 2020. The study area for both surveys extended from New Jersey to Key West, Florida. During the spring 2019 survey, a portion of the proposed tracklines off the southern coast of Georgia was not surveyed due to restricted airspace from military exercises (Figure 3.1). During the winter 2019/20 survey, due to unfavorable weather conditions (mainly fog and heavy winds) throughout the survey the northernmost area surveyed was off the Virginia coast. In addition, from northern South Carolina to Virginia, several segments of the

proposed tracklines were not surveyed due to military exercises being conducted over the area (Figure 3.2).

## 3.4 Methods

Similar to surveys performed by the NEFSC, discussed in Chapter 2, SEFSC surveys were conducted aboard a DeHavilland Twin Otter DHC-6 flying at an altitude of 183 m (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 surveys were conducted along tracklines oriented perpendicular to the shoreline and spaced latitudinally at approximately 20 km intervals starting at a random point.

To conduct the surveys, two pilots and two teams of three marine mammal observers each were onboard the plane. Both teams operated independently to implement the independent observer approach to correct for perception bias (Laake and Borchers 2004). The forward team (Team 1) consisted of two observers stationed in bubble windows on the left and right side of the airplane and an associated data recorder. The aft team (Team 2) consisted of a belly observer looking straight down through a belly port window, an observer stationed on the right side of the aircraft observing through a bubble window, and a dedicated data recorder. The bubble windows allowed downward visibility from approximately 0° in relation to the trackline to 60° upward. The belly observer can see approximately 35° on either side of the trackline. Therefore, the aft team had limited visibility off the left side of the aircraft. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

On 15 – 16 December 2019 and 13 – 14 January 2020 only, the survey was flown with five observers: three on the forward team (complete team) and two on the aft team (belly port and data recorder).

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

During on effort periods (e.g., level flight at survey altitude and speed), observers searched visually from the trackline (0˚) to approximately 60˚ 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. The belly observer only reported the interval for the sighting based on markings on the window (1 thru 4 left or right).

If a mammal sighting was initially seen by the forward observers, they waited until it was aft of the airplane to allow the aft team an opportunity to see the group. Once both teams had the chance to see it, observers asked the pilots to depart from the trackline to circle the sighting to verify species, count group sizes and take photographs. Sea turtle sightings were recorded independently by each team, i.e., without communication. Fish sightings were recorded opportunistically by each team.

Once back from the survey, the data were QA/QC'd and specifically for sea turtles, sightings recorded by each team were reviewed to identify duplicates based upon time, location, and position relative to the trackline.

## 3.5 Results

For the spring survey, 18 survey-days were flown during 18 May – 24 Jun 2019 (Table 3.1, Figure 3.1), covering most of the proposed study area, except for a portion off the Georgia coast. A total of 9,688 km of effort were performed over 106 tracklines. The average sea state during the survey was 2.7 on the Beaufort scale (Table 3.1, Figure 3.2).

During the winter survey, 14 survey-days were flown during 7 Dec 2019 – 24 Jan 2020. No effort was performed in the northern portion of the study area (north of Virginia) (Figure 3.1). Total effort was 6,081.5 km and the average sea state during the survey was 3.1 on the Beaufort scale (Table 3.2, Figure 3.2).

For the spring survey, 256 cetacean sightings including 3,092 individuals were recorded and for the winter survey, 126 cetacean sightings with 840 individuals (Table 3.3). The primary species observed in both surveys was the common bottlenose dolphin with 145 sightings and 1,239 individuals in the spring survey and 110 sightings and 665 individuals during the winter. Other regularly seen species were common dolphins with 31 sightings and 913 individuals and Atlantic spotted dolphins also with 31 sightings and 461 individuals during the spring survey and 7 sightings with 132 individuals of Atlantic Spotted dolphins during the winter survey. Other delphinids detected included Risso's dolphins, pilot whales and rough-toothed dolphins. Eight sightings of baleen whales were recorded during the spring survey and included the common minke, fin and humpback whales. In the winter, the common minke and humpback whales were also seen and in addition, two individuals of North Atlantic right whales. During the spring survey, two cryptic species (Cuvier's beaked whale and pygmy or dwarf sperm whale) were observed as well as one sighting of sperm whales.

For both surveys, Atlantic spotted dolphins were mostly seen south of North Carolina and bottlenose dolphins were concentrated of the Florida/Georgia coasts during the winter survey (Figure 3.3). Common dolphins, Risso's dolphins, pilot whales, as well as all the baleen whales were seen in the northern portion of the survey area during the spring survey (Figures 3.4 – 3.5). During the winter survey, humpback and common minke whales were seen off the Florida coast (Figure 3.5). The two cryptic species seen during the spring survey were recorded north of Cape Hatteras, NC (Figure 3.6).

There was a total of 1,302 unique sightings of sea turtles with 1,765 individuals during the spring survey and 492 unique sightings with 600 individuals during the winter (Table 3.4). For both surveys, loggerhead turtles were the most commonly identified species with 543 sightings and 614 individuals in the spring survey and 227 sightings and 263 individuals in the winter. Green turtles were the second most commonly identified species, with 44 sightings and 52 individuals during the spring survey and 44 sightings with 85 individuals in the winter, followed by leatherbacks with 24 and 21 sightings for spring and winter, respectively. A large portion of sightings included unidentified "hardshell" turtles, which is a generic term that includes all sea turtle species, except leatherbacks, when identification to the species level is not possible. This class accounted for 51% and 39% of all sea turtle sightings for the spring and winter surveys, respectively.

During the spring survey, most sea turtle sightings were recorded off the coasts of Virginia, Delaware and Florida, whereas in the winter survey, most sea turtle sightings were recorded off the coasts of Georgia and Florida; however effort in some of these areas was different between surveys (Figures 3.7 – 3.10).

Opportunistic fish species sighted during the spring survey included primarily ocean sunfish followed by hammerhead and basking sharks (Table 3.5). In the winter survey, most commonly seen species included hammerhead sharks and sunfish (in this order) and in both surveys; great white sharks and manta rays were also seen. In the spring survey, all basking shark sightings were seen in the northern portion of the study area together with sightings of great white sharks, whereas the great white shark sightings recorded during the winter were off the Georgia/Florida coast (Figure 3.11). For both surveys, manta rays were primarily seen off the Florida coast and the vast majority of sunfish sightings in the spring were recorded north of Virginia; however effort in some of these areas was different between surveys (Figures 3.12 – 3.14).

## 3.6 Disposition of Data

All data collected during the aerial survey are archived and managed at the Southeast Fisheries Science Center (SEFSC), Miami, FL. The final audited version is also archived in the Northeast Fisheries Science Center (NEFSC) ORACLE database. The line transect data are available online on the OBIS-SEAMAP website.

## 3.7 Permits

The SEFSC was authorized to conduct marine mammal research activities during the survey under Permit No. 21938 issued to the SEFSC by the National Marine Fisheries Service (NMFS).

## 3.8 Acknowledgements

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Flight time and other aircraft costs were funded by National Oceanic and Atmospheric Administration (NOAA) Aircraft Operations Center and NOAA Fisheries Service, Southeast Fisheries Science Center and Northeast Fisheries Science Center. Staff time was provided by the Southeast Fisheries Science Center and NOAA Aircraft Operations Center. We would also like to thank the airplane's crew and observers that were involved in collecting these data.

## 3.9 References Cited

Laake JL, Borchers DL. 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 3.1. Daily summary of on-effort track line length (km) and sightings during the southeast aerial survey, spring 2019**

| Date in 2019 | Track Length (km) | Number of Cetacean Sightings | Number of Turtle Sightings | Ave Sea State |
|---|---|---|---|---|
| 18-May | 761.4 | 27 | 1 | 2.1 |
| 21-May | 304.7 | 17 | 15 | 2.8 |
| 22-May | 589.8 | 28 | 34 | 2.7 |
| 24-May | 453.4 | 11 | 55 | 2.8 |
| 25-May | 461.5 | 11 | 139 | 3.1 |
| 27-May | 751.7 | 26 | 208 | 2.8 |
| 29-May | 470.4 | 22 | 151 | 2.6 |
| 1-Jun | 326.3 | 0 | 5 | 3.4 |
| 2-Jun | 841.7 | 6 | 23 | 2.3 |
| 3-Jun | 461.6 | 12 | 16 | 2.5 |
| 6-Jun | 816.1 | 5 | 133 | 2.8 |
| 7-Jun | 287.7 | 5 | 138 | 2.7 |
| 15-Jun | 522.5 | 7 | 12 | 3.2 |
| 16-Jun | 629.1 | 17 | 44 | 2.2 |
| 17-Jun | 249 | 10 | 4 | 3.2 |
| 22-Jun | 473.6 | 11 | 58 | 2.9 |
| 23-Jun | 739.8 | 20 | 238 | 2.2 |
| 24-Jun | 547.9 | 21 | 28 | 3.4 |
| TOTAL | 9,688.4 | 256 | 1,302 | 2.7 |

**Table 3.2. Daily summary of on-effort track line length (km), number of sightings and average sea state in the Beaufort scale during southeast aerial survey, winter 2019/2020.**

| Date in 2019 or 2020 | Track length (km) | Number of Cetacean Sightings | Number of Turtle Sightings | Ave. Sea State |
|---|---|---|---|---|
| 7-Dec-2019 | 213.5 | 1 | 18 | 3.0 |
| 9-Dec | 655.1 | 9 | 81 | 2.5 |
| 11-Dec | 576.9 | 6 | 106 | 3.1 |
| 15-Dec | 894.9 | 42 | 67 | 2.6 |
| 16-Dec | 211.7 | 8 | 19 | 1.9 |
| 1-Jan-2020 | 275.5 | 3 | 6 | 3.7 |
| 2-Jan | 691.6 | 22 | 92 | 2.1 |
| 6-Jan | 530.8 | 5 | 9 | 3.6 |
| 8-Jan | 431.8 | 7 | 10 | 3.8 |
| 13-Jan | 244.2 | 3 | 27 | 2.9 |
| 14-Jan | 472.8 | 3 | 9 | 3.2 |
| 15-Jan | 144.0 | 2 | 6 | 2.4 |
| 23-Jan | 347.0 | 10 | 2 | 5.0 |
| 24-Jan | 391.7 | 5 | 40 | 4.2 |
| TOTAL | 6,081.5 | 126 | 492 | 3.1 |

**Table 3-3. Summary of cetacean sightings during southeast aerial surveys, spring 2019 and winter 2019/2020.**

| Common Name | Scientific Name | Spring 2019 Sightings | Spring 2019 Animals | Winter 2019/2020 Sightings | Winter 2019/2020 Animals |
|---|---|---|---|---|---|
| Atlantic spotted dolphin | *Stenella frontalis* | 31 | 461 | 7 | 132 |
| Common bottlenose dolphin | *Tursiops truncatus* | 145 | 1,239 | 110 | 665 |
| Bottlenose/Spotted dolphin | *T. truncatus* or *S. frontalis* | 11 | 24 | 1 | 13 |
| Common dolphin | *Delphinus delphis* | 31 | 913 | 0 | 0 |
| Cuvier's beaked whale | *Ziphius cavirostris* | 1 | 3 | 0 | 0 |
| Fin whale | *Balaenoptera physalus* | 2 | 3 | 0 | 0 |
| Humpback whale | *Megaptera novaeangliae* | 4 | 6 | 1 | 1 |
| Minke whale | *B. acutorostrata* | 2 | 3 | 1 | 1 |
| Pilot whales | *Globicephala* sp. | 13 | 247 | 2 | 22 |
| Pygmy/Dwarf sperm whale | *Kogia sp.* | 1 | 1 | 0 | 0 |
| Risso's dolphin | *Grampus griseus* | 11 | 179 | 0 | 0 |
| Rough-toothed dolphin | *Steno bredanensis* | 1 | 3 | 0 | 0 |
| Sperm whale | *Physeter macrocephalus* | 1 | 2 | 0 | 0 |
| North Atlantic right whale | *Eubalaena glacialis* | 0 | 0 | 1 | 2 |
| Unidentified Dolphin | - | 2 | 8 | 3 | 4 |
| TOTAL | | 256 | 3,092 | 126 | 840 |

**Table 3-4. Summary of sea turtle sightings during southeast aerial surveys, spring 2019 and winter 2019/2020.**

| Common Name | Scientific Name | Spring 2019 Sightings | Spring 2019 Animals | Winter 2019/2020 Sightings | Winter 2019/2020 Animals |
|---|---|---|---|---|---|
| Green Turtle | *Chelonia mydas* | 44 | 52 | 44 | 85 |
| Hardshell turtle | - | 669 | 1,053 | 190 | 220 |
| Hawksbill turtle | *Eretmochelys imbricata* | 0 | 0 | 2 | 2 |
| Kemp's ridley turtle | *Lepidochelys kempii* | 22 | 22 | 8 | 9 |
| Leatherback turtle | *Dermochelys coriacea* | 24 | 24 | 21 | 21 |
| Loggerhead turtle | *Caretta caretta* | 543 | 614 | 227 | 263 |
| TOTAL | | 1,302 | 1,765 | 492 | 600 |

**Table 3-5. Summary of opportunistic fish sightings during southeast aerial surveys, spring 2019 and winter 2019/2020.**

| Common Name | Scientific Name | Spring 2019 Sightings | Spring 2019 Animals | Winter 2019/2020 Sightings | Winter 2019/2020 Animals |
|---|---|---|---|---|---|
| Basking shark | *Cetorhinus maximus* | 41 | 71 | 0 | 0 |
| Blue shark | *Prionace glauca* | 7 | 7 | 0 | 0 |
| Chilean devil ray | *Mobula tarapacana* | 0 | 0 | 1 | 1 |
| Great white shark | *Carcharodon carcharias* | 2 | 2 | 2 | 2 |
| Hammerhead shark | *Sphyrnidae* sp. | 59 | 62 | 35 | 44 |
| Manta ray | *Manta* sp. | 28 | 28 | 12 | 13 |
| Shark school | - | 1 | 1 | 0 | 0 |
| Ocean sunfish | *Mola mola* | 110 | 116 | 24 | 29 |
| Unidentified ray | - | 10 | 11 | 7 | 7 |
| Unidentified shark | - | 126 | 191 | 37 | 53 |
| TOTAL | | 384 | 489 | 118 | 149 |

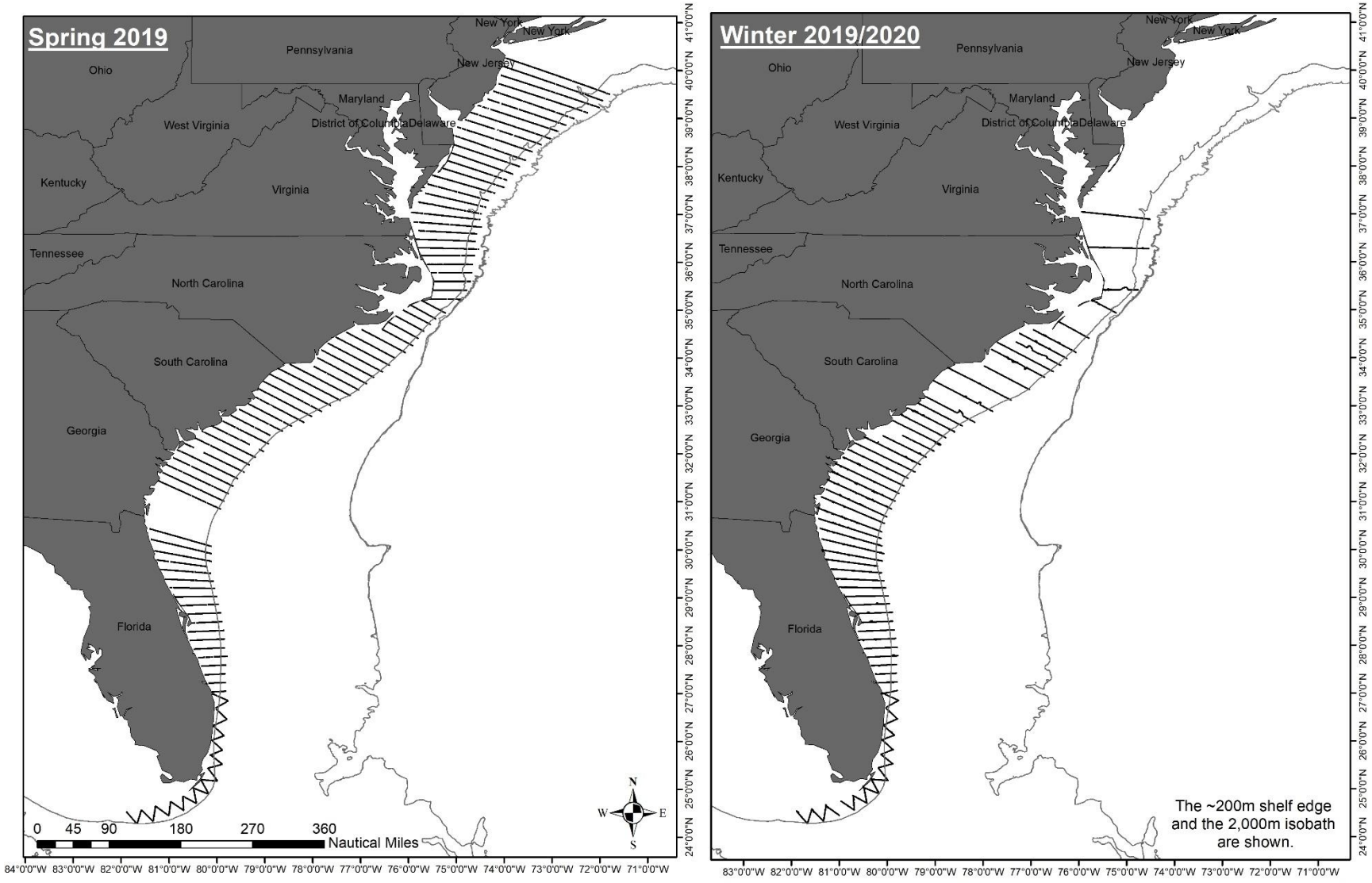


**Figure 3-1. On-effort tracklines during southeast aerial surveys, spring 2019 and winter 2019/2020**

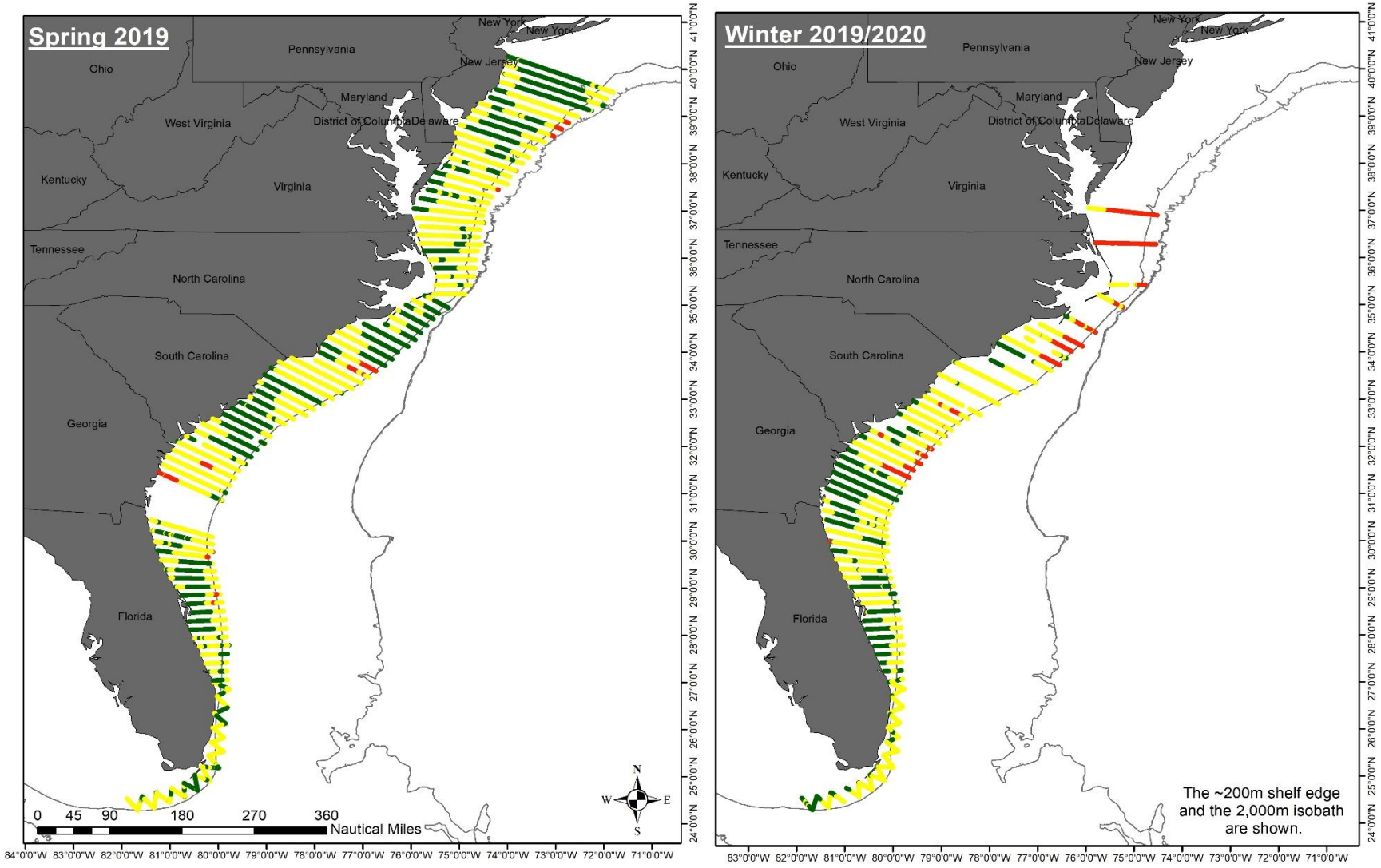


**Figure 3-2. Sea state condition (Beaufort scale) for on-effort tracklines during southeast aerial surveys, spring 2019 and winter 2019/2020**

