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BOEM 2023-061

Megafauna Aerial Surveys in the Wind Energy Areas of Southern New England with Emphasis on Large Whales: Final Report Campaign 7, 2022

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DISCLAIMER

Study collaboration and funding were provided by the US Department of the Interior, Bureau of Ocean Energy Management (BOEM), Environmental Studies Program, Washington, DC, under Agreement Number M17AC00002 to the Massachusetts Clean Energy Center. This report has been technically reviewed by BOEM, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the US Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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ABOUT THE COVER

A humpback whale mother and calf pair sighted on June 14, 2022; photo taken by New England Aquarium aerial survey team.

ACKNOWLEDGMENTS

We would like to extend our thanks to the many people that helped us perform our surveys and conduct our analyses. We thank the Right Whale Catalog ID team at NEAq for confirming right whale identifications and answering questions about right whale sightings. We thank Don LeRoi for continuing to provide input and support on his forward motion compensating camera mount. Finally, we thank the pilots and staff from Aspen Helicopters for providing crew for our surveys.

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List of Abbreviations and Acronyms

#	number
95% CI	95% confidence interval
a	area sampled (in density calculations)
BOEM	Bureau of Ocean Energy Management
d	density (number of individuals per square kilometer)
f(0)	probability density function evaluated at zero distance
GPS	global positioning system
h	hours
km	kilometer
kts	knots
L	length of transect (in density calculations)
MA	Massachusetts
MassCEC	Massachusetts Clean Energy Center
m	meter
mm	millimeter
NARWC	North Atlantic Right Whale Consortium
°N	degrees North
n	number (of animals/groups sighted during a transect)
nm	nautical mile
NMFS	National Marine Fisheries Service
NEAq	New England Aquarium
NEFSC	Northeast Fisheries Science Center
RIMA	Rhode Island / Massachusetts wind energy area
s	average group size (in density calculations)
SNE	Southern New England
°W	degrees West
WEA	wind energy area

List of Definitions

Seasons

- Winter = December, January, and February
- Spring = March, April, and May
- Summer = June, July, and August
- Fall = September, October, and November

Survey leg stages

- Transit: travel in the study area to the first transect line or from the last transect line
- Transect: flight along a defined survey line
- Cross-leg: flight between two transect lines
- Circling: departure from a transect line to document a sighting

Campaign schedule

- Campaigns 1-3: October 2011 – June 2015
- Campaign 4: February 2017 – July 2018
- Campaign 5: October 2018 – August 2019
- Campaign 6A: March 2020 – October 2020
- Campaign 6B: November 2020 – October 2021
- Campaign 7: February 2022 – August 2022

1 Introduction

Beginning in 2013, the Bureau of Ocean Energy Management (BOEM) designated two wind energy areas (WEAs) in New England: one offshore of Massachusetts and the other offshore of both Rhode Island and Massachusetts. Currently, offshore wind developers have lease agreements to build projects in these BOEM designated southern New England wind energy areas. Installation of the first two projects, South Fork and Vineyard Wind 1, is expected to be substantially complete in 2023.

Under the National Environmental Policy Act of 1969 (42 U.S.C. 4371 et seq.), BOEM and other relevant federal agencies are required to conduct environmental assessments for offshore wind construction and operations plans. Offshore wind energy planning, development, and ongoing operations require comprehensive assessments of biological resources within suitable development areas to identify and mitigate any potential effects on marine species. To contribute to meeting this requirement, the Massachusetts Clean Energy Center (MassCEC) and BOEM, under Cooperative Agreement M17AC00002, jointly funded the New England Aquarium (NEAq) to conduct aerial surveys from 2011-2020, and 2022. In 2020, four wind energy developers (Vineyard Wind, Mayflower Wind, Ørsted, and Equinor) contributed funding for Campaign 6B aerial surveys, which were conducted from fall 2020 through fall 2021.

Analyses of the survey data have shown that the study area (which encompasses the Southern New England WEAs and a buffer around the WEAs that includes the Nantucket Shoals; see Figure 1) includes seasonal aggregations of protected species of whales and sea turtles. Early surveys (2011-2015) showed that North Atlantic right whales (*Eubalaena glacialis*), a critically endangered species, occurred in the study area during winter and spring; more recent surveys (2017-2021) showed that right whales occurred in the study area in all seasons, with the highest density occurring in winter and spring. Evidence of right whales feeding and socializing has been observed in the study area in every season. Other protected baleen whales are present in the study area, largely in the spring and summer. Endangered sea turtles are present in the study area in the summer and fall.

This report, "Megafauna Aerial Surveys in the Southern New England Wind Energy Areas with Emphasis on Large Whales: Final Report Campaign 7, 2022", summarizes results from February 2022 through August 2022. This report contains summaries of survey effort, summaries of sightings (e.g., sightings maps), and analyses of effort-corrected data, including sighting rates and calculations of density and abundance.

1.1 Research objectives

The objective of this study was to conduct aerial surveys during each month to continue a time series of data to document species abundance and distribution across all the lease areas. Some of the key objectives of the aerial surveys were to:

1. Collect line-transect sightings from broad-scale surveys that could be used to map the distribution of large whales (with a focus on right; sei, *Balaenoptera borealis*; humpback, *Megaptera novaeangliae*; fin, *Balaenoptera physalus*; and minke whales, *Balaenoptera*

acutorostrata) and sea turtles within the survey area (Figure 1) and estimate their relative abundance.
2. Collect opportunistic observer sightings of other cetaceans, seals, sharks, and fish.
3. Collect digital photography to capture marine mammals, sea turtles, birds, and smaller cryptic species likely to be missed by observers scanning out to 2 nautical miles (nm) (e.g., harbor porpoise, sharks, and fish), and fixed fishing gear.
4. Conduct condensed, directed, and calibration surveys as needed to obtain fine-scale sightings and effort data, increase sample sizes, and understand the effects of conducting surveys at 1,500 feet, rather than 1,000 feet, which would be necessary during and after turbine construction. Data collected during survey legs flown at 1,500 feet would not be counted as survey effort for analysis purposes.
5. Calculate density estimates for species with adequate sampling sizes in an area of outer continental shelf federal waters off the coast of Massachusetts using the aerial observer's data. Species of interest include large whales (with a focus on right, humpback, fin and minke whales), common small cetaceans, and sea turtles.
6. Collect photographs of right whales for individual identification during aerial surveys with digital cameras equipped with telephoto lenses. An attempt will be made to photograph as many individual right whales within a given aggregation as possible to provide data about the residency and demographic patterns of the whales using the survey area. Photographs of right whale callosity patterns will be used as a basis for identification and cataloging of individuals.
7. Turtles and other identifiable large whales (that are not right whales) will be counted and recorded. Typically, sightings of these species will be passed without breaking from the trackline to maximize available flight time.

2 Methods

2.1 Aerial surveys

During the current reporting period (February 2022 to August 2022), four types of aerial surveys were conducted. General, directed, and condensed surveys were conducted in the main study area (shown in Figure 1). One calibration survey was conducted in Massachusetts Bay (Figure 2A).

- General surveys were standardized line-transect surveys that were conducted on a monthly basis and covered the waters of the study area (9,002 km^2, Figure 1). These surveys focused on all marine megafauna visible from the plane (excluding birds) and were comprised of twelve north-south tracklines (Figure 1) evenly spaced at approximately 6 nm. Eight survey options are available: each option shifts all 12 tracklines 0.75 nm east or west, but maintains the six nm spacing between tracklines. Survey options were selected at random before each survey.

- Condensed surveys were standardized line-transect surveys flown in areas used by aggregations of right whales to better determine demographic, distribution, and behavior patterns in the study area. These surveys were comprised of 10–12 tracklines that were 3 nm apart. In Campaign 6B, NEAq expanded the temporal and spatial extent of these surveys to better capture observed changes in right whale distributions (e.g., summer aggregations over the Nantucket Shoals).

- Directed surveys were flown in areas of right whale aggregations, identified by NEFSC or found during general or condensed surveys. These surveys followed line-transect protocols but the area, number of lines, and length of flight varied based on the location of the right whale aggregations.

- Calibration surveys were conducted to estimate the effect of changing altitude on an observer's ability to detect different species. The same set of tracklines were flown back to back on one day: first at 457 m (1,500 ft) and then at the standard 305 m (1,000 ft). The majority of these surveys were flown in Massachusetts Bay to maximize the number of large whale detections. These surveys began in Campaign 6B. An additional calibration survey was flown in Campaign 7 to add right whale detections to the dataset.

2.1.1 Survey methods for aerial detections

Surveys were flown in a Partenavia P68 at an altitude of 305 m (1,000 ft) (457 m or 1,500 ft during calibration surveys) and a ground speed of approximately 185 km/h (100 kts) under Visual Flight Rules. Preferred survey conditions included winds of ≤10 kts, Beaufort sea state ≤ 4, minimum cloud ceiling ≥ 2,000 ft, and visibility ≥ 5 nm. A computer data-logger system (Taylor et al., 2014) automatically recorded flight parameters (e.g., time, latitude, longitude, heading, altitude, speed) at frequent intervals (every 2–5 sec). Two experienced aerial observers were positioned aft of each pilot on either side of the aircraft and scanned the water out to 3.7 km (2 nm) from the transect line.

the aircraft. All sightings recorded by observers were integrated into a single datasheet spanning the entire survey and are listed in a digital survey file.

Sightings, declination angles, environmental data, and survey parameters were recorded in a digital voice recorder and transcribed into the data log post-flight. Survey parameters included the four survey leg stages: transect (flight along a defined survey line); cross-leg (flight between two transect lines); circling (departure from a transect line to document a sighting); and transit (travel in the study area to the first transect line or from the last transect line). Survey parameters also included transect number and specific points of a given transect (begin, end, break off, or resume). Environmental data included general weather conditions (clear, overcast, hazy, etc.), visibility, Beaufort sea state, cloud cover, and sun glare. Sighting data included species identification to the lowest taxonomic level possible, the reliability of that identification (definite, probable, possible), a count of individuals in the group, an index of the precision of that count (+/- 0, 1, 2, 5, 10, and so on), the number of calves, heading of the animal or group, whether or not photographs were taken, and notes on behaviors.

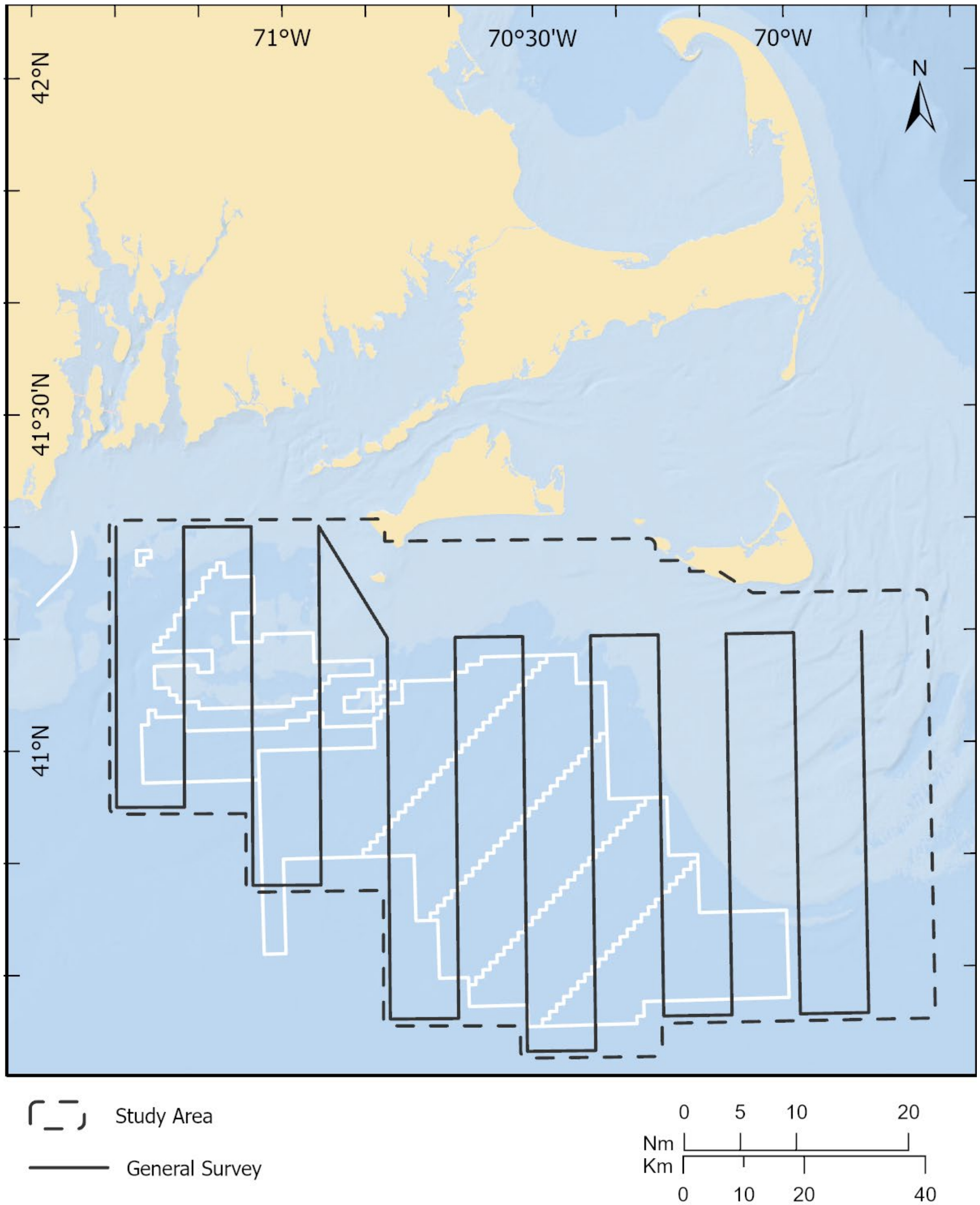

Figure 1. Study area in the offshore waters of Southern New England Study area (dashed black outline) and example general survey lines (black lines). Note: Existing lease areas are depicted in white.

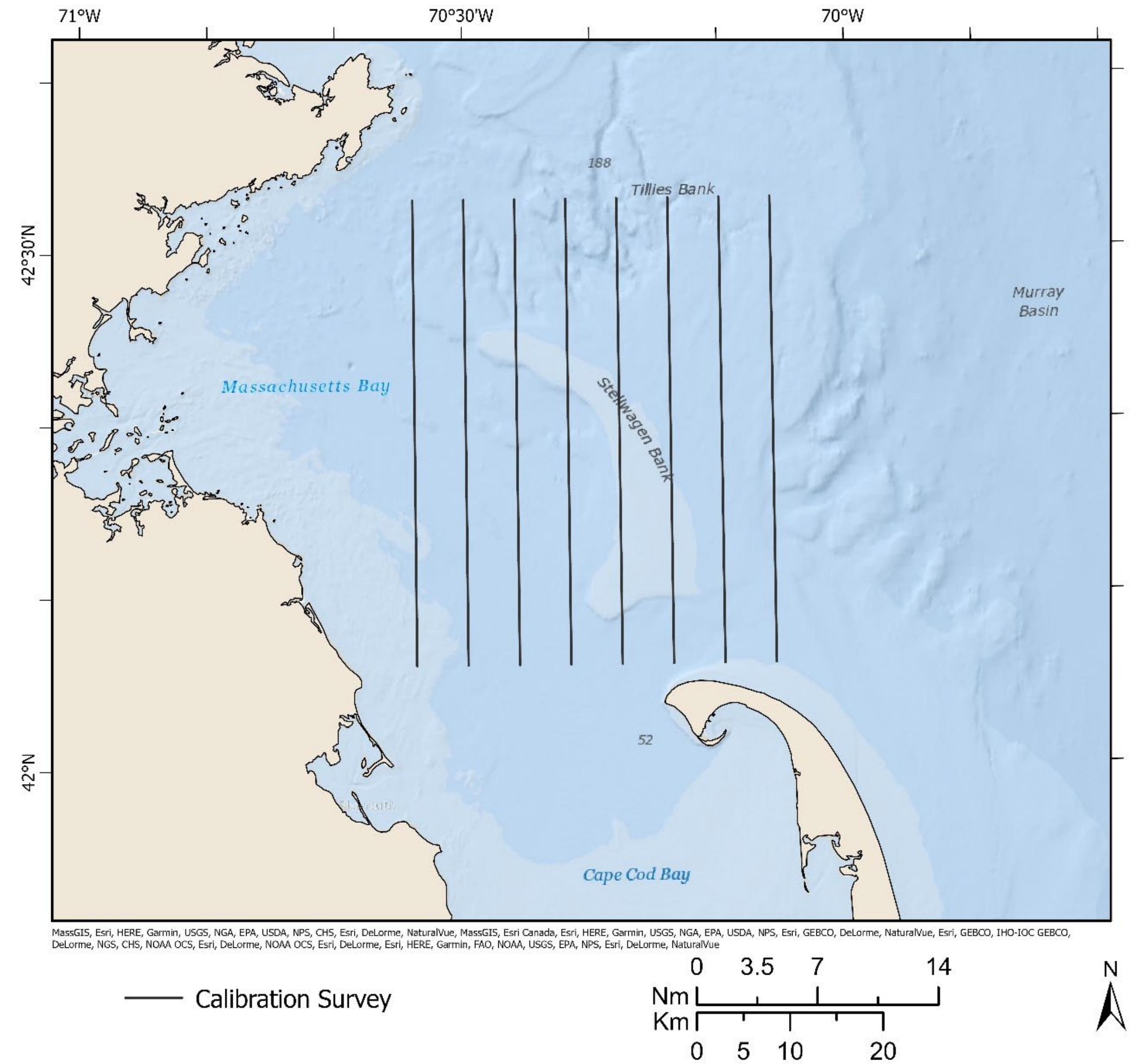

Figure 2. Calibration survey study area showing axample calibration survey tracklines over Massachusetts Bay and Stellwagen Bank.

2.1.2 Sightings: observers and vertical photography

Observers recorded sightings according to the North Atlantic Right Whale Consortium (NARWC) Database guidelines (Kenney, 2021). A sighting is defined as an animal (or group of animals) or object (fishing gear, vessel, etc.) marked by the plane and could include multiple individuals. Sighting locations were added to a data log by remote keypads. When the detected animal was abeam of the aircraft, the observer recorded sighting angle using a declinometer (Dohl et al., 1986). Sighting angle can be used to calculate sighting distance from a known altitude. The observer also noted whether the sighting occurred on the port or starboard side of

Since 2011, a forward motion compensation (FMC) system and a downward facing digital camera has been used to take photographs of the blind spot underneath the plane. The Partenavia has bubble-windows which allow the observers to see directly below the aircraft. However, the FMC mount and belly camera system are still utilized for continuity of data collection methods. In Campaign 7, a Canon 5DS camera with a Canon 85mm lens was fitted in the built-in-camera port of the Partenavia. The system was integrated with a GPS, a Getac E119 Rugged tablet, and observer sighting buttons via a custom data-logging software (d-Tracker).

Vertical photographs were analyzed by trained observers for detections of marine species, fixed fishing gear, and debris using the program FastStone Image Viewer. Data recorded for each sighting included species, identification reliability, number of individuals with an estimate of the level of confidence in the count, frame number, time, observer, and area of image. The vertical photograph sighting information was added to the corresponding event recorded in the survey file by d-Tracker. All detections were reviewed for accuracy and consistency by another trained expert. Completed data files were submitted to the NARWC Database.

Distance sampling protocols dictate how sightings data can be incorporated into abundance estimates. Surveys must not be geographically biased towards any part of the study area and must have a randomized start point (i.e., a randomly chosen survey option). Consequently, sightings from condensed surveys and directed surveys (both of which are geographically biased) are not used to estimate the abundance of animals in the WEA. Sightings must also be observed while on transect; consequently, sightings during transit or cross-legs are not used to estimate abundance. For most species, sightings detected while circling from a trackline were not used. However, since every right whale sighting was circled, we used all right whale sightings to estimate abundance. Hereafter, on-effort refers to sightings that will be used for abundance estimates and off-effort refers to sightings that will not be used for abundance estimates.

Two types of detections are defined: 1) observer detections are sightings marked by observers while in the plane and 2) camera detections are sightings found in vertical photographs during photo analysis and are unique from observer detections. All vertical photographs were analyzed for the presence of marine megafauna during Campaign 7 surveys. On-effort photographs from general and condensed surveys were additionally scrutinized for smaller objects, such as small fishes, birds, debris, and fishing gear.

2.1.3 Right whale photo-identification

North Atlantic right whales were a primary target species of the surveys. The rostral callosity pattern and other obvious scars or markings were used to identify individual right whales. When observers spotted right whales, the plane deviated from the transect and observers attempted to photograph each whale for individual identification (Kraus et al., 1986) using a Nikon D500 camera equipped with a 300 mm f/2.8 telephoto lens (1.4×teleconverter) in February 2022 and a Sony Alpha 7R IV mirrorless camera equipped with a 100-400 mm f/4.5-5.6 telephoto lens beginning in March 2022. When photographic documentation was complete, the aircraft returned to the transect at the point of departure for that sighting and resumed the survey.

2.1.4 Animal density and abundance in the study area

We estimated seasonal[1] density and abundance for baleen whales, common dolphins (*Delphinus delphis*), and bottlenose dolphins (*Tursiops truncatus*) for Campaign 7 following methodology in Buckland et al. (1993).

- **Density** is defined as the estimated number of individuals per square kilometer.
- **Abundance** is computed by multiplying the estimated density by the size of the study area and is defined as the estimated number of individuals in the study area.

To calculate density in the study area, we fit several detection functions to our data using the R package *Distance* (Miller et al., 2019; R Development Core Team, 2018). A detection function models the relationship between the distance of an animal from the trackline and the probability it is detected. This key concept in distance sampling helps us account for animals that are not seen during a survey.

To fit a detection function, it is necessary to have an adequate sample size: at least 25-30 detections, but ideally 60-80 detections. To achieve this sample size for low density species, such as large cetaceans, species with similar sighting cues are often pooled. To achieve appropriate sample size for density estimation, we fit four detection functions: right and humpback whales (using species as covariate), fin and sei whales (using species as covariate), minke whales, and bottlenose and common dolphins (using species and group size as covariates). For all detection functions we used data from April 2021 – August 2022 (the period of time using the Partenavia). We used these detection functions and seasonal encounter rates for each species to calculate abundance.

