MEGAFAUNA AERIAL SURVEYS
IN THE WIND ENERGY AREAS OF MASSACHUSETTS AND RHODE ISLAND
WITH EMPHASIS ON LARGE WHALES
Summary Report Part 1: Sightings and Data – Campaign 5, 2018-2019

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BACKGROUND

Beginning in 2013, the Bureau of Ocean and Energy Management (BOEM) designated two wind energy areas in New England: one offshore of Massachusetts and the other offshore of both Rhode Island and Massachusetts (together, the WEA). Currently, four offshore wind developers have lease agreements to build projects in the BOEM designated Massachusetts (MA) and the Rhode Island/Massachusetts (RIMA) wind energy areas. In August 2016, the Governor of Massachusetts, Charles Baker, signed energy diversity legislation that requires Massachusetts utilities to initiate a procurement of up to 1,600 megawatts of offshore wind energy by June 30, 2017. The procurement amount was increased to 3,200 megawatts in 2019. As of July 2020, utilities in Massachusetts, Rhode Island, Connecticut and New York have contracted to purchase the output from over 4,000 megawatts of offshore wind from the WEAs, with additional procurements planned and in process.

Under the National Environmental Policy Act of 1969 (42 U.S.C. 4371 et seq.), BOEM and other relevant federal agencies are required to integrate environmental assessments into offshore development and construction plans. Offshore wind energy planning and development requires comprehensive assessments of biological resources within suitable development areas to identify and mitigate any potential effects of that development on marine species.

In anticipation of these requirements, the Massachusetts Clean Energy Center (MassCEC), used a competitive procurement process in early 2011 to select a team led by the New England Aquarium (NEAq) to conduct aerial and acoustic surveys of endangered whales and turtles in the MA WEA. Upon conclusion of these initial surveys (Campaign 1), MassCEC and BOEM extended the surveys for an additional two years and expanded the geographic scope of the survey area to include the RIMA WEA (Campaigns 2 and 3). For these three survey campaigns, 76 aerial surveys were conducted between October 2011 and June 2015.

The final report summarizing Campaigns 1-3, released on October 25, 2016, showed that the study area included seasonal aggregations of protected species of whales, sea turtles, and seabirds. It also showed that North Atlantic right whales (*Eubalaena glacialis*), a critically endangered species, occurred in the study area during winter and spring, with a peak in March. Based on these findings, the report provided recommendations for managing geological surveys and construction by scheduling those activities during off-peak right whale seasons to mitigate or avoid impacts. The 2016 final report also provided recommendations for additional surveys to address information gaps and for the collection of additional baseline data.

Acting upon the recommendations in the 2016 final report, MassCEC contracted with NEAq to conduct additional surveys for the period February 2017 through July 2018 (Campaign 4). A further report summarizing Campaign 4 was released in fall of 2018. This report showed continued usage of the study area by protected species of whales and sea turtles. The Campaign 4 report also showed an increase in the number of right whales in the study area and that right whales occurred in the study area throughout the year. To further understand species distribution and abundance patterns in the study area, additional aerial surveys using both observer sightings and automated vertical photography were conducted from October 2018 to August 2019 (Campaign 5).

As part of Campaign 4 and under sub-contracts to NEAq, the Woods Hole Oceanographic Institution (WHOI), in coordination with the Provincetown Center for Coastal Studies, conducted oceanographic surveys from February to May 2017 to assess the physical and biological characteristics of waters used by right whales in the study area. Right whales visit the study area annually during winter and spring, but little is known about why they come to this region. One hypothesis is that they use the region as a feeding habitat, but very few zooplankton samples have been collected in the area for the express purpose of determining right whale prey species and the life history, distribution, and abundance of those prey species. In response to this knowledge gap, WHOI conducted oceanographic and zooplankton sampling in the northern region of the study area during the winter and spring of 2019.

RESEARCH OBJECTIVES

1. Estimate distribution and relative abundance of large whales (with a focus on right, humpback, fin, and minke whales) and turtles in the Massachusetts (MA) and the Rhode Island/Massachusetts (RIMA) wind energy areas (WEA).
2. Assess prey species and oceanographic conditions near right whale aggregations in the WEA.

This report, Part 1: Sightings and Data**,** includes preliminary results from the Campaign 5 surveys in the study area conducted from October 2018 to August 2019. These preliminary results include a list and description of survey flights and summaries of cetacean and other marine megafauna sightings. These preliminary results do not account for survey effort; effort corrected patterns will be presented in part two of the report. This report also includes a list and description of oceanographic surveys and oceanographic data collected, and a preliminary assessment of right whale prey species and oceanographic conditions near right whale aggregations.

METHODS

1. AERIAL SURVEYS

During the period of performance between October 2018 and August 2019, four 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).

- General surveys were standardized line-transect surveys that were conducted on a monthly basis and covered the waters of the study area (5,811 km^2), including the MA and RIMA WEA. 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 10 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 (Figures 1C and 1D) and were compromised 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 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.
- Opportunistic surveys were flown in response to reports of right whales near shore or to provide aerial support to oceanographic sampling of right whale aggregations. Opportunistic surveys were short and did not use planned tracklines.

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 ≥ 2,000 ft, and visibility was ≥ 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.

1.2 Sightings: observers and vertical photography

Observers recorded sightings according to the North Atlantic Right Whale Consortium (NARWC) Database guidelines (Kenney 2010). 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 ⅛, ⅛ to ¼, ¼ to ½, ½ 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.

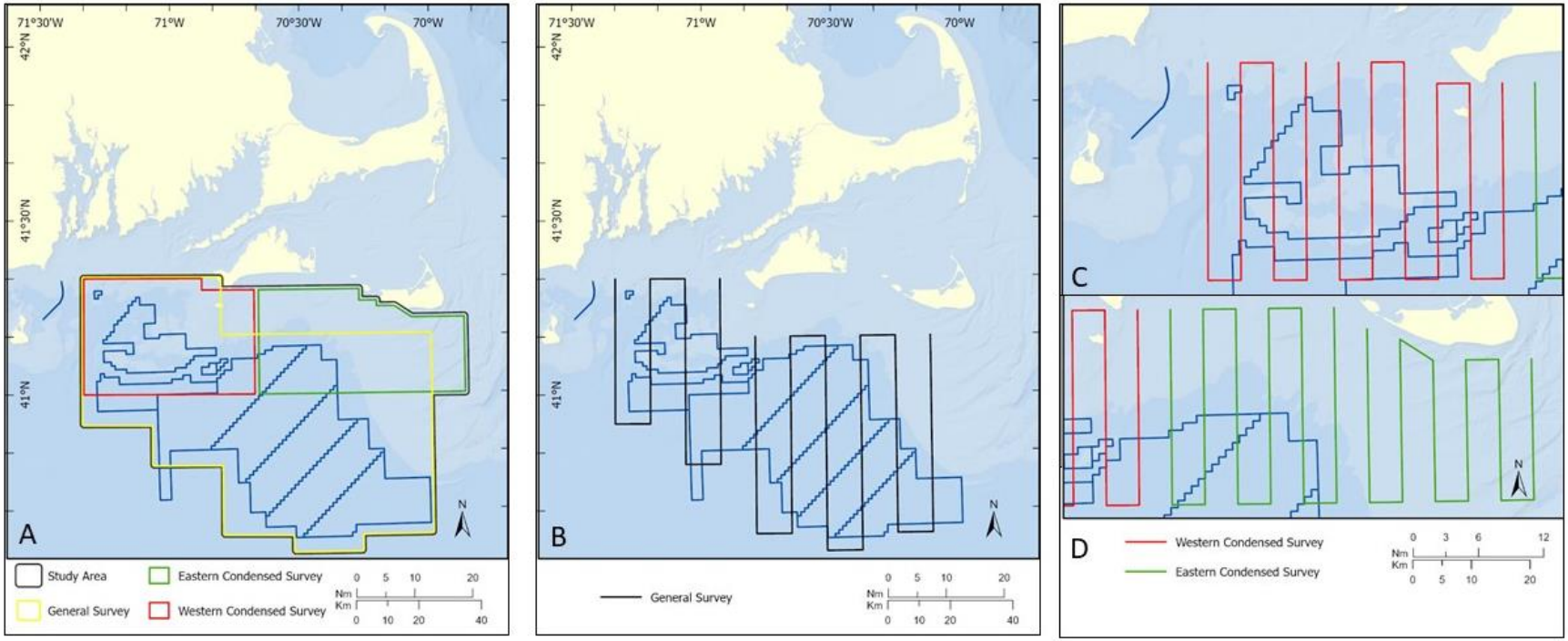

Figure 1. A) Study area (black outline) in the offshore waters of Massachusetts and Rhode Island. The area covered by general surveys is depicted by a yellow polygon and areas covered by condensed surveys are depicted by a red (western side) and a green (eastern side) polygon. Examples of a B) general survey (tracklines are shown for option 1), C) western survey (tracklines are shown for option 1), and D) eastern survey (tracklines are shown for option 1). Note: Existing lease areas are depicted in blue.

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 type of flight leg (transit, transect, cross-leg, or circling), 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 (+/- 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, opportunistic, and directed survey sightings are not used to estimate abundance. Sightings must be observed while on transect; consequently, sightings during transit, cross-leg, or circling are not used 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 5 surveys. On effort photographs were additionally scrutinized for smaller objects, such as small fish, birds, debris, and fishing gear.

1.3 Right whale photo-identifications

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; Figure 2). When photographic documentation was complete, the aircraft returned to the transect at the point of departure for that sighting and resumed the survey.

Figure 2. NEAq observer taking photographs during a whale sighting.

1.4 Right whale photographs and demographics

Right whale images were uploaded and processed in the NARWC Catalog (Hamilton et al. 2007) and were compared to catalogued right whales to identify individuals. Once matched, demographics information such as sex, age, and reproductive status were added to sighting information.

2. OCEANOGRAPHIC SAMPLING

2.1 Sampling design

Zooplankton and oceanographic sampling occurred at four standard stations (Table 1, Figure 3) as well as at stations adaptively located near North Atlantic right whales (right whale sampling stations). The standard stations were located in the northern part of the study area to allow our sampling platforms, the F/V Sea Holly and the R/V Tioga based in Woods Hole, Massachusetts, to visit all of the stations and conduct additional adaptive sampling in a single day. We chose to sample at four stations distributed in the northern part of the study area to understand spatial variability in zooplankton distribution. These standard stations were identical to those used for zooplankton and oceanographic sampling by WHOI during the winter and spring of 2017.

Table 1. Standard station locations.

Station	Latitude	Longitude
1	41 08.8185 N	70 56.6727 W
2	41 01.9200 N	70 42.4440 W
3	41 07.8240 N	70 34.3920 W
4	41 13.7460 N	70 26.2680 W

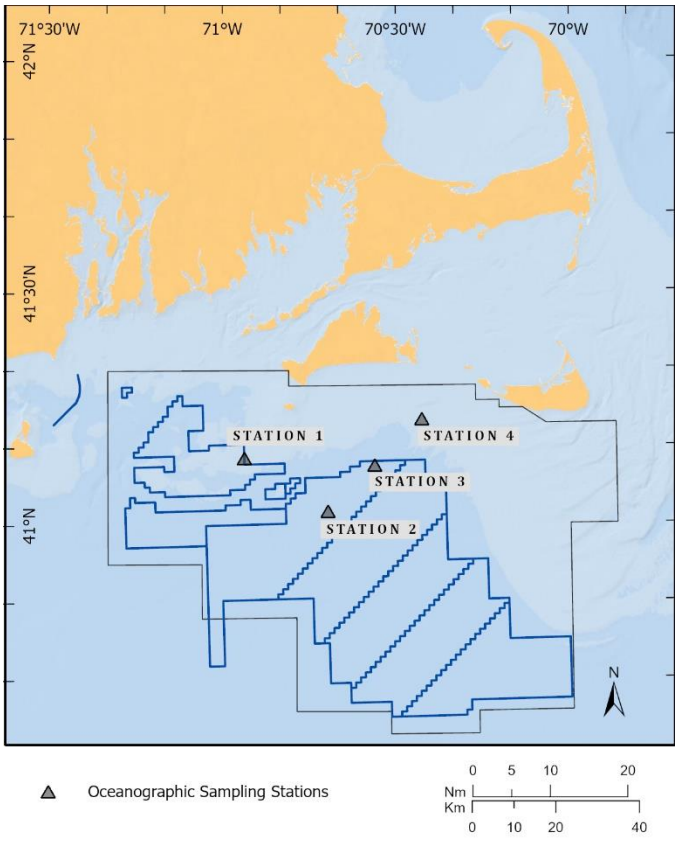

Figure 3. Location of four standard stations in the northern region of the study area.

Two types of survey trips were used: (1) full sampling trips that allowed sampling at all four standard stations and if available, sampling at two right whale sampling stations, and (2) right whale sampling trips that sampled at Station 1 and only at right whale sampling stations thereafter. Sampling trips were closely coordinated with the New England Aquarium aerial survey team and the NOAA Northeast Fisheries Science Center small boat team, who sometimes accompanied us to sea. Both of these groups were surveying for right whales and alerted us to the presence of right whales so that we could sample near them.

At each station, zooplankton were collected throughout the water column with a 70-cm ring net towed from near the sea floor to the surface. In addition to the net sampling, two vertical profiles of temperature, salinity, chlorophyll fluorescence (a rough measure of phytoplankton abundance), and zooplankton distribution and abundance were collected with an instrument package consisting of a conductivity-temperature-depth (CTD) instrument equipped with a chlorophyll fluorometer and an optical plankton counter (OPC). The OPC data are used to determine the vertical distribution and abundance of late-stage *Calanus finmarchicus*, the primary prey of right whales in all spring/summer habitats.

2.2 Net sampling

Zooplankton net sampling was conducted with a 70-cm ring net outfitted with 333-micron mesh net hauled obliquely between the surface and the sea floor. A General Oceanics flowmeter was suspended in the middle of the ring net, and a Seabird SBE39 telemetering temperature-pressure instrument was affixed to the net tow cable to allow the net to sample close to the sea floor. Collected animals were transferred from the net cod end to a 333-micron (or smaller) mesh sieve, and then to a 1-liter sample jar. The sample was preserved with 50 ml of buffered formalin. After the field season, all samples were sent to the Atlantic Sorting Center at the Huntsman Marine Science Center in New Brunswick, Canada for enumeration.

2.3 Oceanographic observations

Vertical profiles of temperature, conductivity (from which salinity is derived), and chlorophyll fluorescence were collected at each sampling station with a conductivity-temperature-depth (CTD) instrument (Figure 4). The instrument was also equipped with a chlorophyll fluorometer, which provides a relative measure of phytoplankton abundance.

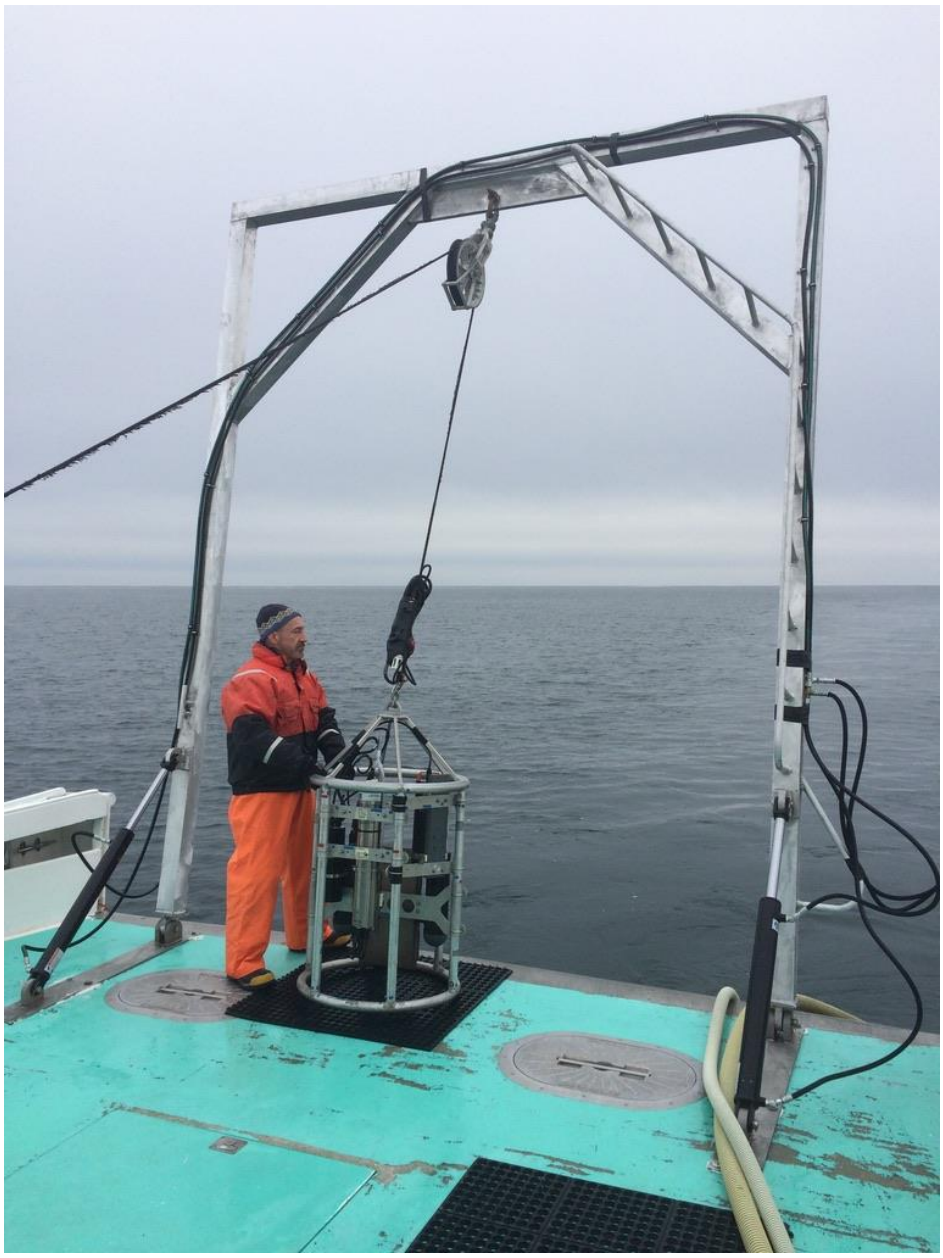

Figure 4. WHOI technician Phil Alatalo prepares to deploy the instrument package containing the conductivity-temperature-depth (CTD) instrument from the stern of the F/V *Sea Holly* on a delightfully calm day at sea in February 2019.

RESULTS

1. AERIAL SURVEYS

1.1 Field effort

A total of 40 aerial surveys were completed in 11 months between October 2018 and July 2019 (Table 2). Specifically, 11 general surveys totaling 68.5 hours of flight time were conducted on a monthly basis from October 2018 to July 2019, 12 condensed surveys totaling 43.4 hours of flight time were conducted from March to July 2019, 16 directed surveys totaling 71.4 hours of flight time were conducted from January to August 2019, and one opportunistic survey totaling 2.5 hours of flight time was flown in July 2019. No surveys were aborted; one general survey was split across two days (six days apart) after daylight restrictions on the first day required the plane to land prior to completing survey. General surveys took an average of 6.1 h (range = 4.5 – 7.5 h; values exclude the split survey), condensed surveys took an average of 3.6 h (range = 3.3 – 5.6 h), and directed surveys took an average of 4.5 h (range = 0.9 – 6.6 h). The total time and the total distance flown for all aerial surveys combined were approximately 185.8 h and 27,298.28 km, respectively (Table 2). During Campaign 5, 106,208 vertical photographs were taken by the vertical camera and 9,937 handheld photographs were taken by aerial observers for a total of 116,145 photographs.

1.2 Detections

Sightings and detections for Campaign 5 are split into two main categories: 1) sightings that can be incorporated into abundance estimates (on effort) and 2) all sightings during general, condensed, directed, and opportunistic surveys. For each species or group of species, sightings maps are provided for both categories; if sightings for a species occurred only on effort or only off effort, a single sightings map is provided.

On effort detections

A total of 409 sightings of marine megafauna (n = 1,924 individuals) were recorded, including both observer (81%, n = 331) and camera (19%, n =78) detections (Table 3). Identification to the species level was possible for 317 sightings and resulted in 15 confirmed species: ten cetacean, two shark, one fish, and two sea turtle. Marine mammals were seen frequently, representing 44% of detections (n = 178) and 87% of all individuals tallied (n=1,684 individuals). Sharks/fish were seen more often (56% of detections, n =229), but in lower numbers (12% of individuals detected, n = 238). The remaining two detections were of two individual sea turtles.

All detections

A total of 3,124 detections of marine fauna (46.0%), human activity (41.2%), natural debris (10.4%), and unknown objects (2.4%) were observed during all Campaign 5 aerial surveys. Of these detections, 70% (n = 2,191) were observer detections and 30% (n = 933) were camera detections.

There were 1,436 detections of marine fauna totaling 10,940 individuals of 17 species (Table 4). 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 (68%, n = 7,479),

followed by birds (25%, n = 2,727), sharks/fish (7%, n = 726), and sea turtles (<1%, n = 8). The majority of marine mammal sightings were cetaceans (84%) and the rest were pinnipeds. Two additional species were detected only off effort: pilot whales and sei whales. Birds were typically not marked by observers in the plane; consequently, reported sightings of birds are exclusively camera detections.

