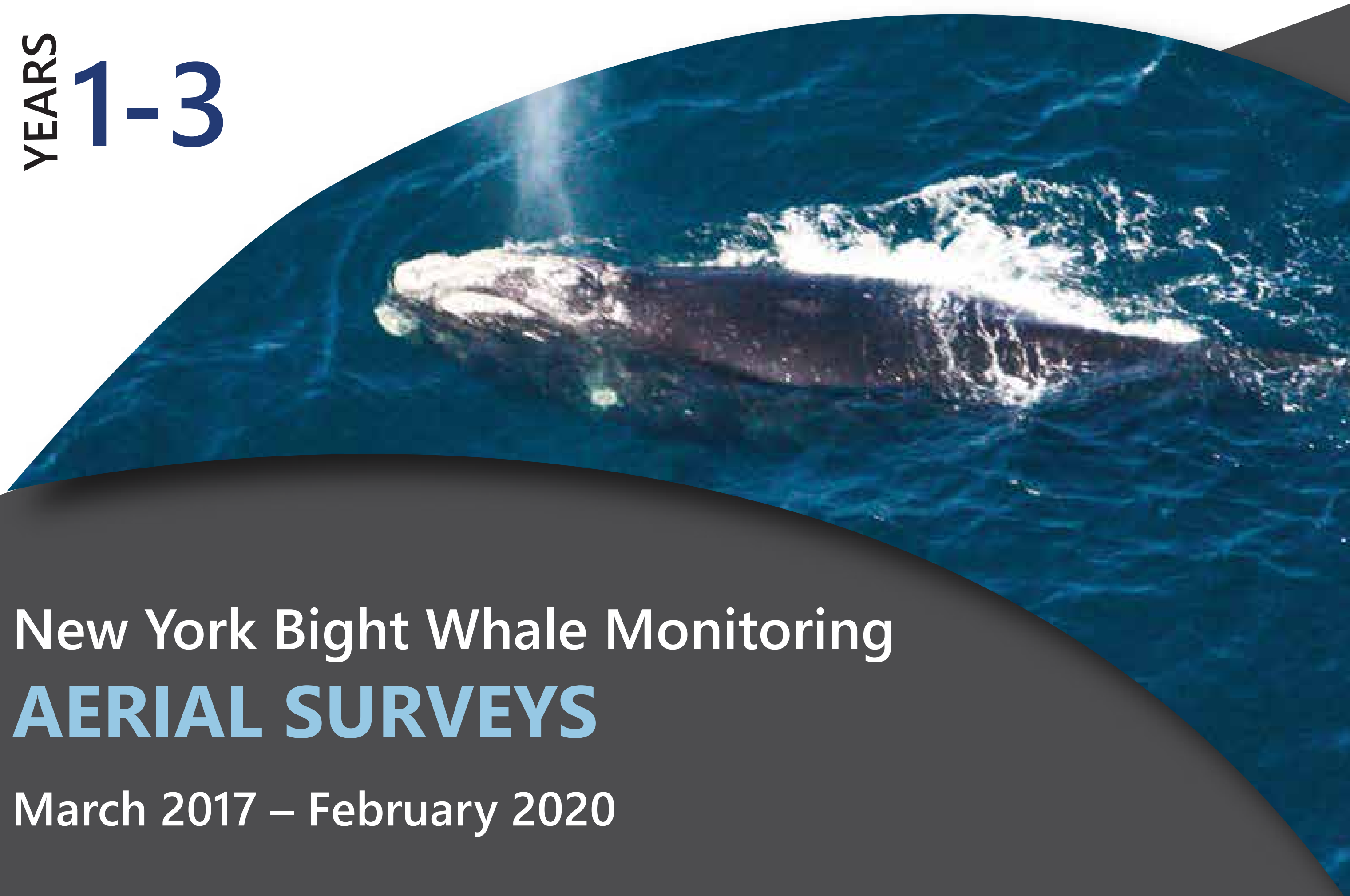
FINAL
COMPREHENSIVE REPORT

YEARS 1-3



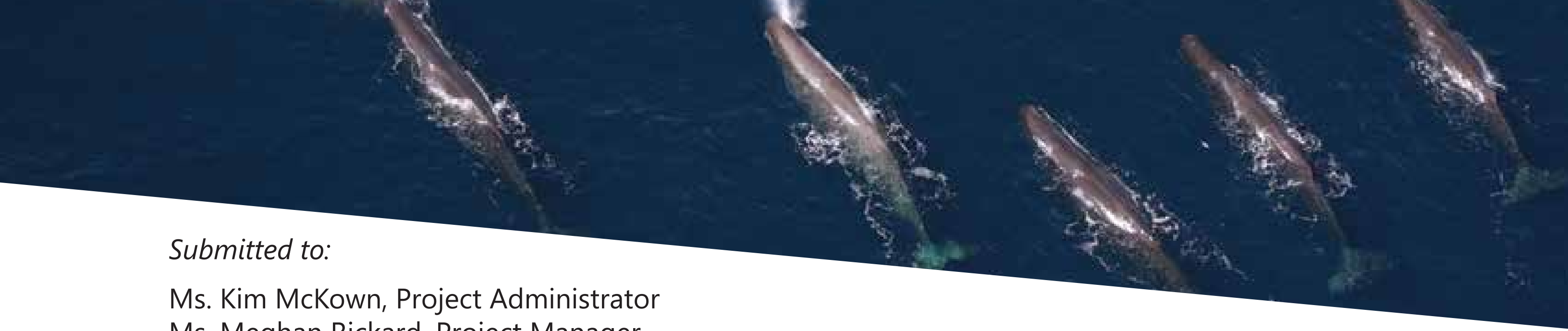
New York Bight Whale Monitoring
AERIAL SURVEYS

March 2017 – February 2020

DIVISION OF MARINE RESOURCES
New York State Department of Environmental Conservation
205 North Belle Mead Road, Suite 1
East Setauket, NY 11733

May 2020

TETRA TECH



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Cover Photo: (top) Right whale, (bottom) Sperm whales - Kate Lomac MacNair
Titile Page Header Photo: Sperm whales - Kate Lomac MacNair
Title Page Footer Photos: (left to right) Humpback whales - Kate Lomac MacNair; Sei whale with common dolphin - Kate Lomac MacNair; Fin whale - Darren Ireland
Back Page Photo: Blue whales and Fin whales - Kate Lomac MacNair



Final Comprehensive Report for New York Bight Whale Monitoring Aerial Surveys March 2017 – February 2020

Contract No. C009926

May 2020

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ACRONYMS AND ABBREVIATIONS

ADIZ	Air Defense Identification Zone
AIC	Akaike's Information Criterion
AMAPPS	Atlantic Marine Assessment Program for Protected Species
AMCS	Atlantic Marine Conservation Society
Beaufort SS	Beaufort Sea State
BOEM	U.S. Bureau of Ocean Energy Management
CCS	Center for Coastal Studies
CDS	Conventional distance sampling
CETAP	Cetacean and Turtle Assessment Program
CV	Coefficient of variation
DOI	U.S. Department of the Interior
DoN	Department of the Navy
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
ft	Feet
GPS	Global positioning system
hr	Hour
ID	Identification
Indiv.	Individuals
km	Kilometer
km^2	Square kilometer
km/hr	Kilometer per hour
kn	Knot
LGL	LGL Ecological Research Associates, Inc.
m	Meter
MCDS	Multiple covariate distance sampling
mi^2	Square mile
mi/hr	Mile per hour
Mysticetus	Mysticetus™ Observation Platform software
NA	Not applicable
NEAQ	New England Aquarium

NEFSC	Northeast Fisheries Sciences Center
nm	Nautical mile
nm^2	Square nautical mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NYB	New York Bight
NYNJHE	New York-New Jersey Harbor Estuary
NY OPA	New York Department of State's "Offshore Planning Area"
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOS	New York State Department of State
NYSERDA	New York State Energy Research and Development Authority
O2	Overlapping option
OPA	Offshore Planning Area
PI	Principle Investigator
PM	Project Manager
PSD	Perpendicular Sighting Distance
S.D.	Standard deviation
SWFSC	Southwest Fisheries Sciences Center
Tetra Tech	Tetra Tech, Inc.
UME	Unusual mortality event
U.S.	United States
USCB	U.S. Census Bureau
USCG	U.S. Coast Guard
WAAS	Wide Area Augmentation System

EXECUTIVE SUMMARY

Tetra Tech, Inc. (Tetra Tech), in coordination with LGL Ecological Research Associates, Inc. and subcontractor Aspen Helicopters, Inc., was contracted by the New York State Department of Environmental Conservation (NYSDEC) Division of Marine Resources to conduct 36 months of whale monitoring in the New York Bight (NYB), for the project titled "New York Bight Whale Monitoring Aerial Surveys." Monitoring consisted of monthly line-transect aerial surveys of the NYB, focused on six large whale species (referred to herein as "priority" or "priority large"). For this project, the Survey Area is a 43,449 square kilometers (km^2) (12,668-square nautical mile [nm^2]) area of ocean from the south shore of Long Island to the continental shelf break and matches the New York Department of State's Offshore Planning Area (NY OPA).

The six species of priority large whales that were the focus of the aerial surveys are the blue whale (*Balaenoptera musculus*), fin whale *(B. physalus*), humpback whale (*Megaptera novaeangliae*), North Atlantic right whale (*Eubalaena glacialis*), sei whale (*B. borealis*), and sperm whale (*Physeter macrocephalus*). Of these, the North Atlantic right whale is the most critically endangered. This longitudinal multi-year study investigated the density and abundance of these species by conducting monthly visual aerial surveys. This comprehensive report presents the results from surveys during Years 1, 2, and 3 and provides new insight into the occurrence, relative abundance, behavior, and densities and abundance of the target priority large whale species in the NYB Survey Area.

A total of 36 monthly aerial surveys were conducted starting in March 2017 and ending in February 2020. Year 1 surveys were March 1, 2017 to February 28, 2018; Year 2 surveys were March 1, 2018 to February 28, 2019; and Year 3 surveys were March 1, 2019 to February 28, 2020. Observations were conducted by two observers from a high-winged, twin-engine Partenavia aircraft: one observer was positioned on each side of the aircraft and looked through bubble windows. Data recorded included all parameters required to estimate density and abundance using distance sampling techniques. The highest priority variables included: date; time; species; group size; declination and bearing angle to the sighting to determine the perpendicular distance; location (latitude/longitude) of the sighting to the aircraft (using global positioning system [GPS] and angle data); and environmental covariates. Behavioral parameters such as behavioral state (e.g., Travel, Mill), events (e.g., breach, tail slap), heading/orientation, group cohesion distances, and reaction/no reaction were also recorded.

For Years 1–3 combined, a total of 263 survey flights were completed over 36 survey months. A total of 733.1 hours (hr) and 149,482 kilometers (km) (80,714 nm) of flight ("in air") time from "wheels up" to "wheels down" was flown, consisting of: 254.7 hr and 52,438 km during Year 1; 236.6 hr and 48,291 during Year 2; and 241.8 hr and 48,753 km during Year 3.

For Years 1–3 combined, a total of 3,052 sightings of 37,410 estimated individuals were recorded, including all six priority species of large whales (blue, fin, humpback, North Atlantic right, sei, and sperm whales), other marine mammals (i.e., delphinids, etc.), sea turtles, and other marine species (i.e., sharks, rays, fish schools, etc.). Of the 3,052 sightings, 318 (629 estimated individuals) were of the priority large whale species, 980 (23,244 estimated individuals) were of other marine mammal species, 474 (557 estimated individuals) were of sea turtles, and 1,280 (12,980 estimated individuals) were of other marine species. Sighting rates of priority large whale species for Years 1–3 combined data were:

- Blue – 3 sightings (estimated 5 individuals); 0.04 whales/1,000 km of effort
- Fin – 124 sightings (estimated 207 total individuals); 1.47 whales/1,000 km of effort
- Humpback – 111 sightings (estimated 279 total individuals); 1.99 whales/1,000 km of effort
- North Atlantic right – 15 sightings (estimated 24 total individuals); sighting rate 0.17 whales/1,000 km of effort
- Sei – 2 sightings (estimated 7 individual) of sei whales; 0.05 whales/1,000 km of effort
- Sperm – 32 sightings (estimated 72 total individuals); 0.51 whales/1,000 km of effort

Priority large whale sighting rates were highest for fin and humpback whales. Sighting rates varied seasonally as shown in Table ES-1. During spring, fin whales had the highest sighting rate, followed by humpback and North Atlantic right whales. During summer and fall, humpback whales had the highest sighting rate, followed by fin and sperm whales. During winter, humpback whales had the highest sighting rate, followed by fin, sperm, and North Atlantic right whales.

TABLE ES-1. SIGHTING RATES BY SEASON FOR PRIORITY LARGE WHALE SPECIES

Common Name	**Whales/1,000 km effort**			
	Spring	Summer	Fall	Winter
Blue Whale	0	0	0.03	0.12
Blue/Fin/Sei Whale	0	0.06	0	0.03
Fin Whale	1.13	3.44	0.53	0.90
Humpback Whale	0.98	4.40	1.45	1.16
North Atlantic Right Whale	0.41	0	0.05	0.24
Sei Whale	0.20	0	0	0
Sperm Whale	0.35	1.28	0.26	0.18
Unidentified Baleen Whale	0.03	0	0	0
Unidentified Large Whale	0.23	0.29	0.08	0.30
All Priority Large Whales Identified to Species*	**3.07**	**9.12**	**2.31**	**2.60**
All Priority Large Whales**	**3.33**	**9.47**	**2.39**	**2.93**

Notes:

*Includes all large whales identified to species (i.e., does not include blue/fin/sei and unidentified large whales).
**Includes all large whales including unidentified to species.

Estimates of density and abundance using line-transect methods (a type of distance sampling [Buckland et al. 2001]) were conducted for the six species of priority large whales observed during Year 3 and the combined Years 1–3.

In Year 3, 51 sightings occurred (including sightings classified as "unidentified large whale") while On Transect under acceptable viewing conditions and were therefore available for the line-transect analysis. "Unidentified large whale" as used herein, is defined as larger than small- or mid-sized cetaceans, and upon first sighting is considered to potentially be one of the six priority large whale species. Total density of the pooled priority species, uncorrected for detectability on the survey line (g[0]), was 1.742 individuals/1,000 km^2, and total abundance was estimated to be 76 whales (coefficient of variation [CV] = 21.22%). When species-specific corrections for g(0) detectability bias were applied, the overall density estimate increased to 6.268 individuals/1,000 km^2, resulting in an abundance estimate of 272, which represents the average estimated year-round abundance in the entire NYB Survey Area for the priority species. The annual average densities corrected for detectability bias for the six priority large whale species in Year 3 were:

- Blue whale – 0.047 individuals/1,000 km^2
- Fin whale – 2.263 individuals/1,000 km^2
- Humpback whale – 1.259 individuals/1,000 km^2
- North Atlantic right whale – 0.283 individuals/1,000 km^2
- Sei whale – 0.214 individuals/1,000 km^2
- Sperm whale – 2.201 individuals/1,000 km^2

After pooling data from Years 1–3, the annual average densities corrected for detectability bias for the six priority large whale species were:

- Blue whale — 0.031 individuals/1,000 km^2
- Fin whale – 2.923 individuals/1,000 km^2
- Humpback whale – 2.461 individuals/1,000 km^2
- North Atlantic right whale – 0.319 individuals/1,000 km^2
- Sei whale – 0.083 individuals/1,000 km^2
- Sperm whale – 1.312 individuals/1,000 km^2

The most commonly observed behavior states of priority large whale species were Rest/Slow Travel (268 estimated individuals) followed by Probable Foraging (168 estimated individuals). There were very few instances of Surface-Active behavior recorded. Fin whales and humpback whales exhibited a wide variety of behaviors and most frequently Rest/Slow Travel and Probable Foraging. North Atlantic right whales most frequently exhibited Rest/Slow Travel behavior followed by Medium Travel, Fast Travel, Mill and Surface-Active Mill. Sperm whales most often exhibited Rest/Slow Travel, Medium Travel, and Mill behaviors, which are commonly recorded between foraging dives. In addition to the priority large whale species, there were 10 other types of marine mammal sightings. Some were not identified to species level but were categorized generally as unidentified dolphin, unidentified cetacean, and unidentified seal, or to the lowest taxonomic level (i.e., *Delphinus/Tursiops/Stenella*, *Tursiops/Grampus* and *Tursiops/Lagenorahynchus)*. The most frequently recorded other marine mammal was the unidentified dolphin (493 groups; estimated 12,974 individuals), followed by Risso's dolphin (*Grampus griseus*) (232 groups; estimated 2,462 individuals). Additionally, there were 39 groups (estimated 45 individuals) of minke whales (*B. acutorostrata*), 39 groups (estimated 385 individuals) of bottlenose dolphin (*Tursiops truncatus*), 51 groups (estimated 3,867 individuals) of common dolphin (*Delphinus delphis*), 20 groups (estimated 472 individuals) of pilot whales (*Globicephala sp.*), 1 group (estimated 2 individuals) of Cuvier's beaked whale (*Ziphius cavirostris*), and 2 groups (estimated 16 individuals) of harbor porpoise (*Phocoena phocoena).*

A total of 474 sea turtle sightings of an estimated 557 individual sea turtles were recorded during Years 1–3 combined. Of these sightings, 50 groups totaling 54 individuals were identified to species, including one Kemp's ridley sea turtle (*Lepidochelys kempii*), 37 leatherback sea turtles (*Dermochelys coriacea*), and 16 loggerhead sea turtles (*Caretta caretta*). The remaining 424 sightings (503 individuals) were of unidentified sea turtles.

Overall, findings from Years 1–3 demonstrate that humpback and fin whales are more common than the other four species, while sperm and North Atlantic right whales are consistently present, but in lower numbers. Sei and blue whales appear to be relatively rare within the NYB. These overall findings, including trends in seasonal occurrence of these species, are generally consistent with expectations based on past research in the region. However, results from Years 1–3 surveys provide focused, systematically collected data in the NYB and show that there can be substantial inter-annual variability in the abundance, distribution, and behavior of large whales in the NYB.

1.0 INTRODUCTION

Tetra Tech, Inc. (Tetra Tech), in coordination with LGL Ecological Research Associates, Inc. and subcontractor Aspen Helicopters, Inc. (collectively, the "survey team"), was contracted by the New York State Department of Environmental Conservation (NYSDEC) Division of Marine Resources to conduct 36 monthly aerial line-transect visual observation surveys focused on six priority large whale species found in the New York Bight (NYB). The project is titled "New York Bight Whale Monitoring Aerial Surveys."

This report presents data collected monthly from March 2017 through February 2020 (Years 1–3), and includes survey goals, objectives, data collection and analysis methodologies, and results. The "survey year" as used herein is defined as the period spanning the first survey in March through February, the last of the 12 monthly surveys. Results from Year 1 surveys (March 2017 through February 2018) were presented in the first-year summary report submitted to NYSDEC in May 2018 (Tetra Tech and SES 2018). Results from Year 2 surveys (March 2018 through February 2019) were presented in the second-year summary report submitted to NYSDEC in May 2019 (Tetra Tech and LGL 2019). NYSDEC made both of the reports available on its website (www.dec.ny.gov/lands/113818.html).

The six large whale species that are the focus of aerial surveys and are referred to herein as "priority" or "priority large" whales are the blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*), North Atlantic right whale (*Eubalaena glacialis*), sei whale (*B. borealis*), and sperm whale (*Physeter macrocephalus*). However, since all large whales are of interest to NYSDEC, all whale sightings were documented, regardless of species. Of the priority large whales, five are listed as "endangered" under the U.S. Endangered Species Act (ESA): North Atlantic right, fin, sei, sperm, and blue. The humpback whale stock in the NYB was delisted from the ESA in 2016 (81 Federal Register 62259).

The survey team opportunistically documented sightings of sea turtles when doing so would not interfere with efforts to search for priority large whales. The four species of sea turtles known to occur in the survey region are the green sea turtle (*Chelonia mydas*), Kemp's ridley sea turtle (*Lepidochelys kempii*), loggerhead sea turtle (*Caretta caretta*), and leatherback sea turtle (*Dermochelys coriacea*). The survey team also opportunistically documented sightings of other marine mammals such as small cetaceans, and other marine species such as sharks, rays, fish schools, etc., when doing so would not interfere with efforts to detect large whales.

1.1 BACKGROUND

Large whales, including this study's priority large whale species and other cetaceans, can be found year-round in mid-Atlantic waters, including the waters of the NYB. The NYB also falls within important migratory pathways for certain species. Some information on the distribution, abundance, and behavior of large whales in the NYB is available from literature, prior surveys, whale-watching trips, and stranding records. However, the NYSDEC has determined available information on the occurrence and distribution of large whales in the NYB is inadequate for management and conservation planning at the state and federal level. This lack of information, coupled with growing concerns over ship strikes and entanglements, and the goal for having substantive data to inform planning for proposed offshore wind energy and other offshore human activities, makes long-term monitoring of large whales in the NYB a priority for NYSDEC. The visual observer line-transect systematic aerial surveys conducted under this contract and presented herein, are one component of a larger baseline data collection effort by NYSDEC, which includes passive acoustic surveys by Cornell University, and digital camera aerial surveys conducted by APEM Ltd. and Normandeau Associates, Inc. These combined study efforts aim to better define species presence, seasonal variations, and the density and abundance of large whale species considered priority by NYSDEC in the NYB.

To meet these data needs, NYSDEC funded this New York Bight Whale Monitoring Aerial Surveys project as part of a 3-year baseline monitoring program focused on six priority species of whales in the NYB. The findings from this study will also provide the necessary baseline data required by federal resource agencies to assess and permit the location and configuration of future offshore wind energy development in the NYB, in the U.S. Bureau of Ocean Energy Management (BOEM) Lease Area, BOEM Wind Planning Area, and New York Department of State's "Offshore Planning Area" (NY OPA).

1.2 SURVEY GOALS

The primary goals of the aerial surveys were:

1. Determine the distribution and estimate relative abundance and density of the six priority species of large whales in the NYB:
    - Blue
    - Fin
    - Humpback
    - North Atlantic right
    - Sei
    - Sperm
2. Determine the monthly and seasonal occurrence, and inter-annual variability of the distribution and estimated abundance, density, and relative abundance for the six priority species.
3. Record data about the behavior of sighted non-priority whales as much as possible while focusing on the six priority whales.
4. Record sightings of sea turtle species including:
    - Green
    - Kemp's ridley
    - Loggerhead
    - Leatherback
5. Record relevant environmental variables.

