

Megafauna Aerial Surveys in the Wind Energy Areas of Massachusetts and Rhode Island with Emphasis on Large Whales: Interim Report Campaign 6A, 2020



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DISCLAIMER

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ABOUT THE COVER

Humpback whales observed bubble-net feeding on June 4, 2020; photo taken by NEAq aerial survey team.

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List of Abbreviations and Acronyms

#	number of vertical photographs
95% CI	95% confidence interval
<i>a</i>	area sampled (in density calculations)
AIC	Akaike's information criterion
BOEM	Bureau of Ocean Energy Management
<i>d</i>	density (number of individuals per square kilometer)
<i>f(0)</i>	probability density function evaluated at zero distance
<i>g</i>	average group size (in density calculations)
GPS	global positioning system
h	hours
km	kilometer
kts	knots
<i>L</i>	length of transect (in density calculations)
m	meter
mm	millimeter
MassCEC	Massachusetts Clean Energy Center
MAWEA	Massachusetts wind energy area
min	minutes
NARWC	North Atlantic Right Whale Consortium
°N	degrees North
<i>n</i>	number (of animals/groups sighted during a transect)
nm	nautical mile
NEAq	New England Aquarium
NEFSC	Northeast Fisheries Science Center
NOAA	National Oceanic and Atmospheric Administration
RIMA	Rhode Island / Massachusetts wind energy area
URI	University of Rhode Island
°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 survey 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 – October 2020

1 Introduction

In 2012, the Bureau of Ocean and 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. There are currently 8 active commercial leases in the MA and RIMA WEAs and 6 projects have been proposed to date. Offshore construction on the first project is anticipated to start in 2022.

Under the National Environmental Policy Act of 1969 (42 U.S.C. 4371 et seq.), BOEM and other relevant federal agencies are required to assess the reasonably foreseeable impacts of offshore development and construction plans on physical, biological and socioeconomic resources and conditions and identify potential mitigation of those impacts. In addition, during the offshore wind energy planning stage, BOEM attempts to identify areas with the least environmental and use conflicts. To contribute to meeting these requirements, BOEM has provided funding and the Massachusetts Clean Energy Center (MassCEC) has contracted New England Aquarium to conduct aerial surveys from 2011-2021.

Analyses of the survey data have showed that the study area 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 (2017-2020) show that right whales occur in the study area in all seasons. 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 summer and fall.

This report, Interim Report: Campaign 6A, 2020, summarizes results from a subset of the ongoing Campaign 6 surveys, funded by BOEM. Campaign 6A surveys were conducted in the study area between March and October 2020 (with an interruption to allow for development of safety protocols related to COVID-19). Specifically, 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 objective

1. Estimate distribution and relative abundance of large whales (with a focus on right; humpback, *Megaptera novaeangliae*; fin, *Balaenoptera physalus*; and minke whales, *Balaenoptera acutorostrata*) and turtles within the study area, which includes the MA and RIMA WEAs.

2 Methods

2.1 Aerial surveys

During the period of performance between March and October 2020, three types of aerial surveys were conducted within the study area. The study area is defined by a polygon surrounding the general and condensed surveys (shown in Figure 1A). During campaign 6A, the eastern side of the study area was expanded by 12 nautical miles to accommodate sightings of right whale aggregations on the eastern edge of the study area.

- General surveys were standardized line-transect surveys that were conducted on a monthly basis and covered the waters of the study area (9,002 km²), including the MA and RIMA WEAs. These surveys focused on all marine megafauna visible from the plane (excluding birds) and were comprised of ten north-south tracklines (Figure 1B) evenly spaced at approximately six nautical miles (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. One of these options was selected at random before each survey.
- Condensed surveys were standardized line-transect surveys conducted in two smaller areas off Martha's Vineyard and Nantucket. These surveys focused on areas identified by Leiter et al. (2017) as having high densities of right whales (Figure 1C) and were comprised of 10-12 tracklines (western side: 10 tracklines, total length: 218 nm; eastern side: 12 tracklines, total length: 221.5 nm) evenly spaced at three nm. Four survey options are available: each option shifts all 10-12 tracklines 0.75 nm east or west but maintains the three nm spacing between tracklines. One of these options was selected at random before each survey.
- 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.

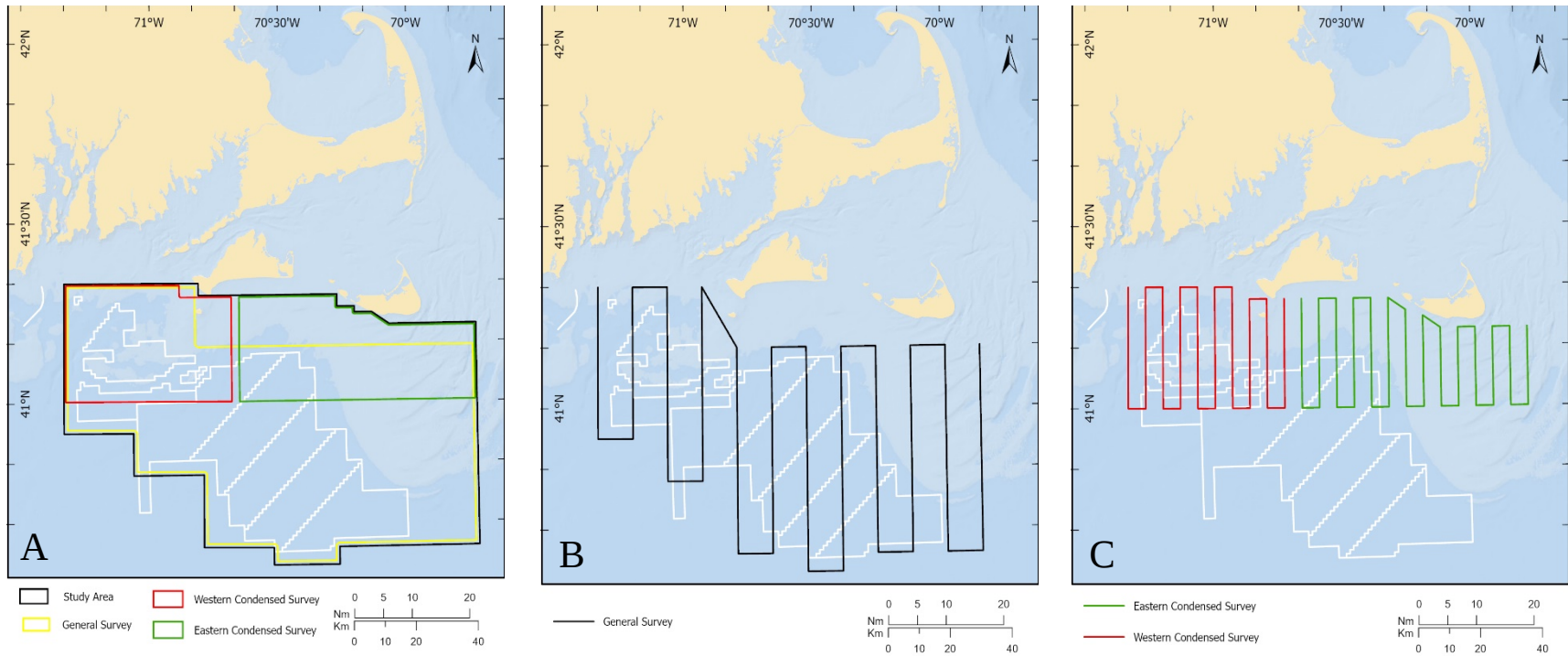


Figure 1. Study area in the offshore waters of Massachusetts and Rhode Island

A) Study area (black outline), with the region covered by general surveys depicted by a yellow polygon and regions covered by condensed surveys depicted by a red (western side) and a green (eastern side) polygon. Examples of tracklines for a B) general survey (tracklines are shown for option 1), C) western and eastern surveys (tracklines are shown for option 1). Note: Existing lease areas are depicted in white.

2.1.1 Survey methods for aerial detections

All surveys were flown in a Cessna Skymaster 337 O-2A at an altitude of 305 m (1,000 ft) and a ground speed of approximately 185 km/h (100 kts) under Visual Flight Rules. Preferred survey conditions included winds of ≤ 10 kts, a Beaufort sea state of ≤ 4 , a minimum cloud ceiling of $\geq 2,000$ 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.

2.1.2 Sightings: observers and vertical photography

Observers recorded sightings according to the North Atlantic Right Whale Consortium (NARWC) Database guidelines (Kenney 2010). 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 estimated distance from the transect line using calibrated markings on the wing strut (Mbugua 1996, Ridgway 2010). Distances (nm) were binned into the following classes: within $\frac{1}{8}$, $\frac{1}{8}$ to $\frac{1}{4}$, $\frac{1}{4}$ to $\frac{1}{2}$, $\frac{1}{2}$ to 1, 1 to 2, 2 to 4, and >4 . The observer also noted whether the sighting occurred on the port or starboard side of 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, distances, 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 survey 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 parameters included general weather conditions (clear, overcast, hazy, etc.), visibility, Beaufort sea state, cloud cover, and sun glare. Sighting data include 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 ($\pm 0, 1, 2, 5, 10$, and so on), the number of calves, heading of the animal or group, whether or not photographs were taken, and notes on behaviors.

