2024

Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in U.S. waters of the Western North Atlantic Ocean

AMAPPS III

South polar skua (*Stercorarius maccormicki*) photographed on eastern half of Georges Bank during summer 2024 EcoMon survey. See https://www.fisheries.noaa.gov/gallery/2024-ecosystem-monitoring-survey-photos for more photos from EcoMon 2024

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List of Abbreviations and Acronyms

Abbreviation	Description
AMAPPS	Atlantic Marine Assessment Program for Protected Species
BOEM	Bureau of Ocean Energy Management
CFF	Coonamessett Farm Foundation
ESA	Endangered Species Act
FM	Frequency modulated
HYCOM	Hybrid Coordinate Ocean Model
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
NCEI	National Center for Environmental Information
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service
OBIS	Ocean Biodiversity Information System
OPR	Office of Protected Resources
PACM	Passive Acoustic Cetacean Map
PAM	Passive acoustic monitoring
PIFSC	Pacific Island Fisheries Science Center
SDM	Species distribution models
SEAMAP	Spatial Ecological Analysis of Megavertebrate Populations
SEFSC	Southeast Fisheries Science Center
Sv	Volume backscattering amplitudes
WEA	Wind energy area

1 Overview of 2023

1.1 Background

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) is a comprehensive multi-agency research program in the U.S. 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 U.S. Atlantic and to place them in an ecosystem context. This information provides spatially explicit information in a format useful to marine resource managers. This information will also 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 and NOAA Fisheries) has inter-agency agreements with the Bureau of Ocean Energy Management (BOEM) and the U.S. Navy. Scientists from NOAA Fisheries' Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) developed the products resulting from the interagency agreements.

Because of the broad nature and importance of the AMAPPS work, this program has evolved beyond the above agencies into a larger collaborative program that involves 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 focuses on documenting the fieldwork conducted and briefly describing the progress of analyses performed during 2024.

1.2 Summary of 2024 Analyses

1.2.1 Field activities

During 2024, we limited field activities (Table 1-1) because we are at the end of the inter-agency agreements and so we are mainly focusing on analyses of previously collected data. The data we collected during 2024 included four-seabird strip transect surveys that piggybacked on EcoMon cruises conducted by the NEFSC (see Chapter 2 for more details). We also collected data from satellite tags deployed on individual sea turtles during three field efforts (see Chapter 3 for more details).

1.2.2 Analysis activities

The analyses we conducted during 2024 that used the marine mammal, sea turtle and seabird visual, acoustic and tag data are in Table 1-2. Details of the methods and preliminary results (when available) are in Chapters 3 – 6. The peer-reviewed papers published during 2024 are in Table 1-3.

1.3 Acknowledgements

Three agencies provided partial funding for the 2024 data collection and analyses discussed in this document:

- US Department of the Interior, BOEM Environmental Studies Program through Interagency Agreement M14PG00005 with the U.S. Department of Commerce, NOAA

- US Department of the Navy, U.S. Fleet Forces Command through Interagency Agreement N4657922GTC0001 with the U.S. Department of Commerce, NOAA
- US Department of Commerce, NOAA, NOAA Fisheries

We acknowledged additional funding sources for specific projects within the following chapter's acknowledgements section.

Table 1-1 General information on the data collected in field projects in 2024

Field collection project[1]	Platform(s)[1]	Dates in 2024	Location	Chapter
Right whale ecosystem monitoring seabird survey (NEFSC)	NOAA ship *Gloria Michelle*	16 – 18 Apr	Off Cape Cod, MA	2
Spring Ecosystem monitoring seabird survey (NEFSC)	NOAA ship *Henry B. Bigelow*	25 May – 14-Jun	Shelf waters from Nova Scotia to North Carolina	2
Summer Ecosystem monitoring seabird survey (NEFSC)	NOAA ship *Henry B. Bigelow*	12 – 22 Aug	Shelf waters from Nova Scotia to North Carolina	2
Fall Ecosystem monitoring seabird survey (NEFSC)	NOAA ship *Pisces*	27 Oct – 13 Nov	Shelf waters from Nova Scotia to North Carolina	2
Loggerhead turtle satellite tagging (NEFSC + Coonamessett)	F/V Salvation	3 – 16 Mar	off North Carolina	3
Loggerhead turtle satellite tagging (NEFSC + Coonamessett)	F/V *Kathy Ann*	5 – 9 Jun; 15 – 21 Jul	Mid-Atlantic Bight	3
Leatherback satellite tagging (SEFSC + NEFSC)	R/V Selkie & R/V *Coriacea*	20 Aug – 5 Sep	off Massachusetts	3

[1] NEFSC = Northeast Fisheries Science Center; SEFSC = Southeast Fisheries Science Center; NOAA = National Oceanic and Atmospheric Administration

Table 1-2 Description of analysis projects conducted during 2024

2024 Analysis Projects	Purpose	Chapter
Distribution and ecology of sea turtles	Document distribution, ecology, and biology of loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles equipped with satellite tags	3
Behavior of leatherback turtles	Investigate movement behavior of leatherback turtles	3
Leatherback surfacing behaviors	Use tag data and machine learning techniques to examine leatherback surfacing and dive behaviors	3
Distribution of depths that sperm whale forage	Estimate depths sperm whales (*Physeter macrocephalus*) forage using passive acoustic monitoring and estimate abundance of these diving whales	4
Sperm whale foraging ecology	Pair sperm whale foraging dives with prey layer information derived from active acoustic data collected during 2016	4, 6
Distribution of deep diving whales	Document the distribution of *Ziphiidae* and *Kogiidae* families using data collected from the NE and SE 2021 shipboard offshore surveys	6
Abundance of whales in wind energy areas	Extend Bayesian hierarchical density surface models to wind energy areas to predict probability of abundance above a user-chosen threshold	5
Spatiotemporal density models and abundance estimates	Apply generalized additive models to quantify abundance and relationships between sea turtles and habitat	5
Image survey methods	Develop equipment, data collection and analysis procedures, and data storage to effectively run future aerial surveys using cameras	5
Develop species identification algorithm	Compile images from aerial surveys and annotate the animals in the images to develop a neural network model to assist finding and identifying species from the images	5
Archive data collected on abundance shipboard and aerial surveys	Archive abundance survey data at website available to the public: OBIS SEAMAP and NCEI	5
Process prey data	Process and analyze prey data collected from midwater trawls and other types of nets, from active acoustics, and on video plankton recorders to estimate density and biomass	6
Develop species identification algorithm	Develop neural network model to assist finding and identifying species or species groups from active acoustic data	6
Larval Atlantic bluefin tuna	Using samples collected from AMAPPS surveys to evaluate the locations of their spawning grounds	6
Archive data and make publicly available	Archive sightings, passive acoustic, tag and ecosystem data and make data and analysis products publicly available	2-6

Table 1-3 Manuscripts using AMAPPS data published in 2024

Published Manuscripts
Barry KP, Mullin KD, Maze-Foley K., Wilcox Talbot LA, Rosel PE, Soldevilla MS, Aichinger Dias L, Ramirez-Leon MR, Litz JA. 2024. Killer whales in the Gulf of Mexico and North Atlantic off the Southeast United States. Front. Mar. Sci. 11:1460314. https://doi.org/10.3389/fmars.2024.1460314
DiMatteo A, Roberts JJ, Jones D, Garrison L and others. 2024. Sea turtle density surface models along the United States Atlantic coast. Endang Species Res 53:227-245. https://doi.org/10.3354/esr01298
Rankin S, Sakai T, Archer F, Barlow J, Cholewiak D, DeAngelis AI, McCullough JLK, Oleson E, Simonis A, Soldevilla M, Trickey JS. 2024. Open-Source machine learning BANTER acoustic classification of beaked whale echolocation pulses. Ecological Informatics 80(102511) https://doi.org/10.1016/j.ecoinf.2024.102511
Rider MJ, Avens L, Haas HL, Hatch JM, Patel SH, Sasso CR. 2024. Where the leatherbacks roam: movement behavior analyses reveal novel foraging locations along the Northwest Atlantic shelf. *Front. Mar. Sci.* 11:1325139. https://doi.org/10.3389/fmars.2024.1325139
Rider MJ, Avens L, Haas HL, Harms CA, Patel SH, Snodgrass D, Sasso CR. 2024. Regional variation in leatherback dive behavior in the northwest Atlantic. *Endang. Species Res.* 55:169-185. https://doi.org/10.3354/esr01365
Roberts JJ, Yack TM, Fujioka E, Halpin PN, Baumgartner MF, et al. 2024. North Atlantic right whale density surface model for the U.S. Atlantic validated with passive acoustic monitoring. Mar Ecol Prog Ser 732:167-192. https://doi.org/10.3354/meps14547
Rogers R, Choate KH, Crowe LM, Hatch JM, James MC, Matzen E, Patel SH, Sasso CR, Siemann LA, Haas, HL. 2024. Investigating leatherback surface behavior using a novel tag design and machine learning. *JEMBE*. 576. https://doi.org/10.1016/j.jembe.2024.152012

2 Sea monitoring of the distributions of pelagic seabirds in the northeast U.S. shelf ecosystem: Northeast Fisheries Science Center

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2.1 Summary

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 NOAA or other organizations. Collecting seabird and marine mammal data concurrently with other biological data and abiotic factors will help to understand the spatiotemporal distributions of the species and relationships with other trophic levels within the changing marine ecosystem on the Northeast Atlantic US shelf. During 2024, four cruises conducted these visual surveys during spring, summer and fall. These cruises covered waters from North Carolina to Maine. We recorded over 17,000 birds and over 2,800 marine mammals, sea turtles and large fish.

2.2 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 (Tasker 1984; Anon 2011; Ballance 2011) including previous Atlantic Marine Assessment Program for Protected Species (AMAPPS) and Bureau of Ocean Energy Management (BOEM) surveys.

Observers collected data on all seabirds within a 300-m strip on one side of the ship's track line. They searched from the bow to 90° to either the port or the starboard side, depending on which side had the best viewing conditions. Observers conducted surveys on the flying bridge whenever possible. Although they worked from the ship's bridge during poor weather conditions. They collected data in sea states up to a Beaufort 7, in light rain, fog, and when ship speeds were between 8 and 12 kn (below 8 kn, the data becomes questionable to use for abundance estimates).

The observers entered the data into the SeaLog (v2.0.5) program on all four of the 2024 surveys. This program drew global position system coordinates and time from a Bluetooth GPS unit, so each observation received a stamp with 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. For the purposes of these cruises, the definition of a flock was an aggregation of seven birds or more seen outside the standard survey area. For flocks, the observers recorded latitude/longitude, time, bearing, distance (numeric distance has its own data field in SeaLog) species composition and number, association, behavior, age, and sex. While SeaLog is primarily a data collection program for seabird data, observers also recorded marine mammal and other species observations anytime an animal was seen both in, and outside of the survey zone.

When there were two observers onboard, they alternated two-hour shifts, with a person on-effort collecting data and the other off-effort (not collecting data). If an animal proved elusive, observers used a pair of 20x60 Zeiss imaged-stabilized binoculars 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).

2.3 Results

During four Ecosystem Monitoring-type surveys conducted in 2024 observed collected seabird surveys (Table 2-1; Figure 2-1).

Table 2-1 Summary of 2024 pelagic seabird surveys
"Seabird sightings" were inside and outside the 300-m survey zone and "Other Sightings" included marine mammals, sea turtles, large fish, and land birds. GM = Gloria Michelle; HB = Henry B. Bigelow; PC = Pisces.

Cruise	Start Date	End Date	Duration (days)	Distance (km)	Seabird Sightings	Other Sightings
GM2402	16-Apr	18-Apr	3	181	391	34
HB2403	25-May	14-Jun	21	2,609	8,076	1,464
HB2406	12-Aug	22-Aug	11	1,987	5,748	1,011
PC2406	27-Oct	13-Nov	18	1,213	3,006	366

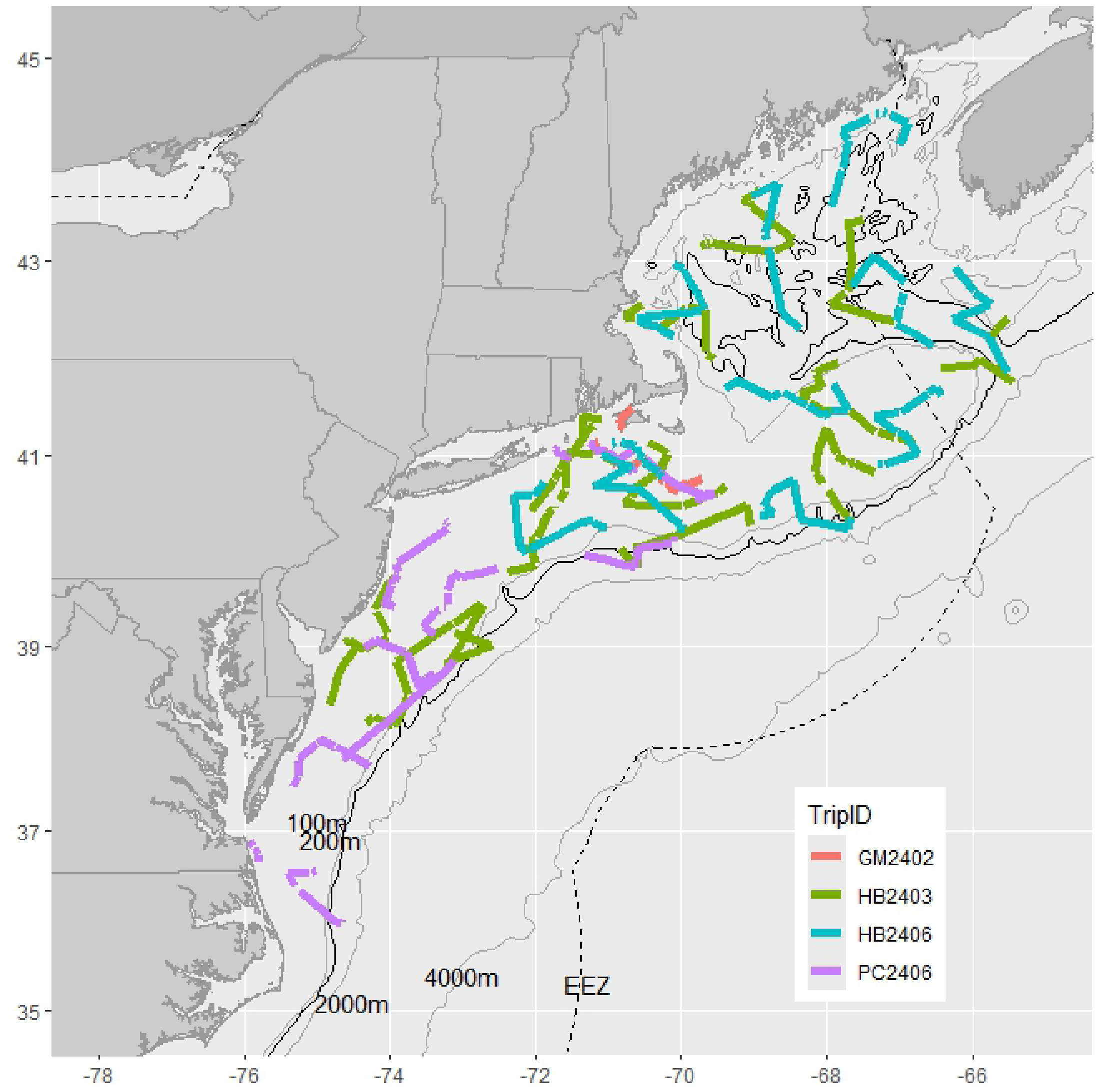

Figure 2-1 Track lines where seabird surveys occurred during the EcoMon cruises

Table 2-2 List of seabirds recorded during the EcoMon cruises
GM = Gloria Michelle; HB = Henry B. Bigelow; PC = Pisces.