An estimate of density (*d*, in individuals/km^2) for a given species was calculated for each survey transect line by:

$$d = \frac{n \cdot s \cdot f(0)}{2L}$$

where *n* is the number of groups sighted during the transect, *s* is the average group size for the species across all sightings, *f(0)* is derived from the detection function, and *L* is the length of the transect (the length is multiplied by two to represent both sides of the trackline). Average density for the study area was calculated using the weighted mean density of all survey transects. Abundance was then calculated by multiplying the density estimates by 9,002 km^2 – the size of the study area in 2022. To estimate density, we used sightings with definite or probable species identification that met the following criteria: collected during general surveys, collected on tracklines or during circling (for right whales), altitude ≤ 366 m, visibility ≥ 3.7 km (2 nm), and sea state ≤ 3 (Leiter et al., 2017; Stone et al., 2017). Upper and lower 95% confidence limits for the abundance estimates were calculated using the weighted average of the variance in encounter rate for all transects flown during each season-year (Buckland et al., 1993).

2.1.5 Sighting rates and temporal variability in the study area

Sighting rates were calculated as the number of individuals divided by the total survey distance. Sighting rates were multiplied by 1,000 to avoid working with small decimal values and are

[1] Note that the "winter" season for density, abundance, and sighting rates is comprised of one month: February.

hereafter referred to as animals/km (Leiter et al., 2017; Stone et al., 2017). Total survey distance was defined as the total distance flown by the aircraft in km including transects, transits, cross-legs, and circling, while the aircraft was within regular survey parameters (altitude ≤ 366 m, visibility ≥ 3.7 km (2 nm), and sea state ≤ 3). Only sightings identified as definite and probable were included in the analysis.

Seasonal sighting rates were calculated for species in the study area with at least 25 sightings during the pooled Campaigns 4-7 study period. We used data from Campaigns 4-7, rather than data from all Campaigns, to ensure that the sightings rates reflect recent sightings patterns. The species included in the analysis were right whales, fin whales, humpback whales, minke whales, sei whales, common and bottlenose dolphins, hammerhead sharks (*Sphyrna* sp.), blue sharks (*Prionace glauca*), and basking sharks (*Cetorhinus maximus*), ocean sunfish (*Mola mola*), and leatherback sea turtles (*Dermochelys coriacea*). Seasons were defined as follows: winter = December, January, and February; spring = March, April, and May; summer = June, July, and August; and fall = September, October, and November.

2.1.6 Right whale photographs and demographics

Right whale images were uploaded and processed in the NARWC Catalog (Hamilton et al., 2010) and were compared by observers to catalogued right whales to identify individuals. Once matched, demographic information such as sex, age, and reproductive status were added to sighting information.

3 Results

3.1 Field Effort

There were a total of 25 surveys during Campaign 7 between February 2022 and August 2022 (Table 1). Surveys commenced in February instead of January as originally planned due to poor weather affecting the survey aircraft's transit to Massachusetts. Surveys were distributed among months according to the contracted schedule: two broad-scale general surveys per month, and condensed, directed, or calibration surveys as needed. Specifically, we conducted 17 general surveys totaling 97.7 hours (h) of flight time, three condensed surveys totaling 16.3 h of flight time, four directed surveys totaling 19.8 h of flight time, and one calibration survey totaling 5.5 h of flight time. General surveys took an average of 5.7 h (range = 2.0 – 8.0 h), condensed surveys took an average of 5.4 h (range = 4.3 – 6.1 h), directed surveys took an average of 5.0 h (range = 3.8 – 5.6 h), and the one calibration survey was 5.5 h. The total time and the total distance flown for all aerial surveys combined were approximately 139.3 h and 23,003.4 km, respectively (Table 1). During Campaign 7, 71,496 vertical photographs were taken by the vertical camera and 1,470 handheld photographs were taken by aerial observers for a total of 72,966 photographs.

3.2 Study Area Aerial Surveys

3.2.1 Detections

Sightings and detections for Campaign 7 are split into two categories: 1) sightings from all survey effort and 2) the subset of sightings that can be incorporated into abundance estimates ("on-effort"). For each species or group of species, a single sightings map is provided showing observer detections and total gridded survey effort ("Total Survey Distance" in map legends) from all surveys and effort types.

3.2.1.1 All detections

A total of 4,203 detections of marine fauna (60%) and human activity (40%) were observed in the study area during all Campaign 7 aerial surveys (Table A-1). Of these detections, 61% (n = 2,557) were observer detections and 39% (n = 1,646) were camera detections.

There were 2,529 observer and camera detections of marine fauna totaling 16,130 individuals of 23 species (Table A-1). Marine fauna included large whales, small cetaceans, birds, sharks, fishes, and sea turtles. Marine mammals had the highest number of individuals observed (75%, n = 12,101), followed by birds (20%, n = 3,170), sharks and fishes (5%, n = 889), and sea turtles (<1%, n = 27). The majority of marine mammal sightings were cetaceans (81%) and the rest were pinnipeds. Birds were not marked by observers in the plane; consequently, reported sightings of birds are exclusively camera detections.

There were 1,665 observer and camera detections of human activity in the study area during all Campaign 7 surveys (Table A-1). Natural debris such as floating sargassum were excluded from debris totals. The majority of human activity detections were related to commercial fishing (58%), which included fixed fishing gear and vessels that were transiting or actively fishing. Recreational vessels accounted for 15% of human activity while other types of vessels such as military, merchant, and research vessels accounted for 9% and anthropogenic debris accounted for 17%.

The analysis of the vertical photographs from all surveys resulted in 1,288 detections of 3,622 animals and 346 detections of human activity. Fourteen species of marine megafauna (not including birds) were identified to the species level from vertical photographs. Detailed analysis of vertical photographs is included in Table A-1.

Table 1. Summary of aerial survey effort during Campaign 7

Year	Month	General Surveys							Other Surveys						
		Total	Day	Direction	Option	Airtime (h)	Flight length (km)	On effort trackline (km)	Total	Day	Direction	Type	Option	Airtime (h)	Flight length (km)
2022	February	4	06	E → W	11	5.9	985.9	624.8	1	07	E → W	D	N/A	3.8	756.4
			09	W → E	1	3.8	673.8	471.3							
			20	E → W	10+14	4.6	733.8	399.1							
			24	W → E	2	4.5	710.4	42.7							
	March	2	23	W → E	5	6.4	1,060.6	916.5	2	01	E → W	D	N/A	5.5	707.6
			26	W → E	4+8	6.9	1,269.2	1141.7		30	W → E	C	2W+2E	5.9	1,008.0
	April	3	21	W → E	3+7	4.4	715.1	605.7	1	25	W → E	Cal	4	5.5	913.4
			24	W → E	3+7	4.8	774.0	534.7							
			25	W → E	3	2.0	459.5	255.1							
	May	2	20	W → E	2	5.3	980.1	785.8	1	23	W → E	D	N/A	5.6	858.0
			25	E → W	14	7.3	1,167.7	1063.2							
	June	2	11	W → E	1	7.1	1,115.3	1118.8	1	14	W → E	C	3W+3E	6.1	1,052.7
			16	W → E	8	5.5	830.4	847.3							
	July	2	10	W → E	3	7.9	1,462.9	1026.2	1	11	W → E	C	1W+1E	4.3	811.2
			15	W → E	5	8.0	1,442.9	1330.2							
	August	2	12	W → E	6	5.6	1,009.9	853.7	1	15	W → E	D	N/A	4.9	809.0
			19	W → E	8	7.7	1,178.1	1116.0							
		17				97.7	**16,477.6**	**13132.8**	8					41.6	6,916.3

"Other Surveys" include calibration, condensed, and directed surveys. Note: W = west, E = east, C = Condensed, Cal = Calibration, D = Directed, NA = Not applicable. Note that more than one survey type may have been flown on a single survey day.

3.2.1.2 Off-effort detections

A total of 725 sightings of marine megafauna (n = 5,253 individuals) were recorded on-effort, including both observer (87%, n = 629) and camera (13%, n = 96) detections (Table A-2). Identification to the species level was possible for 417 sightings and resulted in 16 confirmed species: nine cetacean, three shark, one pinniped, one fish, and two sea turtle. Marine mammals represented 40% of detections (n = 288) and 91% of all individuals tallied (n = 4,789 individuals). Sharks and fishes were seen more often (58% of detections, n = 424), but in lower numbers (9% of individuals detected, n = 451). The remaining 13 detections were of 13 sea turtles.

3.2.2 Cetacean detections

A total of 677 sightings of 9,827 cetaceans were recorded in the study area, on and off effort, during Campaign 7. This total includes 23 sightings by the vertical camera of 69 individuals from six species. There were 267 cetacean sightings on-effort during general surveys, totaling 4,379 individuals. Identification to the species level was possible for 595 sightings and resulted in nine confirmed species. Species ID could not be confirmed for 82 sightings.

Fin whales, humpback whales, and common dolphins were sighted most frequently and accounted for 24%, 20%, and 18%, respectively, of cetacean sightings. The most abundant cetaceans were common and bottlenose dolphins, accounting for 78% and 9%, respectively, of individual cetaceans sighted; although fin whales were the most common large cetacean, they only accounted for 2% of all individual cetaceans sighted.

Baleen whales were represented by five species of two families: Balaenidae and Balaenopteridae. One species of the Balaenidae family was sighted: the North Atlantic right whale. In total, 22 sightings of 31 right whales were recorded during Campaign 7. Right whales are discussed and sighting maps are shown below. Four species of the Balaenopteridae family, or rorqual whales, were sighted: fin whales, humpback whales, minke whales, and sei whales. A total of 399 sightings of 512 rorqual whales were documented in the study area during Campaign 7 surveys. Further details of rorqual whale sightings are discussed below.

Toothed whales were represented by four species in two families: common dolphins, bottlenose dolphins, and pilot whales (*Globicephala* sp.[2]) (family Delphinidae); and harbor porpoise (*Phocoena phocoena*; family Phocoenidae). Toothed whale sightings are discussed below.

3.2.2.1 North Atlantic right whales

During Campaign 7 surveys, 22 sightings (10 on-effort) totaling 31 right whales (12 on-effort) were recorded. Five sightings of eight right whales occurred while off-effort during four general surveys. The remainder of off-effort right whale sightings were recorded during condensed (2 sightings of 2 whales) and directed (5 sightings of 9 whales) surveys. Group size ranged from

[2] By convention aerial surveys do not distinguish between short and long-finned pilot whales.

one to five; average group size was 1.4 whales. Right whales were sighted in every season and in five of seven months surveyed. Seasonal right whale sightings rates were 1.9 whales/km (winter), 2.0 whales/km (spring), and 0.7 whales/km (summer).

Right whale sightings are shown in Figure 3. Compared to previous years, in which distinct seasonal patterns were noted in right whale distributions, right whales were seen both in the WEAs and over the Nantucket Shoals in every season. Most right whales were sighted over the Nantucket Shoals; however, they were also sighted in the WEAs and between the WEAs and shore.

3.2.2.1.1 Abundance estimates

Seasonal density and abundance estimates were calculated for right whales for Campaign7 (Table 2). Right whale seasonal abundance in the study area ranged from three (spring, summer) to five (winter) animals.

Table 2. Density and abundance of right whales during Campaign 7 by season

Season	Effort (km)	# of detections	# of animals	Est. Density	Est. Abundance	95% CI
Winter (February)	1504.9	3	3	0.0006	5	1.8 – 18.0
Spring	3704.2	3	4	0.0003	3	0.9 – 9.9
Summer	3943.2	3	4	0.0003	3	0.9 – 8.1

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more animals. # of animals is the sum of the number of animals used to calculate abundance. Est. density is the estimated number of individuals per km^2. Est. abundance is the estimated number of animals for the study area. 95% CI= 95% confidence interval of abundance.

3.2.2.1.1 Demographic and re-sighting patterns

Preliminary photo analysis identified 19 unique right whales in the study area during all Campaign 7 surveys. Most right whales were adults (68%, n = 13) and males (63%, n = 12) (Table 3). Seven right whales were unable to be photographed due to excessively long dive times (>20 minutes).

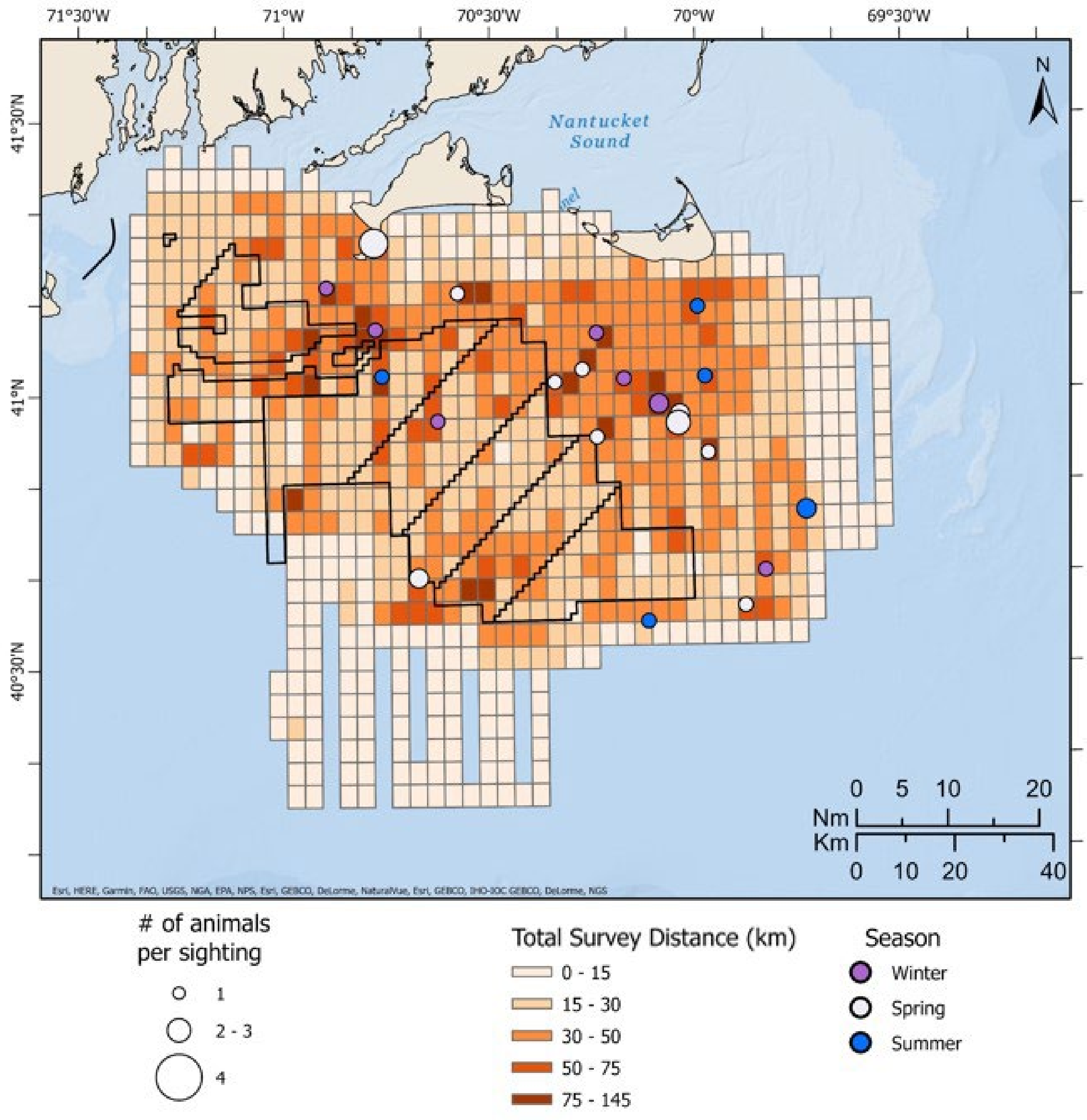

Figure 3. Map of right whale sightings during Campaign 7 aerial surveys

Table 3. Number and percentage of different sex and age classes of right whales identified during Campaign 7 aerial surveys

Sex	N	%	Adult	%	Juvenile	%	Age Unknown	%
Male	12	63	9	47	3	16	0	0
Female	6	32	4	21	2	11	0	0
Unknown	1	5	0	0	1	5	0	0
Total	19	100	13	68	6	32	0	0

Photo identification data has been submitted to, but not yet been confirmed, by the NARWC. Preliminary photo analysis suggests that many of the individual right whales displayed a strongly seasonal use of the study area. During Campaign 7 surveys, 95% (n=18) of individuals were seen in only one season. Spring had the highest number of individual right whales (n=12) identified. Many of these individuals were not resighted in the study area outside of this season. The only whale that was resighted in multiple seasons during Campaign 7 was sighted in the study area twice in March and twice in July.

Of the 19 right whales preliminarily identified during Campaign 7, 63% (n=12) have been identified previously in the study area in two or more years and 58% (n=11) had been sighted at least once in the study area prior to 2020. There were seven individuals identified for the first time inside the study area, including two yearlings born in 2021 and five adult males. Within photographed sightings, the two most common behaviors noted were surface active groups (a socio-sexual behavior) and linear travel (sustained swimming in a single direction). A photograph of a surface active group of four right whales sighted between Noman's Island and Martha's Vineyard included below (Figure 4).

3.2.2.2 Fin whales

During Campaign 7 surveys, 163 sightings (46 on-effort) totaling 212 fin whales (57 on-effort) were recorded. Group size ranged from one to five with an average group size of 1.3 whales. Fin whales were sighted in every season and in six of the seven months surveyed. The majority of fin whale sightings occurred in the summer: 154 sightings of 197 whales. Fin whale sighting rates were 0.4 whales/km (winter), 1.7 whales/km (spring), and 20.3 whales/km (summer). During Campaign 7, fin whales were mostly sighted in the summer and in the western part of the study area (Figure 5).

Figure 4. Surface active group of four right whales photographed on March 23, 2022
This group consisted of two juvenile males, one adult female, and one adult male (photo taken under NMFS Permit #25739).

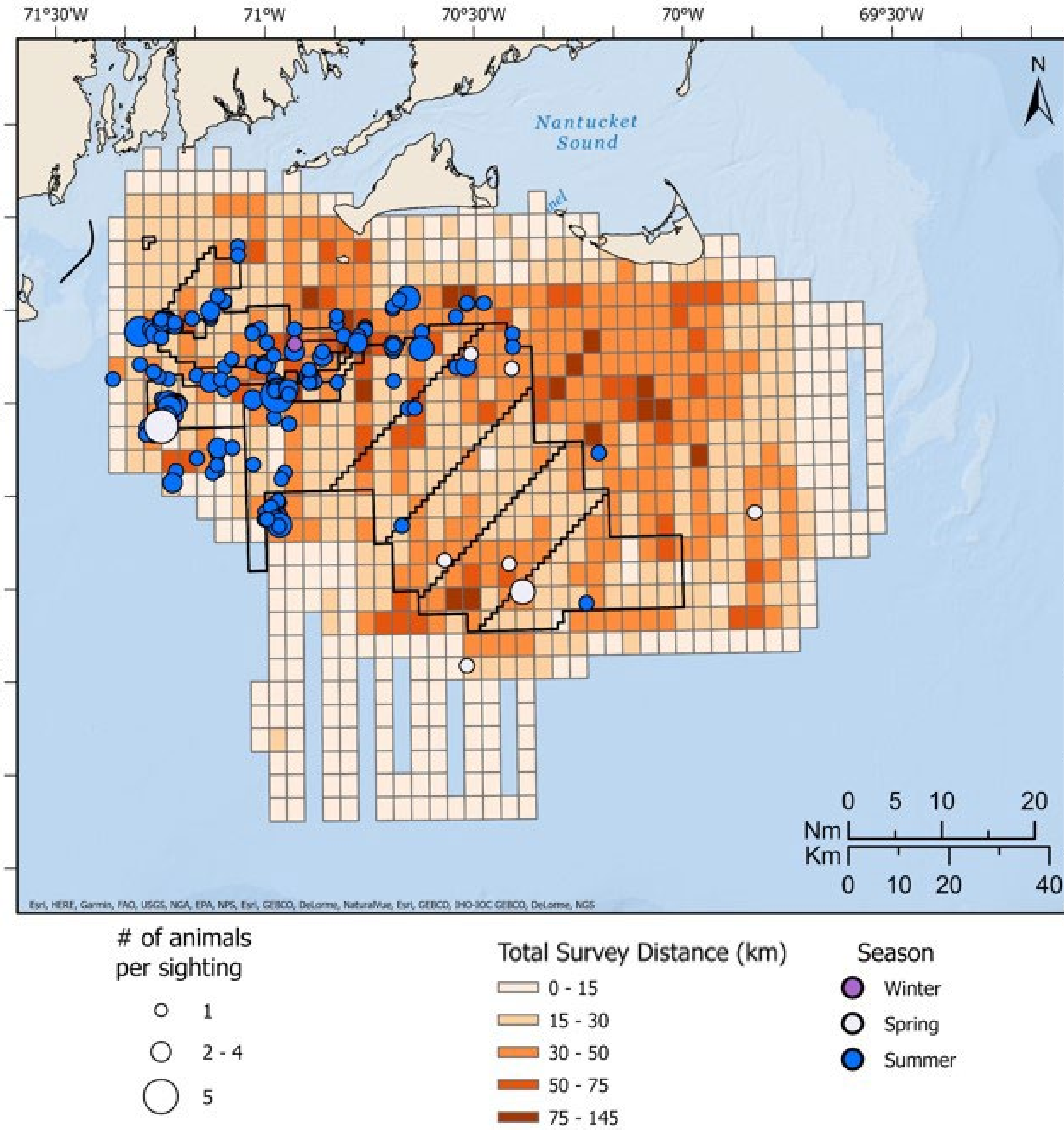

Figure 5. Map of fin whale sightings during Campaign 7 aerial surveys

3.2.2.2.1 Abundance estimates

Seasonal density and abundance estimates were calculated for fin whales for Campaign 7 (Table 4). Fin whale seasonal abundance in the study area ranged from three (winter) to 50 (summer) animals.

Table 4. Density and abundance of fin whales during Campaign 7 by season

Season	Effort (km)	# of detections	# of animals	Est. Density	Est. Abundance	95% CI
Winter (February)	1504.9	1	1	0.0003	3	0.9 – 17.1
Spring	3704.2	4	8	0.0011	10	2.7 – 40.5
Summer	3943.2	37	42	0.0055	50	27.0 – 90.0

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more animals. # of animals is the sum of the number of animals used to calculate abundance. Est. density is the estimated number of individuals per km2. Est. abundance is the estimated number of animals for the study area. 95% CI= 95% confidence interval of abundance.