Observers were unable to see directly under the aircraft. Therefore, a Canon EOS 5D Mark III camera with a Zeiss-85 mm lens and polarizing filter was fitted in the built-in-camera port of the Cessna O-2A Skymaster. A forward motion compensation system was used to reduce motion blur. 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, and 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 have a randomized start point (i.e., a randomly chosen survey option); consequently, directed survey sightings are not used to estimate abundance. Surveys must not be geographically biased

towards any part of the study area, thus condensed surveys were not used to estimate abundance as they only cover the northern half of the study area. Sightings must be observed while on transect; consequently, sightings during transit or cross-leg are not used to estimate abundance. For most species, sightings detected while circling from a trackline were not used. However, since every sighting of a right whale from the trackline was circled, those sightings were included for consistency. 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 6A surveys. On effort photographs were additionally scrutinized for smaller objects, such as small fish, 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). 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

We estimated density and abundance for baleen whales and common dolphins (*Delphinus delphis*) for Campaign 6A 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, we fit a detection function to our data using the R package *Distance* (R Development Core Team, 2018; Miller, 2019). 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. In previous work on this data set, all large whale detections (right; humpback; fin; sei, *Balaenoptera borealis*; and sperm whales, *Physeter macrocephalus*) were pooled to achieve the sample size necessary to fit detection functions. For this report, we used previously fitted detection functions from the Campaign 5 report. These included unique detection functions for right whales, minke whales, and common dolphins, and a pooled detection function for fin, sei, and humpback whales. Using these detection functions, we were able to use seasonal encounter rates for each species to calculate abundance (Tables 2, 4-7).

An estimate of density (d , in individuals/km²) of a given species was calculated for each survey transect line by:

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

where n is the number of groups sighted during the transect, g is the average group size for the species across all sightings, $f(0)$ is derived from the pooled or unpooled 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 survey area was calculated using the weighted mean density of all survey transects. Abundance was then calculated by multiplying the density estimates by 9,002 km² – the size of the survey area in 2020. 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, altitude ≤ 366 m, visibility ≥ 3.7 km (2 nm), and sea state ≤ 3 (Kraus et al. 2016). 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

Sighting rates were calculated as the number of individuals divided by the total distance traveled during survey. Sighting rates were multiplied by 1,000 to avoid working with small decimal values and are hereafter referred to as animals/km (Kraus et al. 2016, Leiter et al. 2017). Effort was defined as the total distance flown by the aircraft in km, including transects, transits, cross-legs, and circling when Beaufort sea state was ≤ 3. Only sightings identified as definite and probable were included in the analysis. Vertical camera detections were used in the calculations, including animals found in photographs while the plane was circling.

Seasonal sighting rates were calculated for species with at least 25 sightings during the pooled Campaigns 4-6A study period. The species included in the analysis were right whales, fin whales, humpback whales, minke whales, common and bottlenose dolphins (*Tursiops truncatus*), leatherback turtles (*Dermochelys coriacea*), and pooled sea turtles. 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. 2007) 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 Aerial surveys

3.1.1 Field effort

A total of 12 aerial surveys were completed during Campaign 6A over 8 months between March 2020 and October 2020 (Table 1). Surveys were not conducted from March 13th through June 1st in response to the Commonwealth of Massachusetts's stay at home order as a result of the Covid-19 pandemic. Seven general surveys totaling 47.4 hours (h) of flight time, two condensed surveys totaling 9.7 h of flight time, and one directed survey totaling 4.0 h of flight time were conducted. Two surveys were aborted for fog and low cloud layers totaling 2.7 hours (h) of flight time. General surveys took an average of 6.8 h (range = 4.8 – 8.0 h) and condensed surveys took an average of 4.9 h (range = 3.9 – 5.8 h). The total time and the total distance flown for all aerial surveys combined were approximately 63.8 h and 10,491.21 km, respectively (Table 1). During Campaign 6A, 33,726 vertical photographs were taken by the vertical camera and 1,414 handheld photographs were taken by aerial observers for a total of 35,140 photographs.

Month	General Surveys						Other Surveys					
	Total	Day	Direction	Option	Airtime (h)	Flight length (km)	Total	Day	Direction	Option	Airtime (h)	Flight length (km)
March	1	11	W → E	6	4.8	828.0						
June	2	04	E → W	9	7.2	1,147.1						
		25	W → E	4	6.6	1,071.0						
July	1	25	W → E	8	7.1	1,177.9	1	05	W → E	2W	3.9	643.9
August	1	19	W → E	5	8.0	1,329.9	2	09	NA	*	1.4	270.2
								23	E → W	D	4.0	679.9
September	1	17	W → E	2	6.6	1,137.3	2	08	NA	*	1.3	240.2
								24	E → W	8E	5.8	832.1
October	1	04	E → W	11	7.1	1,133.6						
	6				47.4	7,824.9	5				16.4	2,666.3

Table 1. Summary of aerial survey effort during Campaign 6A

“Other Surveys” include condensed and directed surveys. Note: W = west, E = east, D = Directed, NA = Not applicable. * Denotes aborted survey.

3.1.2 Detections

Sightings and detections for Campaign 6A are split into two categories: 1) sightings from all survey effort and 2) the subsection 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 all observer detections.

3.1.2.1 All detections

A total of 1,667 detections of marine fauna (39%) and human activity (61%) were observed during all Campaign 6A aerial surveys. Of these detections, 70% (n = 1,155) were observer detections and 30% (n = 512) were camera detections.

There were 651 detections of marine fauna totaling 3,968 individuals of 17 species (Table A-2). Marine fauna included several species of large whales, small cetaceans, birds, sharks/fish, and sea turtles. Marine mammals had the highest number of individuals observed (66%, n = 2,623), followed by birds (23%, n = 927), sharks/fish (10%, n = 396), and sea turtles (<1%, n = 20). The majority of marine mammal sightings were cetaceans (84%) and the rest were pinnipeds. One additional species was detected only off effort: bluefin tuna (*Thunnus thynnus*). Birds were typically not marked by observers in the plane; consequently, reported sightings of birds are exclusively camera detections.

There were 1,016 observer and camera detections of human activity during all Campaign 6A surveys (Table A-2). Natural debris such as floating sargassum were excluded from debris totals. The majority of human activity detections were related to commercial fishing (62%), 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 Coast Guard, merchant, and research vessels accounted for 5% and anthropogenic debris accounted for 17%.

The analysis of the vertical photographs from all surveys resulted in 307 detections of 1,076 animals and 205 detections of human activity. Nine species of marine megafauna (not including birds) were identified to the species level from vertical photographs.

3.1.2.2 On effort detections

A total of 276 sightings of marine megafauna (n = 1,519 individuals) were recorded, including both observer (80%, n = 222) and camera (20%, n = 54) detections (Table A-1). Identification to the species level was possible for 168 sightings and resulted in 14 confirmed species: eight cetacean, three shark, one fish, and two sea turtle. Marine mammals represented 22% of detections (n = 62) and 83% of all individuals tallied (n = 1,255 individuals). Sharks/fish were seen more often (75% of detections, n = 208), but in lower numbers (21% of individuals detected, n = 258). The remaining six detections were of individual sea turtles.

3.1.3 Cetacean detections

A total of 108 sightings of 2,121 cetaceans were recorded during Campaign 6A. This total includes five sightings by the vertical camera, of 61 individuals from three species. Sixty-two of these sightings were on effort during general surveys, totaling 1,255 individuals. Identification to the species level was possible for 92 sightings and resulted in eight confirmed species. Species ID could not be confirmed for 16 sightings.

Humpback whales, common dolphins, and minke whales were sighted most frequently and accounted for 22%, 18%, and 14%, respectively, of cetacean sightings. The most abundant cetaceans were common and bottlenose dolphins, accounting for 68% and 23%, respectively, of individual cetaceans sighted; humpback whales were the most common large cetacean, but only accounted for 2% of all individual cetaceans.

Baleen whales were represented by four species of two families: Balaenidae and Balaenopteridae. One species of the Balaenidae family was sighted: the North Atlantic right whale. In total, 10 sightings of 15 right whales were recorded during Campaign 6A. Right whales are discussed and sighting maps are shown below. Three species of the Balaenopteridae family or rorqual whales were sighted: fin whales, minke whales, and humpback whales. A total of 50 sightings of 80 rorqual whales were documented during Campaign 6A surveys. Further details of baleen whale sightings are discussed below.

Toothed whales were represented by four species in two families: common, bottlenose, and Atlantic white-sided dolphins (*Lagenorhynchus acutus*) (family Delphinidae); and harbor porpoise (*Phocoena phocoena*; family Phocoenidae). Toothed whale sightings are discussed below.

3.1.3.1 North Atlantic right whales

In total, 10 sightings totaling 15 right whales were recorded during Campaign 6A surveys; five sightings of seven total whales were recorded on effort during Campaign 6A. The remainder of the right whales

were recorded during condensed (four sightings of seven whales) and directed (one sighting of one whale) surveys. Group size ranged from one to four; average group size was 1.5 whales.

Right whales were sighted in two of three seasons and in four of six months surveyed. Seasonal right whale sighting rates were higher in the fall (4.36 whales/km) than the summer (0.56 whales/km). No right whales were sighted during the curtailed spring season.

Right whale sightings are shown in Figure 2. During Campaign 6A, right whales were only sighted on the eastern side of the study area, over the Nantucket Shoals. Despite consistent summer survey effort during Campaign 6A, the aggregation that has been present in past years (located on the south shore of Nantucket Island and in the area between Nantucket and the wind energy areas) was not seen. Instead, three individuals were seen only once each during summer surveys over the Nantucket Shoals. All of these individuals were resighted in the fall as more whales moved into the area.