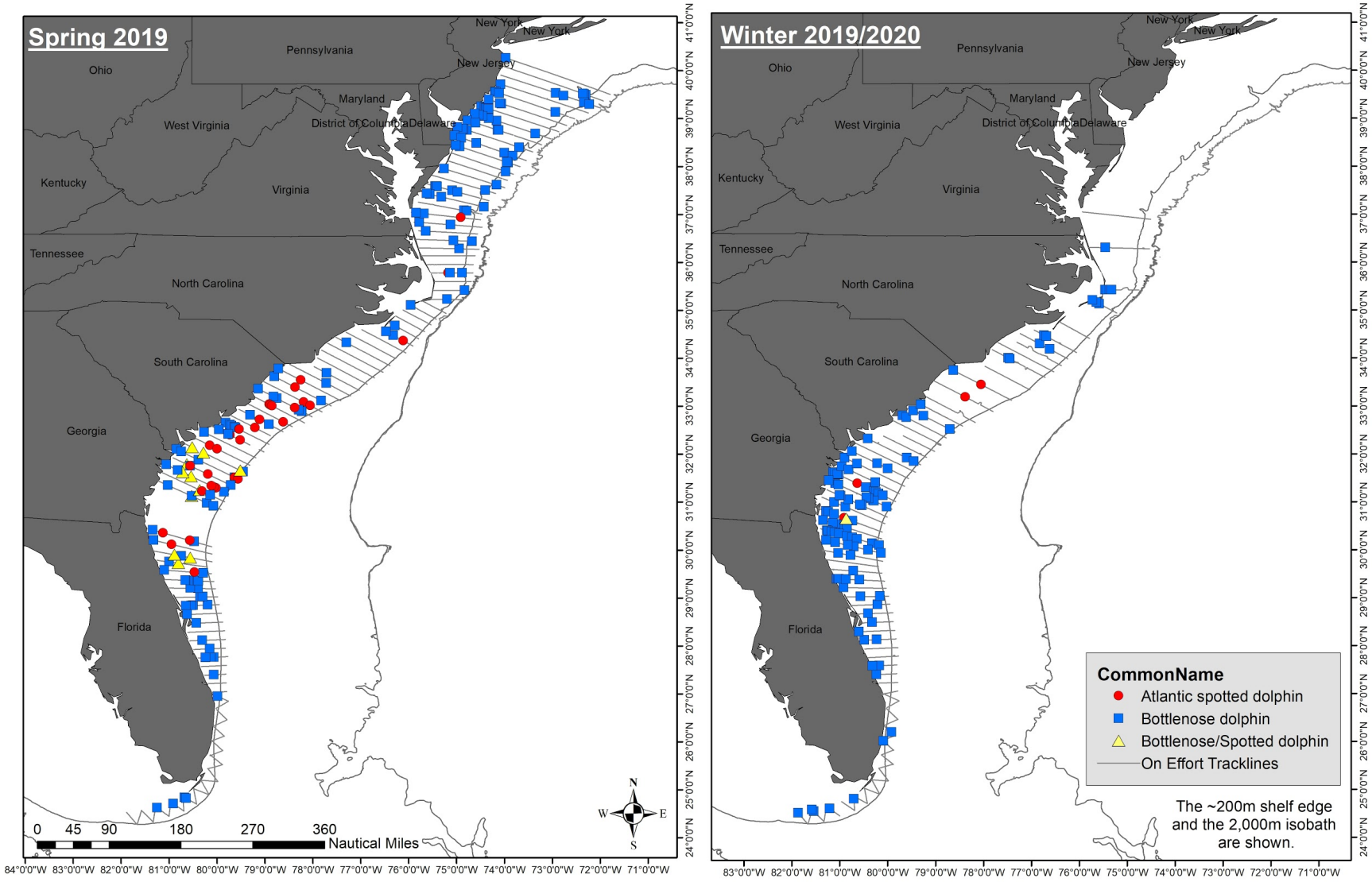


**Figure 3-3. Atlantic spotted and common bottlenose dolphin sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

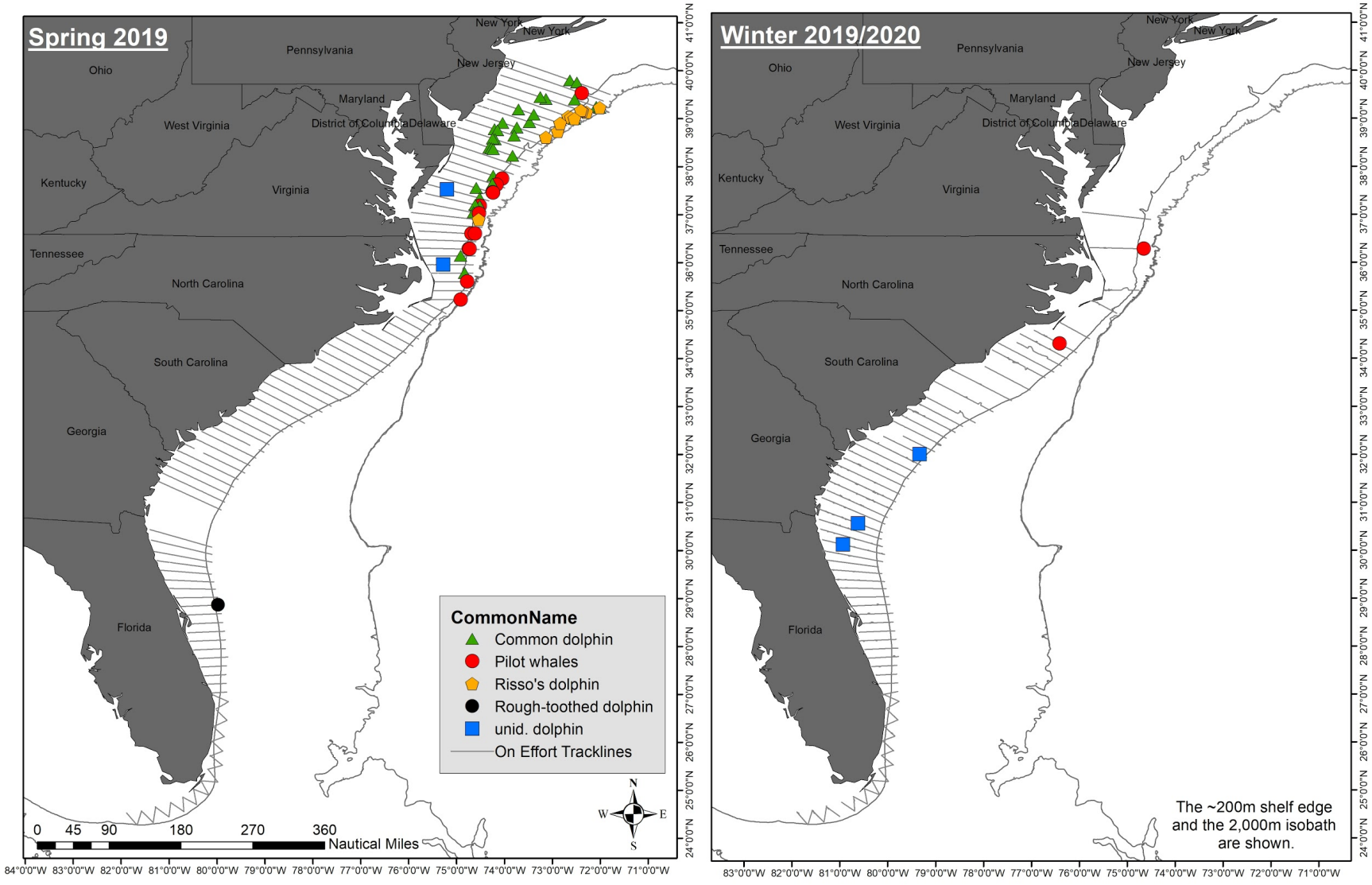


**Figure 3-4. Other Delphinid sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

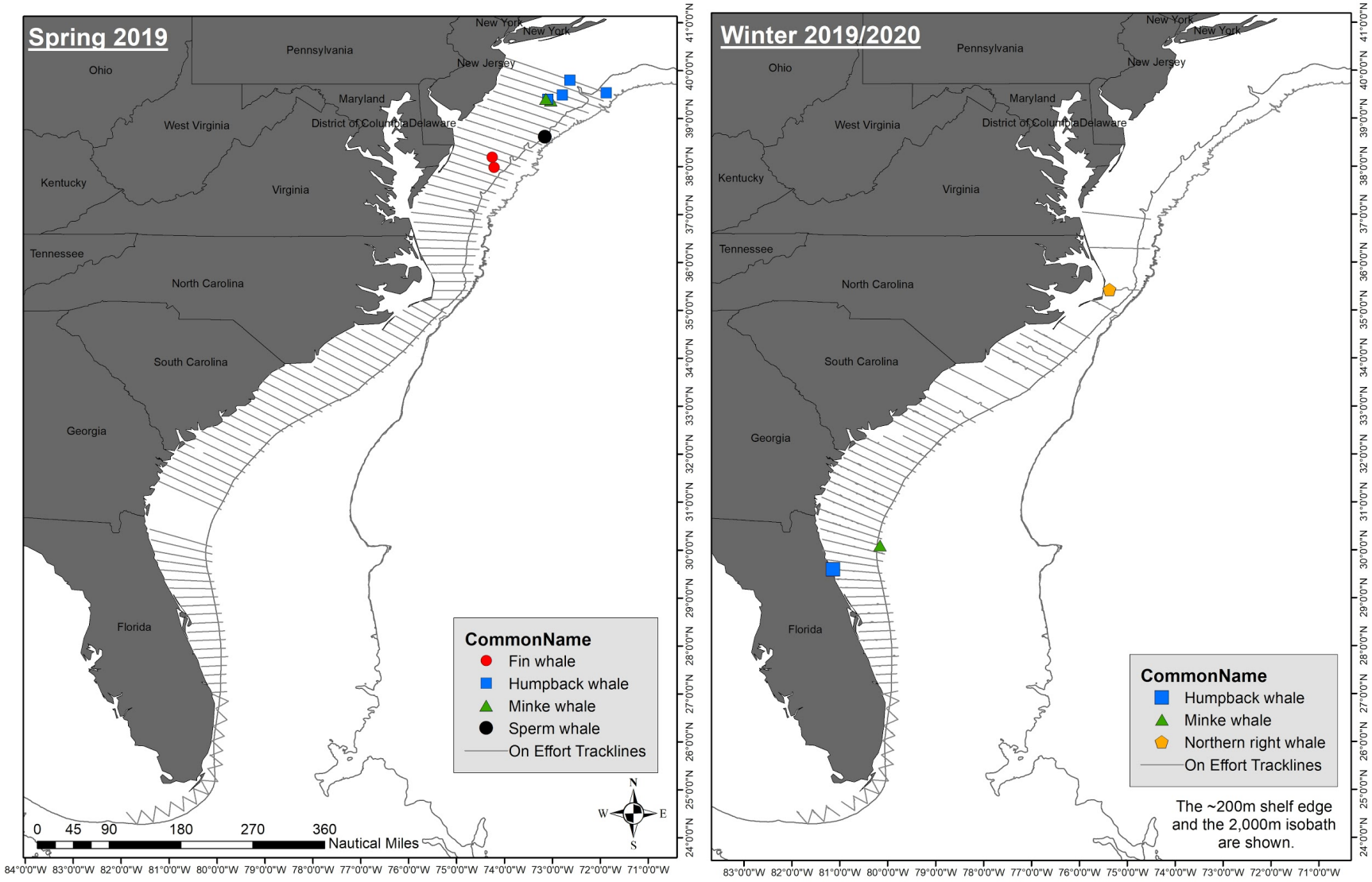


**Figure 3-5. Large whale sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

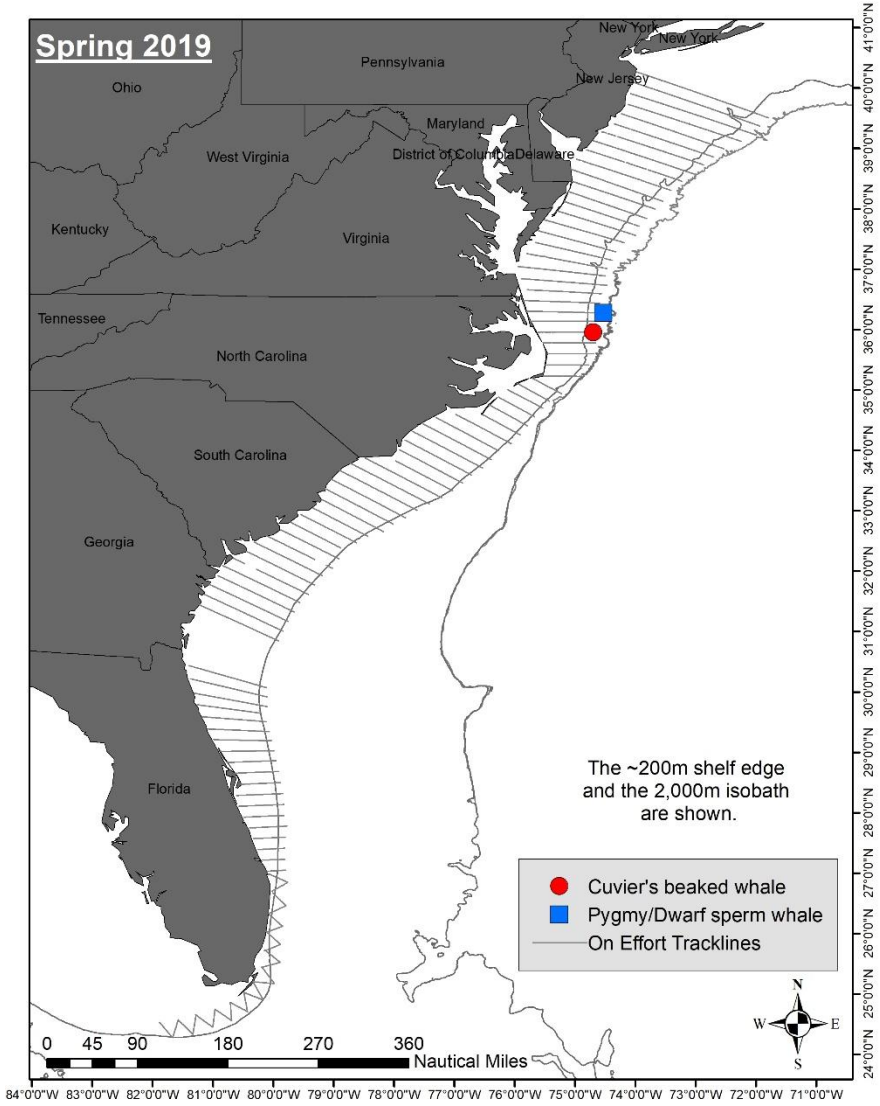


**Figure 3-6. Cryptic species sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

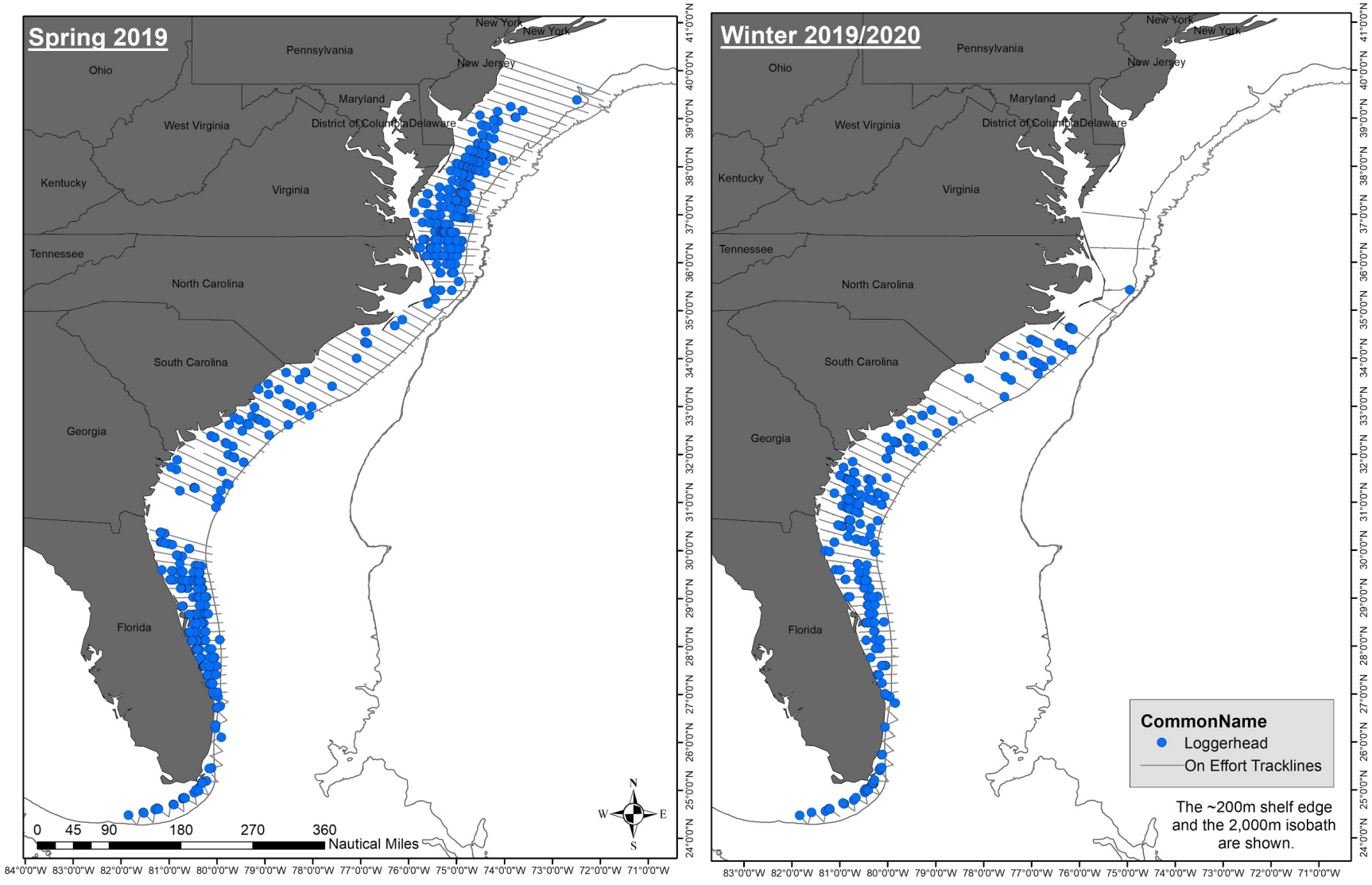


**Figure 3-7. Loggerhead turtle sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

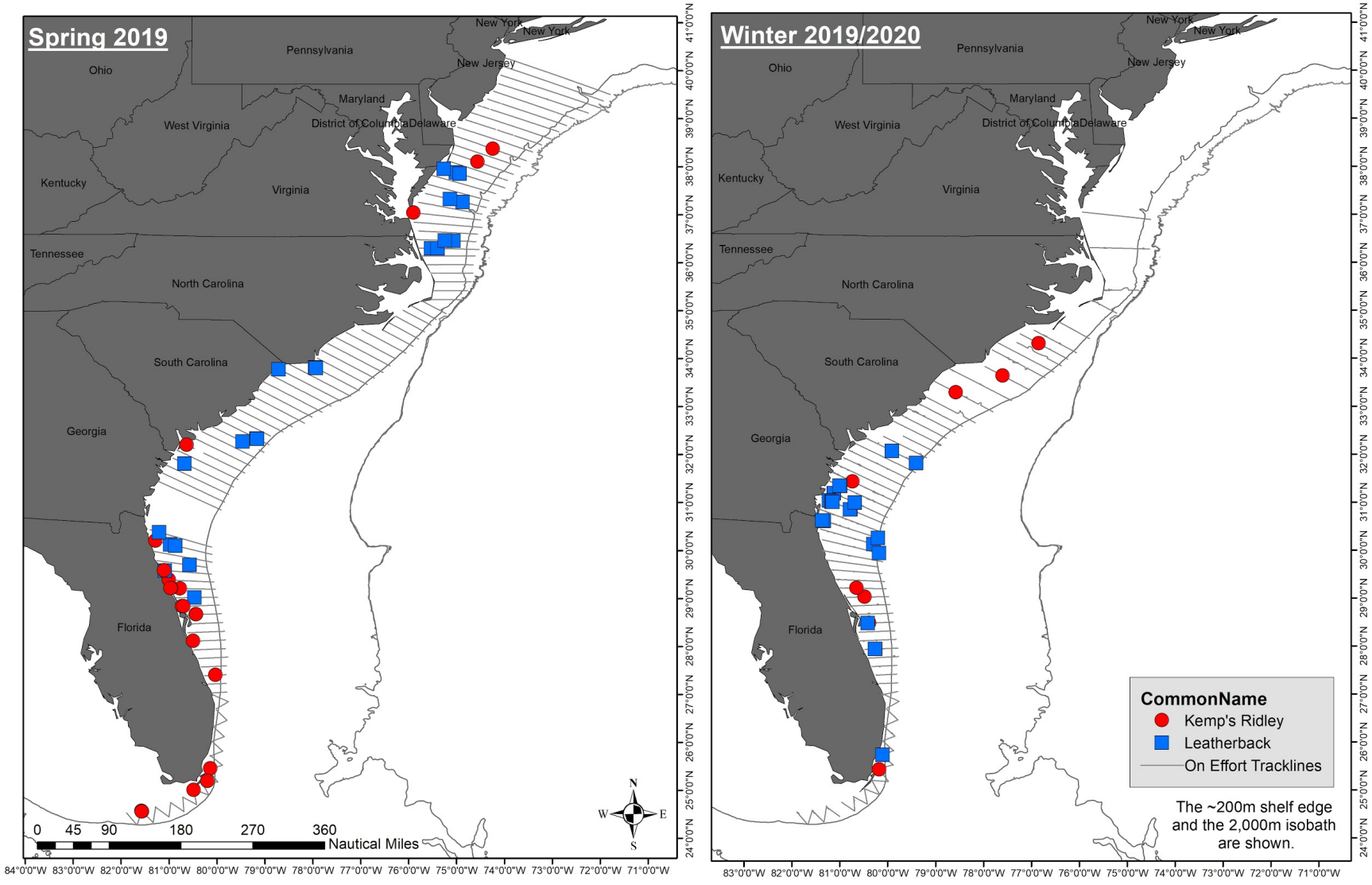


**Figure 3-8. Kemp's Ridley and leatherback turtle sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

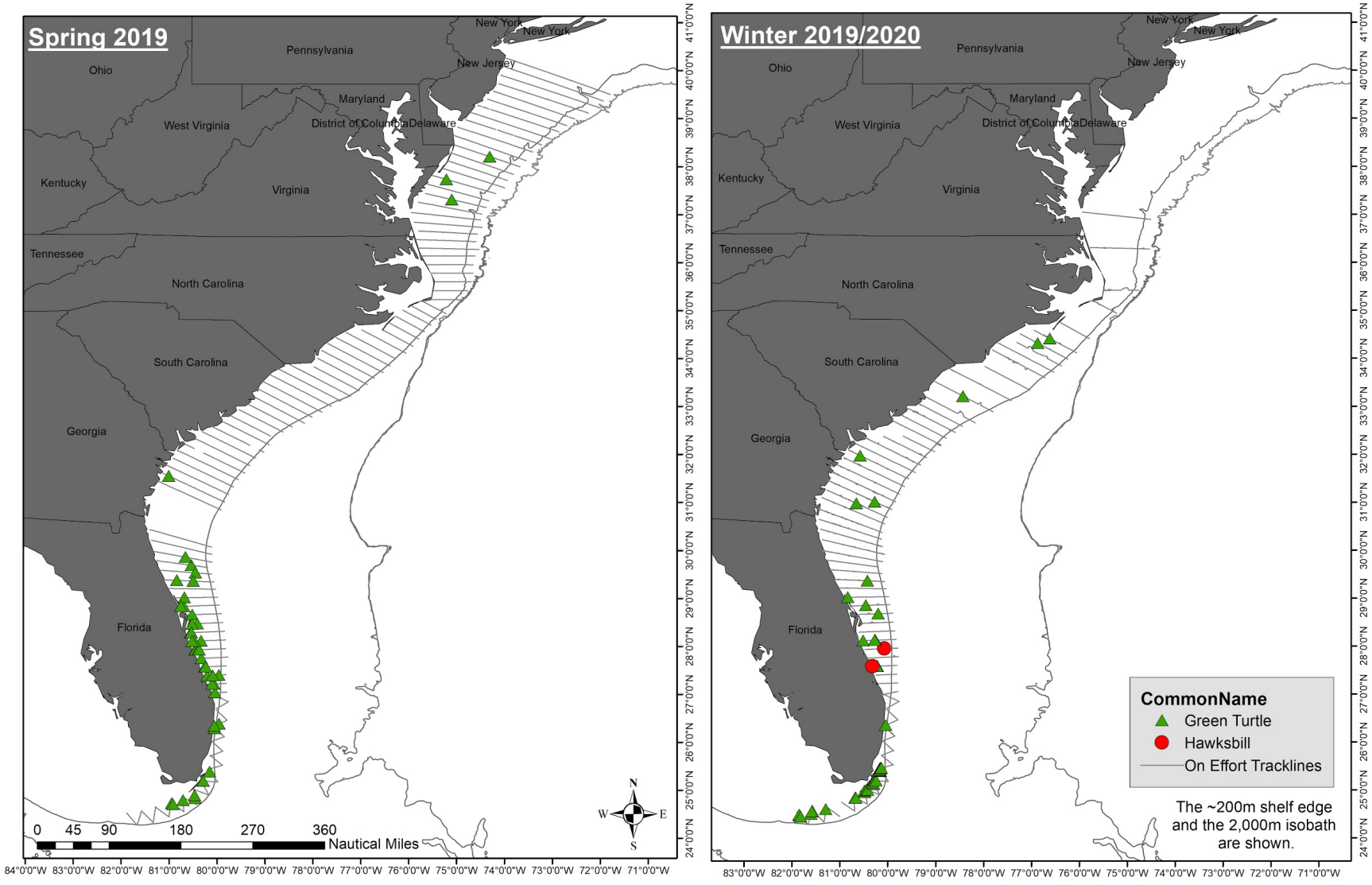


**Figure 3-9. Hawksbill and green turtle sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

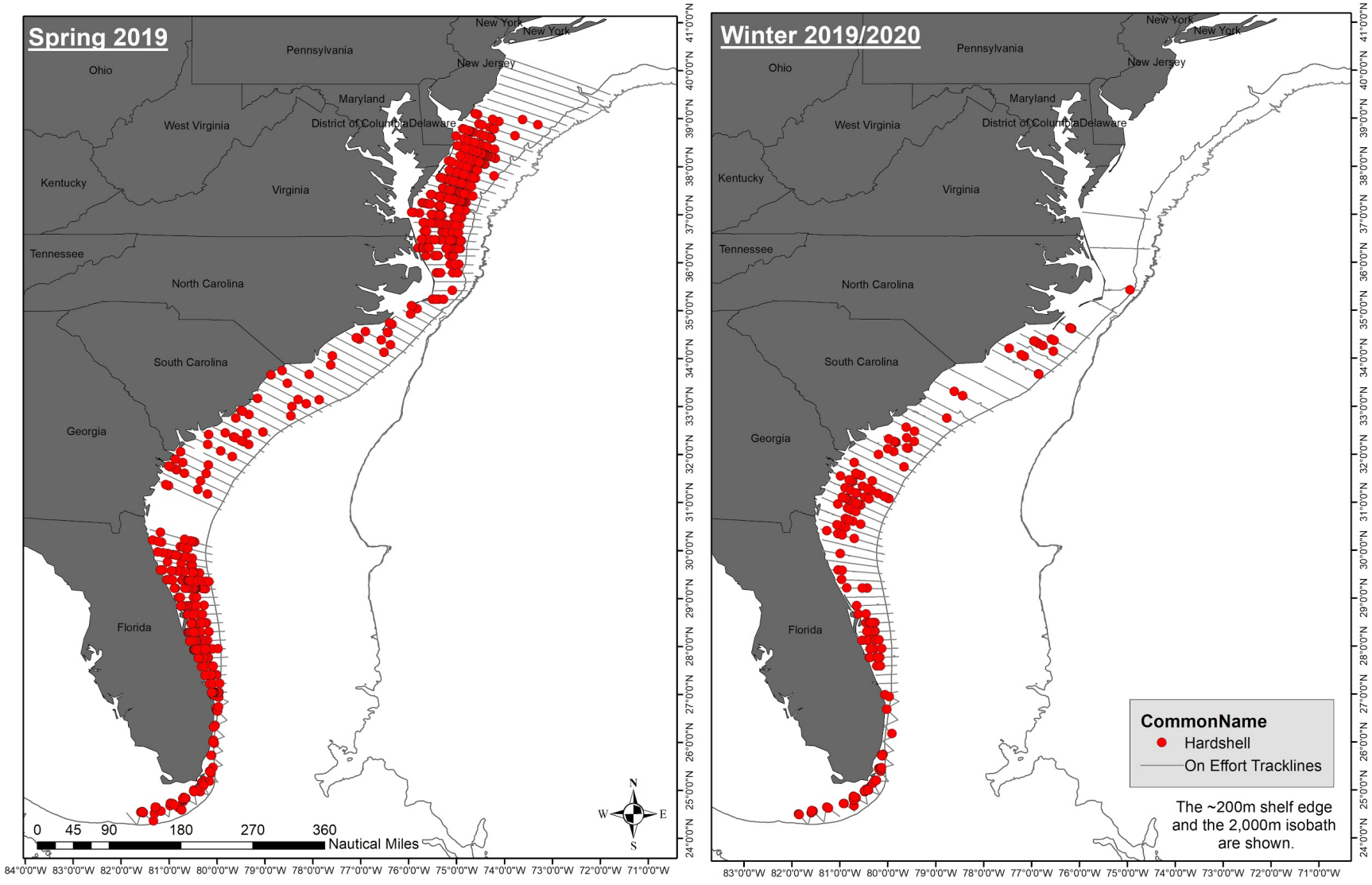


**Figure 3-10. Hardshell turtles sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

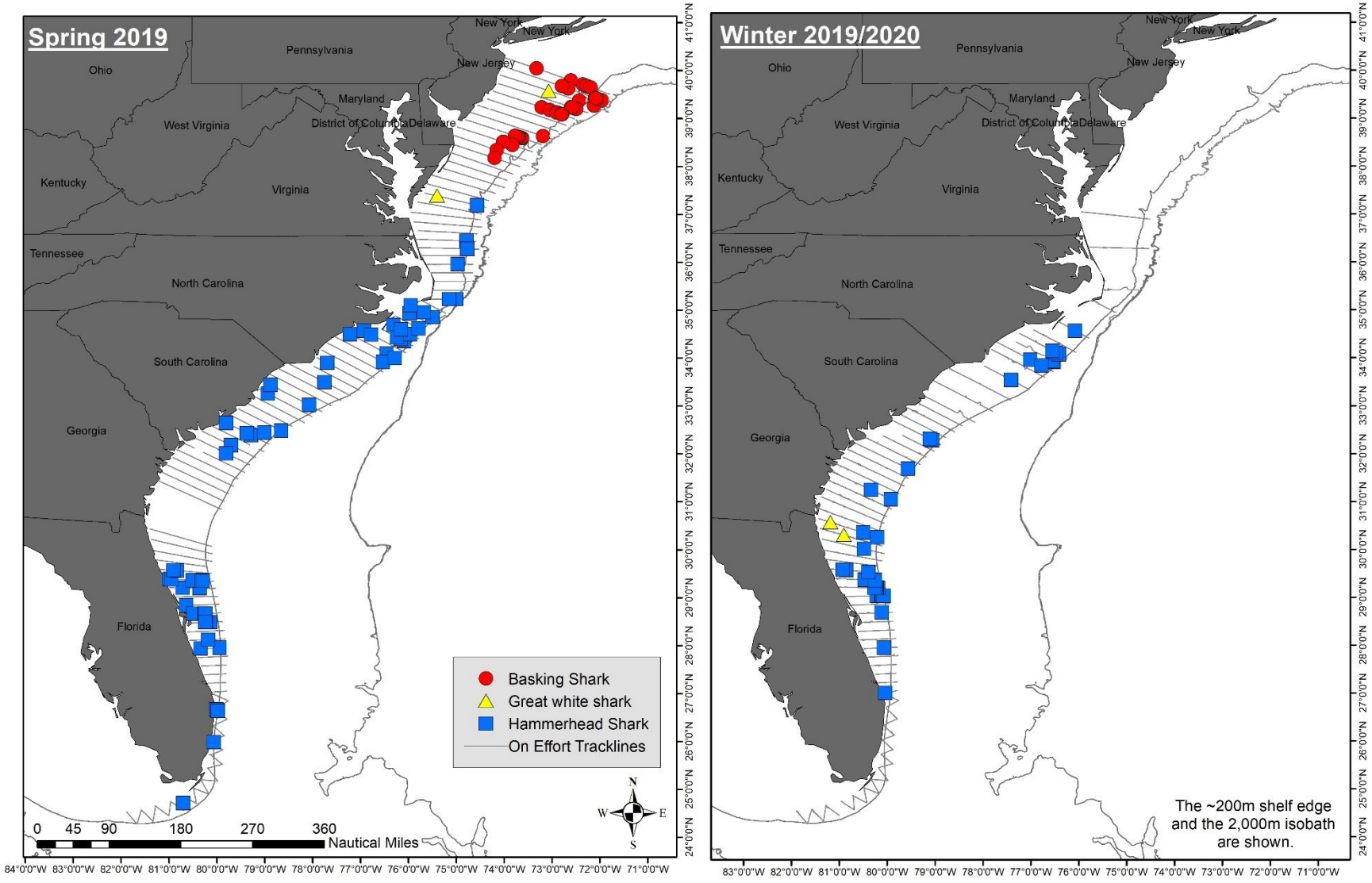


**Figure 3-11. Basking, great white and hammerhead shark sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

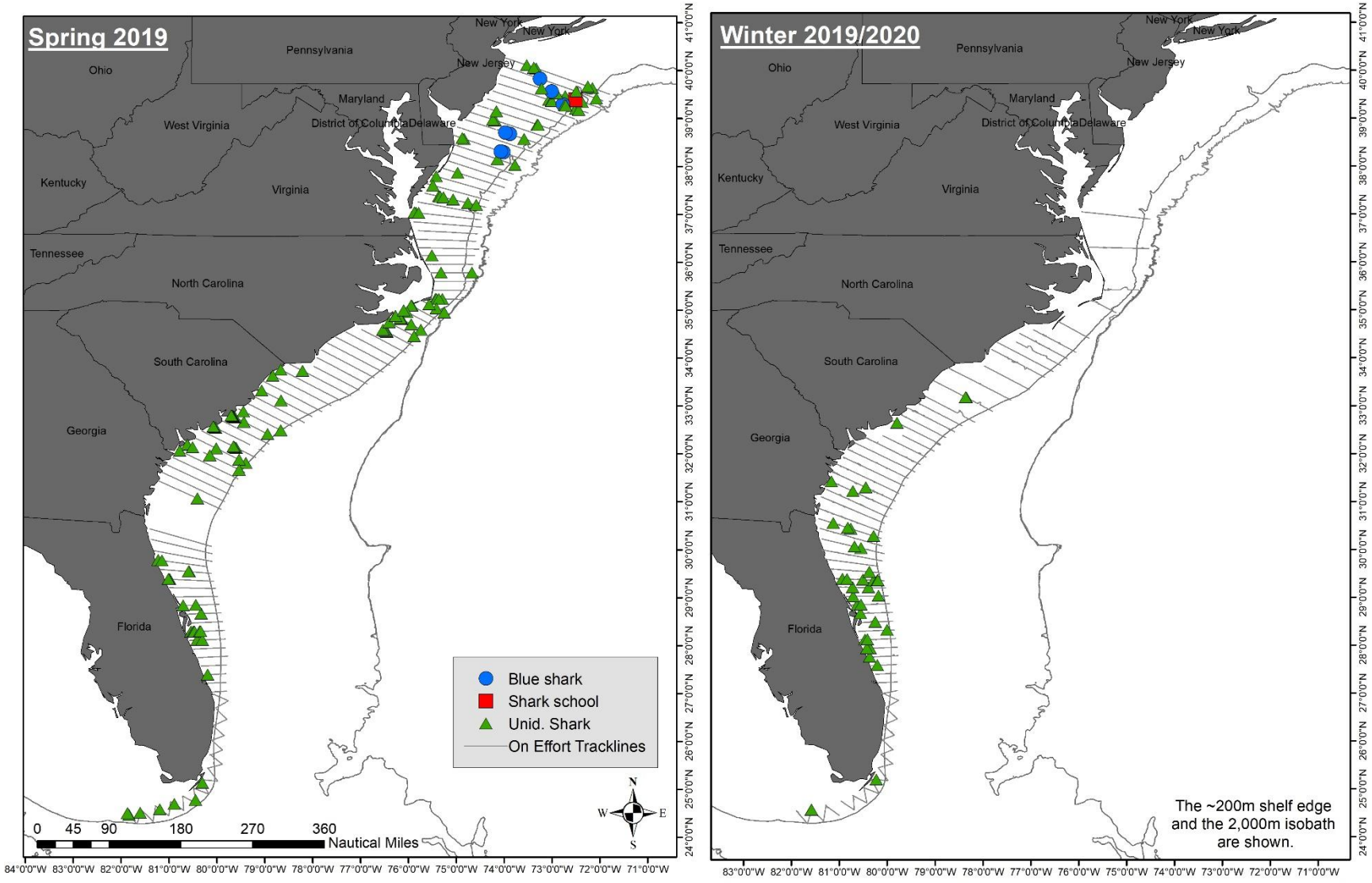


**Figure 3-12. Other shark sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

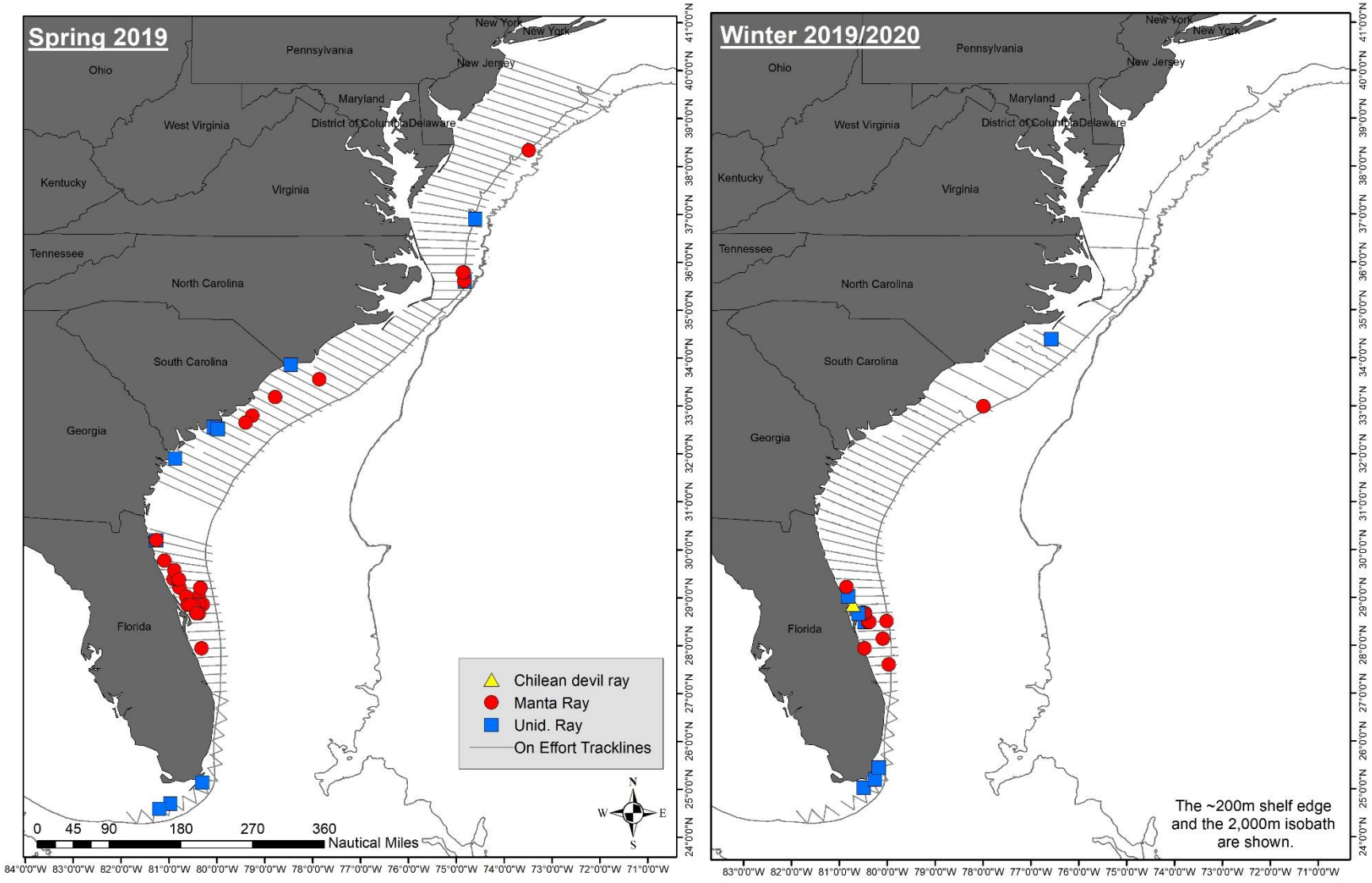


**Figure 3-13. Rays sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

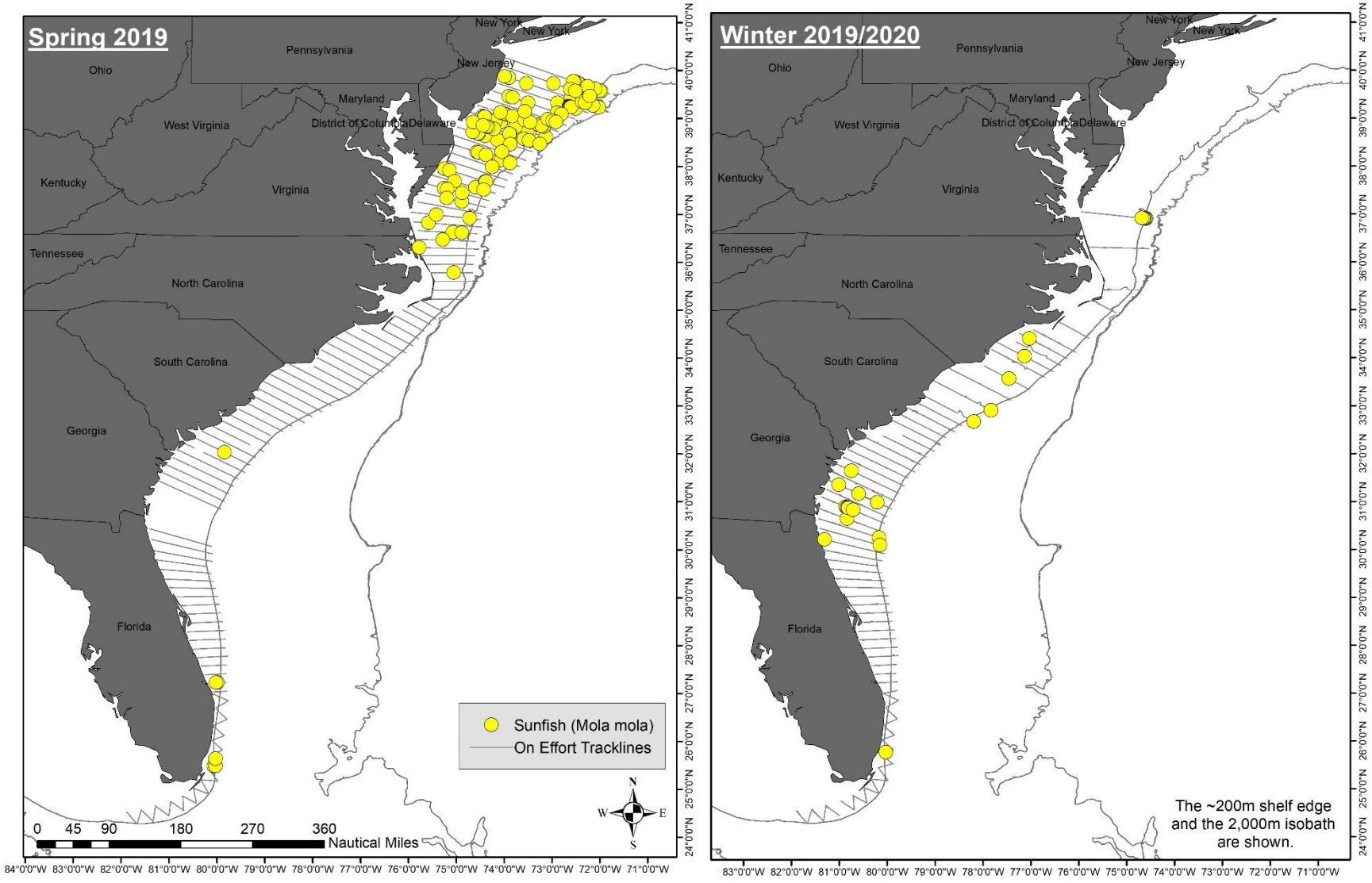


**Figure 3-14. Sunfish sightings during southeast aerial surveys, spring 2019 and winter 2019/2020**

# 4 Investigating southern New England right whale habitat: A pilot study with the University of Rhode Island, 18 – 23 April 2019

**Christopher Orphanides, Elisabeth Broughton, Mike Jech**
Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543

## 4.1 Summary

During 18 – 23 April 2019, the National Science Foundation ship *R/V Endeavor* operated by the University of Rhode Island (URI) conducted a Rhode Island Endeavor Program (RIEP) research cruise intended to explore North Atlantic right whale (*Eubalaena glacialis*) distribution relative to prey layers and physical oceanography south of New England in wind energy regions. The protocols deployed and fine-tuned during this pilot study built off a similar studies in 2017 and 2018. These protocols could provide potential methods used for future high-resolution process studies conducted in regions of interest such as potential energy development regions. The Atlantic Marine Assessment Program for Protected Species (AMAPPS) contributed contractor funds for one marine mammal observer and partial time for one staff member to run a Video Plankton Recorder (VPR). The cruise ran transects to locate marine mammals and deployed a variety of oceanographic and prey sampling methodologies that included: bongo nets, Tucker trawl, ring net, TDRs (time depth recorders), CTDs (Conductivity Temperature Depth sensor), VPR, ADCP (Acoustic Doppler Current Profiler), underway thermosalinograph (TSG) temperature and salinity data, and active acoustics collected with a tow body equipped with 120, 200, and 420 kHz Biosonics transducers. The cruise also tested low-cost custom-built hydrophones and underwater cameras for listening to whales and observing plankton and particle flux. The weather on this short cruise was quite challenging, limiting both visibility and the ship's ability to safely reach areas where whales were recently present. We sighted two minke whales (*Balaenoptera acutorostrata)* and a seal, but unfortunately no right whales. Zooplankton data collected have been sent to Poland for processing, echosounding data are being explored in the vicinity of the minke whale sightings, and VPR data processing is underway. Further research is planned on the *Endeavor* for September 2020 to further investigate right whale foraging in this area. Current plans for the upcoming cruise include an increased reliance on hydrophones to decrease the reliance on good weather for visual searching of whales.

## 4.2 Objectives

The RIEP is designed to provide URI researchers and Rhode Island's educator's access to the scientific research and educational capabilities of an ocean-going research vessel. This particular research cruise was designed as the centerpiece of an undergraduate honors science class in which the undergraduate students participated in data collection while at sea and shared their experiences using telepresence via the URI Graduate School of Oceanography (GSO) Inner Space Center. The cruise's marine mammal focus was chosen because of the potential for students to experience multiple types of oceanographic sampling that examine the linkages between several trophic levels. This was the third such collaboration between URI and the Northeast Fisheries Science Center (NEFSC). The protocols developed during this pilot study could be potential methods used for high resolution sampling during a future AMAPPS process study conducted in regions of interest such as potential energy development regions. A

partnership between the science party and the GSO Inner Space Center (ISC; funded by the GSO Deans office) allowed two ISC staff to accompany the cruise. The ISC worked alongside the students to conduct a series of live broadcasts from the ship into classrooms throughout Rhode Island (Figure 4.1). Nearly 1,000 K-12 students participated in broadcasts that took place on Earth Day (22 April 2019) and the videos have been viewed over 3000 times since. The goal of the course was to increase understanding of the ocean's central role in climate processes and coastal communities and to develop strategies for sharing this knowledge with others.

## 4.3 Cruise Period and Area

The cruise was conducted during 18 – 23 April 2019 on the *R/V Endeavor*. The study area was continental shelf south of Narragansett Bay, Rhode Island (Figure 4.2).

## 4.4 Methods

### *4.4.1 Overview*

The data collection plan was to conduct a mixture of marine mammal observing and oceanographic and prey sampling, much of it conducted simultaneously. Upon finding a group of whales, we planned to extensively sample the physical and biological oceanography in that area with a variety of instruments. This would create a unique dataset allowing the exploration of the physical and biological linkages defining water column habitat for marine mammals and their prey. The cruise ran transects to locate marine mammals, and deployed a VPR, bongo nets, Tucker trawl, ring net, CTDs, hydrophones and experimental camera systems. Plus, underway physical oceanographic data were recorded and active acoustic data on prey layers using a tow body equipped with 120, 200, and 420 kHz Biosonics DT-X echosounders were also recorded. A contractor (funded with AMAPPS funds), a NEFSC federal staff member, who was also a doctoral graduate student at GSO, and one other NEFSC federal staff member participated in the research cruise by running the marine mammal, zooplankton, VPR, and active acoustic portions of the cruise.

### *4.4.2 Marine mammals*

Marine mammal surveying was conducted from the flying bridge of the *R/V Endeavor* when the sea conditions and weather were suitable. Surveying was conducted with the naked eye, handheld binoculars, and two “Big Eye” (25x150) binoculars mounted 10.2 m above the waterline that were calibrated at the dock. Marine mammal observers rotated every half an hour between the two Big Eye stations and a recording station where observations took place using either naked eye or handheld binoculars. Marine mammal observers recorded effort and sightings using a custom-built software program (NE VisSurv) employed on NEFSC marine mammal research cruises. Among the data recorded in this software were the sighting species, distance, latitude, longitude, time, date, behavior, and swim direction. The remaining data were provided by the observer, with the distance from the ship coming reticles embedded in the eye piece of the Big Eyes.

### *4.4.3 Plankton*

Bongo nets were towed in double oblique fashion to within 5 m of the bottom while the ship traveled 1.5 – 2.0 knots. Nets of 333 μ and 150 μ were deployed on the two 61 cm diameter bongo frames. A shipboard's computer system (SCS) monitored bottom depth, time, the ship's position, and surface water temperature, while a Seabird 19+ CTD deployed on the wire just above the bongo nets recorded oceanographic information along the cast. Samples were washed down into the cod end of the net with salt water and flushed into a sieve. Samples from the 333 μ net were preserved in formalin, while the samples from the 150 μ net were preserved in ethanol and the ethanol was changed after 24 – 48 hrs. Zooplankton samples in formalin from bongo nets were sent to the Polish Sorting Center for processing species and quantities. Samples in ethanol are being processed at the NEFSC to preserve the genetic integrity of ichthyoplankton. These samples are also still being processed.

Plankton samples were also collected using a ring net and a Tucker trawl. The ring net matched Canadian Department of Fisheries and Oceans data collection protocols to further comparisons and calibrations between Canadian and US plankton studies associated with foraging North Atlantic right whales. A Tucker trawl with a time-depth recorder (TDR) was also deployed to experiment with sampling zooplankton at a target depth to better target layers of zooplankton observed with echosounding. Regional historical zooplankton data from bongo samples on NEFSC's Ecosystem Monitoring (EcoMon) surveys will also be examined to provide context to the plankton observations recorded on this cruise.