3.2.2.3 Sei whales

During Campaign 7 surveys, three sightings (one on-effort) totaling three sei whales (one on-effort) were recorded. All sightings occurred in May 2022. The seasonal sighting rate for sei whales was 0.47 whales/km (spring) (Figure 6). Only one sei whale was sighted on-effort; consequently, density and abundance were not calculated.

3.2.2.1 Minke whales

During Campaign 7 surveys, 96 sightings (31 on-effort) totaling 100 minke whales (31 on-effort) were recorded (Figure 7). Minke whales were sighted in spring and summer and in five of seven months surveyed. Seasonal sighting rates for minke whales were 2.0 whales/km (spring) and 9.6 whales/km (summer).

3.2.2.1.1 Abundance estimates

Seasonal density and abundance estimates were calculated for minke whales for Campaign 7 (Table 5). Minke whale seasonal abundance estimates ranged from 21 (spring) to 40 (summer) animals.

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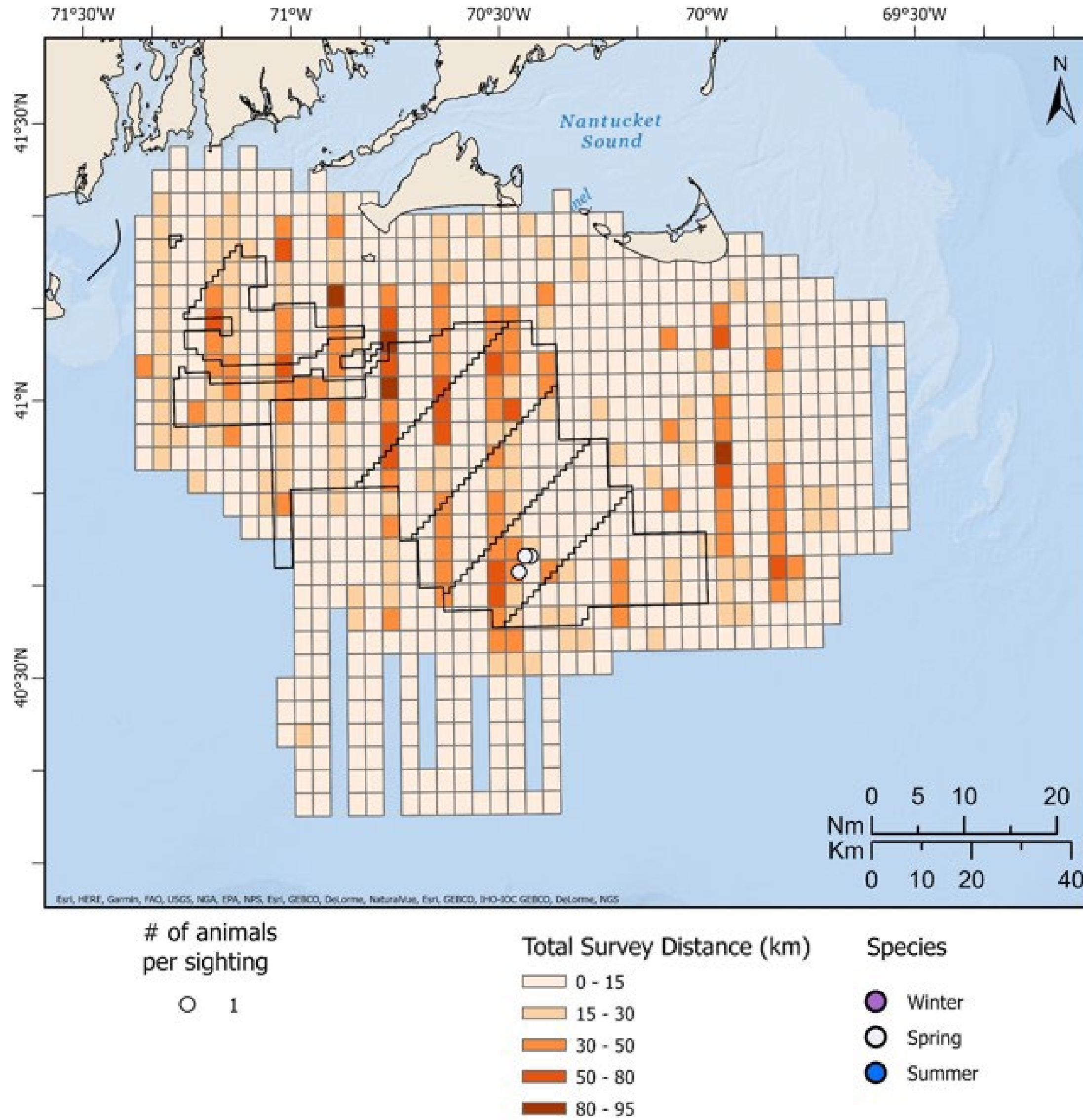

Figure 6. Map of sei whale sighting during Campaign 7 aerial surveys

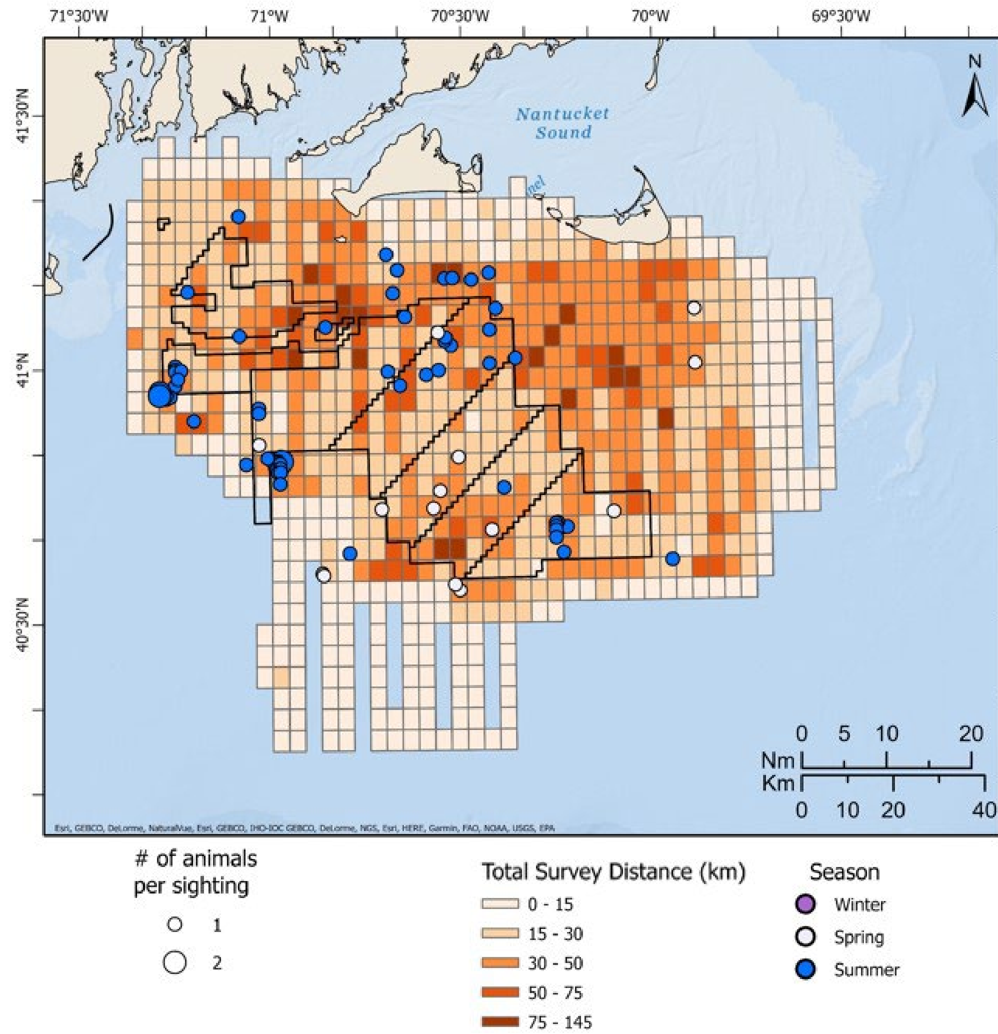

Figure 7. Map of minke whale sightings during Campaign 7 aerial surveys

Table 5. Density and abundance of minke whales during Campaign 7 by season

Season	Effort (km)	# of detections	# of animals	Est. Density	Est. Abundance	95% CI
Winter (February)	1504.9	0	-	-	-	-
Spring	3704.2	10	10	0.0023	21	10 – 45
Summer	3943.2	20	20	0.0044	40	18 – 86

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more animals. # of animals is the sum of the number of animals used to calculate abundance. Est. density is the estimated number of individuals per km2. Est. abundance is the estimated number of animals for the study area. 95% CI= 95% confidence interval of abundance

3.2.2.1 Humpback whales

During Campaign 7 aerial surveys, 137 sightings (37 on-effort) of 197 humpback whales (47 on-effort) were recorded during all surveys (Figure 8). Three sightings of two humpback carcasses (one was re-sighted on separate surveys) were detected during Campaign 7, but are not included in these totals.

Humpback whales were sighted in six of seven months surveyed, in spring and summer. Seasonal sighting rates for humpback whales were 7.8 whales/km (spring) and 14.9 whales/km (summer). Humpback whale group size ranged from 1-6, with an average group size of 1.4 whales. From late spring through summer (May-August), there were 33 sightings of humpback whales bubble-feeding, either as individuals or in small groups of up to five whales. Six sightings of humpback mother-calf pairs were documented during Campaign 7.

3.2.2.1.1 Abundance estimates

Seasonal density and abundance estimates were calculated for humpback whales for Campaign 7 (Table 6). Humpback whale seasonal abundance ranged from six (spring) to 24 (summer) individuals.

3.2.2.1.1 Carcass detections

During Campaign 7 aerial surveys, two humpback whale carcasses were documented, including one sighted on two separate surveys (Figure 9). One humpback whale was observed on May 25, 2022, approximately 38 nm south of Nantucket. This carcass was moderately decomposed and had evidence of shark and gull scavenging but no obvious signs of trauma or attached gear. A second decomposed humpback whale carcass was seen on June 11, 2022, approximately 24 nm south-southeast of Nantucket. A third very scavenged and decomposed carcass was sighted approximately 10 nm southwest of Nantucket on June 14, 2022. This carcass was deemed a likely resight of one of the two previously documented carcasses. Coordinates and photos of all carcasses were sent to the National Marine Fisheries Service (NMFS) after the completion of each aerial survey. These carcasses are included in the totals for the humpback whale Unusual Mortality Event that has been ongoing since 2016 due to elevated mortalities along the Atlantic coast (https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2023-humpback-whale-unusual-mortality-event-along-atlantic-coast).

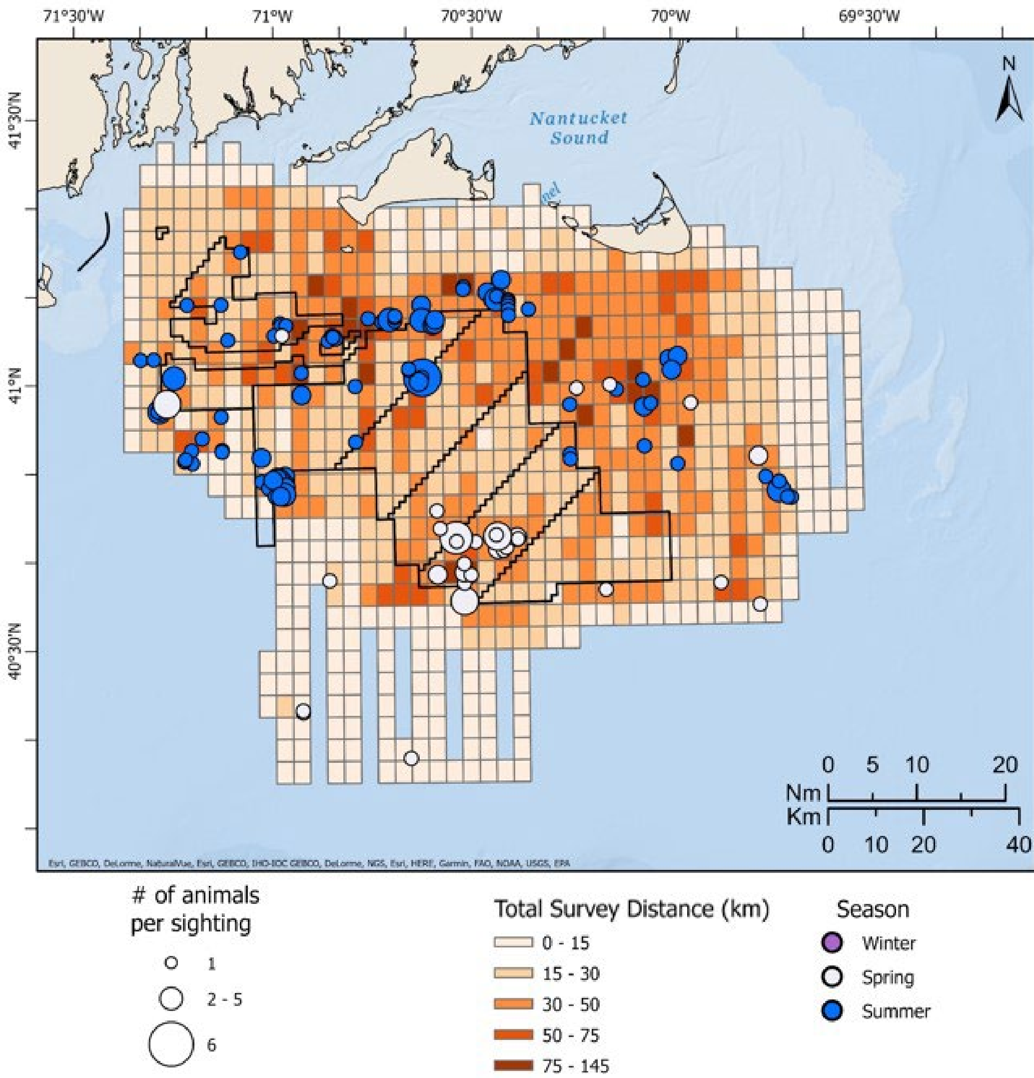

Figure 8. Map of humpback whale sightings during Campaign 7 aerial surveys

Table 6. Density and abundance of humpback whales during Campaign 7 by season

Season	Effort (km)	# of detections	# of animals	Est. Density	Est. Abundance	95% CI
Winter (February)	1504.9	0	-	-	-	-
Spring	3704.2	6	8	0.0007	6	3 – 16
Summer	3943.2	26	31	0.0027	24	13 – 46

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more animals. # of animals is the sum of the number of animals used to calculate abundance. Est. density is the estimated number of individuals per km2. Est. abundance is the estimated number of animals for the study area. 95% CI= 95% confidence interval of abundance.

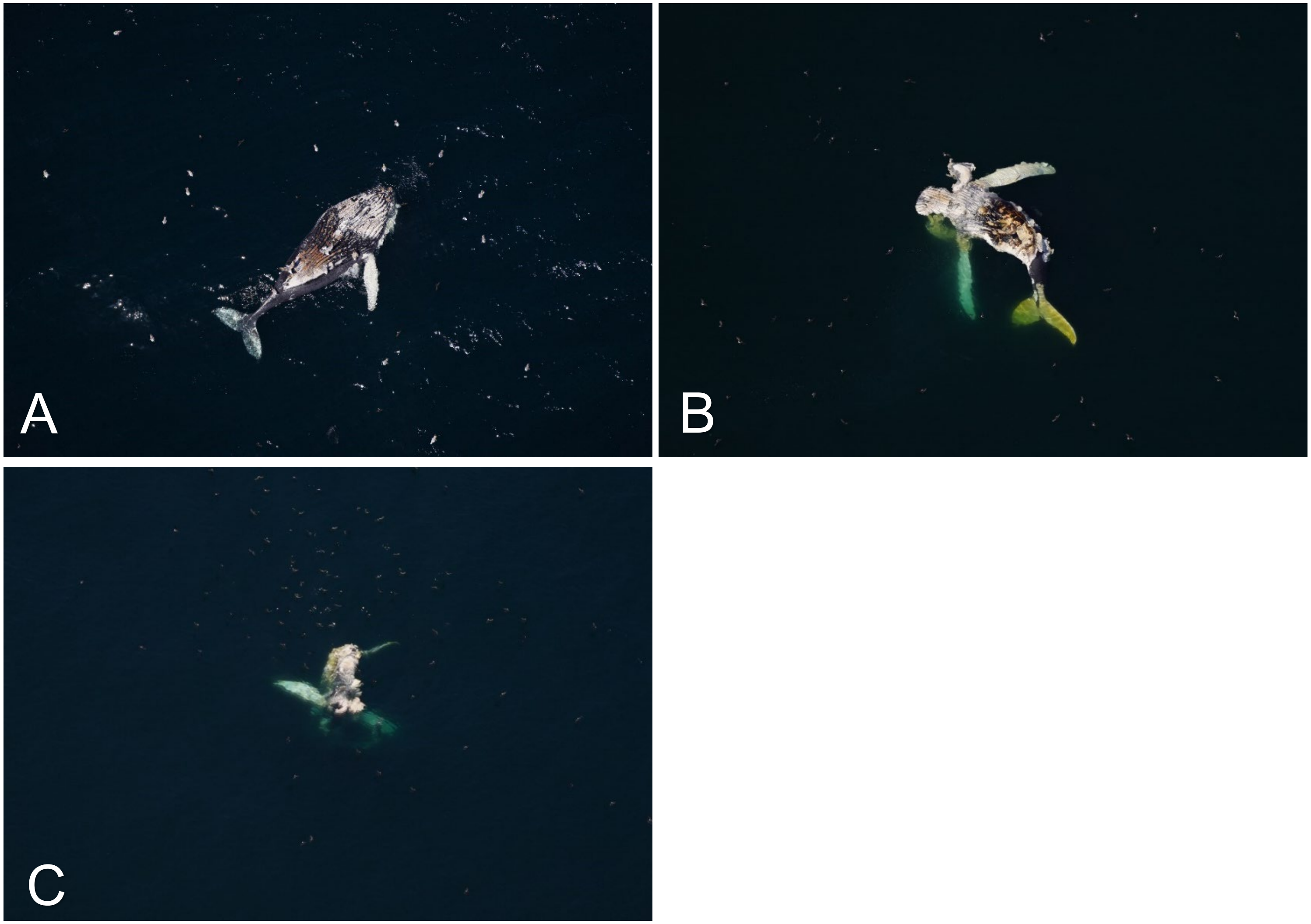

Figure 9. Whale carcasses observed during Campaign 7 aerial surveys. Humpback whale carcasses observed A) May 25th, 2022, B) June 11th, 2022, and C) June 14th, 2022. The sighting on June 14th was likely a resight of one of the previously seen carcasses

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3.2.2.2 Small cetaceans

3.2.2.2.1 Detections

A total of 250 sightings of 9,278 small cetaceans were recorded in the study area during all Campaign 7 surveys. This total includes 8 sightings by the vertical camera of 54 individuals. Of the 250 sightings, 140 sightings were on-effort during general surveys, totaling 4,229 individuals. Small cetacean sightings accounted for 37% of all cetacean detections (250 of 677 detections) and 52% of on-effort cetacean detections (140 of 267 detections). Identification to the species level was possible for 174 sightings and resulted in four confirmed species. Unidentified dolphins accounted for 76 sightings and consisted of small groups of dolphins that the plane did not break track to identify. The four species identified belonged to two families: Phocoenidae and Delphinidae. Phocoenidae included harbor porpoises, and Delphinidae included short-beaked common dolphins, bottlenose dolphins, and pilot whales.

During Campaign 7 surveys, common and bottlenose dolphins were the most commonly detected small cetaceans (50%, n=125, and 18%, n=44, respectively) followed by pilot whales (2%, n=4) and harbor porpoises (<1%, n=1). Small cetaceans were detected in larger groups, with group sizes ranging from one to 550 individuals. The average group size was 37.

3.2.2.2.2 Seasonal and geographic patterns

Small cetacean species were sighted most frequently during the summer. Common and bottlenose dolphins were seen in all seasons surveyed, while pilot whales and harbor porpoise were only seen in the spring.

Seasonal dolphin sighting rates were 12.4 common dolphins/km, 1.2 bottlenose dolphins/km (winter); 62.2 common dolphins/km, 2.0 bottlenose dolphins/km (spring); 787.7 common dolphins/km; 100.5 bottlenose dolphins/km (summer).

Distribution patterns of dolphin species were largely similar; both dolphin species were seen throughout the study area. However, common dolphins were common in the west of study area (Figure 10), and bottlenose dolphins were more common in the center of the study area (Figure 11). However, for both species, sightings were more common in the WEA than the Nantucket Shoals.