Name	ScientificName	GM2402	HB2403	HB2406	PC2406
American redstart	*Setophaga ruticilla*	0	0	1	0
American robin	*Turdus migratorius*	0	0	0	2
Arctic tern	*Sterna paradisaea*	0	0	1	0
Arctic tern	*Sterna paradisaea*	0	0	1	0
Atlantic puffin	*Fratercula arctica*	0	13	76	0
Audubon shearwater	*Puffinus lherminieri*	0	1	4	0
Band-rumped storm-petrel	*Oceanodroma castro*	0	3	0	0
Band-rumped storm-petrel	*Oceanodroma castro*	0	3	0	0
Barn swallow	*Hirundo rustica*	0	3	1	0
Barn swallow	*Hirundo rustica*	0	3	1	0
Barolo shearwater	*Puffinus baroli*	0	16	1	1
Barolo shearwater	*Puffinus baroli*	0	16	1	1
Black-legged kittiwake	*Rissa tridactyla*	0	0	0	9
Black Scoter	*Melanitta americana*	0	1	0	17

Black skimmer	*Rynchops niger*	16	0	0	0
Bobolink	*Dolichonyx oryzivorus*	0	0	1	0
Bonaparte's gull	*Larus philadelphia*	0	0	0	959
Bridled tern	*Sterna anaethetus*	0	0	1	0
Brown-headed cowbird	*Molothrus ater*	0	0	3	0
Brown booby	*Sula leucogaster*	0	1	0	0
Brown pelican	*Pelecanus occidentalis*	0	0	0	38
Canada warbler	*Cardellina canadensis*	0	0	1	0
Cedar waxwing	*Bombycilla cedrorum*	0	0	7	0
Common eider	*Somateria mollissima*	0	1	0	0
Common loon	*Gavia immer*	18	11	0	22
Common murre	*Uria aalge*	8	0	12	0
Common tern	*Sterna hirundo*	0	35	14	0
Cory's shearwater	*Calonectris diomedea*	0	138	80	431
Dark-eyed junco	*Junco hyemalis*	0	0	0	2
Double-crested cormorant	*Phalacrocorax auritus*	23	10	4	47
Dovekie	*Alle alle*	0	15	0	0
Dowitcher	*Limnodromus sp.*	0	48	4	0
Dunlin	*Calidris alpina*	0	2	0	0
Eastern meadowlark	*Sturnella magna*	0	0	0	1
Forster's tern	*Sterna forsteri*	0	1	0	27
Golden-crowned kinglet	*Regulus satrapa*	0	0	0	1
Great black-backed gull	*Larus marinus*	35	209	101	25
Great blue heron	*Ardea herodias*	0	0	0	1
Great blue heron	*Ardea herodias*	0	0	0	1
Great egret	*Ardea alba*	0	0	4	0
Great shearwater	*Puffinus gravis*	0	1,840	2,280	419
Green-winged teal	*Anas crecca*	0	0	0	2
Herring gull	*Larus argentatus*	22	340	26	236
House finch		0	0	0	1
Large-billed Sparrow	*Passerculus sandwichensis rostratus*	0	3	0	0
Laughing gull	*Larus atricilla*	2	5	18	33
Leach's storm-petrel	*Oceanodroma leucorhoa*	0	78	128	0
Least sandpiper	*Calidris minutilla*	0	0	2	0
Lesser black-backed gull	*Larus fuscus*	1	0	7	5
Lesser yellowlegs	*Tringa flavipes*	0	0	1	0
Long-tailed duck	*Clangula hyemalis*	11	0	0	0
Long-tailed jaeger	*Stercorarius longicaudus*	0	0	3	0
Manx shearwater	*Puffinus puffinus*	0	33	24	33
Mourning dove	*Zenaida macroura*	0	0	2	1
Northern fulmar	*Fulmarus glacialis*	0	218	0	1
Northern gannet	*Morus bassanus*	56	14	14	368
Parasitic jaeger	*Stercorarius parasiticus*	0	4	1	10
Passerine (Land Bird)		0	1	0	9
Peregrine falcon	*Falco peregrinus*	0	0	0	1
Pine Siskin	*Spinus pinus*	0	0	0	1
Pomarine jaeger	*Stercorarius pomarinus*	0	1	13	3
Razorbill	*Alca torda*	46	0	2	67
Red-necked phalarope	*Phalaropus lobatus*	0	10	98	0
Red-throated loon	*Gavia stellata*	51	1	0	3
Red-winged blackbird	*Agelaius phoeniceus*	0	0	0	6
Red-winged blackbird	*Agelaius phoeniceus*	0	0	0	6
Red phalarope	*Phalaropus fulicaria*	0	0	140	64
Ring-billed gull	*Larus delawarensis*	0	0	0	3
Roseate tern	*Sterna dougallii*	0	2	0	0
Ruddy turnstone	*Arenaria interpres*	0	0	8	0
Sanderling	*Calidris alba*	0	0	3	0
Savannah sparrow	*Passerculus sandwichensis*	0	0	0	1
Semipalmated plover	*Charadrius semipalmatus*	0	0	1	0

Semipalmated sandpiper	*Calidris pusilla*	0	0	1	0
Sharpbill		0	3	2	0
Shorebird		0	1	0	1
Sooty shearwater	*Puffinus griseus*	4	1,616	5	0
South polar skua	*Stercorarius maccormicki*	0	12	53	1
Spotted sandpiper	*Actitis macularius*	0	0	1	0
Surf Scoter	*Melanitta perspicillata*	0	0	0	27
Thick-billed murre	*Uria lomvia*	0	6	0	0
Tree swallow	*Tachycineta bicolor*	0	0	1	0
Unidentified alcid	*Alcidae sp.*	1	2	0	0
Unidentified diving duck		0	0	0	6
Unidentified gull		0	2	0	0
Unidentified jaeger	*Stercorarius sp.*	0	0	1	2
Unidentified murre	*Uria sp.*	0	1	0	0
Unidentified phalarope	*Phalaropus fulicarius/lobatus*	0	6	56	9
Unidentified sandpiper		0	1	0	0
Unidentified scoter		0	0	0	15
Unidentified shearwater	*Puffinus sp.*	0	20	0	26
Unidentified small gull		0	0	0	2
Unidentified small shearwater	*Puffinus sp.*	0	0	1	0
Unidentified small shorebird		0	0	1	0
Unidentified small shorebird		0	0	1	0
Unidentified storm-petrel	*Oceanodroma sp.*	0	852	0	1
Unidentified swallow		1	0	1	0
Unidentified tern		0	5	15	0
Unidentified warbler		0	0	1	0
White-faced storm petrel	*Pelagodroma marina*	0	0	2	0
White-throated sparrow	*Zonotrichia albicollis*	0	0	0	2
White-winged Scoter	*Melanitta deglandi*	96	0	0	14
Wilson's storm-petrel	*Oceanites oceanicus*	0	2,491	2,518	22
Wood duck	*Aix sponsa*	0	0	0	27
Yellow-rumped warbler	*Setophaga coronata*	0	0	0	1
Yellow warbler		0	0	2	0

Table 2-3 List of non-bird species detected during the EcoMon cruises
GM = Gloria Michelle; HB = Henry B. Bigelow; PC = Pisces.

Species	Scientific Name	GM2402	HB2403	HB2406	PC2406
Bottlenose dolphin	*Tursiops truncatus*	12	84	96	26
Common dolphin	*Delphinus delphis*	0	591	771	129
Common or white-sided dolphin	*D. delphis,, L. acutus*	0	5	0	0
Fin or sei whale	*B. physalus, B. borealis*	0	6	0	0
Fin whale	*Balaenoptera physalus*	0	26	19	6
Humpback whale	*Megaptera novaeangliae*	0	95	23	5
Killer whale	*Orcinus orca*	0	1	0	0
Minke whale	*B. acutorostrata*	0	17	4	0
Offshore bottlenose dolphin	*Tursiops truncatus*	0	50	10	52
Pilot whale spp	*Globicephala sp.*	21	65	12	9
Right whale	*Eubalaena glacialis*	0	1	3	0
Risso’s dolphin	*Grampus griseus*	0	12	0	0
Sei whale	*Balaenoptera borealis*	0	3	0	0
Sperm whale	*Physeter macrocephalus*	0	2	2	0
Unidentified whale	*Mysticeti*	1	54	5	8
White-sided dolphin	*Lagenorhynchus acutus*	0	20	53	0
Gray seal	*Halichoerus grypus*	0	0	2	0
Harbor seal	*Phoca vitulina*	0	1	1	0
Leatherback turtle	*Dermochelys coriacea*	0	2	0	0
Loggerhead turtle	*Caretta caretta*	0	4	0	1
Unidentified turtle	*Chelonioidea*	0	1	0	1
Ocean sunfish spp	*Mola mola*	0	60	10	7

2.4 Disposition of Data

We maintain the data in the NEFSC AMAPPS ORACLE database and we sent the data to the National Centers for Coastal Ocean Science for addition to the seabird compendium database.

2.5 Acknowledgements

We acknowledge the officers and crew of NOAA ships *Gloria Michelle*, *Henry B. Bigelow* and *Pisces*. The analysis time and data collection was funded by the three sources of funds specified in section 1.3 of this document (NOAA Fisheries and the 2 interagency agreements with the Bureau of Ocean Energy Management and the U.S. Navy).

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3 Progress of sea turtle ecology research: Northeast and Southeast Science Centers

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3.1 Summary

During 2024, the AMAPPS Turtle Ecology team and collaborators deployed 43 satellite tags on loggerhead turtles between three fieldwork efforts. The team collaborated on projects that address Atlantic Marine Assessment Program for Protected Species (AMAPPS) goals but led by outside collaborators. A hybrid team completed fieldwork to deploy satellite tags on loggerhead sea turtles (*Caretta caretta*) in March off North Carolina (8 tags) and in June/July in the Mid-Atlantic Bight (35 tags). The objective of this fieldwork was to gather information on turtle behavior and distribution patterns, as well as collect biological samples (scute, blood, skin, cloacal lavage). In August/September, the Southeast Fisheries Science Center (SEFSC), Northeast Fisheries Science Center (NEFSC), Pacific Island Fisheries Science Center (PIFSC), and the Office of Protected Resources (OPR) collaborated for leatherback turtle ((*Dermochelys coriacea*) research off Nantucket, MA. In addition to fieldwork, the Turtle Ecology team continued developing the Oracle database, which stores the satellite tag data and associated metadata. The team also made progress on three manuscripts, all of which were recently published as peer-reviewed articles (Investigating leatherback surface behavior using a novel tag design and machine learning; Where the leatherbacks roam: movement behavior analyses reveal novel foraging locations along the Northwest Atlantic shelf; Regional variation in leatherback dive behavior in the northwest Atlantic).

3.2 Fieldwork

During calendar year 2024, the AMAPPS Turtle Ecology team completed several fieldwork trips. In March, the NEFSC collaborated with the Coonamessett Farm Foundation (CFF) for loggerhead tagging off North Carolina aboard the F/V Salvation. In June and July, the NEFSC collaborated with CFF for two separate loggerhead tagging cruises in the mid-Atlantic Bight aboard the F/V Kathy Ann. Atlantic Sea Scallop Research Set Aside Cooperative Agreement and the New Jersey Research and Monitoring Initiative funded this research. In August, the SEFSC, NEFSC, PIFSC, and OPR collaborated for leatherback research using R/V Coriacea and R/V Selkie in Massachusetts state and federal waters. Across several field efforts, we collected water samples near known turtle locations for environmental DNA analyses.

3.2.1 Leatherback turtles

From 20 August to 5 September 2024, the SEFSC, NEFSC, PIFSC, and OPR collaborated for leatherback research aboard the R/V Coriacea and R/V Selkie south and east of Nantucket with aerial support from the NOAA Twin Otter N46RF. Vessel crew included Chris Sasso, Larisa Avens (SEFSC), Heather Haas

(NEFSC), Kate Choate, Samir Patel (Integrated Statistics, Inc), John Wang, Alexander Gaos, Jamie Barlow (PIFSC), and Brian Stacy (OPR). While stationed on Nantucket in Madaket Harbor, 10 day trips (and at least 5 logistics and training trips) were conducted with the objective of testing a new satellite tag anchoring method (as funded by the NMFS STIFA grant) as well as performing suction cup tagging. Unfortunately, there was a lack of jellies in the area and only a few leatherbacks. Of those we sighted, the leatherbacks had very different surface behavior than in previous years when jellies were present. Despite 10 days of on the water effort, we were unable to tag any turtles during this fieldwork.

Figure 3-1 NOAA Twin Otter N46RF plane flying above the R/V Coriacea

During the August/September 2024 leatherback turtle satellite tagging fieldwork south of Nantucket (NMFS Permit No. 21233).