The VPR was deployed four times during the *Endeavor* research cruise, three times paired with deployment of the active acoustic tow body (Figure 4.3). The VPR was typically towed in a tow-yo mode, oscillating in a sawtooth pattern throughout the water column, and tows times ranged from 61 – 94 mins. In focus images (ROIs) were quantitatively extracted from the raw data files. Images were identified to broad categories with an automated classification system that classified observed organisms and then the density per $m^3$ was calculated (Tang *et al.* 1998). The ROIs were then further hand-processed for finer organism identification. Spreadsheets summarizing the densities and oceanographic data by time and depth interval were created. Oceanographic data including temperature, salinity, fluoresence and turbidity were also plotted.

Three Biosonics DT-X echosounders (120, 200, and 420 kHz) were mounted on a custom-made tow body crafted from a former Klein side-scan sonar towfish. The tow body was deployed from a boom on the port side that was located approximately 4 m forward of the stern. When deployed, the tow body was stable and horizontal while towed 2 – 3 m below the surface at 3 – 4 knts. The echosounders were calibrated using standard methods (Foote *et al.* 1987, Demer *et al.* 2015) with a 38.1-mm sphere for the 120 and 200 kHz frequencies, and with a 15-mm sphere for the 420 kHz frequency, both made of tungsten carbide with a 6% cobalt binder.

Echosounding data were processed using Echoview 10.0 software. Background noise removal was evaluated using noise cleaning established techniques (Ryan *et al.* 2015). Classification of echosounding data to organism type is currently underway. Predicted target strengths of *Calanus finmarchicus* were calculated using Distorted Wave Born Approximation (DWBA) (Lawson *et al.* 2004). Organism's target strengths will then be used to classify potential zooplankton prey types in the water column along the cruise track and their estimated densities.

### 4.4.4 Physical oceanography

Seabird 19+ and 911 CTDs recorded physical oceanographic conditions at specific locations or on towed instrumentation. We attached a Seacat 19+ CTD to the cable above the gear for bongo net and VPR tows. The 911 CTD included a rosette so water samples could be taken. Two instruments recorded along track oceanographic information throughout the cruise. The ADCP recorded currents at depth while the TSG recorded surface salinity and temperature. Current data in the U- and V-directions will be summarized into its component parts (mean, trend, inertial, diurnal, semidiurnal, and residual). Analysis of the TSG data has not yet been completed. Additional data to be examined in relation to this cruise include satellite data of chlorophyll and sea surface temperature.

### 4.4.5 Passive acoustics and experimental camera system

A vertical chain of underwater time-lapse cameras built by students who were onboard as part of a URI undergraduate honors science class was pilot-tested. The camera chain testing was part of a larger project to develop miniature isopycnal-following floats capable of measuring oceanic ambient properties. For our purposes, the cameras provided insight into zooplankton depth distributions and migration behaviors. The floats were designed around a Raspberry Pi Zero – a flexible, low cost platform – with the hope of incorporating additional sensors in the future. We took advantage of this design during the cruise to test the incorporation of a low-cost hydrophone into the platform. This was in addition to testing a different stand-alone low-cost hydrophone designed by a collaborator from the University of Maine.

## 4.5 Results

The short cruise was plagued by challenging weather and sea conditions, particularly for sighting marine mammals. Given the sea state and the short length of the cruise we were not able to reach a primary area where right whales had recently been sighted although we did observe two minke whales (Figure 4.2). The cruise was designed with multiple objectives in case of challenging weather and the oceanographic and educational objectives that were fulfilled. Oceanographic sampling in the region in and adjacent to potential wind energy leases included 4 deployments of the VPR, 5 of the echosounder package, 2 CTDs, and continuous ADCP current data collection. We also collected zooplankton samples from 2 bongo net deployments, 1 Tucker trawl, and 1 ring net. The plankton data have been sent out for analysis, but we have not received the results yet. These data will help inform the pre-wind development conditions of this area and analysis of these data is upcoming. We also successfully tested the development of innovative low-cost underwater cameras and hydrophones which could be used in future monitoring studies. Lastly, the URI Inner Space Center conducted educational outreach through live broadcasts from the ship reaching nearly 1,000 pre-school to 12$^{th}$ grade students.

Analysis of the VPR data revealed low numbers of zooplankton with the three eastern tows (VPR 1 – 3) being dominated by marine snow (purple line in Figure 4.3). The westernmost station, VPR 4, had the least amount of all types of zooplankton including marine snow, though what was there was dominated by gelatinous zooplankton and pteropods less than 1 mm in size. (Figure 4.3). The strong portion of the marine snow distribution did not match up with the strong portion of the turbidity distribution data (Figure 4.4). However, the distribution pattern of

turbidity did match with the distribution pattern of chlorophyll (Figure 4.4) implying that the turbidity layer was caused by phytoplankton too small to be extracted by the VPR software.

Oceanography at the eastern and western ends of the sampling area was markedly different as well. Western data revealed a well-mixed environment with a water temperature around 7°C while the eastern end had a 2°C thermocline between 15 – 20 m depth (Figure 4.5).

This cruise involved testing new equipment. The echosounder tow package employed on past cruises was modified to include a 420 kHz echosounder to help detect zooplankton. The preliminary results were promising in that a layer along the thermocline was visible in the 420 kHz data, which was not as evident in the 120 and 200 kHz data, and could represent a layer of zooplankton (Figure 4.6).

Part of our reason for attempting to investigate the Nantucket Shoals area as right whale habitat was to get a better understanding of the oceanography in this region that may drive prey aggregations. The ADCP data clearly showed the strong tidal influence in this region (Figure 4.7), which could result in tidal fronts that could concentrate oceanographic prey.

Future cruises will build on this experience. We plan to collect additional oceanographic and prey data in this region, while also revising our cruise plan to be robust to weather and sea state disruptions. We aim to make future cruises less reliant on visual sightings by instead making use of passive acoustics to listen for whales using the hydrophones that were partially developed on this cruise.

## 4.6 Disposition of Data

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

All active acoustic data are archived at the NEFSC and at NOAA's National Center for Environmental Information (NCEI) facility in Boulder, CO. The data will be publicly available when they are archived at NCEI.

All plankton samples collected will be maintained by the Oceans and Climate Branch at the NEFSC in Narragansett RI. Plankton samples in formaldehyde will be sent to Poland for identification. After identification and enumeration are complete plankton data can be accessed through the NEFSC's Oracle database. VPR data are available upon request.

Physical oceanographic data from the Seacat 19+ will be processed by the Oceans and Climate Branch and archived on the NCEI World Ocean Database.

Copies of *R/V Endeavor* oceanographic data are housed in the Rolling Deck to Repository (R2D) program that aims to develop comprehensive UNOLS fleet-wide management of underway data to ensure preservation of and access to national oceanographic research data resources.

## 4.7 Permits

The marine mammal research activities were authorized to be conducted under US Permit No. 21371-1 issued to the NEFSC by the NMFS Office of Protected Resources.

## 4.8 Acknowledgments

Most of the funds for this project came from the University of Rhode Island. AMAPPS funds were used for one observer. The AMAPPS funds are from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements with the National Marine Fisheries Service. Data processing and analysis of the oceanography and plankton data was funded by the Oceans and Climate Branch of the NEFSC. Staff time for the NMFS federal employee was provided by the NOAA Fisheries Service, NEFSC. We would like to thank the crew of the *R/V Endeavor* and the University of Rhode Island students and instructors that were involved in planning and collecting these data for their efforts and dedication to this project.