2.0 METHODS

The survey team conducted 36 monthly aerial surveys during Years 1–3 from March 2017 through February 2020. The method employed was visual aerial line-transect surveys, which are a type of distance sampling (Buckland et al. 2001). The Project Manager (PM) coordinated monthly with NYSDEC and other groups working in the survey area, on specific survey timing. Survey area, schedule, design, data collection, and analysis methods are described below.

2.1 SURVEY AREA

For this project, the NYB Survey Area was defined as the ocean area from the south shore of Long Island to the continental shelf break and matches the NY OPA (Figure 1). The NYB Survey Area is 43,449 square kilometers (km^2) (12,668-square nautical miles [nm^2]) (calculated using Albers Equal Area Conic U.S. Coast Guard [USCG] Version in Mysticetus™ Observation Platform software [Mysticetus]) and includes state and federal waters. State waters extend from 0 to 5.6 kilometers (km) (0 to 3 nautical miles [nm]) from shore, and federal waters extend from 5.6 to 370 km (3 to 200 nm) from shore.

2.2 SURVEY SCHEDULE

Surveys were conducted monthly, beginning in March 2017 through February 2020, for a total of 36 survey events (Table 1). Surveys were scheduled in advance to allow for efficient coordination with the survey team and other contractors working with NYSDEC in the NY OPA, and to account for standby/weather days. In general, surveys were separated by a minimum of 14 days between the last flight day of one survey and the first flight day of the next survey; there were typically 3 to 4 weeks between surveys. Surveys were only flown in visual flight regulation conditions. Flights were defined as “in air” time from “wheels up” to “wheels down.”

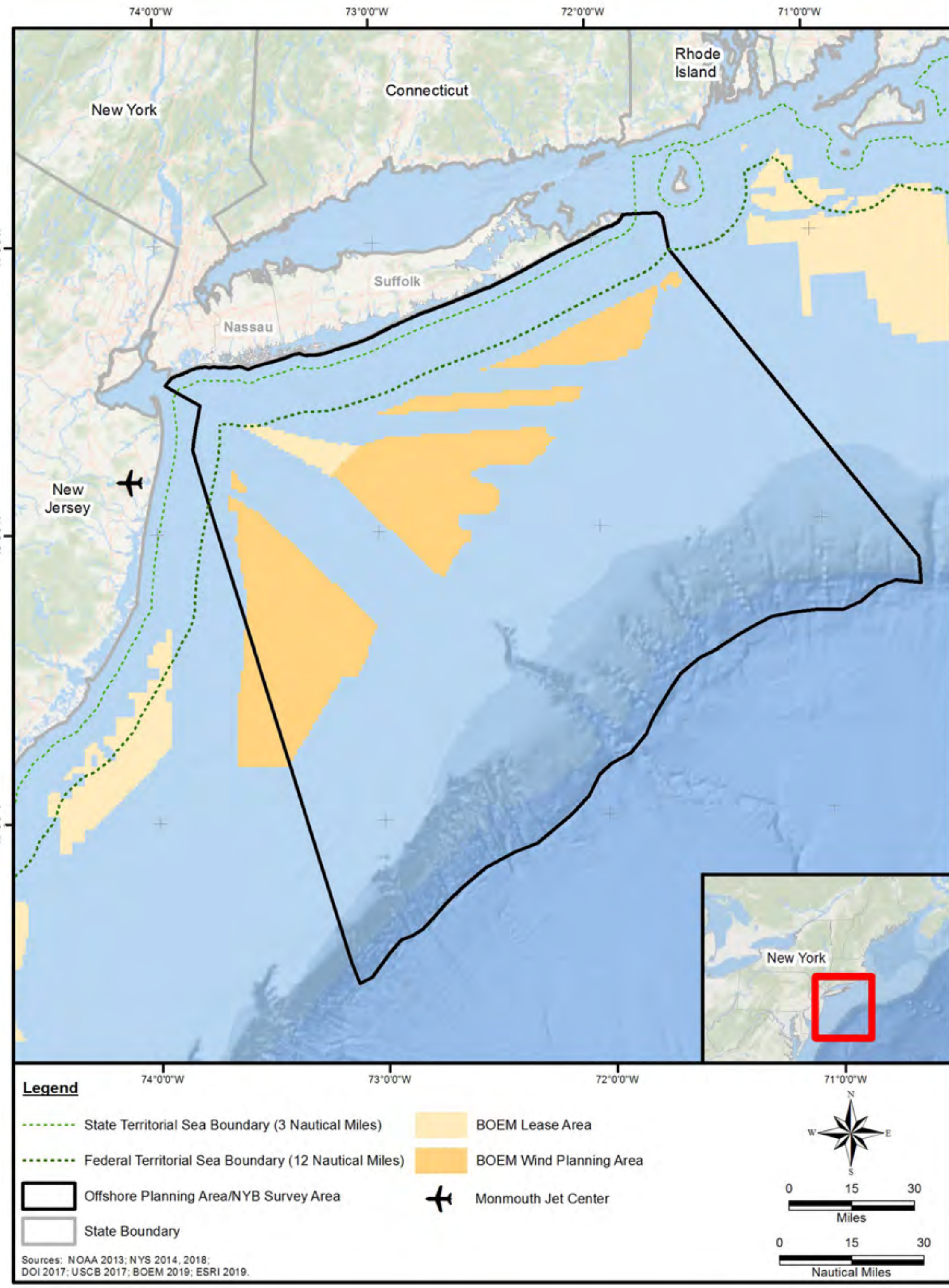

Figure 1. New York Bight Whale Monitoring Aerial Survey Area

TABLE 1. YEARS 1–3 SURVEY DATES

	Survey Dates		
Survey Number	**Year 1**	**Year 2**	**Year 3**
1	March 20–23, 2017	March 12–16, 2018	March 11–14, 2019
2	April 1–3, 2017	April 9–11, 2018	April 8–12, 2019
3	May 8–10, 2017	May 8–15, 2018	May 14–17, 2019
4	June 16–21, 2017	June 14–16, 2018	June 1–4, 2019
5	July 1–4, 2017	July 9–11, 2018	July 24–27, 2019
6	August 25–27, 2017	August 6–8, 2018	August 9–11, 2019
7	September 24–30, 2017	September 9–17, 2018	September 9–11, 2019
8	October 15–18, 2017	October 8–14, 2018	October 24–28, 2019
9	November 7–12, 2017	November 12–17, 2018	November 19–23, 2019
10	December 4–8, 2017	December 9–12, 2018	December 10–13, 2019
11	January 6–11, 2018	January 7–11, 2019	January 13–18, 2020
12	February 5–9, 2018	February 11–16, 2019	February 10–16, 2020

2.3 SURVEY DESIGN

Aerial surveys were flown using a small, high-wing, twin-engine, six-seat aircraft (Partenavia P68-C) operated by Aspen Helicopters, Inc. (www.aspenhelo.com), designed for scientific research and equipped with bubble windows that provide clear visibility of the trackline to the horizon on both sides of the aircraft. The trackline is the area of the survey lines the plane is passing over. The bubble windows allow observers to "guard the trackline" by providing improved visibility directly under the plane relative to flat windows. Observer effort was focused on the trackline out to approximately 3 km (1.62 nm). Additionally, there are opening portholes on each side of the plane in the rear seat that allow handheld photographs to be taken during circling, and a belly port on the floor of the plane for vertical photography.

A Sony Digital 4K video camera recorder was mounted in the belly window of the aircraft behind the middle seat row to guard the trackline and continuously record video. The video will be included in the data deliverable and can support future analysis efforts, if warranted. In addition, a Canon EOS 7D still camera with a Canon EF 100–400 mm f/4.5-5.6L IS USM lens was used to take photo-identification photographs of North Atlantic right whales and to confirm large whale species, group size, and calf presence. Photographs were also taken of unusual sightings, including rarely sighted species, unusual aggregations of species, or unusual behavioral displays. Photographs were taken by an observer through a small opening porthole window on either side window of the aircraft, usually depending on which side of the plane the sighting was made. Photographs were taken in unprocessed raw (CR2) file format to preserve project data in a lossless format for future analyses (e.g., mark recapture, etc.), and in high-resolution JPEG format for easier processing.

Tetra Tech submitted North Atlantic right whale photographs and metadata to the North Atlantic right whale catalog operated by the New England Aquarium (NEAQ), in April and December 2018 (no photographs were obtained of the March 2018 observation). Appendix A contains the North Atlantic right whale submissions to the NEAQ and provides additional detail on North Atlantic right whale sightings during Year 3 surveys. Select photographs are included in Appendix B. All photographs will be included in the data deliverable to support future potential photo-identification efforts. Appendix C provides project protocols regarding circling priorities for species identification and for photography. The table in Appendix C was developed to define priorities and give guidelines for circling, by species and by photographic priority. Appendix D presents recommendations for potential future efforts including additional detailed analyses of existing data, as well as suggestions for potential future monitoring activities, including long-term regional monitoring.

Prior to the start of Year 1 surveys, 15 parallel transect lines were established to provide appropriate coverage of the NYB Survey Area (Figure 2). The transect lines were oriented northwest to southeast and spaced 16.7 km (9 nm) apart. Shorter connecting lines (cross-legs) were flown to travel between the start or end of transect lines. The transect line design was developed based on local coastline configuration, precedent established by other surveys, and statistical, environmental, and safety considerations. Survey lines were developed in consultation with the National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Sciences Center (SWFSC) and modified in consultation with NYSDEC and with input from NOAA Northeast Fisheries Sciences Center (NEFSC) staff provided to Tetra Tech and NYSDEC (Tetra Tech 2017). The orientation of transect lines was developed to minimize glare and optimize observation conditions. The number of transect lines and their spacing was based on the rationale used in the design of an ongoing NOAA aerial survey study (*Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in U.S. Waters of the Western North Atlantic Ocean [[Atlantic Marine Assessment Program for Protected Species ((AMAPPS)];* NOAA Fisheries 2016*)* and presented in a series of annual reports from AMAPPS I (2010—2014; Palka et al. 2017) and AMAPPS II (2015–2019; NOAA Fisheries 2018 and 2019). The transect lines were also based on an extensive assessment of coverage probability relative to known species distributions, relative densities from previous studies in the region, and estimated minimum sample size requirements for distance sampling (Palka 2005; NOAA Fisheries 2016; Kraus et al. 2016). The assessment included using the software Distance 6.2 (Thomas et al. 2010) to design the most appropriate number of transect lines and spacing to cover the NYB Survey Area, given the priority goal of detecting large whales. Figure 2 depicts the layout of the 15 survey transect lines spaced 16.7 km (9 nm) apart, and also the 200-meter (m) isobath where the shelf break occurs.

The initial goal for completing the surveys was to randomly select the survey line start position; however, in practice, decisions on where to begin each survey were often based on weather conditions, airspace restrictions, and other considerations related to how to most effectively and safely complete all the survey lines. Although not randomly chosen, the order the transect lines were flown varied from one survey to the next. The starting point each day was selected by the Lead Observer and the Chief Pilot, considering the aforementioned factors, as well as how to most efficiently complete the full set of survey lines given local weather conditions and predictions for the survey week. Total transect length was approximately 2,514 km (1,357 nm). Depending on localized conditions, survey lines were sometimes interrupted to fly other lines where weather conditions were better. An attempt was later made to "fill in" survey lines when weather conditions improved, usually on subsequent flights or days. The slight offset from shore near the northwest corner of the NYB Survey Area was incorporated to avoid airspace conflict with New York's John F. Kennedy International Airport (Figure 2). Survey lines crossed the Air Defense Identification Zone (ADIZ), thus pilots were required to file, activate, and close a flight plan with the appropriate aeronautical facility prior to entry and exit across the ADIZ.

The following parameters delineate the NYB Survey Area:

- Distance to shelf break: approximately 203.7 km (110 nm)
- Distance between transect lines: 16.7 km (9 nm)
- Number of transect lines: 15
- Total transect length: approximately 2,514 km (1,357 nm)
- Total survey distance (including connector lines): approximately 2,843 km (1,535 nm)
- Total NYB Survey Area: 43,449 km^2 (12,668 nm^2)

Surveys along transect lines were conducted from a target altitude of approximately 305 m (1,000 feet [ft]) and groundspeed of 100 to 110 knots (kn). To maximize survey time and ideal weather conditions, surveys commenced as early as possible each day to take advantage of typically calmer conditions in the mornings. The aircraft and crew were located nearby for quick mobilization during standby conditions (e.g., poor weather). Flights were flown when the Beaufort Sea State (Beaufort SS) was such that large whales could be seen (generally Beaufort SS 5 or lower). During prolonged periods of inclement weather, some flights or portions of flights were conducted in Beaufort SS of 6 (see Section 3.1.4 for more information).

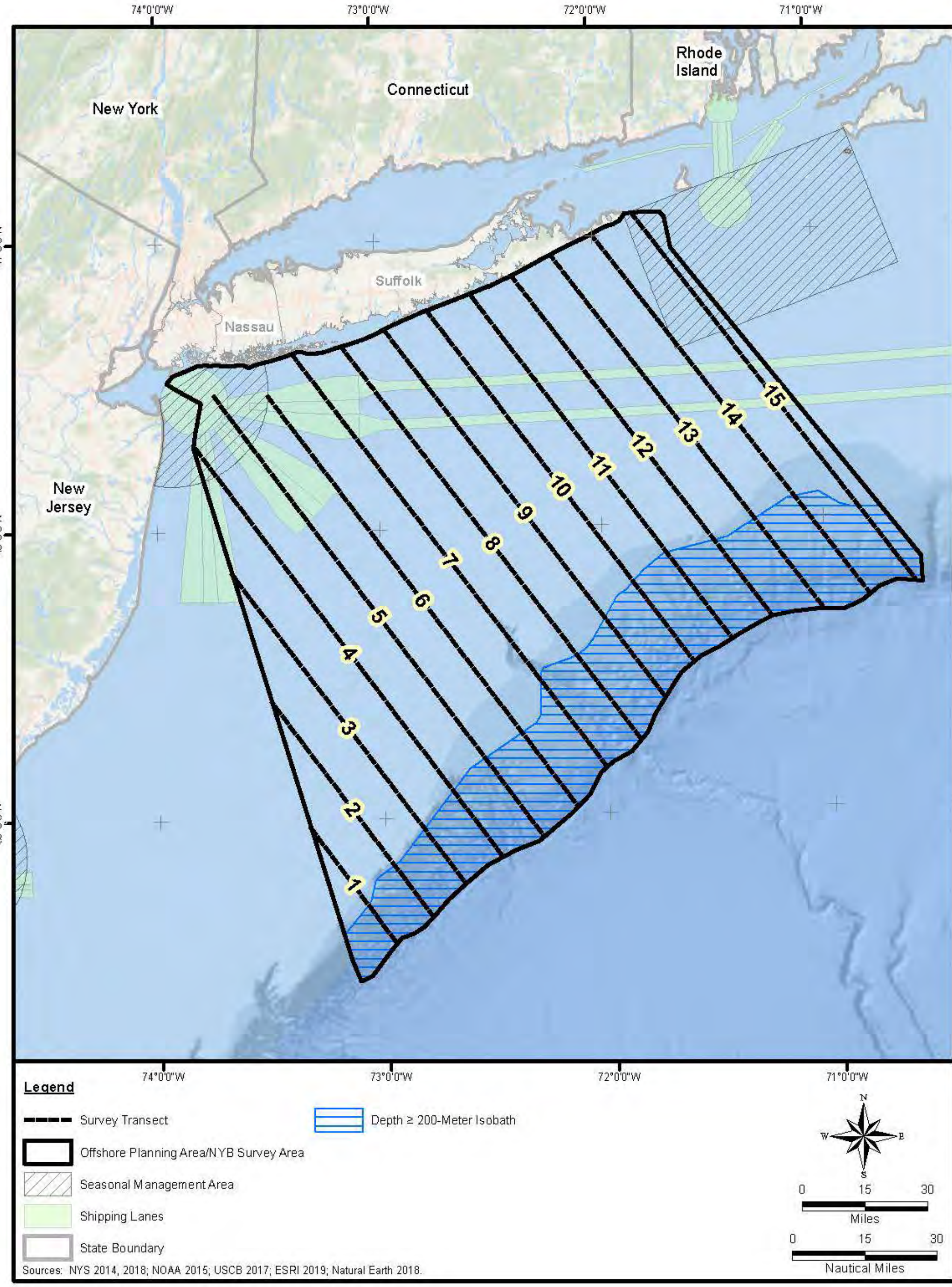

Figure 2. New York Bight Whale Monitoring Aerial Survey Transect Lines

2.4 DATA COLLECTION

Recorded data included all parameters required to estimate density and abundance using distance sampling techniques, as well as selected behavioral and environmental variables identified for AMAPPS surveys as possible or relevant (NOAA Fisheries 2016). Variables of highest priority for estimating density and abundance of whales are date, time, species, group size, declination, and bearing angle to sighting to determine the perpendicular distance and location (latitude/longitude) of the sighting to the aircraft (using global positioning system [GPS] and angle data), and potential environmental covariates. Behavioral parameters (behavioral state [e.g., Travel, Mill] and events [e.g., breach, tail slap], heading/orientation, group cohesion distances, reaction/no reaction) were recorded as possible, consistent with previous aerial surveys with similar survey goals (AMAPPS Annual Reports [e.g., Palka et al. 2017; NOAA Fisheries 2018, 2019]; Kraus et al. 2016).

Data collection focused on the six priority species of large whales. However, basic presence information (date, time, location, species, angle and bearing, group size, calf presence) for other marine mammals and sea turtles was collected opportunistically (i.e., when not interfering with data collection on the six priority species). Observers also recorded general data from other opportunistic sightings (e.g., date, time, species, group size, location of plane), such as large shoals of baitfish (i.e., fish schools), shark species, rays, and ocean sunfish (*Mola mola*).

Observers searched for whales and other marine fauna during all periods the aircraft was over water during amenable viewing conditions (Beaufort SS ≤ 5, unobstructed visibility [e.g., no low clouds or rain blocking or obscuring effective viewing]). Observation effort was divided into the following five categories similar to other line-transect survey studies (Jefferson et al. 2014, 2016): Transect Effort, Cross-leg Effort, Transit Effort, Circling Effort, and Overland Effort (Table 2). Transect Effort consisted of observation effort On Transect and the only effort type included in the density analyses. Cross-leg Effort consisted of observation effort while flying on shorter connector lines connecting transect lines. Transit Effort consisted of observation effort while flying to and from transect lines and the shoreline, usually from or to an airport. Circling Effort consisted of periods when the aircraft broke off the transect line to circle sightings to confirm species and group size, and/or take photographs including for photo-identification of North Atlantic right whales. Overland Effort consisted of periods when the aircraft was transiting overland. Periods of "Off Effort" were when observers were not observing (such as when flying over land or through clouds that obscured the downward view).

Decision factors for circling include weather conditions, location, fuel consumption, and other specifics such as recent Unusual Mortality Events (UMEs). In Year 1 of this study, guidelines for circling priorities were established in coordination with NYSDEC and are listed in Appendix C.

Since observation efforts were focused on searching for priority large whale species, sightings details for other marine mammal species (cetaceans and pinnipeds) were recorded opportunistically. The survey team used hot keys on the laptop running the Mysticetus software, to mark the locations of these sightings when it would not interfere with priority species observation efforts (e.g., in areas where all sightings were relatively low). The other species sightings consisted of those for which locations were noted using the computer in the field, and thus should be considered minimum numbers of sightings. Data for these sightings is entered into the data collection software as feasible, following similar protocols.

TABLE 2. EFFORT TYPE AND DEFINITIONS

Effort Type	Definition
Transect Effort	Pre-determined line-transect legs*
Cross-Leg Effort	Flying between two adjacent transects at the start or end of transect lines (i.e., connector lines)
Transiting Effort	Flying between the airport and the survey grid locations and transiting between transect lines
Overland Effort	Flying over land
Circling Effort	Flying circles around sightings to verify species and group size via photography
Random Effort	Flight path veering off transect, transit or cross-leg. Pilot directed (i.e., due to air traffic in proximity, plane mechanical malfunction, weather, etc.

Note:

*Transect Effort was filtered further using criteria for multiple environmental conditions prior to use in density analyses. These additional sighting condition criteria specific to data used in density analyses are found in Section 2.5.3.

When whales were sighted and species identification was not confirmed, or when a North Atlantic right whale was seen, observers directed the pilot to move off the transect line (thus ending the Transect Effort) and circle back to count and confirm identification and group composition of observed priority large whales (all species), and to take photo-identification pictures of North Atlantic right whales for contribution by NYSDEC to the species' identification catalog (http://rwcatalog.neaq.org/Terms.aspx). After circling, the plane returned to the location the Transect Effort had ended and continued the survey along the transect line.

Sighting and environmental data were collected using customized Mysticetus software on a laptop computer (www.mysticetus.com). Mysticetus data collection software has been successfully used since 2010 for line-transect and behavioral aerial and vessel surveys by NOAA, the NEAQ, U.S. Navy, etc., and numerous academic, non-profit, and for-profit entities around the world. Using Mysticetus, the following functions were included:

- Each new entry was automatically assigned a time stamp, a sequential sighting number, and a Wide Area Augmentation System (WAAS)-enabled GPS position.
- Environmental data were collected at the beginning of each survey leg and whenever conditions changed.
- GPS locations of the aircraft were automatically recorded in duplicate using WAAS-enabled GPS devices (including for real-time backup): (1) at 1-second intervals by a USB GPS (e.g., a Bluetooth® USGlobalsat® BT368i mini GPS); and (2) at 3-second intervals by two handheld Garmins™ (e.g., GPSMAP® 78s GPS).

- Short-cut buttons (i.e., “hot keys”) on the laptop were used to increase efficiency and speed of data entry. To the maximum extent practicable, more detailed data were recorded during non-line transect effort periods such as on Cross-leg Effort lines and during Circling.

In real time on a laptop split screen, Mysticetus displayed on a map the survey tracks and survey lines, sightings, re-sightings, bathymetry, and a spreadsheet to enter sighting and effort data. Mysticetus instantly calculates and displays aircraft altitude, speed, and heading, as well as distances and bearings to sightings relative to the observation aircraft. This feature facilitates quick and accurate re-location of sightings, including relative to bathymetry and coastline geography.

A Suunto™ handheld clinometer was used to measure declination angles to sightings when the sighting was perpendicular to the aircraft, for conversion to Perpendicular Sighting Distance (PSD) as required for density and abundance analyses using distance sampling (the latter was done instantaneously and automatically by Mysticetus during the flight; the bearing and distance to the sighting from the aircraft was also instantly reported and displayed on the nautical chart on the computer screen). Mysticetus also calculated PSD for sightings made at other bearings from the plane in cases where an observer’s clinometer reading was not exactly perpendicular to the aircraft, as happens occasionally (this allows for more accurate positioning of sightings and is consistent with distance sampling protocol). A digital voice recorder with time-stamp capability recorded all voices on the plane’s audio system by placing a mini-microphone in one earpiece of the noise-cancelling headphones worn by the two observers. Observers also used binoculars (7 x 50) as needed to identify species, group size, behaviors, etc., from the aircraft.