There were 1,670 observer and camera detections of human activity (80%) and natural debris (20%) during all Campaign 5 surveys (Table 4). Debris detections are exclusively camera detections. Natural debris consisted mostly of floating sargassum and wood. The majority of human activity detections were related to commercial fishing (78%), which included fixed fishing gear and vessels that were transiting or actively fishing. Other types of vessels such as Coast Guard, merchant, and research vessels accounted for 8% of the human activity observed, while recreational vessels and anthropogenic debris each accounted for 7%.

The analysis of the vertical photographs from all surveys resulted in 520 detections of 4,677 animals and 404 detections of natural debris or human activity. Eleven species of marine megafauna (not including birds) were identified to the species level from vertical photographs.

For additional sighting information referring specifically to opportunistic and directed surveys or complete sighting information for general and condensed surveys including off effort sightings, please refer to the Appendix.

Table 2. Summary of the aerial survey effort during Campaign 5. "Other Surveys" include condensed, directed, and opportunistic surveys. Note: W = west, E = east, NA = Not applicable. A blank in the Day column means that the survey was conducted on the day listed in the row above. * Airtime and flight length combined.

Year	Month	General Surveys						Other Surveys					
		Total	Day	Direction	Option	Airtime (hrs)	Flight Length (km)	Total	Day	Direction	Option	Airtime (hrs)	Flight Length (km)
2018	October	1	26	W → E	1	5.1	905.63						
	November	1	24	E → W	7	5.1	723.76						
			30	W → E	7	2.7	423.74						
	December	2	1	E → W	8	7	974.52						
			20	E → W	8	6.3	846.92						
2019	January	1	15	W → E	8	6.4	975.08	2	13	E → W	NA	6.6	698.76
									27	W → E	NA	5	580.6
	February	1	4	E → W	7	5.8	924.51	3	3	W → E	NA	5.5	676.91
									11	E → W	NA	4.5	770.8
									17	W → E	NA	5	650.05
	March	1	28	E → W	3	4.5	685.43	3	18	W → E	NA	4.7	641.72
									27	W → E	3W	6	916.37
										W → E	3E	*	*
	April	1	7	W → E	7	6.1	876.00	5	2	E → W	4E	4.3	661.16
									7	W → E	NA	0.9	159.46
									25	W → E	3W	3.7	546.34
										W → E	3E	3.5	567.27
									29	W → E	NA	5.6	878.4
	May	1	7	W → E	6	5.8	923.59	5	1	W → E	2W	3.6	561.34
										W → E	2E	3.3	551.9
									15	W → E	NA	4.5	629.49
									25	W → E	NA	6.4	873.96
									28	W → E	NA	5.9	791.92
	June	1	12	E → W	5	7.5	1,036.93	3	7	E → W	NA	5.1	722.65
									24	W → E	1W	3.4	544.67
										W → E	1E	3.6	567.82
	July	1	25	W → E	4	6.2	971.93	5	9	W → E	4W	3.1	521.52
										W → E	4E	3.3	553.01
									15	E → W	2E	5.6	791.92
									16	NA	NA	2.5	343.55
									26	W → E	NA	2.9	434.29
	August	0						3	4	W → E	NA	3.1	521.52
									5	W → E	NA	3.3	462.07
									11	W → E	NA	2.4	410.77
Total		11				68.5	10268.04	29				117.3	17030.24

Table 3. Summary of all on effort aerial observer and vertical photograph detections of marine megafauna during Campaign 5 aerial surveys.

Category	Species/Item	Observers		Vertical photos		Total	
		No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Small cetaceans	Bottlenose dolphin (*Tursiops truncatus*)	9	323	--	--	9	323
	Common dolphin (*Delphinus delphis*)	19	641	8	33	27	674
	White-sided dolphin (*Lagenorhynchus acutus*)	5	181	--	--	5	181
	Unidentified dolphin	3	4	2	2	5	6
	Harbor porpoise (*Phocoena phocoena*)	0	0	10	13	10	13
Large cetaceans	Fin whale (*Balaenoptera physalus*)	3	5	--	--	3	5
	Minke whale (*Balaenoptera acutorostrata*)	36	40	1	1	37	41
	Humpback whale (*Megaptera novaeangliae*)	5	6	--	--	5	6
	Right whale (*Eubalaena glacialis*)	24	67	--	--	24	67
	Sperm whale (*Physeter macrocephalus*)	2	6	--	--	2	6
	Unidentified whale	3	3	1	1	4	4
Pinnipeds	Gray seal (*Halichoerus grypus*)	2	2	--	--	2	2
	Unidentified seal	36	147	8	208	44	355
Sea turtles	Leatherback turtle (*Dermachelys coriacea*)	1	1	0	0	1	1
	Loggerhead turtle (*Caretta caretta*)	0	0	1	1	1	1

Table 3 (continued). Summary of all on effort aerial observer and vertical photograph detections of marine megafauna during Campaign 5 aerial surveys.

Category	Species/Item	Observers		Vertical photos		Total	
		No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Sharks/fish	Basking shark (*Cetorhinus maximus*)	52	52	7	7	59	59
	Blue shark (*Prionace glauca*)	53	54	25	25	78	79
	Hammerhead shark (*Sphyrna* sp.)	--	--	1	1	1	1
	Ocean fish (*Mola mola*)	46	50	7	8	53	58
	Unidentified shark	31	33	6	6	37	39
	Unidentified tuna	--	--	1	2	1	2
Unknown	Unidentified marine mammal	1	1	--	--	1	1

Table 4. Summary of all aerial observer and vertical photograph detections during Campaign 5 aerial surveys. Individual items for natural debris were not tallied and are marked with "*".

Category	Species/Item	Observers		Vertical photos		Total	
		No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Small cetaceans	Bottlenose dolphin (*Tursiops truncatus*)	17	479	--	--	17	479
	Common dolphin (*Delphinus delphis*)	43	1,689	12	46	55	1,735
	White-sided dolphin (*Lagenorhynchus acutus*)	5	181	--	--	5	181
	Unidentified common or white-sided dolphin	3	13	--	--	3	13
	Unidentified dolphin	8	13	6	9	14	22
	Harbor porpoise (*Phocoena phocoena*)	1	15	16	20	17	35
	Pilot whale (*Globicephala* sp.)	3	34	--	--	3	34
Large cetaceans	Fin whale (*Balaenoptera physalus*)	32	53	--	--	32	53
	Minke whale (*Balaenoptera acutorostrata*)	94	111	4	4	98	115
	Sei whale (*Balaenoptera borealis*)	28	55	--	--	28	55
	Unidentified fin or sei whale	7	7	--	--	7	7
	Sperm whale (*Physeter macrocephalus*)	2	6	--	--	2	6
	Humpback whale (*Megaptera novaeangliae*)	30	32	--	--	30	32
	Right whale (*Eubalaena glacialis*)	175	321	2	2	177	323
	Unidentified whale	4	4	2	2	6	6
Pinnipeds	Gray seal (*Halichoerus grypus*)	2	2	1	1	3	3
	Unidentified seal	74	2,710	14	1,669	88	4,379
Sea turtles	Leatherback turtle (*Dermachelys cariacea*)	5	5	1	1	6	6
	Loggerhead turtle (*Caretta caretta*)	--	--	2	2	2	2

Table 4 (continued). Summary of all aerial observer and vertical photograph detections during Campaign 5 aerial surveys. Individual items for natural debris were not tallied and are marked with "*".

Category	Species/Item	Observers		Vertical photos		Total	
		No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Birds	Great Black-backed gull (*Larus marinus*)	--	--	2	2	2	2
	Long-tailed duck (*Clangula hyemalis*)	--	--	2	79	2	79
	Northern gannet (*Sula bassanus*)	--	--	15	16	15	16
	White-winged scoter (*Melanitta fusca*)	--	--	6	19	6	19
	Unidentified bird	--	--	304	2,470	304	2,470
	Unidentified gull	--	--	16	29	16	29
Sharks/fish	Basking shark (*Cetorhinus maximus*)	120	125	18	19	138	144
	Blue shark (*Prionace glauca*)	65	67	42	42	107	109
	Hammerhead shark (*Sphyrna* sp.)	--	--	1	1	1	1
	Ocean fish (*Mola mola*)	68	72	21	22	89	94
	School of fish	52	65	3	3	55	68
	Unidentified fish	--	--	14	201	14	201
	Unidentified shark	72	91	13	13	85	104
	Unidentified tuna	--	--	3	5	3	5
Human activity	Debris (different types)	33	33	57	58	90	91
	Fixed fishing gear	648	1,112	28	29	676	1,141
	Fishing vessel	374	468	5	5	379	473
	Recreational vessel	87	120	2	2	89	122
	Other types of vessels/data stations /coast guard	105	107	3	3	108	110
	Unknown vessel	2	2	--	--	2	2
Other debris	Seaweed/wood/organic material	17	*	309	*	326	*
Unknown	Unidentified animal	9	9	9	9	18	18
	Unidentified marine mammal	1	1	--	--	1	1

1.3 Marine mammal detections

Cetacean sightings

A total of 131 on effort sightings of 1,326 cetaceans were recorded during Campaign 5. When including off effort sightings, 494 sightings of 3,096 cetaceans were recorded. Identification to the species level was possible for 122 on effort sightings and resulted in 11 confirmed species (Table 3). Species ID could not be confirmed for 9 sightings.

Baleen whales were represented by five species of two families: Balaenidae and Balaenopteridae. Toothed whales were represented by six species in the Delphinidae, Phocoenidae, and Physeteridae families. Right whales, minke whales (*Balaenoptera acutorostrata*), and common dolphins (*Delphinus delphis*) were sighted most frequently and accounted for 18%, 28%, and 21%, respectively, of on effort sightings (Figure 5). In contrast, the three dolphin species were the most abundant cetaceans, accounting for 51% (common dolphins), 24% (bottlenose dolphins, *Tursiops truncatus*), and 14% (white-sided dolphins, *Lagenorhynchus acutus*) of individual cetaceans sighted on effort (Figure 6).

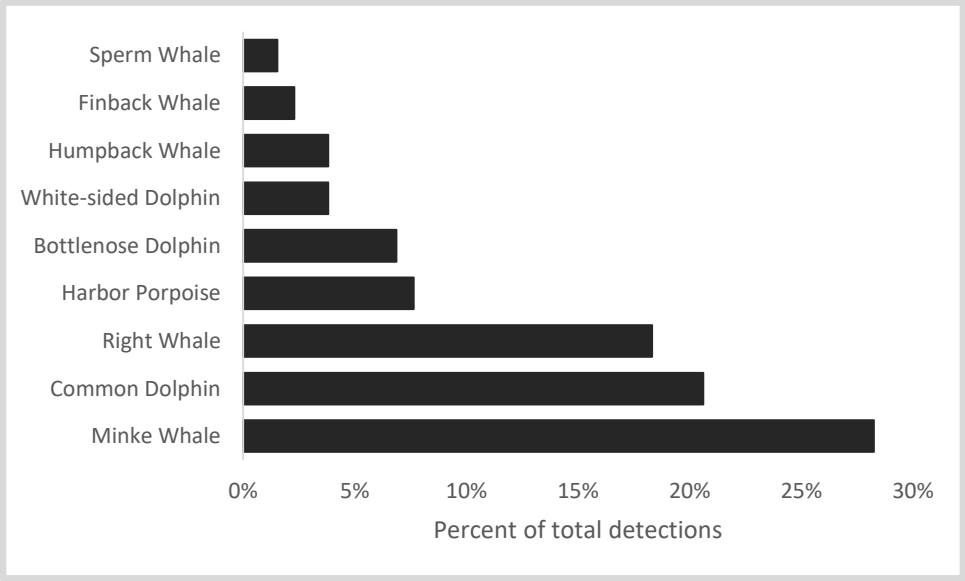

Figure 5. Percentage of on effort sightings per cetacean species identified during Campaign 5 aerial surveys.

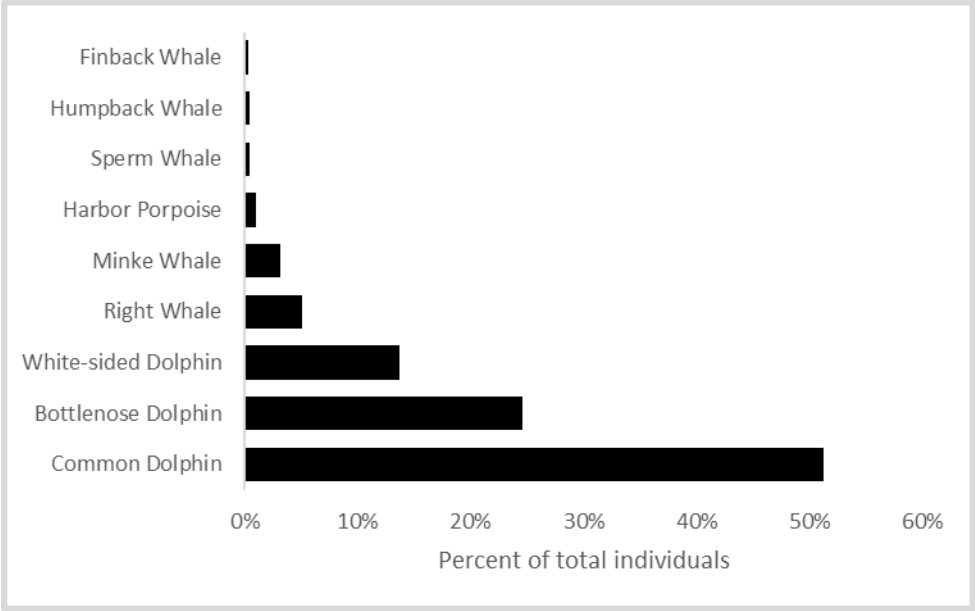

Figure 6. Percentage of individuals identified per cetacean species while on effort during Campaign 5 aerial surveys.

Family Balaenidae: North Atlantic right whales

In total, 62 on effort sightings of 156 right whales were recorded during Campaign 5. During directed surveys, 112 sightings of 164 right whales were recorded. One opportunistic survey was flown, during which three sightings of three right whales were recorded. Sightings usually consisted of single right whales (67%).

Right whales were sighted in every season and in nine of eleven months surveyed. December, January, and February had the highest number of right whale sightings. No right whale sightings were recorded in June or October (Figure 7).

On effort and all right whale sightings are shown in Figure 8 and right whale sightings by season are shown in Figure 9. Seasonal sightings are shown for right whales, but are not shown for other species, because there were sightings of right whales in all seasons. Right whales were primarily found on the eastern side of the study area (Figures 8, 9) although distribution changed seasonally (Figure 9). In the winter, a large aggregation of right whales was observed on the southern portion of the Nantucket shoals. Although this aggregation fluctuated in size, it stayed in this area from December through February. In March, this aggregation moved slightly north, closer to Nantucket. This northward movement resulted in the observation of a large group skim feeding about 10 nm south of Nantucket in early April. After this observation, the feeding aggregation disappeared for a few weeks and then reappeared much further south, in the New York shipping lanes. The feeding aggregation persisted in this location for a few weeks, before a break in all right whale sightings for six weeks from June to mid-July. On July 15th, three right whales were sighted less than a mile south of Nantucket. Over the next several weeks, more whales arrived and the group drifted further south back to the Nantucket Shoals where they remained through the end of Campaign 5 surveys in August.

Most of the right whale sightings were close to, but outside of, the wind energy lease zones. During Campaign 5, there was only one sighting of one right whale within the RIMA WEA lease zone. Most right whale sightings were either close to or inside the southeastern MA WEA lease zones, and all sightings were within 15 nm of existing lease areas.

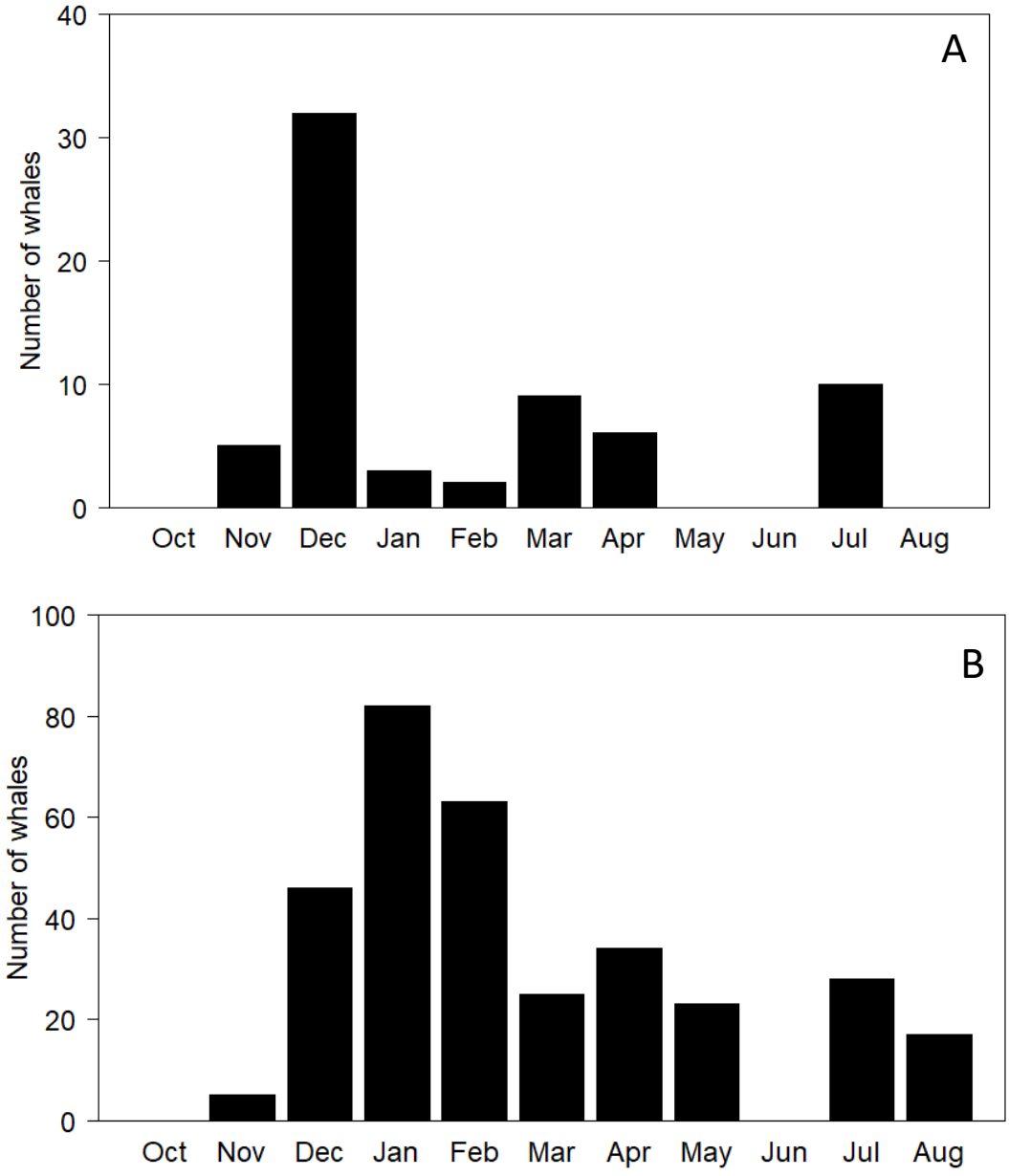

Figure 7. Right whale sightings per month in the study area summarized for A) on effort sightings and B) all sightings during Campaign 5 aerial surveys.

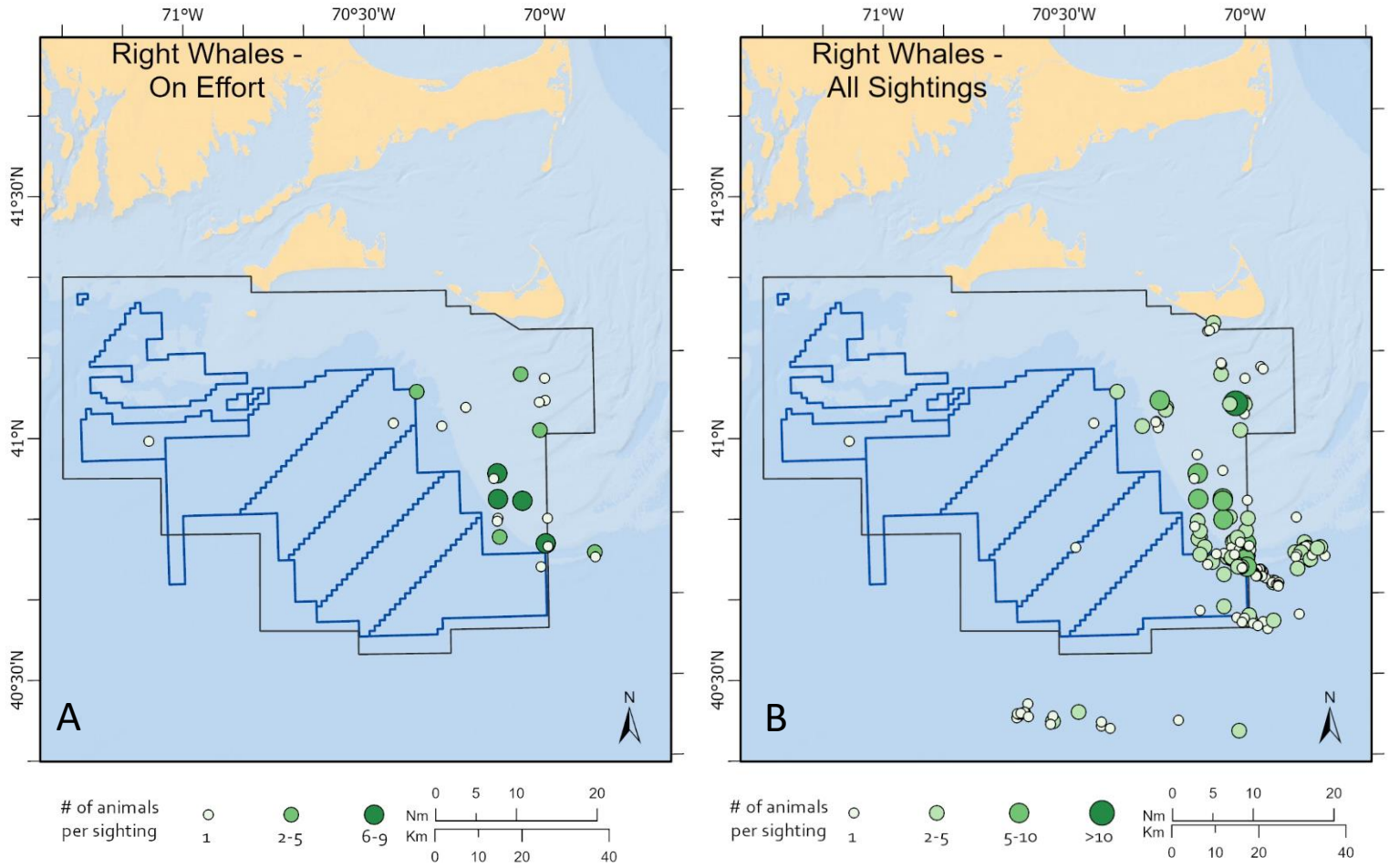

Figure 8. A) On effort and B) all sightings of right whales during Campaign 5 aerial surveys.