## 4.9 References Cited

Demer DA, Berger L, Chabot D, Bernasconi M, Bethke E, Boswell K, Chu D, Domokos R, Dunford A, Fässler S, Stéphane G, Hufnagle LT, Jech JM, Bouffant N, Lebourges-Dhaussy A, Lurton X, Macaulay GJ, Perrot Y, Ryan T, Parker-Stetter S, Stienessen S, Weber T, Williamson N. 2015. Calibration of acoustic instruments. International Council for the Exploration of the Sea, Copehangen, Denmark

Echoview SPL. 2018. Echoview software. Echoview Software Pty Ltd, Hobart, Australia

Foote KG, Knudsen HP, Vestnes G, MacLennan DN, Simmonds EJ. 1987. Calibration of acoustic instruments for fish density estimation: A practical guide. International Council for the Exploration of the Sea, Copenhagen Denmark

Lawson GL, Wiebe PH, Ashjian CJ, Gallager SM, Davis CS, Warren JD. 2004. Acoustically-inferred zooplankton distribution in relation to hydrography west of the Antarctic Peninsula. Deep Sea Res II 5:2041-2072

Ryan TE, Downie RA, Kloser RJ, Keith G. 2015. Reducing bias due to noise and attenuation in open-ocean echo integration data. ICES J Mar Sci 72(8):2482-2493

Simrad. 1996. Operator manual, Simrad EK500, Fishery research echo sounder. Book Revision G, Horten, Norway

Tang X, Stewart KW, Vincent L, Huang H, Marra M, Gallager SM, Davis CS. 1998. Automatic plankton image recognition. Artif Intell Rev 12: 177-199


**Figure 4.1 Inner Space Center staff Holly Morin with honor program students**

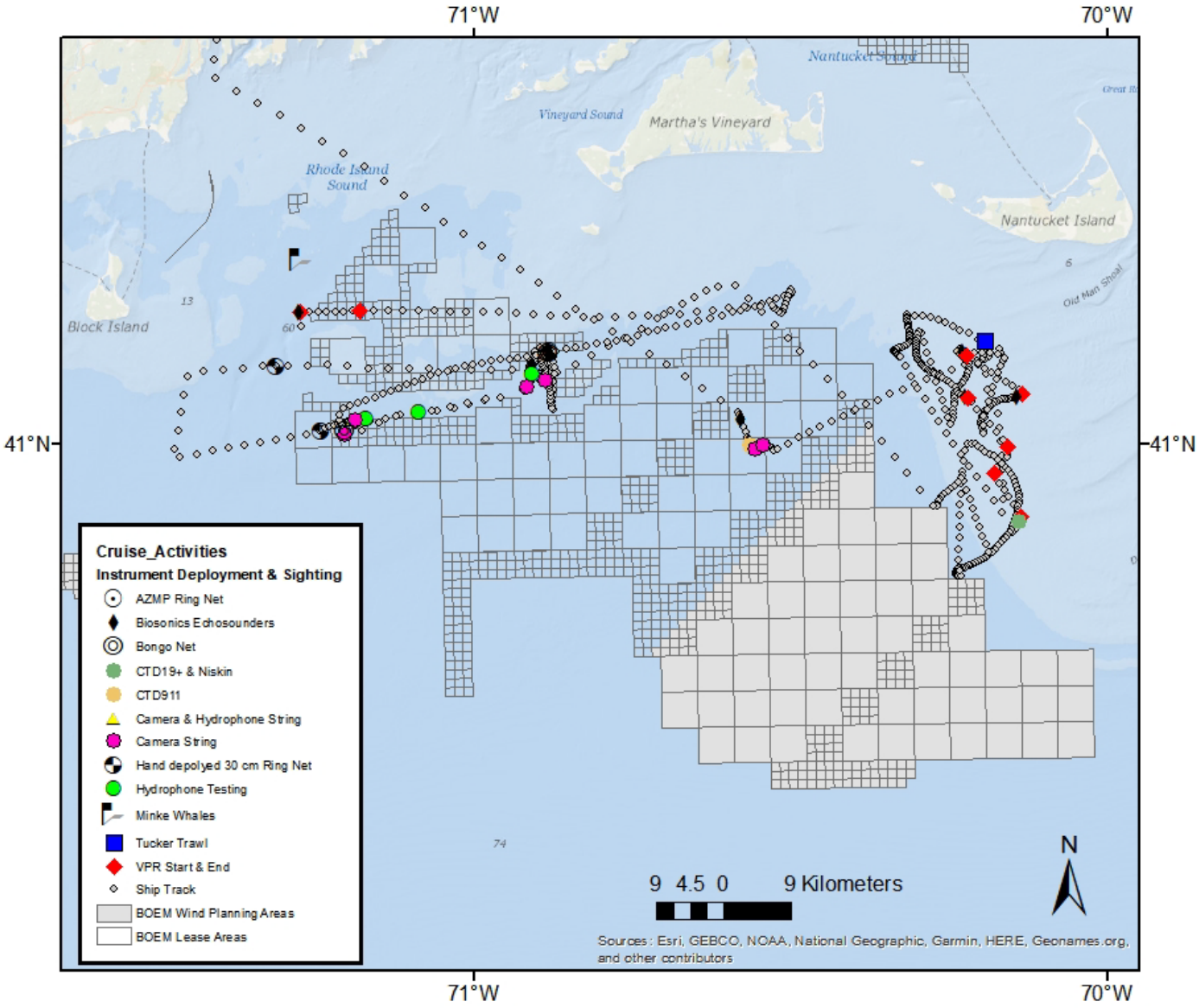


**Figure 4.2. Study area, whale sigthings, and oceanographic sampling locations**

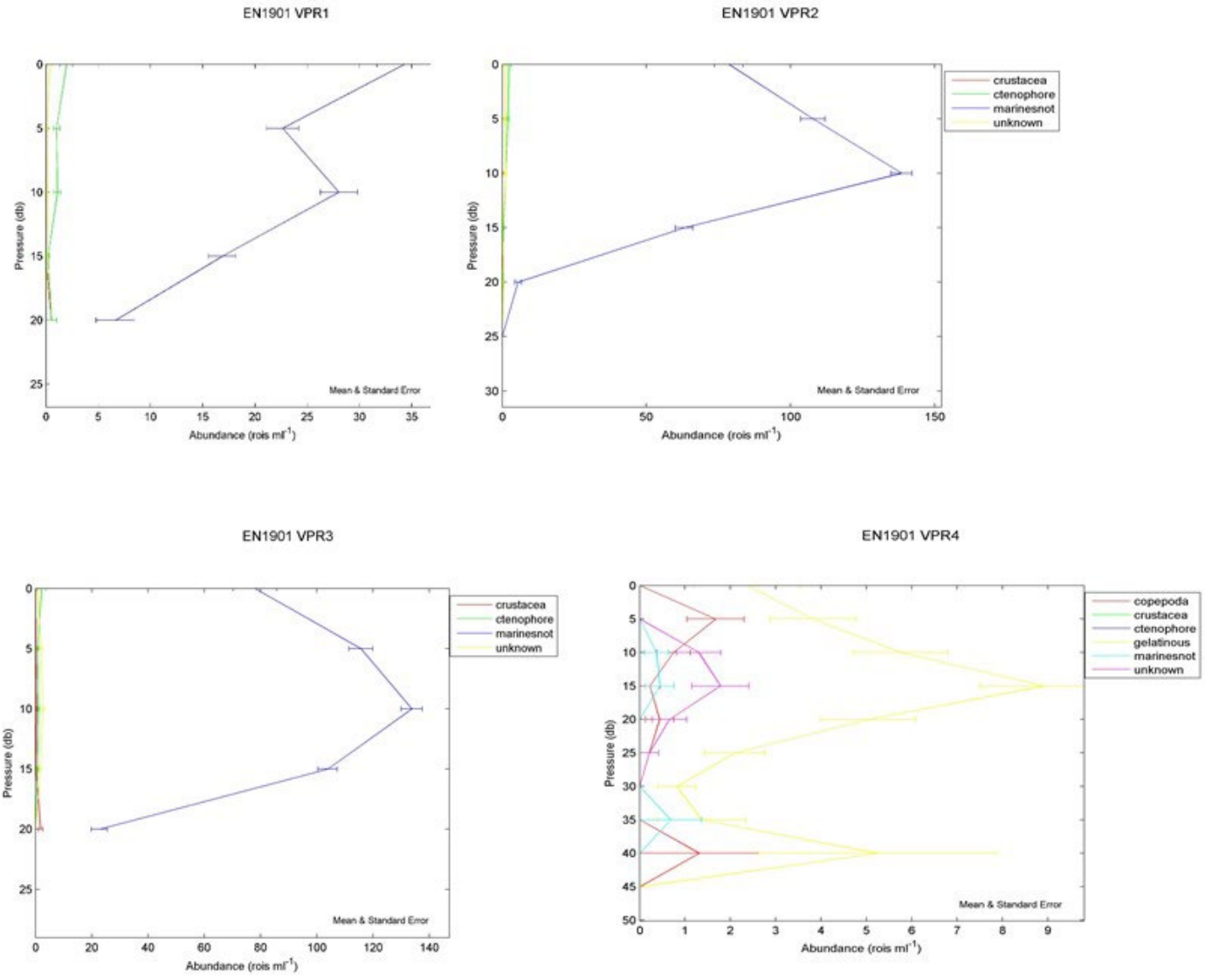


**Figure 4.3. Video Plankton Recorder (VPR) plankton densities in 5 m depth bins. The unknown category represents marine snow. (VPR1 deployment = 41.11 ºN, -70.22 ºW, VPR2 deployment = 41.05 ºN, -70.22 ºW, VPR3 deployment = 40.96 ºN, -70.13 ºW, VPR4 deployment = 41.16 ºN, -71.18 ºW, see Figure 4.2).**

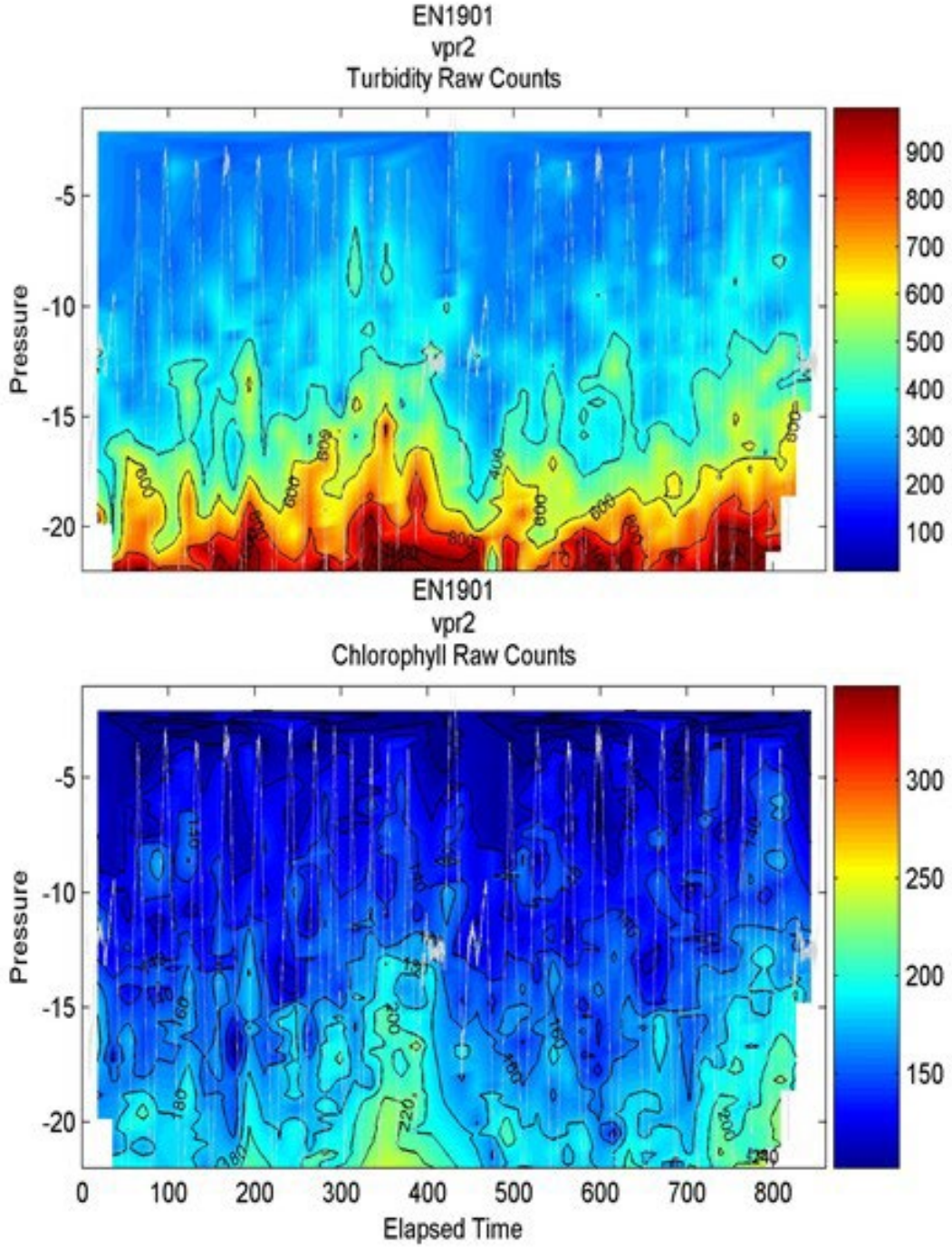


**Figure 4.4. Example turbidity and chlorophyll profiles from VPR 2, one of the eastern VPR tows (VPR2 deployment = 41.05 ºN, -70.22 ºW, VPR2 retrieval = 41.00 ºN, -70.16 ºW, see Figure 4.2).**

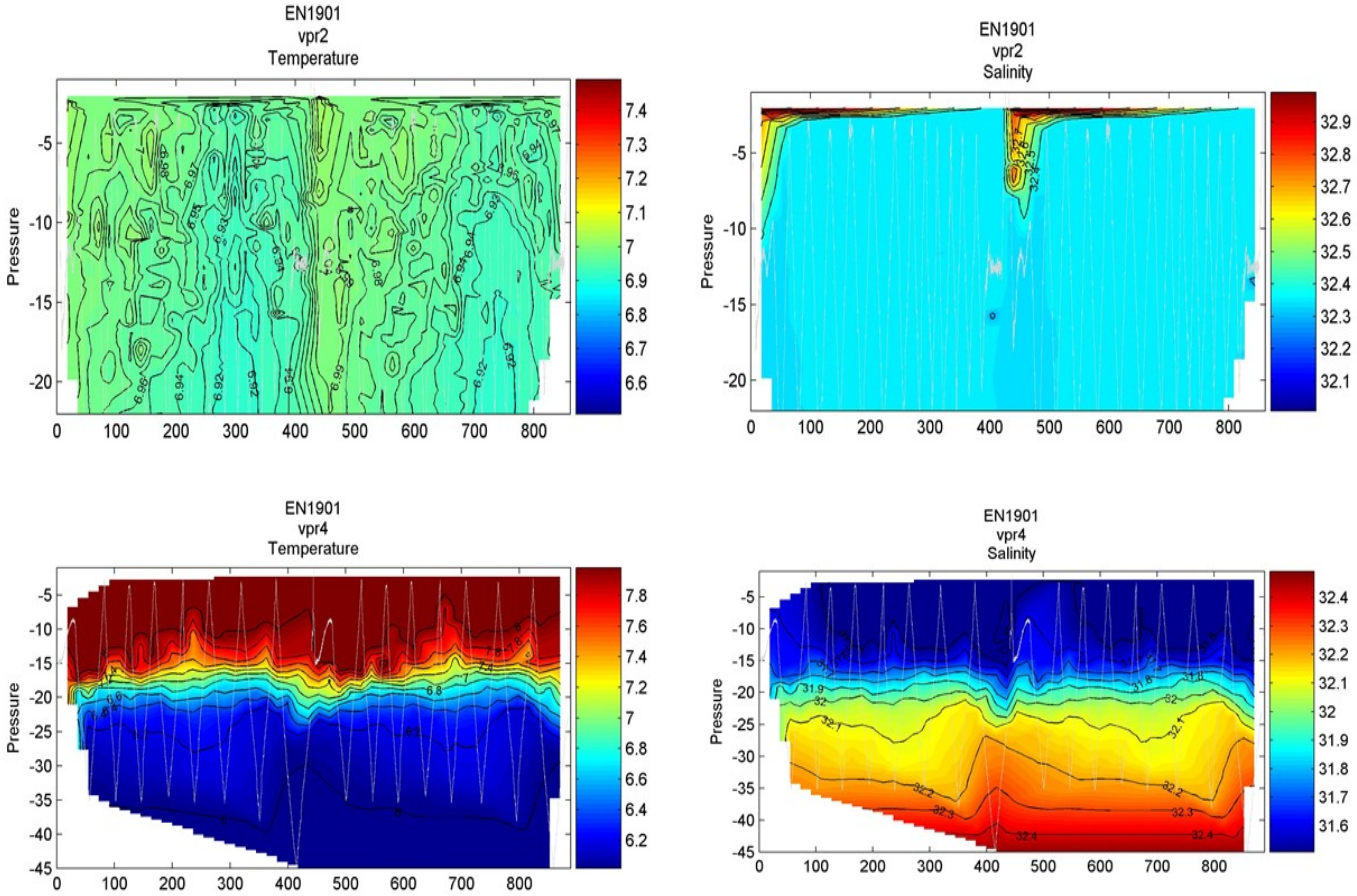


**Figure 4.5. Oceanographic data from the eastern (VPR 2) and western (VPR 4) ends of the sampling area. The salinity spike in the middle of VPR 2 is a sampling artifact caused by the VPR resting at 12 m depth while the ship turned (VPR2 deployment = 41.05 ºN, -70.22 ºW, VPR2 retrieval = 41.00 ºN, -70.16 ºW, VPR4 deployment = 41.16 ºN, -71.27 ºW, VPR4 retrieval = 41.16 ºN, -71.27 ºW (see Figure 4.2 for plotted VPR deployment and recovery locations).**

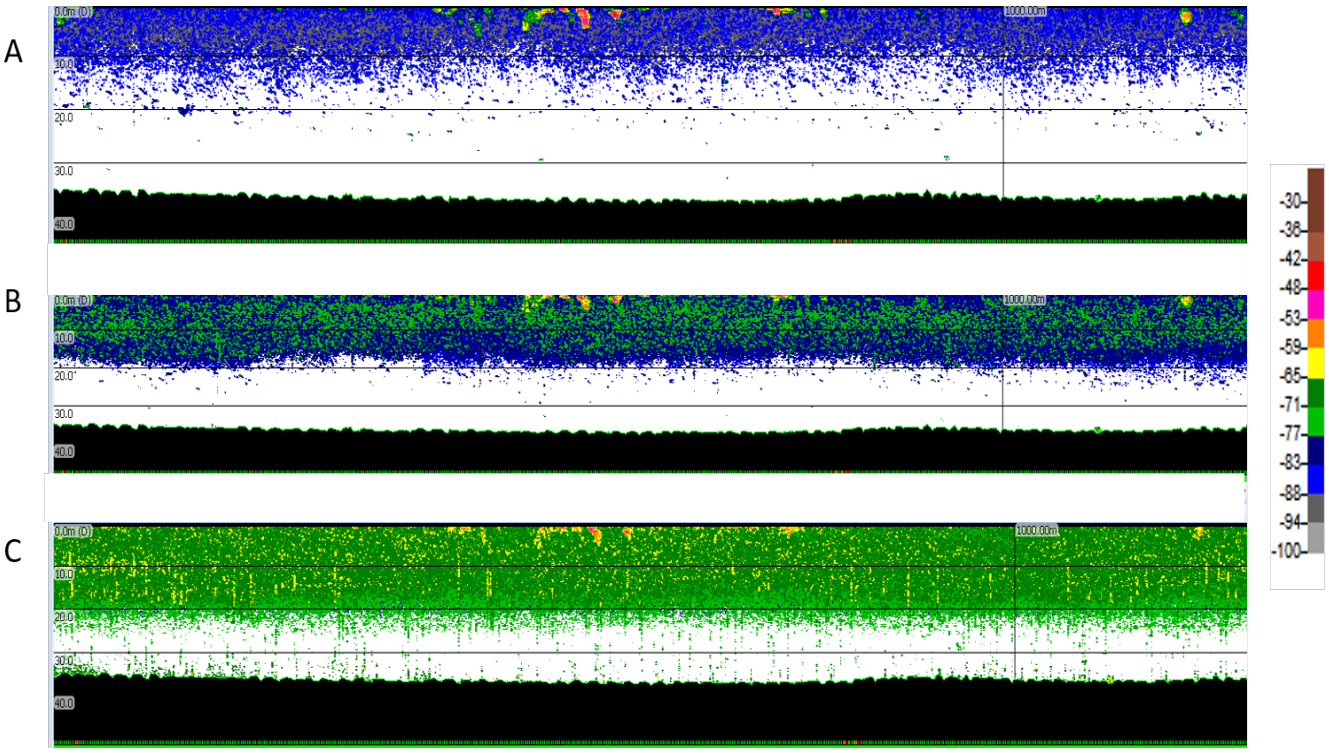


**Figure 4.6. Example acoustic returns near sighting of minke whales (*Balaenoptera acutorostrata*) in 120 (A), 200 (B), and 400 (C) kHz frequencies. Potential prey in the surface layer seen most prominently in A. Additional layer visible at roughly 20 m visible in the 400 kHz layer but not in the lower frequencies.**

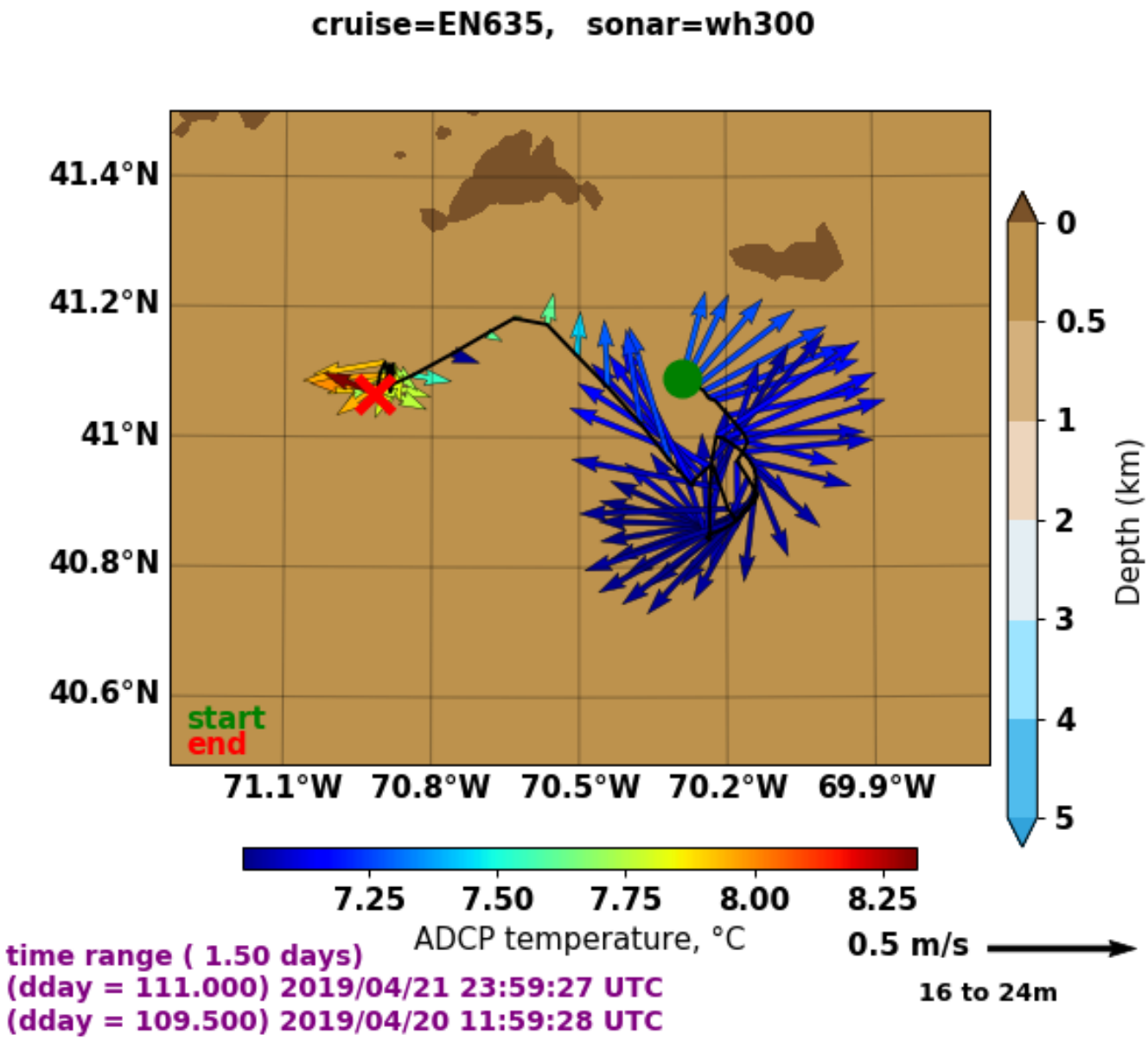


**Figure 4.7. Acoustic Dopler Current Profiler (ADCP) measurements showing strong tidal signal in the primary area of study off Nantucket Shoals**

# 5 Shipboard shelf break ecology survey: Northeast Fisheries Science Center

**Danielle Cholewiak[1], Bridget Mueller-Brennan[2], Kate Sutherland[2]**
[1]Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543
[2]Integrated Statistics, 16 Sumner Street, Woods Hole, MA 02543

## 5.1 Summary

The Northeast Fisheries Science Center conducted a shipboard survey of shelf break and offshore waters from 17 – 28 August 2019, focusing primarily on the region offshore of Georges Bank where there is a consistent presence of deep-diving cetacean species. This was part of a series of surveys from the Integrated Technologies for Deep Diver Ecology Program (ITS.DEEP). The primary goals were to test and integrate multiple new technologies to assess the ecology and distribution of deep diving cetacean species, such as beaked whales (*Ziphiidae*), dwarf/pygmy sperm whales (*Kogia* spp.), and sperm whales (*Physeter macrocephalus*). The 2019 survey focused primarily on True's beaked whale (*Mesoplodon mirus*) habitat, as this is as-yet the only identified region in the world where this species can be reliably studied.

The survey design varied between "exploratory", during which time predetermined tracklines were surveyed at a speed of 13 – 15 km/hr, or "focal follow", when animal-specific data were collected on targeted cetacean groups. The scientific crew included a visual observation team of 6 observers scanning for marine mammals and sea turtles, 1 seabird observer collecting data on avian sightings, and a passive acoustic team of 5 acousticians monitoring a towed hydrophone array. At times, the seabird observer worked with the mammal team and vice versa, depending on data collection priorities. In addition, three High-Frequency Acoustic Recording Packages ("HARPs") were recovered during this cruise after a year of passive recording along the shelf break of the US eastern seaboard. Approximately 580 km were surveyed by the marine mammal visual team; passive acoustic data were collected over an additional 570 km. Conductivity-temperature-depth (CTD) data were collected at 3 stations in conjunction with recovery of the HARPs. Approximately 22 beaked whale groups were sighted. This included 5 groups of True's beaked whales (17 individuals), 4 groups of Cuvier's beaked whales (*Ziphius cavirostris*), and 1 group of Sowerby's beaked whales (*Mesoplodon bidens*). Three groups of pygmy/dwarf sperm whales were sighted, including at least one mother-calf pair. An estimated 60 groups of other cetaceans were sighted, with bottlenose dolphins (*Tursiops truncatus*) and Risso's dolphins (*Grampus griseus*) being the most frequently detected. Over 2,100 seabirds from at least 31 species were detected. The hydrophone arrays were monitored for 120 hrs, yielding over 150 acoustic detections of cetacean groups, including 41 detections of beaked whale groups.

## 5.2 Objectives

The overall objectives were to document the occurrence of beaked whales and other cetacean species in the offshore waters of Georges Bank, including waters of the Northeast Canyons and Seamounts Marine National Monument, and to collect fine-scale cetacean ecology data for target species. The 2019 survey focused primarily on True's beaked whale (Figure 5.1) habitat, as this is as-yet the only identified region in the world where this species can be reliably studied. Detailed objectives included: 1) collect visual data on cetacean distribution as well as

information on movements and dive behavior; 2) collect passive acoustic data from towed hydrophone arrays to track multispecies occurrence in conjunction with prey in deep-water habitats; 3) collect water samples for eDNA testing from the fluke prints of diving animals, in conjunction with biopsy sampling; and 4) collect oceanographic and prey data (primarily related to temperature, salinity, acoustic reflectance, and zooplankton abundance), including targeted EK60 active acoustic backscatter data in areas where animals have been documented foraging.

## 5.3 Cruise Period and Area

The survey was conducted on the R/V *Hugh R Sharp*, departing from Woods Hole, MA. The survey period was 17 – 28 August 2019. The overall resulting survey period was 12 days that included 10 days at sea and two days transiting to and from port. The primary survey region included the shelf break and offshore US waters of Georges Bank, from approximately 39° – 41° N and 64° – 70.5° W (Fig 5.3).

## 5.4 Methods

The design plan for this survey included two data collection modes: 1) "exploratory", during which time the visual and acoustic teams would collect data on all species sighted using modified line-transect methodologies, and 2) "focal follow", during which time dedicated focal-follows would be conducted on groups of the target species. Typical survey speeds were 13 – 15 km/hr (7 – 8 kts) during exploratory phases, but reduced to 3 – 4 km/hr (~2 kts) or less during focal follow mode. During exploratory mode, the vessel surveyed along pre-determined tracklines covering the shelf break and offshore waters. During focal follow mode, the vessel continuously maneuvered to attempt to remain within visual range of the target cetacean group. More details are provided below. The number of observers varied depending on survey mode and weather conditions; see below for more information. Twelve scientists participated in the survey (Table 5.1).

### *5.4.1 Visual marine mammal sighting team*

Visual surveys were conducted during daytime (approximately 0630 – 1900 eastern local time), and in sea states up to Beaufort 6, when rain was not present. Data on all marine mammal, sea turtle, and large fish (i.e., tuna) sightings were collected by a single observation team, operating from stations located on flying bridge, 13.7 m above the sea surface. The observation team was typically comprised of three observers at a time during exploratory mode. Two observers utilized 25x150-power binoculars, to scan from the bow of the ship to 90° port or starboard. A third observer scanned the trackline region using naked eye or handheld 7x50 binoculars, and recorded sightings data. While in exploratory search mode, observers rotated through each position every 30 minutes, and then had a break of at least 30 minutes. When conditions were good, 1 – 2 additional observers often assisted in survey effort using handheld binoculars or naked eye. However, when Beaufort conditions exceeded a sea state 5, observer effort was frequently reduced to one person.