2.4.1 Equipment and Personnel

The following equipment was used during the surveys (and provided in duplicate as back-up):

- 2 Dell laptops with Mysticetus software
- 2 Suunto™ handheld clinometers
- 2 digital voice recorders with time-stamping capability
- 7 x 50 binoculars
- Canon EOS 7D Still Camera with a Canon EF 100-400mm f/4.5-5.6L IS USM lens and SD cards
- Sony Digital 4K Video Camera Recorder with extra SD cards
- Apple iTouch (to display real-time video recording)
- 2 Garmin eTrex handheld GPS units
- Paper notebooks and pens

- USB thumb drive (for automatic back-up of data recorded in Mysticetus)
- Cell phone (for safety, to report North Atlantic right whale sightings between flights while on the ground at the airport, to the North Atlantic right whale hotline phone number, or, to report entanglements, strandings, or mortalities if observed)

Observations were conducted by two observers at all times. Observers were experienced in conducting aerial surveys for marine mammals and sea turtles and were trained in project-specific data collection protocol and species identification. Observers were positioned on each side of the aircraft and looked through bubble windows. Observers rotated each flight between the left and right sides of the aircraft. Each survey had a designated lead observer who acted as team lead during the survey and handled communication with the project Principle Investigator (PI) and PM. The PI or PM were present on some surveys throughout the year. When the PI was present, she acted as lead observer. The PI and PM both have senior subject matter expertise and years of aerial survey experience.

2.4.2 Data Parameters and Definitions

For the purposes of analysis and for this report, "survey year" was defined as the period spanning the first survey in March to the last of the 12 monthly surveys. Year 1 was March 1, 2017 to February 28, 2018; Year 2 was March 1, 2018 to February 28, 2019; and Year 3 was March 1, 2019 to February 29, 2020.

Seasons were defined using calendar months as follows:

- Spring: March 1 – May 30
- Summer: June 1 – August 31
- Fall: September 1 – November 30
- Winter: December 1 – February 28

2.4.3 Sighting Variables

Observational and environmental data collected included:

- Location and time of sighting (via GPS), with PSD and distance and bearing of sighting from the trackline, as applicable.
- Species identification of all marine mammal(s) or sea turtle(s) to the lowest possible taxonomic designation. For example:

- Blue/fin/sei whale was defined as a large slender baleen whale (over approximately 18–20 m in length) with short pectoral fins, darkish body color, rostrum shape of blue/fin/sei, no white pectoral fins, body not rotund like North Atlantic right whale; too large to be North Atlantic right whale or minke whale; could not differentiate any chevrons, right white jaw.

- A grouped category for delphinid species with similar morphology that could not be identified to the lowest taxonomic order was categorized as "*Delphinus/Tursiops/Stenella sp.*, *Tursiops/Lagenorhynchus sp.* or *Tursiops/Grampus sp.*"
- A grouped category for sightings (not including large priority whale) where a whale could not be grouped or identified to any order and may include non-priority species, was categorized as "unidentified whale."
- A grouped category for sightings where a large priority whale could not be grouped or identified to species level, was categorized as "unidentified large whale."
- A grouped category for sightings where a large whale could be classified as a baleen whale but not to which species, was categorized as "unidentified baleen whale."

- Number of individuals, group size (minimum, maximum, and best estimates), and/or group composition (adults, subadults, and relative sizes).

- Number of calves (any species observed).

- Duration of sighting.

- The best possible detailed description of behavior (Table 3), disposition, and reaction/no reaction to the aircraft.

  - Description includes the first observed group behavioral state (Rest/Slow Travel, Travel, Mill, Probable Foraging, Surface Active, Surface Active-Mill, Surface Active-Travel, Unknown, or Other); additional behavioral state modifiers for an individual such as forage/feed, social, behavioral events (e.g., breach, tail slap), and the minimum and maximum spacing between nearest individuals within a group in estimated body lengths.

- Direction of travel (magnetic).

- Photographs and/or video, if needed.

- Environmental information associated with each sighting event (Beaufort SS, wave height, swell direction, wind direction, wind speed, glare severity, percentage of glare [i.e., glare strip width], percentage of cloud cover, visibility, etc.).

TABLE 3. BEHAVIOR STATE AND DEFINITIONS

Behavior State	Definition
Rest/Slow Travel	>50% of group exhibiting little or no forward movement (<1 km/hr) remaining at the surface in the same location or drifting/traveling slowly with no wake.
Travel	>50% of group swimming with an obvious consistent orientation (directional) and speed, no surface activity; Medium travel = 1–3 km/hr wake, no white water; Fast travel = >3 km/hr with white water.
Mill	>50% of group swimming with no obvious consistent orientation (non-directional), characterized by asynchronous headings, circling, changes in speed, and no surface activity.
Probable Foraging	>50% of group apparent searching for prey; the process of finding, catching, and eating food. Probable foraging captures foraging (e.g., bubble-net feeding or lunge feeding visible).
Surface Active	>50% of group occurrence of behavior on the water surface that creates a conspicuous splash (includes all head, tail, pectoral fin, and leaping behavior events).
Surface Active-Mill	>50% of group while milling, occurrence of behavior on the water surface that creates a conspicuous splash (includes all head, tail, pectoral fin, and leaping behavior events).
Surface Active-Travel	>50% of group while traveling, occurrence of behavior on the water surface that creates a conspicuous splash (includes all head, tail, pectoral fin, and leaping behavior events).
Unknown	Not able to determine behavior state. (Animals out of sight, too far to determine, on a dive, etc.).
Other	Describe in notes.

Note:

km/hr = kilometer per hour

2.4.4 Environmental Variables

Environmental variables were collected at the beginning of each transect line, with change of effort type, and whenever conditions changed. Environmental variables collected include: Beaufort SS (Table 4), glare location and intensity, visibility, turbidity, cloud cover, precipitation, and overall conditions (Table 5). These variables were selected as they affect the visible detectability of whales from the aircraft.

TABLE 4. BEAUFORT SEA STATE SCALE

Force	Wind Speed			Name	Conditions at Sea
	knots	km/hr	mi/hr		
0	< 1	< 2	< 1	Calm	Like a mirror
1	1–3	1–5	1–4	Light air	Ripples only
2	4–6	6–11	5–7	Light breeze	Small wavelets (0.2 m), crests have a glassy appearance
3	7–10	12–19	8–11	Gentle breeze	Large wavelets (0.6 m), crests begin to break
4	11–16	20–29	12–18	Moderate breeze	Small waves (1 m), some whitecaps
5	17–21	30–39	19–24	Fresh breeze	Moderate waves (1.8 m), many whitecaps
6	22–27	40–50	25–31	Strong breeze	Large waves (3 m), probably some spray
7	28–33	51–61	32–38	Near gale	Mounting sea (4 m) with foam blown in streaks downwind
8	34–40	62–74	39–46	Gale	Moderately high waves (5.5 m), crests break into spindrift
9	41–47	76–87	47–54	Strong gale	High waves (7 m), dense foam, visibility affected
10	48–55	88–102	55–63	Storm	Very high waves (9 m), heavy sea roll, visibility impaired, surface generally white
11	56–63	103–118	64–73	Violent storm	Exceptionally high waves (11 m), visibility poor
12	64+	119+	74+	Hurricane	14-m waves, air filled with foam and spray, visibility bad

Notes:

km/hr = kilometer per hour
m = meter
mi/hr = mile per hour
Source: Modified from Rowlett and the University of North Carolina, 2001.

TABLE 5. ENVIRONMENTAL DATA COLLECTED

Environmental Data Parameter	Definition
Beaufort Sea State	See Table 4
Visibility	Estimated distance (km) at which the observer could observe a single large whale
Glare Severity	Amount of glare over the forward 180 degrees of view; dropdown options are: None, Little, Moderate, Severe (prevents observations), or Variable
Glare From	"Time" on a clock face (situated over the aircraft, with 12:00 straight ahead) where the glare starts (e.g., 11:00 or 2:00)
Glare To	"Time" on a clock face (situated over the aircraft, with 12:00 straight ahead) where the glare ends (e.g., 12:00 or 3:00)
Precipitation	Type of precipitation; dropdown options are: None, Fog, Light Rain, Rain, Snow
Cloud Cover	Percent cloud cover over 360 degrees; dropdown menu gives ranges: 0–25, 25–50, 50–75, 75–99, or 100%
Turbidity	Turbidity based on: 0 = clear water: objects/animals visible several meters under the surface 1 = moderately clear water: objects/animals visible under the surface 2 = turbid water (e.g., algae, mud): objects/animals only visible very close (<1 foot) to the surface 9 = unknown turbidity
Overall Evaluation	Observer's evaluation of the sighting conditions in their survey area, accounting for all factors (i.e., glare, water color, sun angle, etc.) 1 = excellent 2 = good 3 = moderate 4 = fair 5 = poor (data should not be used) X = observer is Off Effort

Notes:

% = percent
km = kilometer

2.5 ANALYSIS METHODS

The following sections cover the analyses utilized in processing the survey data.

2.5.1 Distribution

As part of the Final (Year 3) Annual Report analyses, distribution of priority large whales in the NYB Study Area was assessed through sighting rates within four designated habitat classes. Four habitat classes are defined herein for the purposes of the distribution analysis, based on distance from shore and standard bathymetric delineations as follows:

- Nearshore: 0—25 km (13.5 nm) from shore
- Shelf: >25 km (13.5 nm) from shore to 200 m water depth
- Slope: >200 m to 1,000 m water depth
- Plain: >1,000 m water depth

This distribution analysis was undertaken to approximate a spatial analysis and mapping output similar to "hot spot" analyses and to provide, where possible, initial trends of potential habitat clusters for large priority whales in the study. Sighting rates were expressed as the number of individual whales seen per 1,000 km of observation effort in each habitat class. Sighting rates were calculated by dividing the total number of individuals by species (or lowest taxonomic level recorded) within each habitat class, by the total kilometers of effort in the respective habitat class and multiplying by 1,000 to obtain the number of individuals seen per 1,000 km of effort. Observation effort used to calculate sighting rates consisted of the pooled number of km flown within each habitat class; "pooled" observation effort includes Transect, Cross-leg, Transit, Random (Year 1), and Circling (i.e., all effort types over water). Certain species were also pooled to increase sample sizes.

2.5.2 Sighting Rates

Relative abundance was evaluated based on sighting rates and expressed as the number of individual whales seen per 1,000 km of observation effort. Sighting rates were calculated by dividing the total number of individuals by species into their lowest taxonomic order observed during each period of interest (e.g., month, season), by the total kilometers of effort during that period, and multiplying by 1,000 to obtain the number of individuals seen per 1,000 km of effort. When sightings were identified as either a blue, fin, or sei whale based on their similar morphology, but could not be identified to the lowest taxonomic order, the sighting was categorized as "blue/fin/sei whale." In cases where a sighting occurred but the unidentified large whale could not be grouped at all to any order, the sighting was categorized as "unidentified large whale."

Observation effort used to calculate sighting rates consisted of the pooled number of km flown during each period of interest; "pooled" includes combined data when similar in type and content, or in this case, certain species were pooled to increase sample sizes. Pooled observation effort includes Transect, Cross-leg, Transit, and Circling (i.e., all effort types over water and excluding Overland Effort). Sighting rates were calculated by month, season, and overall. Additionally, sighting rates were calculated for all priority large whales identified to species and all large whales (including unidentified whales).

2.5.3 Density

Estimates of density and abundance using line-transect methods were conducted for the priority species of large whales observed during Year 3 surveys. (Densities from previous years are shown in Table 20. Additional details from Year 1 and 2 density results are presented in previous annual reports [Tetra Tech and SES 2018; Tetra Tech and LGL 2019]). Both conventional distance sampling (CDS) (Buckland et al. 2001) and a more sophisticated approach, multiple covariate distance sampling (MCDS) (Buckland et al. 2004), were considered to estimate marine mammal density and abundance in the NYB Survey Area. The MCDS approach is generally preferred as it uses information on environmental factors likely to affect detection probability (e.g., variables describing sighting conditions), and often (though not always) produces estimates with higher precision (i.e., lower variances and coefficient of variation [CV]). However, achieving data convergence with small sample sizes can be difficult using MCDS, so this method was not used on the Year 3 data alone. With the larger available sample size in the Years 1–3 combined dataset, both CDS and MCDS methods were used.

To conduct the analyses, a line-transect database was developed using R statistical software (R Core Team 2018) and Microsoft Excel. For the density analyses, Transect Effort was filtered to distinguish periods when Beaufort SS ≤ 5, visibility distance was ≥ 1.5 km, severe glare was present in ≤ 1/3 of the forward 180° viewing area, and overall observation quality was ranked as “fair” or better. The resultant subset of Transect Effort is referred to as “On Effort” and is the only effort type used to estimate density and abundance using distance sampling analyses. Estimated densities were prorated and overall sighting rates adjusted to account for unidentified large whales likely to be one of the priority species. “Prorated” means the unidentified sightings were apportioned out to species based on the species proportions in the identified sample, and assumes unidentified species occur in the same proportions as the identified species.

Generally, sample sizes of 60 to 80 On Effort sightings are recommended for robust estimation of the detection function (Buckland et al. 2001). Using significantly smaller sample sizes can result in less precise results. Due to the smaller than recommended sample size of any single species in Year 3 alone, and the resultant lack of a robust estimation of species-specific detection functions, a pooling approach was used. Sighting distances from all six priority large whale species as well as “blue/fin/sei whale” and “unidentified large whale” sightings were combined to calculate a single pooled detection function that applied to all these species. This is a reasonable approach because all these species have similar detectability characteristics (i.e., adult body size > 10 m, prominent blows, and dorsal fins or large areas of back above the surface in each surfacing). The resulting sample size of 51 sightings in Year 3 was near to the minimum recommended guidelines for detection function estimation. For the Years 1–3 data, the total sample size available for fitting a detection function was 179. Of these 179 sightings, 77 were of fin whales and 55 were of humpback whales, allowing for the evaluation of species-specific detection functions for these two species.

On Effort data were imported into and analyzed using software DISTANCE 7.2, Release 1 (Thomas et al. 2010). Several different key functions were used to model the pooled PSD data (half normal, uniform, and hazard-rate), along with various series expansion terms (cosine, simple polynomial, and hermite polynomial) as recommended in Buckland et al. (2001). For the MCDS analysis of Years 1–3 data, Beaufort SS (as both a factor and non-factor variable), visibility distance, glare severity, and overall sighting score were also included in candidate models. The best-fit model was selected based on the minimum value of Akaike's Information Criterion (AIC) (Akaike 1974), χ^2 goodness-of-fit test, and the coefficient of variation of the density estimate. The AIC is an empirical method to determine which of several competing models best fit the data and is standard practice in line-transect surveys. The sightings data were post-stratified by month to estimate monthly densities of all priority large whales using the best-fit model of the pooled detection function. For CDS analyses, the overlapping option (O2) variance estimator was used to select an empirical estimator for a systematic study design, which is the case in this project. For MCDS analyses, variance was estimated using the bootstrap method implemented in the DISTANCE software.

For the initial density calculations, the trackline detection probability (g[0]) was assumed to be 1.0. Doing so means the density estimates were not corrected for animals on the trackline but missed by the observers (perception bias), or for animals underwater when the survey aircraft passed overhead (availability bias). Thus, these density estimates represent minimum estimates. The annual average and monthly density estimates were then prorated by species based on the proportion of individuals of each priority species among the total identified individuals in each time period.

Estimates of density and abundance (and their associated CVs) were calculated using the following standard formulae:

$$D = \frac{n\, f(0)\, E(s)}{2\, L\, g(0)}$$

$$N = \frac{n\, f(0)\, E(s)\, A}{2\, L\, g(0)}$$

$$\hat{CV} = \sqrt{\frac{\hat{\mathrm{var}}\,(n)}{n^2} + \frac{\hat{\mathrm{var}}\,[\hat{f}(0)]}{[\hat{f}(0)]^2} + \frac{\hat{\mathrm{var}}\,[\hat{E}(s)]}{[\hat{E}(s)]^2} + \frac{\hat{\mathrm{var}}\,[\hat{g}(0)]}{[\hat{g}(0)]^2}}$$

Where:

D = density (of individuals),

n = number of On Effort sightings,

f(0) = detection function evaluated at zero distance,

E(s) = expected average group size (using size-bias correction in DISTANCE),

L = length of transect lines surveyed On Effort,

g(0) = trackline detection probability,

N = abundance,

A = size of the NYB Survey Area,

CV = coefficient of variation, and

var = variance.

For comparison to abundance estimates derived from habitat-based density modeling reported by Roberts et al. (2016, 2017), the uncorrected density estimates were multiplied by the inverse of the same g(0) correction factors used by Roberts et al. (2017) and used to calculate g(0) corrected abundance estimates. Correction factors and their sources were:

- Blue whale, 0.407 (Carretta et al. 2000)
- Fin whale, 0.251 (Lafortuna et al. 2003)
- Humpback whale, 0.451 (Heide-Jorgensen et al. 2012)
- North Atlantic right whale, 0.334 (Cetacean and Turtle Assessment Program [CETAP] 1982)
- Sei whale, 0.53 (Palka 2006)
- Sperm whale, 0.172 (Watwood et al. 2006)

Monthly abundance estimates from Roberts et al. (2017) for fin, humpback, North Atlantic right, sei, and sperm whales were calculated by summing the abundance estimates from all 10 km x 10 km grids with over 50% overlap with the NY OPA (n = 434) from the monthly estimates for each species. Blue whale sightings were insufficient for monthly or seasonal abundance estimates by Roberts et al. (2016, 2017), so the same method as described for the monthly estimates was used on the single stratified annual estimate of blue whale abundance from Roberts et al. (2016).

3.0 RESULTS

This section presents findings for priority large whale sightings by effort, season, month, year Beaufort SS, behavior, and distribution patterns. The results for priority large whales are followed by a summary of sightings of other non-priority species (marine mammal or sea turtle).

For Years 1–3 combined, a total of 3,052 sightings of 37,410 estimated individuals were recorded for all species (Table 6) broken into the following categories:

- 318 sightings (629 estimated individuals) of the six priority large whale species (blue, fin, humpback, North Atlantic right, sei, and sperm whales)
- 980 sightings (23,244 estimated individuals) of other marine mammal species (i.e., delphinids, etc.)
- 474 sightings (557 estimated individuals) of sea turtles
- 1,280 sightings (12,980 estimated individuals) of other marine species (i.e., sharks, rays, fish schools, etc.)

A combination of tables, bar graph or histogram figures, and map figures illustrate the comprehensive set of results. All tables and bar graph or histogram figures (Figures 3 through 27) are included in subsections of Section 3.0. Map figures (Figures 28 through 95) are located at the end of the document due to the high number of results illustrating Year 3 findings or combined Years 1–3 results. Map figures are organized and presented by survey effort, priority whale sightings by month, priority whale sightings by season, priority whale sightings distribution, and non-priority sightings by species, as follows:

- Survey effort figures depict survey lines flown by effort for Year 3 (Figure 28), by season for Year 3 (Figures 29 through 32), and by effort in Year 2 and Year 1 (Figures 33 and 34, respectively). The locations of priority whale sightings in Year 3 are shown on Figure 35. Figure 36 shows the locations by each year with all priority whales grouped. Figure 37 shows the locations for each year with priority whales broken out by species.
- Figures 38 through 61 show priority whale sightings for each month of the year starting with the first month of the survey year. Each month has two figures, one for Year 3 results, and one for Years 1–3 results.
- Figures 62 and 63 show priority whale sightings by season for Year 3 and Years 1–3, respectively. Figures 64 through 81 show seasonal priority whale sightings by species, initially by season in Year 3, followed by Years 1–3, and then by count and season for Years 1–3.

- Figure 82 shows the boundaries of the habitat classes used in the distribution analysis. Figure 83 shows the sighting rates of all priority large whales (grouped) within the habitat classes for Years 1–3. Figures 84 through 89 show sighting rates by habitat class for Years 1–3 by priority whales by species.

- The last set of maps show sighting results for non-priority species, initially for Year 3, followed by Years 1–3. Figures 90 and 91 show non-priority marine mammals, Figures 92 and 93 show sea turtles, and Figures 94 and 95 show other marine species (e.g., rays, sharks, fish, etc.).

Appendix A contains the North Atlantic right whale sighting submissions sent to the NEAQ and information NEAQ relayed back regarding those sightings. Appendix B contains selected photographs from Years 1–3. Tables in this report presenting data by species are listed in alphabetical order (by common name) rather than taxonomic groupings or other organizational order. Appendix C provides guidelines for circling priorities including a table reflecting protocols developed in the course of this survey effort with a goal of providing more detail on circling priorities, with priorities defined both by species and by photographic priorities. Appendix D includes a set of recommendations for future efforts and covers both additional options for other analyses of these data as well as suggestions for other future monitoring including for long-term regional monitoring.