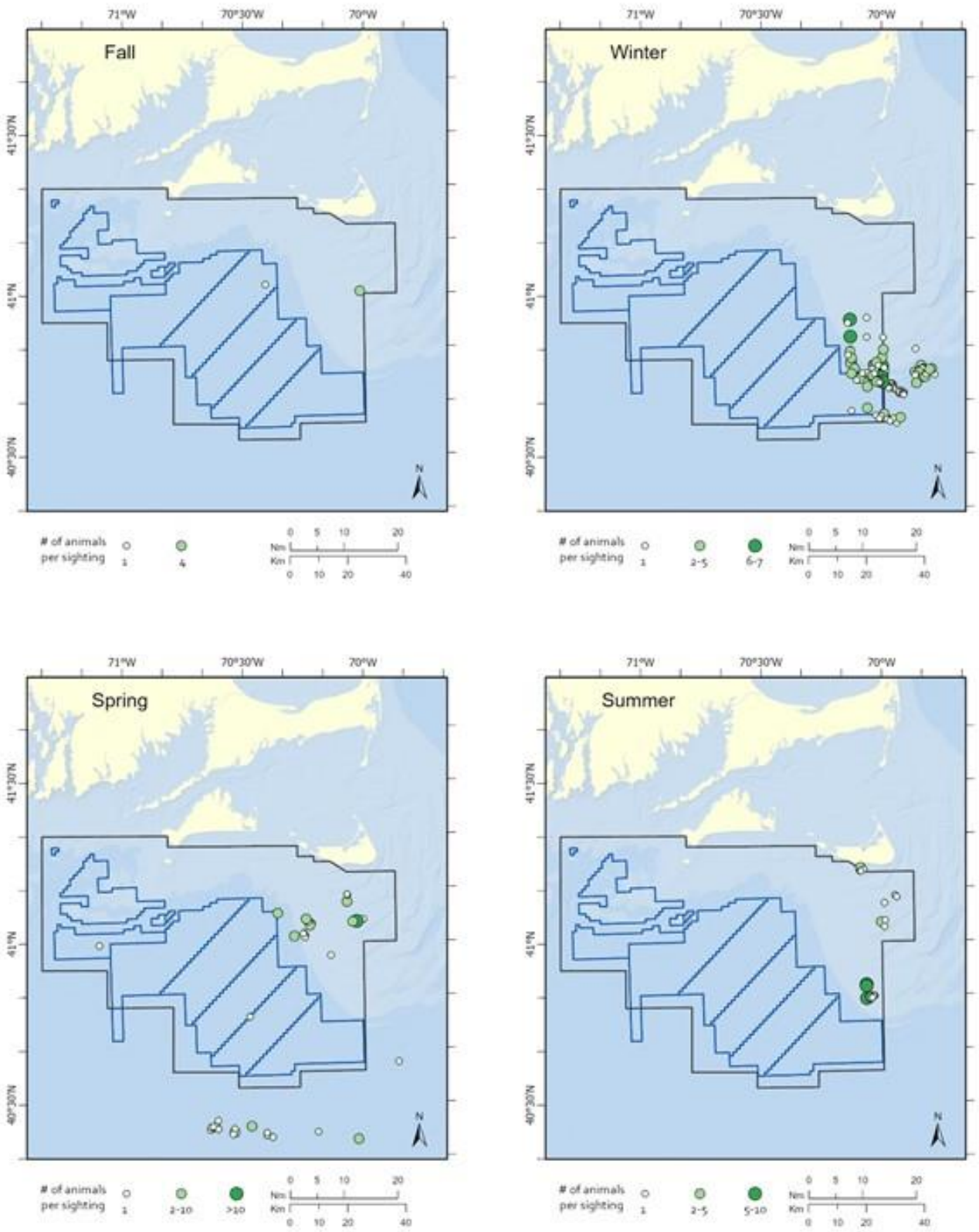

Figure 9. Seasonal sightings of right whales during Campaign 5 aerial surveys.

Demographic and re-sighting patterns

Photo identification data has not yet been confirmed by the NARWC. Preliminary photo analysis identified 137 individual right whales during all Campaign 5 surveys. Most right whales were adults (75%, n = 103) and males (55%, n = 75) (Table 5).

Table 5. Number and percentage of different sex and age classes of right whales identified during Campaign 5 aerial surveys. *Includes one 2019 calf.

	N	%	Adult	%	Juvenile	%	Age Unknown	%
Male	75	55	64	62	11	44	0	0
Female	46	33	34	33	10	40	2	25
Unknown	16	12	5	5	5*	16	6	75
Total	137	100	103	100	26	100	8	100

In March 2019, a right whale mother and calf pair were sighted (Figure 10). Catalog #4180 and calf were seen approximately 15 nm south of Nantucket on March 28th in the vicinity of several other skim feeding whales. Mothers with calves are not often sighted in the study area: calves have only been sighted in this area during two other years (2010, 2015) and this sighting of a mother and calf is the first in the study area by the NEAq aerial survey team. This pair was also seen in fall 2019 (after the conclusion of Campaign 5 surveys) near the Nantucket Shoals by NEFSC.

Figure 10. Right whale #4180 and her calf of the year at the surface side by side.

Photo identification data has not been confirmed by the NARWC, but preliminary analysis suggests that many of the identified right whales (43%, n = 59) were resighted during Campaign 5 surveys. Most whales (n = 41) were resighted only once during Campaign 5, but some whales were resighted up to five times (n = 3). Of these resightings, most occurred in two separate months (n = 40) and one whale was resighted in four separate months (Figure 11).

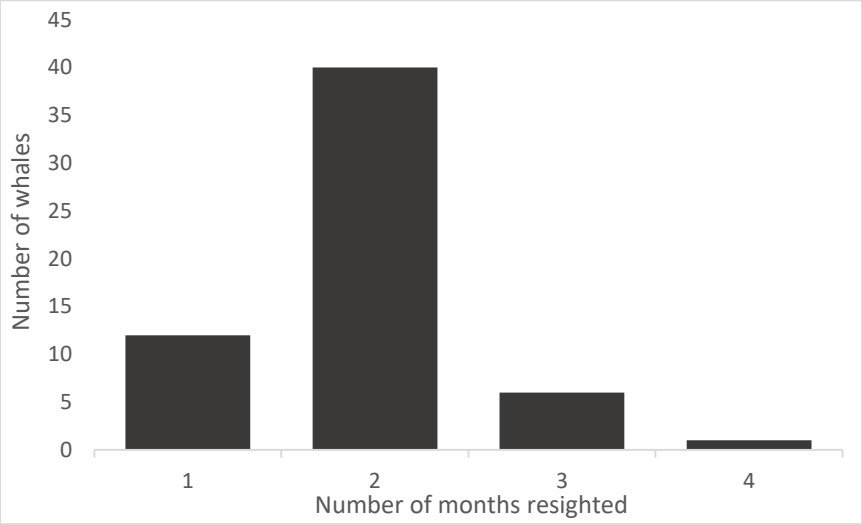

Figure 11. Number of individual right whales resighted across different months during Campaign 5 aerial surveys.

One resighting was of an entangled whale; adult male, Catalog #2310, was first seen entangled in the study area on December 20th, 2018 (Figure 12). This sighting was the first documentation of this whale's entanglement and sighting data was sent to the Marine Animal Entanglement Response (MAER) team at Center for Coastal Studies (CCS). This whale was resighted on February 3rd, still entangled. Although the MAER team was able to mount a response during an April sighting in Cape Cod Bay, they were not able to resolve the entanglement. The whale has not been resighted since this disentanglement attempt.

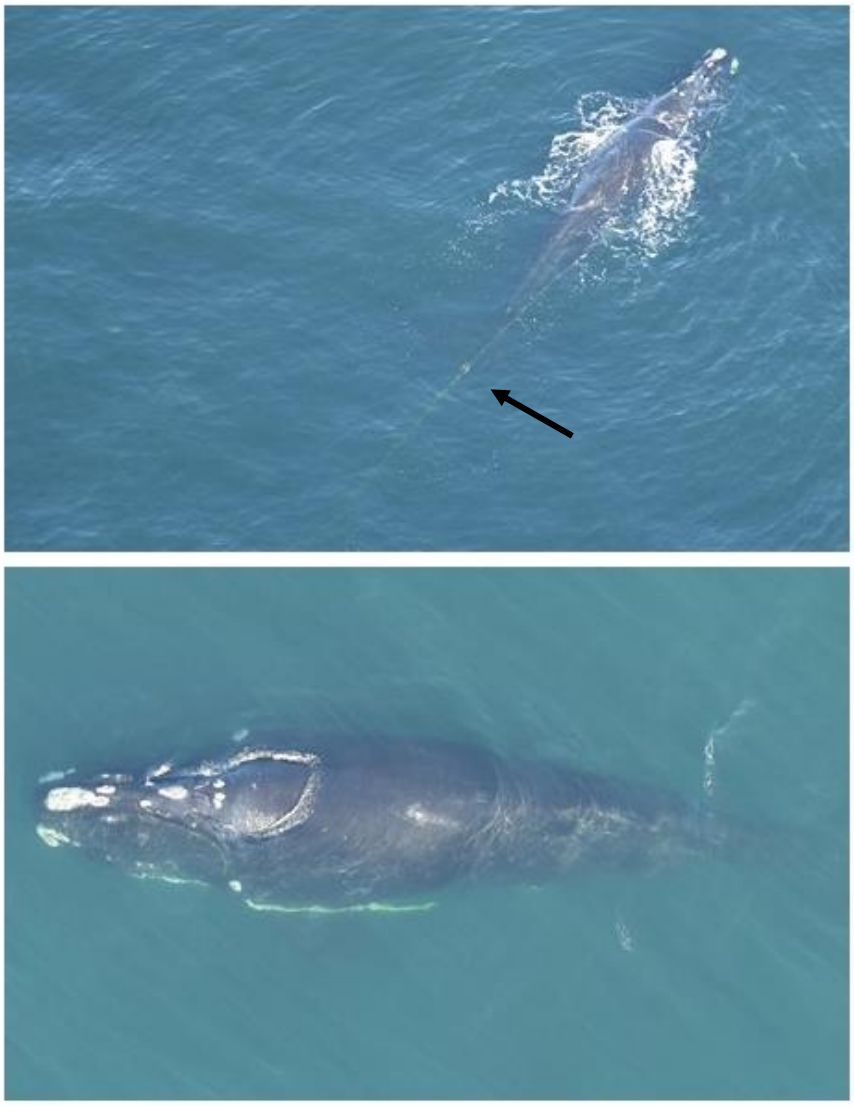

Figure 12. Adult male Catalog #2310 was first sighted entangled by NEAq in the study area on December 20th, 2018 (top). A line, indicated by the arrow, can be seen extending past the right side of the body. This whale was resighted on Febuary 3rd, 2019 by NEAq in the study area still entangled (bottom). In this sighting, a line can be seen exiting the left side of the mouth, and terminating half-way down the body.

Family Balaenopteridae

Four species of the Balaenopteridae family or rorqual whales were sighted during Campaign 5 surveys: fin whales (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*), minke whales, and humpback whales (*Megaptera novaeangliae*). A total of 45 sightings of 52 rorqual whales were documented on effort and a total of 195 sightings of 262 rorqual whales were

documented during all Campaign 5 surveys. Seasonal sighting maps are not provided for rorqual whales because only one or two seasons typically had high numbers of sightings.

Minke whales were detected the most often while on effort (n = 37 sightings, 82%) and were the most abundant species (n = 41 individuals, 79%). This skew towards minke whales is likely due to the fact that the majority of humpback, fin, and sei whale sightings occurred during directed and opportunistic surveys (70%, 84%, and 100% of sightings, respectively).

Humpback, fin, and minke whales were sighted in more than half of the months surveyed (10, 6, and 6 months, respectively). In contrast, sei whales were sighted in only May and June (Table 6).

Table 6. Monthly presence (grey boxes) and absence (white boxes) of rorqual whales during Campaign 5 aerial surveys.

Year/month		IUCN Conservation Status			
		Endangered		Least concern	
		Fin whales	Sei whales	Humpback whales	Minke whale
2018	October				
	November				
	December				
2019	January				
	February				
	March				
	April				
	May				
	June				
	July				
	August				

Fin whales

Fin whales are the largest baleen whale observed in the study area. While on effort, three sightings of five fin whales were observed. A total of 32 sightings of 53 fin whales were seen during all Campaign 5 surveys, with group sizes ranging from one to four whales and an average group size of 1.7 whales. Fin whales were observed most often in the spring and summer (n = 24 whales for each season), while only five fin whales were sighted in the fall and none were seen during the winter (Figure 13). Fin whales were seen throughout the study area; however, more whales were seen in the eastern part of the study area (Figure 14).

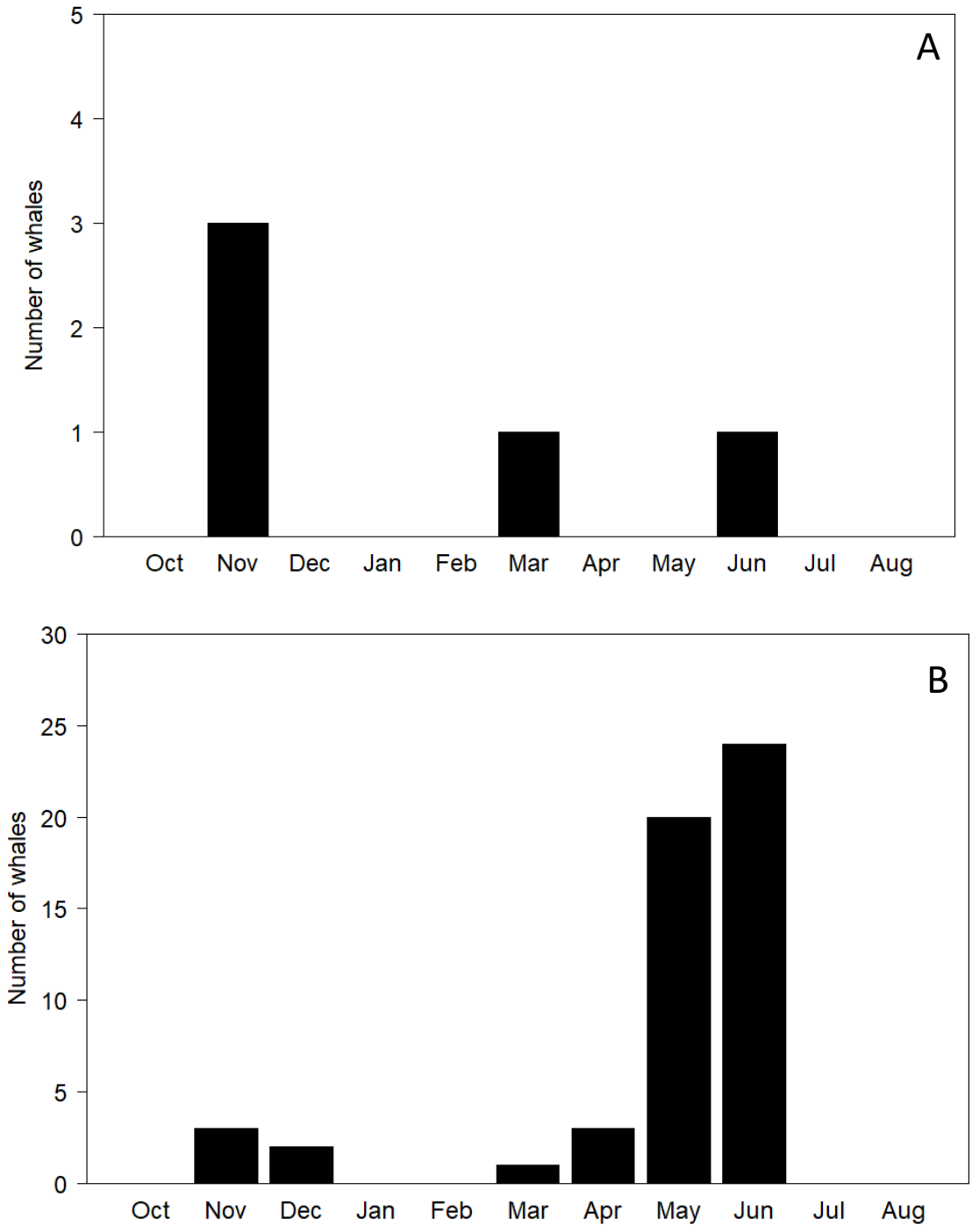

Figure 13. Fin whale sightings per month summarized for A) on effort sightings and B) all sightings during Campaign 5 aerial surveys.

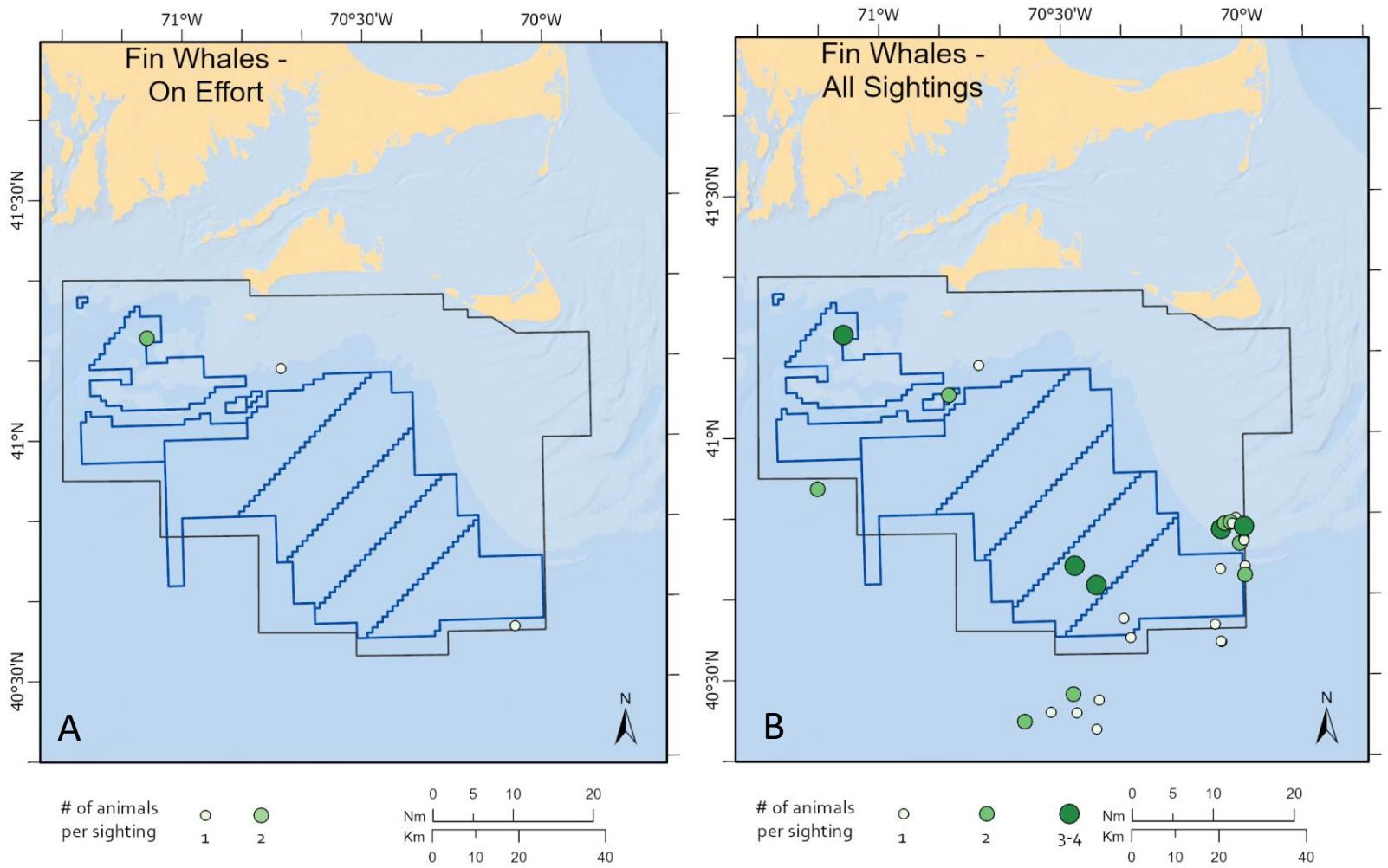

Figure 14. A) On effort and B) all sightings of fin whales during Campaign 5 aerial surveys.