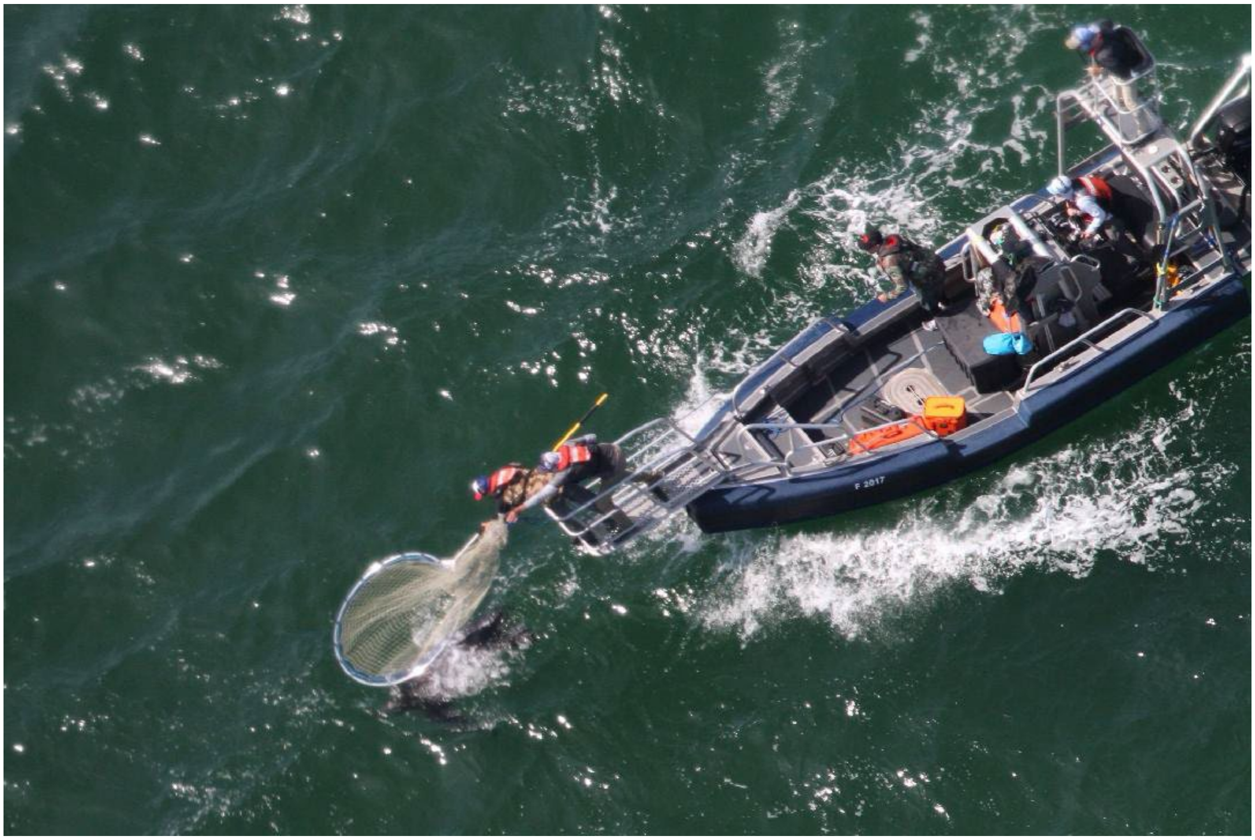

Figure 3-2 Researchers aboard the R/V Coriacea attempt to capture a leatherback sea turtle
During the August/September 2024 leatherback turtle satellite tagging fieldwork south of Nantucket (NMFS Permit No. 21233).

3.2.2 Loggerhead turtles

From 3 - 16 March 2024, the NEFSC collaborated with CFF to deploy satellite tags on loggerhead turtles off North Carolina aboard the F/V Salvation. Eight loggerheads were successfully tagged and four were filmed under U.S. permit 23639 issued to CFF. During this trip, the team attached two flipper tags and inserted a PIT tag (for identification purposes) in each of the loggerhead turtles. We collected biological samples (blood, scute, and skin) for future biochemistry, stable isotope, and genetic analyses. We also affixed Innovasea acoustic telemetry tags to each turtle. Fieldwork crew consisted of Samir Patel, Farrell Davis, and Natalie Jennings (CFF). In addition, we added metadata from these sampled turtles to the NEFSC Turtle Ecology Oracle database, and we added data from satellite tags applied during this trip after the tags stop transmitting.

Figure 3-3 A frontal view of a loggerhead sea turtle
During the March 2024 satellite tagging trip off North Carolina (NMFS Permit No. 23639).

The NEFSC collaborated with CFF from June 5 - 9 for loggerhead satellite tagging aboard the F/V Kathy Ann in the mid-Atlantic Bight. We successfully tagged 23 loggerheads during this trip, with 12 turtles also receiving acoustic telemetry tags. Fieldwork crew included Samir Patel, Nathan Shivers, Allison Myers (CFF), Kate Choate (Integrated Statistics), YiWynn Chan (Purdue University Fort Wayne), and Michael Torselli (Roger Williams University).

The NEFSC collaborated with CFF for a third loggerhead satellite tagging trip from July 15 – 21 aboard the F/V Kathy Ann in the mid-Atlantic Bight. During this trip, 12 loggerheads were successfully tagged, ten with satellite transmitters and two with short-term high-resolution camera tags that were retrieved a few hours after deployment. During both of these fieldwork efforts, the team also attached two flipper tags and inserted a PIT tag (for identification purposes) in each of the loggerhead turtles. Biological samples (blood, scute, and skin) were collected for future biochemistry, stable isotope, and genetic analyses conducted by research collaborators. We will add the data from satellite tags applied during these trips to the NEFSC Turtle Ecology Oracle database. An Atlantic Sea Scallop Research Set Aside Cooperative Agreement and the New Jersey Research and Monitoring Initiative funded this research. We conducted the work performed during both tagging trips under US Permit No. 23639 issued to CFF.

Figure 3-4 Loggerhead sea turtle released with a satellite tag from the F/V Kathy Ann
During the June 2024 loggerhead satellite tagging cruise in the Mid-Atlantic Bight (NMFS Permit No. 23639).

Figure 3-5 Scientific crew pose with a satellite-tagged loggerhead sea turtle
Photo taken aboard the F/V Kathy Ann during the June loggerhead satellite-tagging cruise (NMFS Permit No. 23639). People from left to right are Michael Torselli, Kate Choate, Samir Patel, Allison Myers, YiWynn Chan, and Nathan Shivers

3.3 Progress in sea turtle analyses

In calendar year 2024, we continued to develop our Turtle Ecology Oracle database, maintaining the current system, adding new data, and making adjustments with the addition of views as needed. We continued conversations with the National Centers for Environmental Information (NCEI), collecting data and preparing a submission package for adding information from our Oracle database into the federal archive. This includes satellite-tracking data on almost 300 loggerhead and leatherback turtles from August 2009 to December 2023, ranging in all US Atlantic waters.

With the range of loggerhead samples (blood, scute, skin, feces) we have collected during tagging cruises in the Northwest Atlantic over the years, we are coordinating with Coonamessett Farm Foundation and Nicole Stacy (University of Florida, College of Veterinary Medicine) to submit blood samples for chemical analyses. We are in the process of selecting a representative subset of samples across years, regions, and life stages to analyze for baseline blood chemistry, stress hormones, metabolomics, proteomics, and lipidomics. The New Jersey Department of Environmental Protection Wind Research Monitoring Initiative project led by CFF funded these efforts.

This year we also published three manuscripts that we describe below.

3.3.1 Investigating leatherback surface behavior using a novel tag design and machine learning

Rogers et al. (2024) analyzed multiple data streams from a high-resolution animal-borne tag and machine learning to examine surfacing behaviors of leatherback turtles. Understanding the surfacing behavior of marine wildlife is an important component for improving abundance estimates derived from visual surveys. We monitored the behavior of 18 leatherback sea turtles in coastal habitats off Massachusetts, using a high-resolution camera and satellite tag package (High Resolution Camera and Satellite) that we assembled from commercially available components that work independently. We used nine data streams derived from the multiple sensors and a video camera to explore four different depth thresholds defining surface zones. We compared classification of video images by a human to classification of those images by a machine-learning algorithm. We calculated four metrics to describe surface behavior for each of the nine data streams. From these analyses we observed that the mean percent time at the surface was the only behavior metric that changed systematically as data streams to assess different visible depth thresholds, increasing as the depth threshold increased. Other behavior metrics (mean surface duration, mean dive duration and number of surfacing events per hour) were less similar across data streams, making them unreliable for estimating surface availability. This study highlights the need for sustained data collection to inform better the availability bias estimates used to calculate abundance from visual observations.

We thank Bailey Buckley for preliminary human video coding, George Breen and Rick Brown for aerial support, Lisa Conger for small boat support, Farrell Davis for building the GPS units, Michael Casso for technical advice and assistance in machining the foam bases, and Doug Sigourney for technical review of the manuscript. We also thank the anonymous reviewers of the manuscript for their contributions in improving it.

This study was funded in part by the U.S. Department of the Interior, Bureau of Ocean Energy Management through Interagency Agreements M10PG00075, M14PG00005, and M19PG00007 with the U.S. Department of the Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC), and through the NOAA Bycatch Reduction and Engineering Program grant #NA17NMF4720268 awarded to Coonamessett Farm Foundation.

3.3.2 Movement behavior reveal novel foraging locations along the Northwest Atlantic

Rider et al. (2024a) uses AMAPPS leatherback data to investigate movement behavior in relation to foraging locations along the Northwest Atlantic shelf. Leatherback sea turtles migrate along the east coast of the United States, traversing the South and Mid-Atlantic Bights while traveling to and from well-known northern foraging areas off Southern New England and Nova Scotia. However, there is limited information on leatherback movement behavior in these regions. To identify leatherback movement patterns, we fit hidden Markov models to satellite transmitter data from 52 leatherbacks tagged between 2017 and 2022 off the coasts of Massachusetts and North Carolina to estimate locations of area restricted searching and transient behaviors. We then paired the depth-temperature profiles to locations associated with area restricted searching behavior to understand the vertical use of the water column. We observed leatherbacks displaying area restricted searching behavior in Southern New England as expected, but also in the South and Mid-Atlantic Bights. The hidden Markov models results indicated that leatherbacks were primarily foraging in Southern New England between Nantucket and Long Island Sound and depth-temperature plots from area restricted searching behavior on Nantucket Shoals implied turtles foraging throughout the entire water column. In the Mid-Atlantic Bight, area restricted searching behavior was concentrated between Cape Hatteras, North Carolina, and the mouth of Delaware Bay during the summer.

Turtles were closely associated with a well-defined thermocline, but still appeared to dive to deeper cooler waters, which may be a sign of thermoregulatory behavior. There was evidence of foraging in the Southern Atlantic Bight along the coast as well as along the continental shelf edge. The area restricted searching behavior we documented within the Mid-Atlantic and Southern Atlantic Bights is the first published empirical evidence that both areas may be important foraging grounds. Our results lay a path for future research to understand how leatherbacks use these areas and the potential anthropogenic threats encountered while moving through these regions.

We would like to thank Leah Crowe, Annie Gorgone, Blake Price, Craig Harms, Emily Christiansen, Mike Judge, and Lisa Conger for their expert fieldwork during leatherback captures. We would also like to thank Elizabeth Babcock, Joseph Pfaller, Heather Foley, and Neil Hammerschlag for their helpful comments on earlier versions of this manuscript. This work would not have been possible without the crew of the Warren Jr. and Semper Offshore as well as Val Diers from Anthem Commercial Air Services.

This study was funded by the United States Department of the Interior, Bureau of Ocean Energy Management through Interagency Agreements M14PG00005, M10PG00075, and M19PG00007 with the United States Department of the Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC). This paper is also the result of research funded by the NOAA's National Centers for Coastal Ocean Science, Competitive Research Program to the NOAA Fisheries Northeast Fisheries Science Center (NEFSC). All work was conducted under ESA permits 16733 and 21233 issued to the National Marine Fisheries Service Southeast Fisheries Science Center.

3.3.3 Regional variation in leatherback dive behavior in the northwest Atlantic

Rider et al. (2024b) analyzes dive data from satellite-tagged leatherbacks across several regions in the northwest Atlantic. Understanding the movement patterns and behaviors of a migratory species across all stages of migration is critical to informing successful conservation management strategies. While the movement patterns of northwestern Atlantic leatherbacks have been widely studied, there is still a need to understand area-specific behaviors. We collected and analyzed dive data from 52 satellite-tagged leatherbacks that inhabited documented or proposed foraging areas: the northeastern Gulf of America/Mexico, the Mid-Atlantic Bight, and southern New England. We fit generalized linear mixed models to these data to determine area-specific dive metrics and their relationship to several environmental variables. The most notable result from the models revealed area-specific relationships between dive behavior and sea surface temperature. As SST increased, we observed leatherbacks in the northeastern Gulf of America/Mexico and Mid-Atlantic Bight to increase their surface duration and decrease dive duration, while we observed the opposite trend off southern New England. Additionally, leatherbacks in the northeastern Gulf of America/Mexico performed more deep dives to cooler waters with rising SSTs. Our results suggest that leatherbacks in the northeastern Gulf of America/Mexico are performing thermoregulatory dive behavior that may reduce time available for feeding, potentially inhibiting foraging success relative to the Mid-Atlantic Bight and southern New England. These findings offer a deeper comprehension of leatherback movement ecology in each area, provide critical information needed for population assessments and management, and highlight areas of conservation concern in a warming climate.

We thank Brian Stacy, Leah Crowe, Josh Hatch, Annie Gorgone, Scott Benson, Blake Price, Emily Christiansen, Mike Judge, Karin Forney, and Lisa Conger for their expert fieldwork during leatherback captures. We also thank Paul Richards, Elizabeth Babcock, Martin Grossell, Neil Hammerschlag, and Maria Estevanez for their helpful comments on earlier versions of the manuscript. This work would not have been possible without the crew of the Warren Jr. and Semper Offshore, Val Diers and Anthem Commercial Air Services, and NOAA Aircraft Operations Center.

This study was funded by the United States Department of the Interior, Bureau of Ocean Energy Management through Interagency Agreements M14PG00005, M10PG00 075, and M19PG00007 with the United States Department of the Commerce, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center (NEFSC), and Southeast Fisheries Science Center (SEFSC). This paper is also the result of research funded by the NOAA's National Centers for Coastal Ocean Science Competitive Research Program to the NOAA Fisheries Northeast Fisheries Science Center (NEFSC). The Gulf of America/Mexico work was primarily funded by protected species stock assessment improvement plan funding from the NMFS Office of Science and Technology and SEFSC. All procedures and methods were reviewed and approved by the National Marine Fisheries Service's Atlantic Institutional Animal Care and Use Committee (IACUC). NOAA Fisheries reviewed and approved the animal study. All work was conducted under ESA permits 16733 and 21233 issued to the National Marine Fisheries Service Southeast Fisheries Science Center.

3.4 Disposition of data

The Turtle Ecology team at the NEFSC in Woods Hole, MA maintains data collected from fieldwork, including satellite tag data, in the NEFSC's Oracle database.

3.5 Permits

We conducted the fieldwork during calendar year 2024 under US Permit No. 21233 issued to the SEFSC by the NMFS and US Permit No. 23639 issued to CFF by the NMFS.

3.6 Acknowledgements

The 2024 data collected and analyses discussed in this chapter came in part from three sources of funds specified in section 1.3 of this document (NMFS, and the 2 interagency agreements with the Bureau of Ocean Energy Management (BOEM) and the US Navy). This chapter also contains references to other projects led by NEFSC (funded by National Centers for Coastal Ocean Science) and CFF (funded by the Research Set Aside program, BOEM, and Massachusetts Environmental Trust). We are grateful for the crew aboard F/V Kathy Ann, and for the multiple pilots and aerial observers who have participated in this research.

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4 Progress on passive acoustic data collection and analyses: Northeast and Southeast Fisheries Science Centers

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4.1 Summary

During 2024, the passive acoustic teams focused analyses of the data collected during the NOAA ship *Henry B. Bigelow* HB2102 summer abundance survey. These analyses are investigating the abundance of and diving behavior of foraging sperm whales (*Physeter macrocephalus*), *Ziphiidae* and *Kogiidae*. Specifically, using methodology similar to Westell et al. (2022), we annotated individual sperm whales in the passive acoustic dataset, and estimated the depths to which they foraged. The weighted mean depth of sperm whales in this dataset was 610 m (weighted standard deviation= 270 m). Using the depth corrected perpendicular distance estimates, we estimated a preliminary abundance of 556 animals (SE = 91.29, CV = 0.16) in the HB2102 summer survey area. Due to the distribution of detections observed in the detection function, where fewer detections occurred in the first few bins, we are conducting more work to ensure that the estimate is less biased; thus, this preliminary estimate is not appropriate for inclusion in an assessment of sperm whale population status in the North Atlantic.