Sightings data were recorded onto laptop computers with the custom-built software package VisSurv-NE (version 6), which was initially developed by L. Garrison and customized by D. Palka. The following information was collected:

- Time of the sighting to the nearest second

- Species composition of the group
- Radial distance to the group, estimated by reticles when using big-eye binoculars
- Bearing between the line of sight to the group and the ship's track line, measured by a polarus mounted at the base of the binoculars
- Best estimate of group size
- Swim direction
- Number of calves observed
- Initial sighting cue
- Initial behavior of the group
- Any comments on unusual markings or behavior

The location of the ship (latitude and longitude) was recorded using the ship's GPS every 12 secs, and every time an entry was made into VisSurv-NE. At times when it was not possible to positively identify a species, the ship broke from the survey tracklines to head in the direction of the sighting, until species composition was verified.

Effort and environmental data were recorded when observers rotated or every time there was a noticeable change in environmental state. Environmental data included the apparent Beaufort sea state when scanning ahead of the ship and sightings conditions (horizon clarity; swell height and direction relative to the ship's direction of travel; percentage of the survey area covered with glare; and magnitude of the glare within that region).

On one good weather day when beaked whales were detected and the decision was made to initiate focal follow mode, observer effort changed substantially. Ship speed was slowed to 3 – 4 km/hr, and the seabird observer and members of the passive acoustic team joined the mammal team to augment visual data collection. Effort was made by all available observers to track, photograph, and collect detailed surfacing data on targeted beaked whale groups, while still recording sightings of additional cetacean groups in the area. In this mode, observers rotated on an as-needed basis, and there were frequently more than 3 observers on-effort at a time. When possible, species identification photographs were collected from the ship using a Canon D6 or D7 camera equipped with a 100 – 300 m or 500 m lens.

### *5.4.2 Small boat operations*

The Northeast Fisheries Science Center rigid-hulled inflatable boat ("LGB") was brought on board with the intention to collect focal follow data, photographs and genetic samples from targeted cetacean groups. The LGB was to be deployed when sea states were low enough that it was considered feasible to approach and follow target groups. A team of 3 – 4 personnel were to be deployed with each small boat launch, while the remaining shipboard observers continued to track cetacean groups and provide directions to the small boat. Unfortunately, due to inclement weather, the LGB was only launched once for testing, and there were no encounters with cetaceans during that launch.

### *5.4.3 Biopsy and eDNA sampling*

Plans were made to collect paired water samples for eDNA testing, and to collect biopsy samples for genetic analyses during focal follow data collection from LGB. However, there were no opportunities to collect either type of sample during this survey.

### *5.4.4 Passive Acoustic Operations*

#### *5.4.4.1* Towed hydrophone array

The passive acoustic team consisted of five people who operated the system in 1 – 2 hour shifts. The hydrophone array was deployed for up to 24 hr/day during exploratory survey mode, with periodic retrievals to check on array status. During focal follow survey mode or inclement weather, the array was sometimes recovered to facilitate maneuverability of the ship.

The primary hydrophone array was comprised of a linear, modular, oil-filled section towed 300 m behind the ship. This array was comprised of three High Tech, Inc. (HTI) 96-Min hydrophones as well as a depth sensor (Keller America, PA7FLE). Another array comprised of three HTI's, one American Power Conversion (APC), one Reson and a depth sensor was used at the beginning of the survey but was replaced with the primary array following issues with the preamp. Acoustic data were routed to a custom-built Acoustic Recording System that encompassed all signal conditioning, including A/D conversion, filtering, and gain. Data were high-pass filtered at 1000 Hz to remove flow noise, and variable gain between 0 – 20 dB was added depending on the relative levels of signal and noise. The recording system incorporated two National Instruments soundcards (NI USB-6356), both sampling all three channels at 500 kHz at a resolution of 16 bits. Digitized acoustic data were recorded directly onto desktop computer hard drives using the software program Pamguard, which also recorded simultaneous GPS data, continuous depth data, and allowed manual entry of corresponding notes. Binary click detector files were created using a laptop connected to the second soundcard. Whenever possible, acoustically-active groups that were tracked were matched with visual detections in real-time, for assignment of unambiguous species classification. Frequent communication was established between the acoustic team and the visual team situated on the flying bridge to facilitate this process.

#### 5.4.4.2 High-frequency acoustic recording packages

Three High-frequency Acoustic Recording Packages (HARP; Wiggins and Hildebrand 2007), deployed in 2018 as part of a collaborative multi-year Shelf Break Acoustic Ecology study (NEFSC, SEFSC, and Scripps Institution of Oceanography) were opportunistically recovered during this survey (Figure 5.2).

### *5.4.5 Visual seabird sighting team*

From an observation station on the flying bridge, a single observer conducted a visual daylight survey for seabirds during approximately 0600 – 1800 eastern local time, with breaks as needed throughout the day. Seabird observation effort employed a modified 300 m strip and line-transect methodology. Data on seabird distribution and abundance were collected by identifying and enumerating all birds seen within a 300 m arc on one side of the bow while the ship was underway. The seabird observer maintained a visual unaided eye watch of the 300 m survey strip, with frequent scans of the perimeter using hand-held binoculars for cryptic and/or hard to detect species. Binoculars were also used to confirm species identification, as needed. Ship-following species were counted once and subsequently carefully monitored to prevent re-counts. All birds, including non-marine species, such as raptors, doves, and passerines, were recorded.

Operational limits are higher for seabird surveys compared to visual marine mammal and sea turtle surveys. As a result, seabird survey effort was possible in sea states up to and including a low Beaufort 7. Seabird survey effort was suspended, however, if the ship's speed over ground fell below 11 km/hr (6 kts). During periods of marine mammal focal follow data collection mode, the seabird observer joined the marine mammal visual team to collect marine mammal data; at those times seabird data were collected only opportunistically. Therefore, due to the unique objective for this survey, survey speed, and the split effort between surveying for seabirds and surveying for marine mammals required of the seabird observer, off-effort sightings were incorporated into survey effort and summary charts.

All data were entered in real time into a Panasonic Toughbook laptop running *Seebird (*version 4.3.7)*,* a data collection program developed at the Southwest Fisheries Science Center. The software was linked to the internal GPS of the Toughbook. The following data were collected for each sighting: species identification, number of birds within a group, distance between the observer and the group, behavior, flight direction, age, and sex. 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 mins. *Seebird* incorporates a time synchronization feature to ensure the computer clock matches the GPS clock to assist with post-processing of the seabird data. All data underwent a quality assurance and data integrity check each evening and saved to disk and to an external backup dataset. During off-effort periods, opportunistic seabird sightings were recorded in the marine mammal database or by hand.

### *5.4.6 Oceanographic and environmental sampling*

Every 10 secs, the ship's surface mapping system (SMS) recorded the ship's position, wind speed and direction (relative and true), air temperature, pressure and humidity, sea surface temperature, salinity, and fluorescence. Due to the effects of shipboard echosounders on beaked whale detection rates (Cholewiak *et al.* 2017), echosounders were operated in passive mode for the majority of the survey.

Conductivity, Temperature, and Depth (CTD) profile data were collected using a Seabird 911 instrument package at sites where HARPs were recovered. CTDs were lowered to 900 m at two sites and 400 m at one site. An additional CTD cast was lowered to 24 m to test equipment functionality.

## 5.5 Results

### *5.5.1 Visual marine mammal sighting team*

The visual team surveyed approximately 580 km across 8 sea days (Figure 5.3). Inclement weather precluded data collection on additional days; the ship sheltered from poor weather in the lee of Nantucket Island on one day. Visual survey effort was comprised primarily of exploratory data collection, with little focal follow data collection due to lack of suitable weather conditions. Overall, only 6% of track line coverage was spent in sea state conditions of Beaufort 2 or less, the conditions needed to confidently detect beaked whales (Table 5.2).

Fourteen species of cetaceans were identified during the survey (Tables 5.4 – 5.5). Three species of beaked whales were positively identified, including Cuvier's (*Ziphius cavirostris*), True's (*Mesoplodon mirus*) and Sowerby's (*Mesoplodon bidens*) beaked whales (Figure 5.4; Table 5.3).

There were 22 sightings of beaked whale groups, comprising an estimated 63 individuals (Table 5.3). Brief focal follow data were collected on one group of Sowerby's beaked whales, but poor weather conditions throughout the survey precluded the collection of additional focal follow data.

There were 63 groups of approximately 950 individuals of other cetaceans detected (Figure 5.5; Table 5.4). Of note were several sightings of *Kogia* sp., including at least two mothers with calves, which are rarely documented. Bottlenose dolphins (*Tursiops truncatus)* and Risso's dolphins (*Grampus griseus)* were the most frequently encountered delphinids, though striped dolphins (*Stenella coeruleoalba*) were the most numerically abundant (Table 5.4). For baleen whales, only one humpback whale (*Megaptera novaeangliae*) was detected and it was in nearshore waters (Figure 5.5). The visual team also recorded one sea turtle, and several tuna and other fish species (Table 5.4).

### *5.5.2 Small boat operations*

Only one small boat deployment was conducted to test equipment; no marine mammals were approached during the deployment. Weather conditions did not permit subsequent small boat work.

### *5.5.3 Passive acoustic detection team*

Towed array acoustic monitoring effort was conducted on 9 survey days when in waters deeper than 100 m. Overall, 122 hrs of recordings were collected. The array was monitored continuously by an acoustician in real time for 120 hrs (99% of the total time), including during daytime concurrently with visual survey effort and during nighttime with acoustic-only monitoring.

Real-time monitoring of the linear array resulted in 41 acoustic detections of beaked whales (Figure 5.4; Table 5.5). Beaked whale detections were acoustically classified in real time as Cuvier's beaked whale, Sowerby's beaked whale or as either True's or Gervais' beaked whale (MmMe, *Mesoplodon mirus or M. europaeus*). It is likely that most or all detections in the MmMe category were clicks produced by True's beaked whale as no Gervais' beaked whales were visually detected. However, similarities between the clicks produced by True's and Gervais' beaked whales make it difficult to unambiguously distinguish the two species.

The focus of real-time acoustic monitoring on this survey was to detect and localize beaked whales; other vocally-active odontocetes were also recorded, but only opportunistically noted in real-time (Figure 5.5; Table 5.5). Sperm whales (*Physeter microcephalus)* were acoustically detected on all but one survey day, with 50 encounters documented. Delphinid encounters also occurred on all but one survey day; though generally they were not classified to species. The exception cases were when detections clearly corresponded to simultaneous visual detections, such as when animals approached the bow and passed alongside the ship and hydrophone array. Delphinid species represented in the data include bottlenose dolphins, striped dolphins, Risso's dolphins, and pilot whales (*Globicephala spp.)*.

### *5.5.4 Visual seabird sighting team*

Seabird survey effort was conducted on 9 sea days covering roughly 505 km. Nomenclature of species identifications follow that reported in the eBird/Clements Checklist of Birds of the World: v2019.

A total of 2,129 birds were recorded while on and off seabird effort (Table 5.6). These counts are notable as few seabird surveys are conducted so far offshore, and rarely with repeated search effort conducted in the same areas in consecutive years. Thus, an attempt was made to record numbers of species seen at all times of the day, regardless of survey effort. Daily species lists were also entered into eBird and these totals were incorporated into the species counts in Table 5.6. In total, 31 species of birds and 4 unidentified species groups (for example, unidentified shearwater or unidentified shore bird) were documented. However, 5 species comprised approximately 90% of the total birds recorded. In declining order of occurrence these were: Cory's Shearwater *(Calonectris diomedea,* n=722*),* Wilson's Storm-Petrel (*Oceanites oceanicus*, n=522), Great Shearwater *(Ardenna gravis*, n=382), Audubon's Shearwater (*Puffinus lherminieri*, n=174), and Leach's Storm-Petrel (*Oceanodroma leucorhoa*, n=117). Distribution maps of the sightings as entered in *Seebird* are shown in Figure 5.8; several off-effort sightings are not shown in the maps.

Gulf Stream waters covered most of the study area during the survey time period. The Gulf Stream current was moving at least 3 kts to the east/northeast and was composed of waters that were 26 – 28° C. Species commonly found in Gulf Stream waters included Black-capped Petrel (*Pterodroma hasitata*), Audubon's Shearwater, and Band-rumped Storm-Petrel (*Oceanodroma castro*). *Sargassum*, the genus of brown algae often associated with the Gulf Stream, was present and Audubon's Shearwaters were seen foraging in and around this microhabitat.

Species that are typically found in cooler waters and near productive areas like the shelf break, canyons, and sea mounts, were also present, though in larger numbers than the Gulf Stream specialists. Cory's and Great Shearwaters along with Wilson's Storm-Petrel were the top three most numerous seabirds recorded. Leach's Storm-Petrel, another species expected to be found near these bathymetric features, was the fifth most recorded seabird behind the Audubon's Shearwater. One Sooty Shearwater (*Ardenna grisea*) and a handful of Manx Shearwaters (*Puffinus puffinus*) were also found in the study area, both are seen from shore at this time of year, but their presence was not notable in the survey area.

On 20 August 2019 in the more eastern section of the study area, sea surface temperatures were a bit cooler, around 24 – 25° C, and we recorded White-faced Storm-Petrel (*Pelagodroma marina*) and one Barolo Shearwater (*Puffinus baroli*), a rarely recorded species in the western north Atlantic. While *Sargassum* was still present, and some of the White-faced Storm-Petrels were associated with it, only a few Audubon's Shearwaters were recorded, one Band-rumped Storm-Petrel, and no Black-capped Petrels. These seabird observations were markedly different from other dates we surveyed, and this was an area with the highest diversity of beaked whales; one group of seven True's beaked whales was recorded.

Red-billed Tropicbird (*Phaethon aetherus*) has been recorded at and above this latitude, but its distribution in the area covered by this survey is unknown, so encountering two individuals is notable. Two sub-adult Masked Boobies (*Sula dactylatra*) were recorded as well, and while it is likely they were associated with the warm Gulf Stream water, these are notable for the latitude. Recently, more coverage offshore by pelagic birding trips in the western north Atlantic is adding

to current knowledge about the distribution of this gadfly petrels. We documented one Trindade Petrel (*Pterodroma arminjoniana*) and while rarely seen in the study area it could be due to low coverage and it is possible they occur in the study area in low density numbers.

South Polar Skua (*Stercorarius maccormicki*) and Pomarine Jaeger (*Stercorarius pomarinus*) were the only species of the Stercorariidae family encountered during the survey, both in low numbers. Two species of larid were recorded, Great Black-backed Gull (*Larus marinus*) and Herring Gull (*Larus argentatus*), all individuals were sub-adult birds. Two Arctic Terns (*Sterna paradisaea*), one Common Tern (*Sterna hirundo*), and one Least Tern (*Sternula antillarum*) were recorded offshore plus one unknown tern species. A number of shorebirds, swallows, and warblers were also recorded, the species and counts are included in Table 5.6.

### *5.5.5 Oceanographic and environmental sampling*

CTD sampling was conducted at 4 stations over the course of the survey. This included 3 stations where HARPs were recovered, as well as 1 shallow water station for equipment testing.

## 5.6 Disposition of Data

All visual, acoustic, and oceanographic data will be maintained by the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. Visual sightings data will be archived in the NEFSC's Oracle database and submitted to OBIS SEAMAP for public access. Active acoustic data are archived at the NEFSC and at NOAA's National Center for Environmental Information (NCEI) facility in Boulder, CO. The data will be publicly available when they are archived at NCEI. Seabird data will also be distributed to the Seabird Compendium.

## 5.7 Permits

NEFSC was authorized to conduct these research activities during this survey under US Permit No. 21719-01 issued to the NEFSC by the NMFS Office of Protected Resources.

## 5.8 Acknowledgements

Funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements with the National Marine Fisheries Service for the Atlantic Marine Assessment Program for Protected Species (AMAPPS) project. Staff time was also provided by the NOAA Fisheries Service, NEFSC. We would like to thank the ship's crew and all of the scientists involved in collecting these data for their efforts and dedication to this project.

## 5.9 Literature Cited

Cholewiak D, DeAngelis AI, Palka D, Corkeron PJ, Van Parijs SM. 2017. Beaked whales demonstrate a marked acoustic response to the use of shipboard echosounders. *Roy. Soc. Open Sci.* 13;4(12):170940.

DeAngelis AI, Stanistreet JE, Baumann-Pickering S, Cholewiak DM. 2018. A description of echolocation clicks recorded in the presence of True's beaked whale (Mesoplodon mirus). *The Journal of the Acoustical Society of America.* 144(5):2691-700.

Griffiths ET, Barlow J. 2015. Equipment performance report for the drifting acoustic spar buoy recorder (DASBR). NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-543.

Griffiihs ET, Barlow J. 2016. Cetacean acoustic detections from free-floating vertical hydrophone arrays in the southern California Current. *The Journal of the Acoustical Society of America*, *140*(5), EL399-EL404.
NEFSC and SEFSC. 2018. 2018 Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the Western North Atlantic Ocean – AMAPPS II. https://www.nefsc.noaa.gov/psb/AMAPPS/
Wiggins SM, Hildebrand JA. 2007. High-frequency Acoustic Recording Package (HARP) for broad-band, long-term marine mammal monitoring. In *2007 Symposium on Underwater Technology and Workshop on Scientific Use of Submarine Cables and Related Technologies* (pp. 551-557). IEEE.

**Table 5.1. Scientific team participating in data collection aboard the R/V *Hugh R Sharp* from 17 – 28 August 2019**

| Name | Title | Institution |
|---|---|---|
| Danielle Cholewiak | Chief Scientist (on shore) | NOAA NMFS NEFSC |
| Dee Allen | Acting Chief Scientist | Marine Mammal Commission |
| Andrea Bendlin | Marine Mammal Observer | Integrated Statistics, Woods Hole, MA |
| Shannon Coates | Passive Acoustics/ Mammal Observer | Integrated Statistics, Woods Hole, MA |
| Lisa Conger | Marine Mammal Observer | NOAA NMFS NEFSC |
| Pete Duley | Marine Mammal Observer | NOAA NMFS NEFSC |
| Skye Haas | Marine Mammal/ Seabird Observer | Integrated Statistics, Woods Hole, MA |
| Jennifer Keating McCullough | Passive Acoustics/ Mammal Observer | NOAA NMFS PIFSC |
| Bridget Mueller-Brennan | Passive Acoustics/ Mammal Observer | Integrated Statistics, Woods Hole, MA |
| Madison Pickett | Passive Acoustics/Mammal Observer | NOAA Hollings Scholar, MIT |
| Kate Sutherland | Seabird Observer | Integrated Statistics, Woods Hole, MA |
| Jennifer Trickey | Passive Acoustics/ Mammal Observer | Scripps Institution of Oceanography |
| Suzanne Yin | Marine Mammal Observer | Integrated Statistics, Woods Hole, MA |

**Table 5.2. Visual survey effort (km) categorized by Beaufort sea state for the mammal and seabird teams**

| Beaufort Sea State | Mammal Team | Seabird Team |
|---|---|---|
| 2 | 34 | 63 |
| 3 | 208 | 271 |
| 4 | 173 | 23 |
| 5 | 121 | 137 |
| 6 | 43 | 10 |
| TOTAL | 579 | 505 |

**Table 5.3. Number of beaked whale groups sighted by the visual team**

| Common Name | Scientific Name | Number of Groups | Number of Individuals |
|---|---|---|---|
| Cuvier's beaked whale | *Ziphius cavirostris* | 4 | 16 |
| Sowerby's beaked whale | *Mesoplodon bidens* | 1 | 4 |
| True's beaked whale | *Mesoplodon mirus* | 5 | 17 |
| Unidentified Mesoplodont | *Mesoplodon spp.* | 5 | 13 |
| Unidentified beaked whale | *Ziphiidae* | 7 | 13 |
| TOTAL | | 22 | 63 |

**Table 5.4. Species other than beaked whales sighted by the visual team.**

| Common Name | Scientific Name | Number of groups | Number of individuals |
|---|---|---|---|
| Atlantic spotted dolphin | *Stenella frontalis* | 5 | 69 |
| Bottlenose dolphin | *Tursiops truncatus* | 14 | 157 |
| Common dolphin | *Delphinus delphis* | 1 | 7 |
| Humpback whale | *Megaptera novaeangliae* | 1 | 1 |
| Pantropical spotted dolphin | *Stenella attenuata* | 1 | 50 |
| Pilot whale | *Globicephala spp.* | 2 | 23 |
| Pygmy killer whale | *Feresa attenuata* | 1 | 2 |
| Pygmy/Dwarf sperm whale | *Kogia sp.* | 3 | 5 |
| Risso's dolphin | *Grampus griseus* | 9 | 123 |
| Sperm whale | *Physeter macrocephalus* | 7 | 10 |
| Striped dolphin | *Stenella coeruleoalba* | 3 | 420 |
| Unidentified cetacean | | 4 | 4 |
| Unidentified dolphin | | 9 | 83 |
| Unidentified large whale | | 2 | 2 |
| Unidentified Odontocete | | 1 | 1 |
| Loggerhead turtle | *Caretta caretta* | 1 | 1 |
| Billfish | | 1 | 1 |
| Ocean sunfish | *Mola mola* | 1 | 1 |
| Tuna | *Tuna sp* | 5 | 11 |

**Table 5.5. Summary of passive acoustic detections from data collected in real time during the survey. Note that an acoustic detection may represent one animal or groups of animals.**

| Species | Number of acoustic events |
|---|---|
| Cuvier's beaked whale | 17 |
| Sowerby's beaked whale | 1 |
| True's/Gervais' beaked whale | 17 |
| True's beaked whale | 1 |
| Unidentified beaked whale | 5 |
| Sperm whale | 50 |
| Bottlenose dolphin | 2 |
| Risso's dolphin | 3 |
| Short-finned pilot whale | 1 |
| Striped dolphin | 1 |
| Unidentified dolphin | 59 |
| Unidentified cetacean | 1 |
| **TOTAL** | 158 |

**Table 5.6. Birds detected on and off effort by seabird team**

| Common Name | Scientific Name | Number of Individuals |
|---|---|---|
| American Redstart | *Setophaga ruticilla* | 1 |
| Arctic Tern | *Sterna paradisaea* | 2 |
| Audubon's Shearwater | *Puffinus lherminieri* | 174 |
| Band-rumped Storm-Petrel | *Oceanodroma castro* | 46 |
| Barn Swallow | *Hirundo rustica* | 12 |
| Barolo Shearwater | *Puffinus baroli* | 1 |
| Black Tern | *Chlidonias niger* | 1 |
| Black-bellied Plover | *Pluvialis squatarola* | 12 |
| Black-capped Petrel | *Pterodroma hasitata* | 50 |
| Cliff Swallow | *Petrochelidon pyrrhonota* | 8 |
| Common Tern | *Sterna hirundo* | 1 |
| Cory's Shearwater | *Calonectris diomedea* | 722 |
| Great Black-backed Gull | *Larus marinus* | 2 |
| Great Shearwater | *Ardenna gravis* | 382 |
| Herring Gull | *Larus argentatus* | 1 |
| Leach's Storm-Petrel | *Oceanodroma leucorhoa* | 117 |
| Least Tern | *Sternula antillarum* | 1 |
| Manx Shearwater | *Puffinus puffinus* | 11 |
| Masked Booby | *Sula dactylatra* | 2 |
| Ovenbird | *Seiurus aurocapillus* | 1 |
| Pomarine Jaeger | *Stercorarius pomarinus* | 4 |
| Purple Martin | *Progne subis* | 1 |
| Red-billed Tropicbird | *Phaethon aethereus* | 2 |
| Red-necked Phalarope | *Phalaropus lobatus* | 4 |
| Semipalmated Sandpiper | *Calidris pusilla* | 1 |
| Sooty Shearwater | *Ardenna grisea* | 1 |
| South Polar Skua | *Stercorarius maccormicki* | 4 |
| Tree Swallow | *Tachycineta bicolor* | 2 |
| Trindade Petrel | *Pterodroma arminjoniana* | 1 |
| Unidentified *Puffinus* shearwater | *Puffinus* species | 4 |
| Unidentified storm-petrel | *Oceanodroma* species | 28 |
| Unidentified swallow | swallow species | 1 |
| Unidentified tern | *Sterna* species | 1 |
| White-faced Storm-Petrel | *Pelagodroma marina* | 6 |
| Wilson's Storm-Petrel | *Oceanites oceanicus* | 522 |
| TOTAL | | 2129 |

**Figure 5.1. True's beaked whale (*Mesoplodon mirus*). Photo taken under NMFS permit # 21371 by K. Sutherland**

**Figure 5.2. Image of a HARP recovery. The HARP (high-frequency acoustic recording package) is released from the seafloor using an acoustic signal transmitted by a shipboard transducer and must be spotted visually once it surfaces. The ship then approaches and a hook is thrown to pull it in. The HARP is then attached to the ship's crane and lifted onto the deck.**

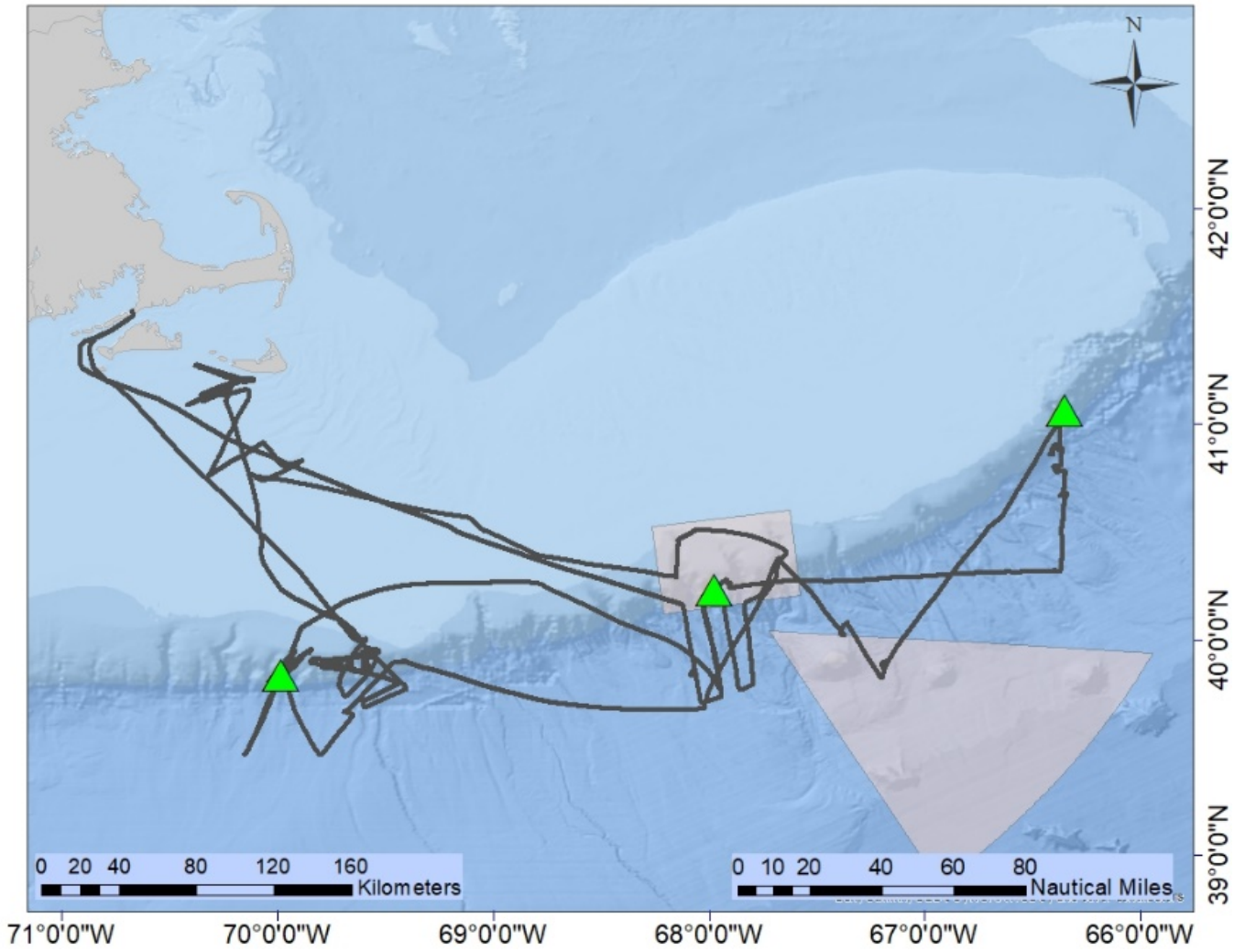


**Figure 5.3. Overall survey coverage. Gray lines indicate area surveyed, including both daytime and nighttime effort. Passive acoustic data were collected at night when in waters deeper than 100m; visual effort was only conducted during daylight hours. The green triangles indicate locations of the High-frequency acoustic recording packages (HARPs) that were recovered; a conductivity temperature depth (CTD) sampler was conducted at each site as well. The Northeast Canyons and Seamounts Marine National Monument is shown in pink-grey polygons.**