Sei whales

No sei whales were observed on effort during Campaign 5 surveys. Sei whales were only encountered on directed surveys. On these surveys, 28 sightings of 55 individuals were observed during two of the 11 months of aerial surveys. Sightings of one to ten sei whales were observed and the average group size was two whales. Most sightings occurred in May (n = 51 whales) (Figure 15). Sei whales were seen only in the southern parts of the study area (Figure 16). Most of the sei whale sightings were south of the defined study area during directed surveys over an aggregation of right whales found within the New York shipping lanes.

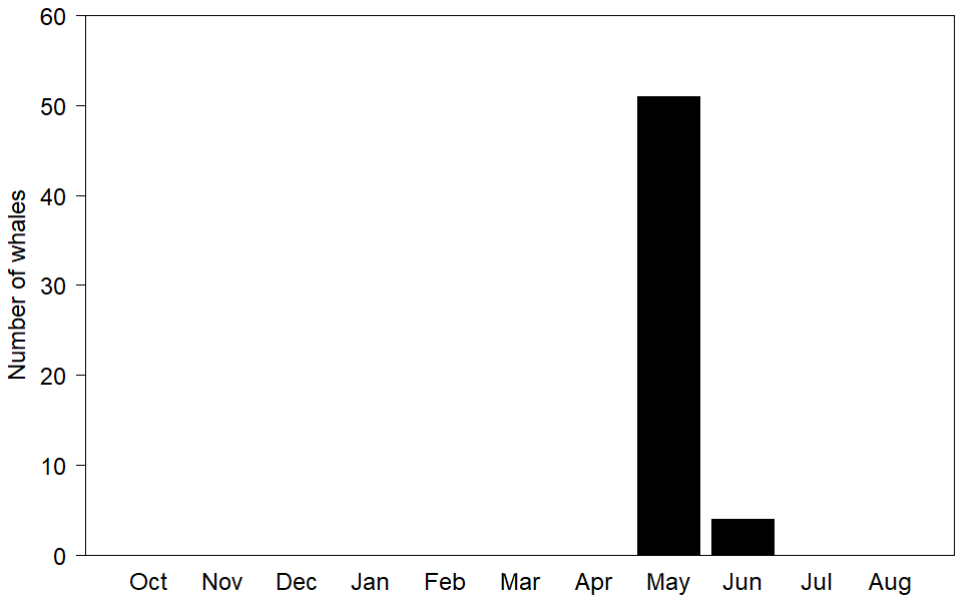

Figure 15. Sei whale sightings per month summarized for all sightings during Campaign 5 aerial surveys.

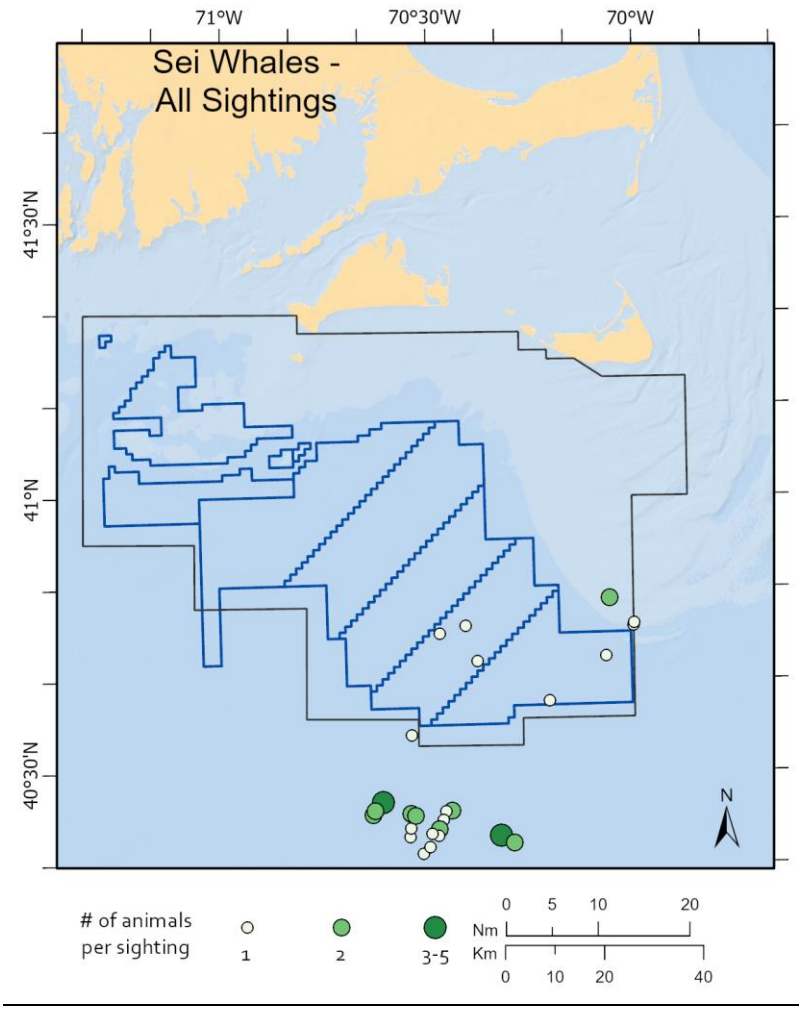

Figure 16. All sightings of sei whales during Campaign 5 aerial surveys. There were no on effort sightings of sei whales during Campaign 5 because all sightings occurred on directed surveys.

Minke whales

Minke whales are the smallest baleen whale observed in the study area. There were 37 on effort detections of 41 whales. A total of 98 sightings of 115 whales were observed when including on and off effort sightings. Their group size varied from one to five whales with an average group size of 1.2 whales. Minke whales were the most frequently sighted rorqual whale in the study area. They were observed most frequently in the spring (n = 41 whales) and summer (n = 72 whales) with only two sightings of two whales in the winter and none in the fall (Figure 17). Most sightings occurred in the months of June (n = 54 sightings) and April (n = 21 sightings). Minke whale sightings were distributed throughout the study area, mainly in the northern portion of the study area (Figure 18). Off effort sightings were mainly in the southeastern part of the study area.

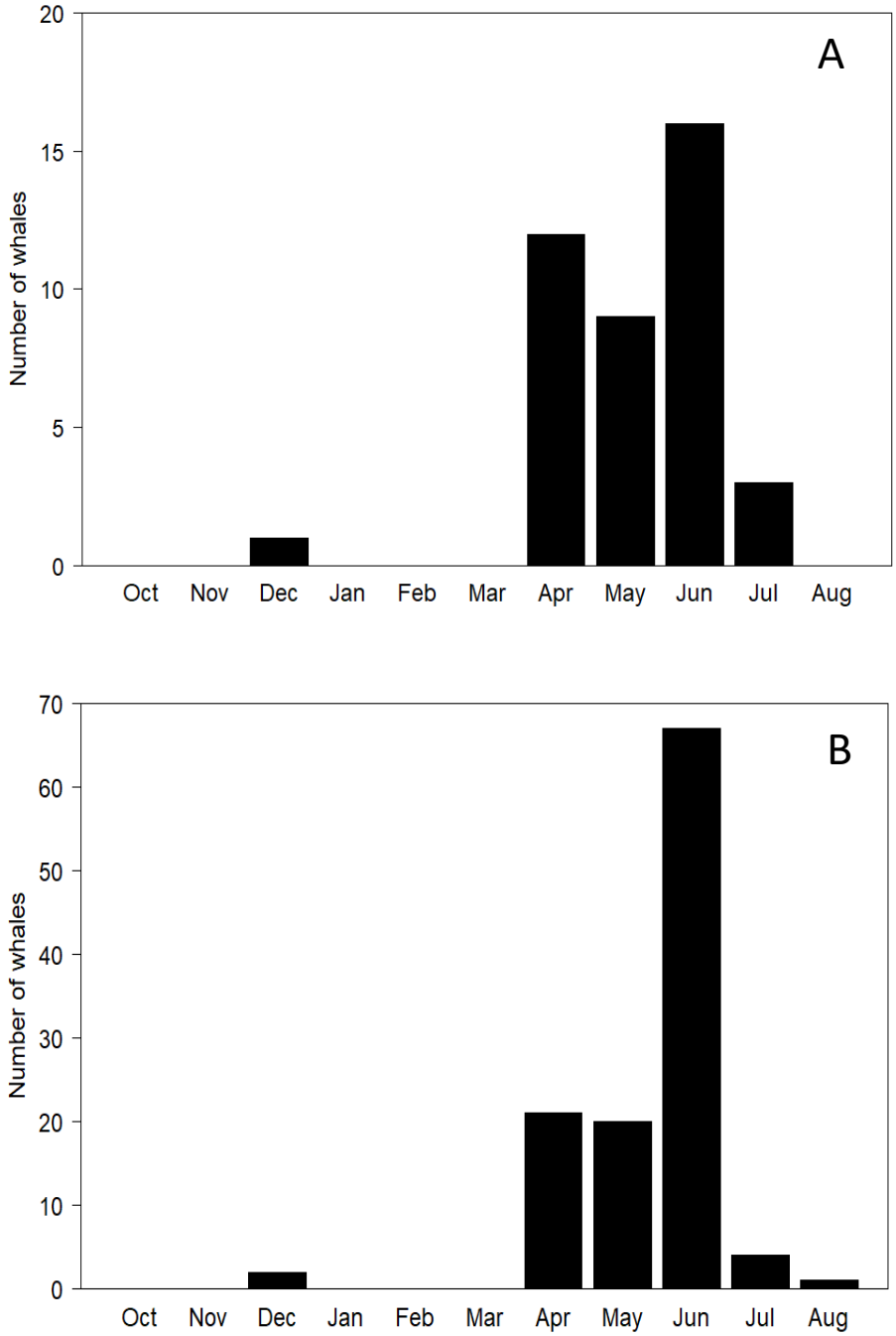

Figure 17. Minke whale sightings per month summarized for A) on effort sightings and B) all sightings during Campaign 5 aerial surveys.

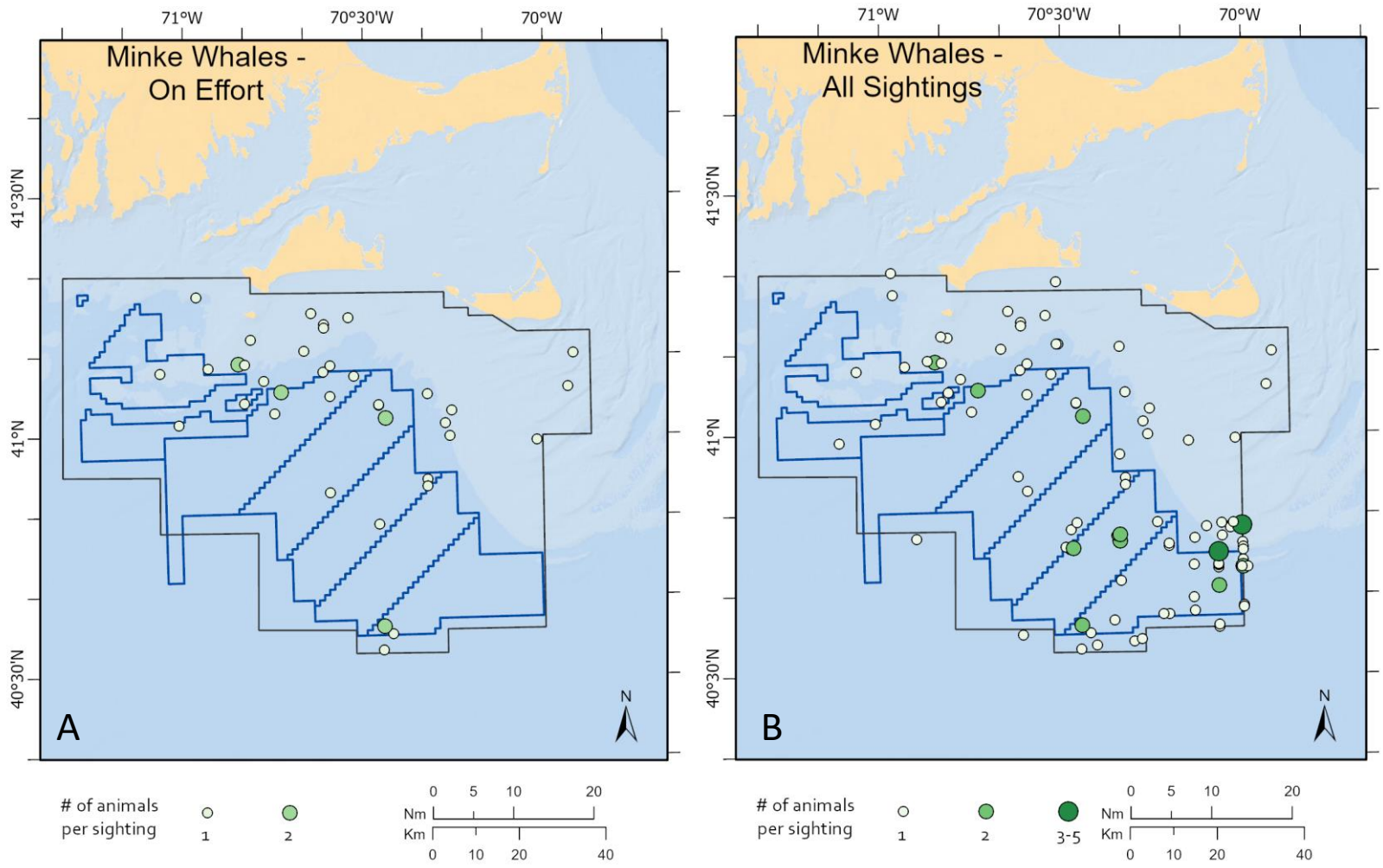

Figure 18. A) On effort and B) all sightings of minke whales during Campaign 5 aerial surveys.

Humpback whales

While on effort, five detections of six humpback whales were recorded. When including on and off effort sightings, a total of 30 sightings of 32 humpback whales were observed with at least one sighting in every season (Figure 19). Humpback whales were observed most frequently in the spring (n = 10 whales) and summer (n = 14 whales) and less frequently in the fall (n = 2 whales) and winter (n = 6 whales). The highest number of humpback whales sightings occurred in June (n = 9 detections, 30%).

Four of the five on effort sightings occurred in existing WEA lease zones and one was just outside the RIMA lease zones (Figure 20). When including off effort sightings, humpback whale sightings were much more common on the eastern side of the study area.

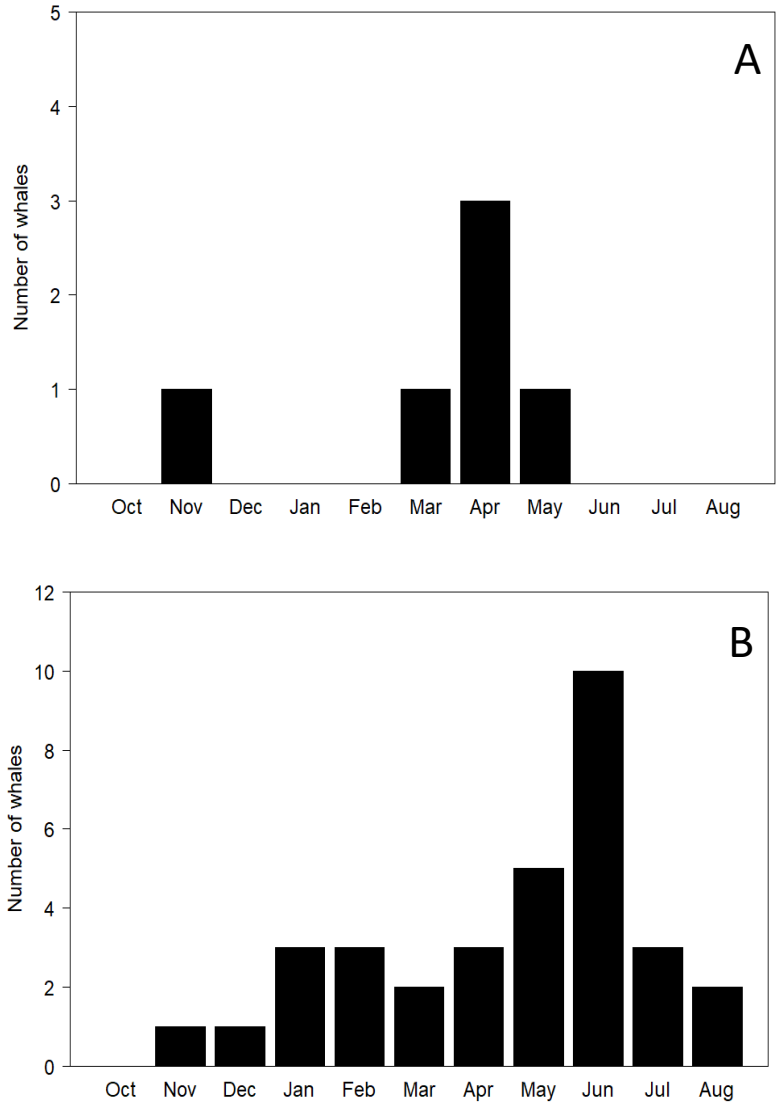

Figure 19. Humpback whale sightings per month summarized for A) on effort sightings and B) all sightings during Campaign 5 aerial surveys.

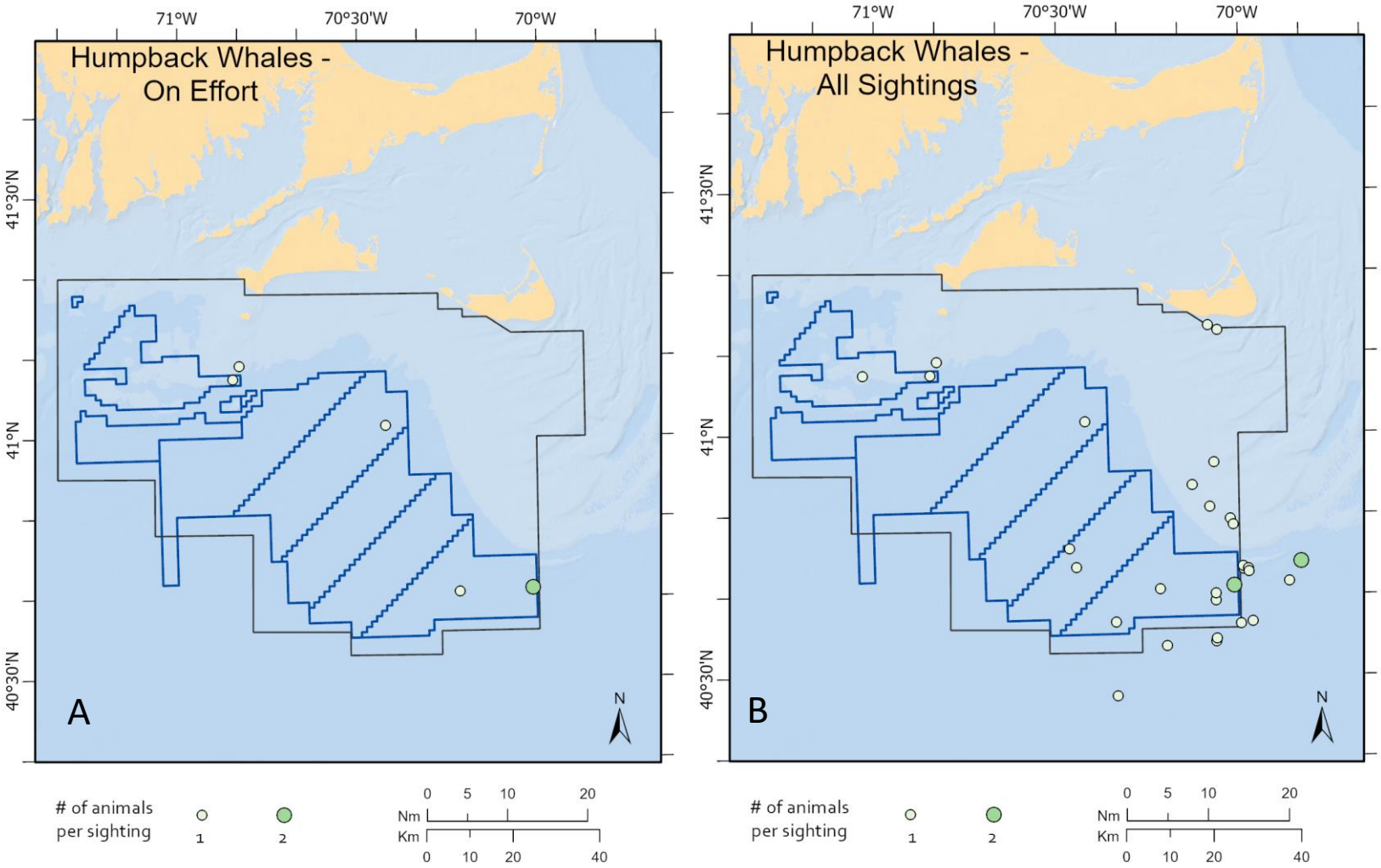

Figure 20. A) On effort and B) all sightings of humpback whales during Campaign 5 aerial surveys.