To examine sperm whale foraging behavior, we combined the dive profiles of sperm whales estimated from the passive acoustic data from the NOAA ship *Henry B. Bigelow* HB1603 summer abundance survey with the prey backscatter data collected from the EK60/EK80 active acoustic data. Thus, far, we have investigated one dive profile out of 14 profiles available with both data sources. In that one dive, the sperm whale spent more time in water layers containing organisms with gas-filled inclusions.

We also are investigating the distribution of the *Ziphiidae* and *Kogiidae* families using the HB2102 passive acoustic data. Out of 32 survey days, we have analyzed 29 days for the presence of beaked whales. So far, most beaked whale detections were goose-beaked whale (*Ziphius cavirostris*; n = 53 detections), and most beaked whale detections occur when the EK60 was in passive mode (n = 99 detections). We are developing a more efficient process to review the data for clicks belonging to *Kogiidae*, which includes using a matched click template and click train autogrouper that will allow the analyst to jump to sections of the data containing the highest likelihood of clicks closely matching the *Kogiidae* templates gathered from the NOAA ship *Gordon Gunter* GU1803 dataset.

4.2 HB2102 Sperm whale presence

4.2.1 Methods

We estimated sperm whale acoustic abundance using acoustic data collected in 2021 during the Northeast Fisheries Science Center's shipboard survey (Palka et al., 2022). Over 31 days, from 17 Jun to 19 Aug 2021, we completed >5500 km of on-effort acoustic line transects between North Carolina and Maine. A shipboard echosounder was turned on and off periodically throughout each day. The goal of this analysis was to detect and localize in three-dimensions all sperm whale acoustic encounters and conduct distance analysis using depth-corrected perpendicular distances (Westell et al., 2022).

We processed on-effort acoustic data using the PAMGuard sperm whale click detector (Gillespie et al. 2008) and manually marked detections matching characteristics of sperm whale clicks into "events". We define an event as a series of clicks organized into click trains along a similar bearing angle. These events are analogous to a single individual. Events were labelled based on click type with "usual" being echolocation click trains with intervals less than 2 s, "codas" being repeated sequences of clicks, "slow" being clicks with an interval greater than 2 s, and "uncertain" being those we could not fit into a given click type (Backus and Schevill, 1966, Gordon, 1987, Weilgart and Whitehead, 1987). We localized events containing usual echolocation clicks using PAMGuard's Target Motion Analysis module's two-dimensional Simplex Optimisation algorithm and slant range. This algorithm provides the distance between the trackline and the animal when the animal is perpendicular to the towed array. This distance is a slant range due to the sperm whales echolocating at deep depths (Watwood et al. 2006). Following Westell et al. (2022), we truncated events that had a slant range of more than 6500 m and excluded events with a duration of less than two minutes. We used the methods described by Westell et al. (2022) to calculate average dive depths and depth corrected perpendicular distances in custom R scripts and using the R package PAMPal (v. 1.4.0, Sakai et al., 2024). We also conducted an additional manual review of the slant delay measurements to remove likely false detections of surface reflected echoes. For events within the truncation distance that we did not localize in three-dimensions or where we rejected the average depth, we used the third quartile (75th percentile) of the average depths as an assumed depth to calculate the perpendicular distance. We then used the R package Distance (Miller et al., 2019) to conduct an initial distance analysis using depth corrected perpendicular distances. We selected the best detection function based on the Akaike's Information Criterion score, the Cramer-von Mises test, and quantile-quantile plots. Analysis is ongoing where we will be testing additional models.

4.2.2 Results

Sperm whales were detected on 29 out of 32 survey days and on all but 6 transect lines (Figure 4-1). We localized 498 events, 269 of which we classified as usual events during on effort time and had a duration greater than 2 min. These usual events were included in the distance analysis. We calculated dive depth profiles and average dive depths for 120 events (Figure 4-2). The weighted mean of average depths was 610 m (weighted standard deviation = 270 m), and the first and third quartiles were 379 m and 746 m respectively. We used the third quartile of the average depths as an assumed depth for 149 events with implausible depth estimates or that we excluded from the three-dimensional localization. We then performed a preliminary distance analysis. The distribution of depth corrected distances truncated at 6500 m with a hazard rate fitted detection function is in Figure 4-3. This results in a preliminary acoustic abundance estimate of 556 animals (SE = 91.29, CV = 0.16). Analyses are ongoing, and we will submit a manuscript in FY25.

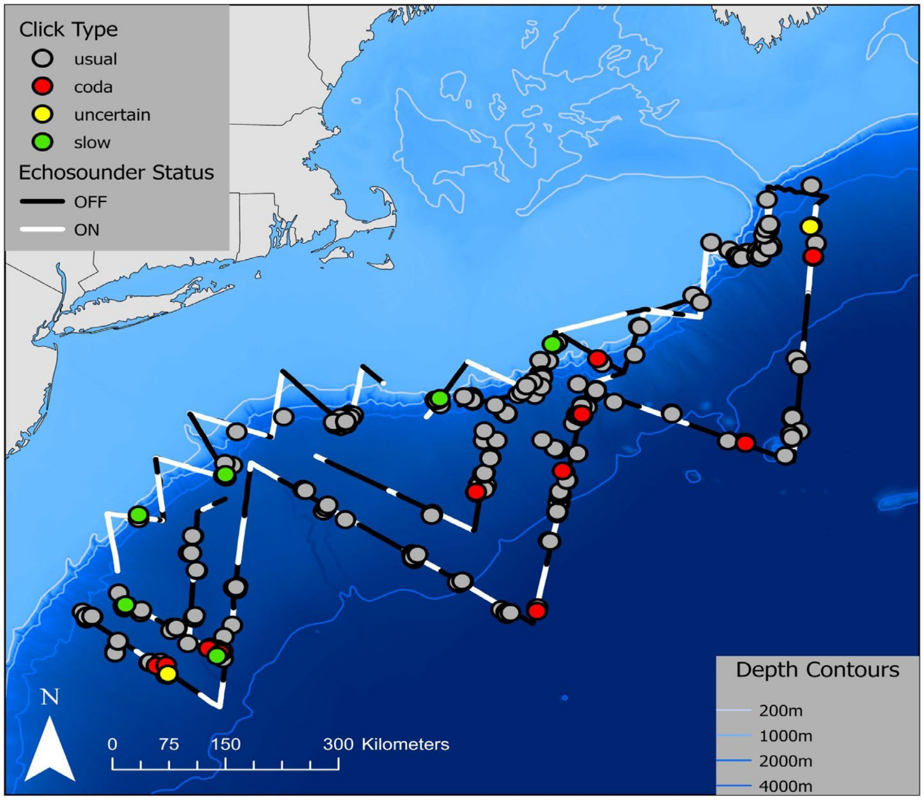

Figure 4-1 On-effort acoustic line transect survey and sperm whale events during 2021 cruise
Data from 17 Jun to 19 Aug 2021 on the NOAA ship *Henry B. Bigelow*. White lines indicate when echosounder is active, black lines indicate echosounder is on standby mode. Map sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors.

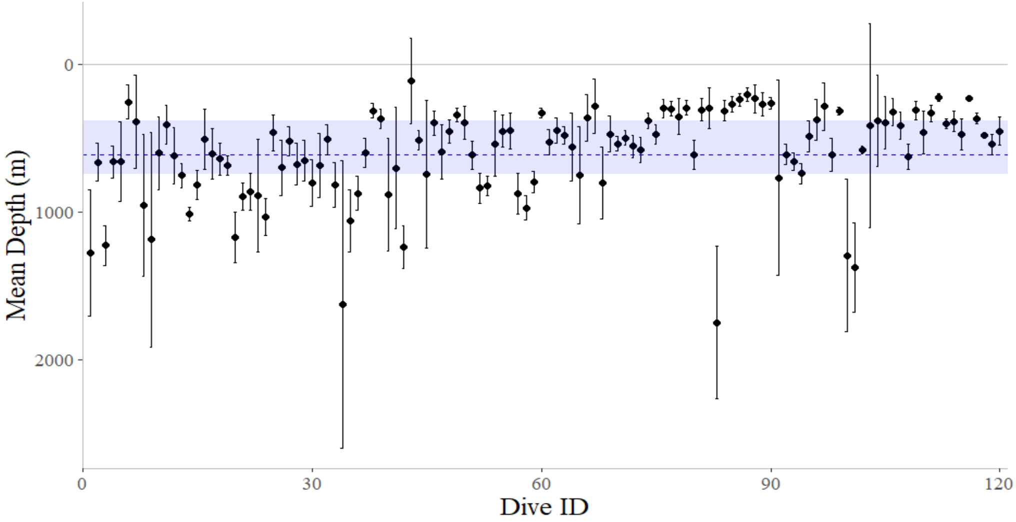

Figure 4-2 Mean sperm whale dive depths (m) with depth error for 120 sperm whale events
The vertical lines represent the estimated error for each dive depth. The depth error ranged from 6.8% to 76.2% with most falling below 20%. The interquartile range is in light blue shading (Q1 = 379 m, Q3 = 746 m) with the dark blue dashed line representing the weighted mean of all mean depths (610 m).

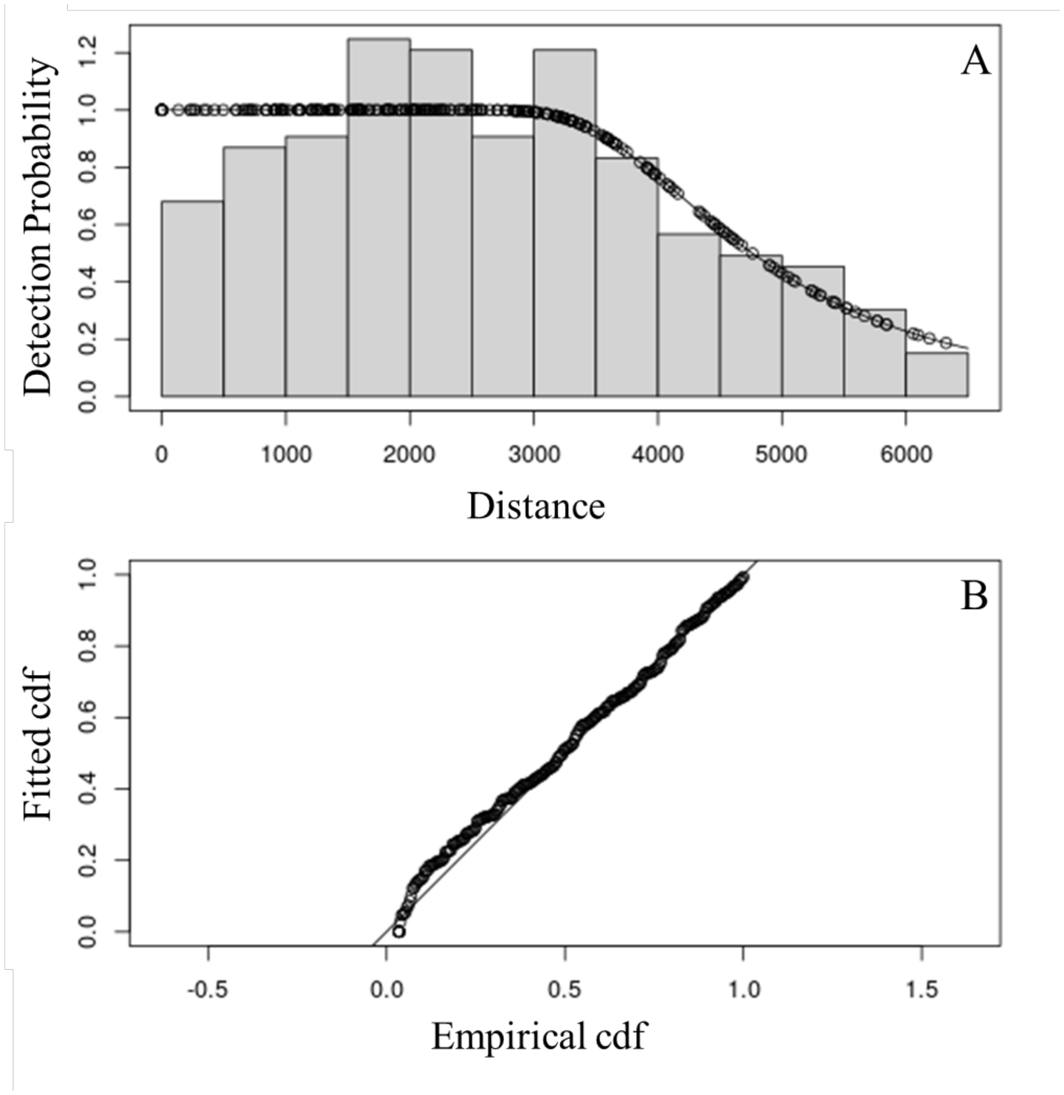

Figure 4-3 Fitted line transect hazard rate model for acoustic detections of sperm whales
(A) Histogram bars represent the depth corrected perpendicular horizontal distance of sperm whale detections (n = 260) truncated at 6500 m. The solid line represents the fitted hazard rate model. (B) The corresponding quantile-quantile plot.

4.3 Examine deep scattering layer and sperm whale diving behaviors

To better understand how sperm whales exploit prey layers in the continental shelf waters of the northeast coast of the US, this project pairs sperm whale foraging dive profiles (Westell et al., 2022) with prey layer information derived from the active acoustic (EK60) data collected during the 2016 Northeast shipboard survey. We paired 14 sperm whale dives with simultaneously collected EK60 data (2023 Annual Report, 2024). In 2024, we manually reviewed and filtered the dive profiles. We applied a LOESS smoothing (span = 0.2) using the statistical software R (v. 4.2.1; R Core Team 2021) to the data and extracted the depth value along the fitted curve. We resolved the spatial offset between the collection location the active acoustic data, off the bow of the research vessel, and the locations of the sperm whale dive data, collected using a towed hydrophone array 300 m behind the vessel, to better pair the sperm whale movements with the prey layers detected.

As sperm whales often dive deeper and forage at depths greater than 200 m, we selected the 18 and 38 kHz narrowband EK60 active acoustic to map the vertical distributions of the mesopelagic fish and plankton communities (Figure 4-4). We developed a simple classification scheme of the relationship of the volume backscattering amplitudes (*Sv* dB re m^2 m^{-3}) between the two frequencies *Sv*(18) and *Sv*(38)). The codes were: *Sv*(18) > *Sv*(38) (code=1), *Sv*(18) = *Sv*(38) (code=2), and *Sv*(18) < *Sv*(38) (code=3), where differences between *Sv*(18) and *Sv*(38) of less than or equal to 3 dB are considered equal (Figure 4-5). *Sv* data were vertically and horizontally averaged into 2-m by 10-s bins (Figure 4-6). The cumulative mean *Sv* profiles (Figure 4-7) are consistent with the coded echograms where values coded as 3 (yellow color) correspond to depths where *Sv*(38) is greater than *Sv*(18) and values coded as 1 (blue color) correspond to depths where *Sv*(18) is greater than *Sv*(38).