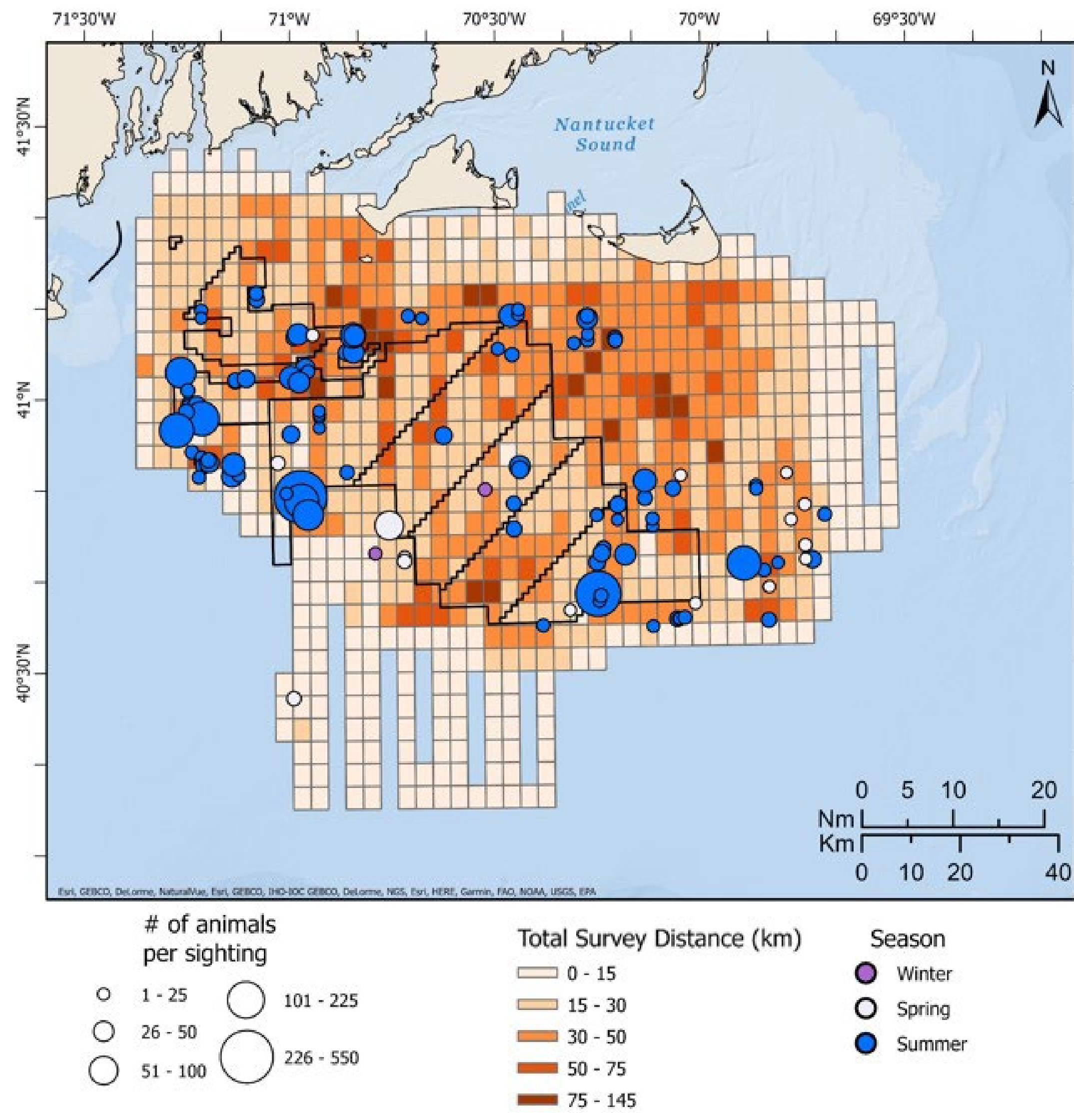

Figure 10. Map of common dolphin sightings during Campaign 7 aerial surveys

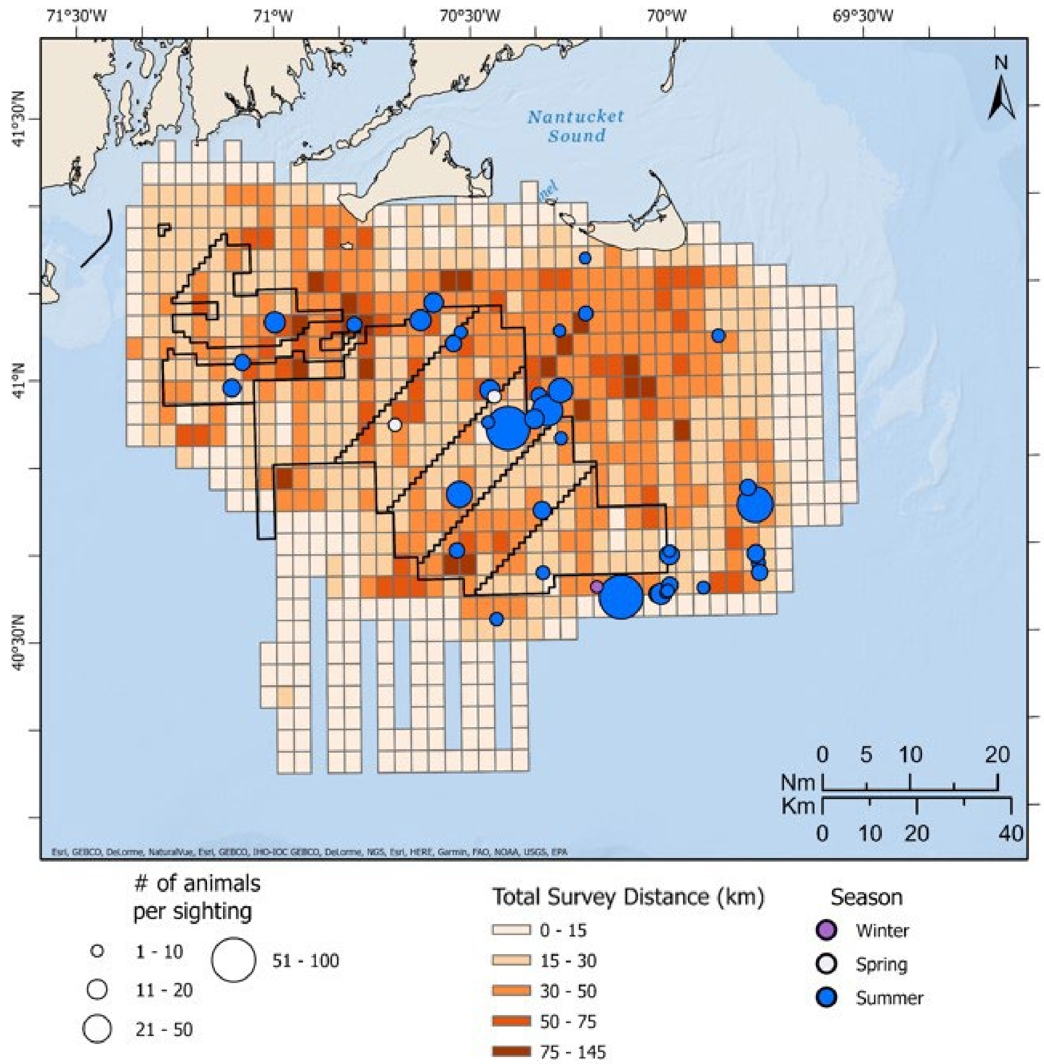

Figure 11. Map of bottlenose dolphin sightings during Campaign 7 aerial surveys

3.2.2.2.3 Abundance estimates

Seasonal density and abundance estimates were calculated for common dolphins for Campaign 7 (Table 7). Common dolphin abundance ranged from 549 (spring) to 2,801 (summer) animals.

Table 7. Density and abundance of common dolphins during Campaign 7 by season

Season	Effort (km)	# of detections	# of animals	Est. Density	Est. Abundance	95% CI
Winter (February)	1504.9	0	-	-	-	-
Spring	3704.2	11	350	0.031	549	143 – 2101
Summer	3943.2	41	2390	0.3112	2801	1473 – 5331

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more animals. # of animals is the sum of the number of animals used to calculate abundance. Est. density is the estimated number of individuals per km2. Est. abundance is the estimated number of animals for the study area. 95% CI= 95% confidence interval of abundance.

Seasonal density and abundance estimates were calculated for bottlenose dolphins for Campaign 7 (Table 8). Bottlenose dolphin abundance ranged from 12 (spring) to 548 (summer) animals.

Table 8. Density and abundance of bottlenose dolphins during Campaign 7 by season

Season	Effort (km)	# of detections	# of animals	Est. Density	Est. Abundance	95% CI
Winter (February)	1504.9	0	-	-	-	-
Spring	3704.2	1	6	0.0014	12	3 – 70
Summer	3943.2	17	459	0.0609	548	265 – 1137

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more animals. # of animals is the sum of the number of animals used to calculate abundance. Est. density is the estimated number of individuals per km2. Est. abundance is the estimated number of animals for the study area. 95% CI= 95% confidence interval of abundance.

3.2.3 Sea turtles

During all Campaign 7 aerial surveys, there were 27 detections of 27 sea turtles recorded, including five camera detections. Sea turtles were sighted only during the summer, but in all three summer months. Seven sightings of seven leatherback turtles were recorded while on-effort during general surveys; all seven were recorded by observers. Four sightings of four loggerhead sea turtles were recorded while on-effort during general surveys (two of these sightings were from the vertical camera). Two sightings of unidentified sea turtles were observed while on-effort (one of these sightings was from the vertical camera).

Seasonal sea turtle sighting rates were 2.3 leatherback sea turtles/km and 0.6 loggerhead sea turtles/km (summer). Sea turtle sightings were spread across the survey area (Figure 12). Most leatherback sea turtles were sighted over the Nantucket Shoals, although they were seen within the WEA as well. Loggerhead and unidentified sea turtles were not seen over the Nantucket Shoals—they were seen in the WEA and in the survey area between the WEA and Martha’s Vineyard and Nantucket.

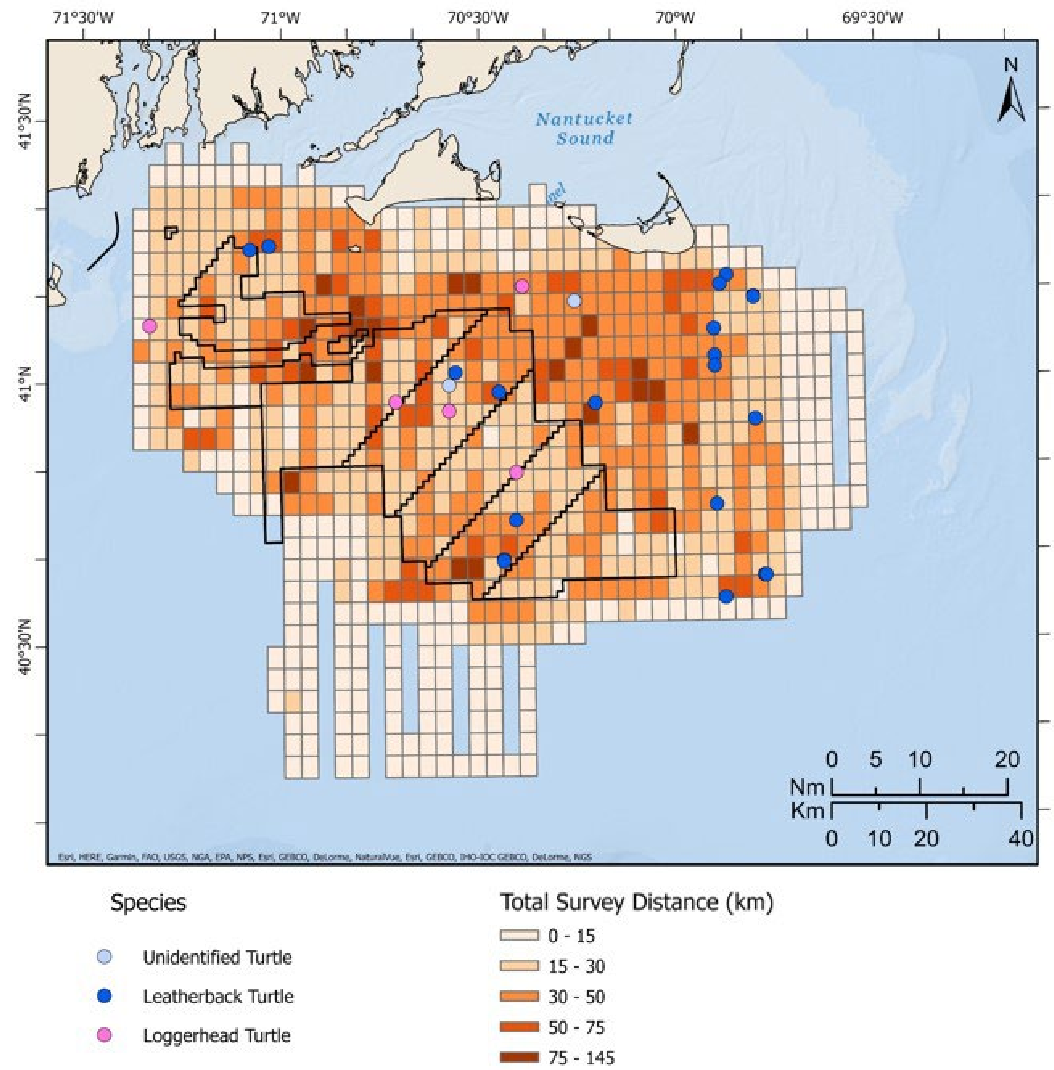

Figure 12. Map of sea turtle sightings during Campaign 7 aerial surveys

3.2.4 Other marine megafauna

Several species of sharks and bony fishes were observed during Campaign 7 aerial surveys. During all Campaign 7 aerial surveys, 56 basking sharks, 80 blue sharks, 92 hammerhead sharks, 375 unidentified sharks, and 100 ocean sunfish were sighted by observers and in vertical photographs. One sighting of one unidentified tuna, one sighting of one Atlantic bluefin tuna (*Thunnus thynnus*), 47 sightings of 57 schools of fish, and 59 sightings of 127 unidentified fishes were spotted by the vertical camera. Sharks were only seen during spring and summer; ocean sunfish were seen in all seasons. Sightings rates were higher in the summer for blue sharks, hammerhead sharks, and ocean sunfish (8.7 animals/km, 10.2 animals/km, and 10.2 animals/km, respectively), compared to the spring (0.5 animals/km, 0 animals/km, and 1.1 animals/km, respectively). Basking shark sighting rates were higher in the spring than the summer (4.8 animals/km, 2.0 animals/km respectively). Sharks and fish were sighted more often in the parts of the study area west and south of the Nantucket Shoals; there were fewer shark and fish sightings over the Nantucket Shoals (Figure 13).

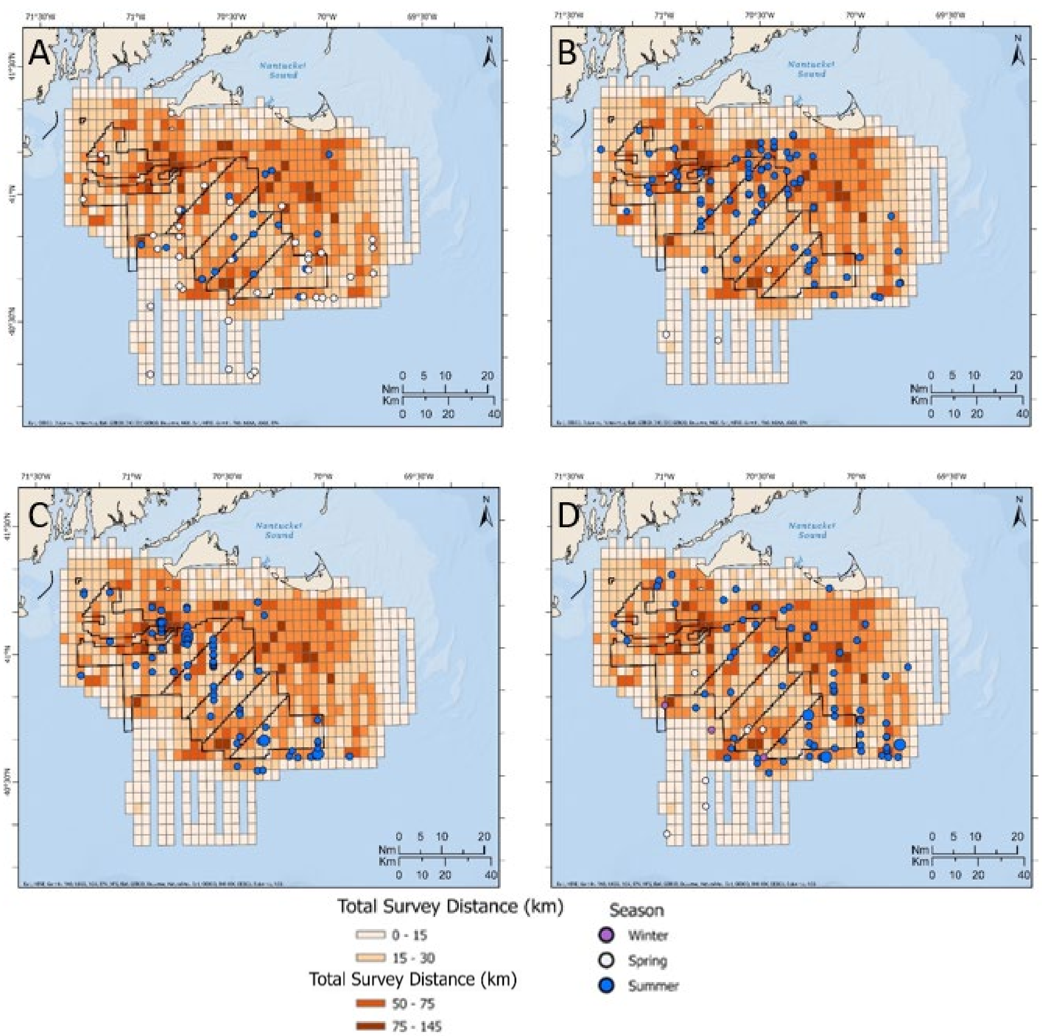

Figure 13. Maps of shark and fish sightings during Campaign 7 aerial surveys: A) basking sharks, B) blue sharks, C) hammerhead sharks, and D) ocean sunfish

3.3 Calibration Surveys

3.3.1 Detections

During Campaign 6B, nine calibration surveys were conducted to begin to understand the effect of altitude on detection of marine megafauna. While calibration surveys were not a primary focus of Campaign 7, there was flexibility to fly calibration surveys. In late April, right whales began leaving Cape Cod Bay and were sighted in Massachusetts Bay – the calibration survey area. Therefore, on April 25th a calibration survey was conducted in Massachusetts Bay with the intention of adding right whales to the calibration detection function (no right whales were seen during Campaign 6B calibration flights). During seven back to back tracklines flown first at 457 m (1500 ft) and then at 305 m (1000 ft), 28 right whales, 42 humpbacks, nine fin whales, 19 sei whales, 10 minke whales, four unidentified fin/sei whales, 23 unidentified large whales, and 153 unidentified dolphins were detected.

4 Discussion

4.1 Cetaceans

In Campaign 7, there was an increase in sightings of balaenopterids and a decrease in sightings of right whales. Sightings of right whales were relatively rare in every season and right whale behavior was dominated by dives in excess of 15 – 20 minutes, which made detection and documentation challenging. In contrast, the summer was dominated by large aggregations of feeding humpback, fin and minke whales. These feeding aggregations shifted locations throughout the summer and were dominated by surface feeding events and multispecies groupings.

Rorqual density and sighting rates followed previously observed seasonal patterns: rorqual density was highest in summer. However, summer rorqual density was much higher than most previous summers (Kraus et al., 2016; O'Brien et al., 2020, 2021; O'Brien, McKenna, et al., 2022; Quintana et al., 2019). Fin whale density in summer 2022 (0.0055 whales/ km^2) was the second highest since 2011 (2011 – 2021 range: 0 – 0.0076 whales/ km^2) and humpback whale density in summer 2022 (0.0027 whales/ km^2) was the second highest since 2011 (2011 – 2021 range: 0 – 0.0034 whales/ km^2). Both fin and humpback summer 2022 sighting rates (20.3 whales/km, 14.9 whales/km) were the highest observed since 2011 (2011 – 2021 ranges: 3.2 – 10.2 whales/km, 1.9 – 7.6 whales/km)

Many rorquals were observed in multi-species feeding aggregations, involving whales, dolphins, birds, and large fish. Changes in baleen whale abundance, especially humpback and fin whales, have been linked with the abundance of baitfish, such as American sandlance (*Ammodytes* spp.), in the Gulf of Maine (Payne et al., 1986, 1990). Surface-feeding fin and humpback whales and bubble-feeding humpback whales were observed throughout the summer. Surface feeding behavior in humpbacks has been linked to abundant prey in the water column (Friedlaender et al., 2009); thus, the high density of rorqual whales is likely linked to abundant prey.

Contrastingly, right whale abundance was lower than in previous years (O'Brien, Pendleton, et al., 2022). Abundance in the study area was the lowest documented by surveys in winter 2022 (5 whales/ km^2 compared to 11 – 123 whales/ km^2 between 2011 – 2021), second lowest in spring 2022 (3 whales/ km^2 compared to 2 – 103 whales/ km^2 between 2011 – 2021), and second lowest in summer 2022 (3 whales/ km^2 compared to 0 – 30 whales/ km^2 between 2011 – 2021). Right whale sightings rates were also lower than in the past: lowest in the winter (1.9 whales/km compared to 2.4 – 28.3 whales/km between 2011-2021), second lowest in spring (2.0 whales/km compared to 0 – 7.2 whales/km between 2011-2021), and second lowest in the summer (0.7 whales/km compared to 0.56 – 6.26 whales/km between 2011-2021). Right whale behavior made detection and documentation more challenging in Campaign 7 than in previous years: many right whales sighted were noted as having long dive times, which not only made individuals harder to photograph for identification, but likely contributed to an increase in availability bias. Availability bias, which occurs when animals are unavailable for detection (for instance, whales not visible while diving) results in an underestimation in abundance (Buckland et al., 1993). Availability bias can vary depending on season, behavior, and area; however, estimating availability bias requires an external data source, such as double-observer aerial surveys or dive times from focal follows or tagging (Ganley et al., 2019). Increased availability bias, if present, would help explain, but not entirely account for, the decrease in right whale abundance in 2022.

The increase in right whale abundance in study area from 2017 – 2021 (O'Brien, Pendleton, et al., 2022; Quintana-Rizzo et al., 2021) has been associated with the redistribution of the entire population (Meyer-Gutbrod et al., 2022). Other habitats that have emerged at the same time, such as the Gulf of St Lawrence, have consistently hosted large numbers of right whales every year (Crowe et al., 2021; Howe et al., 2023). This has not been the case in SNE, where there has been greater interannual variability in right whale abundance (O'Brien et al., 2020, 2021; O'Brien, McKenna, et al., 2022). Interannual variability in right whale prey – and thus, right whale abundance – has been known to occur in other habitats (e.g., (McKinstry et al., 2013; Wishner et al., 1988). Additional surveys are needed to determine whether the decreased abundance in Campaign 7 is part of a natural cycle or a shift in right whale distributions.

4.2 Turtles and fishes

Leatherback turtle sightings were lower in Campaign 7 than in previous campaigns (2.3 animals/km compared to 4.7 – 5.3 animals/km between 2011-2021) (Kraus et al., 2016; O'Brien et al., 2020, 2021; O'Brien, McKenna, et al., 2022; Quintana et al., 2019). In previous years, almost all sightings occurred over the Nantucket Shoals. In Campaign 7, more sightings occurred in the WEAs; while most leatherback sightings were over the Nantucket Shoals, approximately 1/3 of the sightings were in the study area but not over the Nantucket Shoals.