Right whale sightings were close to, but outside of, the wind energy lease zones. Specifically, all sightings were within 15 nm of existing lease areas.

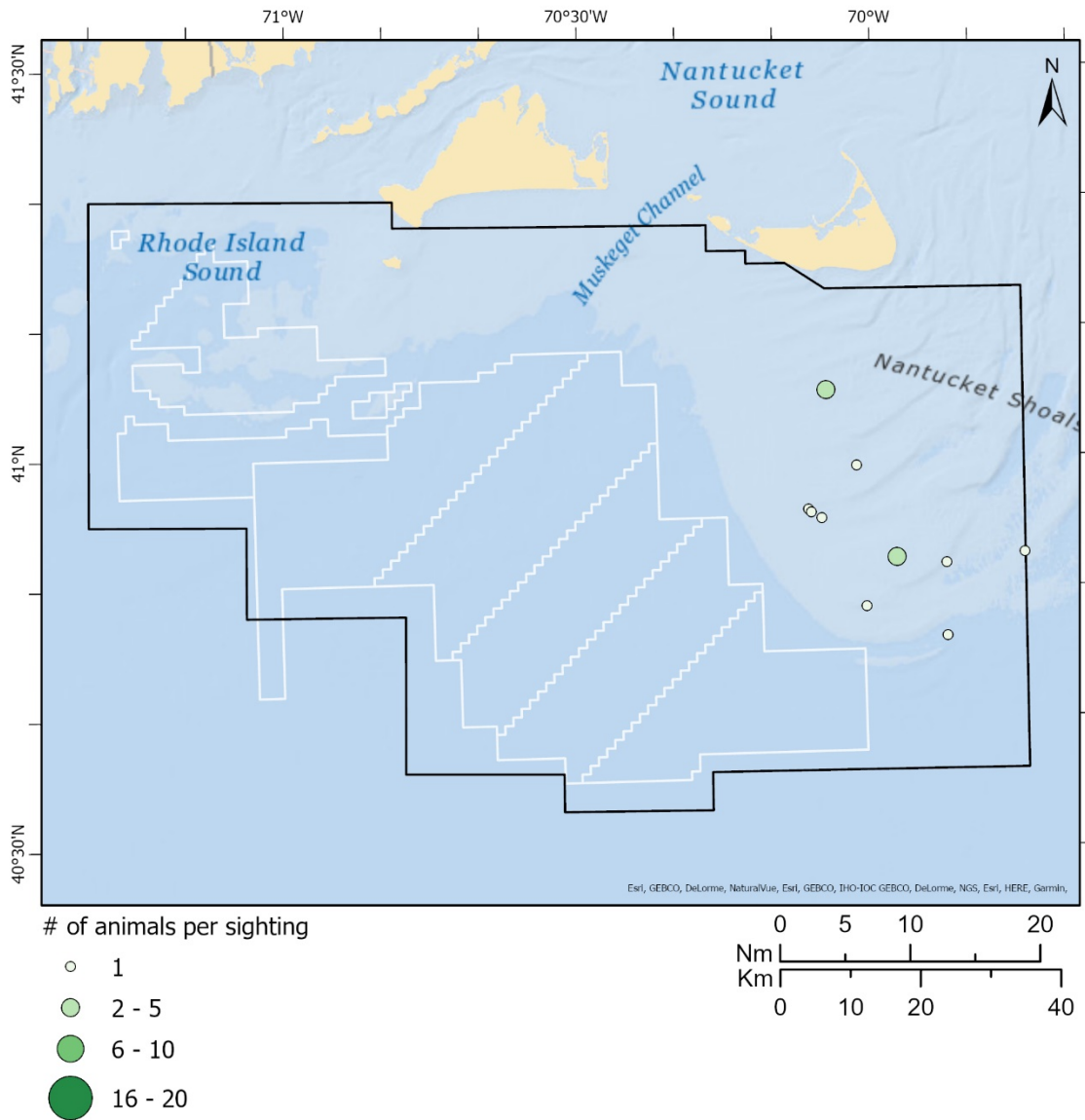


Figure 2. Map of right whale sightings during Campaign 6A aerial surveys

3.1.3.1.1 Abundance estimates

Seasonal density and abundance estimates were calculated for right whales for Campaign 6A (Table 2); estimates were calculated for all three seasons although the spring season consisted of only one survey. Right whale seasonal abundance in the study area was estimated between two (summer) and 17 (fall) animals.

Table 2. Density and abundance of right whales during Campaign 6A by season

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more individual animals. # of animals is the number of individual animals summed over all sightings and transects. Est. density is the estimated number of individuals per km². Est. abundance is the estimated number of individuals for the survey area. 95% CI= 95% confidence interval of abundance. * = sightings present but they did not occur within the truncation distance.

Season-year	Effort (km)	# of detections	# of animals	Est. Density	Est. Abundance	95% CI
Spring – 20	530.5	0	0	0	0	-
Summer – 20	2845.0	1	1	0.0002	1.8	0-9
Fall – 20	1453.7	3	5	0.0019	17	4-77

3.1.3.1.2 Demographic and re-sighting patterns

Preliminary photo analysis identified eight individual right whales during all Campaign 6A surveys. Most right whales were adults (63%, n = 5) and males (75%, n = 6) (Table 3).

Table 3. Number and percentage of different sex and age classes of right whales identified during Campaign 6A aerial surveys

Sex	N	%	Adult	%	Juvenile	%	Age Unknown	%
Male	6	75	5	100	1	50	0	0
Female	1	12.5	0	0	1	50	0	0
Unknown	1	12.5	0	0	0	0	1	100
Total	8	100	5	100	2	100	1	100

Photo identification data has not been confirmed by the NARWC, but preliminary analysis suggests that many of the identified right whales (62.5%, n = 5) were resighted during Campaign 6A surveys. Most whales (n = 4) were resighted only once during Campaign 6A, but one whale was resighted three times (Figure 3). All resightings occurred in either two separate months (n = 7) or three separate months (n = 1).



Figure 3. Right whale catalog #4360 photographed on July 25, 2020

This whale was observed in July, September, and October 2020 by the NEAq aerial survey team (photo taken under NMFS Permit # 19674).

3.1.3.2 Fin whales

Fin whales are the largest baleen whale observed in the study area. During Campaign 6A surveys, 11 sightings totaling 17 fin whales were recorded; three of these sightings totaling four individuals were recorded on effort. Group size ranged from one to six, with an average group size of 1.55 whales. Fin whales were seen exclusively during summer months, and all but one whale was seen during the month of June. The summer sighting rate was 3.19 whales/km. During Campaign 6A, fin whales were mostly sighted in the southern part of the study area (Figure 4).