Biological interpretation of the codes remains challenging, but broadly, we can say that code 1 indicates organisms with a gas inclusion, e.g., fish with a gas-filled swimbladder or siphonophores; code 3 indicates organisms that do not have a gas inclusion, such as squid or other non-gas-bearing fish; and code 2 is uncertain at this time.

Sperm whale dives often consist of a descent, bottom foraging, and ascent phase, however they can forage during the descent and ascent phase. If we assume the amount of time is an indicator of preference, then the amount of time per code would indicate a preference for that type of scatter that is at that depth. This analysis showed that there is availability of non-gas-bearing animals (Code 3) at depths between 500 and 600 m and gas-bearing animals above 500 m (Code 1; Figure 4-5). Summing the amount of time per code for this dive was 7.73 min for “Code 1”, 6.35 min for “Code 2”, and 5.4 min for “Code 3”, suggesting an overall preference for organisms with a gas-filled inclusion (Code 1), however this time likely includes descent and ascent from the foraging depth. Analysis is ongoing and includes assessing prey availability and preference for all fourteen sperm whale dives.

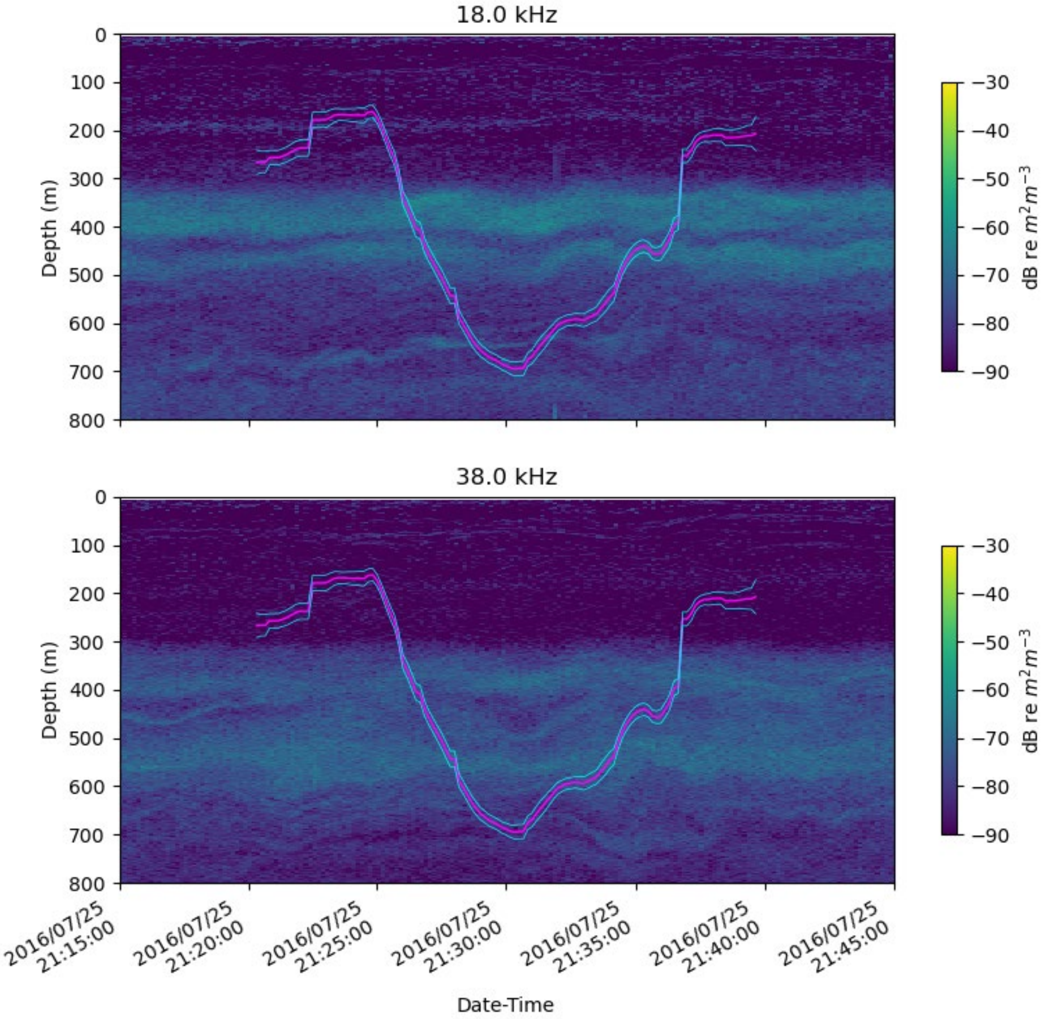

Figure 4-4 18 (top panel) and 38 (lower panel) kHz volume backscatter (Sv) echograms
Data collected on 25 July 2016 from 2115 to 2145 UTC during the 2016 survey on the NOAA ship *Henry B Bigelow*. Brighter background colors represent higher backscatter. The time-synchronized accompanying sperm whale dive profile (magenta line) with 95% confidence intervals (cyan lines).

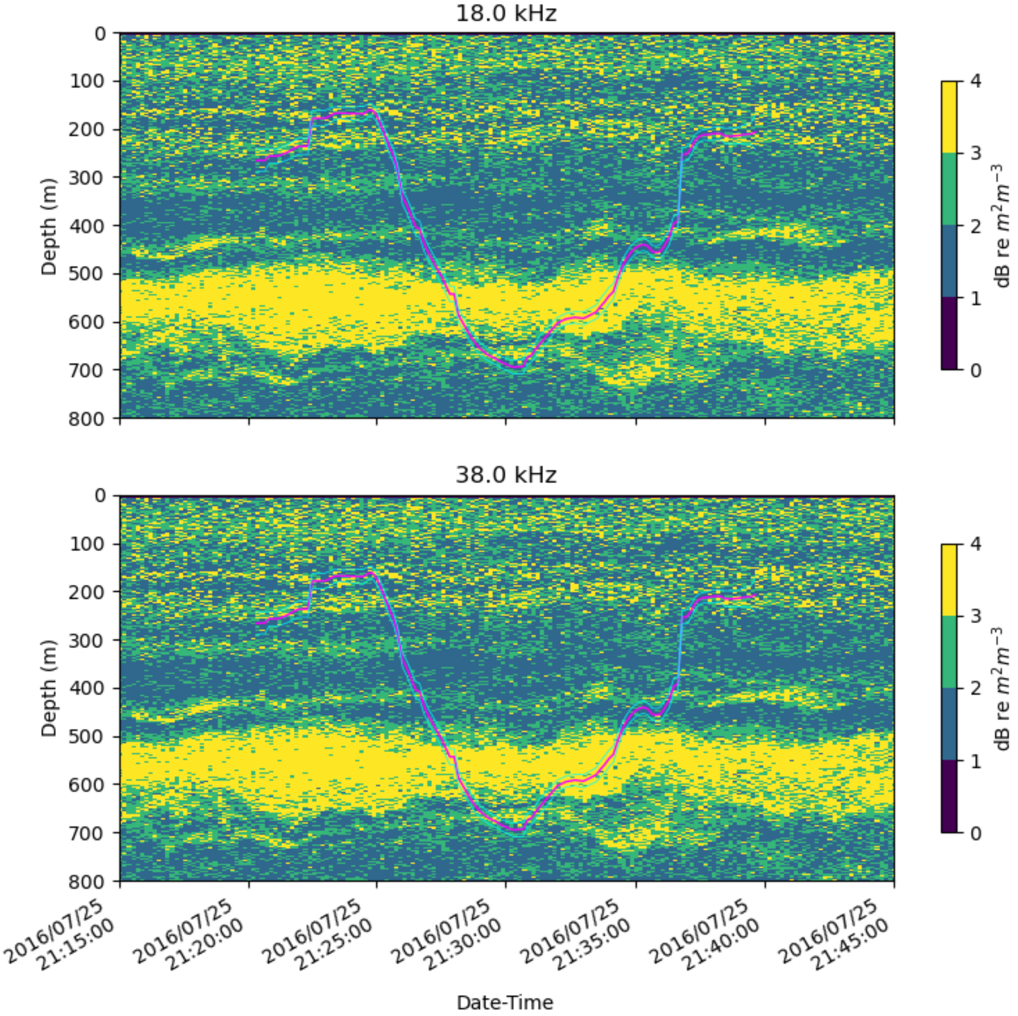

Figure 4-5 18 and 38 kHz Sv relationships for data in Figure 4-4

Color denotes classification scheme, not backscatter amplitude. Code “1” indicates organisms with a gas inclusion (e.g., fish with a gas-filled swimbladder or siphonophores), code “3” indicates organisms without a gas inclusion (e.g., squid), and code “2” is indeterminant.

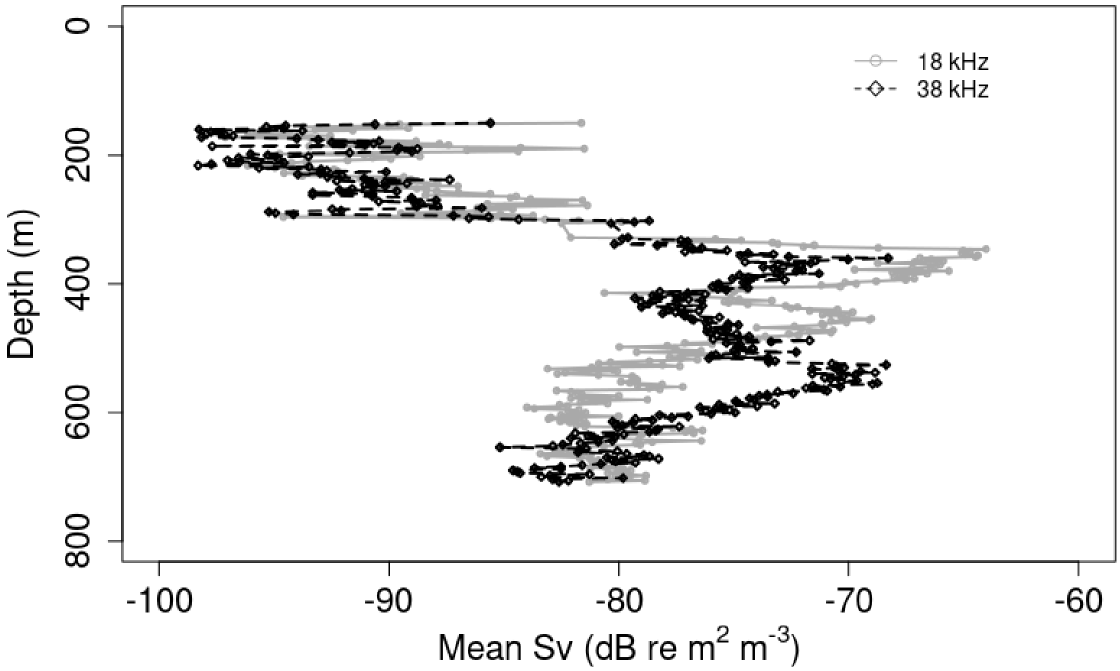

Figure 4-6 Mean Sv (dB re m2 m-3) profiles for 18 and 38 kHz

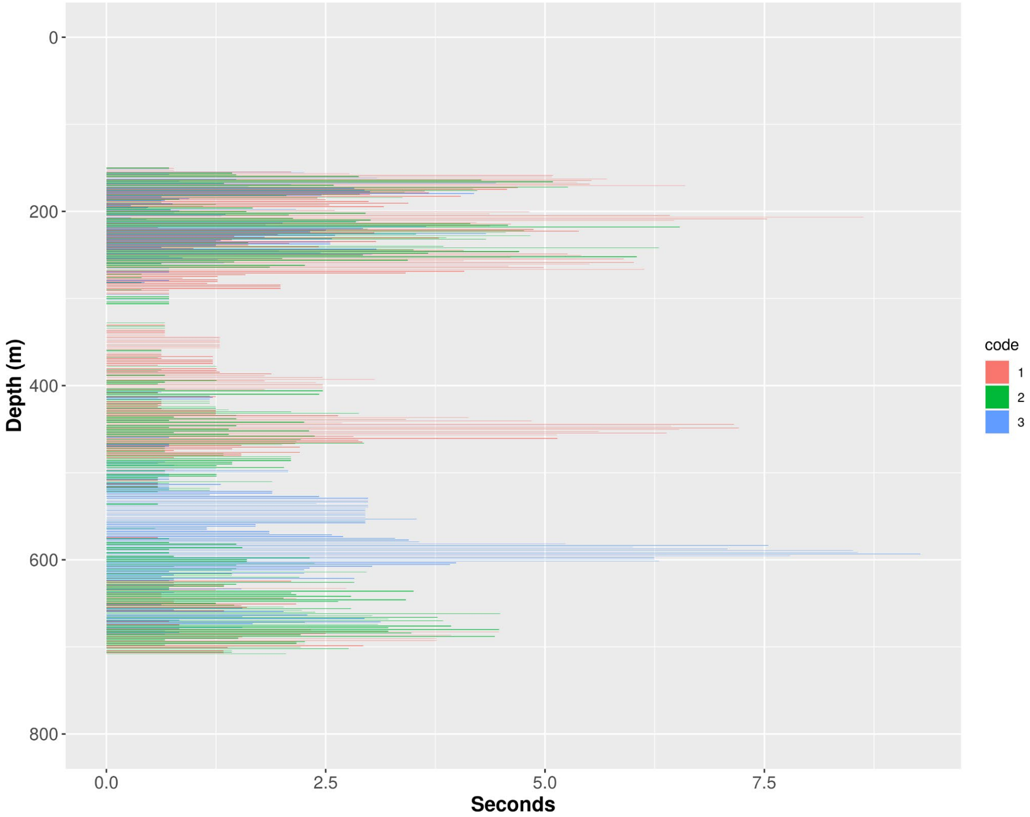

Figure 4-7 Cumulative time spent at each 2-m depth bin by acoustic classification code
Code “1” indicates organisms with a gas inclusion (e.g., fish with a gas-filled swimbladder or siphonophores), code “3” indicates organisms without a gas inclusion (e.g., squid), and code “2” is indeterminant.