Small cetaceans

On effort sightings

Sightings of small cetaceans accounted for 41% of cetacean detections (51 of 125 detections) and 89% of individual cetaceans (1,016 of 1,144 individuals). Three species were identified and belonged to two families: Phocoenidae and Delphinidae. Phocoenidae included harbor porpoises (*Phocoena phocoena*) and Delphinidae included short-beaked common dolphins and bottlenose dolphins. Common dolphins accounted for 53% (n = 27) of the small cetacean sightings, followed by harbor porpoises (20%, n = 10), and bottlenose dolphins (18%, n = 9). Unidentified dolphin sightings accounted for 10% (n = 5) of small cetaceans and consisted of small groups of 1-2 dolphins that the plane did not break track to identify. All on effort harbor porpoise detections were camera detections.

All sightings

Patterns for all detections of small cetaceans were similar. In particular, common dolphins, harbor porpoises, and bottlenose dolphins were the most common small cetacean detections (48%, 15%, and 15%, respectively). However, small cetaceans accounted for fewer cetacean detections overall (23%, 114 of 494 cetacean sightings). An additional two species were detected during off effort sightings: pilot whales **(***Globicephala* sp.) and Atlantic white-sided dolphins. Small cetaceans were detected in larger groups, with group sizes ranging from 1 – 250 and an average group size of 22.

Seasonal and geographic patterns

Small cetacean species were sighted in higher numbers during the spring and summer (Figure 21). Three species, pilot whales, bottlenose dolphins, and Atlantic white-sided dolphins, were sighted only between the months of April and July. Common dolphins were seen in all seasons (Figure 22), while harbor porpoises were seen in the winter, spring, and summer.

Distribution patterns of small cetacean species varied (Figure 23). Common (Figure 24) and bottlenose dolphins were seen throughout the study area. Harbor porpoises were distributed further north than any small cetacean species, with many sightings occurring outside of the lease zones in the northernmost part of the study area. Pilot whales were seen only on the eastern side of the study area, south of the Nantucket shoals, and white-sided dolphins were seen only on the western side of the study area. However, we cannot infer general distribution patterns in the study area from the small number of sightings for these two species.

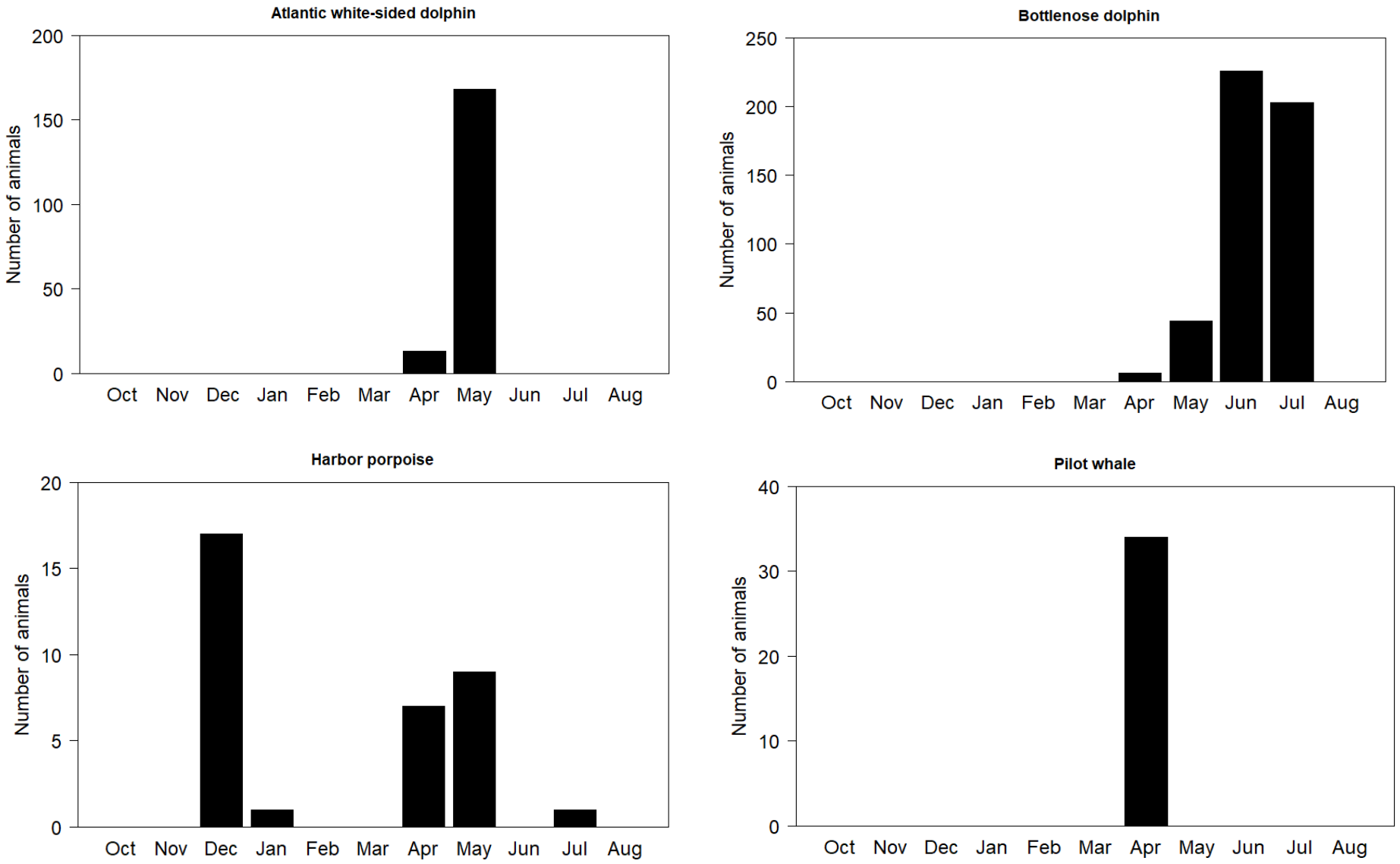

Figure 21. Sightings per month of A) Atlantic white-sided dolphins, B) bottlenose dolphins, C) harbor porpoises, and D) pilot whales summarized for all Campaign 5 aerial surveys.

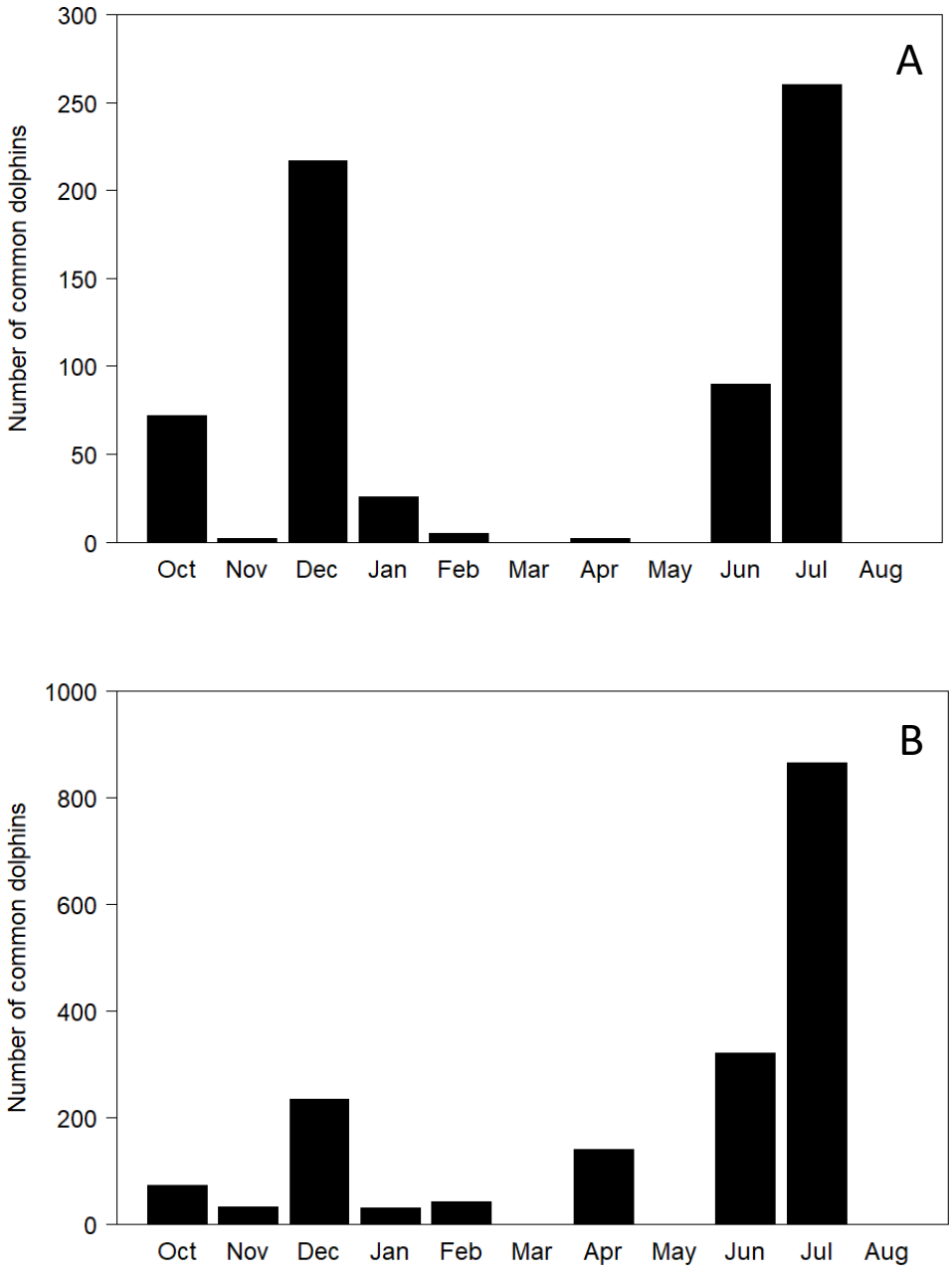

Figure 22. Common dolphin sightings per month summarized for A) on effort sightings and B) all sightings during Campaign 5 aerial surveys.

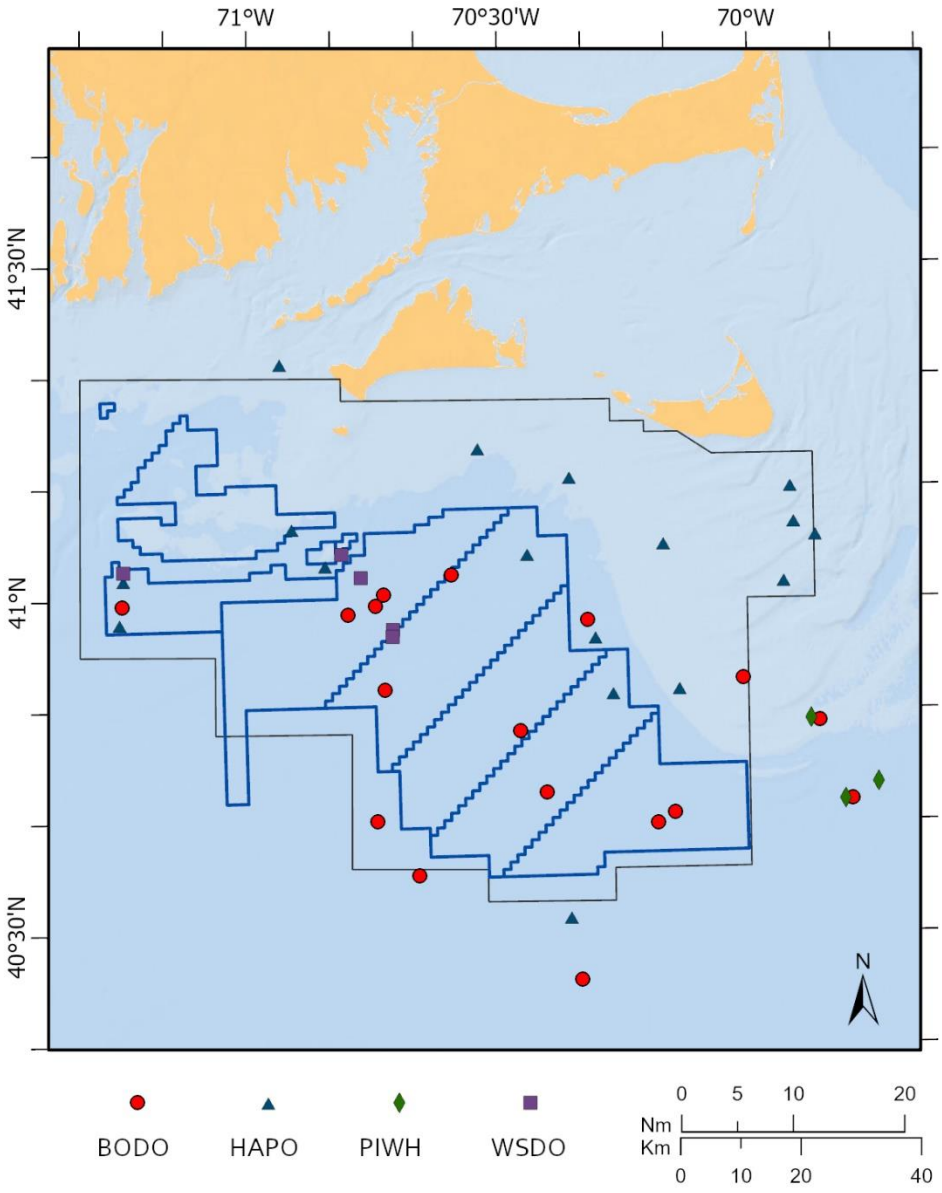

Figure 23. All sightings of small odontocetes (bottlenose dolphins, harbor porpoises, pilot whales, and white-sided dolphins) during Campaign 5 aerial surveys.

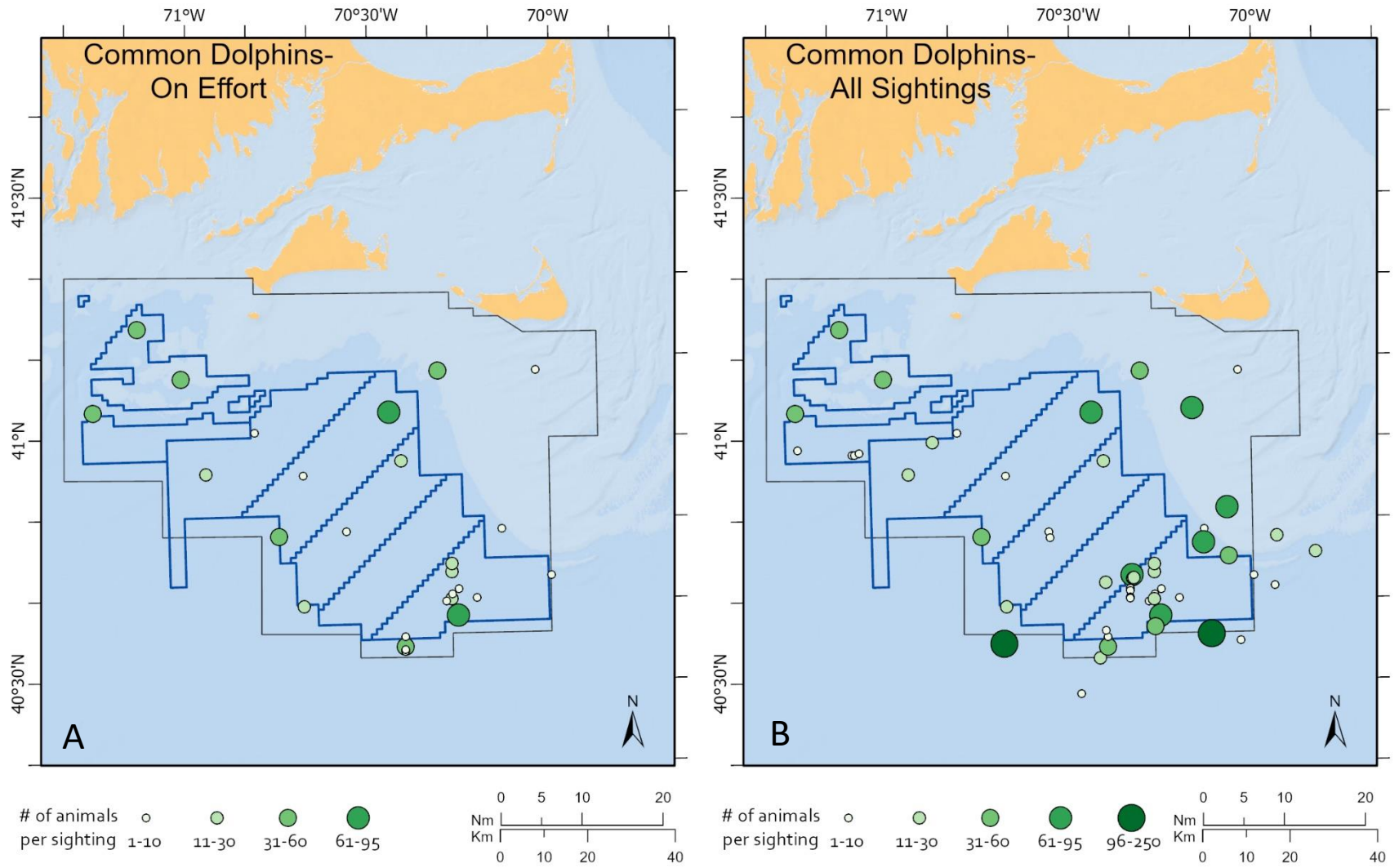

Figure 24. A) On effort and B) all sightings of common dolphins during Campaign 5 aerial surveys.

Other cetacean sightings

In June and July of 2019 the aerial team spotted two groups sperm whales (*Physeter macrocephalus*) (Figure 25). A group of four sperm whales was sighted during a June 12th general survey and a pair of sperm whales was spotted during a July 15th condensed survey. Live sperm whales have been sighted in the study area by NEAq on only four other occasions (a sperm whale carcass was observed during Campaign 4).

Sperm whale sightings occurred close to shore in relatively shallow water, which is unusual because sperm whales generally occur in deep water. The June 12th sighting was 10 nm south of Nantucket Island and the July 15th sighting was 13 nm southwest of Nantucket. These two sightings were approximately five nm away from each other. Preliminary photo analysis suggests that each sighting contained unique individuals, meaning that at least six individual sperm whales were in the study area during 2019.

Both groups of whales were observed milling at the surface and diving. In the June sighting, one whale was observed sleeping (Figure 26); sperm whales often sleep vertically in the water column, at or near the surface.

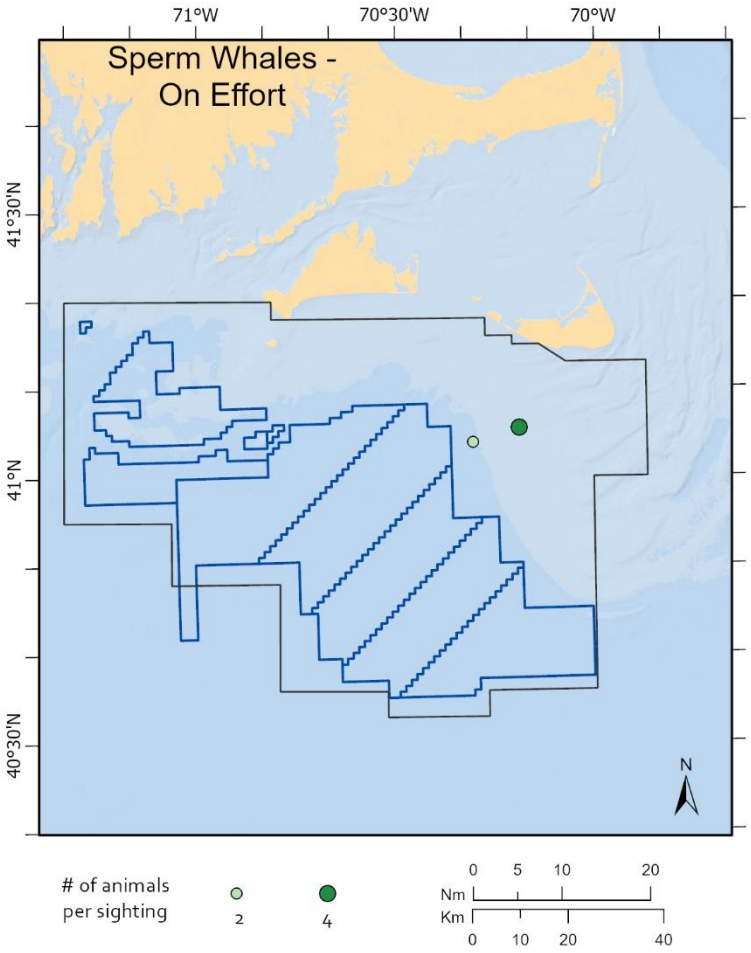

Figure 25. All sightings of sperm whales during Campaign 5 aerial surveys.