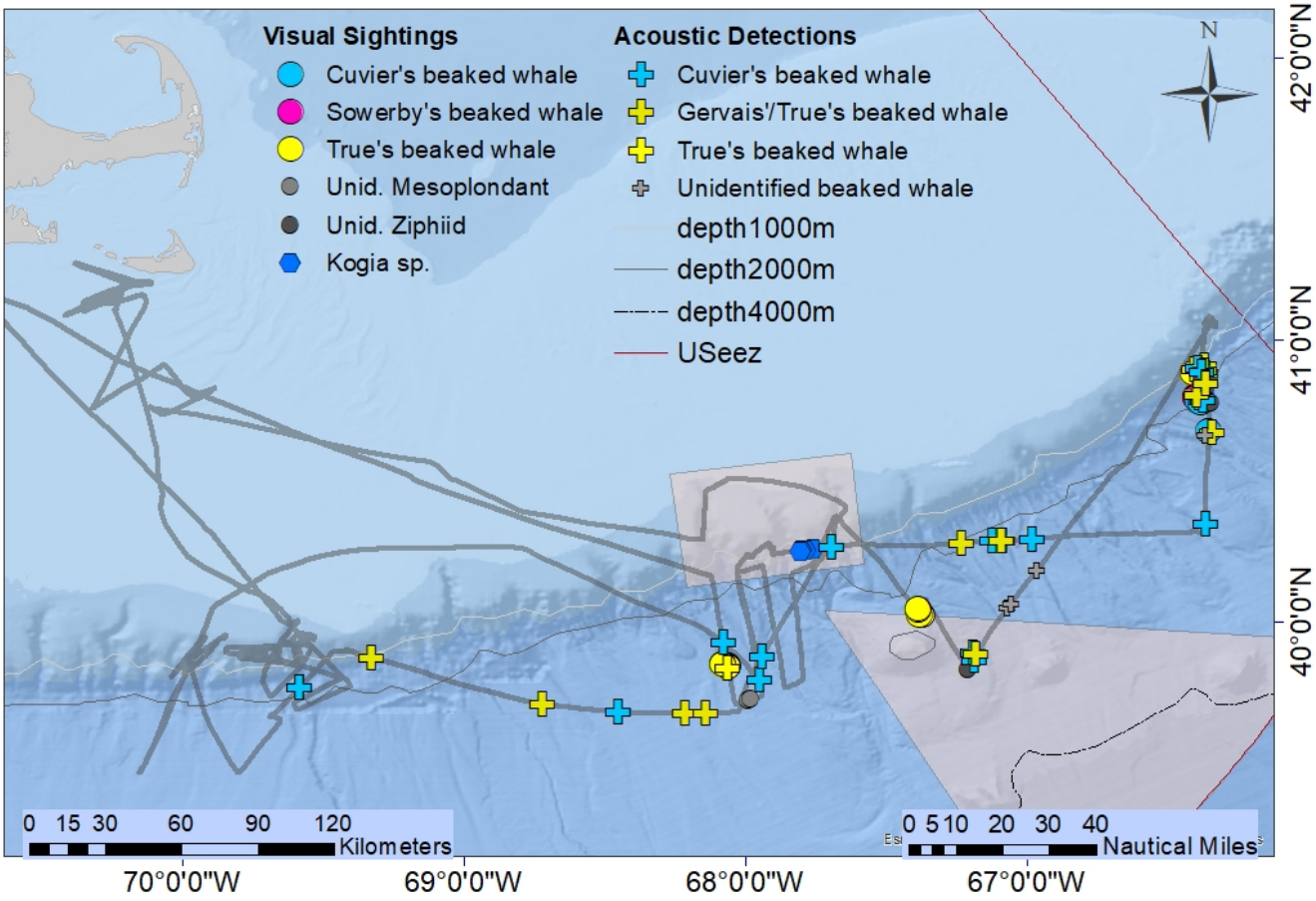


**Figure 5.4 Visual sightings of beaked whales and Kogia sp., and acoustic detections of beaked whales. Acoustic data were not monitored for Kogia sp. in real time during the survey. Survey tracklines, including daytime and nighttime transits, are shown in gray.**

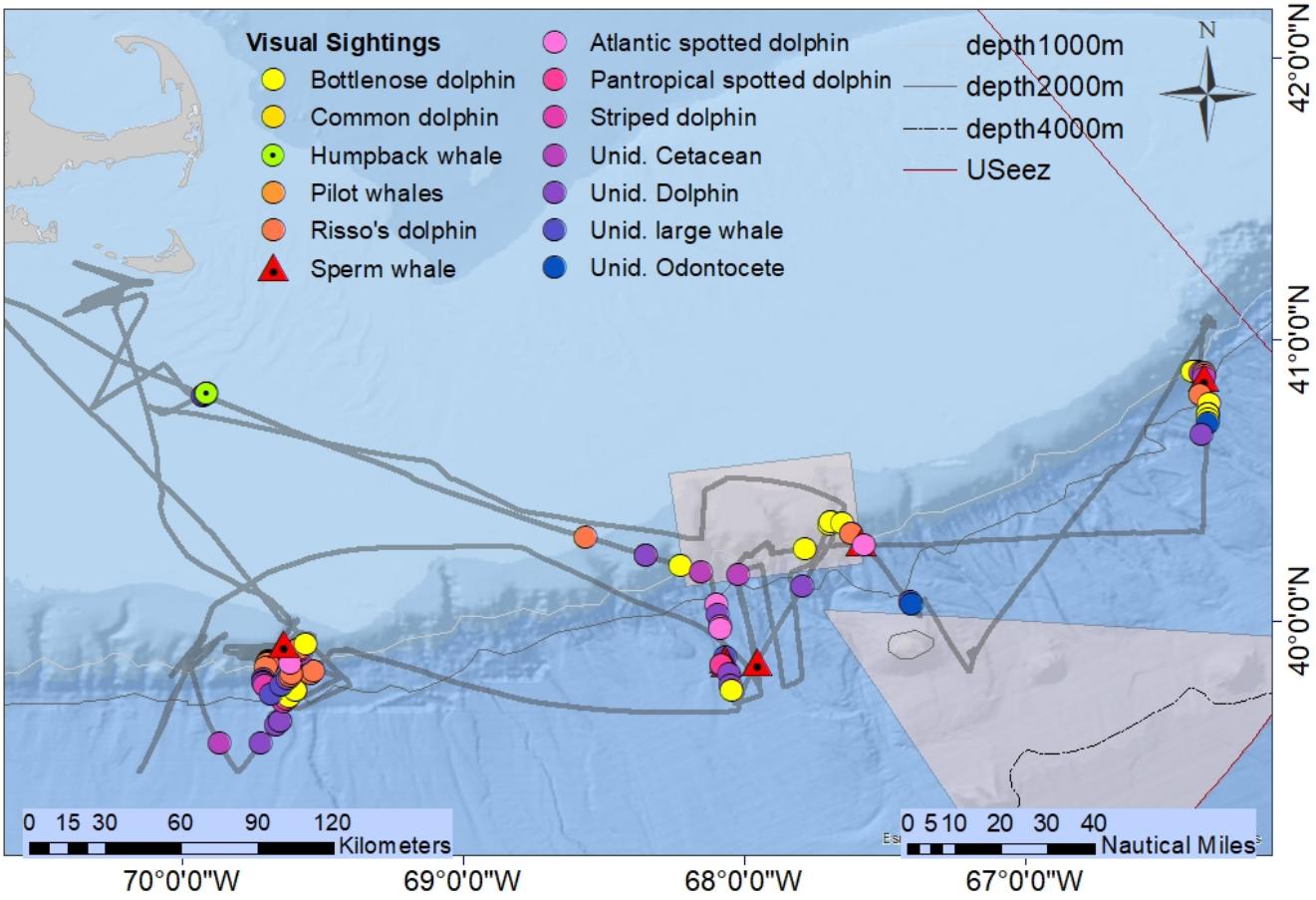


**Figure 5.5. Visual sightings of dolphins and large whales. Survey track lines, including daytime and nighttime transits, are shown in gray.**

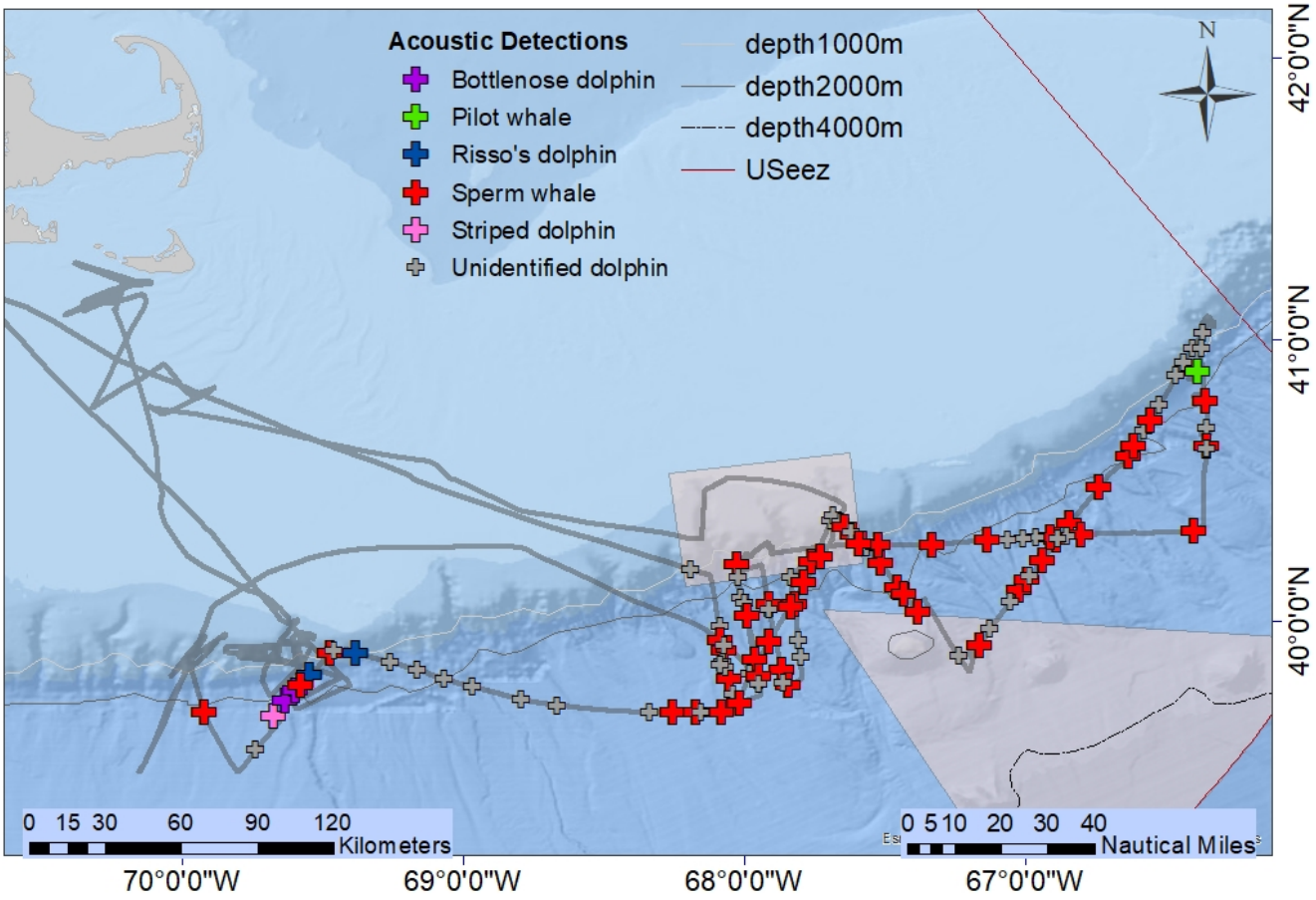


**Figure 5.6. Acoustic detections of dolphins and sperm whales. Survey tracklines, including daytime and nighttime transits, are shown in gray.**

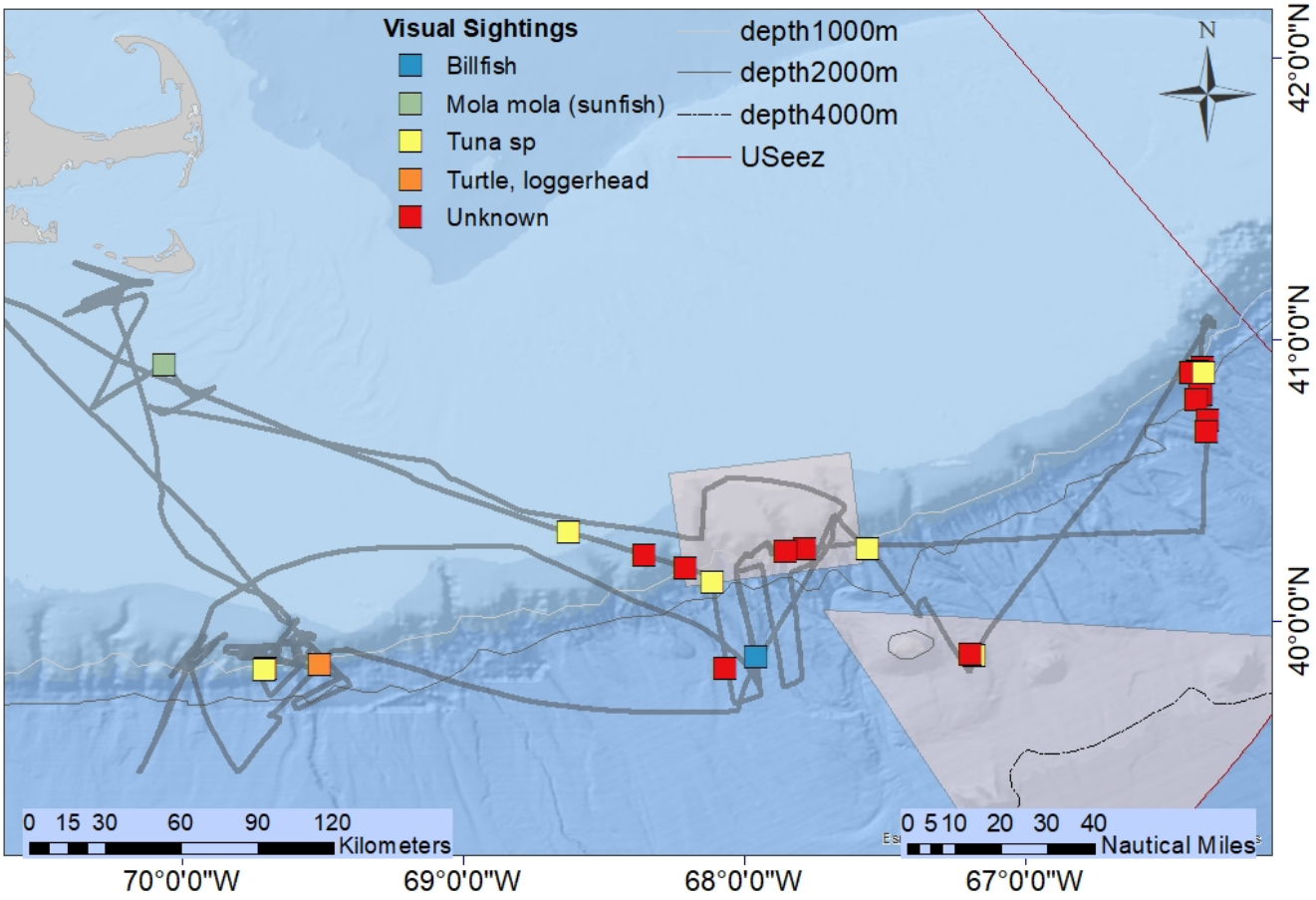


**Figure 5.7. Visual sightings of fishes and turtles. Survey tracklines, including daytime and nighttime transits, are shown in gray.**

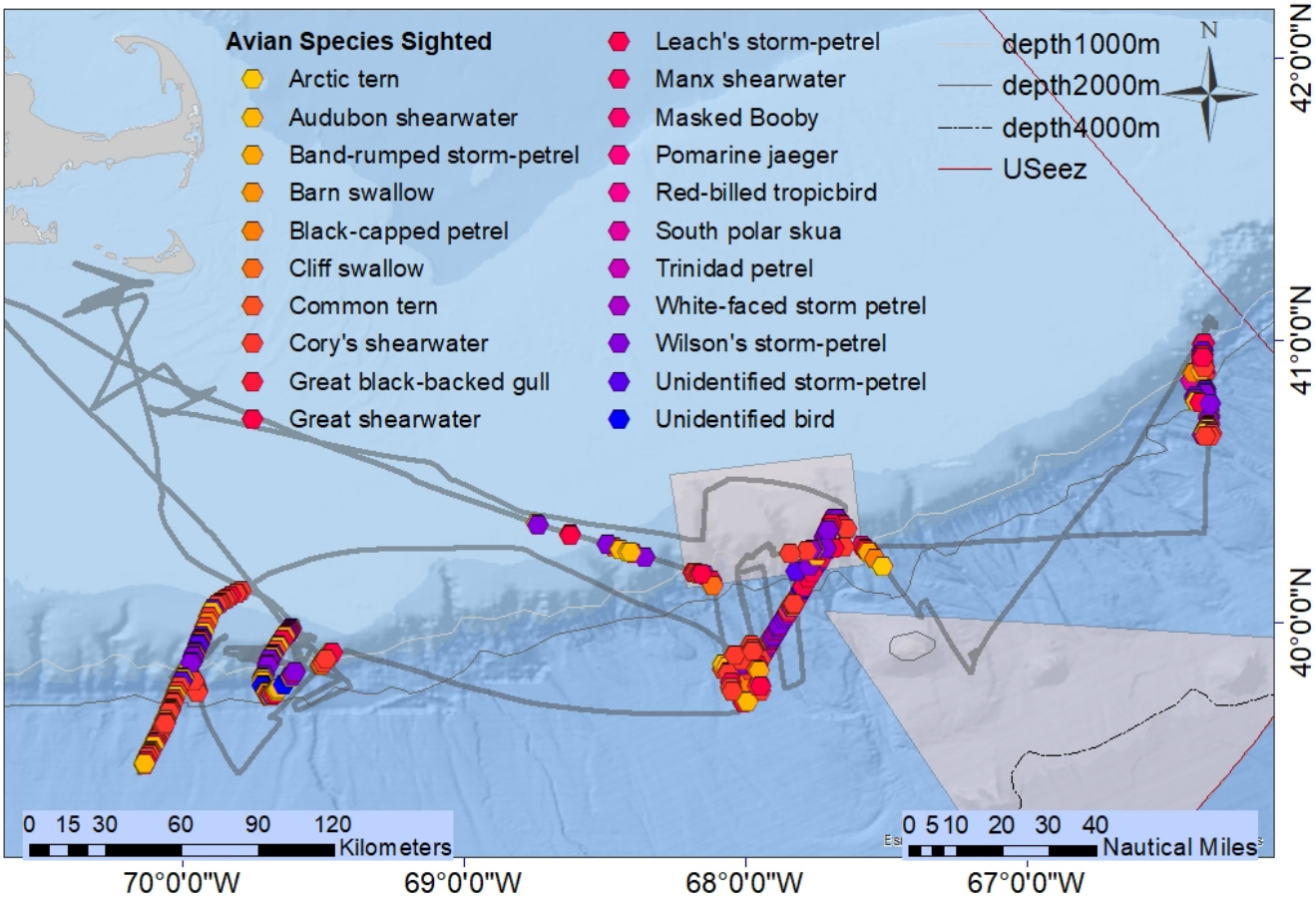


**Figure 5.8. Visual sightings of bird species. Survey tracklines, including daytime and nighttime transits, are shown in gray.**

# 6 Sea turtle tagging 2019: Northeast and Southeast Fisheries Science Centers

**Heather Haas[1], Chris Sasso[2]**

[1]Northeast Fisheries Science Center, 166 Water St, Woods Hole, MA 02543
[2]Southeast Fisheries Science Center, 75 Virginia Beach Dr., Key Biscayne, FL 33149

## 6.1 Summary

Three major field programs occurred in 2019: loggerhead turtle (*Caretta caretta*) satellite tagging, leatherback turtle (*Dermochelys coriacea*) satellite tagging, and leatherback suction cup tagging. All tagged turtles remained for months in the Atlantic and will provide important surfacing time data to be used to improve relative abundance estimates from line transect surveys.

## 6.2 Objectives

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) program coordinates the data collection and analysis efforts of the National Marine Fisheries Service (NMFS) Northeast and Southeast Fisheries Science Centers (NEFSC and SEFSC) to accomplish six primary objectives, three of which are relevant to the AMAPPS Turtle Ecology task:

- Collect data on distribution and abundance at finer scales using visual and acoustic survey techniques
- Conduct tag telemetry studies within surveyed regions of marine turtles, pinnipeds and seabirds to develop corrections for availability bias in the abundance survey data and collect additional data on habitat use and life-history, residence time, and frequency of use
- Explore alternative platforms and technologies to improve population assessment studies

To conduct tag telemetry studies in 2019 in the absence of dedicated ship time on NOAA's offshore vessels, the NEFSC and SEFSC used shore-based small boats to satellite tag leatherbacks in coastal waters off of North Carolina and Massachusetts. In addition, they collaborated with Coonamessett Farm Foundation (CFF) who deployed satellite tags on loggerheads in offshore waters in the southern Mid-Atlantic waters.

## 6.3 Cruise Periods and Areas

No large-scale AMAPPS turtle tagging cruises were planned for 2019. However, we did participate in day trips and three collaborative projects:

- Loggerhead turtle satellite tagging project. Cruise led by CFF during 5 – 8 Jun 2019 primarily in the southern Mid-Atlantic waters
- Leatherback turtle satellite tagging project. Small boat day trips during 13 – 23 May 2019 off of North Carolina and 19 – 30 August 2019 off of Massachusetts
- Leatherback turtle suction cup tagging. Small boat day trips primarily off Massachusetts during August – October 2019.

## 6.4 Methods and Results

### *6.4.1 Loggerhead satellite tagging*

Coonamessett Farm Foundation (funded via an Atlantic Sea Scallop research set aside project) deployed ten AMAPPS satellite tags on loggerheads in early June 2019 on the Mid-Atlantic shelf (Figure 6.1). The turtles were captured and handled using methods consistent with previous cruises (Patel *et al.* 2018). Standard morphometrics measurements were recorded, and tissue samples were taken. Three satellite tags were sent to Canada for hopeful deployment, but deployment was not possible. In 2020, we plan to have time aboard the NOAA ship *Gordon Gunter* in 2020. In addition to deploying satellite tags, we are hopeful that collaborators may be willing to perform laparoscopies so that sex ratios can be determined.

In preparation for availability analysis, tracks of 180 loggerhead turtle were post-processed similar to Winton *et al.* (2018) to reconstruct the tracks using a Continuous Time Correlated Random Walk movement model by making improvements (incorporation of GPS data, implementation of a speed filter, and finer scale output). Loggerhead satellite tag data are being analyzed for percent time at surface, dive duration, and surface duration. The data from the leatherback suction cup tags are being compiled and will be analyzed for turtle behavior, including percent time on the surface.

The estimated distribution of tagged loggerhead turtles from Winton *et al.* (2018) was published within the Northeast and Mid-Atlantic Ocean Data Portals.

Together with partners, physiological data from satellite tagged loggerheads were published in Yang *et al.* (2019). This publication established a physiological baseline for a globally important foraging assemblage of loggerhead sea turtles.

### *6.4.2 Leatherback satellite tagging*

Thirteen towable satellite tags were successfully deployed on leatherbacks in May 2019 in coastal North Carolina. The turtles were captured and tagged from small vessels with the assistance of a spotter plane to locate turtles. Once located, turtles were captured via a large hoop net and then brought aboard a floating platform (TAKAKAT) for tagging as well as measurements and health monitoring. The tagged turtles have dispersed widely after tagging (Figure 6.2). Some remained on the shelf for months after tagging and others dispersed more broadly into the Atlantic Ocean. We also deployed nine satellite tags in Cape Cod Bay in August 2019. All nine turtles moved out of the Bay and into southern New England waters within a week of being tagged (Figure 6.3). The towed satellite tags performed excellent. The data on surface time will be used as correction factors for aerial survey estimates. The tags are providing much needed information on leatherback use of Atlantic waters along the U.S. coast. Data are still being transmitted and we plan for additional tag deployments in 2020 at both locations.

### *6.4.3 Leatherback suction cup tagging*

The NEFSC, SEFSC, Coonamessett Farm Foundation, Department of Fisheries and Oceans Canada, and Loggerhead Instruments collaborated on leatherback suction cup tagging in support of a NOAA-funded Bycatch Reduction Engineering Project (BREP) and AMAPPS objectives. Together we tested several new suction cup tag designs. One design was the result of a collaboration between NMFS, CFF, and Loggerhead Instruments; this tag is an extension of the

AMX tag. The second design was a simpler tag with video, depth, time, temperature, and location. The third design was a new hybrid design incorporating both high resolution video as well as a standard satellite tag. We were able to simultaneously collect data on animal behavior (including surface duration) and improve the capability of the tags. Through collaboration with the BREP projects, suction cup camera tags were deployed on 24 leatherbacks, primarily in Massachusetts state waters. The results from the suction cup tagging will be used to describe surfacing behavior, foraging behavior, and dive behavior.

## 6.5 Disposition of Data

Data from all Sea Mammal Research Unit (SMRU) satellite tags purchased by AMAPPS as well as those deployed by Coonamessett Farm Foundation in support of Research Set Aside objective are maintained in an Oracle Database at NEFSC. Data from all leatherback satellite tags are maintained by the SEFSC.

## 6.6 Permits

The deployment leatherback tags were authorized under the US Permit No. 21233 issued to the SEFSC and US Permit No. 22218 issued to NEFSC. Loggerhead research in 2019 was primarily under US Permit No. 18526 issued to Coonamessett Farm Foundation.

## 6.7 Acknowledgements

We acknowledge the substantial contributions of our non-NOAA collaborators at Coonamessett Farm Foundation (East Falmouth, MA), Fisheries and Oceans Canada (Dartmouth, Nova Scotia, Canada), University of North Carolina (Department of Biology and Marine Biology, Wilmington, NC), North Carolina State University's College of Veterinary Medicine, and Loggerhead Instruments. We also thank James Gutowski of Viking Village Fisheries and the captains, crew, and scientists on the F/V *Kathy Ann* for their expert field work. Within NOAA, AMAPPS research has been supported by the skills and effort of Annie Gorgone, Larisa Avens, Leah Crowe, Jamie Clark, Joshua Hatch, Mike Judge, Eric Matzen, Joanne Braun McNeil, and Blake Price. Research was funded in part by the scallop industry Sea Scallop Research Set Aside program administered by the Northeast Fisheries Science Center under grants; by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC, through Inter-Agency Agreement Number with the National Marine Fisheries Service as the Atlantic Marine Assessment Program for Protected Species (AMAPPS); and by the Northeast and Southeast Fisheries Science Centers.

## 6.8 References Cited

Patel SH, Barco SG, Crowe LM, Manning JP, Matzen E, Smolowitz RJ, Haas HL. 2018. Loggerhead turtles are good ocean-observers in stratified mid-latitude regions. Estuarine, Coastal and Shelf Science. Nov 30;213:128-36.

Yang T, Haas HL, Patel S, Smolowitz R, James MC, Williard AS. 2019. Blood biochemistry and haematology of migrating loggerhead turtles (*Caretta caretta*) in the Northwest Atlantic: reference intervals and intra-population comparisons. Conservation physiology 7(1):coy079.