Distribution of sharks and ocean sunfish was similar to previous years – most of the sightings identified to species were in the study area to the west and south of the Nantucket Shoals. Sightings of sharks and bony fish were generally highest in the summer, especially for ocean sunfish, blue sharks, and hammerhead sharks. However, basking shark sightings were higher in the spring than the summer (4.83 animals/km in spring, 2.04 animals/km in summer). In the early years of the project, summer often had the highest sightings of basking sharks. However, beginning in 2017, this pattern was less reliable: in three of the past six years (2017, 2018, 2022) basking shark sightings have been higher in the spring than summer (O'Brien et al., 2020, 2021; O'Brien, McKenna, et al., 2022; Quintana et al., 2019). Basking shark sightings rates also dropped from roughly 13 animals/km in 2019-2020 to 2.04 animals/km this summer. In contrast, summer hammerhead sighting rates have risen in the past few years, climbing from 0.1 animals/km in 2019 to 10.2 animals/km in 2022. Basking shark and hammerhead shark species may both respond to changes in sea surface temperature (Austin et al., 2019; Osgood et al., 2021). Consequently, these changes in sighting rates could be part of a larger distribution shift that is driven by climate change.

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Appendix A: Sightings Tables and Maps

Table A-1. Summary of on and off-effort aerial observer and vertical photograph detections during all Campaign 7 aerial surveys

		Observers		Vertical photos		Totals	
Category	**Species**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**
Small cetaceans	Bottlenose dolphin (*Tursiops truncatus*)	43	904	1	4	44	908
	Common dolphin (*Delphinus delphis*)	119	7608	6	49	125	7657
	Harbor porpoise (*Phocoena phocoena*)	--	--	1	1	1	1
	Pilot whale (*Globicephala* sp.)	4	72	--	--	4	72
	Unidentified dolphin	76	640	--	--	76	640
Large cetaceans	Fin whale (*Balaenoptera physalus*)	160	209	3	3	163	212
	Minke whale (*Balaenoptera acutorostrata*)	85	89	11	11	96	100
	Humpback whale (*Megaptera novaeangliae*)	136	196	1	1	137	197
	Right whale (*Eubalaena glacialis*)	22	31	--	--	22	31
	Sei whale (*Balaenoptera borealis*)	3	3	--	--	3	3
	Unidentified whale	6	6	--	--	6	6
Pinnipeds	Gray seal (*Halichoerus grypus*)	11	69	2	42	13	111
	Unidentified seal	32	2158	3	4	35	2162
Sea turtles	Leatherback sea turtle (*Dermochelys coriacea*)	18	18	2	2	20	20
	Loggerhead sea turtle (*Caretta caretta*)	3	3	2	2	5	5
	Unidentified sea turtle	1	1	1	1	2	2
Birds	Great Black-backed gull (*Larus marinus*)	--	--	12	13	12	13
	Northern gannet (*Morus bassanus*)	--	--	3	3	3	3

Table A-1 continued. Summary of on and off-effort aerial observer and vertical photograph detections during all Campaign 7 aerial surveys

		Observers		Vertical photos		Totals	
Category	**Species**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**
Birds	Unidentified bird	--	--	975	3117	975	3117
	Unidentified gull	--	--	11	17	11	17
	Unidentified tern *(Sterna* sp.*)*	--	--	2	20	2	20
Sharks and fishes	Basking shark (*Cetorhinus maximus*)	48	48	8	8	56	56
	Blue shark (*Prionace glauca*)	43	43	37	37	80	80
	Atlantic Bluefin tun *(Thunnus thynnus)*	--	--	1	1	1	1
	Hammerhead shark (*Sphyrna* sp.)	68	73	19	19	87	92
	Ocean sunfish (*Mola mola*)	71	82	18	18	89	100
	Schools of fish	--	--	47	57	47	57
	Unidentified fish	--	--	59	127	59	127
	Unidentified shark	291	311	62	64	353	375
	Unidentified tuna	--	--	1	1	1	1
Human activity	Debris (different types)	5	7	279	296	284	303
	Fixed fishing gear	587	2525	63	65	650	2590
	Fishing vessel	314	337	3	3	317	340
	Recreational vessel	257	367	--	--	257	367
	Other types of vessels/data stations/coast guard	156	156	1	1	157	157
Unknown	Unidentified animal	3	3	11	19	14	22

Table A-2. Summary of all on-effort aerial observer and vertical photograph detections of marine megafauna during Campaign 7 general surveys.

		Observers		Vertical photos		Totals	
Category	**Species**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**
Small cetaceans	Bottlenose dolphin (*Tursiops truncatus*)	21	489	--	--	21	489
	Common dolphin (*Delphinus delphis*)	60	3250	2	15	62	3265
	Harbor porpoise (*Phocoena phocoena*)	--	--	1	1	1	1
	Pilot whale (*Globicephala* sp.)	4	72	--	--	4	72
	Unidentified dolphin	52	402	--	--	52	402
Large cetaceans	Fin whale (*Balaenoptera physalus*)	45	56	1	1	46	57
	Humpback whale (*Megaptera novaeangliae)*	37	47	--	--	37	47
	Minke whale (*Balaenoptera acutorostrata*)	30	30	1	1	31	31
	Right whale (*Eubalaena glacialis*)	10	12	--	--	10	12
	Sei whale (*Balaenoptera borealis*)	1	1	--	--	1	1
	Unidentified whale	2	2	--	--	2	2
Pinnipeds	Gray seal (*Halichoerus grypus*)	5	54	2	42	7	96
	Unidentified seal	12	311	2	3	14	314
Sea turtles	Leatherback sea turtle (*Dermochelys coriacea*)	7	7	--	--	7	7
	Loggerhead sea turtle *(Caretta caretta)*	2	2	2	2	4	4
	Unidentified sea turtle	1	1	1	1	2	2

Table A-2 continued. Summary of all on-effort aerial observer and vertical photograph detections of marine megafauna during Campaign 7 general surveys

		Observers		Vertical photos		Totals	
Category	**Species**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**
Sharks and fishes	Basking shark (*Cetorhinus maximus*)	30	30	5	5	35	35
	Blue shark (*Prionace glauca*)	15	15	20	20	35	35
	Hammerhead shark (*Sphyrna* sp.)	52	55	13	13	65	68
	Ocean sunfish (*Mola mola*)	40	50	11	11	51	61
	Unidentified shark	203	216	35	36	238	252

Table A-3. Summary of all on-effort aerial observer and vertical photograph detections of marine megafauna during the Campaign 7 Massachusetts Bay calibration survey.

		Observers		Vertical photos		Totals	
Category	**Species**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**	**Number of detections**	**Number of individuals**
Small cetaceans	Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	0 (0)	0 (0)	0 (1)	0 (10)	0 (1)	0 (10)
	Unidentified dolphin	5 (8)	39 (102)	1 (2)	1 (3)	6 (10)	40 (105)
Large cetaceans	Fin whale (*Balaenoptera physalus*)	5 (2)	5 (2)	0 (0)	0 (0)	5 (2)	5 (2)
	Minke whale (*Balaenoptera acutorostrata*)	3 (3)	3 (6)	0 (1)	0 (1)	3 (4)	3 (7)
	Humpback whale (*Megaptera novaeangliae)*	5 (14)	8 (26)	0 (0)	0 (0)	5 (14)	8 (26)
	Right whale (*Eubalaena glacialis*)	5 (6)	8 (6)	0 (0)	0 (0)	5 (6)	8 (6)
	Sei whale (*Balaenoptera borealis*)	6 (9)	7 (12)	0 (0)	0 (0)	6 (9)	7 (12)
	Unidentified fin or sei whale	0 (1)	0 (2)	0 (0)	0 (0)	0 (1)	0 (2)
	Unidentified whale	3 (14)	5 (17)	0 (0)	0 (0)	3 (14)	5 (17)
Pinnipeds	Gray seal (*Halichoerus grypus*)	3 (0)	4 (0)	1 (1)	1 (2)	4 (1)	5 (2)
	Unidentified seal	5 (1)	5 (1)	0 (0)	0 (0)	5 (1)	5 (1)
Sharks and fishes	Ocean sunfish (*Mola mola*)	1 (0)	1 (0)	0 (0)	0 (0)	1 (0)	1 (0)

Note: Numbers without parentheses are sightings at 1,000 feet and numbers within parentheses are sightings at 1,500 feet. Sightings from vertical photos that were also seen by observers are not included in these counts.

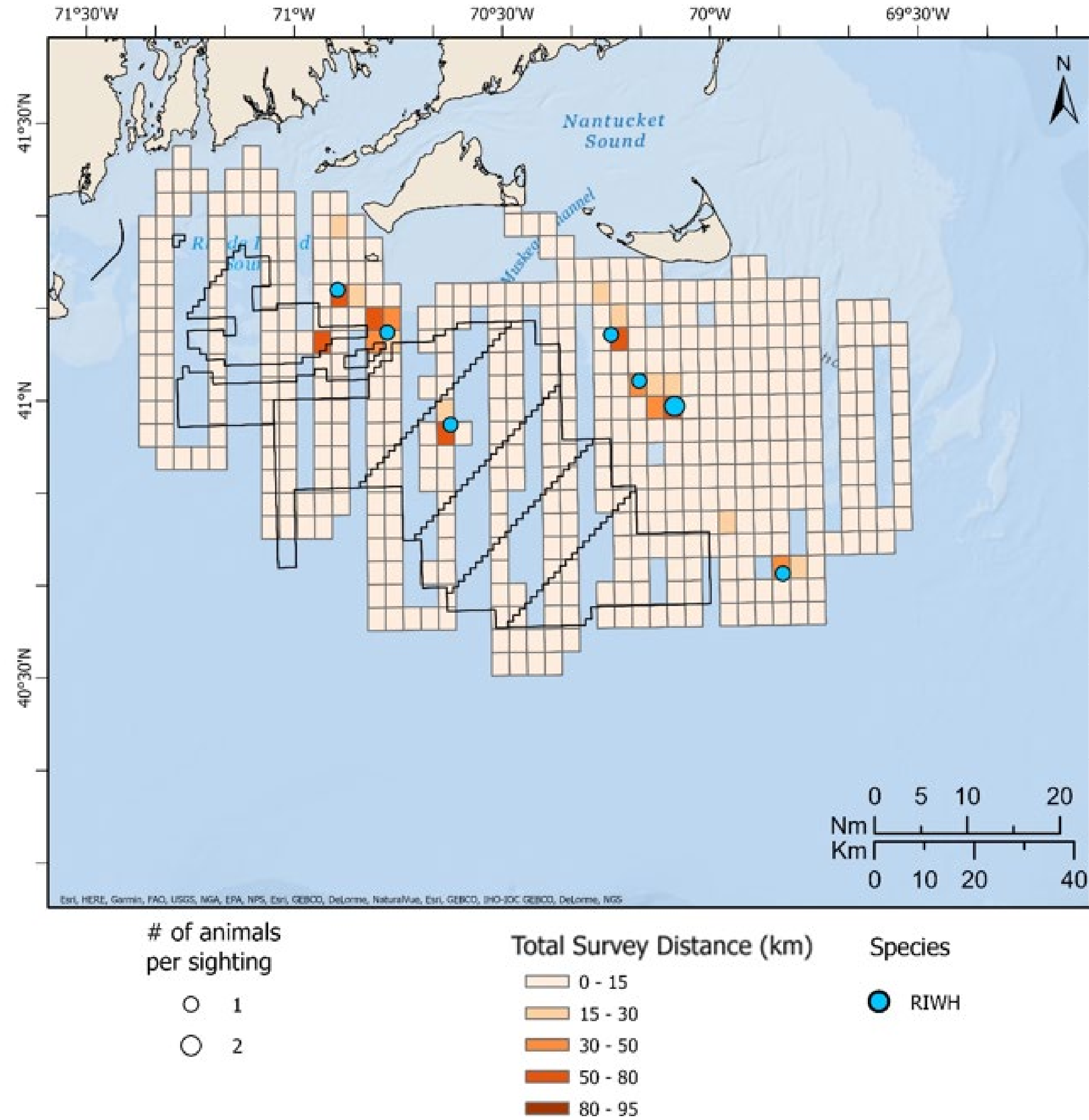

Figure A-1. Map of February 2022 effort and right whale sightings.

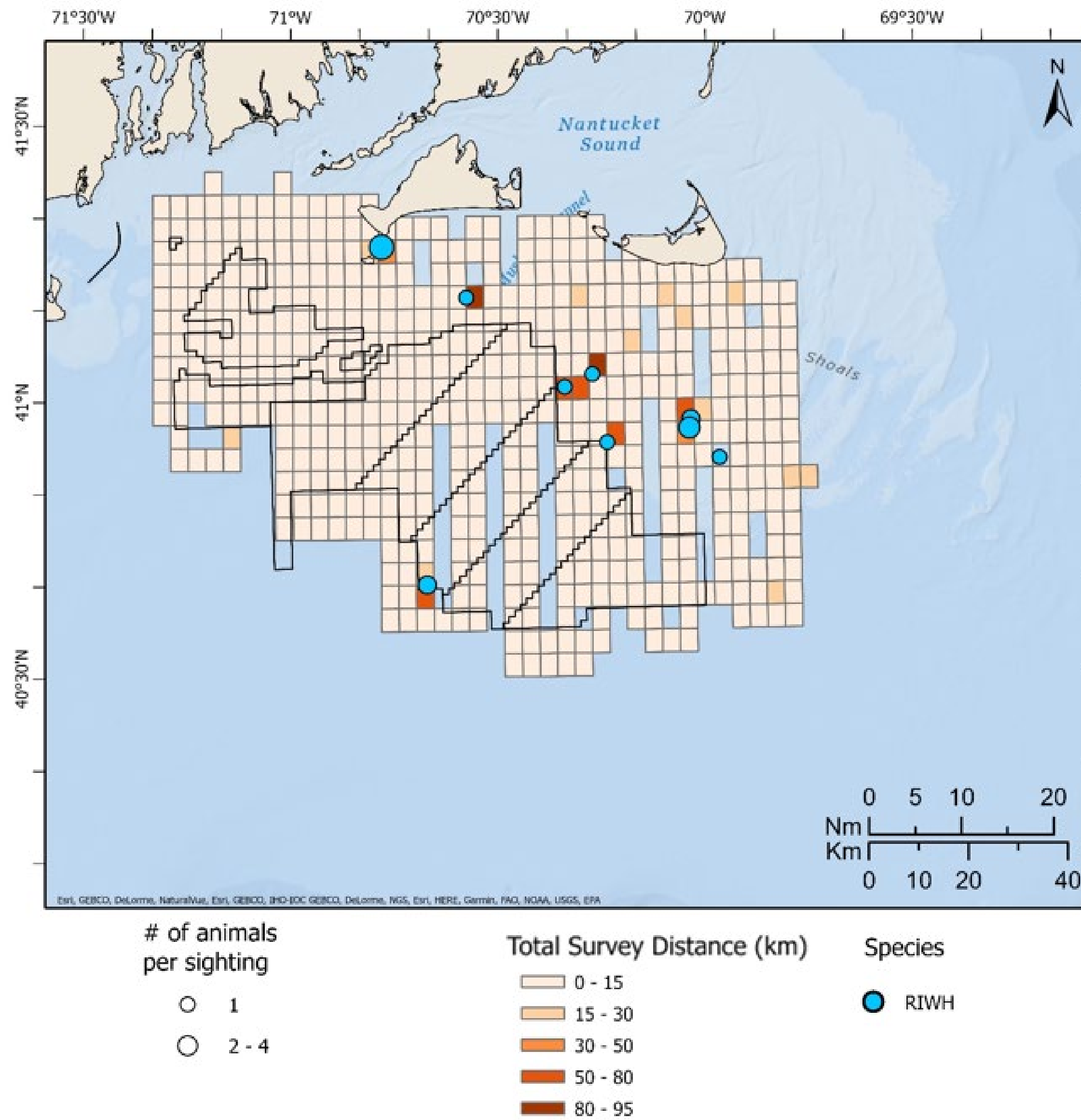

Figure A-2. Map of March 2022 effort and right whale sightings.

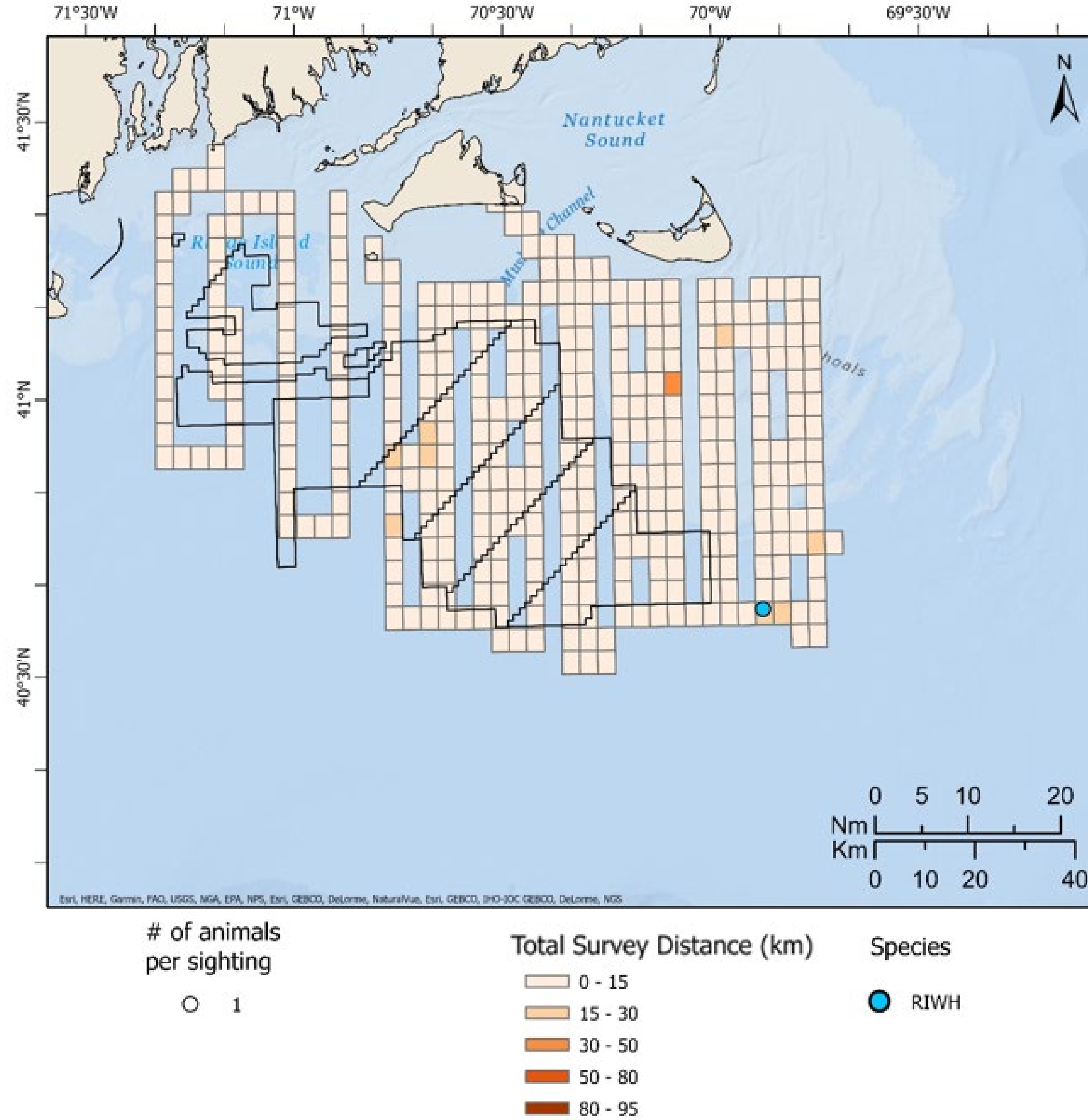

Figure A-3. Map of April 2022 effort and right whale sightings.

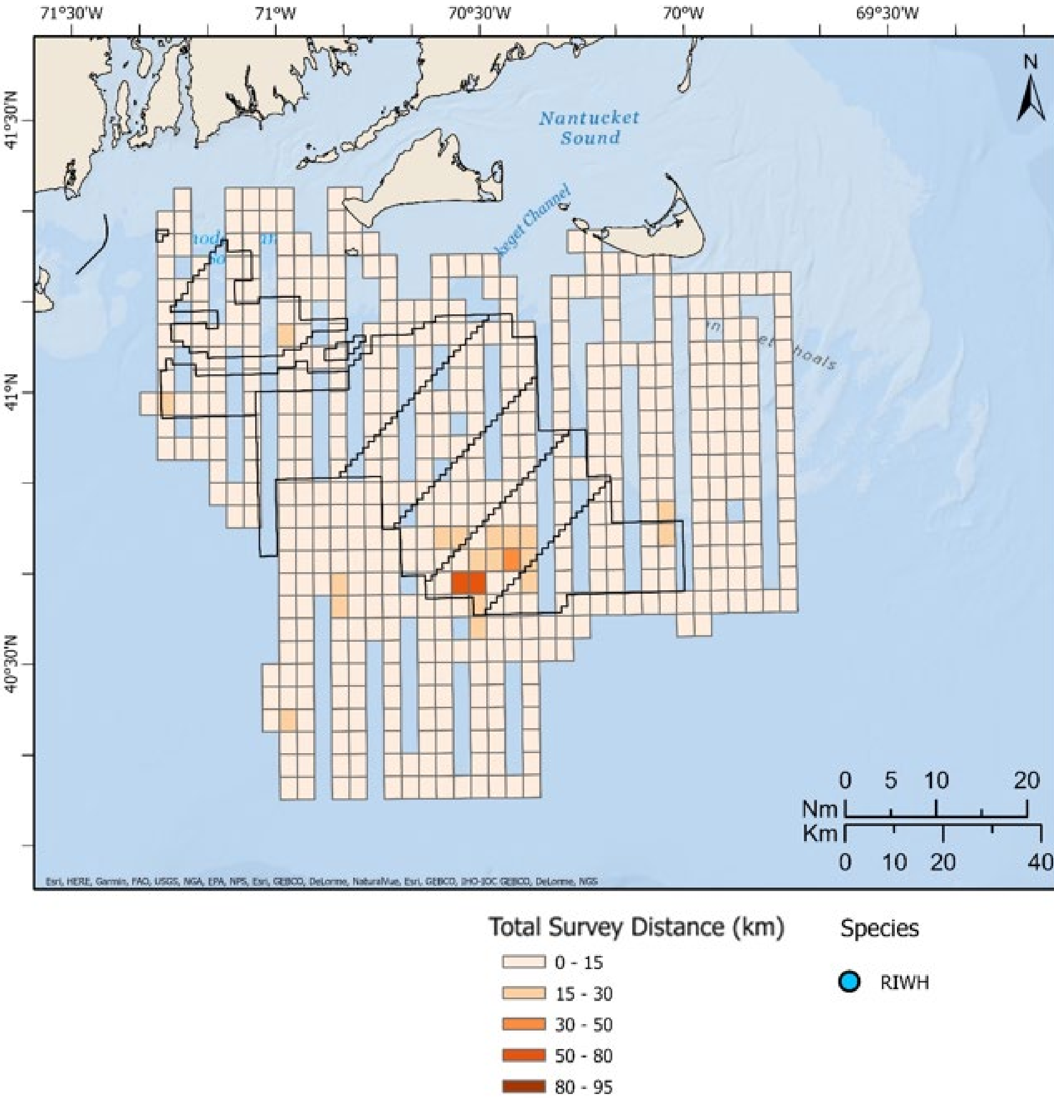

Figure A-4. Map of May 2022 effort and right whale sightings.