Figure 26. Two sperm whales sighted south of Nantucket on June 12, 2019. One whale (upper left-hand corner) was observed sleeping vertically in the water column.

1.4 Sea turtles

Eight sea turtles from two species were identified during the Campaign 5 aerial surveys. One leatherback (*Dermochelys coriacea*) and one loggerhead (*Caretta caretta*) were observed on effort. An additional five leatherbacks and one loggerhead were observed off effort. All sightings occurred in June, July, and August with leatherbacks sighted in June and August while loggerheads were only sighted in July (Figure 27).

Leatherback turtles were sighted on three separate days, all directly south of Nantucket and fairly close to shore (within ten nm). Only two loggerhead turtles were detected, on two separate days; one was north of the study area and the other was near the southern boundary of the study area. We cannot infer general distribution patterns in the study area from the small number of sightings for these two species (Figure 28).

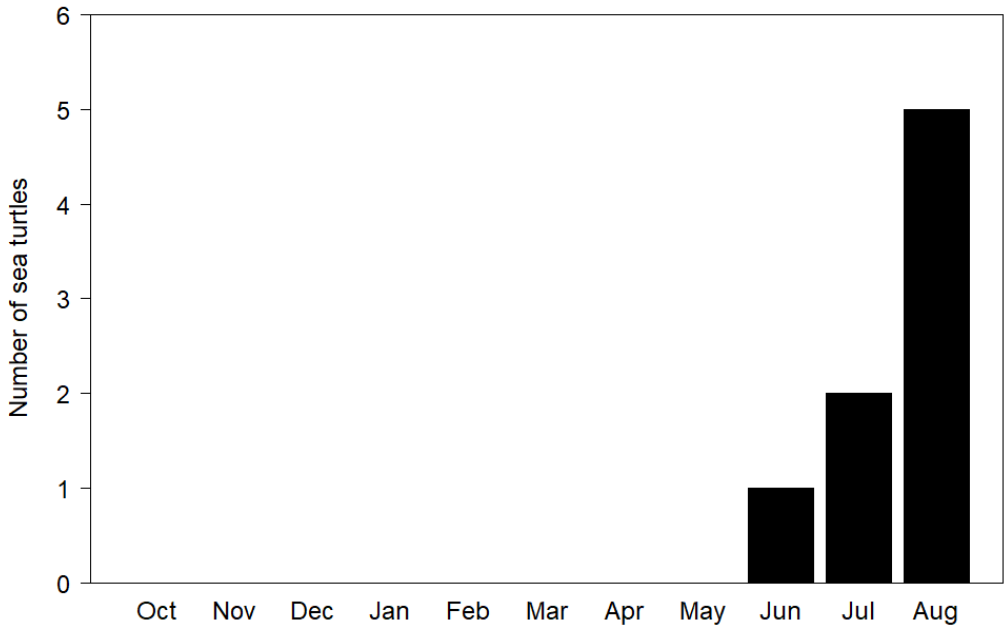

Figure 27. Sea turtle sightings per month summarized for all Campaign 5 aerial surveys

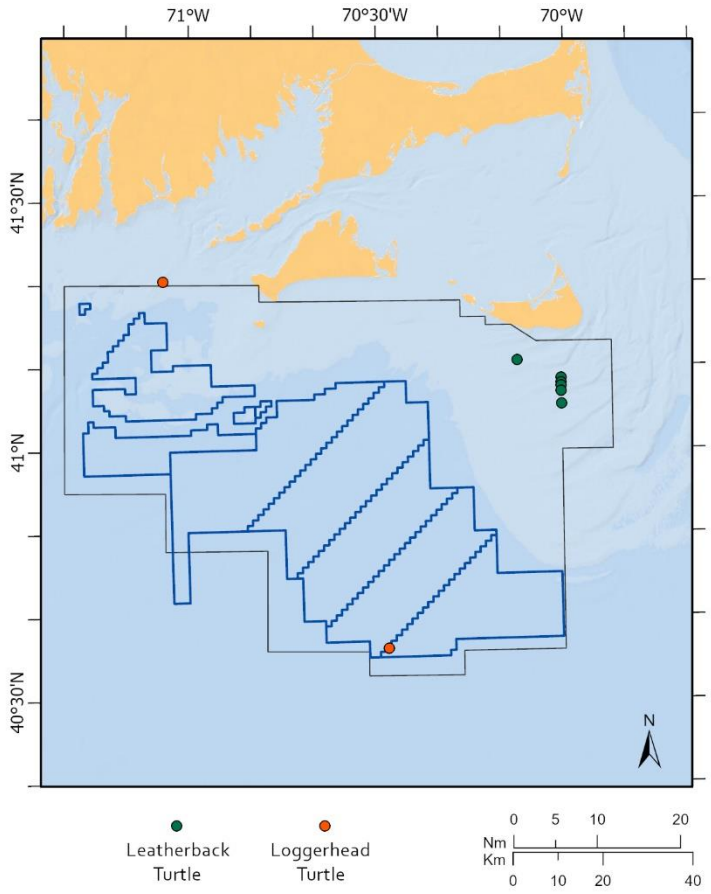

Figure 28. All sightings of loggerhead and leatherback sea turtles during Campaign 5 aerial surveys.

1.5 Other marine megafauna

Several other species of marine megafauna were observed during Campaign 5 aerial surveys. On effort sightings include 59 basking sharks (*Cetorhinus maximus*), 79 blue sharks (*Prionace glauca*), one hammerhead shark (*Sphyrna* sp.), and 58 ocean sunfish (*Mola mola*) (Figure 29). An additional 85 basking sharks, 30 blue sharks, and 36 ocean sunfish were sighted off effort. The three most common species (basking sharks, blue sharks, and ocean sunfish) were seen in all parts of the study area (Figure 30). However, blue sharks tended to be more common on the western side of the study area and basking sharks tended to be more common in the eastern and southern parts of the study area.

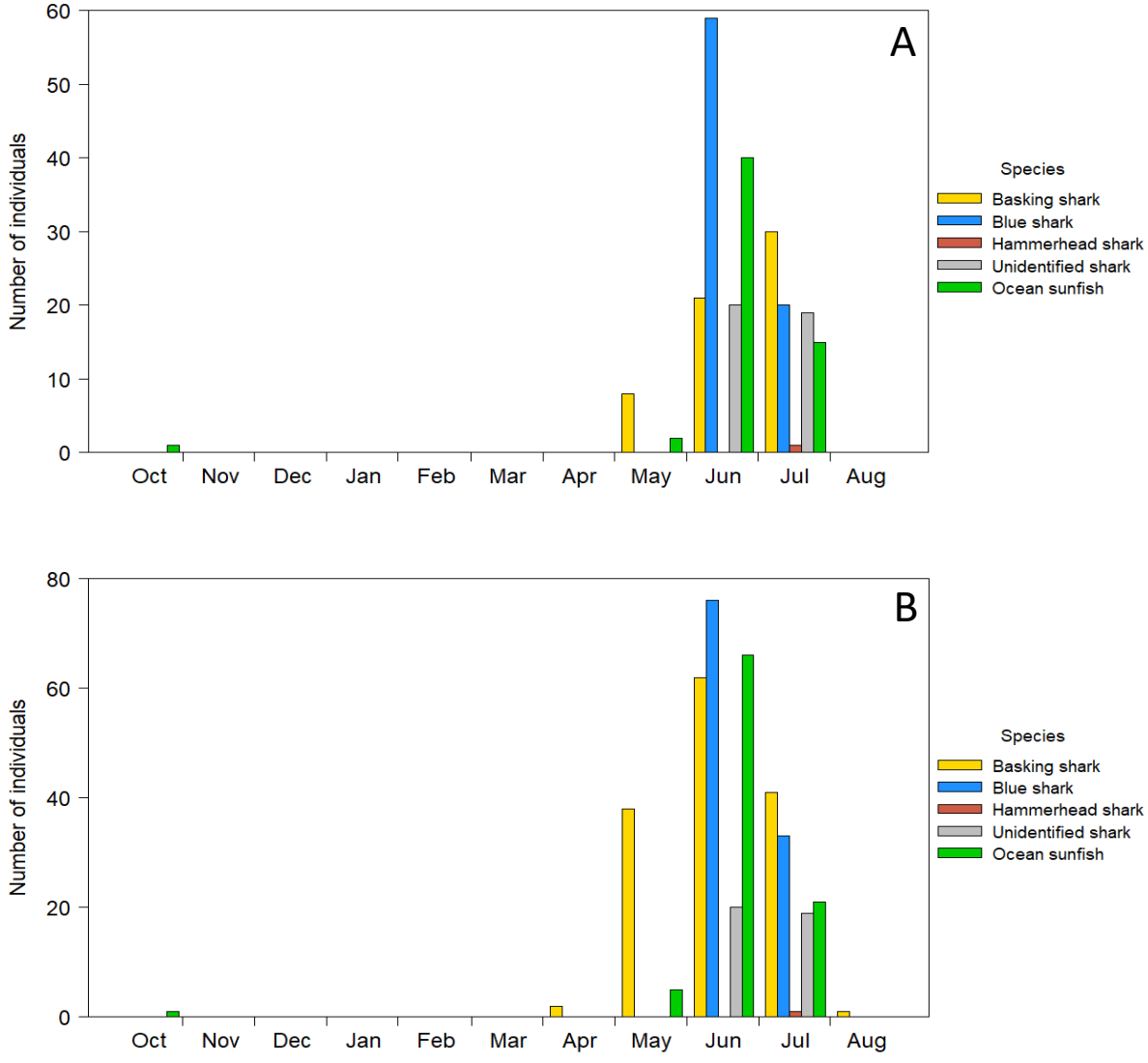

Figure 29. Shark and fish sightings per month summarized for A) on effort sightings and B) all sightings during Campaign 5 aerial surveys.

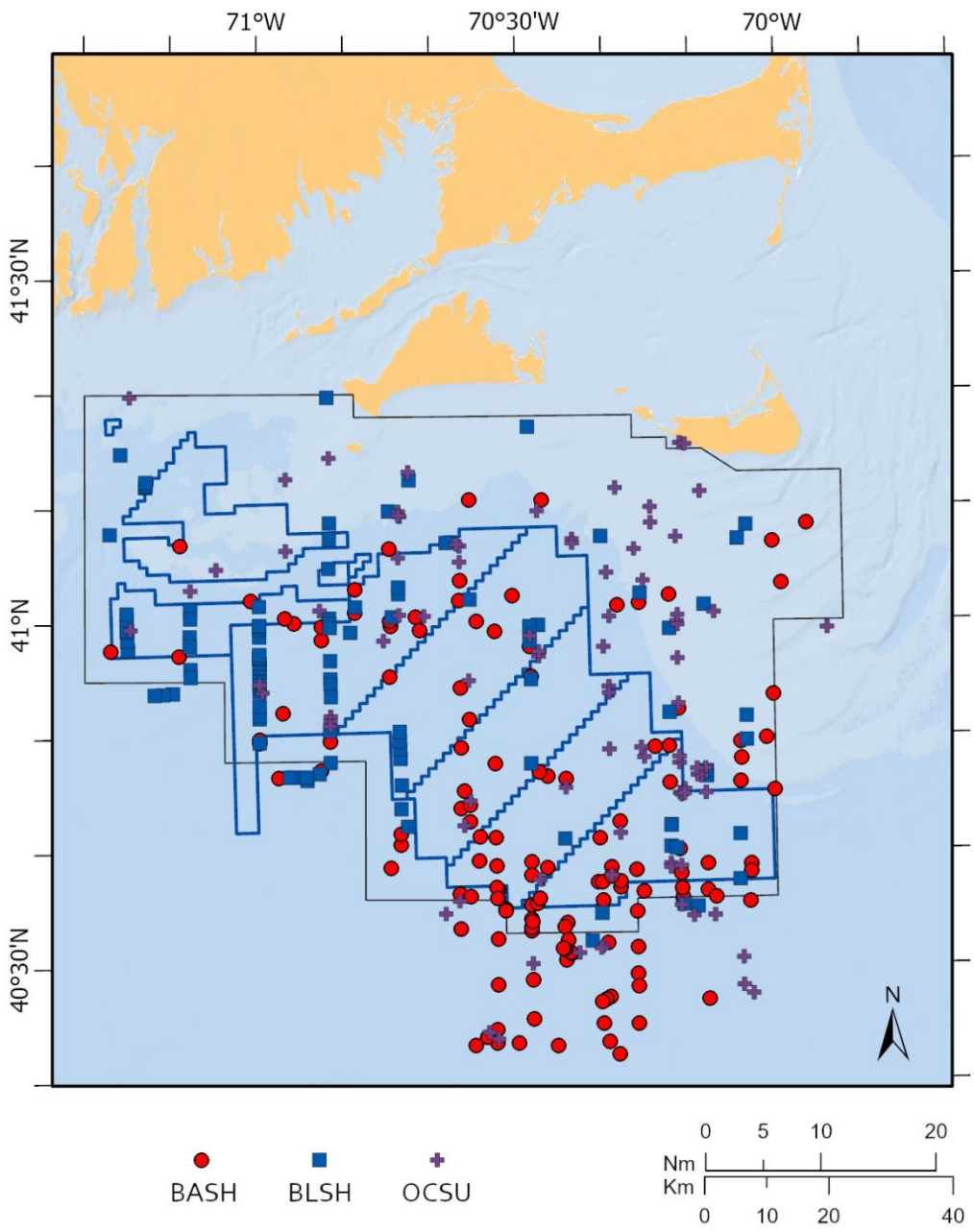

Figure 30. All sightings of basking sharks, blue sharks, and ocean sunfish during Campaign 5 aerial surveys.

2. OCEANOGRAPHIC SAMPLING

Sampling during Campaign 5 was conducted weekly from February 20 to April 25, 2019, and then once every other week from April 25 to June 18, 2019. A final trip to sample near right whales was conducted on July 16, 2019 just south of Nantucket Island. Late winter and early spring are particularly difficult times to sample regularly at sea in a small vessel, so we were very pleased with the frequency at which we were able to sample. Sixty standard stations and five near-whale stations were occupied for a total of 65 stations (Table 7). Right whale abundance in the northern part of the study area was low during our study, so opportunities to sample near right whales were unfortunately scarce.

Table 7. Summary of oceanographic surveys during Campaign 5.

Date	Survey type	Time on water (hours)	Standard stations	Near-whale stations
2/20/19	Full	10	4	0
2/27/19	Full	8.5	4	0
3/8/19	Full	8.5	4	0
3/14/19	Full	8.5	4	0
3/15/19	Right whales	9.5	0	2
3/18/19	Right whales	9.0	0	1
3/20/19	Full	9.5	4	0
3/28/19	Full	9.5	4	0
4/2/19	Full	9.5	4	0
4/5/19	Full	9.5	4	0
4/11/19	Full	9.5	4	0
4/17/19	Full	9.5	4	0
4/25/19	Full	9.5	4	0
5/9/19	Full	9.5	4	0
5/22/19	Full	9.5	4	0
6/4/19	Full	9.5	4	0
6/18/19	Full	9.5	4	0
7/16/19	Right whales	9.0	0	2
Total	18 trips	158.5	60	5

Observations from the conductivity-temperature-depth (CTD) instrument indicated that the water column was well mixed during February, March, and early April (Figure 31-35). This well-mixed water column changed temperature and salinity regularly, likely from heating/cooling at the surface (temperature) and precipitation/river runoff (salinity) that was mechanically mixed throughout the water column from the wind during frequent storm events in late winter and early spring. The onset of vernal stratification occurred in mid-April (Figure 33, when the water column developed into a two-layer system with warm fresh water at the surface and cooler saltier water at the bottom. The temperature/salinity properties did not suggest the existence of a cold pool in this region; the cold pool is a common feature of continental shelves in which very cold leftover winter water near the bottom becomes isolated from the surface due to surface warming and therefore remains cold. The bottom waters in the study area warmed from < 5°C in winter to > 10°C by the beginning of summer, suggesting that this area is either too shallow or advection from neighboring

shallow areas (e.g., Nantucket Shoals) is too strong to support the formation or maintenance of a cold pool.

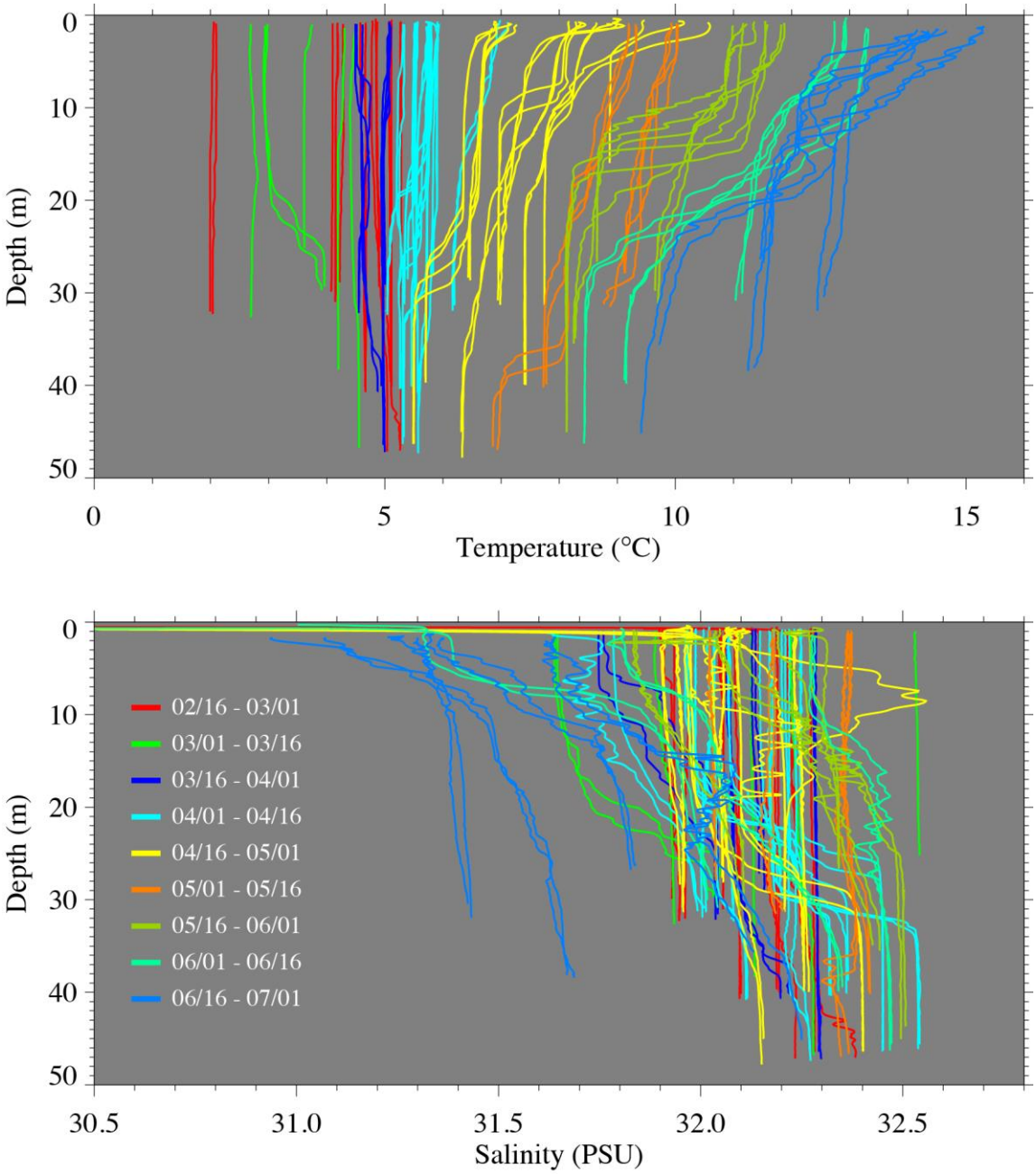

Figure 31. Temperature and salinity profiles collected at all stations. The water column is well mixed throughout February, March, and early April. Stratification was first observed in mid-April.