4.4 HB2102 Beaked whale presence

4.4.1 Methods

We analyzed the data collected from the HB2102 abundance survey for beaked whale presence. Using the acoustical software PAMGuard (v. 2.02.09, Gillespie et al. 2008), we used a basic click detector to detect impulsive signals, and we used a suite of click classifiers to identify different clicks based on their main spectral energy content (Keating and Barlow 2013). We viewed the resulting classified clicks with a two-minute page window within PAMGuard to identify beaked whale frequency modulated (FM) clicks. An analyst then visually confirmed the species from the clicks as a specific beaked whale FM clicks (Baumann-Pickering et al. 2013, DeAngelis et al. 2017). Ambiguity remains in distinguishing True's beaked whale (*Mesoplodon mirus*) FM clicks from Gervais' beaked whale (*Mesoplodon europaeus*) FM clicks if few clicks are available (DeAngelis et al. 2018). In those instances, we used a combination "True's/Gervais'" beaked whale class. We grouped clicks that occurred along a similar change in bearing from the same species into acoustic "events", which could possibly be attributed to an individual level. We localized these events using PAMGuard's Target Motion module, where the resulting information included the slant range to the animal when perpendicular to the array along with the slant range error, and the latitude and longitude of the localized animal. In instances where beaked whale events could not be localized (e.g. too few clicks), we used the position of the ship at the start of the event in lieu of a localized animal position. We then visualized these events using ArcGIS Pro v.3.1.0 to examine species-specific distributions.

4.4.2 Results

Analysis of this dataset is ongoing and to date, we have completed analyses of 29 of the 32 survey days, resulting in 53 detections of goose-beaked whales, 42 detections of True's beaked whales, 10 detections of True's/Gervais' beaked whales, and 7 detections of Sowerby's beaked whales (*Mesoplodon bidens,* Figure 4-8). We acoustically detected goose-beaked whales throughout the survey area. True's beaked whales were predominately throughout the abyssal waters (>2000 m water depth) of the study area. True's/Gervais' beaked whales were only in the abyssal water, and Sowerby's beaked whales were only around the 1000 m contour at the mouth of the Northeast Channel and off of New Jersey.

As in previous AMAPPS surveys (Cholewiak et al. 2017; Palka et al. 2021), fewer beaked whales were detected when the echosounder was in active mode ("on", n= 13 events) versus passive mode ("off", n= 99 events). Most of the beaked whale detections while the echosounders were on were of goose-beaked whales (n= 11 events), with the remaining two events comprising of one True's/Gervais' beaked whale and one Sowerby's beaked whale. We expect to complete this analysis in 2025.

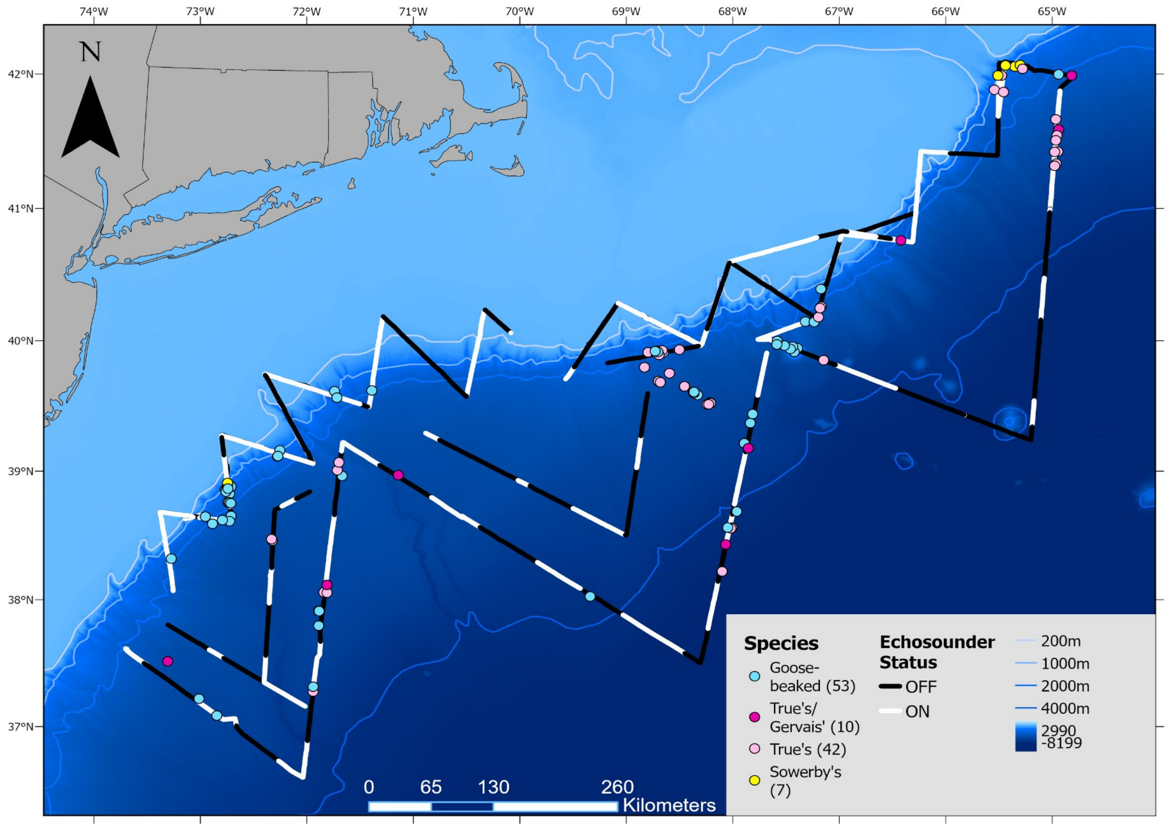

Figure 4-8 Spatial distribution of beaked whale species detected during the HB2102
White lines indicate echosounder is active, black lines indicate echosounder is in standby mode. Map sources: Esri, GEBCO, NOAA, National Geographic, DeLorme, HERE, Geonames.org, and other contributors.

4.5 HB2102 Kogia sp. presence

4.5.1 Methods and results

We seldom detect species of the *Kogiidae* family with the towed array (Palka et al., 2021). Since each of these rare detections are important for collecting information on their distribution, we needed a new analytical process to reduce analyst time reviewing data from this family. Efforts this year focused on developing a customized matched click template classifier in PAMGuard v. 2.02.10bd to identify clicks matching the signal characteristics of the *Kogiidae* family (previously, it is only possible to attribute clicks to a family level). We also applied the new template to past datasets (NOAA *Gordon Gunter* GU1803) that we previously manually reviewed for *Kogiidae* species. By changing the template threshold, the classifier performance is now at no false positives, and few true negatives (4/24 clicks). The next step in this process is to auto-generate PAMGuard events based on this classification for the analyst to use as an index into reviewing the HB2102 data. We expect to complete this template in 2025.

4.6 Disposition of data

All detection data are on the NEFSC Passive Acoustic Cetacean Map (PACM) website: https://apps-nefsc.fisheries.noaa.gov/pacm/#/. We are in the process of putting PACM and all of our detections into the Google Cloud Platform for ease of use within and outside of NOAA.

4.7 Acknowledgements

Thank you to our data analysts Madison Medina and Amanda Holdman for their work on our beaked whale and *Kogiidae* classification projects, and Jennifer McCullough, Anne Simonis, and Taiki Sakai for their technical assistance.

The 2024 data collected and analyses discussed in this chapter came in part from three sources of funds specified in section 1.3 of this document (NMFS, and the 2 interagency agreements with the Bureau of Ocean Energy Management (BOEM) and the US Navy).

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5 Progress on visual sightings data collection and analyses: Northeast and Southeast Fisheries Science Centers

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5.1 Summary

During 2024, we analyzed previously collected Atlantic Marine Assessment Program for Protected Species (AMAPPS) sighting data of marine mammals and sea turtles. This year we conducted quality control checks of the AMAPPS sighting data and updated the environmental covariates associated with these data. Using these data, we developed Bayesian hierarchical density models of large whales that quantified the probability of exceeding a user-defined threshold in a user-defined area within the AMAPPS study area. We also developed sea turtle density-habitat models using generalized additive models that mapped and quantified the density and abundance of four species of sea turtles that demonstrated their spatiotemporal shifts and trends. During 2024, several external colleagues used the AMAPPS sightings data to publish three journal papers, while one is in press, another is in review and others are still in preparation. We have archived all of the AMAPPS sighting data and are sharing these data with the public by making them available on public websites.

5.2 Updating environmental covariates

During 2024, we acquired sea-surface temperature data from 2022 and 2023. We extracted these data from updated sources and processed the data with improved algorithms in the process documented in Palka et al. (2021). We then compared the newly acquired data with the annual trend from the 2010 – 2021 data and found only a few minor differences. In addition, we initiated the analysis of the Hybrid Coordinate Ocean Model (HYCOM) databases to acquire the data from 2022 and 2023 to complete the environmental database.

5.3 Bayesian hierarchical density models of large whales

5.3.1 Summary

In 2024, we finished the development of a Bayesian hierarchical density surface model and applied it to five species of large whales: fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), minke whales (*Balaenoptera acutorostrata*), sei whales (*Balaenoptera borealis*) and sperm whales (*Physeter macrocephalus*). We summarized this work in a manuscript that we will submit for peer review (Sigourney et al. in review). As detailed in the previous AMAPPS Annual Report, the Bayesian hierarchical density surface model framework includes 1) a hierarchical distance-sampling component to model detection probabilities, 2) a rigorous model selection process, and 3) code to diagnose extrapolations within the study area. We used the Bayesian hierarchical density surface model to assess seasonal changes in abundance and quantify the probability of exceeding a user-defined threshold in a user-defined area, such as a wind energy area. Work in 2024 included:

- Updating the time series to include data from 2010 to 2021
- Finalizing analyses for all large whale species
- Presenting preliminary results at the State of the Science Workshop on Wildlife and Offshore Wind Development 2024 conference in July 2024
- Updating GitHub repository for code and data
- Revising drafts to submit to a journal

Below we provide a description of the methods and results for one of the five species of large whales.

5.3.2 Methods

We used the updated environmental covariates in the model selection process outlined in the AMAPPS 2023 Annual Report (NEFSC and SEFSC 2024). We averaged over an 8-day period the dynamic covariates to summarize into layers. Using the parameters from the fitted Bayesian hierarchical density surface models, we made seasonal predictions of density for the AMAPPS study area for all five species of large whales. As an example of user-defined areas, we chose three areas associated with the wind energy areas (WEAs) in the waters of Massachusetts and Rhode Island (MA-RI WEAs). One area was the combination of all adjacent lease areas (Figure 9-1). The other two user-defined areas were different buffer zones of 4 km and 12 km around a target location within the WEA (Figure 5-1). For each area, we used the posterior predictions of abundance for the 10x10 km grid cells within each area and for all 8-day layers. We predicted the animal abundance for each year and 8-day layer and summed predictions over all grid cells to estimate total abundance at the scale of each chosen area. We then used these posterior draws of abundance for each grid cell to calculate the probability of exceeding a user-defined threshold level of abundance within that area. As an example of a user-defined threshold, we chose the Level B take level as reported in an Incidental Harassment Authorization report by the South Forks Wind energy company for this area**.** The Marine Mammal Protection Act mandates only allowing up to the Level B take level by ocean users and therefore, this type of threshold could be relevant to management decisions regarding the construction within a WEA.

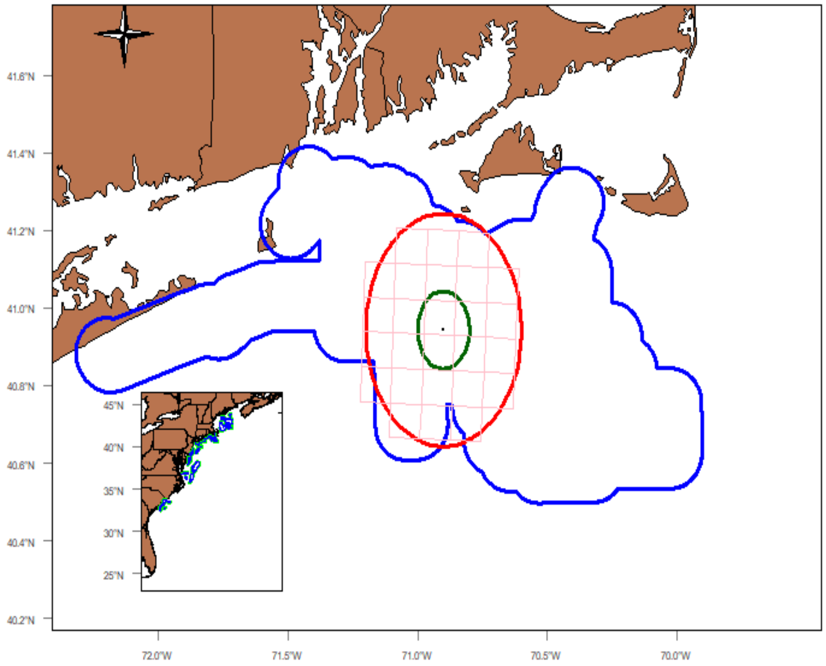

Figure 5-1 Map of Massachusetts-Rhode Island Wind Energy Area

Blue line represents 10 km buffer around all leases within this Wind Energy Area. Red line represents the 12 km buffer and green line represent the 4 km buffer around a chosen target location (black dot).

5.3.3 Preliminary Results

The most common covariates chosen for a well-fit density-habitat model for the large whales were bottom temperature and distance to the 125 m isobath; we show the model for fin whales in Table 5-1. Overall, predicted seasonal distributions resulting from the Bayesian hierarchical density surface model models (Figure 5-2) were similar to other studies (Roberts et al. 2016; Palka et al. 2021). Within the MA-RI WEA, peaks in fin whale average abundance were in May and January (Figures 5-3A). Seasonal changes in the posterior probability of exceeding the user-defined threshold largely correlated with patterns in abundance (Figure 5-3B).

Table 5-1 Top habitat model for fin whales (*Balaenoptera physalus*)
Also provided are an indication of whether random years effects (Random Effects) were included in the final model and the resulting Bayesian p-value associated with the fit of the model.

Whale Species	Model[1]	Random Effects	Bayesian p-value
Fin	BTemp + Latitude + Dist125 + Dist1000	Y	0.59

[1] BTemp = Bottom temperature. Dist125 = Distance to 125 m isobath. Dist1000 = Distance to 1000 m isobath.