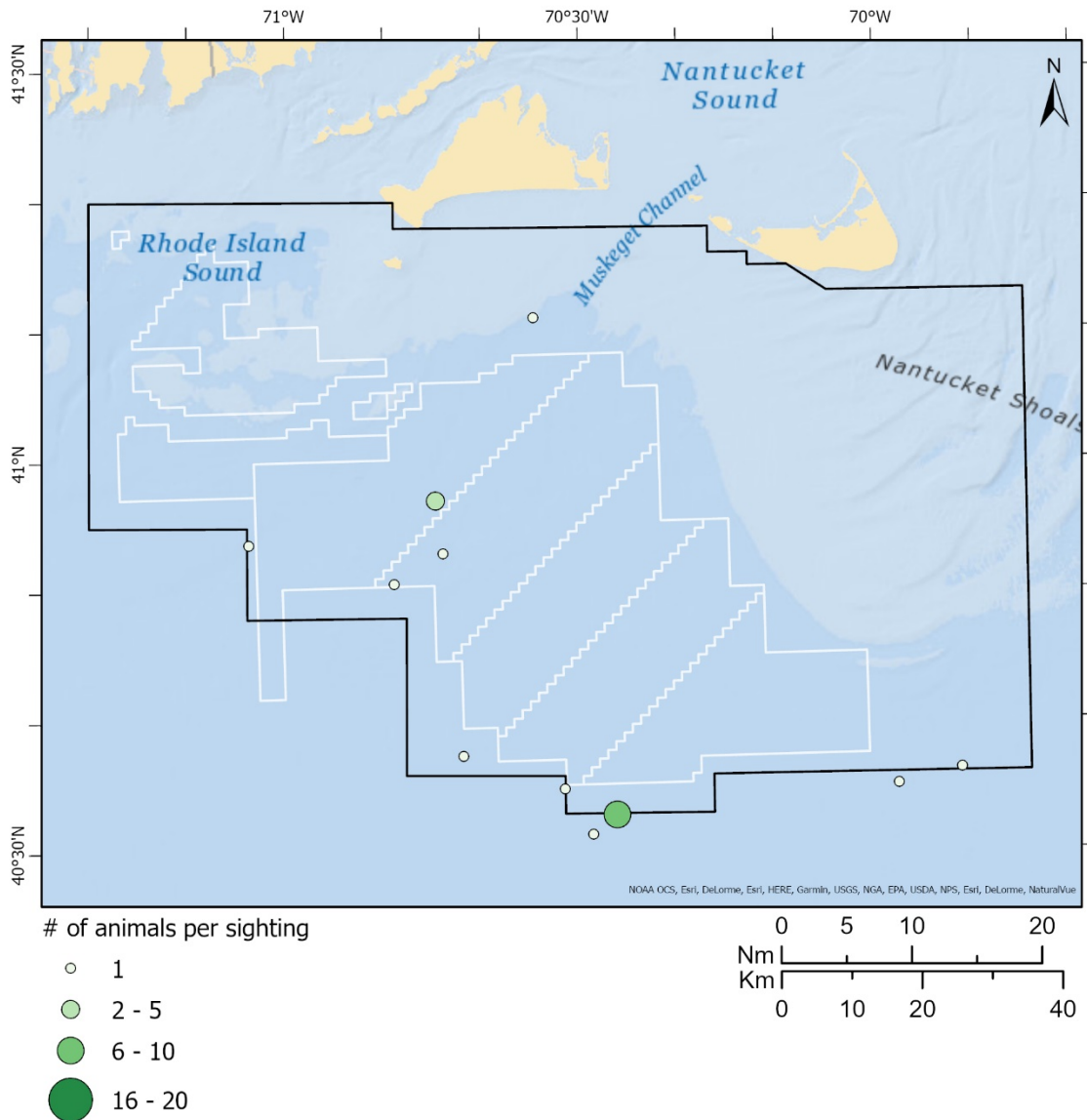


Figure 4. Map of fin whale sightings during Campaign 6A aerial surveys

3.1.3.2.1 Abundance estimates

Seasonal density and abundance estimates were calculated for fin whales for Campaign 6A (Table 4); estimates were calculated for all three seasons although the spring season consisted of only one survey. Fin whales were only detected in the summer – estimated abundance for this season was five whales.

Table 4. Density and abundance of fin whales during Campaign 6A by season

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more individual animals. # of animals is the number of individual animals summed over all sightings and transects. Est. density is the estimated number of individuals per km². Est. abundance is the estimated number of individuals for the survey area. 95% CI= 95% confidence interval of abundance. * = sightings present but they did not occur within the truncation distance.

Season-year	Effort (km)	# of detections	# of animals	Density	Abundance	95% CI
Spring – 20	530.5	0	0	0	0	-
Summer – 20	2845.0	3	4	.0006	5	2-16
Fall – 20	1453.7	0	-	-	-	-

3.1.3.3 Sei whales

No sei whales were observed during Campaign 6A surveys.

3.1.3.4 Minke whales

Minke whales are the smallest baleen whale observed in the study area. During Campaign 6A surveys, 15 sightings totaling 17 whales were recorded (Figure 5); seven whales were recorded on effort during general surveys. Minke whales were sighted in every month during Campaign 6A except March and October. Seasonal sighting rates for minke whales were higher in the summer (3.00 whales/km) compared to the fall (0.36 whales/km). Minke whale sightings were distributed throughout the study area.

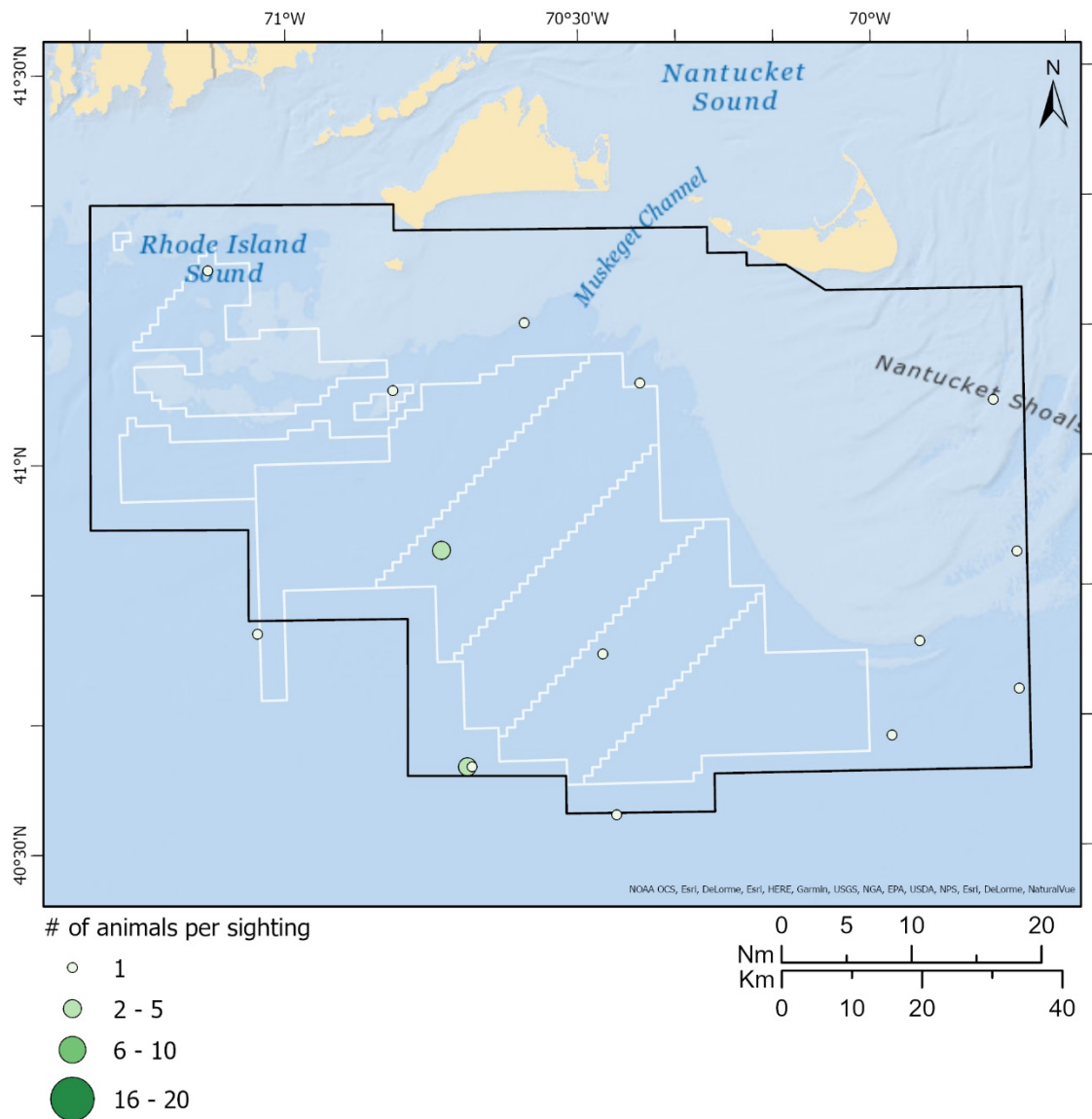


Figure 5. Map of minke whale sightings during Campaign 6A aerial surveys

3.1.3.4.1 Abundance estimates

Seasonal density and abundance estimates were calculated for minke whales for Campaign 6A (Table 5); estimates were calculated for all three seasons although the spring season consisted of only one survey. Minke whale seasonal abundance estimates ranged between five and 14 animals. Abundance was higher in the summer than in the fall.

Table 5. Density and abundance of minke whales during Campaign 6A by season

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more individual animals. # of animals is the number of individual animals summed over all sightings and transects. Est. density is the estimated number of individuals per km². Est. abundance is the estimated number of individuals for the survey area. 95% CI= 95% confidence interval of abundance. * = sightings present but they did not occur within the truncation distance.

Season-year	Effort (km)	# of detections	# of animals	Density	Abundance	95% CI
Spring – 20	530.5	0	0	0	0	-
Summer – 20	2845.0	6	6	0.0016	14	6-33
Fall – 20	1453.7	1	1	0.0005	5	1-27

3.1.3.5 Humpback whales

Humpback whales were the most commonly sighted whale during Campaign 6A. In total, 22 sightings of 44 whales were recorded during all surveys (Figure 6). Nine sightings totaling 12 whales were detected while on effort during general surveys (one of these detections was from the vertical camera). In addition, two humpback carcasses were detected during Campaign 6A, but are not included in these totals.

Humpback whales were sighted in every month surveyed (one whale was detected by the vertical camera during the month of March). Seasonal sighting rates for humpback whales were highest in the summer (7.31 whales/km), followed by fall (1.45 whales/km), and spring (1.39 whales/km). Humpback group size ranged from 1-17, with an average group size of 1.9. The group of 17 was an aggregation of bubble-feeding whales, a cooperative behavior where group size can be much larger than normal. This group was observed during a June survey; the behavior was not recorded on subsequent surveys (Figure 7).