Dd

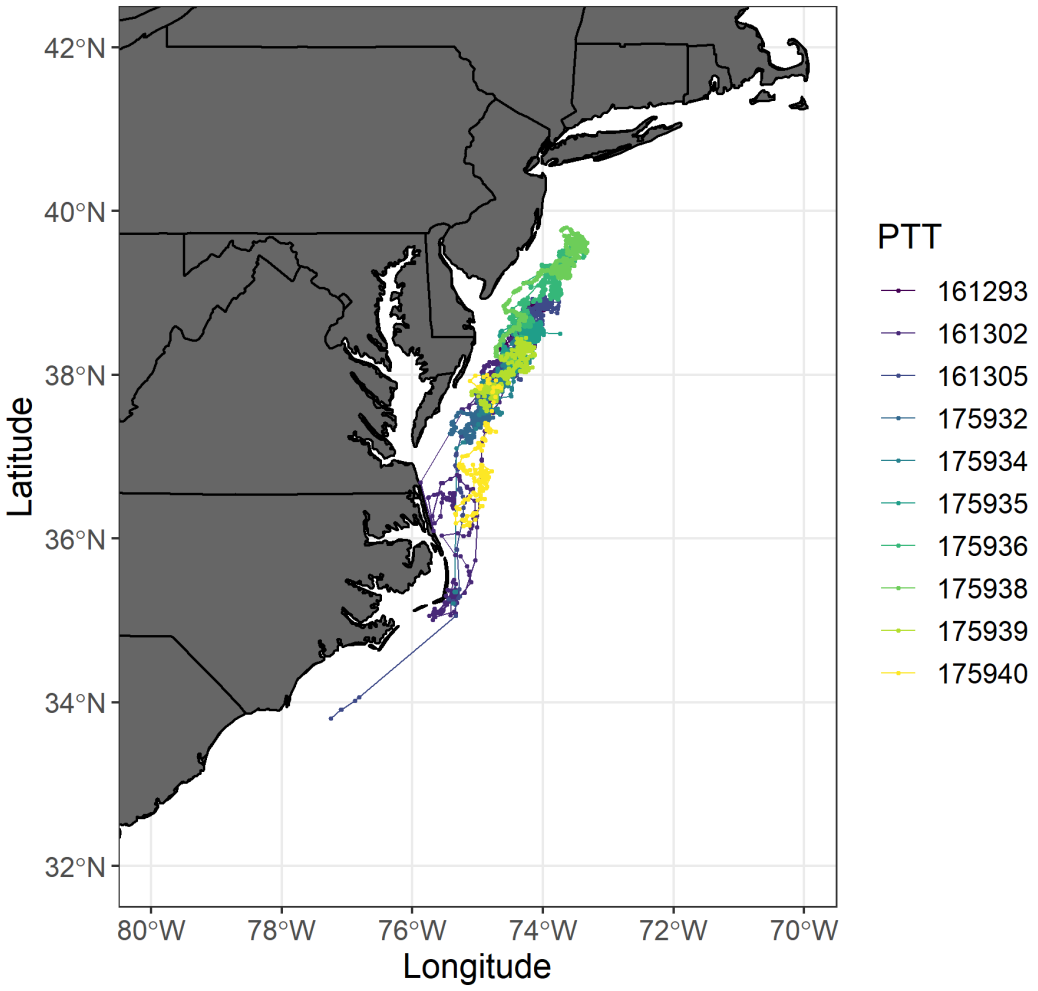


**Figure 6-1 Tracks of loggerhead turtles (*Caretta caretta*) tagged in 2019**

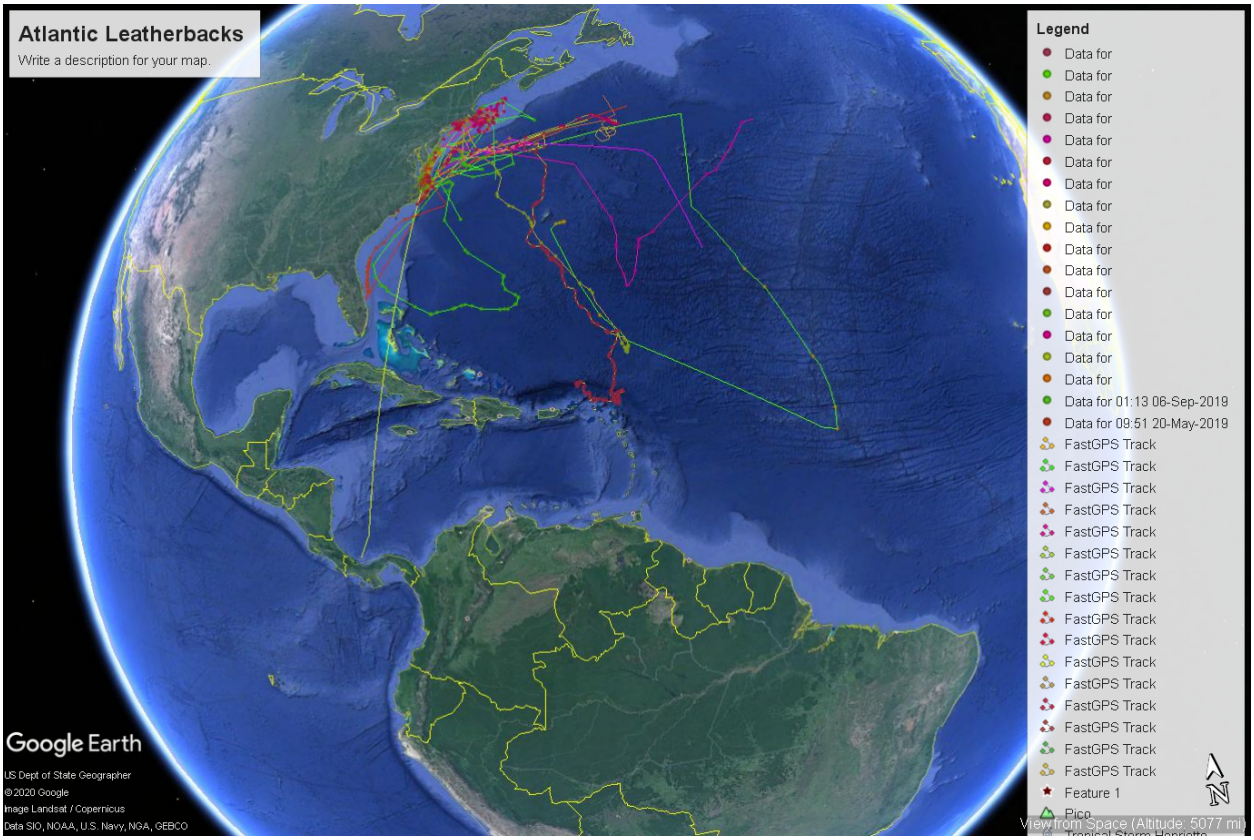


**Figure 6-2 Full extent of tracks of leatherback turtles (*Dermochelys coriacea*) tagged during 2019, up to 1 July 2020**

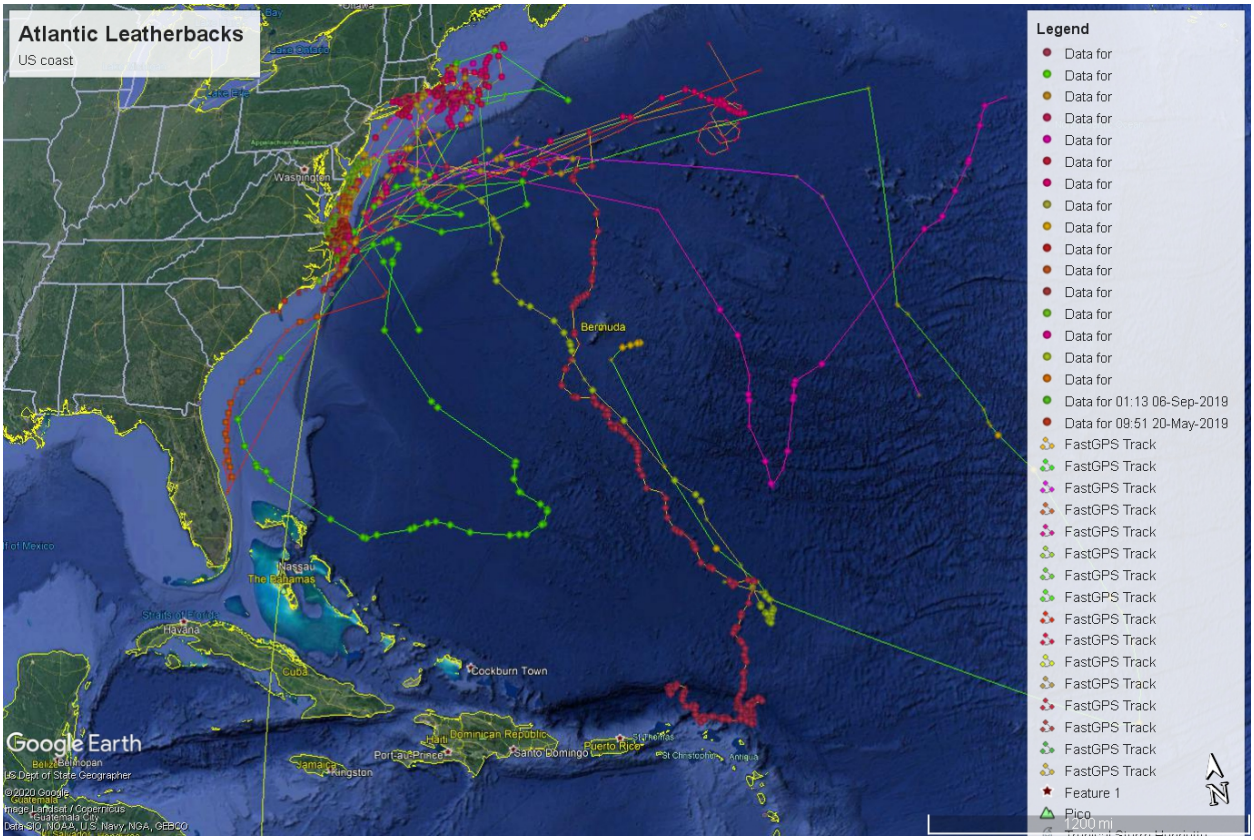


**Figure 6-3 Close up view near US east coast of tracks of leatherback turtles (*Dermochelys coriacea*) tagged in 2019, up to 1 July 2020**

# 7 At-sea monitoring of the distributions of pelagic seabirds in the northeast US shelf ecosystem: Northeast Fisheries Science Center

**Harvey J. Walsh[1], Nicholas Metheny[2], Allison Black[2]**

[1] Northeast Fisheries Science Center, 28 Tarzwell Dr, Narragansett RI 02882
[2] Integrated Statistics, Inc., 16 Sumner St., Woods Hole, MA 02543

## 7.1 Summary

Three shipboard surveys were completed in 2019 during Ecosystem Monitoring Surveys (EcoMon), and an additional two surveys were opportunistically conducted on Woods Hole Oceanographic Institution trips that were part of a National Science Foundation sponsored project entitled "Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications". These surveys sampled regions from the Gulf of Maine to the Mid-Atlantic Bight. A total of 15,724 sightings of seabirds and 2,797 other marine megafauna were recorded. The majority of sea bird species for each survey varied by season and region but were dominated by Shearwaters (*Puffinus* sp.), Storm-Petrels (*Oceanites* sp.), Cormorants (*Phalacrocorax* sp.), Gannets (*Morus* sp.), and Phalaropes (*Phalaropus sp.*). In general, spring was dominated by Phalaropes and Storm-Petrels, summer by Shearwaters, and fall by Shearwaters, Cormorants, and Gannets.

## 7.2 Objective

The goal of this at-sea monitoring program is to conduct comprehensive visual surveys of seabirds, marine mammals, turtles, large pelagic fish, and marine debris on shipboard cruises being conducted on the Northwest Atlantic US shelf ecosystem by piggy-backing on research cruises conducted by the National Oceanic and Atmospheric Administration (NOAA) or other organizations. Collecting seabird and marine mammal data in conjunction with other biological data and abiotic factors that were being concurrently collected will help to understand the spatial-temporal distributions of the species and relationships with other trophic levels within the changing marine ecosystem on the Northeast Atlantic US shelf.

## 7.3 Methods

The data collection protocol was based on a standardized 300 m strip transect methodology, like that used by various agencies in North America and Europe (Anon 2011, Ballance 2011, Tasker 2004). Observers collected data on all seabirds within a 300 m strip on one side of the ship's track line. Observers searched from the bow to 90° to either the port or the starboard side, depending on which side had the best viewing conditions. Surveys were conducted on the flying bridge of the ship, whenever possible. Observations were conducted in sea states up to a Beaufort 7, in light rain, fog, and ship speeds between 8 – 12 knots (below 8 knots, the data becomes questionable to use for abundance estimates).

A new SeaScribe program (version 1.2.1) was used for data entry (Merrill *et al.* 2019). The SeaScribe app draws GPS coordinates, as well as time from a GPS device via bluetooth, so each observation received data on the latitude-longitude position, time stamp, and ship's course. The standard data collected for observations included species identification, distance between the

ship and the animal, number of individuals, association, behavior, flight direction, flight height, and if possible or applicable, age, sex, and plumage status. While SeaScribe was not specifically designed to collect data on other marine megafauna, other species were recorded anytime an animal was seen, both in and outside of the 300 m strip survey zone.

On HB1902, the SeaScribe program was attempted, but issues with the location services/GPS positioning of the tablet device running the program was not continuously updating sighting positions, and therefore after the first afternoon, data were recorded using the Seebird (version 4.3.7) data entry program, which had been used in previously years. The data collected on SeeBird were similar to that described above for the SeaScribe data entry program. For the purposes of the HB1902 survey a flock was deemed an aggregation of seven birds or more and were recorded even if seen outside the standard survey area. For flocks, latitude-longitude location, time, bearing, distance (estimated distances were made in the comment section), species composition and number, association, behavior, age, and sex were recorded.

During surveys, one on-effort observer utilized binoculars (10x42) to scan within the survey strip. When there were two observers onboard, they alternated two-hour shifts, with one person on-effort collecting data and the other was off-effort (not collecting data). If an animal proved elusive a pair of 20x60 Zeiss imaged-stabilized binoculars were used to attain positive identifications. To aide in approximating distance observers used custom made range finders based on height above water and the observers' personal body measurement (Heinemann 1981).

## 7.4 Results

During 2019, five research cruises were utilized to conduct strip transect monitoring of seabirds, along with marine mammals, sea turtles and large fish species. Three of the cruises were part of the "Ecosystem Monitoring (EcoMon)" project led by the Northeast Fisheries Science Center:

- HB1902 on the NOAA ship *Henry B. Bigelow* during 22 May – 6 June 2019
- GU1902 on the NOAA ship *Gordon Gunter* during 15 – 29 August 2019
- GU1905 on the NOAA ship *Gordon Gunter* during 15 October – 1 November 2019.

EcoMon's principal objective is to survey the hydrographic, planktonic and pelagic components of the Northeast U.S. continental shelf ecosystem. Specifically, to quantify the spatial distribution of the following parameters: water currents, water properties, phytoplankton, microzooplankton, mesozooplankton, sea birds, sea turtles and marine mammals.

The other two cruises were part of the "Shelfbreak frontal dynamics: mechanisms of upwelling, net community production, and ecological implications" project led by the Woods Hole Oceanographic Institution:

- RB1904 on the NOAA ship *Ronald H. Brown* during 12 – 24 May 2019
- TN368 on the R/V *Thomas G. Thompson* during 7 – 17 July 2019.

This program's principal objective is to explore the relationship between upwelling mechanisms and productivity in the Middle Atlantic Bight, focused on the shelf break front.

Detailed results from each cruise are documented below.

### 7.4.1 RB1904: 12 – 24 May 2019

Over the course of the twelve-day cruise, the ship sampled primarily along the Ocean Observatories Initiative (OOI) Pioneer Array south of Martha's Vineyard, Massachusetts (Figure 7.1). The array is a combination of moored instrumentation and mobile assets (gliders, AUVs) that sample the frontal system of the shelf. The marine species observer was Allison Black.

A total of 1,280 birds were observed, of which 760 were in the survey strip (Table 7.1). Red Phalaropes (*Phalaropus fulicarius*) and Common Terns (*Sterna hirundo*) were the most frequently sighted birds.

Of special note, on 13 May 2019, a falcon that landed on the ship was photographed. Originally it was identified as a Peregrine falcon. However, after sharing the photos with other experts, the bird was subsequently identified as a Eurasian Hobby (*Falco Subbuteo*) due to several unique characters documented in the photograph, and the record was accepted at the Twenty-third Report of the Massachusetts Avian Records Committee.

A total of 108 marine mammals were observed, of which 35 were in the survey strip (Table 7.2). The common dolphin (*Delphinus delphis*) was the most frequently sighted marine mammal. The sei whale (*Balaenoptera borealis*) was the most frequently sighted large whale. No sea turtles, sharks, or large pelagic fish sightings were detected.

### 7.4.2 HB1902: 22 May – 6 June 2019

Over the course of the cruise approximately 1,487 nautical miles were surveyed, from the Delamarva Peninsula, to Georges Bank, and to the western Gulf of Maine (Figure 7.2). The marine species observers were Nicholas Metheny and John Loch.

A total of 2,589 birds were observed in the survey strip, within an additional 1,686 birds observed outside the strip during on- and off-effort time periods (Table 7.3). As is usual at this time of year, migration was under way with high arctic breeders nearly absent, and denizens from further south, and elsewhere coming to feed during the summer months and/or rear young. At the species level, Sooty Shearwaters (*Ardenna grisea*), unidentified Scoters (*Melanitta sp*.), and Wilson's Storm Petrels (*Oceanites oceanicus*) were the most abundant birds seen, making up 18%, 14.7% , and 13.6% relatively of the total count of birds recorded. It should be noted Wilson's Storm Petrels were the most abundant bird seen inside the survey strip zone, whereas, Sooty Shearwaters were the most abundant in all areas. The abundance of unidentified Scoters was from a single sighting event at a far distance while the ship was steaming near Nantucket Shoals. Further, seabirds that were seen in large numbers were Red Phalaropes (*Phalaropus fulicarius*), Northern Fulmars (*Fulmarus glacialis*), Great Shearwaters (*Puffinus gravis*), and Northern Gannets (*Morus bassanus*), making up 8%, 7.5%, 7.4%, and 6.7% relatively, of the total birds seen.

Of special note, unexpected bird sightings detected so late in the season were Dovekie (*Alle alle*) and Red Throated Loons (*Gavia stellate*), all adults in breeding plumage. Of further note were the six identified passerine species that were seen on their northward migration.

The most commonly seen marine mammal, was the common dolphin, accounting for approximately 66.4% of all mammal sightings, followed by the common bottlenose dolphin (*Tursiops truncatus*), at approximately 12.8% of all mammal sightings (Table 7.4). Of the large whales, humpback whales (*Megaptera novaengliae*) made up almost half of identified whales,

followed by unidentified whales, making up about a quarter of all whales seen. There were more sei whales seen on this survey as compared to past EcoMon cruises, with a total of eight being seen in the Wilkinson Basin area of the Gulf of Maine.

There were only two confirmed loggerhead sea turtles (*Caretta caretta*) sighted in the warmer waters off the Mid-Atlantic. Basking sharks (*Cetorhinus maximus*) were also mostly seen in Mid-Atlantic warm waters (Table 7.4). It should be noted that a large concentration of basking sharks continued to be seen after the end of the survey day on 26 May 2019, with over forty more basking sharks seen until around 8 pm, at which time light conditions limited the ability to detect more.

### *7.4.3 TN368: 7 – 17 July 2019*

Over the course of the eleven-day cruise, the ship sampled primarily along the Ocean Observatories Initiative (OOI) Pioneer Array south of Martha's Vineyard, Massachusetts (Figure 7.3). The array is a combination of moored instrumentation and mobile assets (gliders, AUVs) that sample the frontal system of the shelf. The marine species observer was Allison Black.

A total of 457 birds were observed, of which 192 were in the survey strip (Table 7.5). Great Shearwaters and Wilson's Storm Petrels were the most frequently sighted birds. Of special note, were the three Brown Boobys (*Sula leucogaster*).

A total of 22 marine mammals were observed, of which 17 were in the survey strip (Table 7.6). Risso's dolphins (*Grampus griseus*) and common bottlenose dolphins, were the most frequently sighted marine mammals. Unidentified flying fish (*Exocetus* sp.) were also sighted.

### *7.4.4 GU1902: 15 – 30 August 2019*

Over the course of the fifteen-day cruise, the ship sampled the northeast US shelf from Chesapeake Bay, Virginia, to Georges Bank, and the central and western Gulf of Maine (Figure 7.4). The marine species observers were Allison Black and Christopher Vogel.

A total of 3851 birds were observed, of which 2214 were in the survey strip (Table 7.7). Greater Shearwaters, Cory's Shearwaters (*Calonectris diomedea*) and Wilson's Storm Petrels were the most frequently sited birds.

A total of 1079 other megafauna were observed, of which 887 were in the survey strip (Table 7.8). The common dolphin was the most frequently sighted marine mammal. Pilot whales (*Globicephala* sp.) were the most frequently sighted whale. Seven turtles were sighted, 4 were unidentified turtles and 3 were leatherback turtles (*Dermochelys coriacea*). Cownose rays (*Rhinoptera bonasus*) were the most frequently sighted fish.

### *7.4.5 GU1905: 15 October – 1 November 2019*

Over the course of the eighteen-day cruise, the ship sampled the northeast US shelf from Cape Hatteras, North Carolina, to Georges Bank, and some of the western Gulf of Maine (Figure 7.5). The marine species observers were Allison Black and Christopher (Skye) Haas.

A total of 5861 birds were observed, of which 2831 in the survey strip (Table 7.9). Great Shearwaters and Northern Gannets were the most frequently sighted birds.

A total of 736 other megafauna were observed, of which 593 were in the survey strip (Table 7.10). The common dolphin was the most frequently sighted marine mammal. Short-finned pilot whales (*Globicephala macrorhynchus*) was the most frequently sighted whale. Ten turtles were sighted, of which 9 were loggerhead turtles and 1 was a leatherback turtle. Ocean sunfish (*Mola mola*) were the most frequently sighted fish.

## 7.5 Disposition of Data

The visual sightings data from each cruise is maintained in an Oracle Database at the Northeast Fisheries Science Center and distributed to the Seabird Compendium.

## 7.6 Acknowledgements

We acknowledge the officers and crew of National Oceanic and Atmospheric Administration (NOAA) ships *Ronald H. Brown, Henry B. Bigelow* and *Gordon Gunter* and the R/V *Thomas G. Thompson* for their great ship support. We would also like to thank Dr. Dennis McGillicuddy of Woods Hole Oceanographic Institution for providing a berth for an observer aboard their research cruises. This seabird monitoring project was funded by the U.S. Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC, through an Inter-Agency Agreement with the National Marine Fisheries Service as the Atlantic Marine Assessment Program for Protected Species (AMAPPS); and by the Northeast Fisheries Science Center.

## 7.7 References Cited

Anonymous. 2011 Seabird Survey Instruction Protocol. Seabird distribution and abundance, Summer 2011. NOAA RV Henry B. Bigelow. Northeast Fisheries Science Center.

Ballance LT. 2011. Seabird Survey Instruction Manual, PICEAS 2011. Ecosystems Studies Program Southwest Fisheries Science Center, La Jolla, California.

Heinemann, D. 1981. A range finder for pelagic bird censusing. Journal of Wildlife Management 45:489-493.

Merrill M, Wadington J., Gilbert A, Connelly E, Stenhouse I, McNally R, Edwards D. Avian survey application (SeaScribe v.1.3.6) User Manual. https://www.boem.gov/sites/default/files/documents/renewable-energy/SeaScribe_Manual.pdf

Tasker ML, Hope Jones P, Dixon T, Blake BF. 1984. Counting seabirds at sea from ships; a review of methods employed and a suggestion for a standardized approach. Auk 101: 567 – 577.