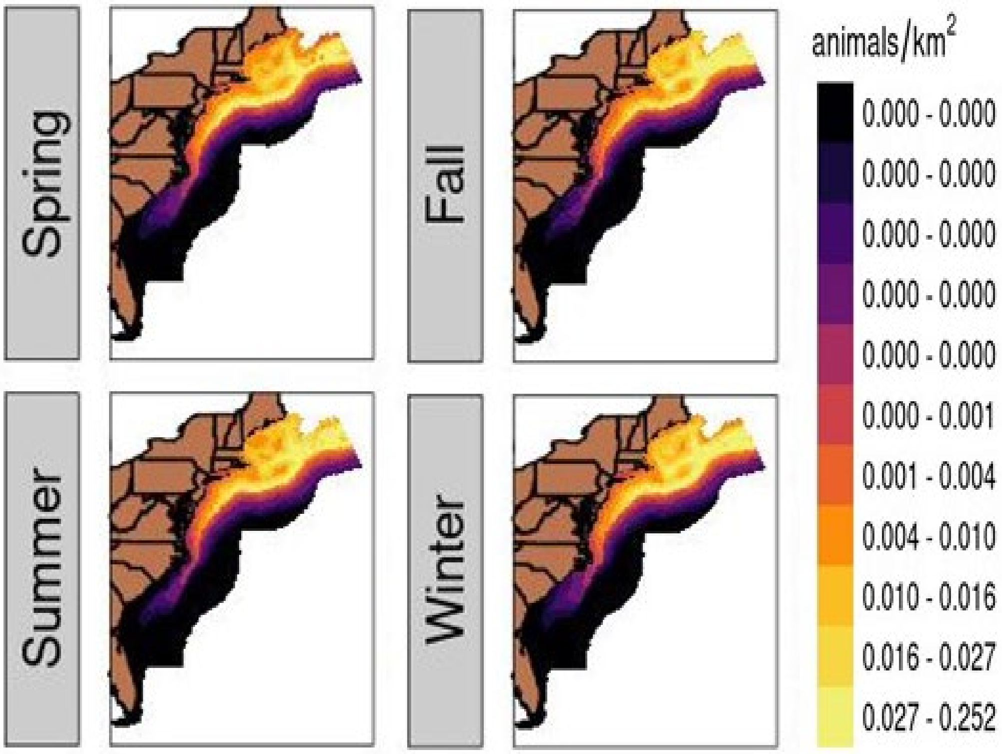

Figure 5-2 Predicted densities of fin whales (*Balaenoptera physalus*) for the AMAPPS study area

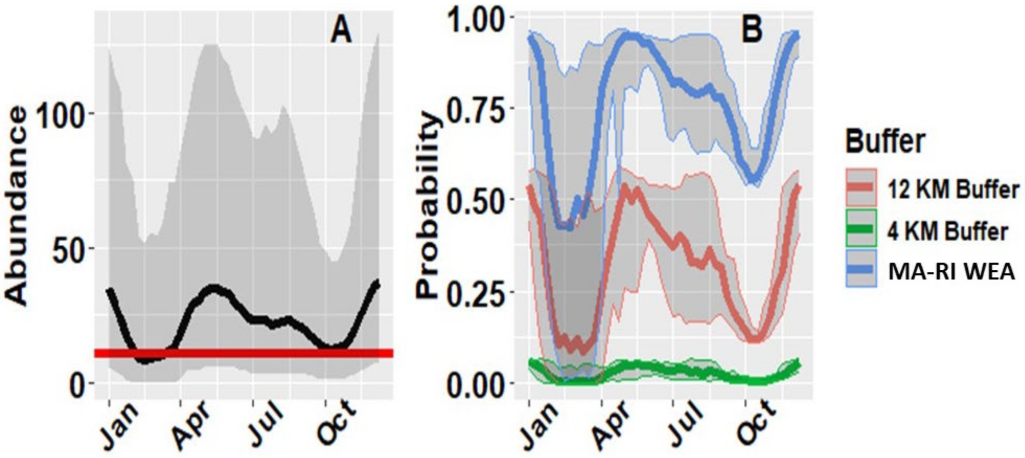

Figure 5-3 Abundance trends (A) and probability of exceeding a user-defined threshold (B)
For fin whales (*Balaenoptera physalus*) within three regions in the Massachusetts-Rhode Island wind energy area, as defined in Figure 5-1. The user-defined threshold is the red line in (A).

5.4 Sea turtle abundance analysis

5.4.1 Summary

AMAPPS collected extensive data on sea turtles and cetaceans, which is crucial for understanding the impacts of environmental factors on species distribution and abundance. This type of data is especially useful in light of the rapid development of ocean resources and the changing oceanic environment. This year's data analysis focused on establishing a current habitat description and abundance estimates of four species of sea turtles in the Northwest Atlantic: Kemp's ridley (*Lepidochelys kempii*), green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles. We identified key environmental factors, interannual variability, and estimated turtle abundance based on their habitat relationships. The full results are in Chavez-Rosales et al. (in review).

5.4.2 Methods

The AMAPPS study area spans Atlantic waters from Halifax, Nova Scotia, to Florida's southern tip, covering 1,193,320 km² of offshore and coastal habitats. We conducted abundance surveys in the AMAPPS study area across all months of the year and followed standard two-team line transect procedures using NOAA aircraft and ships. During 2010 – 2021, these surveys detected over 13,000 sightings of sea turtles. The aerial surveys accounted for 98% of detections, while the shipboard surveys contributed just 2%. We aggregated the survey data and associated environmental data into 10x10 km cells and 8-day intervals, similar to that done for cetacean analyses (Palka et al., 2021).

We reclassified sightings recorded in the field as unidentified hardshell turtles as a specific species by using hierarchical clustering and principal components analysis based on environmental conditions. We then used a two-step density surface modeling to create seasonal spatial models and maps of sea turtle densities. The first step involved estimating detection probabilities. The second step involved modeling observed densities as functions of environmental covariates. Ultimately, we predicted densities across the entire AMAPPS study (similar to that documented in Chavez-Rosales et al. 2019).

We used generalized additive modeling techniques for density modeling, optimizing parameter estimates and avoiding overfitting (Miller *et al.* 2013). We used several diagnostic tests and cross-validation to determine the best-fitting accurate model for each species. We used these models to generate a time series of abundance estimates for 2010-2021 and to forecast abundance through 2025. We also produced seasonal and monthly density maps, along with tabulations of the mean seasonal abundances (Chavez-Rosales et al., in review).

5.4.3 Results

Density models for each sea turtle species used 7 – 9 environmental covariates, with latitude and sea surface temperature (SST) being the most influential parameters (Table 5-2). These models captured the seasonal and monthly movement patterns observed in the data. Abundance estimates trends varied by species. Abundance drastically changed during 2010 – 2020, but at least for loggerhead and green turtles, abundance was more stable during 2020 – 2024 (Figure 5-4). Loggerhead turtles had the highest mean annual abundance, followed by green, Kemp's ridley, and leatherback turtles. Loggerhead turtle abundance appear to have been affected differently that the other sea turtle species.

Table 5-2 Environmental factors included in the turtle density-habitat models

Loggerhead	Kemp's Ridley	Green	Leatherback
Latitude	Latitude	Latitude	Latitude
SST	SST	-	SST
Dist2GSSw	Dist2GSSw	Dist2GSSw	-
Dist1000	Dist1000	Dist1000	-
-	-	-	Dist125
-	MLP	MLP	MLP
Dist2GSNw	-	-	Dist2GSNw
Dist2shore	Dist2shore	-	-
Dist200	Dist200	Dist200	-
PP	-	-	-
-	-	-	BTemp
Depth	-	-	-
-	ChlAf	-	-
-	-	-	LY-SST

BTemp = Bottom temperature. ChlAf = Chlorophyll A front. Depth = Bottom depth. Dist1000 = Distance to the 1000 m isobath. Dist125 = Distance to the 125 m isobath. Dist200 = Distance to the 200 m isobath. Dist2GSNw = Distance to the Gulf Stream North wall. Dist2GSSw = Distance to the Gulf Stream south wall. Dist2shore = Distance to shore. LY-SST = Interaction term between time layer and SST. PP = Primary productivity. SST = Sea surface temperature.

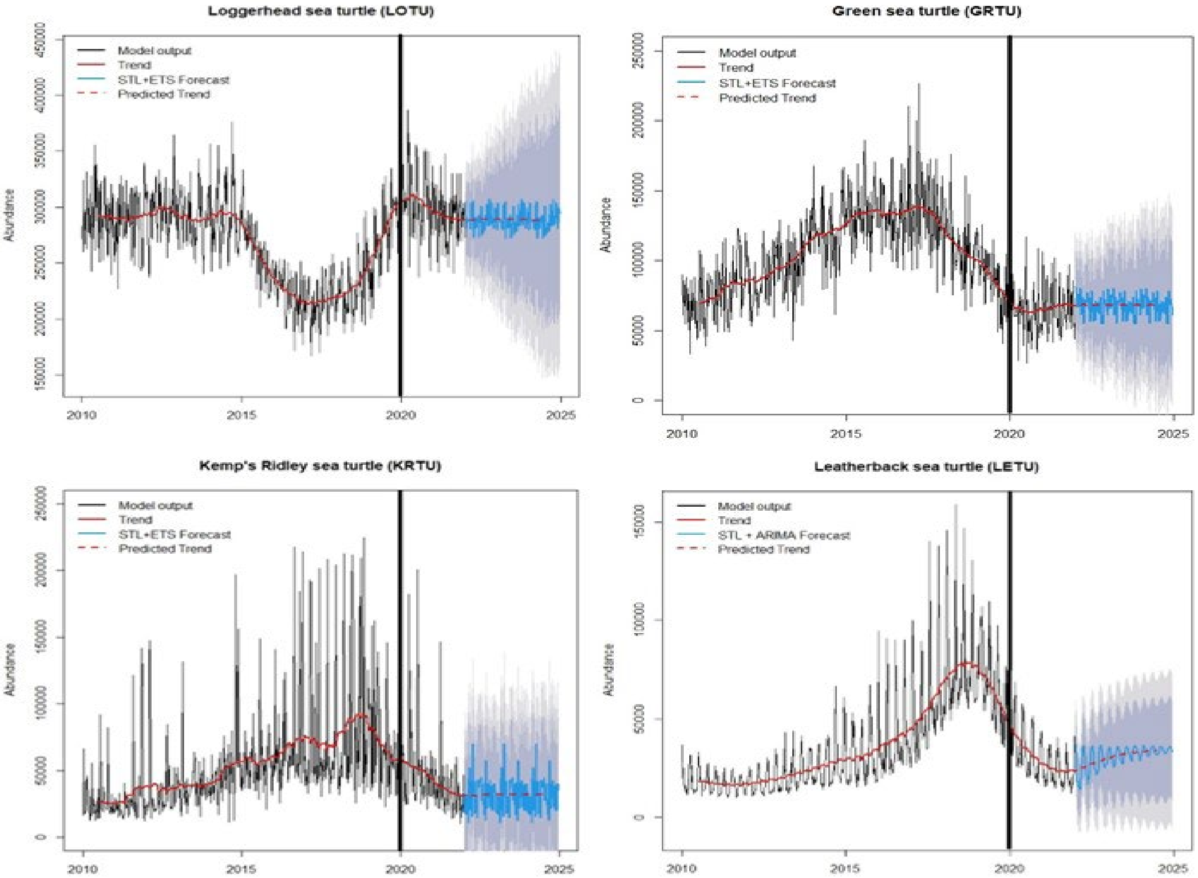

Figure 5-4 Turtle estimated abundance for 2010 – 2021 (black and red) with forecast to 2025 (blue)
Gray areas are the confidence intervals at 80% and 95% of the forecast.

5.5 Development of image surveys

During 2022, we conducted a pilot aerial survey that collected data from visual observers and a 3-camera system that was forward motion compensated (Figure 5-5A). During 2023 – 2024 we amassed over 400K images (> 9 TB of data) from various surveys and annotated about 1025 images in Kitware's open source do-it-yourself deep learning toolkit, called VIAME. This is the first step to train machine-learning models to identify automatically potential animals in the images.

In addition, during 2024, the NOAA Fisheries (not funded with AMAPPS funds) built another KAMERA system that uses very high-resolution Phase One color cameras to collect imagery of marine mammals and map them over the survey area (Figure 5-5B; https://www.kitware.com/project-spotlight-noaa-kamera/). We will use the KAMERA system in an AMAPPS marine mammal aerial survey on the NOAA Twin Otter in early 2025 that will cover continental waters off the Mid-Atlantic States. The KAMERA system comprises of nine synchronized cameras: 3 Ultraviolet, 3 Infrared, and 3 Color cameras. The hardware includes rugged computer systems with a GPU for real-time deep learning. The onboard software includes deep learning techniques developed by Kitware within VIAME, and artificial intelligence models from the University of Washington for real-time seal and polar bear detection.

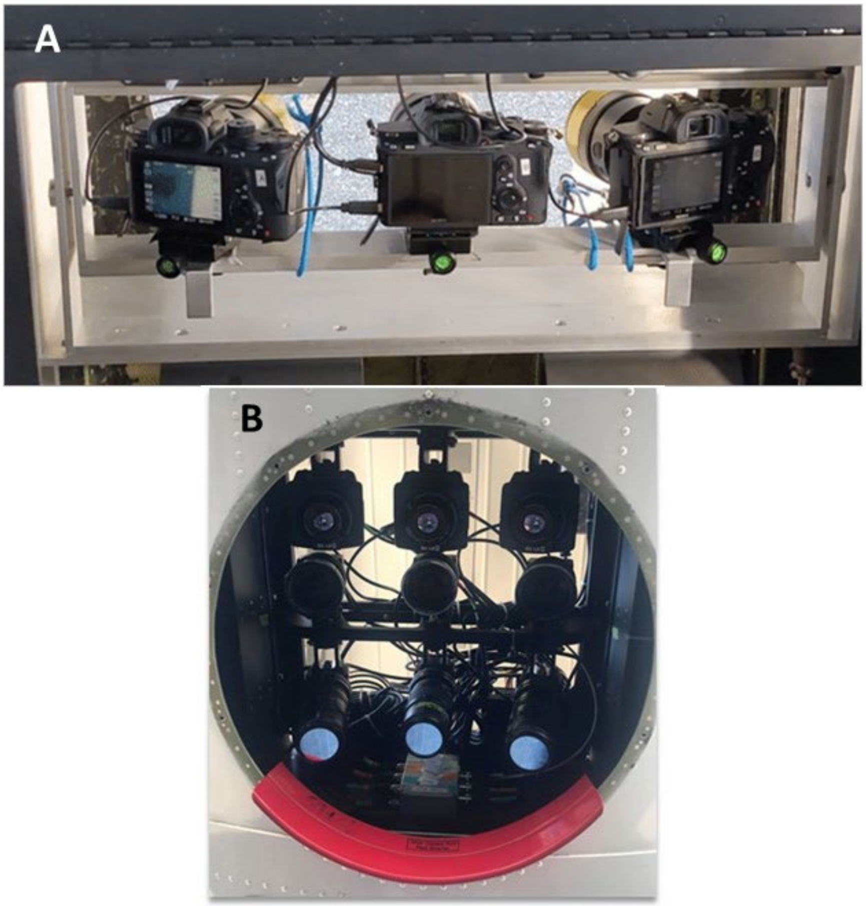

Figure 5-5 Camera systems used in aerial surveys
Forward motion compensated 3-camera system (A). KAMERA 9-camera system (B).

5.6 Data management

We archive the sightings data collected during the AMAPPS aerial and shipboard sighting surveys and resulting data products in several places:

- The raw data are in an Oracle database housed at the Northeast Fisheries Science Center in Woods Hole, MA.
- A subset of the variables are on the public OBIS-SEAMAP website.
- All sightings and associated data will be on the publically available National Centers for Environmental Information website (NCEI).
- Many of the resulting papers are available on the NOAA Institutional Repository

The plan is to have all the AMAPPS survey data archived on NCEI and OBIS-SEAMAP. There is now a NCEI AMAPPS landing page and survey specific pages. For example, during 2024 we archived the shipboard survey on the *NOAA ship Gordon Gunter* conducted during Feb – Apr 2023 in OBIS-SEAMAP (https://seamap.env.duke.edu/dataset/2291 (Dias and Garrison 2024) and NCEI (https://doi.org/10.25921/hhxz-vm91 (Palka et al. 2024).