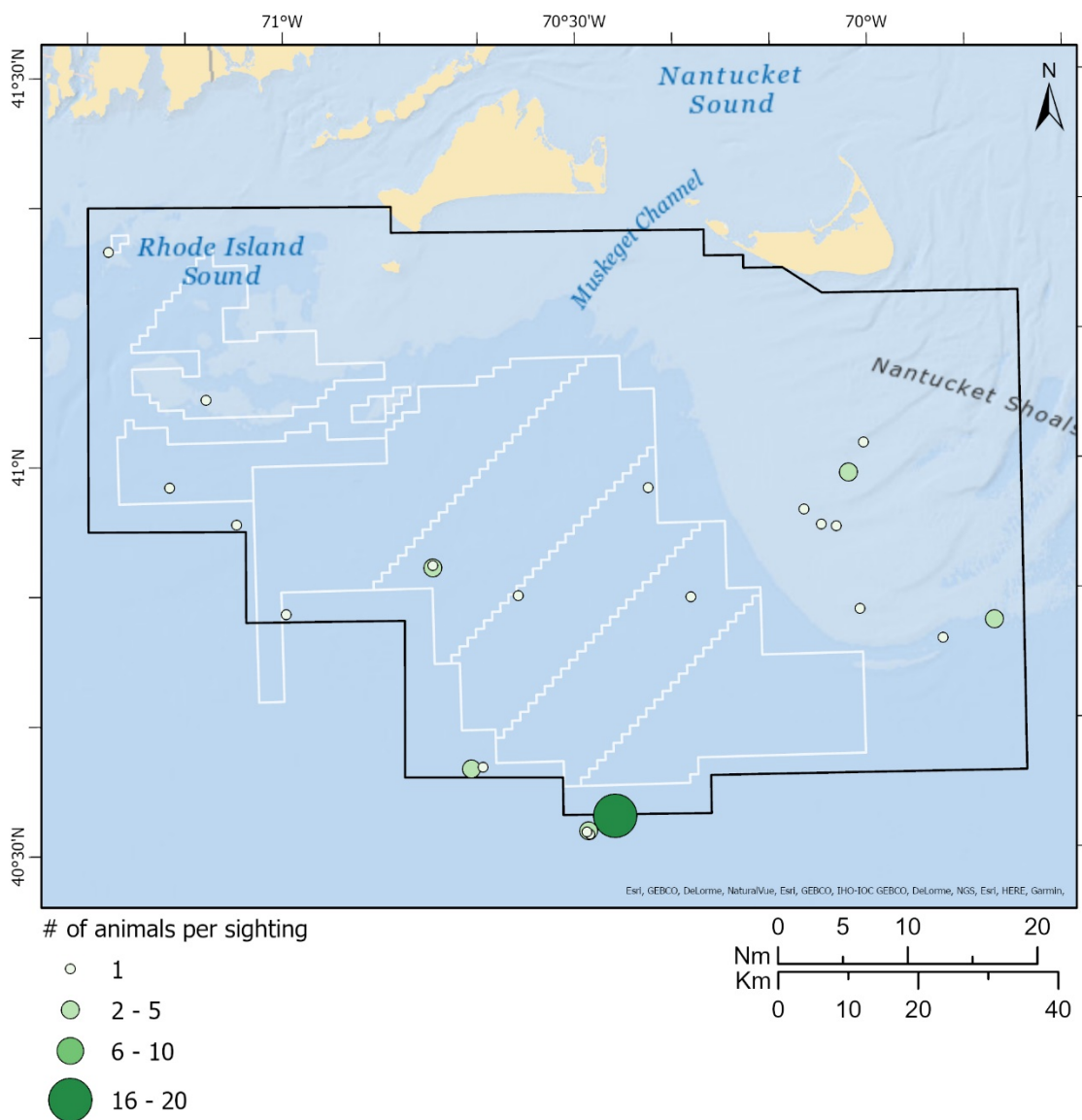


Figure 6. Map of humpback whale sightings during Campaign 6A aerial surveys

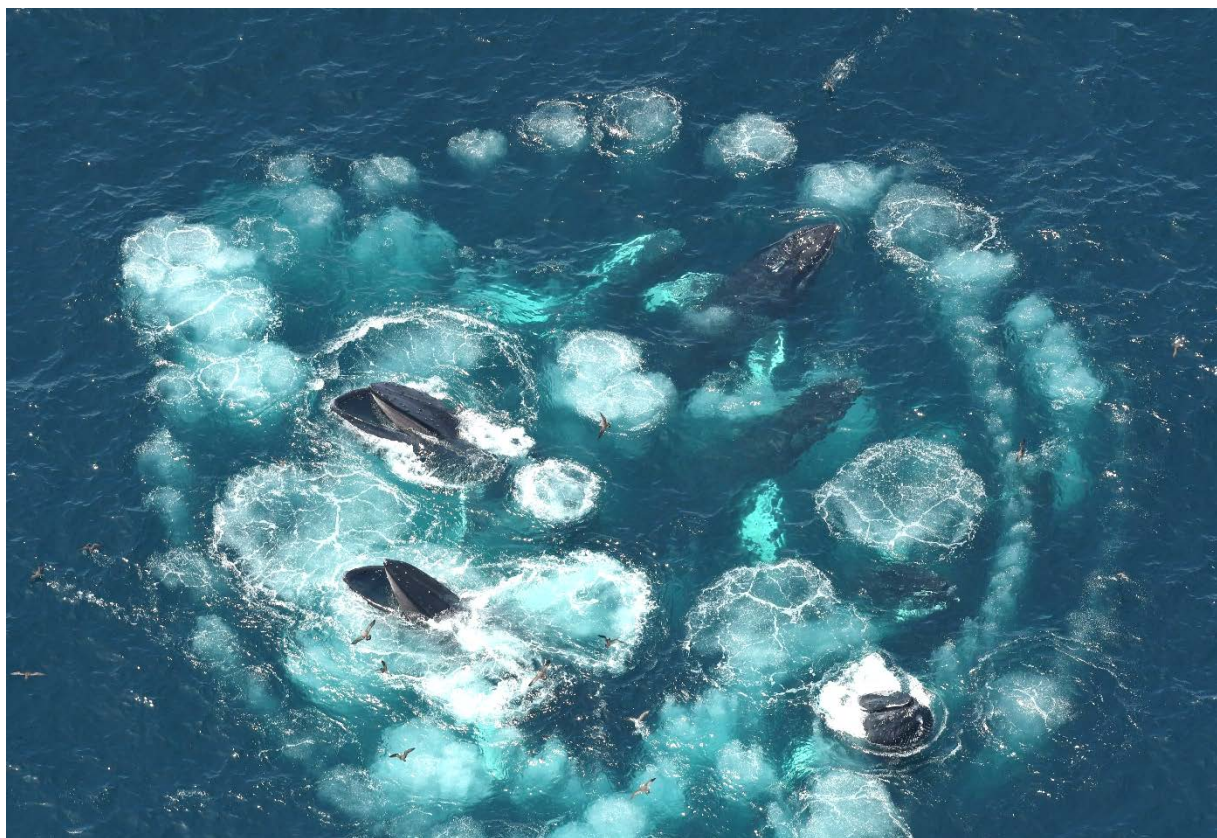


Figure 7. Humpback whales observed bubble-net feeding on June 4, 2020

3.1.3.5.1 Abundance estimates

Seasonal density and abundance estimates were calculated for humpback whales for Campaign 6A (Table 6); estimates were calculated for all three seasons although the spring season consisted of only one survey. Humpback whale seasonal abundance was highest during summer when it was estimated at 14 animals, and lower during the fall (five animals estimated). One humpback was sighted during the spring survey, but it was outside of the truncation distance for the detection function.

Table 6. Density and abundance of humpback whales during Campaign 6A

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more individual animals. # of animals is the number of individual animals summed over all sightings and transects. Est. density is the estimated number of individuals per km². Est. abundance is the estimated number of individuals for the survey area. 95% CI= 95% confidence interval of abundance. * = sightings present but they did not occur within the truncation distance.

Season-year	Effort (km)	# of detections	# of animals	Density	Abundance	95% CI
Spring – 20	530.5	*	*	0	0	-
Summer – 20	2845.0	7	10	0.0015	14	6-30
Fall – 20	1453.7	2	2	0.0006	5	2-20

3.1.3.5.2 Carcass detections

During two Campaign 6A general surveys, there were two humpback whale carcasses detected while on effort. The first carcass was sighted on March 11, 2020 and was approximately 30 nm south of Martha's Vineyard (Figure 8A) and the second carcass was sighted on September 17, 2020 and was approximately 19 nm SW of Nantucket (Figure 8B). Both carcasses had evidence of shark scavenging, especially the second carcass, and there were no obvious signs of injury or cause of death. Coordinates and photos of the carcasses were sent to NMFS after the completion of each aerial survey.



Figure 8. Humpback whale carcasses observed during Campaign 6A aerial surveys

A) Humpback whale carcass observed on March 11, 2020. B) Heavily scavenged humpback whale carcass observed on September 17, 2020.

3.1.3.6 Small cetaceans

3.1.3.6.1 Detections

A total of 46 sightings of 2,022 small cetaceans were recorded during all Campaign 6A surveys. This total includes four sightings by the vertical camera (three sightings totaling 59 common dolphins, and one sighting of a harbor porpoise). Thirty-three of the 46 sightings were on effort during general surveys, totaling 1,220 individuals. Small cetacean sightings accounted for 46% of all cetacean detections (46 of 106 detections) and 56% of on effort cetacean detections (33 of 59 detections). Identification to the species level was possible for 32 sightings and resulted in four confirmed species. Unidentified dolphins accounted for 14 sightings and consisted of small groups of dolphins that the plane did not break track to identify. Four species were identified and belonged to two families: Phocoenidae and Delphinidae. Phocoenidae included harbor porpoises and Delphinidae included short-beaked common dolphins, bottlenose dolphins, and Atlantic white-sided dolphins.

During Campaign 6A surveys, common and bottlenose dolphins were the most commonly detected small cetaceans (41%, n=19 and 22%, n=10, respectively) followed by harbor porpoises (4%, n=2) and white-sided dolphins (2%, n=1). Small cetaceans were detected in larger groups, with group sizes ranging from one to 600 individuals and an average group size of 44.