TABLE 6. SUMMARY OF SIGHTINGS FOR YEARS 1–3

Common Name*	Scientific Name	Year 1		Year 2		Year 3		Years 1–3	
		Groups	Indiv.	Groups	Indiv.	Groups	Indiv.	Groups	Indiv.
Priority Whales									
Blue Whale	*Balaenoptera musculus*	2	4	0	0	1	1	3	5
Blue/Fin/Sei Whale	*Balaenoptera sp.***	1	1	1	1	1	1	3	3
Fin Whale	*Balaenoptera physalus*	23	33	64	122	37	52	124	207
Humpback Whale	*Megaptera novaeangliae*	22	36	52	177	37	66	111	279
North Atlantic Right Whale	*Eubalaena glacialis*	8	13	3	4	4	7	15	24
Sei Whale	*Balaenoptera borealis*	0	0	1	1	1	6	2	7
Sperm Whale	*Physeter macrocephalus*	7	7	9	23	16	42	32	72
Unidentified Baleen Whale	*Mysticeti*	1	1	0	0	0	0	1	1
Unidentified Large Whale	*Cetacea*	9	10	13	15	5	6	27	31
All Priority Large Whales		**73**	**105**	**143**	**343**	**102**	**181**	**318**	**629**
Other Marine Mammals									
Bottlenose Dolphin	*Tursiops truncatus*	15	144	6	107	18	134	39	385
Common Dolphin	*Delphinus delphis*	30	2,713	5	657	16	497	51	3867
Cuvier's Beaked Whale	*Ziphius cavirostris*	1	2	0	0	0	0	1	2
Delphinus/Tursiops/Stenella	*Delphinus/Tursiops/Stenellas sp**.*	28	699	38	1,994	4	226	70	2,919
Harbor Porpoise	*Phocoena phocoena*	0	0	0	0	2	16	2	16
Minke Whale	*Balaenoptera acutorostrata*	9	9	23	28	7	8	39	45
Pilot Whale	*Globicephala melas*	8	279	1	2	11	191	20	472
Risso's Dolphin	*Grampus griseus*	96	788	67	820	69	854	232	2,462
Tursiops/Grampus	*Tursiops/Grampus sp.*	1	1	0	0	0	0	1	1
Tursiops/Lagenorhynchus	*Tursiops/Lagenorhynchus sp.***	0	0	1	1	3	15	4	16
Unidentified Beaked Whale	*Ziphiidae sp.*	3	8	0	0	1	5	4	13
Unidentified Cetacean	*Cetacea*	2	2	11	54	7	12	20	68
Unidentified Dolphin	*Delphinidae sp.*	126	3,108	120	4,300	247	5,566	493	12,974
Unidentified Seal	*Pinnipedia*	0	0	1	1	1	1	2	2
Unidentified Whale	*Cetacea*	2	2	0	0	0	0	2	2
All Other Marine Mammals		**321**	**7,755**	**273**	**7,964**	**386**	**7,525**	**980**	**23,244**
Sea Turtles									
Kemp's Ridley	*Lepidochelys kempii*	0	0	1	1	0	0	1	1
Leatherback Turtle	*Dermochelys coriacea*	7	7	18	20	9	10	34	37
Loggerhead Turtle	*Caretta caretta*	1	1	7	7	7	8	15	16
Unidentified Sea Turtle	--	215	248	"88	118	121	137	424	503
All Sea Turtles		**223**	**256**	**114**	**146**	**137**	**155**	**474**	**557**

TABLE 6. SUMMARY OF SIGHTINGS FOR YEARS 1–3 (CONTINUED)

Common Name*	Scientific Name	Year 1		Year 2		Year 3		Years 1–3	
		Groups	Indiv.	Groups	Indiv.	Groups	Indiv.	Groups	Indiv.
Other Marine Species									
Atlantic Manta Ray	*Manta birostris*	2	2	10	13	17	36	29	51
Basking Shark	*Cetorhinus maximus*	17	86	95	267	108	645	220	998
Blue Shark	*Prionace glauca*	0	0	0	0	1	1	1	1
Fish School	--	93	NA***	110	NA***	112	NA***	315	NA***
Great White Shark	*Carcharodon carcharias*	0	0	3	5	2	2	5	7
Hammerhead Shark	*Sphyrnidae sp.*	5	12	7	7	33	65	45	84
Ocean Sunfish	*Mola mola*	86	93	143	156	134	161	363	410
Other Unknown	--	5	5	9	9	10	98	24	112
Small Ray	*Batoidea*	1	6	10	2,222	0	0	11	2,228
Unidentified Ray	*Batoidea*	38	3,478	3	502	42	4351	83	8,331
Unidentified Shark	*Selachimorpha*	92	127	37	67	47	553	176	747
Whale Shark	*Rhincodon typus*	0	0	1	1	7	10	8	11
	All Other Marine Species	**339**	**3,809**	**428**	**3,249**	**513**	**5,922**	**1,280**	**12,980**
	All Sightings Total	**956**	**11,925**	**958**	**11,702**	**1,138**	**13,783**	**3,052**	**37,410**

Notes:

* Species listed in alphabetical order by common name (for all tables in Section 3.0).

** *Grouped categories used for species with similar morphology that could not be identified to the lowest taxonomic order: e.g. blue/fin/sei whale (Balaenoptera sp.)* and for delphinids: *Tursiops/Grampus sp., Delphinus/Tursiops/Stenella* sp., and *Tursiops/Lagenorhynchus* sp.

*** Not applicable; estimated individuals not calculated for fish schools.

3.1 EFFORT

The following sections detail survey effort for Years 1–3 and Year 3 by overall effort, effort by season, by month, and by Beaufort SS. Figure 3 shows survey effort as a function of Beaufort SS; Figures 28 through 34 (at the end of this report) depict survey lines flown by effort.

3.1.1 Overall Effort

A total of 263 survey flights were completed over 36 survey months (Table 7); key statistics are:

- 733.1 hours (hr) and 149,482 km (80,714 nm) of flight ("in air") time from "wheels up" to "wheels down" was flown over 3 years, consisting of:
  - 254.7 hr and 52,438 km (28,314 nm) during Year 1
  - 236.6 hr and 48,291 km (26,075 nm) during Year 2
  - 241.8 hr and 48,753 km (26,325 nm) during Year 3.
- 688.3 hr and 140,359 km (75,788 nm) of in-air flight effort occurred over water. The majority of all in-air flight time effort consisted of Transect (59%) followed by Transit (25%), Overland (6%), Cross-leg (5%), and Circling (5%).

Figures 28, 33, and 34 show flight effort for each year; Figures 29 through 32 show Year 3 flight effort by season.

3.1.2 Effort by Season

Flight effort in each year occurred across all four seasons (Table 7). The total for Years 1–3 of 149,482 km (80,714 nm) flight effort was comprised of:

- 27% during the fall (198.1 hr in the air and 40,532 total km [21,886 nm])
- 25% during the summer (184.2 hr in the air and 36,581 km [19,752 nm])
- 24% during the spring (176.9 hr in the air and 36,538 km [19,729 nm])
- 24% during the winter (174.0 hr in the air and 35,831 km [19,347 nm])

Flight effort in Year 3 was comprised of:

- 27% during the summer (66.5 hr in the air and 13,302 total km [7,183 nm])
- 26% during the spring (63.5 hr in the air and 12,834 km [6,930 nm])
- 26% during the fall (63.3 hr in the air and 12,575 km [6,790 nm])
- 21% during the winter (48.6 hr in the air and 10,042 km [5,422 nm])

Figures 29 through 32 show Year 3 flight effort by season.

3.1.3 Effort by Month

During all survey years, one survey was conducted during each of the 12 months. Each survey consisted of multiple flights ranging from 2 to 8 days (Table 8).

3.1.4 Effort by Beaufort Sea State

Survey effort by Beaufort SS for Years 1–3 was Beaufort SS 2 (18%), Beaufort SS 3 (29%), Beaufort SS 4 (19.5%), and Beaufort SS 5 (17%) (Table 9, Figure 3). A small percentage of the survey effort was conducted in Beaufort SS 1 (4%) and Beaufort SS 6–7 (5%). When Beaufort SS 6 or higher was encountered for more than approximately 10 minutes, the survey route was aborted and another region with better Beaufort SS conditions was surveyed, or the flight was terminated or postponed to avoid poor sighting conditions.

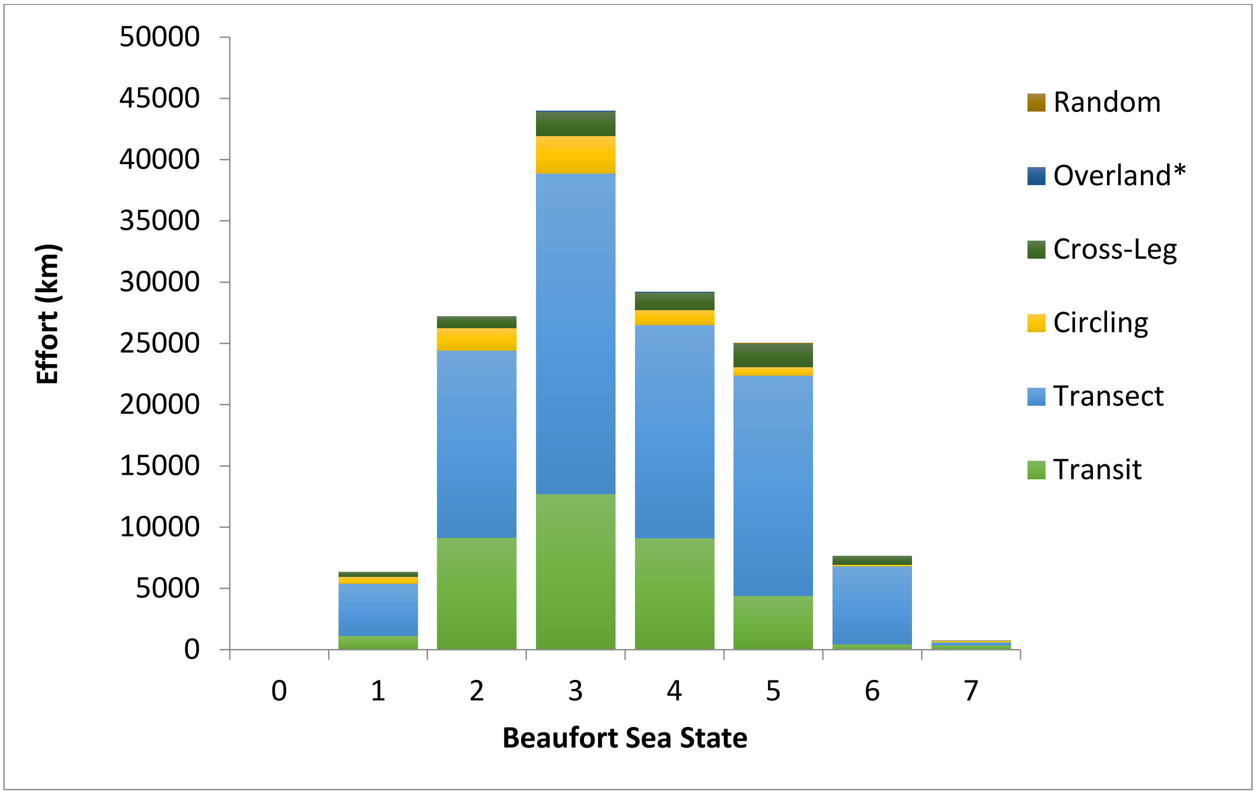

Figure 3. Beaufort Sea State by Effort Type

* Overland Beaufort SS effort was recorded only during the transition from overland to transit over water and back.

Table 7. Flight Time and Distance by Season and Year

Season	Hours (hr) and Kilometers (km) by Type of Flight Effort													
	Overland		Transit		Transect		Circling		Cross-Leg		Random		Total	
	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km
Year 1														
Spring	2.4	495	11.1	2,623	35.8	7,526	3.3	622	3.5	750	0	0	56.1	12,017
Summer	3.2	642	13.2	2,754	34.0	6,440	2.3	426	2.8	548	0	0	55.5	10,811
Fall	4.6	955	25.9	5,754	40.8	8,246	2.6	505	3.1	633	0	0	77.1	16,093
Winter	4.3	832	17.9	4,060	38.2	7,533	2.8	538	2.7	545	0.1	9	66	13,517
Year 1 Total	**14.6**	**2,924**	**68.1**	**15,191**	**148.8**	**29,745**	**11**	**2,092**	**12.1**	**2,476**	**0.1**	**9**	**254.7**	**52,438**
Year 2														
Spring	3.4	691	12.3	2,832	35	6,921	3.3	594	3.2	648	0	0	57.3	11,687
Summer	4.3	842	9.9	2,256	38.6	7,536	5.9	1,127	3.5	707	0	0	62.2	12,468
Fall	3.6	749	13.4	3,107	36.7	7,194	1.4	278	2.5	536	0	0	57.7	11,864
Winter	3.7	750	12.9	2,976	38.1	7,561	1.8	346	3	640	0	0	59.4	12,272
Year 2 Total	**15.0**	**3,032**	**48.5**	**11,171**	**148.5**	**29,212**	**12.4**	**2,345**	**12.3**	**2,531**	**0**	**0**	**236.6**	**48,291**
Year 3														
Spring	3.9	819	13.0	2,947	39.1	7,585	4.4	851.16	3.1	631.98	0	0	63.5	12,834
Summer	3.8	773	14.5	3,187	39.9	7,704	5.2	1,001	3.1	636.08	0	0	66.5	13,302
Fall	4.0	806	12.1	2,741	40.2	7,635	3.8	754.81	3.1	639.47	0	0	63.3	12,575
Winter	3.6	759	10.6	2,484	29.4	5,751	3.0	609.65	2.1	438.81	0	0	48.6	10,042
Year 3 Total	**15.3**	**3,156**	**50.2**	**11,359**	**148.6**	**28,675**	**16.4**	**3,216**	**11.4**	**2,346**	**0**	**0**	**241.8**	**48,753**
Years 1–3														
Spring	9.7	2,005	36.4	8,402	109.9	22,032	11.0	2,067	9.8	2,030	0	0	176.9	36,538
Summer	11.3	2,257	37.6	8,197	112.5	21,680	13.4	2,554	9.4	1,891	0	0	184.2	36,581
Fall	12.2	2,510	51.4	11,602	117.7	23,075	7.8	1,538	8.7	1,808	0	0	198.1	40,532
Winter	11.6	2,341	41.4	9,520	105.7	20,845	7.6	1,494	7.8	1,624	0.1	9	174.0	35,831
Years 1–3 Total	**44.9**	**9,112**	**166.8**	**37,721**	**445.9**	**87,632**	**39.8**	**7,653**	**35.8**	**7,353**	**0.1**	**9**	**733.1**	**149,482**

Note:

Columns may not add to the total shown due to rounding.

Table 8. Flight Time and Distance by Month and Year

Survey Dates	Number of Flights	Hours (hr) and Kilometers (km) by Type of Flight Effort													
		Overland		Transit		Transect		Circling		Cross-Leg		Random		Total	
		hr	km	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km
Year 1															
March 20–23, 2017	5	0.7	161	4.0	936	12.0	2,516	0.8	172	1.4	307	0	0	18.9	4,091
April 03–04, 2017	4	0.8	132	2.6	628	11.7	2,502	0.6	118	1.1	241	0	0	16.9	3,621
May 08–10, 2017	6	0.9	202	4.5	1,059	12.0	2,508	1.9	333	1.0	203	0	0	20.3	4,305
June 16–21, 2017	2	0.3	59	1.6	279	6.1	1,116	0	0	0.7	147	0	0	8.7	1,601
July 01–04, 2017	8	1.6	302	7.1	1,501	14.7	2,806	1.0	176	1.1	202	0	0	25.4	4,986
August 25–27, 2017	7	1.4	281	4.5	975	13.2	2,518	1.4	250	1.0	199	0	0	21.4	4,224
September 24–30, 2017	12	2.1	427	12.3	2,651	15.3	2,955	0.7	130	1.2	232	0	0	31.5	6,395
October 15–18, 2017	7	1.2	251	7.1	1,506	13.1	2,524	1.1	201	1.0	199	0	0	23.6	4,680
November 07–12, 2017	8	1.3	277	6.5	1,597	12.4	2,767	0.9	175	0.9	202	0	0	22.0	5,017
December 04–08, 2017	9	1.4	296	6.4	1,460	12.5	2,414	1.2	226	0.7	143	0	0	22.3	4,539
January 04-11, 2018	9	1.4	270	7.1	1,514	13.1	2,578	0.9	172	1.0	212	0.1	9	23.6	4,755
February 05–09, 2018	7	1.5	266	4.5	1,087	12.6	2,541	0.7	140	0.9	190	0	0	20.1	4,223
Year 1 Total	**84**	**14.6**	**2,924**	**68.1**	**15,191**	**148.8**	**29,745**	**11.0**	**2,092**	**12.1**	**2,476**	**0.1**	**9**	**254.7**	**52,438**
Year 2															
March 12–16, 2018	7	1.1	232	4.6	1,083	12.8	2,507	0.4	68	1.2	231	0	0	20.0	4,121
April 09–11, 2018	7	1.1	227	2.9	652	12.6	2,504	2.3	398	1.0	213	0	0	20.0	3,994
May 08–15, 2018	7	1.2	232	4.7	1,098	9.6	1,910	0.7	127	1.0	204	0	0	17.3	3,572
June 14–16, 2018	8	1.3	274	3.6	814	12.7	2,507	2.4	455	1.1	216	0	0	21.0	4,266
July 9–11, 2018	7	1.4	289	2.9	656	12.9	2,511	1.8	341	1.1	219	0	0	20.1	4,016
August 6–8, 2018	8	1.6	280	3.5	785	13.1	2,519	1.7	330	1.4	272	0	0	21.2	4,186
September 9–17, 2018	6	1.1	211	2.7	604	11.1	2,142	0.4	81	0.9	188	0	0	16.2	3,226
October 8–14, 2018	9	1.4	298	7.2	1,673	13	2,537	0.1	21	0.7	141	0	0	22.4	4,671
November 12–17	7	1.1	240	3.5	830	12.6	2,515	0.9	175	1.0	207	0	0	19.1	3,968
December 9–12, 2018	7	1.1	240	3.8	871	12.8	2,514	1.5	269	1.0	209	0	0	20.2	4,104
January 7–11, 2019	7	1.1	234	4.1	957	12.4	2,521	0.2	35	1.0	222	0	0	18.7	3,969
February 11–16, 2019	9	1.4	275	5.0	1,148	12.9	2,525	0.2	42	1.0	209	0	0	20.4	4,199
Year 2 Total	**89**	**15**	**3,032**	**48.5**	**11,171**	**148.5**	**29,212**	**12.4**	**2,345**	**12.3**	**2,531**	**0**	**0**	**236.6**	**48,291**

Table 8. Flight Time and Distance by Month and Year (Continued)

Survey Dates	Number of Flights	Hours (hr) and Kilometers (km) by Type of Flight Effort													
		Overland		Transit		Transect		Circling		Cross-Leg		Random		Total	
		hr	km	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km
Year 3															
March 11–14, 2019	8	1.2	251	4.7	1057	12.9	2528	1.1	234	1.0	205	0	0	20.9	4,276
April 8–12, 2019	8	1.4	277	4.8	1103	13.1	2526	1.3	235	1.1	221	0	0	21.7	4,362
May 14-17, 2019	8	1.4	291	3.5	787	13.1	2531	2.0	382	1.0	206	0	0	20.9	4,196
June 1-4, 2019	7	1.1	217	4.5	1012	13.1	2513	1.5	287	1.0	204	0	0	21.1	4,233
July 24-27, 2019	9	1.5	302	6.5	1420	14.0	2675	2.1	402	1.0	206	0	0	25.2	5,005
August 9-11, 2019	7	1.2	255	3.4	754	12.9	2517	1.6	312	1.1	225	0	0	20.2	4,063
September 9-11, 2019	7	1.4	260	3.1	687	13.5	2515	0.9	166	1.0	215	0	0	19.9	3,843
October 24-28, 2019	7	1.2	237	4.0	901	13.2	2512	1.1	232	1.0	208	0	0	20.5	4,090
November 19-23, 2019	9	1.5	309	5.0	1153	13.5	2607	1.8	357	1.1	216	0	0	22.9	4,642
December 10-13, 2019	6	1.1	233	2.7	654	9.4	1850	0.9	180	0.5	103	0	0	14.7	3,019
January 13-18, 2020	6	1.1	235	4.6	1073	7.0	1382	1.1	234	0.5	107	0	0	14.2	3,031
February 10-16, 2020	8	1.4	291	3.3	757	13.0	2519	1.0	196	1.1	229	0	0	19.7	3,993
Year 3 Total	**90**	**15.3**	**3,156**	**50.2**	**11,359**	**148.6**	**28,675**	**16.4**	**3,216**	**11.4**	**2,346**	**0**	**0**	**241.8**	**48,753**
Years 1–3															
March	20	3.0	644	13.3	3076	37.7	7551	2.3	474	3.6	743	0	0	59.8	12,488
April	19	3.3	636	10.3	2383	37.4	7532	4.2	751	3.2	675	0	0	58.6	11,977
May	21	3.5	725	12.7	2944	34.7	6949	4.6	842	3.0	613	0	0	58.5	12,073
June	17	2.7	550	9.7	2105	31.9	6136	3.9	742	2.8	567	0	0	50.8	10,100
July	24	4.5	893	16.5	3577	41.6	7992	4.9	919	3.2	627	0	0	70.7	14,007
August	22	4.2	816	11.4	2514	39.2	7554	4.7	892	3.5	696	0	0	62.8	12,473
September	25	4.6	898	18.1	3942	39.9	7612	2.0	377	3.1	635	0	0	67.6	13,464
October	23	3.8	786	18.3	4080	39.3	7573	2.3	454	2.7	548	0	0	66.5	13,441
November	24	3.9	826	15.0	3580	38.5	7889	3.6	707	3.0	625	0	0	64.0	13,627
December	22	3.6	769	12.9	2985	34.7	6778	3.6	675	2.2	455	0	0	57.2	11,662
January	22	3.6	739	15.8	3544	32.5	6481	2.2	441	2.5	541	0.1	9	56.5	11,755
February	24	4.3	832	12.8	2992	38.5	7585	1.9	378	3.0	628	0	0	60.2	12,415
Years 1–3 Total	**263**	**44.9**	**9,112**	**166.8**	**37,721**	**445.9**	**87,632**	**39.8**	**7,653**	**35.8**	**7,353**	**0.1**	**9**	**733.1**	**149,482**

Note:

Columns may not add to the total shown due to rounding.