**Table 7-1 Total number of birds detected on the RB1904 (RB), HB1902 (HB), TN368 (TN), GU1902 (G2), and GU1905 (G5) surveys**

| Common Name | Latin Name | RB | HB | TN | G2 | G5 |
|---|---|---|---|---|---|---|
| American pipit | *Anthus rubescens* | | | | | 1 |
| Arctic tern | *Sterna paradisaea* | | 13 | | | |
| Atlantic puffin | *Fratercula arctica* | | 44 | | | 39 |
| Audubon shearwater | *Puffinus lherminieri* | 1 | | 2 | 54 | 21 |
| Band-rumped storm-petrel | *Oceanodroma castro* | | | | 8 | |
| Barn swallow | *Hirundo rustica* | | 3 | | 23 | |
| Belted kingfisher | *Megaceryle alcyon* | | | | | 1 |
| Black-bellied plover | *Pluvialis squatarola* | 2 | | | | |
| Black-capped petrel | *Pterodroma hasitata* | 1 | | | 1 | 2 |
| Black-legged kittiwake | *Rissa tridactyla* | | 2 | | | 11 |
| Black-throated blue warbler | *Setophaga caerulescens* | | | | | 1 |
| Black scoter | *Melanitta americana* | | | | | 62 |
| Black skimmer | *Rynchops niger* | | | | 12 | |
| Black tern | *Chlidonias niger* | | | | 5 | |
| Blackpoll warbler | *Setophaga striata* | | 1 | | | 3 |
| Blue-headed vireo | *Vireo solitarius* | | | | | 1 |
| Bonaparte's gull | *Larus philadelphia* | | | | 1 | |
| Brant | *Branta bernicla* | | | | | 7 |
| Brown-headed cowbird | *Molothrus ater* | | | 1 | 5 | 2 |
| Brown booby | *Sula leucogaster* | | | 3 | 1 | |
| Brown pelican | *Pelecanus occidentalis* | | | | 76 | 11 |
| Cedar waxwing | *Bombycilla cedrorum* | | 2 | | | |
| Chimney swift | *Chaetura pelagica* | | 1 | | | |
| Cliff swallow | *Petrochelidon pyrrhonota* | | | | 5 | |
| Common eider | *Somateria mollissima* | | 1 | | | |
| Common loon | *Gavia immer* | | 14 | | 1 | |
| Common tern | *Sterna hirundo* | 92 | 144 | | 75 | |
| Common yellowthroat | *Geothlypis trichas* | | 1 | | | |
| Cory's shearwater | *Calonectris borealis* | 2 | 16 | 24 | 567 | 230 |
| Dark-eyed junco | *Junco hyemalis* | | | | | 1 |
| Dark scoter (black or surf) | *Melanitta sp.* | | | | | 37 |
| Double-crested cormorant | *Phalacrocorax auritus* | 1 | 37 | | 80 | 1847 |
| Dovekie | *Alle alle* | 1 | 9 | | | |
| Dowitcher | *Limnodromus sp.* | 10 | | 24 | 3 | 98 |
| Dunlin | *Calidris alpina* | | | | | 9 |
| Euraisian hobby | *Falco Subbuteo* | 1 | | | | |
| Field sparrow | *Spizella pusilla* | | | | | 1 |
| Forster's tern | *Sterna forsteri* | | | | 1 | |
| Golden-crowned kinglet | *Regulus satrapa* | | | | | 1 |
| Gray catbird | *Dumetella carolinensis* | | | | | 2 |

| Common Name | Latin Name | RB | HB | TN | G2 | G5 |
|---|---|---|---|---|---|---|
| Great black-backed gull | *Larus marinus* | 16 | 120 | | 182 | 62 |
| Great blue heron | *Ardea herodias* | | 1 | | | 41 |
| Great cormorant | *Phalacrocorax carbo* | | | | | 1 |
| Great shearwater | *Puffinus gravis* | 4 | 315 | 299 | 1074 | 1049 |
| Great skua | *Stercorarius skua* | | | | 1 | 4 |
| Greater yellowlegs | *Tringa melanoleuca* | | 1 | | | |
| Green heron | *Butorides virescens* | | 1 | | | |
| Hermit thrush | *Catharus guttatus* | | | | | 1 |
| Herring gull | *Larus argentatus* | 10 | 176 | | 133 | 193 |
| Hooded warbler | *Setophaga citrina* | | | | 1 | |
| Laughing gull | *Leucophaeus atricilla* | | 58 | | 50 | 48 |
| Leach's storm-petrel | *Oceanodroma leucorhoa* | | 208 | 4 | 155 | 3 |
| Lesser black-backed gull | *Larus fuscus* | | | | 1 | 15 |
| Lincoln's sparrow | *Melospiza lincolnii* | | | | | 1 |
| Long-tailed jaeger | *Stercorarius longicaudus* | 1 | 2 | | | 2 |
| Magnolia warbler | *Setopaga magnolia* | | 2 | | | |
| Manx shearwater | *Puffinus puffinus* | 2 | 6 | | 10 | 12 |
| Marsh wren | *Cistothorus palustris* | | | | | 1 |
| Mourning dove | *Zenaida macroura* | | | | | 2 |
| Northern flicker | *Colaptes auratus* | | | | | 1 |
| Northern fulmar | *Fulmarus glacialis* | 53 | 320 | | | 175 |
| Northern gannet | *Morus bassanus* | 15 | 288 | | 54 | 867 |
| Osprey | *Pandion haliaetus* | | 1 | | 2 | |
| Palm warbler | *Setophaga palmarum* | | | | | 1 |
| Parasitic jaeger | *Stercorarius parasiticus* | | | | | 5 |
| Passerine (Land Bird) | - | | 43 | | 3 | 1 |
| Peregrine falcon | *Falco peregrinus* | | | | | 5 |
| Pine warbler | *Setophaga pinus* | | | | | 1 |
| Pomarine jaeger | *Stercorarius pomarinus* | 5 | | | 22 | 152 |
| Prairie warbler | *Setophaga discolor* | | | | 1 | |
| Prothonotary warbler | *Protonotaria citrea* | | | | | 1 |
| Razorbill | *Alca torda* | | 2 | | | |
| Red-necked phalarope | *Phalaropus lobatus* | | 2 | | 73 | |
| Red-throated loon | *Gavia stellata* | | 1 | | | |
| Red-winged blackbird | *Agelaius phoeniceus* | | | | 2 | 1 |
| Red knot | *Calidris canutus* | | | | 40 | |
| Red phalarope | *Phalaropus fulicarius* | 693 | 345 | | 1 | 70 |
| Ring-billed gull | *Larus delawarensis* | | 1 | | | 5 |
| Royal tern | *Thalasseus maximus* | | 1 | | 110 | 9 |
| Ruby-crowned kinglet | *Regulus calendula* | | | | | 1 |
| Ruddy turnstone | *Arenaria interpres* | | 18 | | | |
| Sanderling | *Calidris alba* | | | | 1 | |

| Common Name | Latin Name | RB | HB | TN | G2 | G5 |
|---|---|---|---|---|---|---|
| Sandwich tern | *Sterna sandvicensi* | | | | 1 | |
| Semipalmated plover | *Charadrius semipalmatus* | | | | 1 | |
| Shorebird | - | | | | 3 | 1 |
| Song sparrow | *Melospiza melodia* | | | | | 6 |
| Sooty shearwater | *Ardenna grisea* | 22 | 771 | 3 | 11 | 1 |
| South polar skua | *Stercorarius maccormicki* | 3 | 12 | | 16 | 1 |
| Sulid sp. | Unidentified Sulid | | | | | 1 |
| Surf Scoter | *Melanitta perspicillata* | | | | | 3 |
| Swamp sparrow | *Melospiza georgiana* | | | | | 3 |
| Tree swallow | *Tachycineta bicolor* | | | | 3 | |
| Unidentified Alcid | - | | 6 | | | |
| Unidentified blackbird | - | | | | | 1 |
| Unidentified jaeger | Stercorarius sp. | | 2 | 1 | 1 | 6 |
| Unidentified large alcid | - | | | | | 1 |
| Unidentified large gull | - | 3 | | | | 1 |
| Unidentified large shearwater | - | | | 1 | 323 | |
| Unidentified large tern | - | | | | 5 | |
| Unidentified phalarope | *Phalaropus fulicarius/lobatus* | 93 | 12 | | 7 | |
| Unidentified puffin | - | | | | 1 | |
| Unidentified sandpiper | - | | 2 | | | |
| Unidentified scoter | - | | 630 | | | |
| Unidentified shearwater | Puffinus sp. | | | | 2 | |
| Unidentified shorebird | - | | 4 | | | |
| Unidentified skua | Catharacta sp. | | | | 1 | 4 |
| Unidentified small shearwater | Puffinus sp. | | | 1 | 6 | 1 |
| Unidentified small shearwater (Audubon's, Manx or Little) | Puffinus sp. | 1 | | | | |
| Unidentified small shorebird | - | 151 | | 1 | 9 | 1 |
| Unidentified small tern | - | 55 | | | 10 | |
| Unidentified sparrow | - | | | | | 2 |
| Unidentified storm-petrel | Oceanodroma sp. | | 11 | 2 | 10 | 3 |
| Unidentified swallow | - | | | | 18 | |
| Unidentified tern | - | | 40 | | | |
| Unidentified warbler | - | | 1 | | | |
| White-throated sparrow | *Zonotrichia albicollis* | | | | | 4 |
| White-winged Scoter | *Melanitta deglandi* | | 2 | | | 672 |
| Wilson's storm-petrel | *Oceanites oceanicus* | 42 | 582 | 91 | 589 | 19 |
| Winter Wren | *Troglodytes hiemalis* | | | | | 2 |
| Yellow-rumped warbler | *Setophaga coronata* | | | | | 10 |

**Table 7-2 Total number of non-bird species detected on the RB1904 (RB), HB1902 (HB), TN368 (TN), GU1902 (G2), and GU1905 (G5) surveys**

| Common Name | Latin name | RB | HB | TN | G2 | G5 |
|---|---|---|---|---|---|---|
| Atlantic spotted dolphin | *Stenella frontalis* | | | | 7 | 30 |
| Atlantic white-sided dolphin | *Lagenorhynchus acutus* | | 38 | | | |
| Basking shark | *Cetorhinus maximus* | | 18 | | | |
| Bottlenose dolphin | *Tursiops truncatus* | | 103 | 6 | 71 | |
| Bottlenose/Spotted dolphin | - | 20 | | | | |
| Common bottlenose dolphin | *Tursiops truncatus* | | | | | 125 |
| Common dolphin | *Delphinus delphis* | 28 | 535 | | 680 | 515 |
| Cownose ray | *Rhinoptera bonasus* | | | | 160 | |
| Fin whale | *Balaenoptera physalus* | | 1 | | 1 | 1 |
| Fin/Sei whale | - | | 8 | | | |
| Grey seal | *Halichoerus grypus* | | 5 | | | 2 |
| Hammerhead shark | *Sphyrna* | | | | 1 | |
| Harbor seal | *Phoca vitulina* | | 2 | | | |
| Humpback whale | *Megaptera novaeangliae* | | 40 | | 15 | 11 |
| Leatherback turtle | *Dermochelys coriacea* | | | | 3 | 2 |
| Loggerhead turtle | *Caretta caretta* | | 2 | | | 9 |
| Long-finned pilot whale | *Globicephala melas* | 19 | | | | |
| Manta ray | *Manta sp.* | | | | | 1 |
| Minke whale | *Balaenoptera acutorostrata* | | 4 | | | |
| Monarch butterfly | *Danaus plexippus* | | | | 2 | 1 |
| Ocean sunfish | *Mola mola* | | 22 | | 24 | 5 |
| Pilot whale species | *Globicephala sp* | | 7 | | 45 | |
| Risso's dolphin | *Grampus griseus* | 7 | 26 | 8 | | |
| Sei whale | *Balaenoptera borealis* | 16 | 8 | | | 1 |
| Short-finned pilot whale | *Globicephala macrorhynchus* | | | | | 26 |
| Sperm whale | *Physeter macrocephalus* | 1 | | | | |
| Sulphur butterfly | *Coliadinae* | | | | 7 | |
| Tuna sp | Tuna sp. | | | | 1 | |
| Unidentified baleen whale | *Balaenoptera sp* | | 4 | | | |
| Unidentified beaked whale | *Ziphiidae* | | | | 2 | 3 |
| Unidentified flying fish | Exocetus sp. | | | 7 | 32 | |
| Unidentified large whale | - | | | | 11 | 2 |
| Unidentified shark | - | | 2 | | 10 | |
| Unidentified small whale | - | | | 1 | 1 | |
| Unidentified turtle | *Cheloniidae* | | 2 | | 4 | 1 |
| Unidentified whale | - | 17 | 22 | | 1 | 1 |

| Common Name | Latin name | RB | HB | TN | G2 | G5 |
|---|---|---|---|---|---|---|
| Whale shark | *Rhincodon typus* | | | | 1 | |
| White-beaked dolphin | *Lagenorhynchus albirostris* | | 3 | | | |

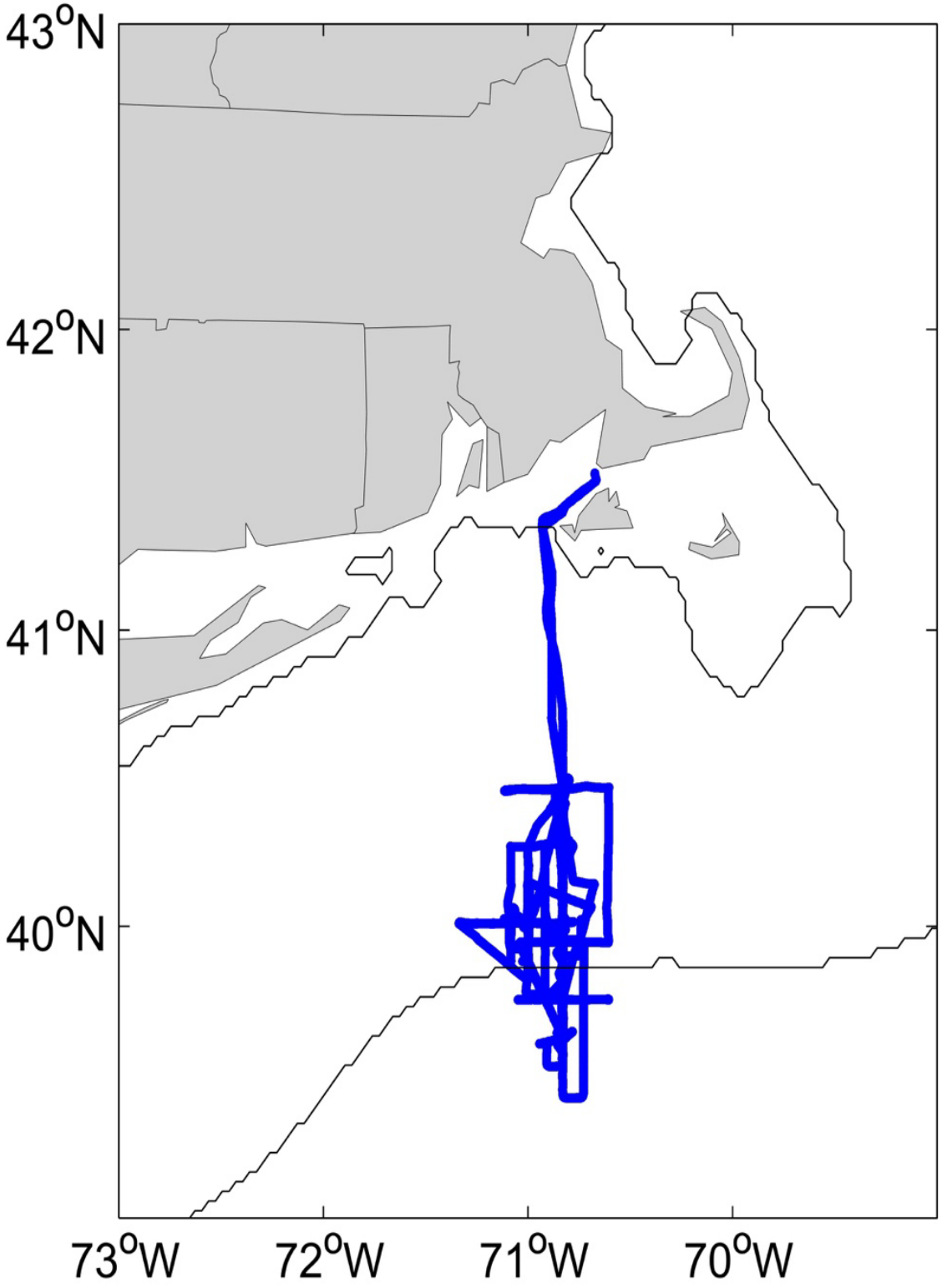


**Figure 7.1. Track lines of the RB1904 cruise during 12 – 24 May 2019**

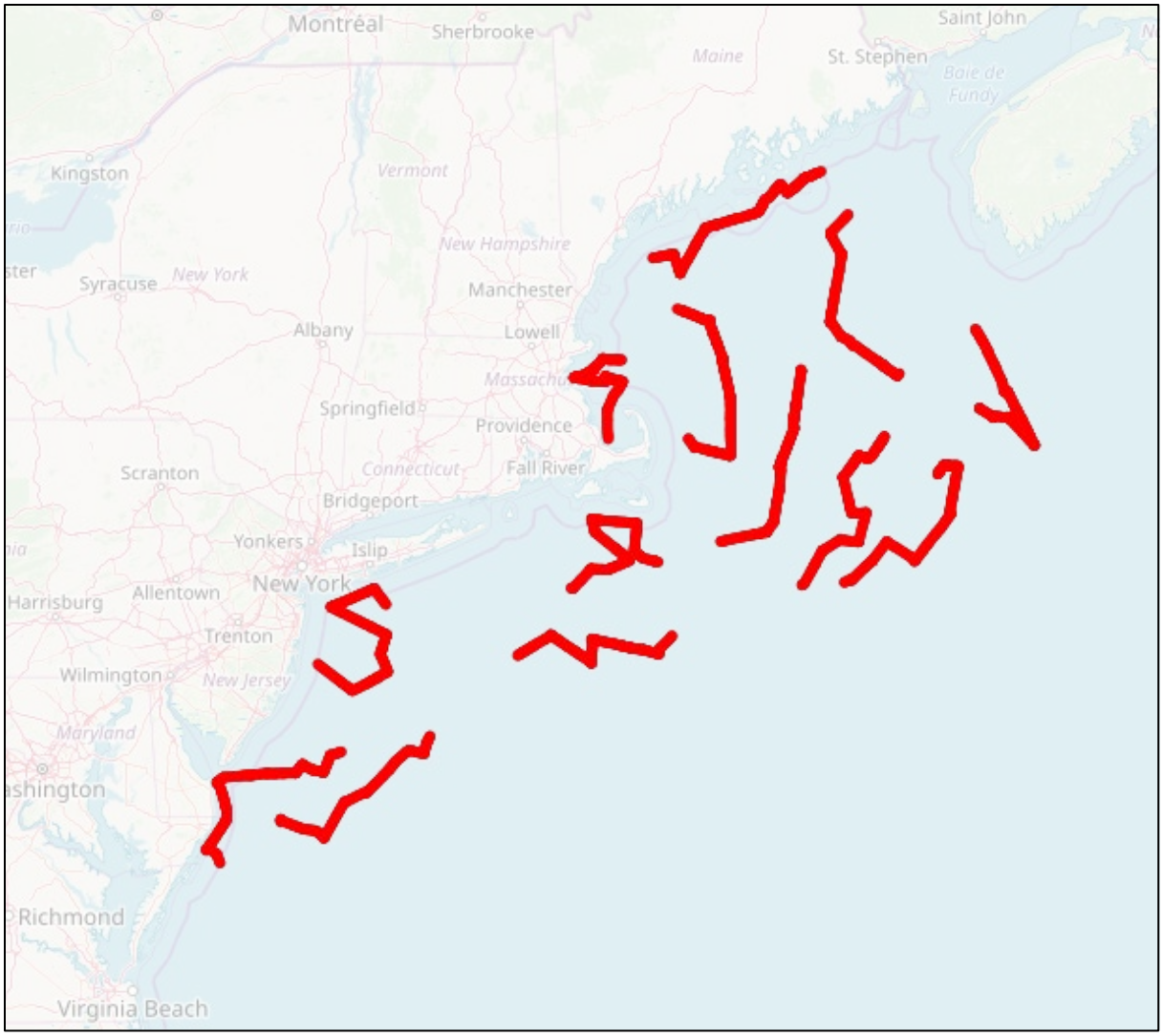


**Figure 7.2. Track lines of the HB1902 cruise during 22 May – 6 June 2019**

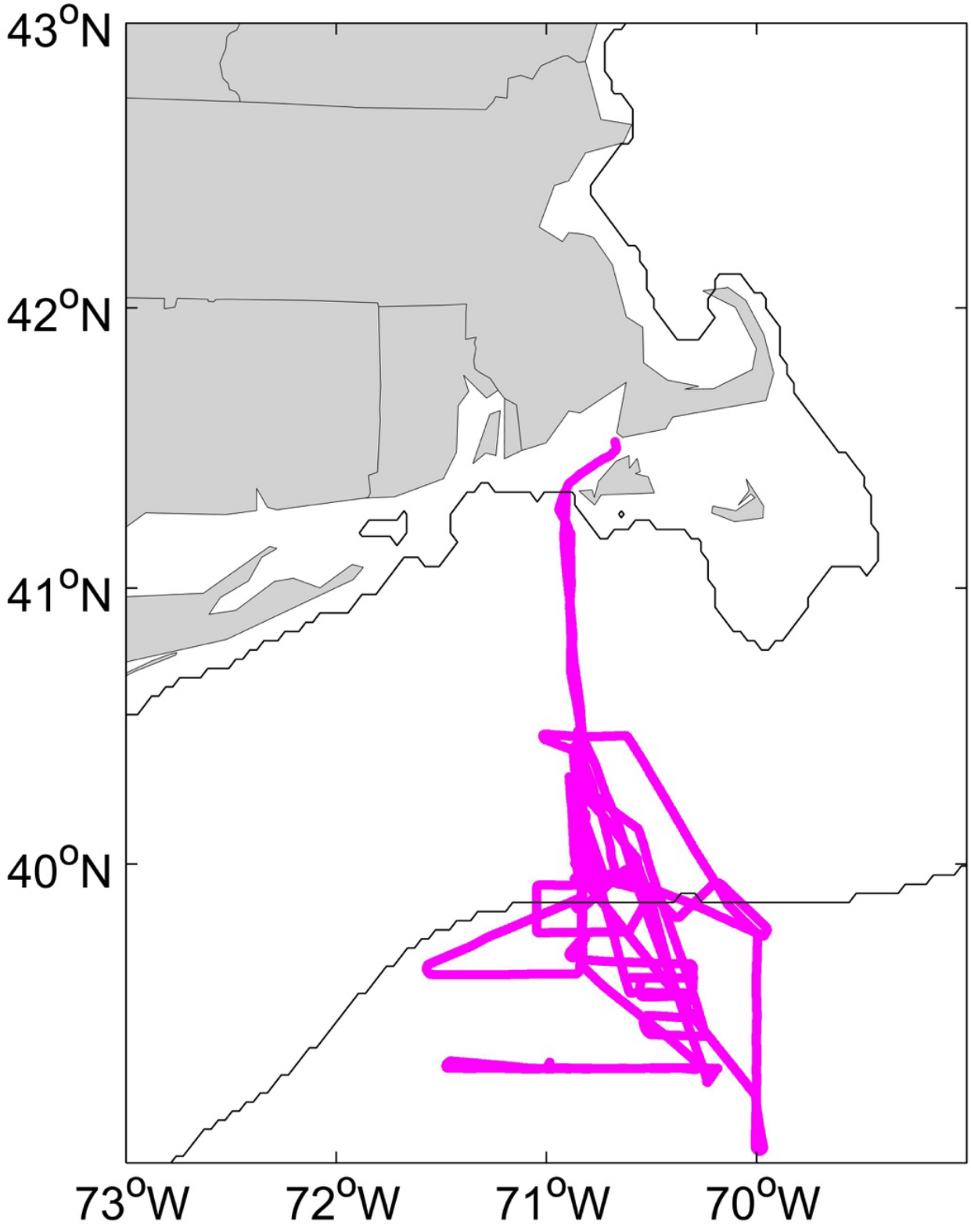


**Figure 7.3 Track lines of the TN368 cruise during 7 – 17 July 2019**

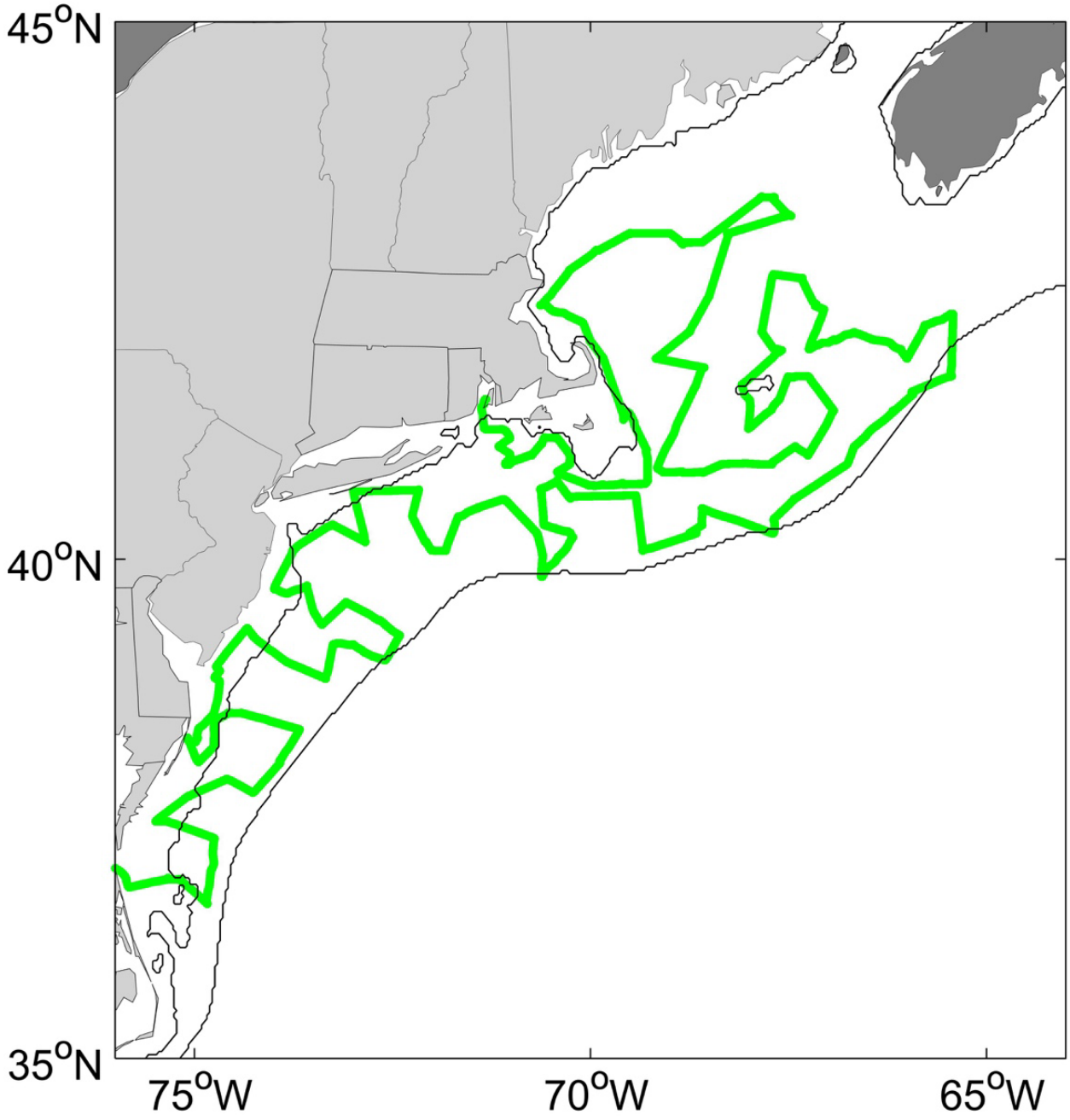


**Figure 7.4. Track lines of the GU1902 cruise during 15 – 29 August 2019**

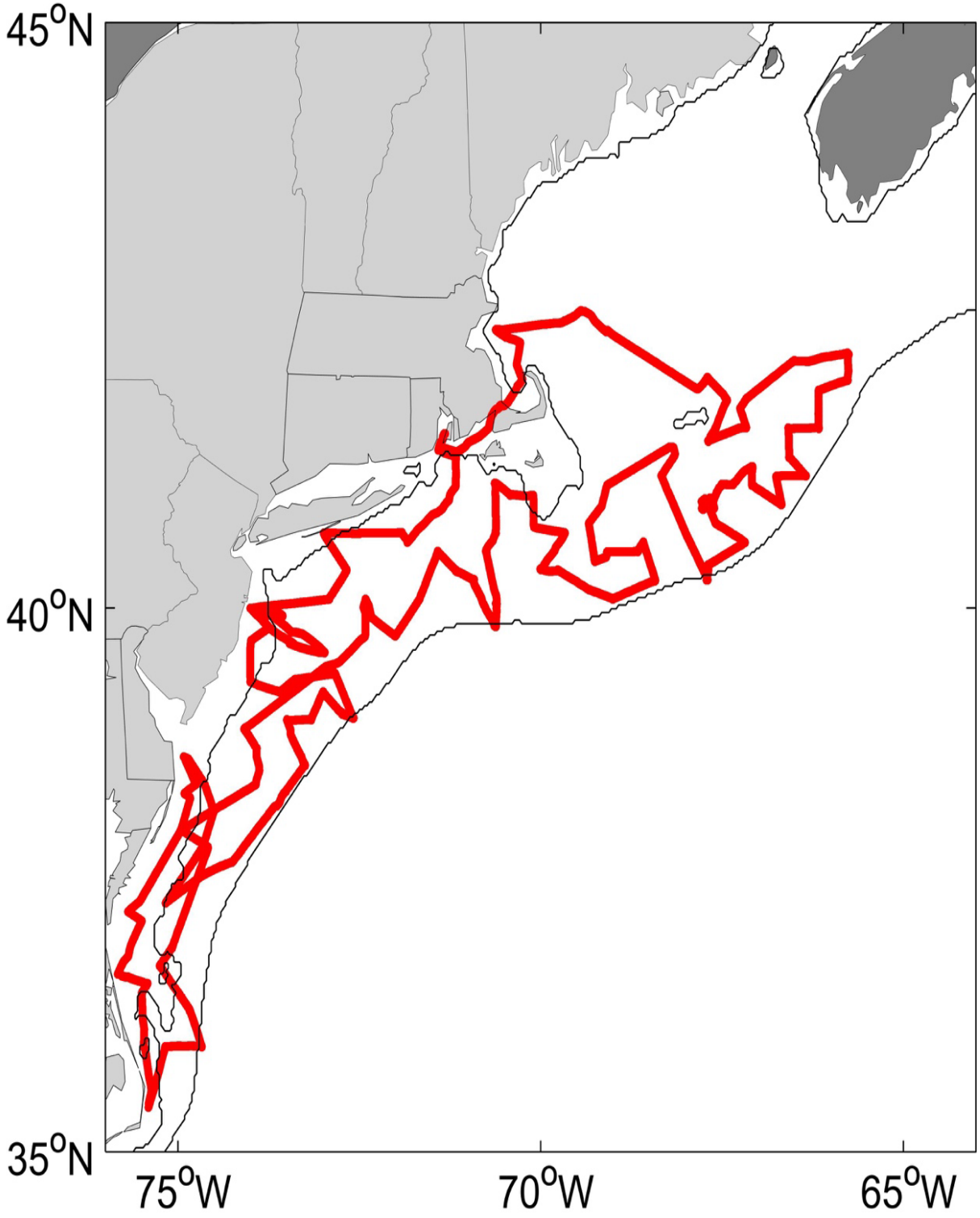


**Figure 7.5 Track lines of the GU1905 cruise during 15 October – 1 November 2019**