5.7 Other studies using AMAPPS sightings data

Below are the abstracts from papers that used AMAPPS data and published or were in press during 2024.

Roberts J.J. et al. (2024). **North Atlantic right whale density surface model for the U.S. Atlantic validated with passive acoustic monitoring**

> *The Critically Endangered North Atlantic right whale Eubalaena glacialis entered a population decline around 2011. To save this species without closing the ocean to human activities requires detailed information about its intra-annual density patterns that can be used to assess and mitigate human-caused risks. Using 2.9 million km of visual line-transect survey effort from the US Atlantic and Canadian Maritimes conducted in 2003–2020 by 11 institutions, we modeled the absolute density (individuals/km^2) of the species using spatial, temporal, and environmental covariates at a monthly time step. We accounted for detectability differences between survey platforms, teams, and conditions, and corrected all data for perception and availability biases, accounting for platform differences, whale dive behavior, group composition, and group size. We produced maps of predicted density and evaluated our results using independently collected passive acoustic monitoring (PAM) data. Densities correlated positively ($r = 0.46$, $\rho = 0.58$, $\tau = 0.46$) with acoustic detection rates obtained at 492 stationary PAM recorders deployed across the study area (mean recorder duration = 138 d). This is the first study to quantify the concurrence of visual and acoustic observations of the species in US waters. We summarized predictions into mean monthly density and uncertainty maps for the 2003–2009 and 2010–2020 eras, based on the significant changes in the species' spatial distribution that began around 2010. The results quantify the striking distribution shifts and provide effort- and bias-corrected density surfaces to inform risk assessments, estimations of take, and marine spatial planning.*

DiMatteo et al. (2024). **Sea turtle density surface models along the United States Atlantic coast**.

> *Spatially explicit estimates of marine species distribution and abundance are required to quantify potential impacts from human activities such as military training and testing, fisheries interactions, and offshore energy development. There are 4 protected species of sea turtle (loggerhead, green, Kemp's ridley, and leatherback) commonly found along the east coast of the USA, our study area, and which require impact assessments. Data from 7 different survey organizations were used to create density surface models for the 4 sea turtle species utilizing 1.2 million km of line transect surveys. A substantial portion (29.7%) of available sightings were not identified to the species level. Not including these sightings would underestimate density, so a conditional random forest model was used to assign unidentified sightings to species. Higher densities of loggerhead, green, and Kemp's ridley sea turtles were predicted south of the Outer Banks in cool months, transitioning northwards in late spring to occupy seasonal neritic habitats. The highest leatherback densities were predicted off the coasts of Georgia and Florida. Leatherbacks were also predicted throughout offshore areas. The predicted distribution patterns generally matched satellite tracking and strandings data, indicating the models reproduced established seasonal movements. Surveys rarely detect sea turtles smaller than 40 cm, so these age classes are not represented. The models are the first for the study area to apply availability bias estimates developed in or near the study area and attempt to classify unidentified sightings to the species level, providing an updated, critical tool for conservation management along the eastern seaboard.*

Barry et al. (2024). **Killer whales in the Gulf of Mexico and North Atlantic off the Southeast United States**.

> *Killer whales occur in the Gulf of Mexico (GoMex) and the North Atlantic, including off the southeastern United States (SEUS). Data from cetacean surveys during 1990 – 2021 and other sources were combined to assess killer whale biology, including spatial and temporal distribution, social structure, genetics, morphology, acoustics, and predatory behavior. GoMex records occurred predominantly in oceanic waters (>200 m) during spring and summer. SEUS records occurred primarily in winter and spring off the North Carolina region along the shelf-edge and deeper waters, and off the east coast of Florida. Photo-identification analysis of GoMex killer whales resulted in 49 individuals sighted up to seven times with sighting histories up to 26 years, and social analysis provided evidence of long-term relationships up to 16 years. The GoMex genetic samples revealed two mtDNA haplotypes, one of which does not match any outside the GoMex. Most GoMex whales had wide non-faint saddle patches and many had cookiecutter shark scars while no scars were noted on SEUS whales. Three groups recorded in the GoMex made few calls, but a group harassing sperm whales produced many. Cetaceans and tuna are known prey in the GoMex and SEUS, respectively. Directed studies of killer whales in the GoMex areas would be difficult to implement as this species is very rare. It is therefore important to pursue ongoing efforts to collect behavioral, acoustic and any biological samples that will contribute to improve our understanding of the biology and ecology of killer whales in tropical and subtropical regions.*

Roberts S.M. et al. (in press). **Humpback whale densities are increasing in the Great South Channel: concurrent multi-trophic level shifts in abundance**

> *Humpback whale Megaptera novaeangliae populations have exhibited higher local abundance in parts of the Gulf of Maine in recent years, a region that is heavily impacted by both climate change and other anthropogenic effects. The Gulf of Maine is one of the most rapidly warming ecosystems in the ocean, and humpback whales use the region to feed, suggesting that there may be interactions between humpback whales, climate, and prey species in this region. We sought to understand how humpback whale densities and distributions are changing in this area in the context of prey and the environment, focusing on a particular conservation area with ample survey coverage, the Great South Channel Habitat Management Area. We used data from 16 yr of overlapping humpback whale, fish, and invertebrate surveys to relate changing humpback whale densities to environmental covariates as well as fish and invertebrate biomass. We found that humpback whale densities are increasing in the Great South Channel faster than in the surrounding area, and these increases are related to increasing biomass of squid, small gadids, and crabs and lobsters; warming temperatures; and decreasing salinity. Sand lance and herring, 2 common humpback whale prey species, decreased in this area during the study period. These interactions between humpback whales, temperature, and fish and invertebrate species could signify that increases in humpback densities are related to both biotic and abiotic variables and suggests that this conservation area may be effective at promoting the biomass of a variety of trophic levels.*

Hirtle et al. (in press). **Modeling decisions for quantifying range shifts in the face of climate change**

> *Global increases in temperature driven by anthropogenic greenhouse gas emissions have caused rapid changes in ecosystems worldwide, with many organisms responding*

via large-scale range shifts. Identifying and anticipating these range shifts is critical to understanding ecosystem impacts and implementing successful management strategies. Species distribution models (SDMs) are often used to quantify species-habitat relationships and to predict distributional shifts, particularly for highly mobile species. Constructing these models requires many decisions which will affect model predictions, but most studies only present results from a single decision pathway, and typically assume static species-environment relationships. 2. We examined how eight different model specifications for incorporating spatial and temporal variability influenced model performance and detected range shifts for six odontocete species. We utilized nearly 1.4 million kilometers of line transect survey data collected over 24 years along the east coast of the United States to evaluate these specifications that varied in the extent of temporal and spatial variability incorporated. 3. We found marked differences in model performance and estimated range shifts among different model specifications. The best performing model specifications included temporally dynamic species-environment relationships and temporally dynamic spatial terms. These model specifications identified significant poleward range shifts in bottlenose dolphins (Tursiops spp.), Risso's dolphins (Grampus griseus), Atlantic spotted dolphins (Stenella frontalis), and common dolphins (Delphinus delphis). In contrast, model specifications which only included static terms performed poorly and identified smaller range shifts than those which incorporated temporal variability. 4. These results challenge the assumption of static species-environment relationships that is frequently made with modeling range shifts and demonstrate the importance of carefully considering assumptions and model specifications when modeling distributional shifts. The range shifts we identified for odontocetes are likely causing substantial impacts on the northeast US marine ecosystem, and the framework we present offers a diagnostic approach for modeling and identifying range shifts in other wide-ranging species.

5.8 Acknowledgements

We would like to thank all of the many scientific observers, NOAA pilots, and NOAA ships' crewmembers who have spent hours on projects throughout the Atlantic Ocean. With their dedication, we were able to collect large amounts of high quality data, resulting in new insights into the marine life in our Northwest Atlantic waters.

The 2024 data collected and analyses discussed in this chapter came in part from three sources of funds specified in section 1.3 of this document (NMFS, and the 2 interagency agreements with the Bureau of Ocean Energy Management (BOEM) and the US Navy). In addition, the Cooperative Institute for Marine and Atmospheric Studies, a Cooperative Institute of the University of Miami and the NOAA, cooperative agreement NA20OAR4320472 staffed the SEFSC contract scientists. Azura Consulting LLC and Integrated Statistics, Inc., contract NFFM7320 staffed NEFSC contract scientists.

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6 Progress on analyses of oceanographic, active acoustic, and plankton data: Northeast Fisheries Science Center

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6.1 Summary

During 2024, we worked on a collaborative project between active and passive acoustic groups to investigate the potential prey of sperm whales by using the 18 and 38-kHz echosounder data. This year we completed processing the Video Plankton Recorder images from the 2021 NOAA ship *Henry B. Bigelow* AMAPPS survey (HB2102). The enumeration of small zooplankton was especially notable in images with large quantities of phytoplankton or marine snow that overwhelm Region of Interest extraction using Autodeck. We also reanalyzed the plankton data collected on previous AMAPPS and other surveys to evaluate the patterns of Atlantic bluefin tuna (*Thunnus thunnus*) spawning in the western North Atlantic and quantify changes in the spawning suitability of different regions of the western Atlantic

6.2 Merging sperm whale dive profiles and active acoustic data

To merge the sperm whale dive profiles with the results from the active acoustic data, we aligned the EK60 data with the sperm whale dives. To help us interpret the active acoustic data we aligned the active acoustic data with the midwater trawl results. In addition, we further developed machine-learning methods to classify the multifrequency EK60 data (e.g., volume backscatter data, Sv dB re m^2 m^{-3}).

See section 4.3 in this report describes the collaborative project between active and passive acoustic groups to investigate the potential prey of sperm whales by using the 18 and 38-kHz echosounder data.

6.3 Video plankton recorder data

We did not conduct any new Video Plankton Recorder hauls in 2024.

This year we completed processing the Video Plankton Recorder images from the 2021 NOAA ship *Henry B. Bigelow* AMAPPS survey (HB2102). We completed image extractions using Autodeck and identification of the plankton in the images using two independent programs: the DIVE annotation program associated with the machine-learning program VIAME and a vector analysis program called Visual Plankton. A comparisons of the results from these two programs showed that the DIVE/VIAME annotation of full frame Autodeck images provided the most complete data. The full frame annotation allows for enumeration of overlapping zooplankton, correct size annotation of gelatinous species, and enumeration of small zooplankton outside the size parameters of Autodeck (Figure 6-1). The enumeration of small zooplankton was especially notable in images with large quantities of phytoplankton or marine snow that overwhelm Region of Interest extraction using Autodeck.

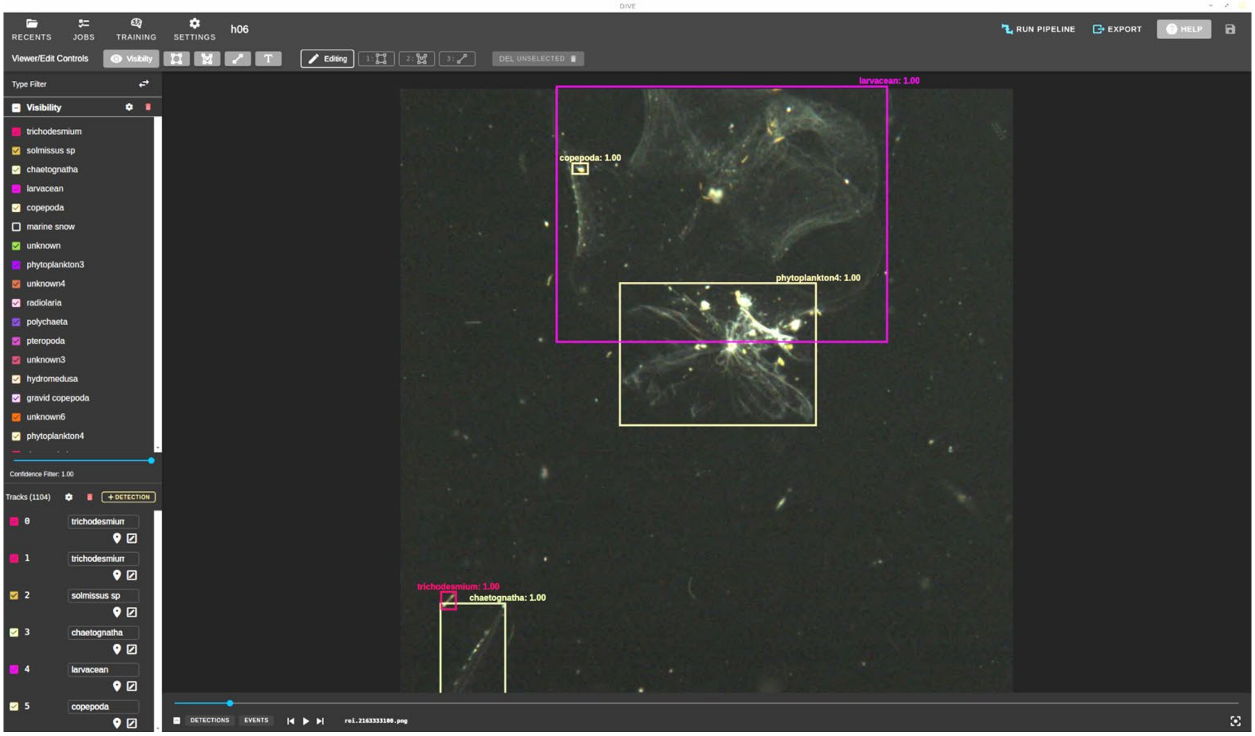

Figure 6-1 Screen shot of the DIVE image annotation workspace
The full frame image annotations highlight the ability to enumerate overlapping regions of interest and correctly delineate the size of gelatinous zooplankton with edges that are difficult to discern when utilizing edge detection algorithms.

6.4 Oceanographic and plankton data

During 2024, we reanalyzed the plankton data collected on previous AMAPPS and other surveys to evaluate the patterns of Atlantic bluefin tuna (*Thunnus thunnus*) spawning in the western North Atlantic and quantify changes in the spawning suitability of different regions of the western Atlantic. We plan to publish this in 2025 (Richardson et al. in prep).

6.5 Disposition of data

Trawl catch data are in Open Office and Excel spreadsheets. These spreadsheets contain deployment information (cruise ID, trawl ID, date, time, latitude, and longitude), catch data, and length data.

Active acoustic data are at the NEFSC and at NOAA's National Center for Environmental Information (NCEI) facility in Boulder, Colorado https://www.ncei.noaa.gov/maps/water-column-sonar/.

The NEFSC Oceanography Branch maintain the oceanographic data that are accessed through the NCEI World Ocean Database https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html.

The NEFSC Oceanography Branch maintained the plankton data in an ORACLE database, which are available upon request.

6.6 Acknowledgements

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