TABLE 9. FLIGHT TIME AND DISTANCE BY BEAUFORT SEA STATE AND YEAR

Beaufort SS	Transit		Transect		Circling		Cross-Leg		Random		Overland**		Total	
	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km
Year 1														
NA*	0	0	0	0	0	0	0	0	0	0	14.8	2,967	14.8	2,967
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	2.8	583	7.7	1,540	0.7	134	0.8	164	0	0	0	0	12	2,421
2	15.7	3,621	25.9	5,190	3.2	604	1.8	361	0	0	0	0	46.6	9,776
3	27.8	6,305	54.7	10,995	5.1	986	3.9	801	0	0	0	0	91.5	19,087
4	15.8	3,407	31.3	6,268	0.7	124	2.3	450	0	0	0	0	50.1	10,248
5	4.7	1,009	24.5	4,832	1.3	244	2.9	607	0.1	9	0	0	33.5	6,701
6	0.7	146	4.8	920	0	0	0.6	119	0	0	0	0	6	1,185
7	0.2	53	0	0	0	0	0	0	0	0	0	0	0.2	53
Year 1 Total	**67.7**	**15,124**	**148.9**	**29,745**	**11**	**2,092**	**12.3**	**2,502**	**0.1**	**9**	**14.8**	**2,967**	**254.7**	**52,438**
Year 2														
NA*	0	0	0	0	0	0	0.0	0	0	0	15.8	3,228	15.8	3,228
0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0
1	1.7	401	8.1	1,545	1.0	199	0.5	106	0	0	0	0	11.3	2,251
2	11.0	2,551	24.7	4,810	3.3	570	1.2	244	0	0	0	0	40.2	8,175
3	9.6	2,265	34.5	6,759	5.0	959	2.7	569	0	0	0.3	66	52.1	10,618
4	13.4	3,083	26.8	5,241	2.0	389	2.5	498	0	0	0	2	44.8	9,213
5	10.8	2,459	36.4	7,413	0.6	117	3.4	719	0	0	0	0	51.2	10,708
6	0.8	148	18.0	3444	0.6	111	1.7	377	0	0	0	0	21.1	4,080
7	0	0	0	0	0	0	0.1	18	0	0	0	0	0.1	18
Year 2 Total	**47.3**	**10,907**	**148.5**	**29,212**	**12.4**	**2,345**	**12.3**	**2,531**	**0**	**0**	**16.1**	**3,296**	**236.6**	**48,291**
Year 3														
NA*	0.2	36	0	0	0	0	0	0	0	0	15.3	3,156	15.4	3,192
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.7	178	6.0	1,146	1.1	225	0.5	102	0	0	0	0	8.3	1,651
2	13.2	2,993	27.3	5,243	3.6	690	1.6	335	0	0	0	0	45.7	9,262
3	18.2	4,128	43.9	8,421	5.8	1,121	2.9	603	0	0	0	0	70.9	14,273
4	11.4	2,602	30.5	5,916	3.5	705	2.5	500	0	0	0	0	47.9	9,722
5	4.3	927	29.6	5,737	1.6	328	3.0	623	0	0	0	0	38.5	7,615
6	0.8	168	10.0	1,977	0.2	37	0.9	182	0	0	0	0	11.9	2,365

TABLE 9. FLIGHT TIME AND DISTANCE BY BEAUFORT SEA STATE AND YEAR (CONTINUED)

Beaufort SS	Transit		Transect		Circling		Cross-Leg		Random		Overland**		Total	
	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km	hr	km
7	1.4	327	1.3	235	0.5	109	0	0	0	0	0	0	3.1	672
Year 3 Total	**50.2**	**11,359**	**148.6**	**28,675**	**16.4**	**3,216**	**11.4**	**2,346**	**0**	**0**	**15.3**	**3,156**	**241.8**	**48,753**
Years 1–3														
NA*	0.2	36	0	0	0	0	0	0	0	0	45.9	9,351	46.0	9,387
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	5.2	1,162	21.7	4,231	2.8	558	1.8	372	0	0	0	0	31.6	6,323
2	40.0	9,165	77.9	15,243	10.0	1,864	4.6	940	0	0	0	0	132.5	27,213
3	55.6	12,698	133.1	26,175	15.9	3,066	9.6	1,973	0	0	0.3	66	214.5	43,978
4	40.6	9,092	88.6	17,425	6.3	1,218	7.3	1,448	0	0	0	2	142.8	29,183
5	19.8	4,395	90.6	17,982	3.5	689	9.3	1,949	0	9	0	0	123.3	25,024
6	2.2	462	32.8	6,341	0.7	148	3.3	678	0	0	0	0	38.9	7,630
7	1.6	380	1.3	235	0.5	109	0.1	18	0	0	0	0	3.4	743
Years 1–3 Total	**165.2**	**37,390**	**446.0**	**87,632**	**39.8**	**7,653**	**35.9**	**7,379**	**0.1**	**9**	**46.2**	**9,419**	**733.1**	**149,482**

Notes:

Columns may not add to the total shown due to rounding.
hr = hour
km = kilometers
*NA = Not applicable. (No value was recorded during the transition from overland to transit over water.)
** Overland Beaufort SS effort was recorded only during the transition from overland to transit over water and back; as such, Overland, Transit, and total kilometers presented here differ from totals shown in Table 7 and 8.

3.2 SIGHTINGS

For Years 1–3 combined, a total of 3,052 sightings of 37,410 estimated individuals were recorded, including the six confirmed priority species of large whales (blue, fin, humpback, North Atlantic right, sei, and sperm whales), other marine mammals (i.e., delphinids, etc.), sea turtles, and other marine species (i.e., sharks, rays, fish schools, etc.) (Table 6). Of the 3,052 sightings, 318 (629 estimated individuals) were of the priority large whale species, 980 (23,244 estimated individuals) were of other marine mammal species, 474 (557 estimated individuals) were of sea turtles, and 1,280 (12,980 estimated individuals) were of other marine species. Sightings are detailed on Figures 35 through 95, at the end of this report.

Table 6 (and other species tables in this report) include the "blue/fin/sei whale" category for instances when whales could not be identified more precisely, and categories for unidentified large whales (both baleen or odontocete) or unidentified baleen whales. Other unidentified categories include unidentified beaked whale, and unidentified cetacean, dolphin, seal or whale. Additionally, grouped categories were used for delphinid species with similar morphology that could not be identified to the lowest taxonomic order (e.g., *Tursiops/Grampus* sp., *Delphinus/Tursiops/Stenella* sp., and *Tursiops/Lagenorhynchus* sp.).

3.2.1 Sightings - Six Priority Large Whale Species

For Years 1–3 combined, a total of 318 priority large whale sightings of an estimated 629 individual whales were recorded (Table 10). Of these sightings, 287 groups (90%) totaling 594 individuals were identified to species. The remaining sightings of 31 groups and 35 individuals were of blue/fin/sei whale, unidentified baleen whale, and unidentified large whale. The sightings of large whales not identified to species is plotted separately on maps and presented separately in tables. Sightings are presented by minimum and maximum estimated group sizes; standard deviation (S.D.) is calculated using mean group size values.

Sections 3.2.1.1 through 3.2.1.6 describe the sightings of the priority large whale species by species and the species initial behavioral state. Table 11 shows the individual priority large whale species sightings by month and season. Table 12 shows the group sightings of priority large whale species sightings by month and season. Table 13 shows the breakdown of behavioral state for each species or species category sighted. Most (44%) whales sighted exhibited Rest/Slow Travel (266 estimated individuals), followed by Probable Foraging (28%, 168 estimated individuals). There were very few incidences of Fast Travel or of surface activity.

Figures 35 and 36 show locations of grouped priority whales in Year 3, and by all priority whales grouped and combined in Years 1–3, respectively. Figure 37 shows locations of priority whales by year broken out by species. Figures 38 through 61 show locations of priority whale sightings by month, first in Year 3 and then in Years 1–3. Figures 62 through 81 show locations of priority whale sightings by season, first in Year 3 and then in Years 1–3. Figures 62 and 63 show grouped priority whale sightings and the subsequent maps (Figures 64 through 81) broken out by species.

TABLE 10. PRIORITY LARGE WHALE SIGHTINGS - YEARS 1–3

Common Name	Year 1			Year 2			Year 3			Years 1–3		
	Number	**Group Size**		**Number**	**Group Size**		**Number**	**Group Size**		**Number**	**Group Size**	
	Groups (Indiv.)	**Mean (S.D.)**	**Range**	**Groups (Indiv.)**	**Mean (S.D.)**	**Range**	**Groups (Indiv.)**	**Mean (S.D.)**	**Range**	**Groups (Indiv.)**	**Mean (S.D.)**	**Range**
Blue Whale	2 (4)	2.0 (1.4)	1-3	0 (0)	NA	NA	1 (1)	1.0 (NA)	1-1	3 (5)	1.7 (1.2)	1-3
Blue/Fin/Sei Whale	1 (1)	1.0 (NA)	1-1	1 (1)	1.0 (NA)	1-1	1 (1)	1.0 (NA)	1-1	3 (3)	1.0 (0.0)	1-1
Fin Whale	23 (33)	1.4 (1.0)	1-5	64 (122)	1.9 (2.2)	1-16	37 (52)	1.4 (0.7)	1-4	124 (207)	1.7 (1.7)	1-16
Humpback Whale	22 (36)	1.6 (1.5)	1-8	52 (177)	3.4 (7.7)	1-52	37 (66)	1.8 (1.9)	1-10	111 (279)	2.5 (5.4)	1-52
North Atlantic Right Whale	8 (13)	1.6 (0.5)	1-2	3 (4)	1.3 (0.6)	1-2	4 (7)	1.8 (0.5)	1-2	15 (24)	1.6 (0.5)	1-2
Sei Whale	0 (0)	NA	NA	1 (1)	1.0 (NA)	1-1	1 (6)	6.0 (NA)	6-6	2 (7)	3.5 (3.5)	1-6
Sperm Whale	7 (7)	1.0 (NA)	1-1	9 (23)	2.6 (2.1)	1-7	16 (42)	2.6 (2.0)	1-7	32 (72)	2.3 (1.9)	1-7
Unidentified Baleen Whale	1 (1)	1.0 (NA)	1-1	0 (0)	NA	NA	0 (0)	NA	NA	1 (1)	1.0 (NA)	1-1
Unidentified Large Whale	9 (10)	1.1 (0.3)	1-2	13 (15)	1.2 (0.4)	1-2	5 (6)	1.2 (0.4)	1-2	27 (31)	1.1 (0.4)	1-2
All Priority Large Whales	**73 (105)**			**143 (343)**			**102 (181)**			**318 (629)**		

Notes:

Indiv. = Individual
NA = Not applicable
S.D. = Standard deviation

TABLE 11. PRIORITY LARGE WHALE INDIVIDUALS RECORDED BY MONTH AND SEASON - YEARS 1–3

	Spring				**Summer**				**Fall**				**Winter**				**All Seasons**
Common Name	Mar	Apr	May	*Total*	Jun	Jul	Aug	*Total*	Sep	Oct	Nov	*Total*	Dec	Jan	Feb	*Total*	*Total**
Blue Whale									**1**			**1**		**3**	**1**	**4**	**5**
Year 1														3	1	4	4
Year 2																	
Year 3									1			1					1
Blue/Fin/Sei Whale					**1**	**1**		**2**						**1**		**1**	**3**
Year 1														1		1	1
Year 2					1			1									1
Year 3						1		1									1
Fin Whale	**12**	**5**	**22**	**39**	**55**	**37**	**26**	**118**	**5**	**4**	**11**	**20**	**16**	**2**	**12**	**30**	**207**
Year 1	2		16	18		1	2	3	1	1	2	4	4	2	2	8	33
Year 2	1	5	5	11	50	25	18	93	3	3	3	9	9			9	122
Year 3	9		1	10	5	11	6	22	1		6	7	3		10	13	52
Humpback Whale	**6**	**7**	**21**	**34**	**107**	**18**	**26**	**151**	**28**	**17**	**10**	**55**	**8**	**19**	**12**	**39**	**279**
Year 1	3	2	6	11			5	5		7	2	9		2	9	11	36
Year 2	1	1	2	4	98	11	16	125	22	3	1	26	8	14		22	177
Year 3	2	4	13	19	9	7	5	21	6	7	7	20		3	3	6	66
North Atlantic Right Whale	**5**	**6**	**3**	**14**							**2**	**2**	**3**	**4**	**1**	**8**	**24**
Year 1	3	5		8							2	2		2	1	3	13
Year 2	2	1		3									1			1	4
Year 3			3	3									2	2		4	7
Sei Whale		**7**		**7**													**7**
Year 1																	
Year 2		1		1													1
Year 3		6		6													6

TABLE 11. PRIORITY LARGE WHALE INDIVIDUALS RECORDED BY MONTH AND SEASON - YEARS 1–3 (CONTINUED)

Common Name	Spring				Summer				Fall				Winter				All Seasons
	Mar	Apr	May	*Total*	Jun	Jul	Aug	*Total*	Sep	Oct	Nov	*Total*	Dec	Jan	Feb	*Total*	*Total**
Sperm Whale	**5**	**7**		**12**	**7**	**15**	**22**	**44**	**8**	**2**		**10**	**2**	**2**	**2**	**6**	**72**
Year 1	1			1		3		3	1	1		2		1		1	7
Year 2		5		5	3		11	14					2		2	4	23
Year 3	4	2		6	4	12	11	27	7	1		8		1		1	42
Unidentified Baleen Whale		**1**		**1**													**1**
Year 1		1		1													1
Year 2																	
Year 3																	
Unidentified Large Whale	**3**	**3**	**2**	**8**	**1**	**5**	**4**	**10**	**1**	**1**	**1**	**3**	**6**	**1**	**3**	**10**	**31**
Year 1	3			3		2	1	3						1	3	4	10
Year 2		3	1	4	1	3	1	5			1	1	5			5	15
Year 3			1	1			2	2	1	1		2	1			1	6
All Priority Large Whales	**31**	**36**	**48**	**115**	**171**	**76**	**78**	**325**	**43**	**24**	**24**	**91**	**35**	**32**	**31**	**98**	**629**

Note:

*Based on total number of whales (individuals).

Table 12. Priority Large Whale Groups Recorded by Month and Season - Years 1–3

Common Name	Spring				Summer				Fall				Winter				All Seasons
	Mar	Apr	May	*Total*	Jun	Jul	Aug	*Total*	Sep	Oct	Nov	*Total*	Dec	Jan	Feb	*Total*	*Total**
Blue Whale									**1**			**1**		**1**	**1**	**2**	**3**
Year 1														1	1	2	2
Year 2																	
Year 3									1			1					1
Blue/Fin/Sei Whale					**1**	**1**		**2**						**1**		**1**	**3**
Year 1														1		1	1
Year 2					1			1									1
Year 3						1		1									1
Fin Whale	**9**	**3**	**11**	**23**	**20**	**29**	**18**	**67**	**5**	**3**	**8**	**16**	**9**	**2**	**7**	**18**	**124**
Year 1	2		9	11		1	2	3	1	1	1	3	2	2	2	6	23
Year 2	1	3	1	5	17	18	12	47	3	2	2	7	5			5	64
Year 3	6		1	7	3	10	4	17	1		5	6	2		5	7	37
Humpback Whale	**5**	**7**	**9**	**21**	**19**	**12**	**16**	**47**	**8**	**12**	**8**	**28**	**5**	**6**	**4**	**15**	**111**
Year 1	2	2	5	9			4	4		4	1	5		2	2	4	22
Year 2	1	1	2	4	17	8	9	34	4	2	1	7	5	2		7	52
Year 3	2	4	2	8	2	4	3	9	4	6	6	16		2	2	4	37
North Atlantic Right Whale	**3**	**4**	**2**	**9**							**1**	**1**	**2**	**2**	**1**	**5**	**15**
Year 1	2	3		5							1	1		1	1	2	8
Year 2	1	1		2									1			1	3
Year 3			2	2									1	1		2	4
Sei Whale		**2**		**2**													**2**
Year 1																	
Year 2		1		1													1
Year 3		1		1													1

TABLE 12. PRIORITY LARGE WHALE GROUPS RECORDED BY MONTH AND SEASON - YEARS 1–3 (CONTINUED)

Common Name	Spring				Summer				Fall				Winter				All Seasons
	Mar	Apr	May	*Total*	Jun	Jul	Aug	*Total*	Sep	Oct	Nov	*Total*	Dec	Jan	Feb	*Total*	*Total**
Sperm Whale	**2**	**2**		**4**	**6**	**6**	**6**	**18**	**3**	**2**		**5**	**2**	**2**	**1**	**5**	**32**
Year 1	1			1		3		3	1	1		2		1		1	7
Year 2		1		1	2		3	5					2		1	3	9
Year 3	1	1		2	4	3	3	10	2	1		3		1		1	16
Unidentified Baleen Whale		**1**		**1**													**1**
Year 1		1		1													1
Year 2																	
Year 3																	
Unidentified Large Whale	**2**	**2**	**2**	**6**	**1**	**4**	**3**	**8**	**1**	**1**	**1**	**3**	**6**	**1**	**3**	**10**	**27**
Year 1	2			2		2	1	3						1	3	4	9
Year 2		2	1	3	1	2	1	4			1	1	5			5	13
Year 3			1	1			1	1	1	1		2	1			1	5
All Priority Large Whales	**21**	**21**	**24**	**66**	**47**	**52**	**43**	**142**	**18**	**18**	**18**	**54**	**24**	**15**	**17**	**56**	**318**

Note:

*Based on total number of sightings (groups).

TABLE 13. Priority Large Whale Species by Initial Behavior State Observed - Years 1–3

Common Name	Rest/Slow Travel	Medium Travel	Fast Travel	Surface Active Travel	Mill	Surface Active Mill	Probable Foraging	Unknown	Entangled	Dead	Total*
Blue Whale	**4**	**1**									**5**
Year 1	3	1									4
Year 2											
Year 3	1										1
Blue/Fin/Sei Whale	**2**							**1**			**3**
Year 1	1										1
Year 2								1			1
Year 3	1										1
Fin Whale	**94**	**26**	**3**	**2**	**21**	**5**	**56**				**207**
Year 1	15	4	1		4		9				33
Year 2	38	16	2	2	17	5	42				122
Year 3	41	6					5				52
Humpback Whale	**86**	**25**	**1**	**9**	**37**	**8**	**111**			**2**	**279**
Year 1	2	11			18	3	2				36
Year 2	55	10		6	19	2	85				177
Year 3	29	4	1	3		3	24			2	66
North Atlantic Right Whale	**14**	**3**	**2**		**2**	**2**	**1**				**24**
Year 1	8	3	2								13
Year 2	4										4
Year 3	2				2	2	1				7
Sei Whale	**1**				**6**						**7**
Year 1											
Year 2	1										1
Year 3					6						6

TABLE 13. Priority Large Whale Species by Initial Behavior State Observed - Years 1–3 (Continued)

Common Name	Rest/Slow Travel	Medium Travel	Fast Travel	Surface Active Travel	Mill	Surface Active Mill	Probable Foraging	Unknown	Entangled	Dead	Total*
Sperm Whale	**47**	**11**	**1**		**7**	**5**			**1**		**72**
Year 1	2	4	1								7
Year 2	15				7				1		23
Year 3	30	7				5					42
Unidentified Baleen Whale		**1**									**1**
Year 1		1									1
Year 2											
Year 3											
Unidentified Large Whale	**20**	**4**		**1**		**3**		**3**			**31**
Year 1	2	3		1		2		2			10
Year 2	13	1						1			15
Year 3	5					1					6
All Priority Large Whales	**268**	**67**	**7**	**12**	**73**	**23**	**168**	**4**	**1**	**2**	**629**

Note:

*Based on total number of whales (individuals).

3.2.1.1 Blue Whale

A total of 3 sightings (estimated 5 total individuals) of blue whales (Table 10) were recorded during the 3-year survey. Blue whales were recorded during Year 1 (2 groups, 4 individuals) and Year 3 (1 individual). No blue whales were recorded in Year 2. One sighting in June of Year 2 could not be confirmed as a blue whale, thus was coded in the combined blue/fin/sei category (Tables 11 and 12). Blue whales were recorded during September, January, and February. No blue whales were recorded during spring or summer months. Sighting rates were highest during winter (0.12 whales/1,000 km effort) followed by fall (0.03 whales/ 1,000 km effort). Blue whales were most frequently observed exhibiting Rest/Slow Travel behavior (4 whales), followed by Medium Travel behavior (1 whale) (Table 13). Figures 64 through 66 show blue whale locations by season in Year 3, by season in Years 1–3, and by count and season in Years 1–3, respectively.

3.2.1.2 Fin Whale

A total of 124 sightings (estimated 207 total individuals) of fin whales (Table 10) were recorded during the 3-year survey. Fin whales were recorded in all three years. Sighting rates were highest during Year 2 (2.7 whales/1,000 km effort), followed by Year 3 (1.14 whales/1,000 km effort), and lowest during Year 1 (0.67 whales/1,000 km effort) (Section 3.2.2, Table 14). Fin whales were recorded in all four seasons and all months. Fin whales were observed most frequently during summer months (118 whales [55 whales in June, 37 whales in July, and 26 whales in August]), followed by spring (39 whales [12 whales in March, 5 whales in April, and 22 whales in May]), then winter (30 whales [16 in December, 2 in January and 12 in February]), and fall (20 whales [5 in September, 4 in October, and 11 November]) (Tables 11 and 12). Sighting rates for fin whales were highest during summer (3.44 whales/1,000 km effort), followed by spring (1.13 whales/1,000 km effort), winter (0.90 whales/1,000 km effort), and fall (0.53 whales/1,000 km effort) (Section 3.2.2, Table 15). Figures 67 through 69 show fin whale locations by season in Year 3, by season in Years 1–3, and by count and season in Years 1–3, respectively.

Fin whales were observed most frequently exhibiting Rest/Slow Travel behavior (94 whales) followed by Probable Foraging (56 whales) (Table 13). Probable Foraging behavior occurred during spring (March and May), summer (June and July), and fall (November). Several notable foraging events occurred during June and July in Year 2 where lunge-feeding behaviors were recorded. On two occasions, fin whales were observed in a mixed-species association feeding with common dolphin (*Delphinus delphis*). Photographs of these events are in Appendix B.

3.2.1.3 Humpback Whale

A total of 111 sightings (estimated 279 total individuals) of humpback whales (Table 10) were recorded during the 3-year survey. Humpback whales were recorded during all years. Sighting rates were highest during Year 2 (3.91 whales/1,000 km effort), followed by Year 3 (1.45 whales/1,000 km effort), and lowest during Year 1 (0.73 whales/1,000 km effort) (Section 3.2.2, Table 14). Humpback whales were recorded during all four seasons and all months. Humpback whales were most frequently recorded during summer (151 whales [107 in June, 18 in July, and 26 in August]) and fall (55 whales [28 in September, 17 in October, and 10 in

November]). A total of 39 humpback whales were recorded during winter (8 in December, 19 in January, and 12 in February) and 34 whales during spring (6 in March, 7 in April, and 21 in May) (Tables 11 and 12). Sighting rates for humpback whales were highest during summer (4.40 whales/1,000 km effort), followed by fall (1.45 whales/1,000 km effort), winter (1.16 whales/1,000 km effort), and spring (0.98 whales/1,000 km effort) (Section 3.2.2, Tables 14 and 15). Figures 70 through 72 show humpback whale locations by season in Year 3, by season in Years 1–3, and by count and season in Years 1–3, respectively.

Humpback whales were recorded most frequently exhibiting Probable Foraging behavior (111 whales), followed by Rest/Slow Travel (86 whales), and Mill (37 whales) (Table 13). All Probable Foraging occurred during spring (May) and summer (June and July) months. Several notable foraging events occurred; specifically, during June and July in both Year 2 and Year 3 when large bubble-net feeding was recorded. Photographs of these events are in Appendix B.

3.2.1.4 North Atlantic Right Whale

A total of 15 sightings (estimated 24 total individuals) of North Atlantic right whales (Table 10) were recorded during the 3-year survey. North Atlantic right whales were recorded in all three years. Sighting rates were highest during Year 1 (0.26 whales/1,000 km effort) followed by Year 3 (0.15 whales/1,000 km effort), and lowest during Year 2 (0.09 whales/1,000 km effort) (Section 3.2.2, Table 14). North Atlantic right whales were observed during fall (2 whales in November), winter (8 whales [3 whales in December, 4 whales in January and 1 whale in February]) and spring (14 whales [5 whales in March, 6 whales in April, and 3 whales in May]) (Tables 11 and 12). No North Atlantic right whale sightings occurred during summer months. Sighting rates for North Atlantic right whales were highest during spring (0.41 whales/1,000 km effort), followed by winter (0.24 whales/1,000 km effort) (Section 3.2.2, Tables 14 and 15).