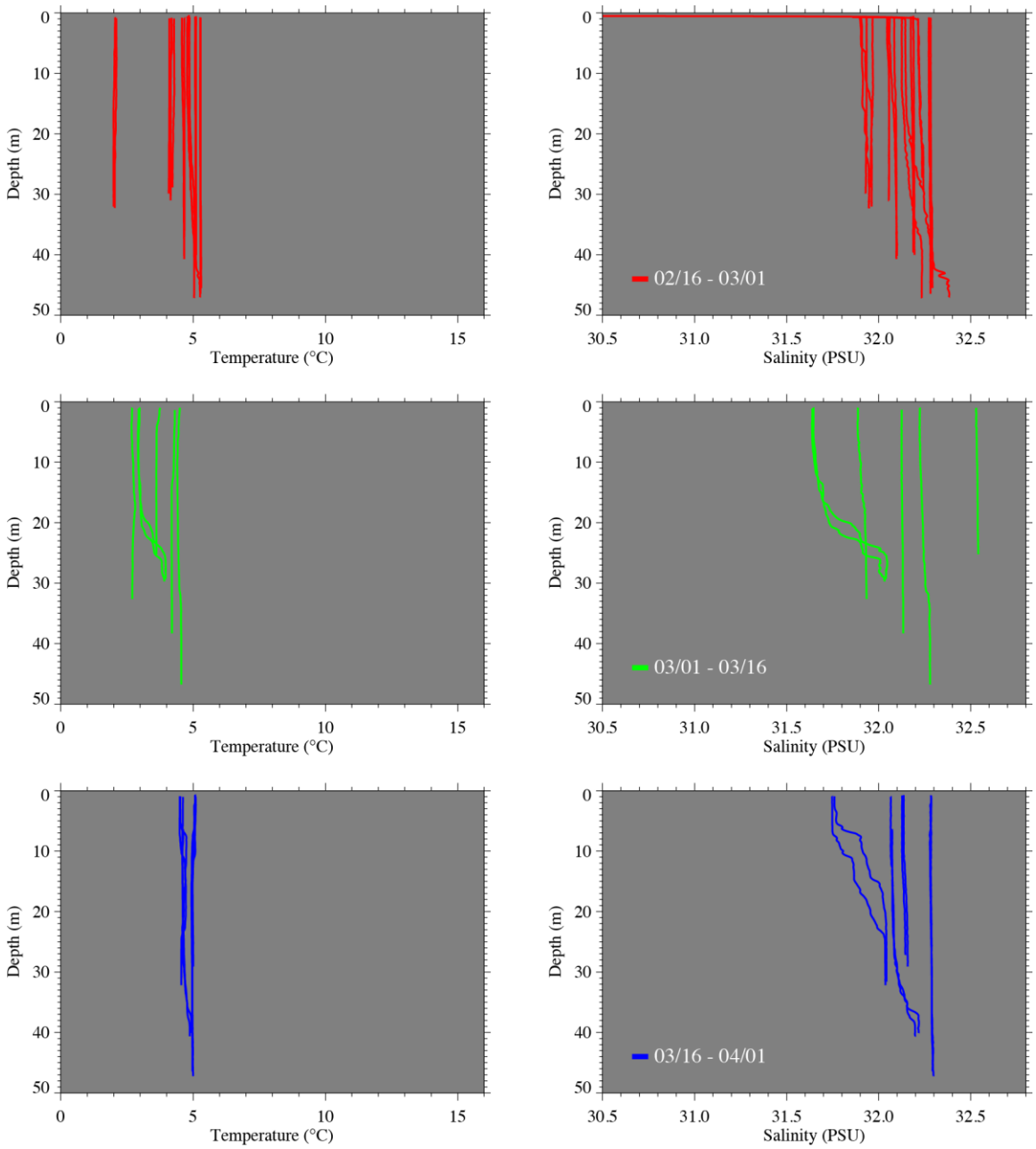

Figure 32. Temperature and salinity profiles collected at all stations.

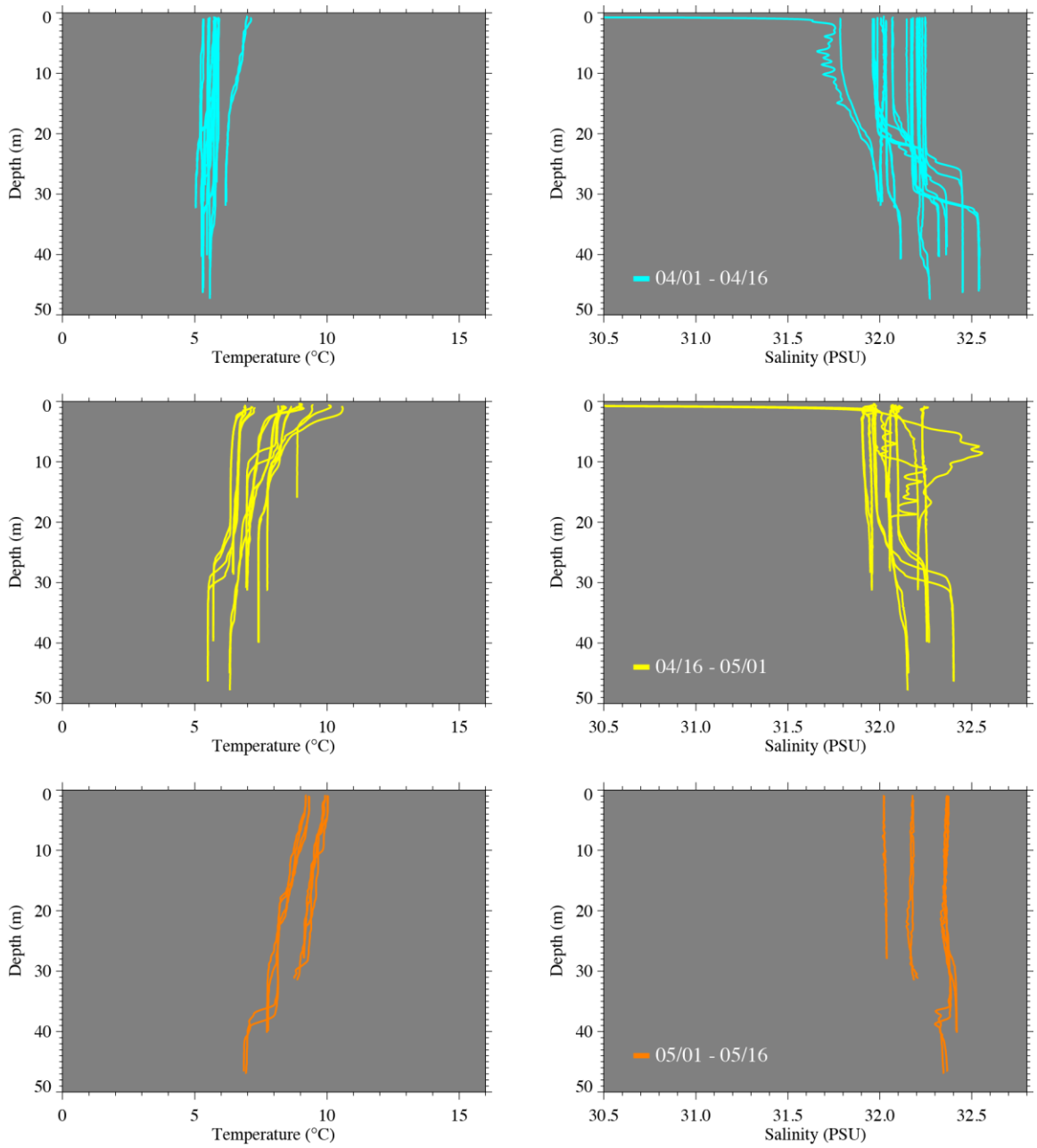

Figure 33. Temperature and salinity profiles collected at all stations.

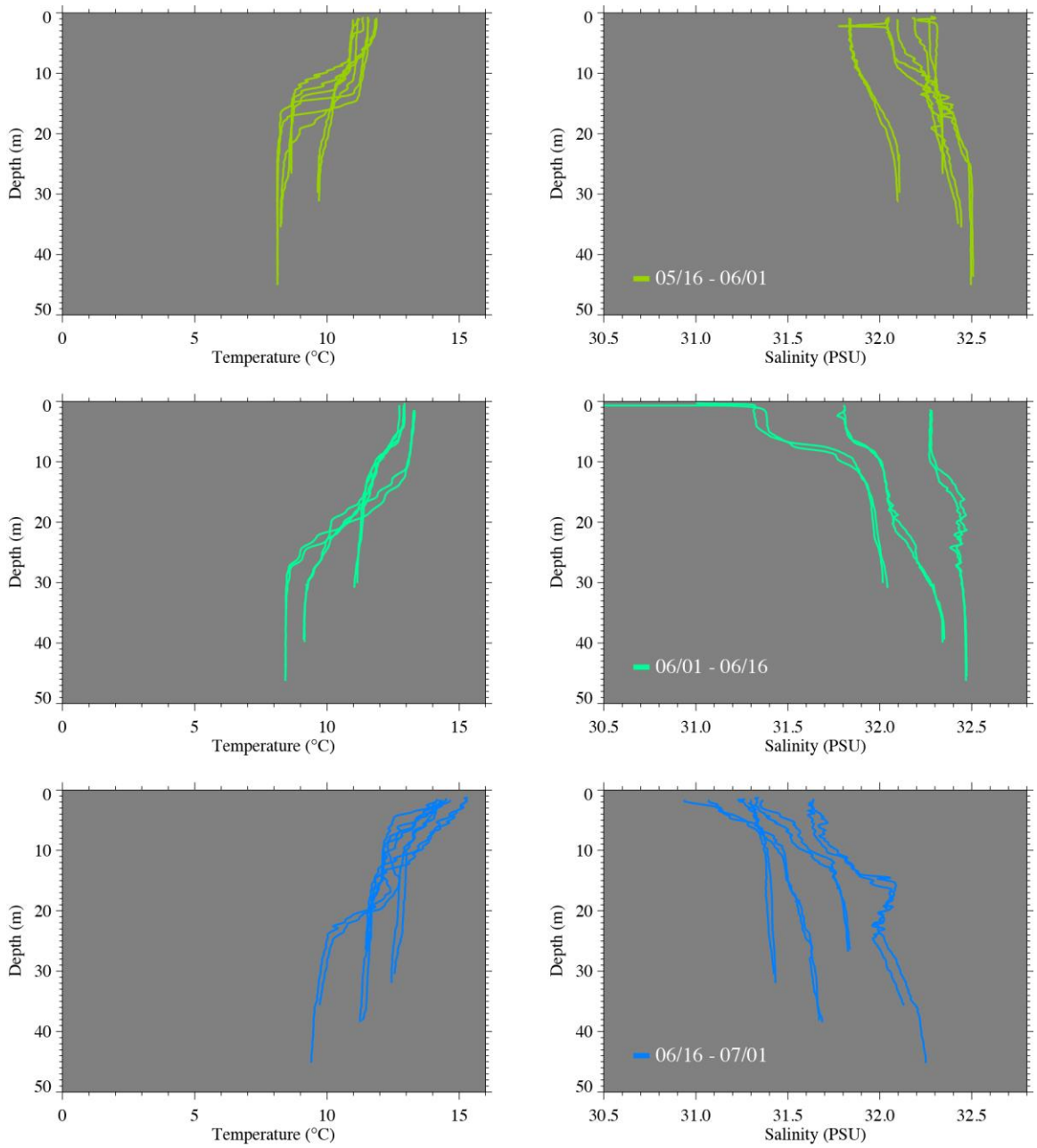

Figure 34. Temperature and salinity profiles collected at all stations.

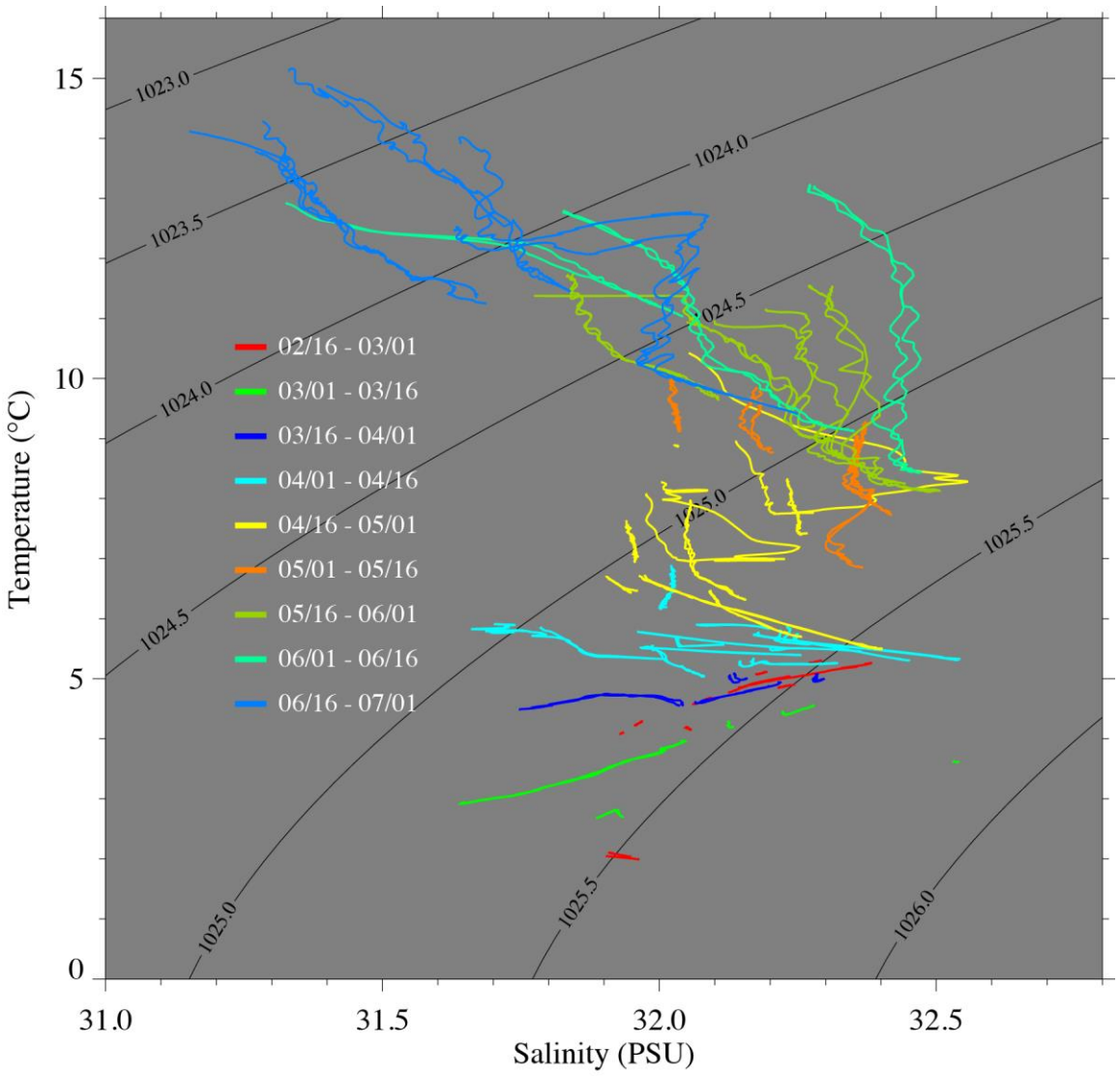

Figure 35. Temperature/salinity profiles plotted in T/S space. Contours in black show isopleths of constant water density (kg m^{-3}).

The zooplankton sample data were analyzed to elucidate the seasonal progression of zooplankton species composition and abundance. Figure 8 shows the community composition of the 65 collected and enumerated samples from the study area. These data indicate a high proportion of the zooplankton community was comprised of barnacle nauplii throughout February and March, and high proportions of *Pseudocalanus* species during April. Interestingly, *C. finmarchicus* never comprised a high proportion of the zooplankton community by numerical abundance, even in the samples collected near right whales (Figure 36). However, some of the highest *C. finmarchicus* abundances were collected near right whales in early March (Figure 9). The data in Figure 8 suggest that the zooplankton community composition in the study area during winter-spring 2019 was quite diverse, and it remained diverse throughout the study period.

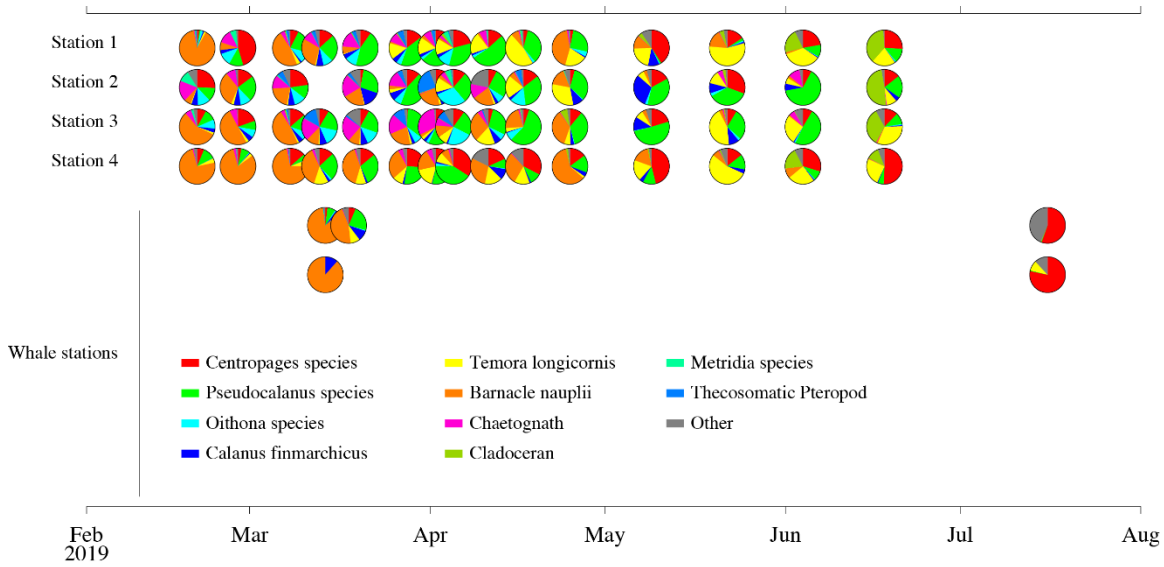

Figure 36. Zooplankton community composition at the four standard stations (upper pie diagrams) and at locations near right whales (lower pie diagrams).

There were seasonal trends in the numerical abundances of copepods that serve as right whale prey in other habitats (Figure 37). The abundance of *Centropages* species (a late winter prey of right whales in Cape Cod Bay) decreased in the late winter, but increased again around the time of the onset of stratification in mid-April and was highest at the end of the study period. *Pseudocalanus* species abundance showed little variation throughout the study period; *Pseudocalanus* species are another late winter prey of right whales in Cape Cod Bay. The most numerous organism in the late winter, barnacle nauplii, decreased in abundance during late winter, but increased in mid-April coincident with vernal stratification; after stratification, barnacle nauplii decreased by almost two orders of magnitude. Right whales have been observed apparently feeding on barnacle nauplii in Cape Cod Bay, albeit rarely. The abundance of *C. finmarchicus*, the primary right whale prey in spring/summer habitats, was modest throughout the study period, but increased after the onset of stratification in mid-April.

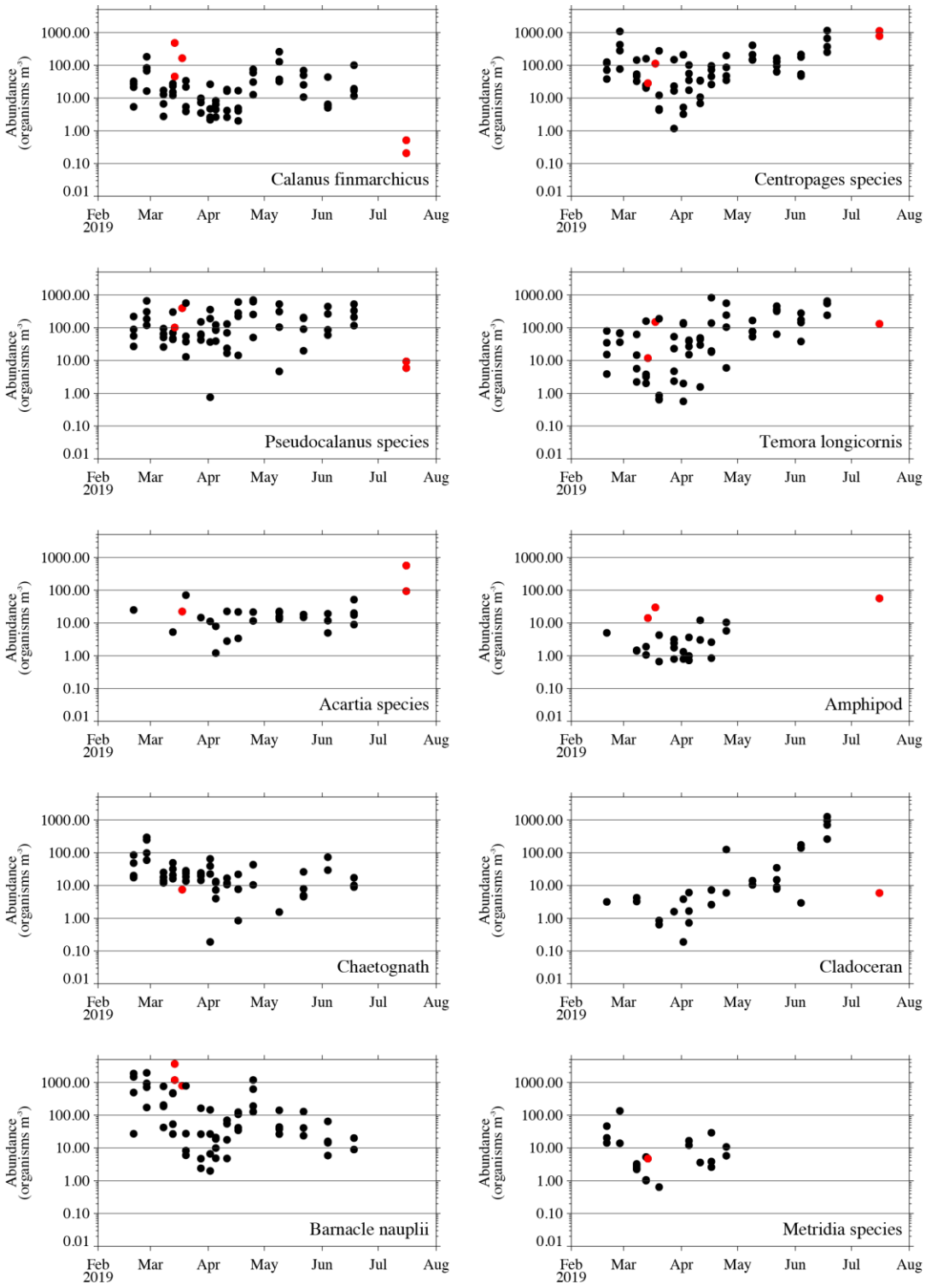

Figure 37. Time series of abundance (organisms m^{-3}) for various taxa collected at all standard stations (filled black circles) and near right whales (filled red circles).