3.1.3.6.2 Seasonal and geographic patterns

Small cetacean species were sighted in highest numbers during the summer. Common dolphins were seen in all seasons, while bottlenose dolphins were seen only in the summer. There were only two sightings of single harbor porpoise and one sighting of 15 Atlantic white-sided dolphins, all three of which occurred in summer.

Seasonal dolphin sighting rates were highest in the summer (common dolphins, 233.10 dolphins/km; bottlenose dolphins, 90.95 dolphins/km), followed by fall (common dolphins, 65.36 dolphins/km), and spring (common dolphins, 12.47 dolphins/km).

Distribution patterns of dolphin species varied. Common dolphins were seen throughout the study area (Figure 9), whereas bottlenose dolphins were seen only in the southern part of the study area (Figure 10).

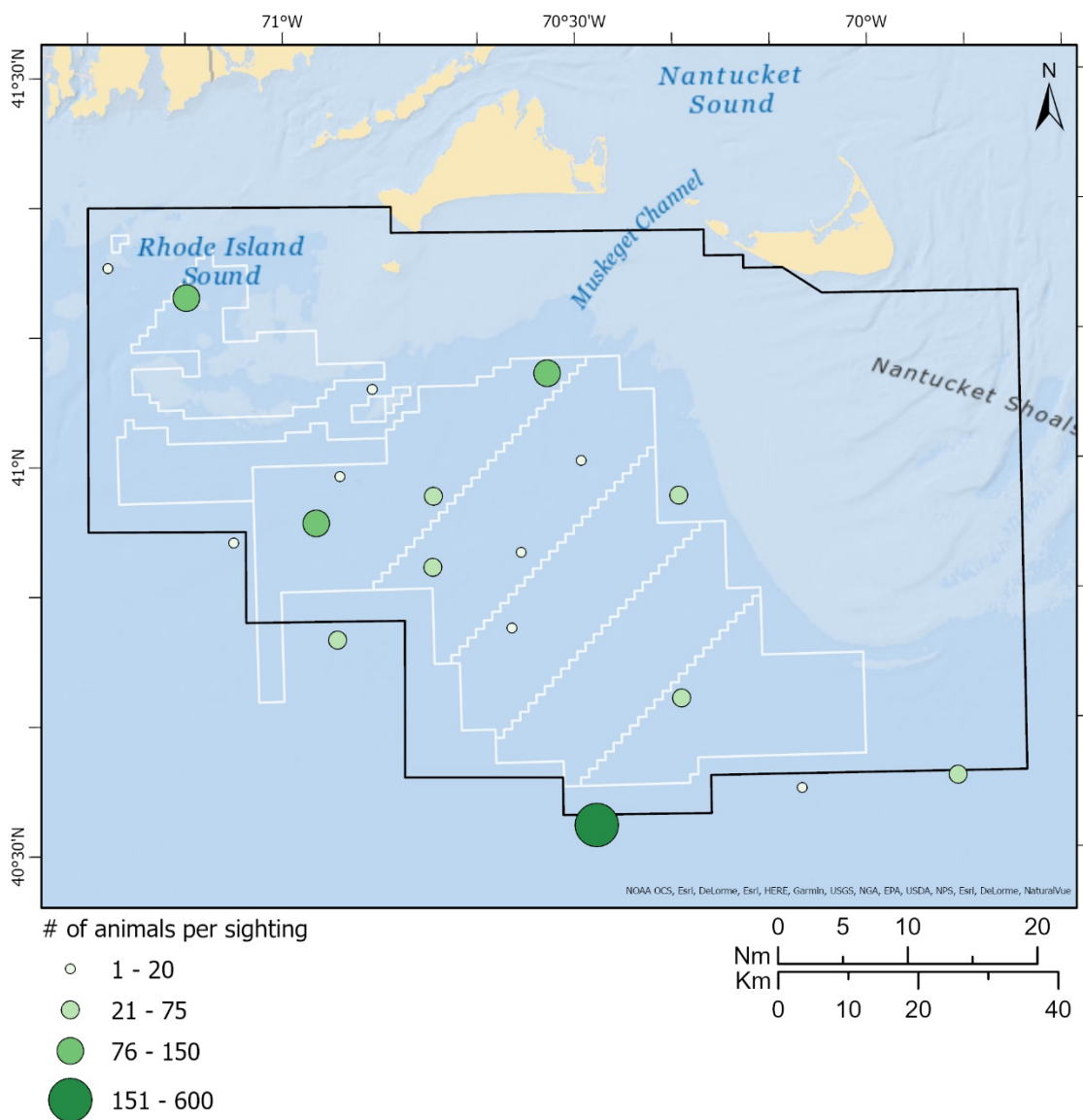


Figure 9. Map of common dolphin sightings during Campaign 6A aerial surveys

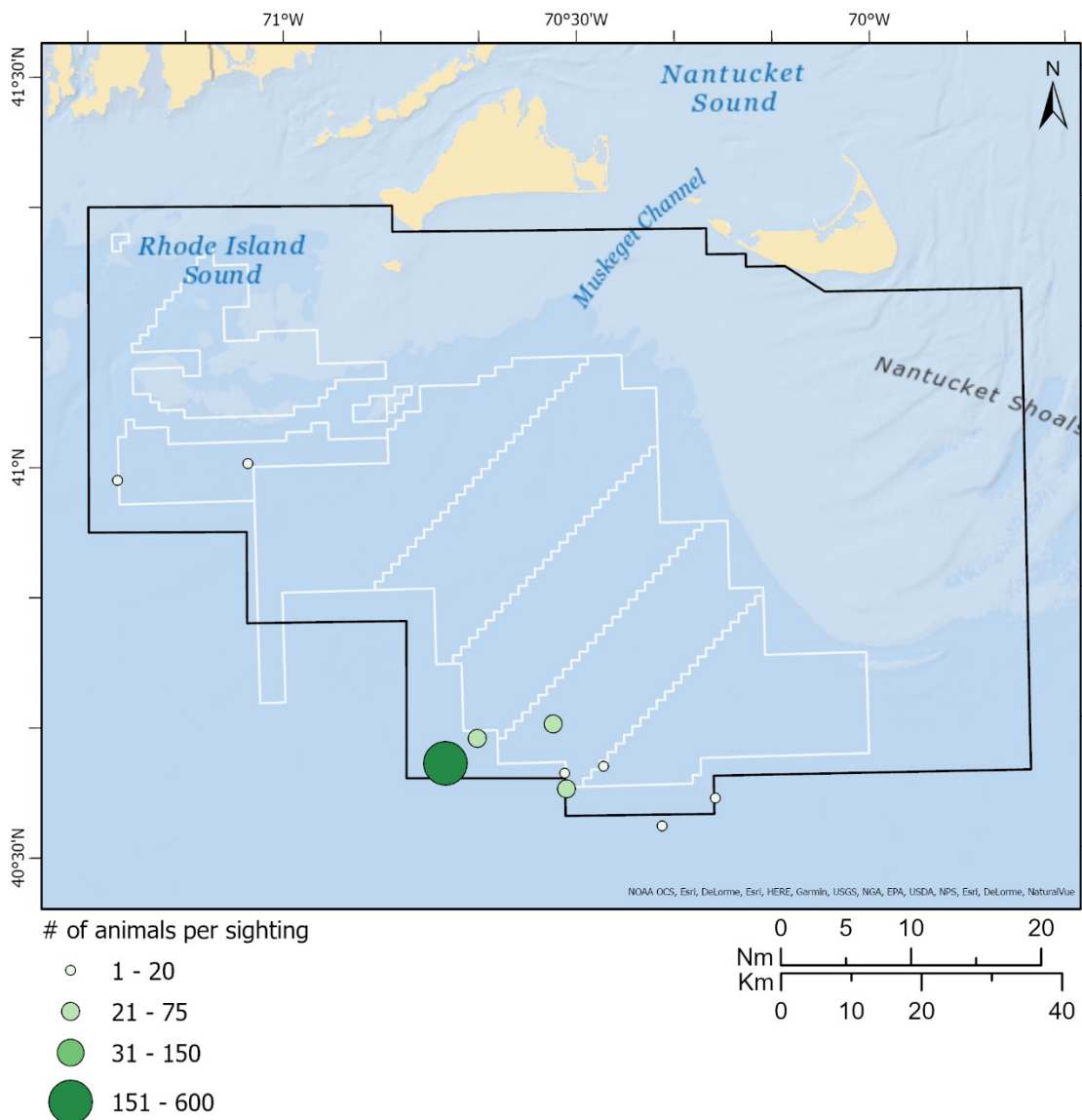


Figure 10. Map of bottlenose dolphin sightings during Campaign 6A aerial surveys

3.1.3.6.3 Abundance estimates

Seasonal density and abundance estimates were calculated for common dolphins for Campaign 6A (Table 7); estimates were calculated for all three seasons although the spring season consisted of only one survey. Common dolphin abundance was higher in the summer (estimated at 732 animals) compared to the fall (estimated at 90 animals). Common dolphins were sighted during the spring survey, but outside of the truncation distance of the detection function.

Table 7. Density and abundance of common dolphins during Campaign 6A

Effort (km) is the summed on-effort distance surveyed for all transects. # of detections is the number of sightings of one or more individual animals. # of animals is the number of individual animals summed over all sightings and transects. Est. density is the estimated number of individuals per km². Est. abundance is the estimated number of individuals for the survey area. 95% CI= 95% confidence interval of abundance. * = sightings present but they did not occur within the truncation distance.