North Atlantic right whales were observed exhibiting Rest/Slow Travel (14 whales), Medium Travel (3 whales), Fast Travel (2 whales), Mill (2 whales), Surface Active Mill (2 whales), and Probable Foraging (1 whale) behaviors (Table 13). On December 12, 2019, a group of two North Atlantic right whales were sighted exhibiting possible socio-sexual behaviors. Both individuals were similar in size and appeared to be adults. The sighting was classified as Surface Active Mill and several interesting behavioral events were recorded during the sighting. One individual was observed hanging vertically in the water column with its mouth open and baleen plates exposed. During this behavior, both individuals were oriented head-to-head. Body contact was observed several times, including belly-to-belly contact while rolling with pectoral fins out of the water, head-to-body contact, and head-to-head contact. The pair was circled and photographed for over 17 minutes and 204 photographs were taken. Figures 73 through 75 show North Atlantic right whale locations by season in Year 3, by season in Years 1–3, and by count and season in Years 1–3 respectively.

3.2.1.5 Sei Whale

A total of 2 sightings (estimated 7 total individuals) of sei whales (Table 10) were recorded during the 3-year survey. Both sightings were recorded during April in Year 2 and 3. There were no sei whale sightings during Year 1. During Year 2, a single sei whale was recorded in April; and during Year 3, one group (6 individuals) was recorded in April (Tables 11 and 12). Sighting rates were highest during Year 3 (0.13 whales/1,000 km effort), followed by Year 2 (0.02 whales/1,000 km effort (Section 3.2.2, Table 14). The sighting rate calculated for spring was 0.20 whales/1,000 km effort (Section 3.2.2, Tables 14 and 15).

The sei whale during Year 2 was observed exhibiting Rest/Slow Travel behavior and the sei whales during Year 3 were observed exhibiting Mill behavior (Table 13). The group of 6 sei whales sighted during Year 3 (April 2019) were exhibiting possible socio-sexual behaviors. Individuals were observed rolling on their sides and presenting bellies in close proximity. Additionally, they exhibited rapid movements and directional changes. No surface-active behaviors were recorded. Figures 76 through 78 show sei whale locations by season in Year 3, by season in Years 1–3, and by count and season in Years 1–3, respectively.

3.2.1.6 Sperm Whale

A total of 32 sightings (estimated 72 total individuals) of sperm whales (Table 10) were recorded. Sperm whales were recorded during all years; sighting rates were highest during Year 3 (0.92 whales/1,000 km effort), followed by Year 2 (0.51 whales/1,000 km effort), and lowest during Year 1 (0.14 whales/1,000 km effort) (Section 3.2.2, Table 14). Sperm whales were recorded during all seasons and all months except May and November. Sperm whales were recorded most frequently during summer (44 whales [7 whales in June, 15 whales during July, and 22 whales in August]), followed by spring (12 whales [5 whales in March and 7 whales during April]). A total of 10 sperm whales were recorded during fall (8 in September and 2 in October), and 6 whales during winter (2 in December, 2 in January, and 2 in February) (Tables 11 and 12). Sighting rates for sperm whales were highest during summer (1.28 whales/1,000 km effort), followed by spring (0.35 whales/1,000 km effort), fall (0.26 whales/1,000 km effort), and then winter (0.18 whales/1,000 km effort) (Section 3.2.2, Table 15).

Sperm whales were most frequently observed exhibiting Rest/Slow Travel behavior (47 whales) followed by Medium Travel (11 whales), Mill (7 whales), Surface Active Mill (5 whales), and Fast Travel behavior (1 whale) (Table 13). On September 10, 2019, a group of 5 sperm whales were sighted exhibiting possible socio-sexual behaviors. The sighting was classified as Surface Active Travel and several interesting behavioral events were recorded during the sighting. The individuals in this group made short, shallow dives, changed directions and travelled at the surface. Photographs revealed rubbing and belly-to-belly contact by two individuals in the group. The rapid movements, changes in direction, and close proximity of the individuals was unusual relative to most previous sperm whale sightings during this survey. The behavior and location of body contact between the two individuals is suggestive of mating or courtship behavior.

During Year 2, one sperm whale was recorded Entangled (Table 13). Section 3.5.2 has additional details on the sperm whale entanglement event.

Figures 79 through 81 show sperm whale locations by season in Year 3, by season in Years 1–3, and by count and season in Years 1–3, respectively.

3.2.2 Sighting Rates

Sighting rates for priority large whale species were calculated for each year and for Years 1–3 combined (Table 14), seasonally (Table 15), and by month (Table 16), detailed in the following sections. Additionally, sighting rates were calculated for all priority large whales identified to species (i.e., blue/fin/sei, unidentified baleen whale, and unidentified large whales are not included) and all large whales (including blue/fin/sei, unidentified baleen whale, and unidentified large whales) by pooling all priority large whale sightings. Sighting rates are based on number of whales (i.e., individuals) per 1,000 km of effort. Pooled observation effort includes Transect, Cross-leg, Transit, Random, and Circling efforts (i.e., all effort types that occurred over water); Overland Effort was removed for sighting rate calculations.

TABLE 14. SIGHTING RATES BY YEAR FOR PRIORITY LARGE WHALE SPECIES

Common Name	YEAR 1		YEAR 2		YEAR 3		YEARS 1–3	
	49,513 km Total Effort		*45,259 km Total Effort*		*45,597 km Total Effort*		*140,370 km Total Effort*	
	Whales	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**
Blue Whale	4	0.08	0	0	1	0.02	5	0.04
Blue/Fin/Sei Whale	1	0.02	1	0.02	1	0.02	3	0.02
Fin Whale	33	0.67	122	2.70	52	1.14	207	1.47
Humpback Whale	36	0.73	177	3.91	66	1.45	279	1.99
North Atlantic Right Whale	13	0.26	4	0.09	7	0.15	24	0.17
Sei Whale	0	0	1	0.02	6	0.13	7	0.05
Sperm Whale	7	0.14	23	0.51	42	0.92	72	0.51
Unidentified Baleen Whale	1	0.02	0	0	0	0	1	0.01
Unidentified Large Whale	10	0.20	15	0.33	6	0.13	31	0.22
All Priority Large Whales Identified to Species*	**93**	**1.88**	**327**	**7.23**	**174**	**3.82**	**594**	**4.23**
**All Priority Large Whales ** **	**105**	**2.12**	**343**	**7.58**	**181**	**3.97**	**629**	**4.48**

Notes:

Sighting rates are based on number of whales (i.e., individuals).
Pooled observation effort includes Transit, Transect, Circling, Cross-leg, and Random (for Year 1) efforts; does not include Overland effort.
*Includes all large whales identified to species (i.e., does not include blue/fin/sei, unidentified baleen whale, and unidentified large whales).
**Includes all large whales including unidentified to species.

TABLE 15. SIGHTING RATES BY SEASON FOR PRIORITY LARGE WHALE SPECIES - YEARS 1–3

Common Name	SPRING		SUMMER		FALL		WINTER	
	34,534 km Total Effort		*34,323 km Total Effort*		*38,023 km Total Effort*		*33,491 km Total Effort*	
	Whales	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**
Blue Whale	0	0	0	0	1	0.03	4	0.12
Blue/Fin/Sei Whale	0	0	2	0.06	0	0	1	0.03
Fin Whale	39	1.13	118	3.44	20	0.53	30	0.90
Humpback Whale	34	0.98	151	4.40	55	1.45	39	1.16
North Atlantic Right Whale	14	0.41	0	0	2	0.05	8	0.24
Sei Whale	7	0.20	0	0	0	0	0	0
Sperm Whale	12	0.35	44	1.28	10	0.26	6	0.18
Unidentified Baleen Whale	1	0.03	0	0	0	0	0	0
Unidentified Large Whale	8	0.23	10	0.29	3	0.08	10	0.30
All Priority Large Whales Identified to Species*	**106**	**3.07**	**313**	**9.12**	**88**	**2.31**	**87**	**2.60**
All Priority Large Whales**	**115**	**3.33**	**325**	**9.47**	**91**	**2.39**	**98**	**2.93**

Notes:

Sighting rates are based on number of whales (i.e., individuals).
Pooled observation effort includes Transect, Cross-leg, Transit, Circling Efforts, and Random (for Year 1), does not include Overland Effort.
*Includes all large whales identified to species (i.e., does not include blue/fin/sei, unidentified baleen whale, and unidentified large whales).
**Includes all large whales including unidentified to species.

TABLE 16. SIGHTING RATES BY MONTH FOR PRIORITY LARGE WHALE SPECIES - YEARS 1–3

Common Name	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Total effort (km)											
	11,843	*11,342*	*11,349*	*9,550*	*13,114*	*11,658*	*12,567*	*12,655*	*12,801*	*10,893*	*11,016*	*11,583*
	Sighting Rate (whales per 1,000 km of effort)											
Blue Whale	0	0	0	0	0	0	0.08	0	0	0	0.27	0.09
Blue/Fin/Sei Whale	0	0	0	0.1	0.08	0	0	0	0	0	0.09	0
Fin Whale	1.01	0.44	1.94	5.76	2.82	2.23	0.4	0.32	0.86	1.47	0.18	1.04
Humpback Whale	0.51	0.62	1.85	11.2	1.37	2.23	2.23	1.34	0.78	0.73	1.72	1.04
North Atlantic Right Whale	0.42	0.53	0.26	0	0	0	0	0	0.16	0.28	0.36	0.09
Sei Whale	0	0.62	0	0	0	0	0	0	0	0	0	0
Sperm Whale	0.42	0.62	0	0.73	1.14	1.89	0.64	0.16	0	0.18	0.18	0.17
Unidentified Baleen Whale	0	0.09	0	0	0	0	0	0	0	0	0	0
Unidentified Large Whale	0.25	0.26	0.18	0.1	0.38	0.34	0.08	0.08	0.08	0.55	0.09	0.26
All Priority Large Whales Identified to Species*	2.36	2.82	4.05	17.7	5.34	6.35	3.34	1.82	1.8	2.66	2.72	2.42
All Priority Large Whales**	2.62	3.17	4.23	17.91	5.80	6.69	3.42	1.90	1.87	3.21	2.90	2.68

Notes:

Sighting rates are based on number of whales (i.e., individuals).
Pooled observation effort includes Transect, Cross-leg, Transit, Circling Efforts, and Random (for Year 1), does not include Overland Effort.
*Includes all large whales identified to species (i.e., does not include blue/fin/sei, unidentified baleen whale, and unidentified large whales).
**Includes all large whales including unidentified to species.

3.2.2.1 Annual: Years 1–3

For the priority large whales sighted for Years 1–3 combined, sighting rates were highest for humpback whales (1.99 whales/1,000 km of effort), followed by fin whales (1.47 whales/1,000 km effort), sperm whales (0.51 whales/1,000 km of effort), North Atlantic right whales (0.17 whales/1,000 km of effort), sei whales (0.05 whales/1,000 km of effort), and blue whales (0.04 whales/1,000 km of effort) (Table 14, Figure 4).

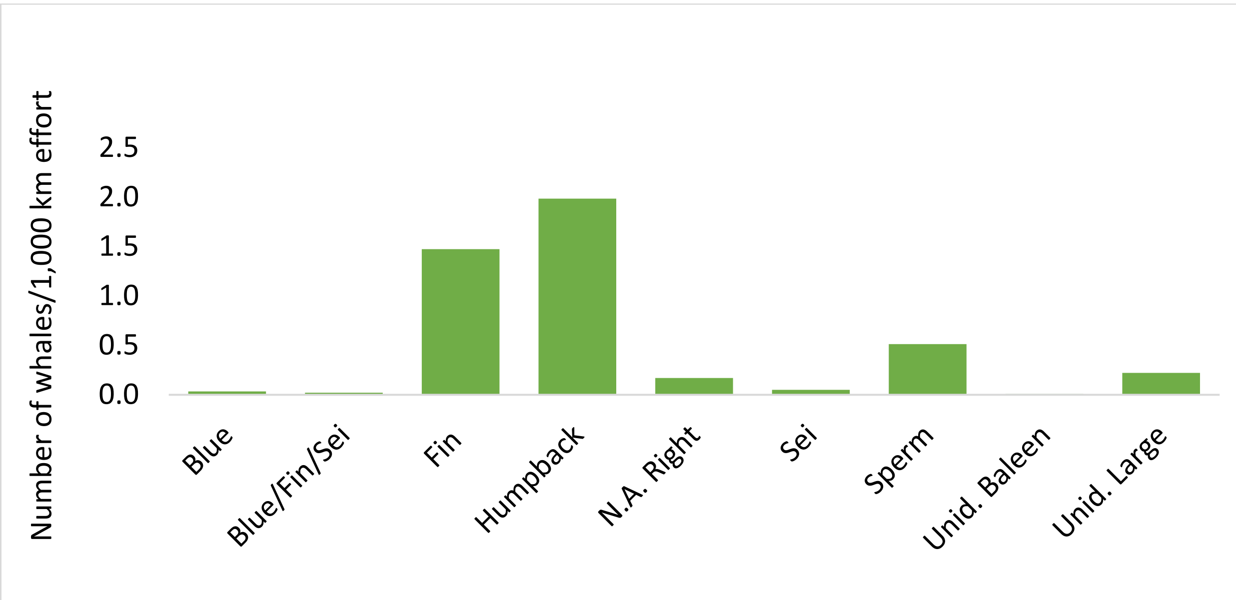

Figure 4. Sighting Rates for Priority Large Whale Species - Years 1–3 Combined

3.2.2.2 Seasonal: Years 1–3

For Years 1–3 combined, sighting rates varied seasonally:

- For all large whales, pooled sightings rates were the highest during summer (9.47 whales/1,000 km effort), followed by spring (3.33 whales/1,000 km effort). Sighting rates were lowest during fall and winter (2.39 and 2.93 whales/1,000 km effort, respectively) (Table 15, Figure 5).
- During spring, fin whales had the highest sighting rate (1.13 whales/1,000 km effort), followed by humpback whales (0.98 whales/1,000 km effort) and North Atlantic right whales (0.41 whales/1,000 km effort) (Table 15, Figure 5 and 6).
- During summer, humpback whales had the highest sighting rate (4.40 whales/1,000 km effort), followed by fin whales (3.44 whales/1,000 km effort) and sperm whales (1.28 whales/1,000 km effort) (Table 15, Figure 5 and 6).

- During fall, humpback whales had the highest sighting rate (1.45 whales/1,000 km effort), followed by fin whales (0.53 whales/1,000 km effort) and sperm whales (0.26 whales/1,000 km effort) (Table 15, Figure 5 and 6).

- During winter, humpback whales had the highest sighting rate (1.16 whales/1,000 km effort), followed by fin whales (0.90 whales/1,000 km effort) and North Atlantic right whales (0.24 whales/1,000 km effort) (Table 15, Figure 5 and 6).

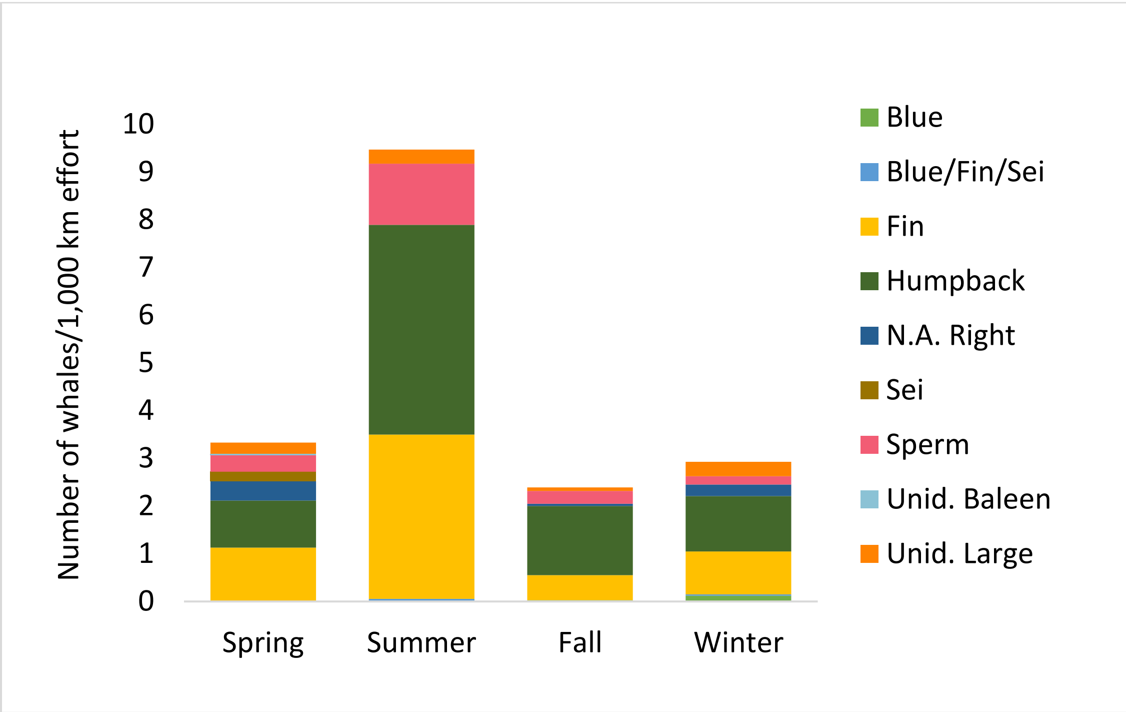

Figure 5. Sighting Rates by Season for Priority Large Whale Species - Years 1–3 Combined

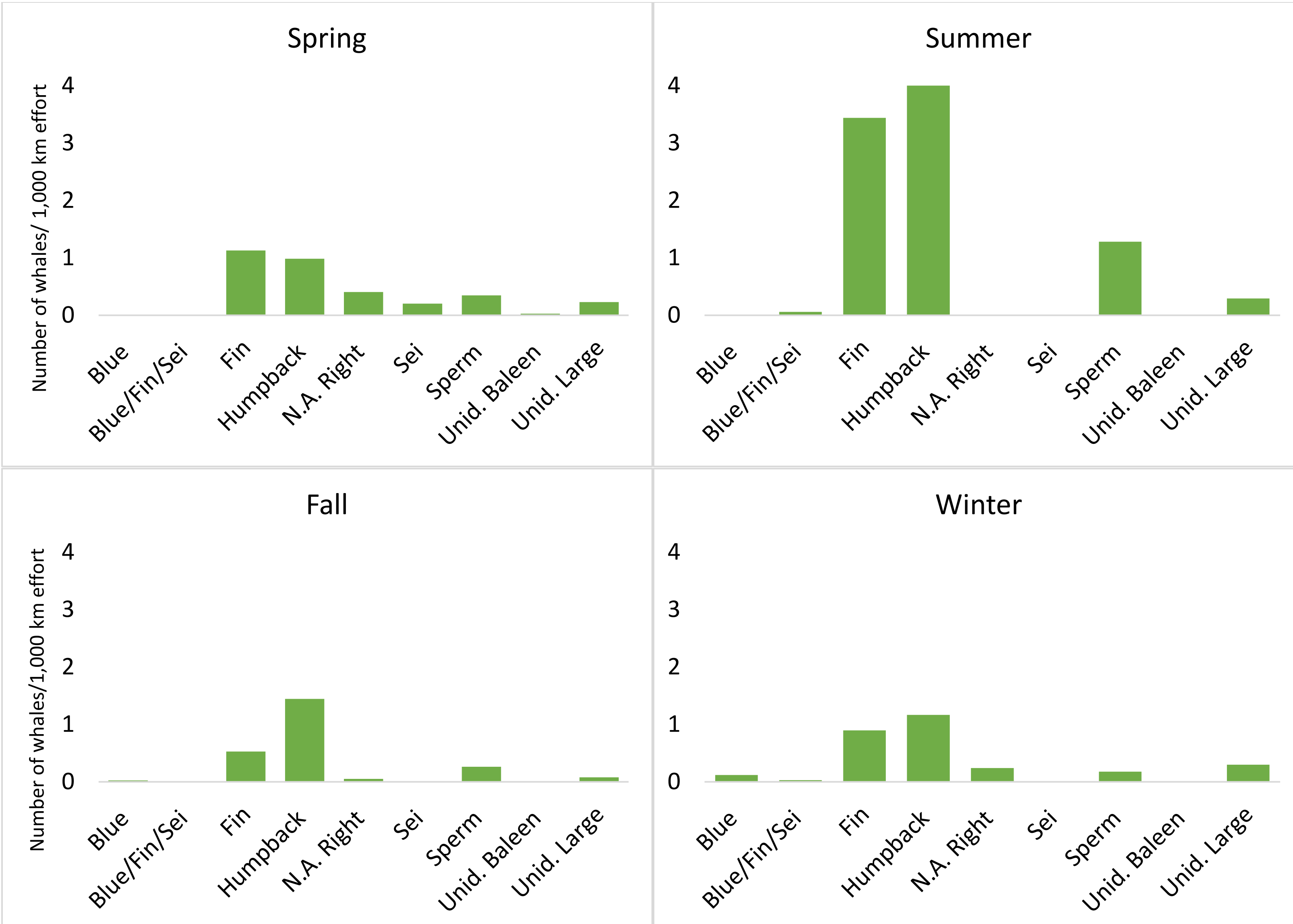

Figure 6. Sighting Rates by Season and Priority Large Whale Species - Years 1–3 Combined

3.2.2.3 Monthly: Years 1–3

For priority large whales, sighting rates were highest during June (17.91 whales/1,000 km of effort), followed by August (6.69 whales/1,000 km effort) and July (5.80 whales/1,000 km effort) (Table 16, Figure 7). Sighting rates were lowest during November (1.87 whales/1,000 km of effort), followed by October (1.90 whales/1,000 km effort), February (2.68 whales/1,000 km effort), and January (2.90 whales/1,000 km effort) (Table 16, Figure 7).