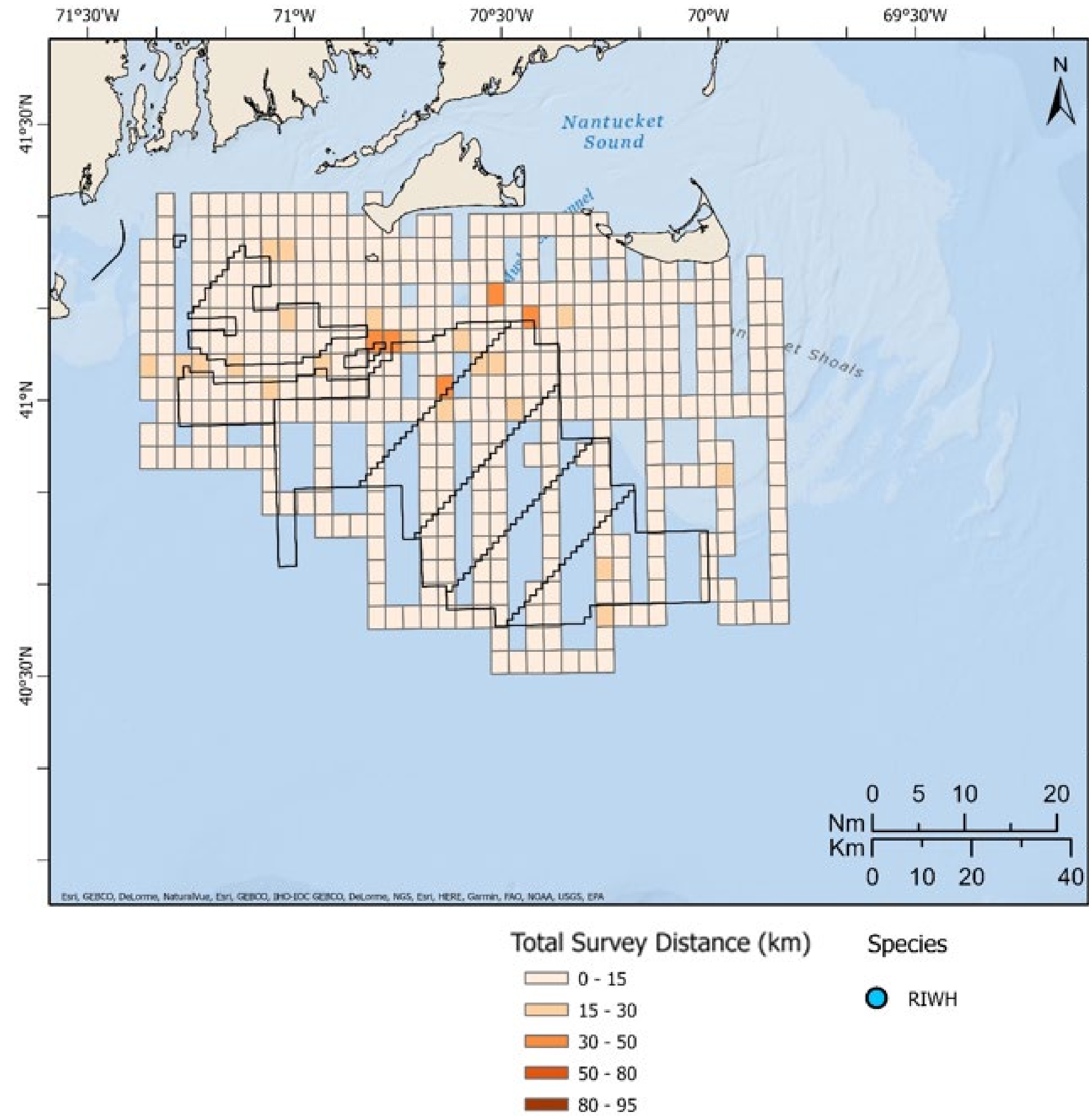

Figure A-5. Map of June 2022 effort and right whale sightings.

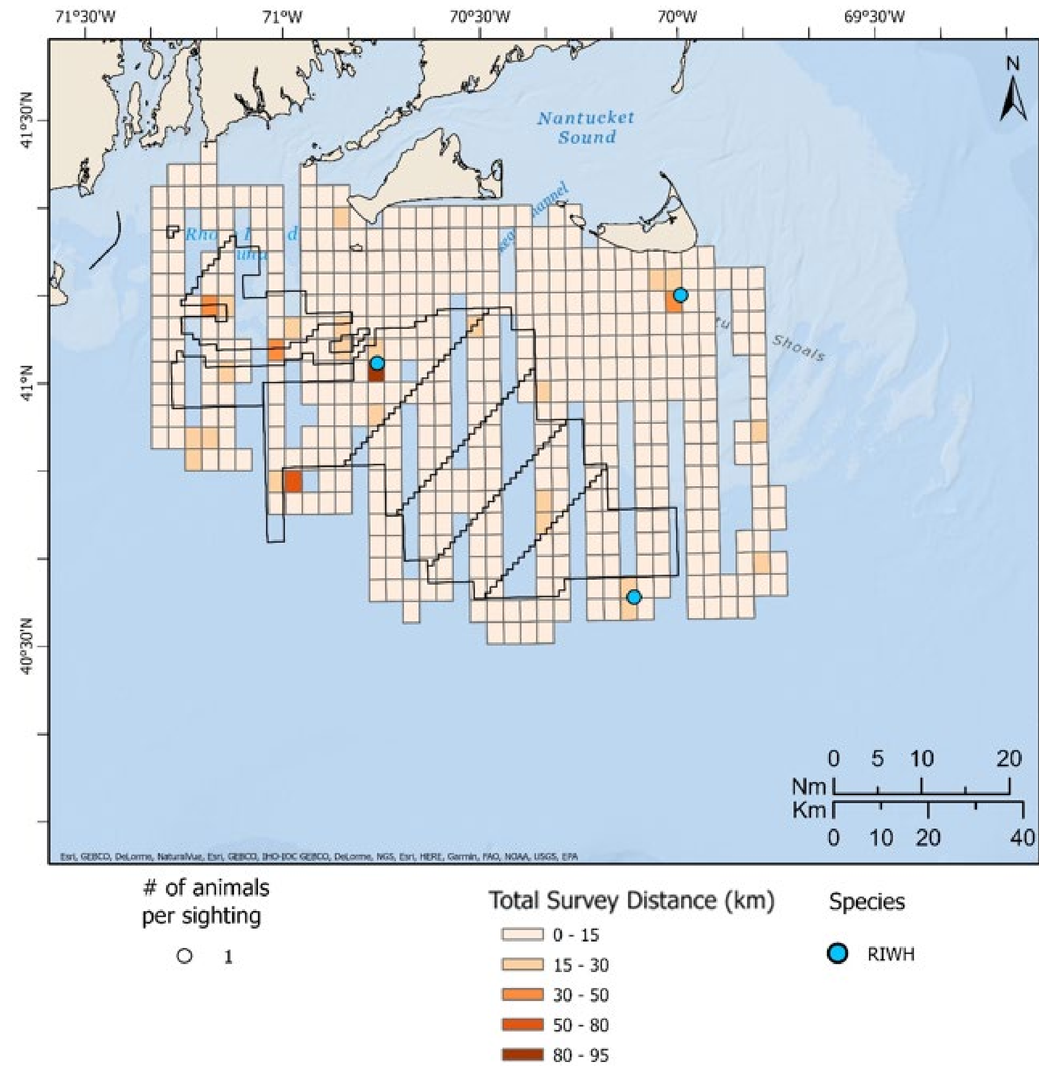

Figure A-6. Map of July 2022 effort and right whale sightings.

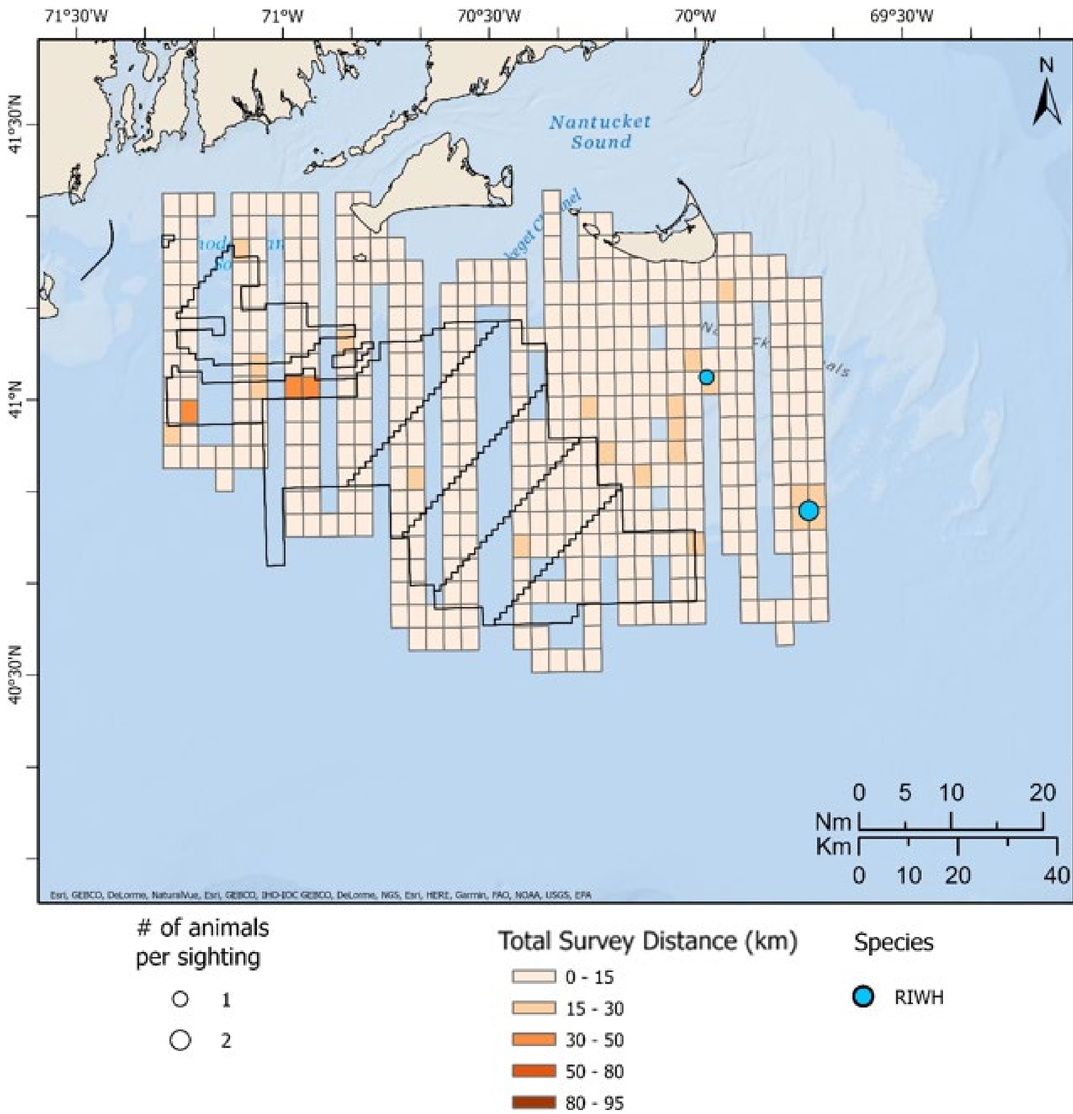

Figure A-7. Map of August 2022 effort and right whale sightings.

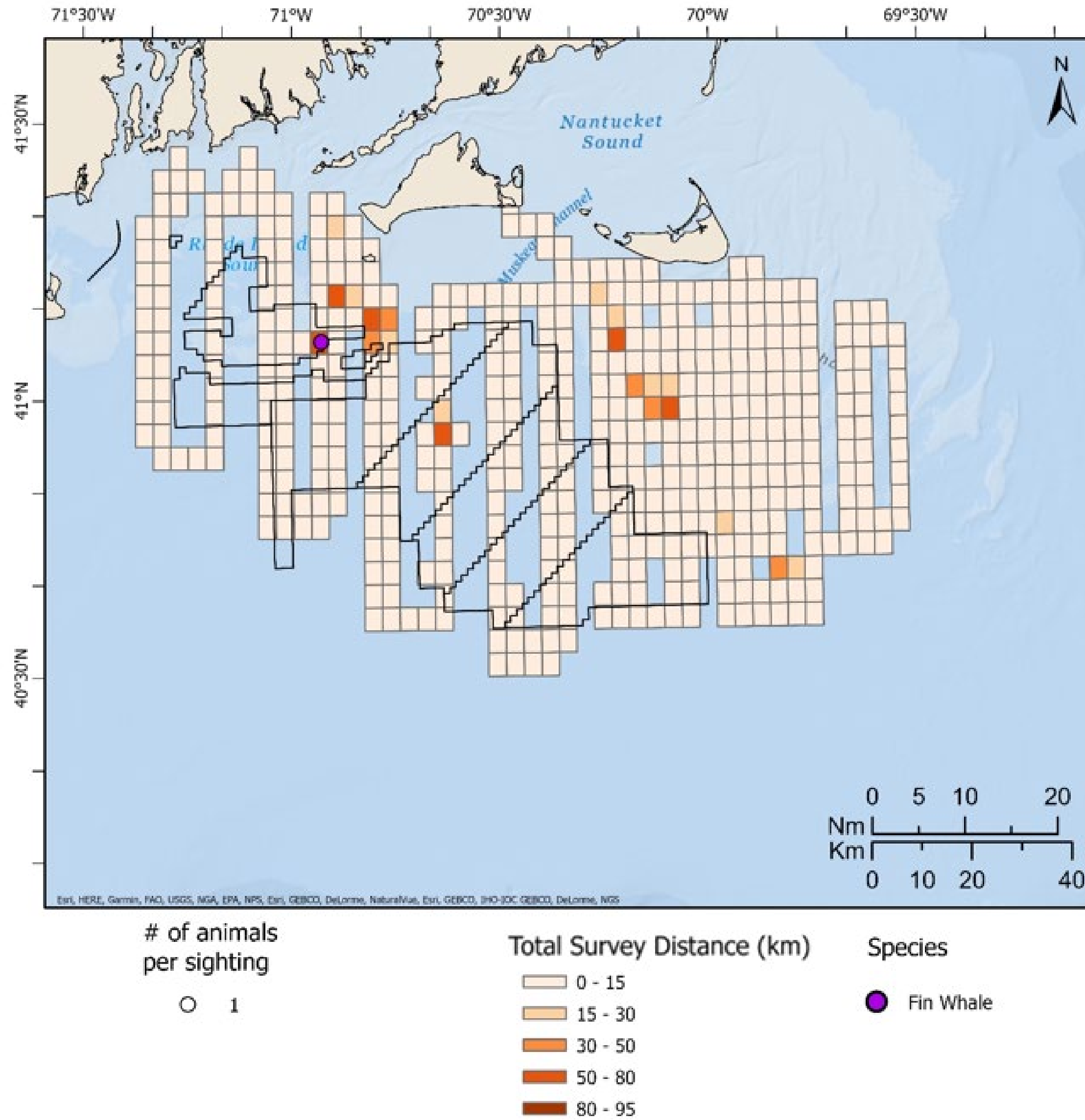

Figure A-8. Map of February 2022 effort, and fin, humpback, and sei whale sightings.

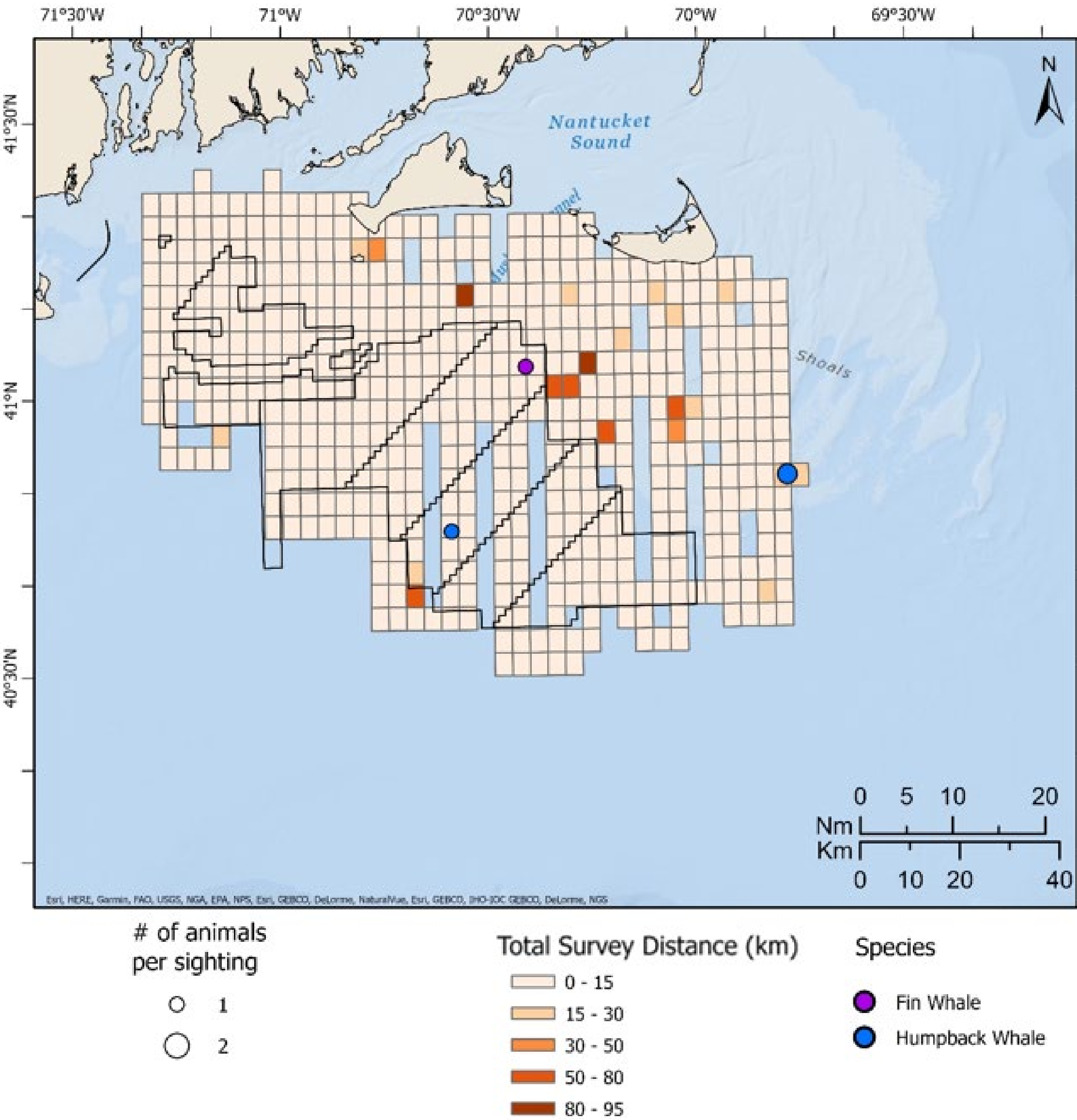

Figure A-9. Map of March 2022 effort, and fin, humpback, and sei whale sightings.