Season-year	Effort (km)	# of detections	# of animals	Density	Abundance	95% CI
Spring – 20	530.5	*	*	0	0	-
Summer – 20	2845.0	7	436	0.0813	732	282-1903
Fall – 20	1453.7	2	30	0.01	90	23-423

3.1.4 Sea turtles

During all Campaign 6A aerial surveys, there were 15 detections of 20 sea turtles recorded, which includes four camera detections of four sea turtles. Three leatherback sea turtles, two loggerhead sea turtles (*Caretta caretta*), and one unidentified sea turtle were observed while on effort during general surveys (three of these sightings were from the vertical camera). The majority of sightings occurred in the fall (80%, n = 12) and only three sightings occurred in the summer, all in July.

Leatherback turtles were sighted on four separate days and all sightings except one were over the Nantucket Shoals. Seasonal sighting rates were higher in the fall (5.81 turtles/km) than the summer (0.19 turtles/km). Only two loggerhead turtles were detected during Campaign 6A; one was in the central part of the study area and the other was near the western side of the study area. Sea turtle sightings were generally in the eastern part of the study area (Figure 11).

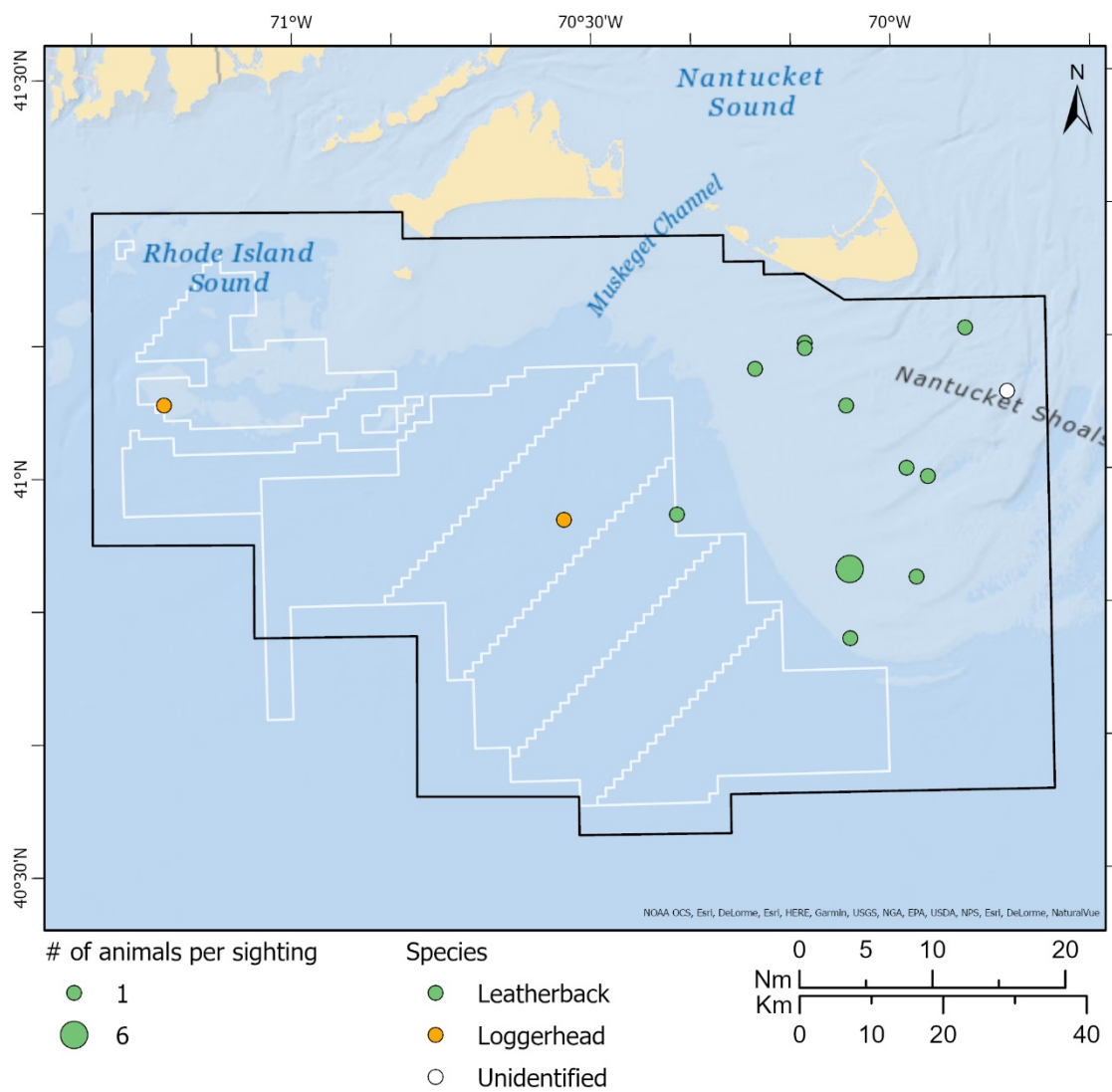


Figure 11. Map of sea turtle sightings during Campaign 6A aerial surveys

3.1.5 Other marine megafauna

Several species of sharks and bony fish were observed during Campaign 6A aerial surveys. During all Campaign 6A aerial surveys, 73 basking sharks (*Cetorhinus maximus*), 12 blue sharks (*Prionace glauca*), 14 hammerhead shark (*Sphyrna* sp.), 149 unidentified sharks, and 91 ocean sunfish (*Mola mola*) were sighted by observers and the camera. The four most common species (basking, blue, and hammerhead sharks, and ocean sunfish) were seen in all parts of the study area (Figure 12), but basking sharks tended to be more common in the southern and southwestern part of the study area. Other sightings of note include a school of 40 bluefin tuna observed in close proximity to bubble-net feeding humpback whales in June and the first tiger shark (*Galeocerdo cuvier*) recorded by the surveys, found as a camera detection in September.

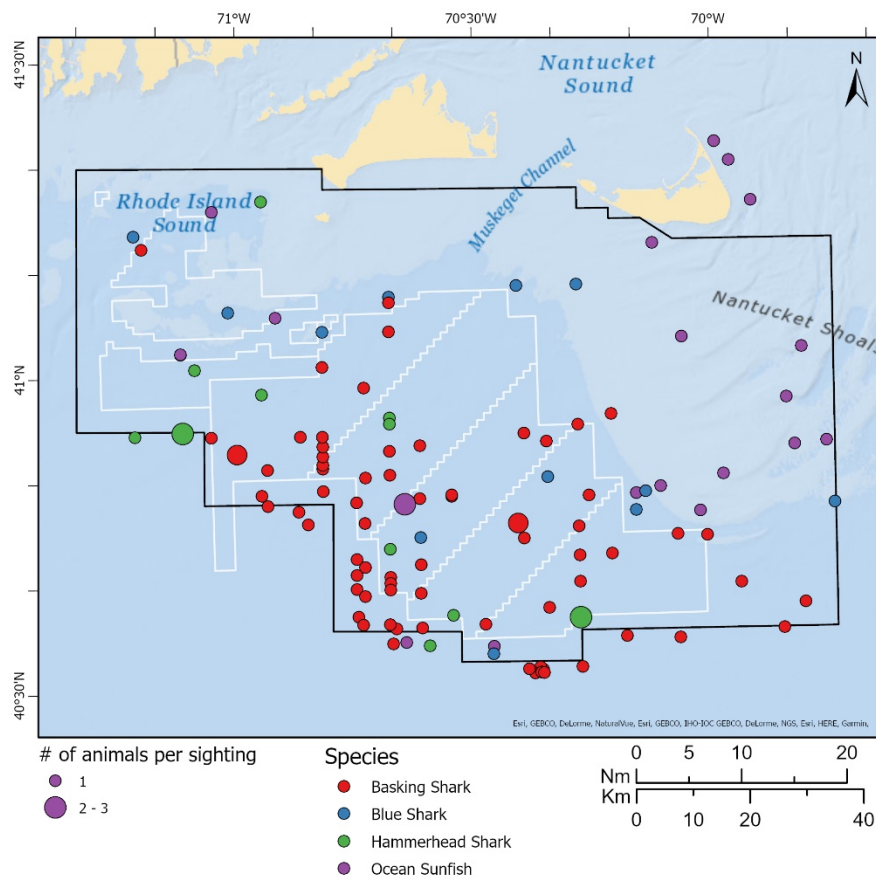


Figure 12. Map of shark and fish sightings during Campaign 6A aerial surveys

4 Discussion

This report represents part of a larger effort to characterize use of the study area by marine megafauna. The short time frame of Campaign 6A makes it difficult to extrapolate results; additionally, the Covid-19 pandemic interrupted the spring season. Although we did complete one survey during early March, we do not believe we can draw meaningful conclusions from the single spring survey. Consequently, the spring season is not included in the remainder of this discussion.

4.1 Cetaceans

Patterns in baleen whale density and sighting rates were largely similar to Campaigns 4 & 5 (O'Brien et. al., 2020, Quintana & Kraus, 2019). Right whale density in summer and fall of 2020 was comparable to densities in recent seasons (summer 2020, 0.0002 whales/km; summer 2017-2019 range 0 – 0.0041 whales/km; fall 2020, 0.0019 whales/km; fall 2017-2018 range 0-0.0016 whales/km). Density was higher in fall than summer, following the same pattern as in the only survey year (2017) when densities could be calculated for both seasons. Summer sighting rates for right whales were lower in Campaign 6A than either Campaigns 4 or 5 and fall sighting rates were higher than fall 2017.