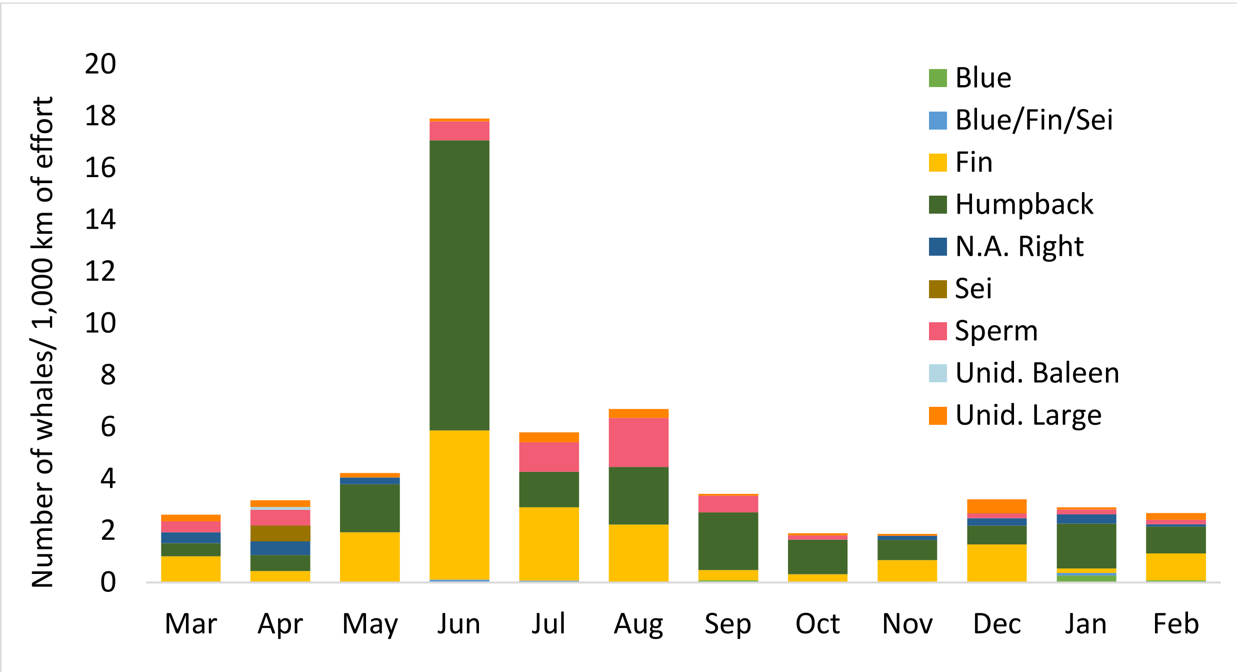

Figure 7. Sighting Rates by Month for Priority Large Whale Species - Years 1–3 Combined

3.2.2.4 Interannual

Sighting rates varied between Years 1, 2, and 3 for all priority large whales and by species. For all priority large whales pooled, annual sighting rates were highest in Year 2 (7.58 whales/1,000 km effort), followed by Year 3 (3.97 whales/1,000 km effort), and lowest in Year 1 (2.12 whales/1,000 km effort) (Table 14, Figure 8). In all three years, humpback and fin whales had the highest sighting rates (0.73 and 0.67 whales/1,000 km effort, respectively, during Year 1; 3.91 and 2.70 whales/1,000 km effort during Year 2; and 1.45 and 1.14 whales/1,000 km effort during Year 3; Figure 9).

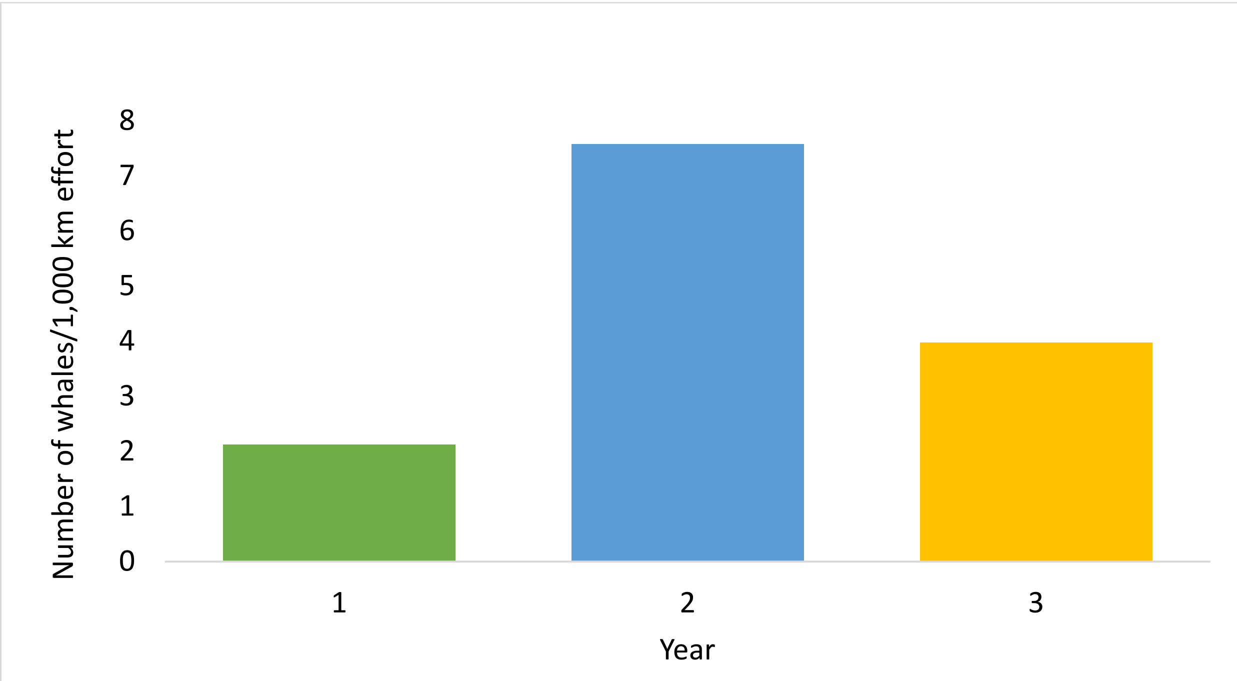

Figure 8. Sighting Rates by Year for Priority Large Whale Species

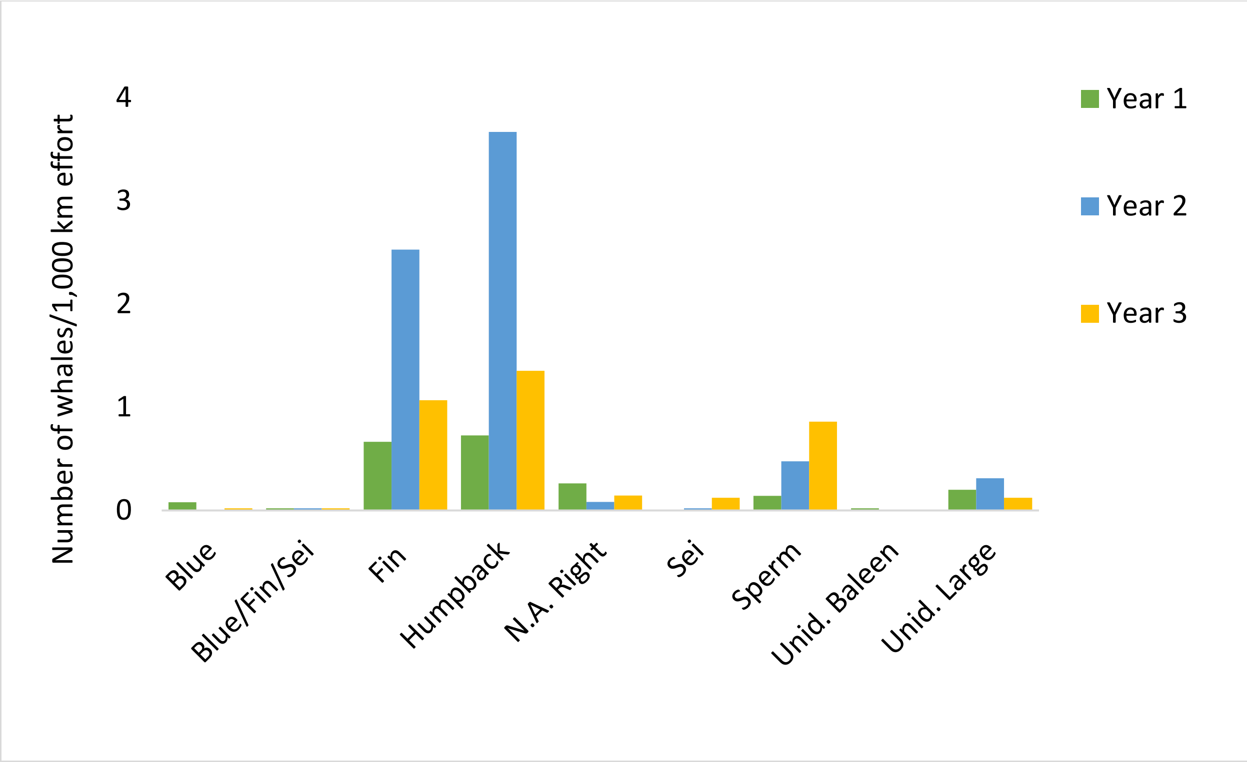

Figure 9. Sighting Rates by Species for Priority Large Whale Species - Years 1–3

3.2.2.4.1 Interannual Variation by Season

Interannual sighting rates varied seasonally and by species between Years 1, 2, and 3:

- During spring, sighting rates of fin whales and North Atlantic right whales were higher during Year 1 than Years 2 and 3. Sighting rates of humpback, sperm, and sei whales were higher during Year 3 than Years 1 and 2. (Figures 10 and 11, Table 17).
- During summer, fin and humpback whales were higher during Year 2 than all other years and all other seasons. Sperm whales were observed more frequently in Year 3 than Years 1 or 2. North Atlantic right whales and sei whales were not observed during summer in Years 1, 2, or 3 (Figures 10 and 11, Table 17).
- During fall, sighting rates of fin whales and humpback whales were highest during Year 2, followed by Year 3, and lowest in Year 1. Sperm whales were more frequent in Year 3 than in Year 1 and were absent in Year 2 (Figures 10 and 11, Table 17).
- During winter, blue whales and blue/fin/sei whales were recorded in Year 1 and absent in Years 2 and 3. Fin whales and North Atlantic right whales were more common during Year 3. Humpback whales and sperm whales were more common during Year 2 (Figures 10 and 11, Table 17).

- Figure 10 shows interannual variation by season for the six priority large whale species (including those not identified to species). Sighting rates of fin and humpback whales during the summer of Year 2 were much higher than those of any other species or year. Figure 11 shows seasonal variation by year for the six priority large whale species (including those not identified to species).

TABLE 17. SIGHTING RATES BY SEASON FOR PRIORITY LARGE WHALE SPECIES - YEARS 1––3

Common Name	Spring			Summer			Fall			Winter		
	Year 1	*Year 2*	*Year 3*	*Year 1*	*Year 2*	*Year 3*	*Year 1*	*Year 2*	*Year 3*	*Year 1*	*Year 2*	*Year 3*
	Total Effort (km)											
	11,522	*10,996*	*12,016*	*10,169*	*11,626*	*12,528*	*15,138*	*11,115*	*11,770*	*12,685*	*11,522*	*9,284*
Blue Whale	0	0	0	0	0	0	0	0	0.08	0.32	0	0
Blue/Fin/Sei Whale	0	0	0	0	0.09	0.08	0	0	0	0.08	0	0
Fin Whale	1.56	1.00	0.83	0.30	8.00	1.76	0.26	0.81	0.59	0.63	0.78	1.40
Humpback Whale	0.95	0.36	1.58	0.49	10.75	1.68	0.59	2.34	1.70	0.87	1.91	0.65
North Atlantic Right Whale	0.69	0.27	0.25	0	0	0	0.13	0	0	0.24	0.09	0.43
Sei Whale	0	0.09	0.50	0	0	0	0	0	0	0	0	0
Sperm Whale	0.09	0.45	0.50	0.30	1.20	2.16	0.13	0	0.68	0.08	0.35	0.11
Unidentified Baleen Whale	0.09	0	0	0	0	0	0	0	0	0	0	0
Unidentified Large Whale	0.26	0.36	0.08	0.30	0.43	0.16	0	0.09	0.17	0.32	0.43	0.11
All Priority Whales Identified to Species*	3.30	2.18	3.66	1.08	19.96	5.59	1.12	3.15	3.06	2.13	3.12	2.59
All Priority Whales**	3.65	2.55	3.75	1.38	20.47	5.83	1.12	3.24	3.23	2.52	3.56	2.69

Notes:

Sighting rates are based on number of whales (i.e., individuals).
Pooled observation effort by season includes Transect, Cross-leg, Transit, and Circling Efforts, and does not include Overland or Random Effort.
*Includes all large whales identified to species (i.e., does not include blue/fin/sei whale, unidentified baleen whales, and unidentified large whales).
**Includes all large whales including those not identified to species (i.e., includes blue/fin/sei whale, unidentified baleen whales, and unidentified large whales).

Figure 10. Sighting Rates by Season for Priority Large Whale Species - Years 1–3

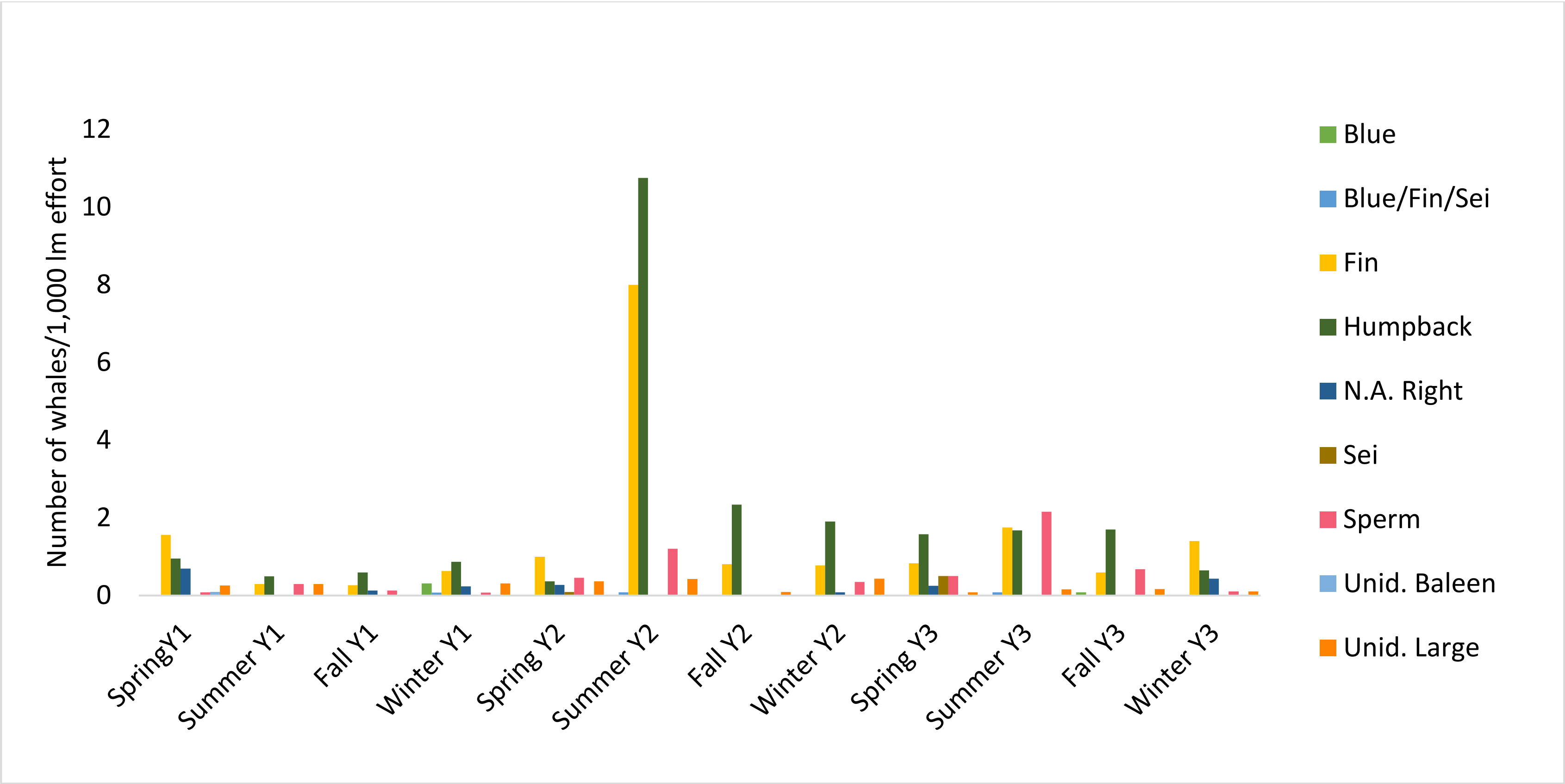

Figure 11. Seasonal Sighting Rate Variations by Priority Large Whale Species – Years 1-3

3.2.2.4.2 Interannual Variation by Month

Interannual sighting rates varied monthly by species between Years 1, 2, and 3:

- Across the 3-year study, fin whale sightings occurred during all months of the year. Sighting rates were substantially higher in Year 2 from June through August, and these sightings were a primary contributor to the overall higher sighting rate in Year 2 (Tables 11, 14, 17, and Figure 12).

- Like fin whales, across the 3-year study, humpback whale sightings occurred during all months of the year and overall sightings rates were much higher during Year 2 than both Year 1 and Year 3 in the months of June through September, lending to the overall higher sighting rate in Year 2. In Year 3, humpback whales were sighted in all months except December (Tables 11, 14, 17, and Figure 13).

- In Year 1, North Atlantic right whales were sighted in 5 months: March, April, November, January and February. In Year 2, they were sighted in 3 months: March, April, and December (Table 11). In March and April, sighting rates were higher during Year 1 (Table 17). In Year 3, North Atlantic right whales were sighted in May, December, and January. Though the sighting records were the same for Year 1 and Year 3 in January, the sighting rate was higher in Year 3 (Figure 14).

- Sperm whales were absent in May and November during all years of the study. Sightings occurred at low levels in all months they were recorded, but were highest during summer months for Years 2 and 3 (Tables 11 and 17, Figure 15).