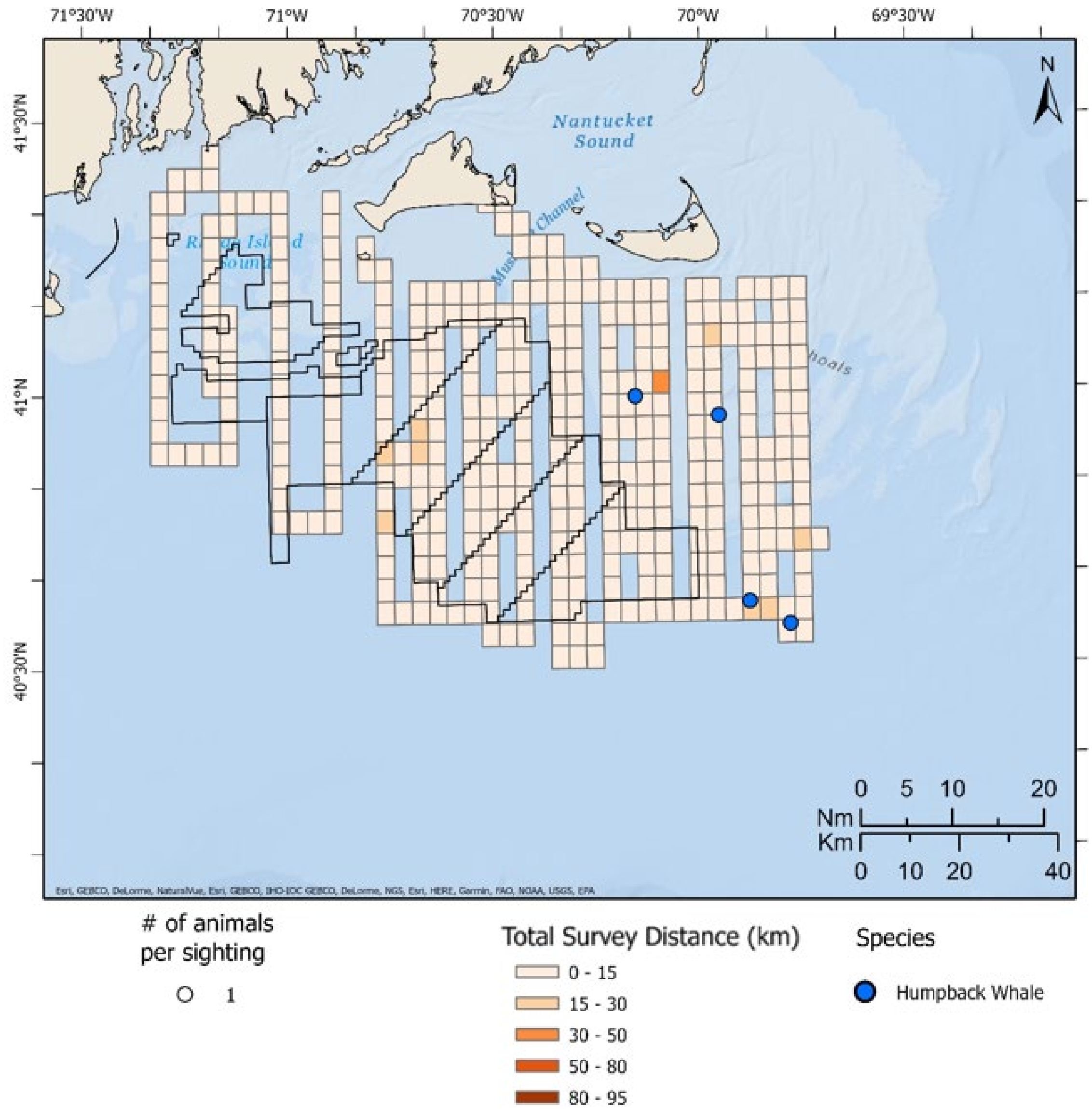

Figure A-10. Map of April 2022 effort, and fin, humpback, and sei whale sightings.

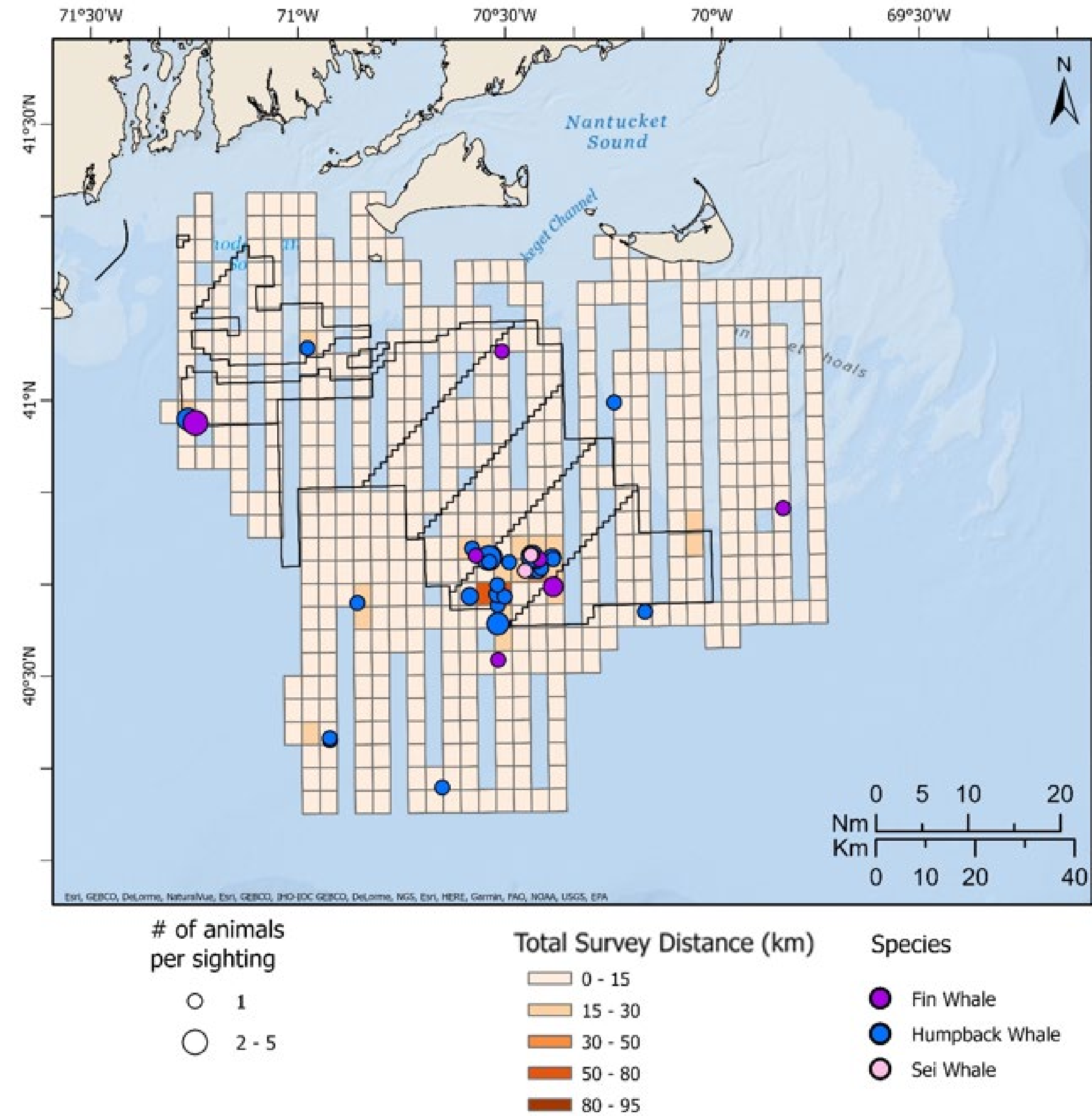

Figure A-11. Map of May 2022 effort, and fin, humpback, and sei whale sightings.

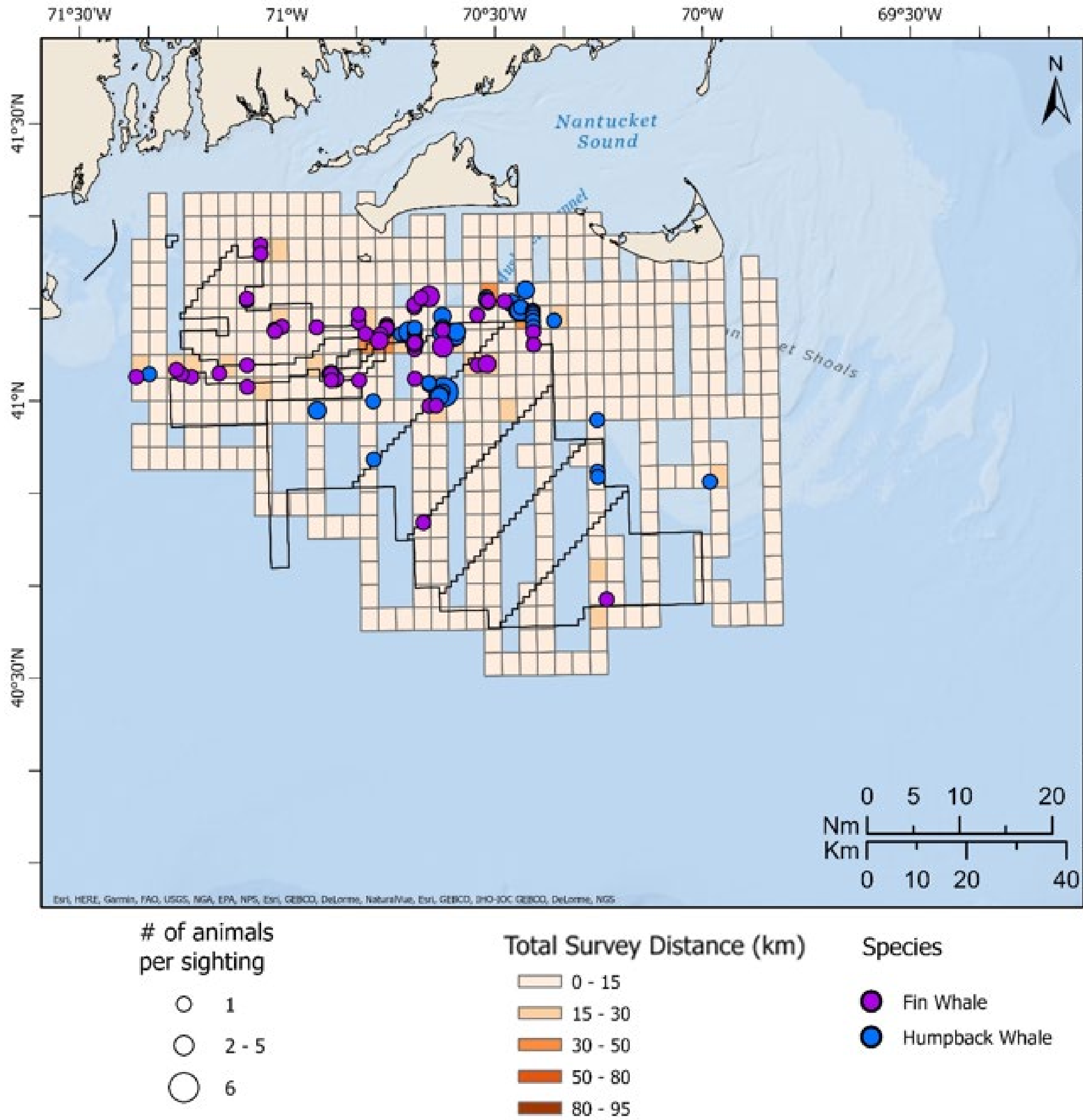

Figure A-12. Map of June 2022 effort, and fin, humpback, and sei whale sightings.

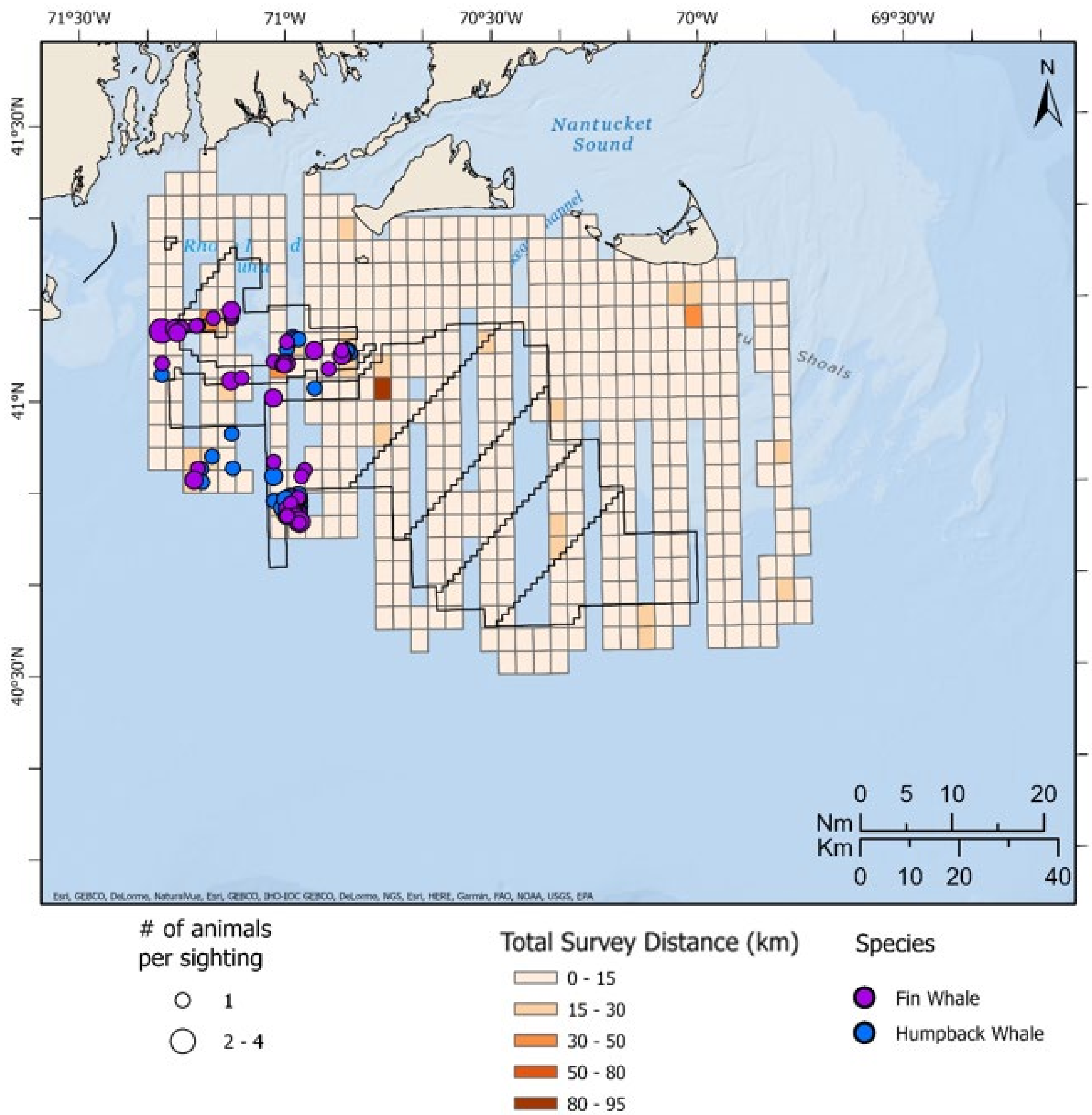

Figure A-13. Map of July 2022 effort, and fin, humpback, and sei whale sightings.

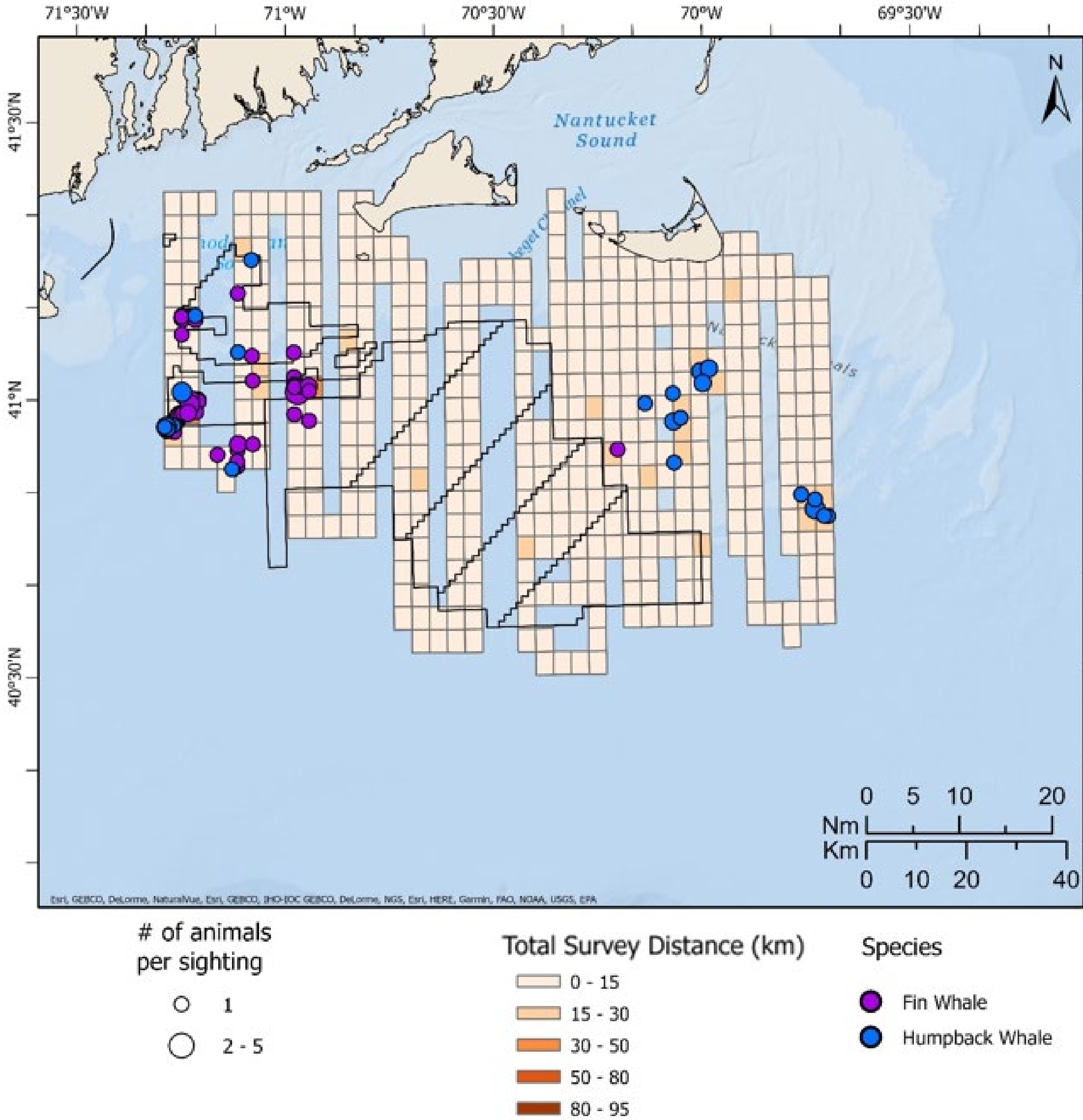

Figure A-14. Map of August 2022 effort, and fin, humpback, and sei whale sightings.

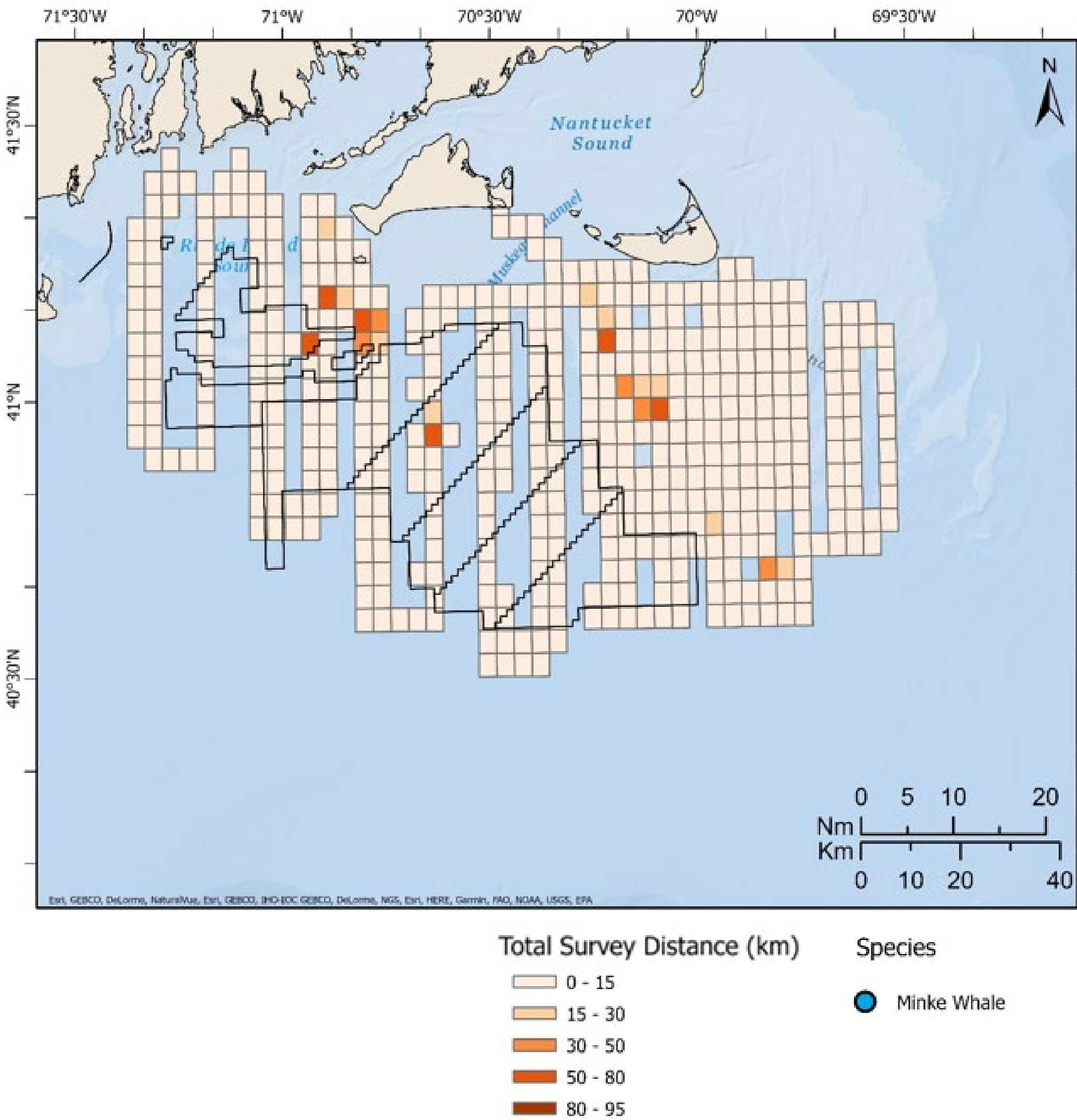

Figure A-15. Map of February 2022 effort and minke whale sightings.