Rorqual density and sighting rates followed previously observed seasonal patterns with some exceptions. Fin whale summer density (0.0006 whales/km) was low compared to previous campaigns (0.0004 – 0.0076 whales/km; Stone et. al., 2017) and was zero in the fall, which is not unprecedented. Humpback whales have not shown any clear patterns in summer and fall densities over Campaigns 1-5. Summer 2020 density was 0.0015 whales/km, which is less than half the highest summer density recorded in 2017 (0.0040 whales/km), but summer density has also been estimated at zero in four summers. Humpback fall density was the highest recorded since 2011—every intervening fall recorded (2012-2015, 2017) has been zero. Minke whale summer density in 2020 (0.0016 whales/km) was similar to other summer densities, with the exception of two high density summers in 2017 and 2019 (0.0087 and 0.0078 whales/km). Interestingly, the fall of 2020 was the first recorded minke whale density estimated at greater than zero in the history of the project. There were no sei whale sightings in Campaign 6A, which is unsurprising because their density and sighting rates tend to be highest in the spring.

Cetaceans were distributed across the study area fairly evenly, with some exceptions. Right whales were only seen over the Nantucket Shoals, a pattern that was also seen in surveys from 2018-2019 (Campaign 5). Bottlenose dolphins were generally only seen in the southern part of the study area, whereas in 2018-2019 (Campaign 5) bottlenose dolphins were more evenly spread across the study area.

4.2 Turtles and fish

The majority of sea turtle sightings during Campaign 6A were during the fall. The Campaign 6A surveys are only the second complete summer to fall transition documented by aerial surveys conducted since 2017, making comparisons among more recent surveys (i.e., from 2017 onward) difficult. Seasonal turtle

sighting rates during Campaign 6A were higher in the fall compared to Campaign 4 (6.17 turtles/km, 1.68 turtles/km respectively), and lower in the summer (0.56 turtles/km, 4.75 turtles/km respectively).

As in previous years, shark, and large bony fish sightings were most common during the summer season. There were no distinct distributional patterns in the most commonly sighted species: basking shark, blue shark, and ocean sunfish. During Campaign 6A, more hammerhead sharks were recorded than during any previous summer season, and more than all previous sightings combined. Fourteen hammerhead sharks were detected, all during the month of July. The previous tally of hammerhead sharks was four in 2012, two in 2014, and one in 2019. While this pattern seems to indicate an upward trend in the use of the wind energy area by this species, we currently do not have enough data to draw that conclusion.

4.3 Conclusions and future work

This report represents part of a larger effort to characterize use of the study area by marine megafauna. The short and fractured time frame of Campaign 6A makes it difficult to extrapolate results. We look forward to combining these results with results from surveys in 2021 to better understand species distribution and abundance. In addition to our surveys, there has been an increase in survey effort in recent years by other aerial teams using different methodology than described here (primarily mark recapture). While comparison and integration of these different techniques is not a simple task, we believe that as multiple groups continue to survey this area it is critical to be able to combine these varied sources of data. As a first step, we plan to compare right whale abundance estimates from line transect and mark recapture methodologies (e.g., Calambokidis & Barlow, 2004).

It is important to note that the Campaign 6A surveys fill an important gap during the summer-fall transition, which is critical for documenting sea turtle presence, and more recently, year-round right whale presence. The fall surveys in 2020 represent only the second time this season has been surveyed since NEAq aerial surveys were resumed in 2017. Surveys are currently funded through the summer of 2021; continued funding to cover the summer-fall transition would provide valuable information on sea turtle and right whale presence.

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Appendix A: Aerial Sightings

Table A-1. Summary of all on effort aerial observer and vertical photograph detections of marine megafauna during Campaign 6A general surveys.

Category	Species	Observers		Vertical photos		Totals	
		Number of detections	Number of individuals	Number of detections	Number of individuals	Number of detections	Number of individuals
Small cetaceans	Bottlenose dolphin (<i>Tursiops truncatus</i>)	8	461	--	--	8	461
	Common dolphin (<i>Delphinus delphis</i>)	10	616	1	50	11	666
	Harbor porpoise (<i>Phocoena phocoena</i>)	1	1	1	1	2	2
	White-sided dolphin (<i>Lagenorhynchus acutus</i>)	1	15	--	--	1	15
	Unidentified dolphin	11	76	--	--	11	76
Large cetaceans	Fin whale (<i>Balaenoptera physalus</i>)	3	4	--	--	3	4
	Minke whale (<i>Balaenoptera acutorostrata</i>)	7	7	--	--	7	7
	Humpback whale (<i>Megaptera novaeangliae</i>)	8	11	1	1	9	12
	Right whale (<i>Eubalaena glacialis</i>)	5	7	--	--	5	7
Pinnipeds	Unidentified seal	3	3	--	--	3	3
Sea turtles	Leatherback sea turtle (<i>Dermochelys coriacea</i>)	1	1	2	2	3	3
	Loggerhead sea turtle (<i>Caretta caretta</i>)	1	1	1	1	2	2
	Unidentified sea turtle	1	1	--	--	1	1

Table A-1 continued. Summary of all on effort aerial observer and vertical photograph detections of marine megafauna during Campaign 6A general surveys

Category	Species	Observers		Vertical photos		Totals	
		Number of detections	Number of individuals	Number of detections	Number of individuals	Number of detections	Number of individuals
Sharks and fish	Basking shark (<i>Cetorhinus maximus</i>)	49	51	5	5	54	56
	Blue shark (<i>Prionace glauca</i>)	5	5	6	6	11	11
	Hammerhead shark (<i>Sphyrna</i> sp.)	5	6	3	3	8	9
	Ocean sunfish (<i>Mola mola</i>)	41	46	8	8	49	54
	Tiger shark (<i>Galeocerdo cuvier</i>)	--	--	1	1	1	1
	Unidentified shark	60	96	24	30	84	126
	Unidentified tuna	--	--	1	1	1	1

Table A-2. Summary of on and off effort aerial observer and vertical photograph detections during all Campaign 6A aerial surveys

Category	Species	Observers		Vertical photos		Totals	
		Number of detections	Number of individuals	Number of detections	Number of individuals	Number of detections	Number of individuals
Small cetaceans	Bottlenose dolphin (<i>Tursiops truncatus</i>)	10	485	--	--	10	485
	Common dolphin (<i>Delphinus delphis</i>)	16	1,373	3	59	19	1,432
	White-sided dolphin (<i>Lagenorhynchus acutus</i>)	1	15	--	--	1	15
	Harbor porpoise (<i>Phocoena phocoena</i>)	1	1	1	1	2	2
	Unidentified dolphin	14	88	--	--	14	88

Table A-2 continued. Summary of on and off effort aerial observer and vertical photograph detections during all Campaign 6A aerial surveys

Category	Species	Observers		Vertical photos		Totals	
		Number of detections	Number of individuals	Number of detections	Number of individuals	Number of detections	Number of individuals
Large cetaceans	Fin whale (<i>Balaenoptera physalus</i>)	11	17	--	--	11	17
	Minke whale (<i>Balaenoptera acutorostrata</i>)	15	17	--	--	15	17
	Humpback whale (<i>Megaptera novaeangliae</i>)	21	43	1	1	22	44
	Right whale (<i>Eubalaena glacialis</i>)	10	15	--	--	10	15
	Unidentified whale	2	4	--	--	2	4
Pinnipeds	Unidentified seal	6	504	--	--	6	504
Sea turtles	Leatherback sea turtle (<i>Dermochelys coriacea</i>)	9	14	3	3	12	17
	Loggerhead sea turtle (<i>Caretta caretta</i>)	1	1	1	1	2	2
	Unidentified sea turtle	1	1	--	--	1	1
Birds	Great Black-backed gull (<i>Larus marinus</i>)	--	--	3	3	3	3
	Great shearwater (<i>Ardenna gravis</i>)	--	--	3	3	3	3
	Unidentified bird	--	--	216	921	216	921

Table A-2 continued. Summary of on and off effort aerial observer and vertical photograph detections during all Campaign 6A aerial surveys

Category	Species	Observers		Vertical photos		Totals	
		Number of detections	Number of individuals	Number of detections	Number of individuals	Number of detections	Number of individuals
Sharks and fish	Basking shark (<i>Cetorhinus maximus</i>)	64	66	7	7	71	73
	Blue shark (<i>Prionace glauca</i>)	6	6	6	6	12	12
	Hammerhead shark (<i>Sphyrna</i> sp.)	6	7	5	7	11	14
	Bluefin tuna (<i>Thunnus thynnus</i>)	1	40	--	--	1	40
	Ocean sunfish (<i>Mola mola</i>)	63	73	18	18	83	91
	Schools of fish	6	6	6	6	12	12
	Unidentified fish	--	--	3	3	3	3
	Unidentified shark	76	114	29	35	105	149
	Unidentified tuna	--	--	1	1	1	1
Human activity	Debris (different types)	3	3	171	183	174	186
	Fixed fishing gear	439	623	24	24	472	656
	Fishing vessel	158	163	--	--	158	163
	Recreational vessel	145	204	--	--	145	204
	Other types of vessels/data stations/coast guard	66	66	--	--	66	66
Unknown	Unidentified animal	2	2	--	--	2	2



Department of the Interior (DOI)

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.



Bureau of Ocean Energy Management (BOEM)

The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program

The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM's Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).