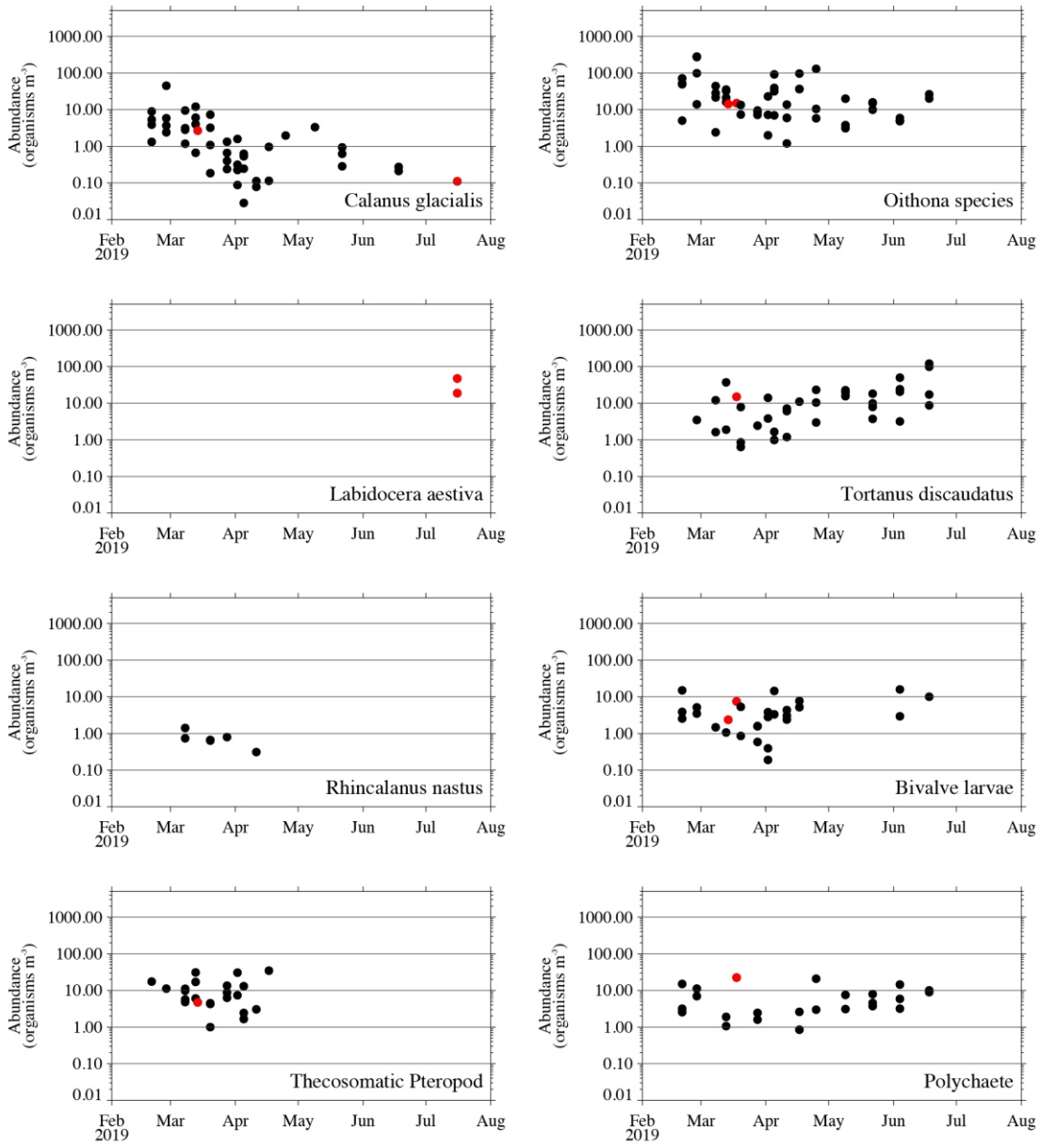

Figure 37 (continued). Time series of abundance (organisms m^{-3}) for various taxa collected at all standard stations (filled black circles) and near right whales (filled red circles).

Despite modest abundances, *C. finmarchicus* was found in all samples. The proportion of developmental stages (Figure 38) can help us understand how the life history of *C. finmarchicus* may influence their availability in the region, and in turn, the occurrence of right whales in the region. In late February and March, *C. finmarchicus* is mostly in the later copepodid stages, primarily C3-5. These are most likely first-of-the-year copepods that were spawned in December or January and have grown up throughout the winter. This first generation spawns a second generation, which appears in the data as the increasing percentage of young copepodid stages (C1-2) during April. Being the second generation of the year, it is more abundant than the first, which likely explains the increase in abundance observed around the onset of vernal stratification (Figure

37). During May and June, the population has a much higher proportion of late-stage copepodids, although there are some young stages (e.g., C2) that appear in June that indicate a possible third generation. Right whale baleen can efficiently filter the later stages (C4-C6), so it is the appearance of these later stages after stratification that is of particular importance for understanding right whale occurrence in the study area.

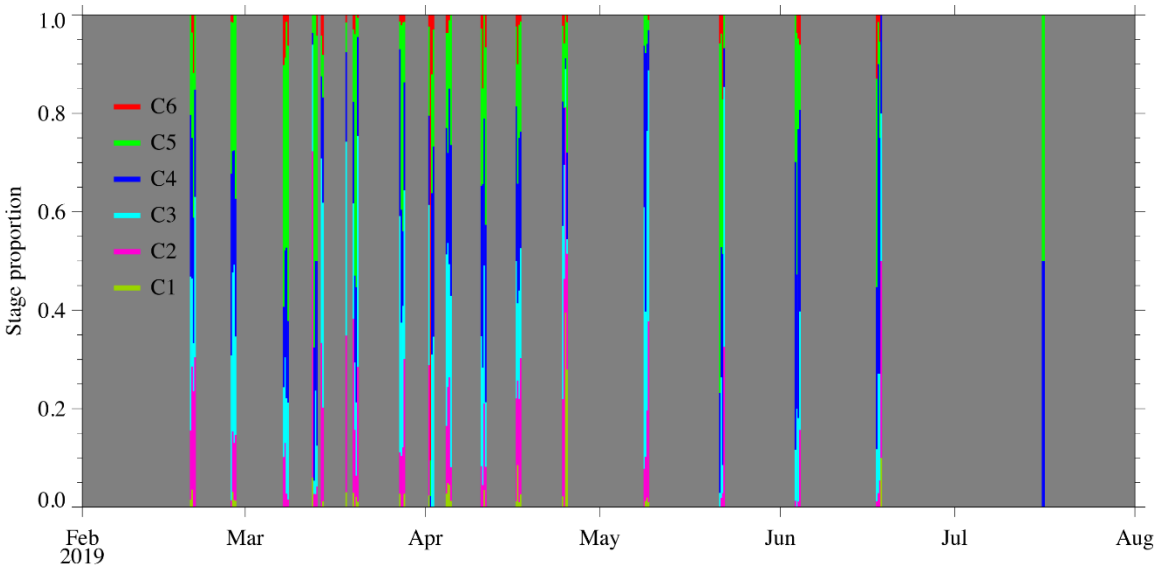

Figure 38. Proportion of developmental stages for *C. finmarchicus* collected during zooplankton sampling. Each vertical stripe is a single zooplankton sample. Stripes immediately adjacent to one another were collected on the same day. Data from both standard stations and whale stations are shown together.

DISCUSSION

1. AERIAL SURVEYS

Part one of the Campaign 5 report summarizes preliminary sightings data from 11 months of aerial surveys and oceanographic sampling at 65 stations over 7 months. A major caveat to the sightings data is that they have not been effort corrected. Reporting on relative abundance and density (e.g., sightings per unit effort and number of animals per trackline mile) will be included in part two of the Campaign 5 report. Here we discuss preliminary findings about animal sightings and distribution that are likely to be supported by the analyses that incorporate survey effort.

Some seasonal patterns in right whale distribution and numbers observed in Campaigns 1-4 were also observed during Campaign 5. In particular, right whales were distributed mainly over the Nantucket Shoals during the winter and the highest numbers of whales were spotted during winter and spring. In contrast to the earlier surveys (Campaigns 1-3, Kraus et al., 2016), the more recent surveys (Campaigns 4 and 5) show differences in the number of individual right whales, the size of right whale aggregations, and the length of time right whales are present in the study area. For example, Campaign 4 results and preliminary Campaign 5 results show more right whales in the study area during the winter and spring compared to Campaigns 1-3. They also show the presence of right whales in the study area during the summer and fall. In both Campaigns 4 and 5, a mid-summer aggregation of right whales was spotted south of Nantucket Island.

Preliminary Campaign 5 results also suggest some changes in right whale distribution and sightings patterns. Specifically, right whales were sighted in the western side of the study area less frequently than the eastern side of the study area during all seasons. While the magnitude of this pattern may be affected by a bias in effort away from the western side (this will be evaluated in the Part 2 report), it is probable that the overall pattern exists. In Campaign 4, right whales spread west across the study area during spring. In Campaign 5, this pattern was not observed. In general, very few right whales were observed west of the Nantucket Shoals and only one right whale was observed in the RIMA WEA zones during Campaign 5. Instead, during the spring of 2019, right whales were observed in an area where they had not been seen on previous surveys: south of the study area, in and around the shipping lane entering New York harbor. While we have no reason to suspect there were sizable aggregations in this area in previous years, there was undoubtedly increased survey effort in this area during 2019.

Right whales may also have been present in larger numbers in the study area during Campaign 5 than during the 2011-2015 surveys (Leiter et al. 2017, Stone et al. 2017) or during Campaign 4. Preliminary data suggests that at least 137 unique whales were identified during Campaign 5 surveys (11 months) compared to 94 unique whales during Campaign 4 (18 months) and an annual average of 35 unique whales during Campaigns 1-3 (Leiter et al. 2017). It should be noted that the number of right whales identified is likely biased upwards in Campaign 5 compared to other years because directed surveys were flown to known right whale aggregations. Regardless of the trend in the number of right whales in the study area, Campaign 4 and 5 results show that a large segment of the right whale population uses this area.

Right whales were sighted more often than any other large whale species. This result is in part due to the increased effort during times of high right whale density, which happens to occur during times of low density for other large whale species. However, even when looking at sightings only for general surveys, right whales were still sighted most often and in the highest numbers.

Patterns in the number of seasonal sightings of Balaenopterids were similar to those observed in previous years. Fin whales were seen most often in the late spring and early summer. Sei whales were seen for only a short period of time during May and June. Minke whales were seen most often in the spring and early summer and humpback whales were seen most often in May and June. For humpback whales, the peak in sightings was the same as in previous years. However, during Campaign 5, humpback whales were seen in more months.

Distribution patterns for Balaenopterids appeared to differ between Campaigns 4 and 5. Minke whales were distributed further north (i.e., closer to Martha's Vineyard and Nantucket) during Campaign 5 than during Campaign 4. Fin, sei, and humpback whale sightings were more common on the western side of the study area during Campaign 4 and more common on the eastern side of the study area during Campaign 5. However, the differences for all species may be the result of the increased effort on the eastern side of the study area during Campaign 5. Consequently, further assessment of these results is needed and will be conducted in Part 2 of the Campaign 5 report.

The highest numbers of common dolphins were observed in fall and summer during Campaigns 1-4. Similarly, Campaign 5 found the highest numbers of common dolphins in June and July; no surveys were conducted in September during Campaign 5. The results from our study area differ from the results of Kenney and Vigness (2010) that found high numbers of this species in the northeastern United States region during the winter. Other small cetaceans sighted in Campaign 5 had similar seasonal patterns to Campaign 4, as well as Campaigns 1-3 (Stone et al., 2017): most sightings occurred during spring or summer.

The downward trend in sea turtle sightings observed in Campaign 4 seemed to continue during Campaign 5. Additionally, Kemp's ridley turtles were only seen in Campaigns 1-3 and were not seen in Campaigns 4 or 5. The small number of turtle sightings in Campaign 5 may be a result of the lack of surveys flown in September, which is historically a month of high turtle sightings.

Shark and fish sightings during Campaign 5 peaked in June and were generally not seen outside of late spring and summer months. This pattern of a peak in fish sightings in the summer is consistent with previous years of data. The common species identified here, ocean sunfish, basking shark, and blue shark, are all easily identifiable. In one case, an identification of a hammerhead shark was possible from a vertical photograph because of its distinctive body shape. Our surveys likely miss some shark species because New England waters include many shark species that are difficult to differentiate, such as dusky and sandbar sharks. Consequently, these species are simply recorded as unidentified sharks.

It is clear that many species of marine megafauna continue to use the study area in high numbers. The patterns in seasonal and geographic distribution patterns for large whales are likely related to patterns of their prey. For right whales in particular, the presence of copepods likely

explains the high number of animals observed and is an important predictor of right whale presence in the future.

2. OCEANOGRAPHIC SAMPLING

Our data analysis is incomplete to date, as there is still much to be learned from comparing the results of our 2019 sampling with our similar work completed in 2017, as well as the examination of historical right whale occurrence and zooplankton community composition for publicly accessible datasets. These expanded analyses are ongoing, but we discuss here some preliminary observations from the 2019 sampling campaign.

The zooplankton abundances observed in the oceanographic study area were not particularly high (compared with abundances observed in other right whale habitats) and the zooplankton community was quite diverse, two factors that may explain why right whale occurrence and abundance was so low in the area of oceanographic sampling. Right whales were observed south of Nantucket for much of the winter and spring of 2019, but few were encountered in the area where our sampling occurred. The three zooplankton samples collected near right whales in March (Figure 36 and 37) were dominated by barnacle nauplii with some *C. finmarchicus* included. Both the barnacle nauplii and *C. finmarchicus* abundances in these near-whale samples were among the highest observed for these two taxa during the entire study period (Figure 37). The 2 samples collected near right whales in July were dominated by *Centropages* species (Figure 36), again at abundances that were near the highest observed for this taxon during the entire study period (Figure 37).

It appears that one of the important results from this and our 2017 study is that there is not one single primary prey that right whales target in the northern part of the study area. Like Cape Cod Bay, there are several possible prey species, including *Centropages* species, *Pseudocalanus* species, *C. finmarchicus*, and perhaps barnacle nauplii. It is important to keep in mind that we report numerical abundances here, and the differences in body size and lipid content among all of these potential prey makes their biomasses and nutritional content quite different. *Centropages* and *Pseudocalanus* spp. are small copepods compared to *C. finmarchicus* (e.g., an adult female *Pseudocalanus* sp. is about 11 times smaller than an adult female *C. finmarchicus*). Right whales use the study area during the late winter, a period of time when the larger lipid-rich *C. finmarchicus* is in developmental stages that are too small for right whales to efficiently filter, so it is not surprising that they feed on other, smaller, less nutritious organisms like *Centropages* sp., *Pseudocalanus* sp., and barnacle nauplii at that time. What is interesting about 2019 is that the abundance of *C. finmarchicus* did not increase dramatically in early spring, and right whales were generally absent from the northern study area. We are looking forward to putting these preliminary observations in the context of the 2017 sampling as well as the historical record of right whale occurrence and zooplankton abundance in the area as part of our remaining efforts on this project.

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APPENDIX

Supplementary Table 1. Summary of all aerial observer and vertical photographic analysis detections during general and condensed line-transect aerial surveys conducted during Campaign 5. Individual items for natural debris were not tallied and are marked with "*".

Category	Species/Item	Observers		Vertical photos		Total	
		No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Small cetaceans	Bottlenose dolphin (*Tursiops truncatus*)	12	431	--	--	12	431
	Common dolphin (*Delphinus delphis*)	30	1,231	8	33	38	1,264
	White-sided dolphin (*Lagenorhynchus acutus*)	5	181	--	--	5	181
	Unidentified dolphin	3	4	5	8	8	12
	Harbor porpoise (*Phocoena phocoena*)	1	15	15	19	16	34
Large cetaceans	Fin whale (*Balaenoptera physalus*)	5	9	--	--	5	9
	Minke whale (*Balaenoptera acutorostrata*)	49	53	2	2	51	55
	Humpback whale (*Megaptera novaeangliae*)	9	10	--	--	9	10
	Right whale (*Eubalaena glacialis*)	62	156	--	--	62	156
	Sperm whale (*Physeter macrocephalus*)	2	6	--	--	2	6
	Unidentified large whale	1	1	2	2	3	3
	Unidentified whale	2	2	--	--	2	2
Pinnipeds	Gray seal (*Halichoerus grypus*)	2	2	1	1	3	3
	Unidentified seal	63	2,294	14	1,669	77	3,963
Sea turtles	Leatherback turtle (*Dermachelys coriacea*)	1	1	--	--	1	1
	Loggerhead turtle (*Caretta caretta*)	--	--	2	2	2	2

Supplementary Table 1 (continued). Summary of aerial observer and vertical photographic analysis detections during Campaign 5 general and condensed line-transect aerial surveys. Individual items for natural debris were not tallied and are marked with "*".

		Observers		Vertical photos		Total	
Category	Species/Item	No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Birds	Great black-backed gull (*Larus marinus*)	--	--	2	2	2	2
	Long-tailed duck (*Clangula hyemalis*)	--	--	2	79	2	79
	Northern gannet (*Sula bassanus*)	--	--	15	16	15	16
	White-winged scoter (*Melanitta fusca*)	--	--	16	19	16	19
	Unidentified gull	--	--	16	29	16	29
	Unidentified storm-petrel	--	--	4	4	4	4
	Unidentified shearwater	--	--	4	4	4	4
	Unidentified tern	--	--	1	1	1	1
Sharks/fish	Basking shark (*Cetorhinus maximus*)	69	70	9	10	78	80
	Blue shark (*Prionace glauca*)	64	66	35	35	99	101
	Hammerhead shark (*Sphyrna* sp.)	--	--	1	1	1	1
	Ocean fish (*Mola mola*)	59	63	15	16	74	79
	School of fish	24	29	3	3	27	32
	Unidentified fish	--	--	14	201	14	201
	Unidentified shark	37	39	8	8	45	47
	Unidentified tuna	--	--	3	5	3	5
Human	Debris (different types)	22	22	57	58	79	80
activity	Fixed fishing gear	520	973	28	29	548	1,002
	Fishing vessel	331	354	4	4	335	358
	Recreational vessel	80	112	2	2	82	114
	Other types of vessels/data stations/coast guard	88	89	3	3	91	92
	Unknown vessel	2	2	--	--	2	2
Natural debris	Seaweed/wood/organic material	14	*	309	*	323	*
Unknown	Unidentified marine mammal	1	1	--	--	1	1
	Unknown object/animal	7	7	8	8	15	15

Supplementary Table 2. Summary of aerial observer and vertical photographic analysis detections during directed and opportunistic aerial surveys conducted during Campaign 5.

Category	Species/Item	Observers		Vertical photos		Total	
		No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Small cetaceans	Bottlenose dolphin (*Tursiops truncatus*)	5	48	--	--	5	48
	Common dolphin (*Delphinus delphis*)	13	458	4	13	17	471
	Unidentified common or white-sided dolphin	3	13	--	--	3	13
	Unidentified dolphin	5	9	1	1	6	10
	Harbor porpoise (*Phocoena phocoena*)	--	--	1	1	1	1
	Pilot whale (*Globicephala* sp.)	3	34	--	--	3	34
Large cetaceans	Fin whale (*Balaenoptera physalus*)	27	44	--	--	27	44
	Minke whale (*Balaenoptera acutorostrata*)	45	58	2	2	47	60
	Sei whale (*Balaenoptera borealis*)	28	55	--	--	28	55
	Unidentified fin or sei whale	7	7	--	--	7	7
	Humpback whale (*Megaptera novaeangliae*)	21	22	--	--	21	22
	Right whale (*Eubalaena glacialis*)	113	165	2	2	115	167
	Unidentified medium whale	1	1	--	--	1	1
Pinnipeds	Unidentified seal	11	416	--	--	11	416
Sea turtles	Leatherback turtle (*Dermachelys coriacea*)	4	4	1	1	5	5

Supplementary Table 2 (continued). Summary of aerial observer and vertical photographic analysis detections during directed and opportunistic aerial surveys conducted during Campaign 5.

Category	Species/Item	Observers		Vertical photos		Total	
		No. of detections	No. of individuals	No. of detections	No. of individuals	No. of detections	No. of individuals
Sharks/fish	Basking shark (*Cetorhinus maximus*)	51	55	9	9	60	64
	Blue shark (*Prionace glauca*)	1	1	7	7	8	8
	Ocean fish (*Mola mola*)	9	9	6	6	15	15
	Unidentified shark	35	52	5	5	50	57
Human activity	Fixed fishing gear	128	139	--	--	128	139
	Fishing vessel	43	114	1	1	44	115
	Recreational vessel	7	8	--	--	7	8
	Other types of vessels/ data stations /coast guard	17	18	--	--	17	18
Unknown	Unidentified animal	2	2	1	1	3	3