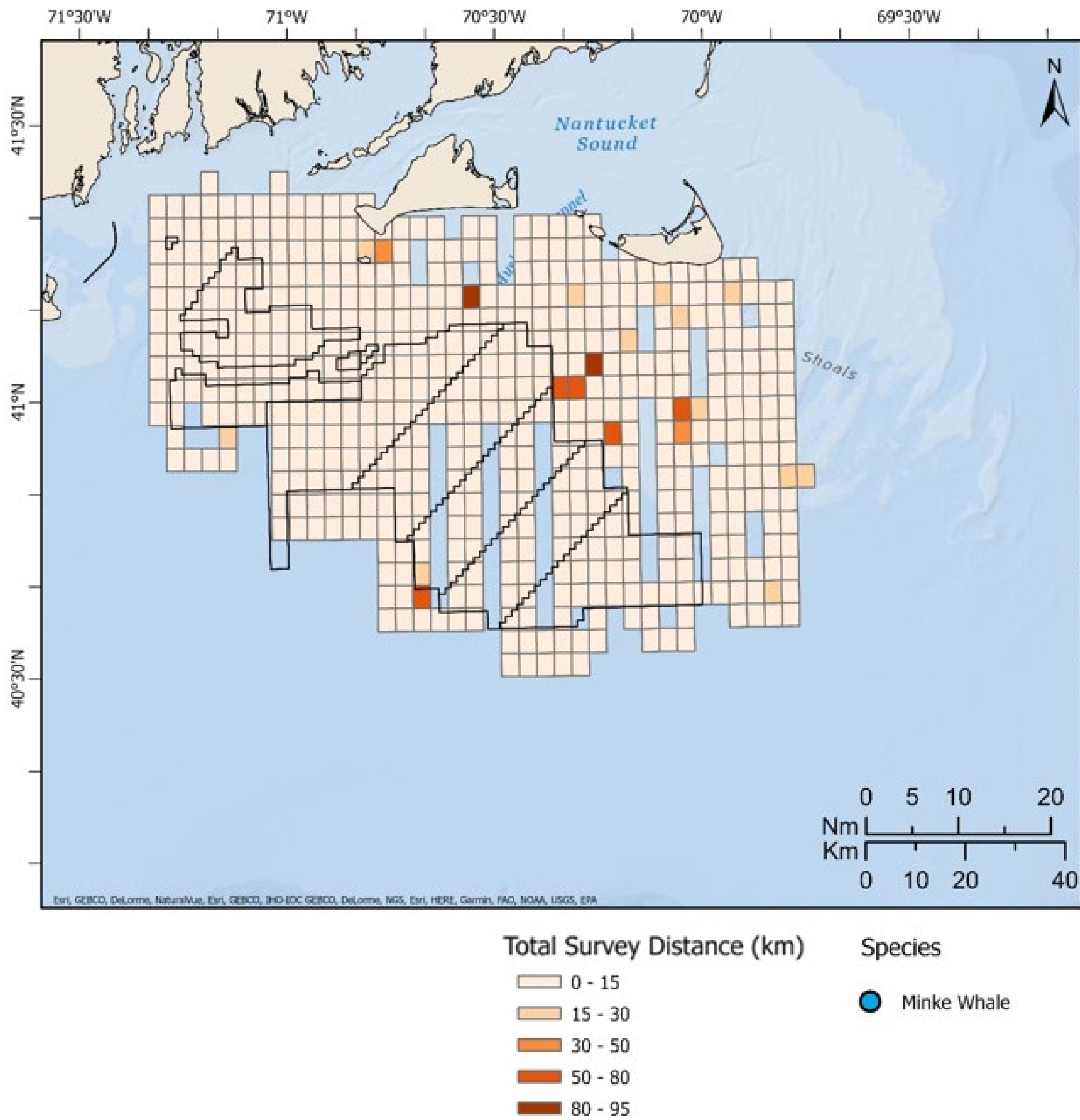

Figure A-16. Map of March 2022 effort and minke whale sightings.

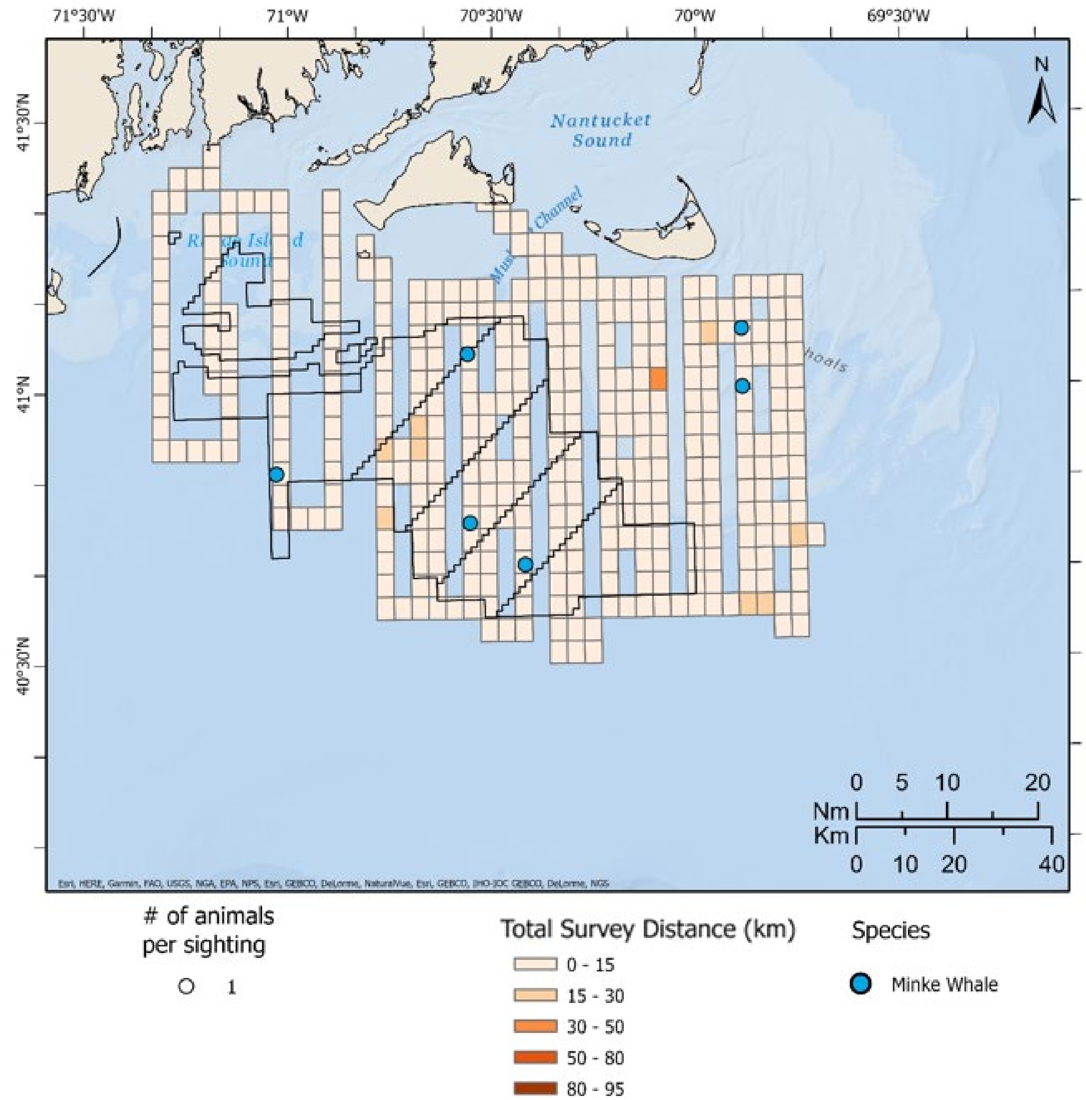

Figure A-17. Map of April 2022 effort and minke whale sightings.

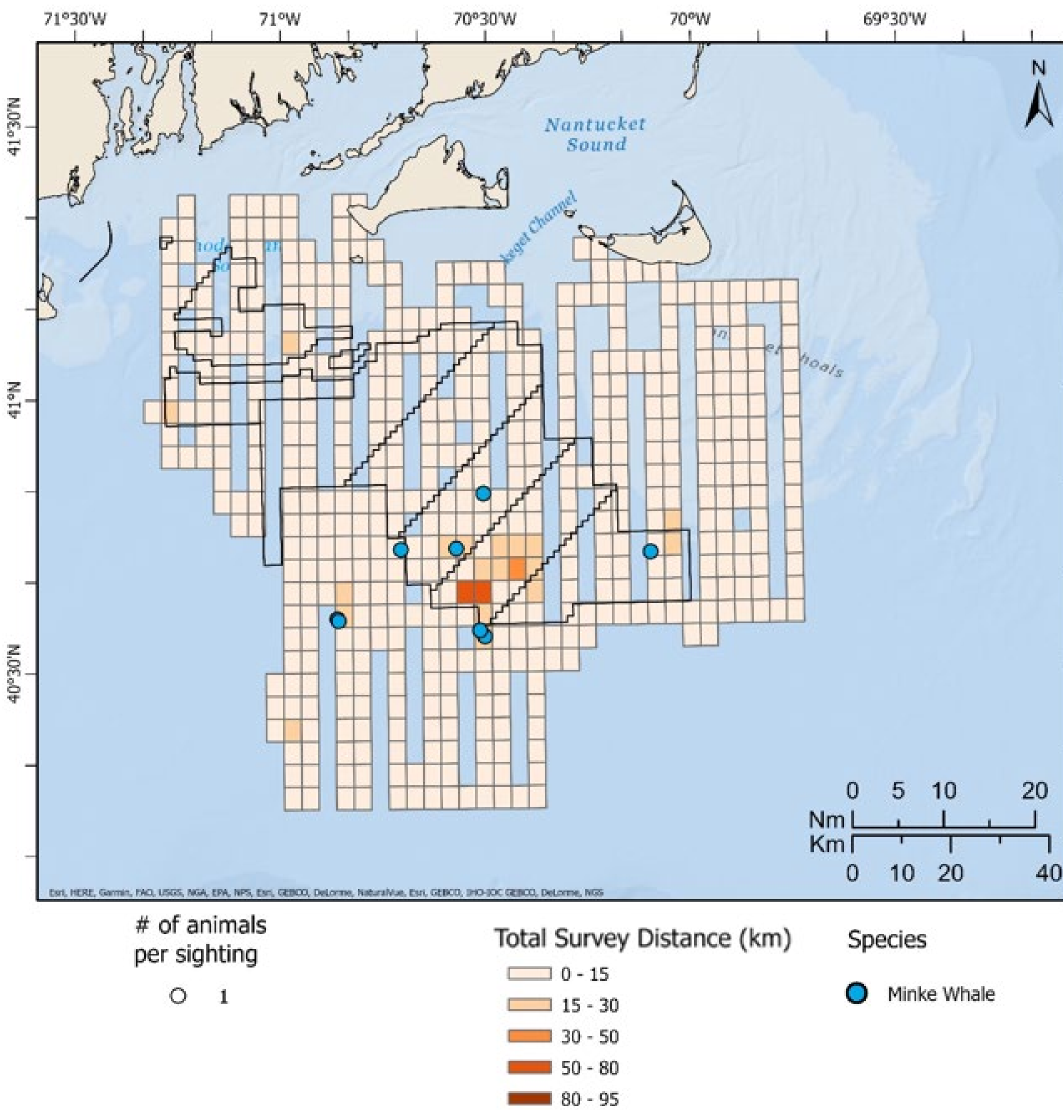

Figure A-18. Map of May 2022 effort and minke whale sightings.

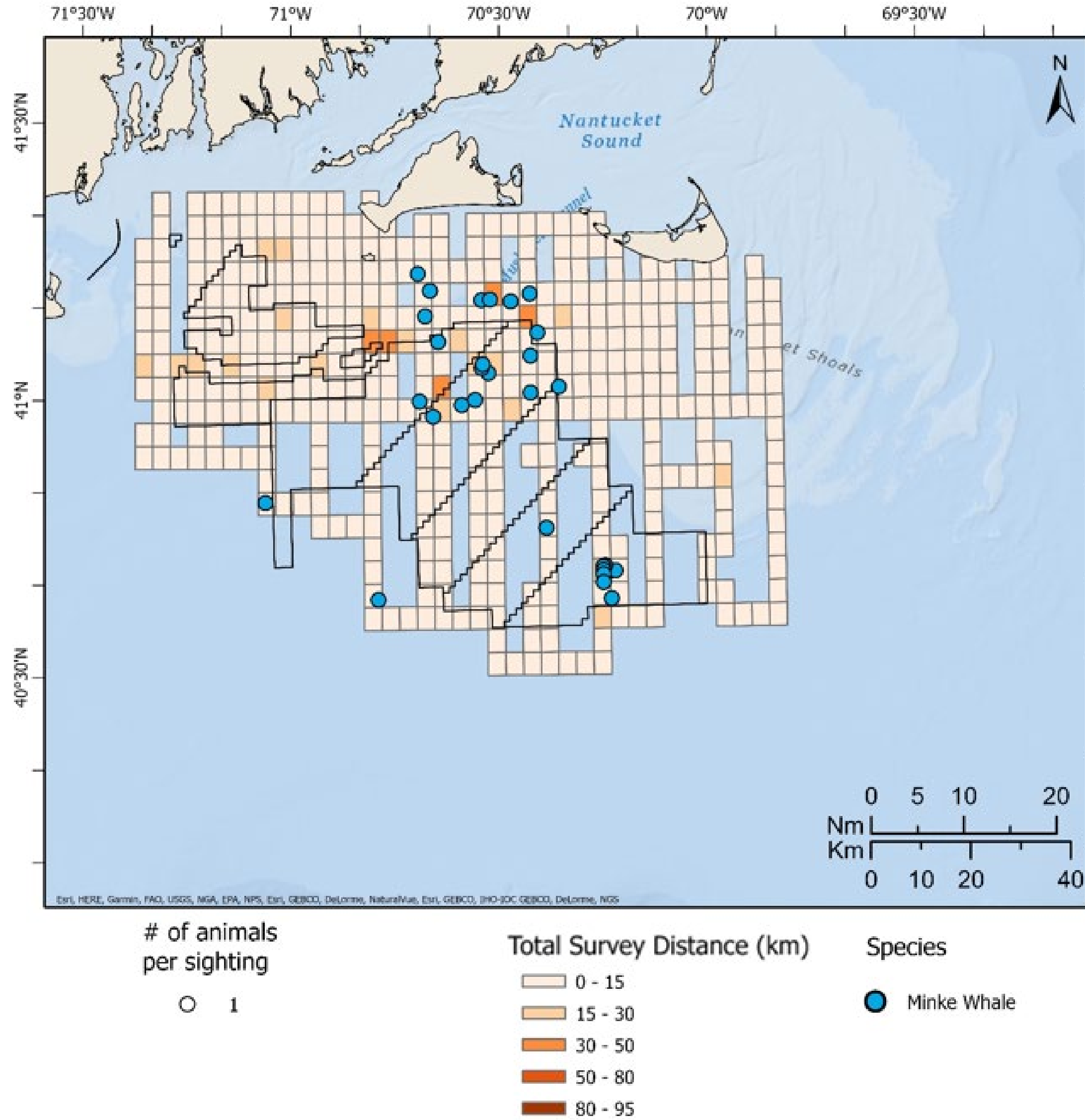

Figure A-19. Map of June 2022 effort and minke whale sightings.

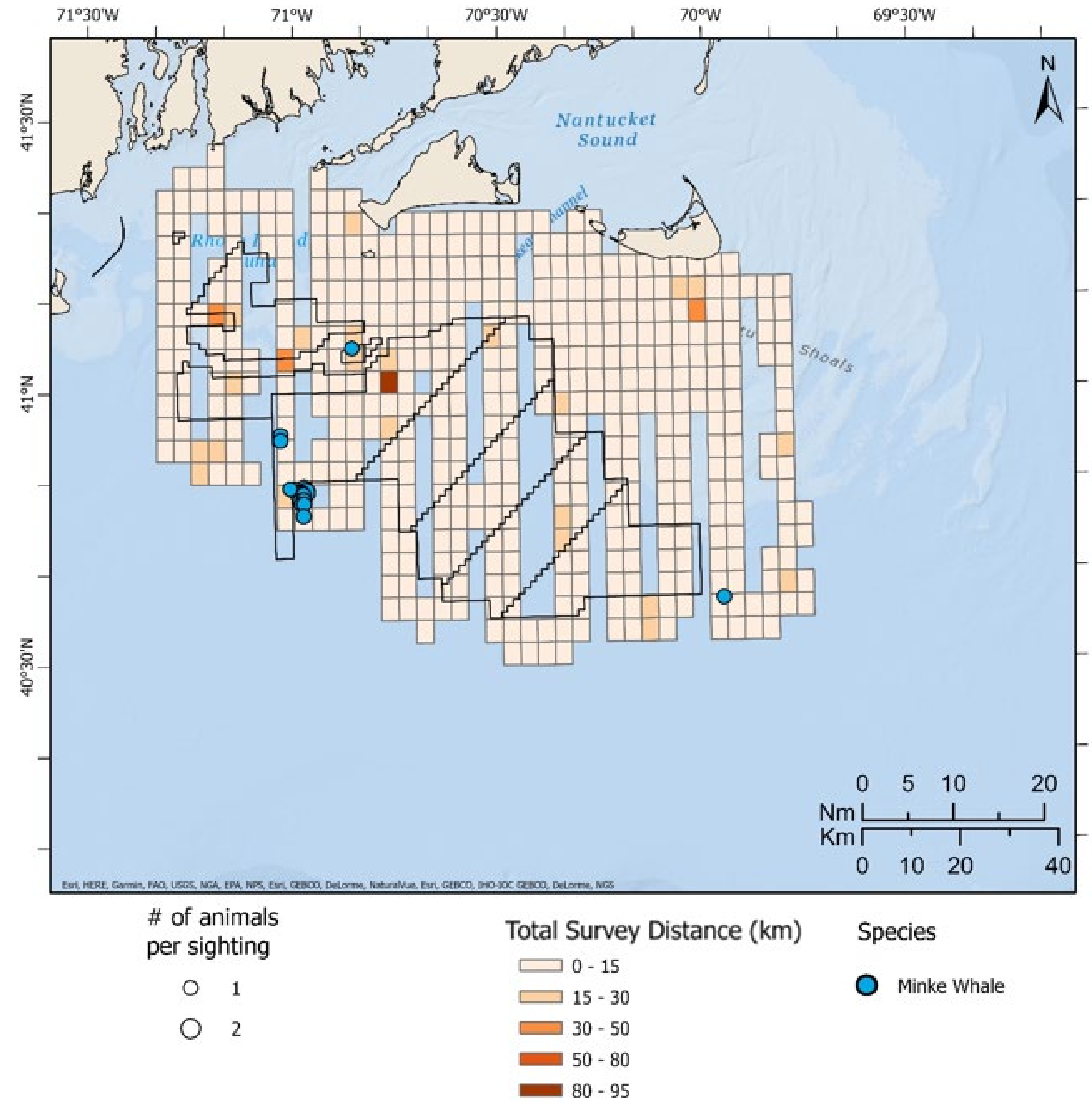

Figure A-20. Map of July 2022 effort and minke whale sightings.

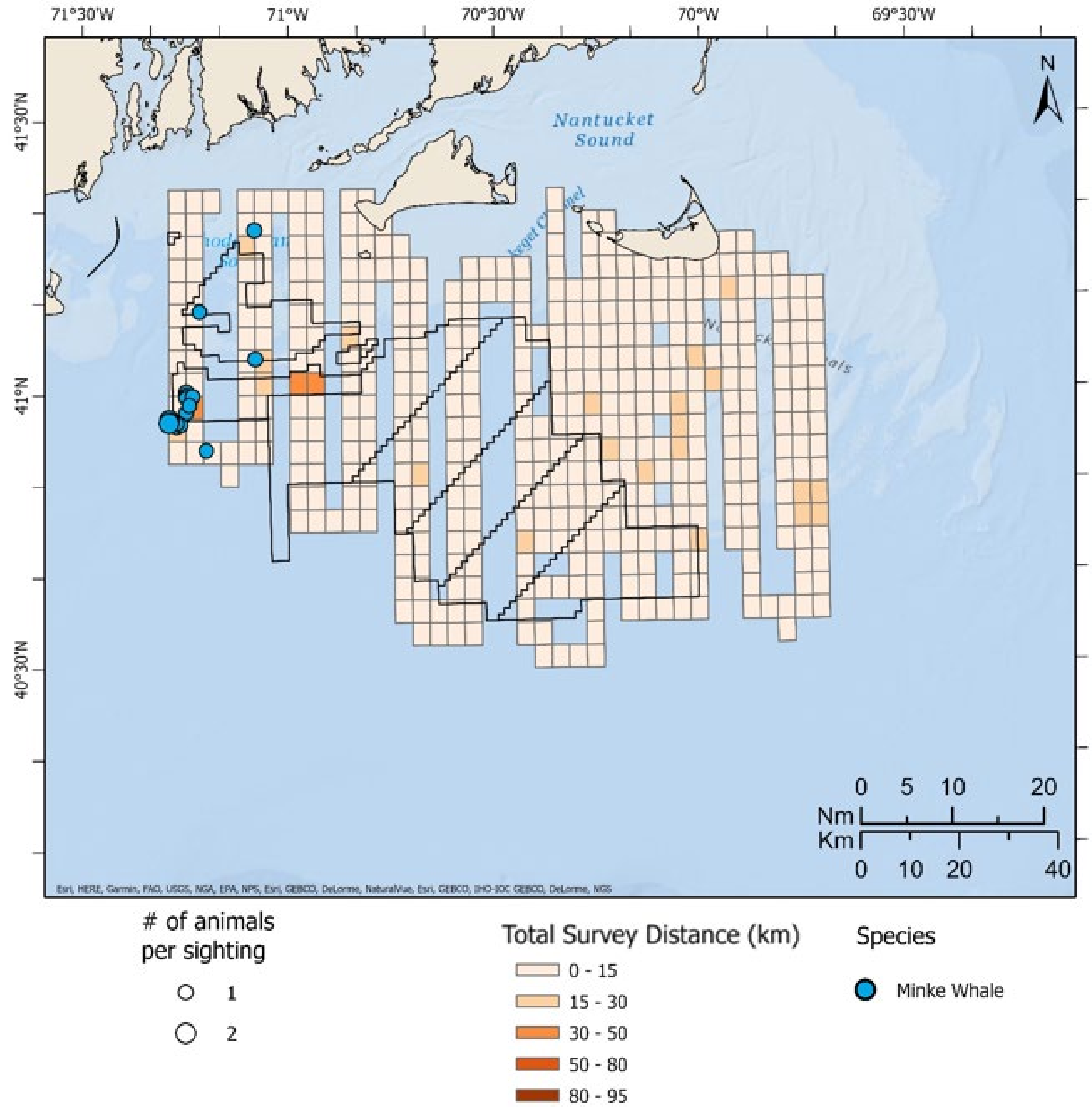

Figure A-21. Map of August 2022 effort and minke whale sightings.

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Bureau of Ocean Energy Management (BOEM)

BOEM's mission is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.