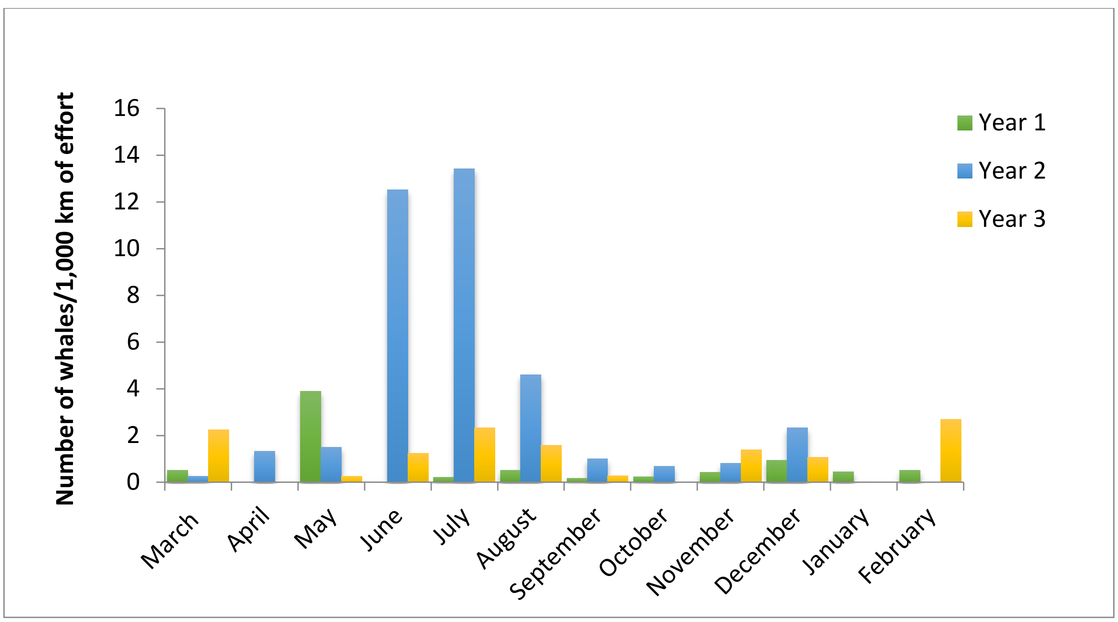

Figure 12. Sighting Rates for Fin Whales - Years 1–3

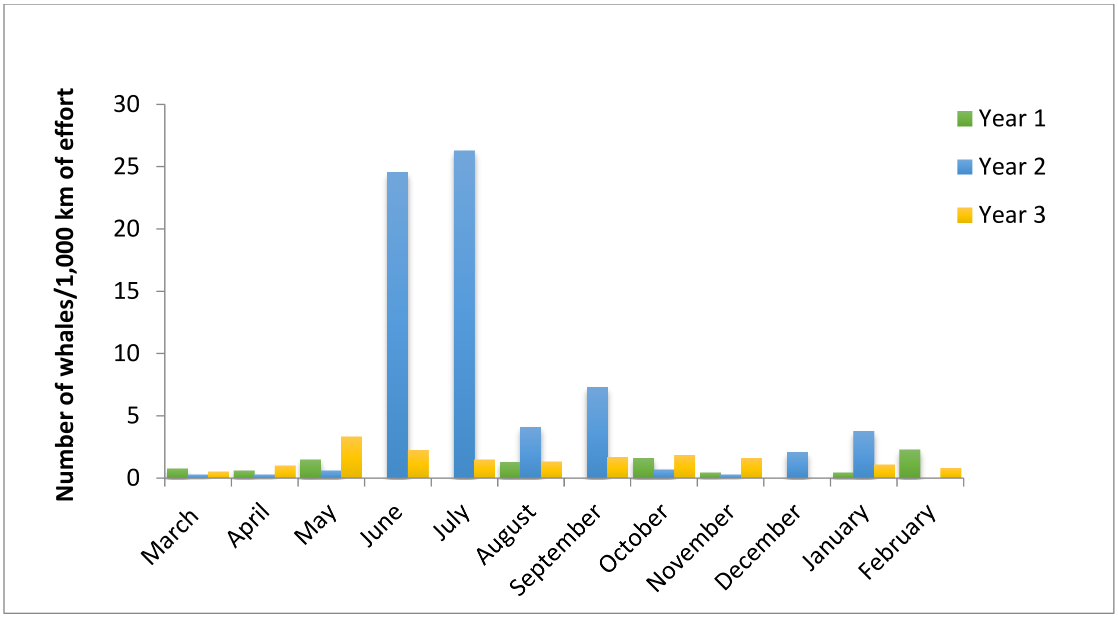

Figure 13. Sighting Rates for Humpback Whales - Years 1–3

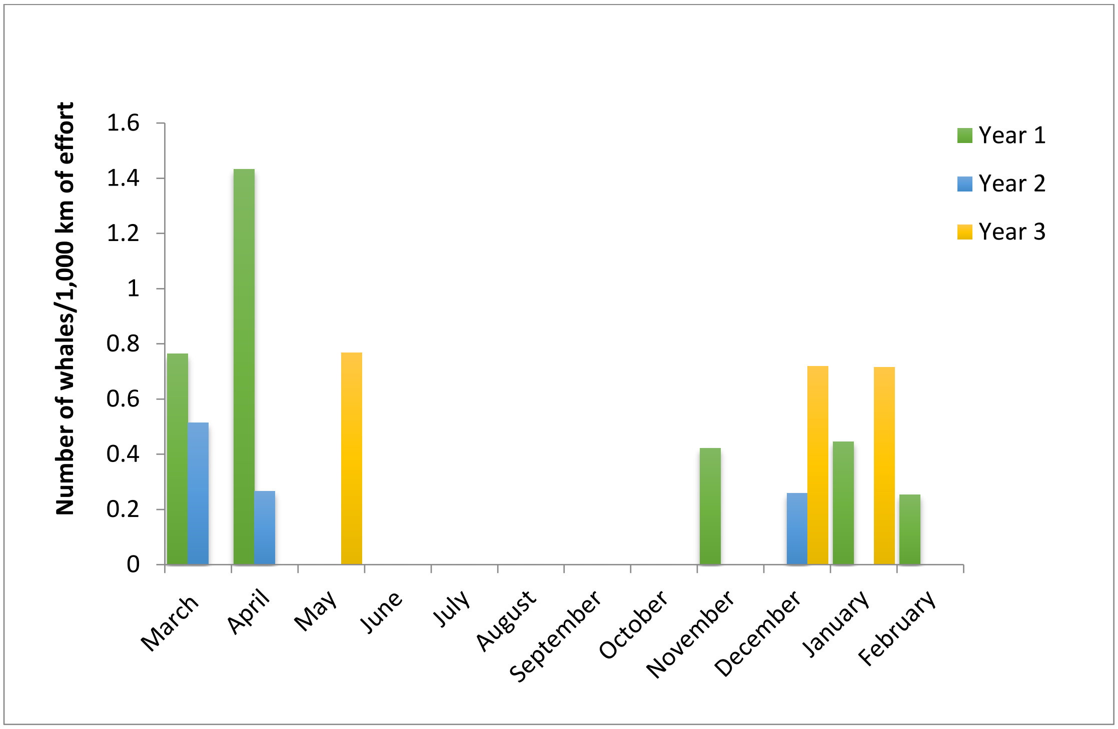

Figure 14. Sighting Rates for North Atlantic Right Whales during Years 1–3

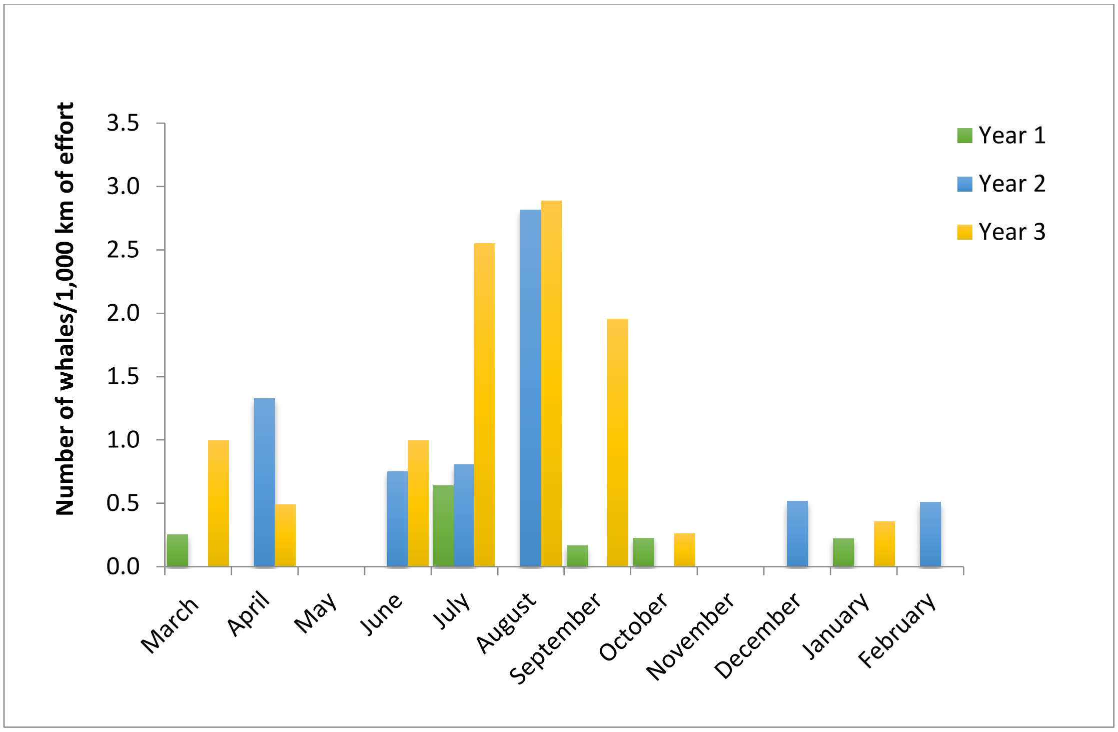

Figure 15. Sighting Rates for Sperm Whales - Years 1–3

3.2.3 Distribution

When pooled, all large whales were most frequently sighted on the shelf (5.2 whales/1,000 km effort). The slope and plain habitats had slightly lower, but similar large whale sighting rates (4.9 whales/1,000 km effort and 4.7 whales/1,000 km effort, respectively), while the nearshore habitat had the lowest overall sighting rate (3.23 whales/1,000 km effort). Results are displayed in Figures 16 and 17, and, Figures 83 through 89. Figure 16 shows sighting rates for priority large whale species for Years 1–3 by habitat class and Figure 17 shows sighting rates for priority large whale species by season and habitat class. Figure 82 illustrates the habitat distribution classes assigned for this study, with no whale sightings superimposed. Figure 83 shows distribution of all priority whales (grouped) by Years 1–3. Figures 84 through 89 show distribution for Years 1–3 combined, for each priority whale by species.

Tables 18 and 19 show sighting rates for priority large whale species by habitat class, and habitat class by season.

Distribution differed by season:

- During spring pooled all priority large whale sighting rates were highest on the shelf (8.0 whales/1,000 km effort), followed by the slope (3.3 whales/1,000 km effort), the plain (2.8 whales/1,000 km effort), and the nearshore (2.1 whales/1,000 km effort).

- During summer pooled all priority large whale sighting rates were highest on the slope (12.9 whales/1,000 km effort), followed by the plain (10.7 whales/1,000 km effort), the nearshore (4.7 whales/1,000 km effort), and the shelf (4.5 whales/1,000 km effort).
- During fall pooled all priority large whale sighting rates were relatively similar for all categories; however, they were highest on the slope (2.8 whales/1,000 km effort), followed by the nearshore (2.3 whales/1,000 km effort), the plain (2.2 whales/1,000 km effort), and the shelf (2.0 whales/1,000 km effort).
- During winter pooled all priority large whale sighting rates were relatively similar for all categories; however, they were highest on the shelf (5.1 whales/1,000 km effort), followed by the nearshore (4.0 whales/1,000 km effort), the plain (2.9 whales/1,000 km effort), and the slope (2.0 whales/1,000 km effort).

Distribution differed by large whale species:

- Blue whale presence (Table 18 and Figure 84) was highest in the plain habitat class (0.26 whales/1,000km effort), followed by the slope (0.01 whales/1,000 km effort). No blue whales were recorded in the nearshore or shelf habitats. Blue whale presence in the plain was only recorded during winter, while presence in the shelf was only recorded during fall.
- Fin whales (Table 18 and Figure 85) were recorded in all four habitat classes with the highest presence in the shelf and slope (1.97 whales/1,000 km effort and 1.47 whales/1,000 km effort, respectively). Sighting rates were still relatively high in both the nearshore (0.87 whales/1,000 km effort) and plain (0.96 whales/1,000 km effort) habitats. During spring, fin whale occurrence was highest in the plain and slope. During summer, fin whale occurrence was highest in the shelf and slope. During fall, fin whale occurrence was highest in the shelf and plain; and during winter, fin whale occurrence was highest in the nearshore and slope.
- Humpback whales (Table 18 and Figure 86) were recorded in all four habitat classes with the highest occurrence in the nearshore and shelf (1.98 whales/1,000 km effort and 2.73 whales/1,000 km effort, respectively) habitats. Sighting rates were lower in the slope and plain (0.49 whales/1,000 km effort and 0.13 whales/1,000 km effort, respectively) habitats. During summer, fall, and winter, humpback whale presence was highest in the nearshore and shelf. During spring, it was highest in the shelf and slope. The only occurrence of humpback whales in the plain occurred during winter.
- North Atlantic right whales (Table 18 and Figure 87) were recorded in three of the four habitat classes with the highest occurrence in the shelf (0.27 whales/1,000 km effort). No North Atlantic right whales were recorded in the slope. During spring, North Atlantic right whales occurred most frequently in the shelf. During fall, the North Atlantic right whale was only recorded in the shelf and during winter in nearshore and shelf habitats.

- Sei whale distribution (Table 18 and Figure 88) was highest in the shelf (0.49 whales/1,000 km effort), followed by the slope (0.01 whales/1,000 km effort). Sei whales were not recorded in the nearshore or plain habitats and were only recorded during spring.
- Sperm whale distribution (Table 18 and Figure 89) was highest in the plain (3.08 whales/1,000 km effort, followed by the slope (1.97 whales/1,000 km effort). Sperm whales were not recorded in the nearshore or shelf habitats. During spring, sperm whales were only recorded in slope. During summer, sperm whales occurred in both the slope and plain but were higher in in the plain habitat. During fall and winter, sperm whales occurred in both the slope and plain, but were higher in the slope habitat.

TABLE 18. SIGHTING RATES BY HABITAT CLASS FOR PRIORITY LARGE WHALE SPECIES

Common Name	Nearshore		Shelf		Slope		Plain	
	0-25 km from shore		>25 km from shore to 200 m water depth		>200 m to 1,000 m water depth		>1,000 m water depth	
	Whales	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**	**Whales**	**Whales/ 1,000 km effort**
Blue Whale	0	0	1	0.01	0	0	4	0.26
Blue/Fin/Sei Whale	0	0	1	0.01	1	0.08	1	0.06
Fin Whale	34	0.87	140	1.97	18	1.47	15	0.96
Humpback Whale	77	1.98	194	2.73	6	0.49	2	0.13
North Atlantic Right Whale	4	0.10	19	0.27	0	0	1	0.06
Sei Whale	0	0	1	0.01	6	0.49	0	0
Sperm Whale	0	0	0	0	24	1.97	48	3.08
Unidentified Baleen Whale	1	0.03	0	0	0	0	0	0
Unidentified Large Whale	10	0.26	14	0.20	5	0.41	2	0.13
All Priority Large Whales Identified to Species*	**115**	**2.95**	**355**	**5.00**	**54**	**4.42**	**70**	**4.50**
All Priority Large Whales**	**126**	**3.23**	**370**	**5.21**	**60**	**4.91**	**73**	**4.69**

Notes:

Sighting rates are based on number of whales (i.e., individuals).
Pooled observation effort includes Transit, Transect, Circling, Cross-leg, and Random (for Year 1) efforts for each habitat class; does not include Overland effort.
*Includes all large whales identified to species (i.e., does not include blue/fin/sei, unidentified baleen whales, and unidentified large whales).
**Includes all large whales including unidentified to species.

TABLE 19. SIGHTING RATES BY HABITAT CLASS AND SEASON FOR PRIORITY LARGE WHALE SPECIES

Common Name	Nearshore 0-25 km from shore				Shelf >25 km from shore to 200 m water depth				Slope >200 m to 1,000 m water depth				Plain >1,000 m water depth			
	Spring	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**
Blue Whale	0	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	1.15
Blue/Fin/Sei Whale	0	0	0	0	0	0.06	0	0	0	0.32	0	0	0	0	0	0.29
Fin Whale	0.84	1.41	0.19	1.12	1.13	5.50	0.75	0.59	0.64	2.55	0	2.71	2.26	0.25	0.98	0.29
Humpback Whale	0.53	3.26	2.00	2.15	1.47	6.87	1.76	0.88	0.96	0.32	0.33	0.34	0	0	0	0.57
North Atlantic Right Whale	0.21	0	0	0.20	0.62	0	0.11	0.35	0	0	0	0	0.25	0	0	0
Sei Whale	0	0	0	0	0.06	0	0	0	1.91	0	0	0	0	0	0	0
Sperm Whale	0	0	0	0	0	0	0	0	3.82	0.64	1.67	1.70	0	10.42	1.23	0.29
Unidentified Baleen Whale	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unidentified Large Whale	0.42	0	0.10	0.51	0.06	0.46	0.11	0.18	0.64	0.64	0	0.34	0.25	0	0	0.29
All Priority Whales Identified to Species*	1.58	4.67	2.19	3.48	3.28	12.37	2.66	1.81	7.33	3.51	2.01	4.75	2.51	10.66	2.21	2.30
All Priority Whales**	2.11	4.67	2.29	3.99	3.33	12.89	2.77	1.99	7.97	4.47	2.01	5.09	2.76	10.66	2.21	2.87

Notes:

Sighting rates are based on number of whales (i.e., individuals).
Pooled observation effort includes Transit, Transect, Circling, Cross-leg, and Random (for Year 1) efforts for each habitat class; does not include Overland effort.
*Includes all large whales identified to species (i.e., does not include blue/fin/sei, unidentified baleen whale, and unidentified large whales).
**Includes all large whales including unidentified to species.

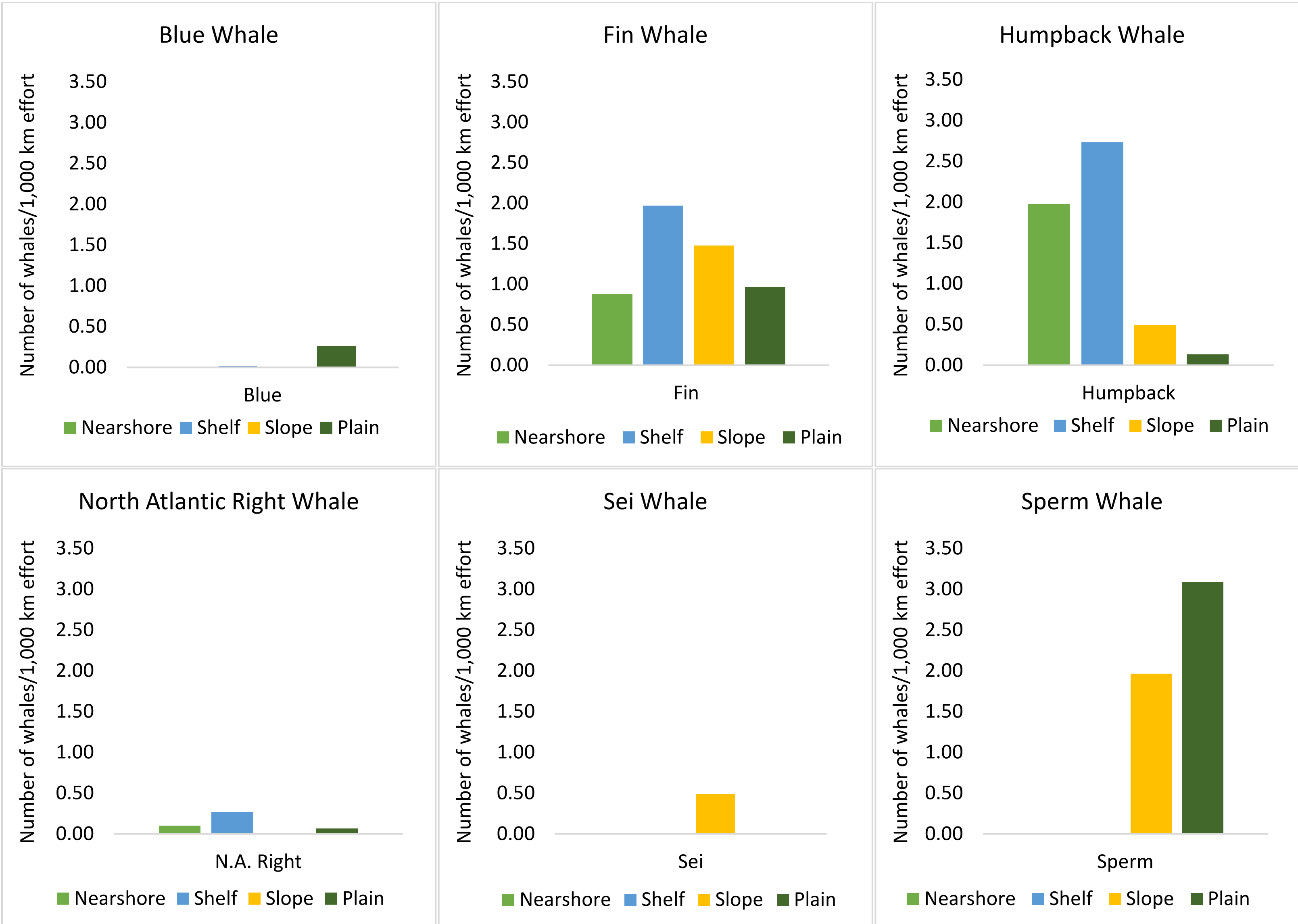

Figure 16. Sighting Rates by Habitat Class for Priority Large Whale Species - Years 1–3

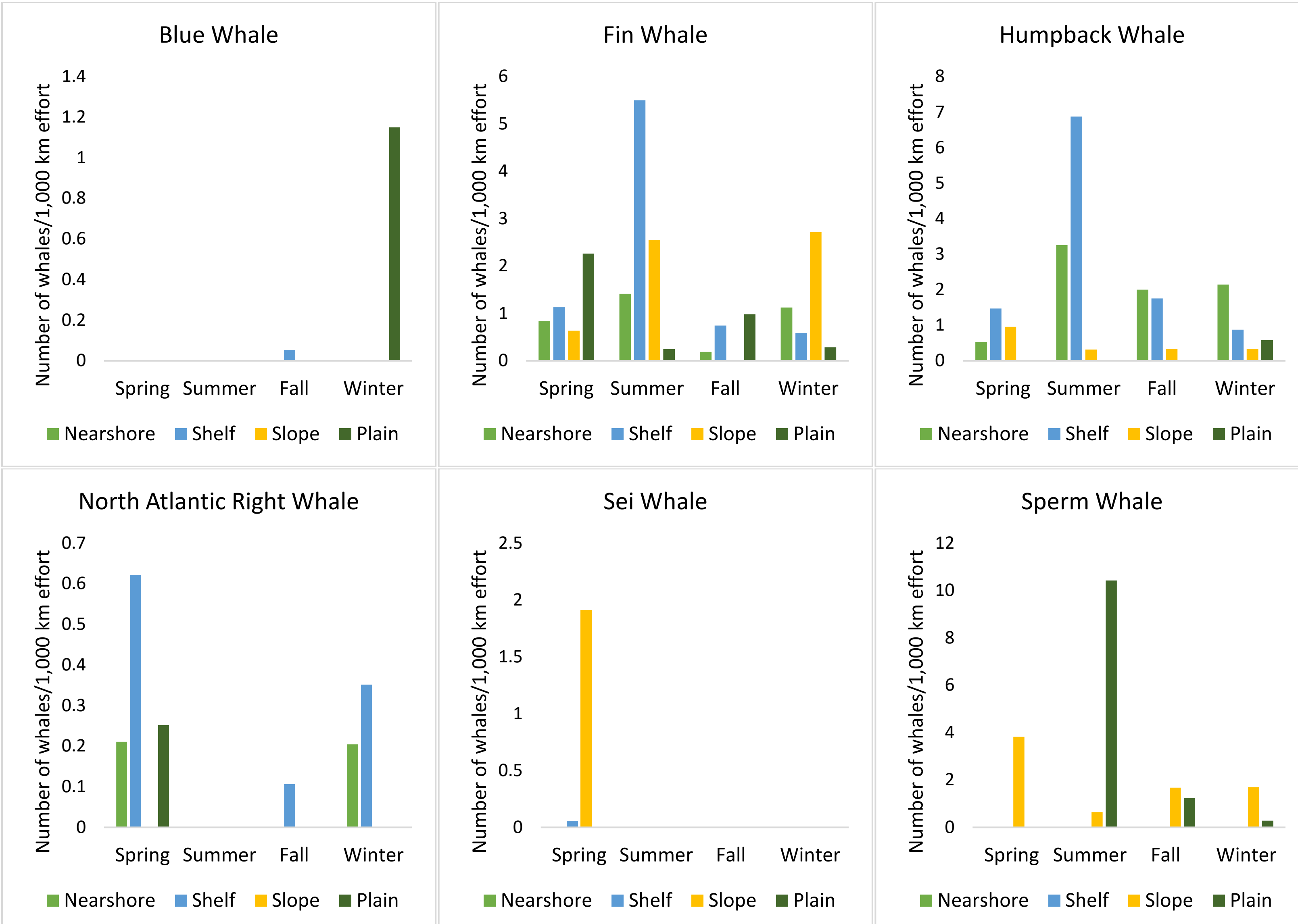

Figure 17. Sighting Rates by Season and Habitat Class for Priority Large Whale Species

3.2.4 Density

The size of the NYB Survey Area was calculated as 43,449 km^2 (12,668 nm^2) using North American Albers Equal Area Conic NAD 83 in ArcGIS (ESRI 2017). After filtering, the On Effort survey distance in Year 3 totaled 25,354 km (13,690 nm), and for Years 1–3 totaled 77,064 km (41,611 nm). Including priority large whales identified to species and sightings classified as unidentified large whale or blue/fin/sei whale, 51 sightings of 96 individuals were available for the line-transect density analysis in Year 3 bringing the total for Years 1–3 to 179 sightings of 376 individuals.

Using CDS methods on Year 3 data, and both CDS and MCDS methods on Years 1–3 data, several sets of exploratory analyses were conducted to determine the best truncation distance and modeling strategy. Histograms of the data showed fewer sightings closer to the trackline than somewhat further out, violating the shape criterion when fitting a detection function. This is not uncommon in aerial surveys, even when bubble windows are used, as it can still be difficult to maintain good visibility directly under the aircraft. To correct this, sightings in both datasets were left-truncated at 0.2 km based on recommendations in Buckland et al. (2001), as they were in Years 1 and 2. A variety of right-truncation distances were evaluated when assessing the fit of detection function models to the data. This included truncation distances from 1 km to 3 km in 0.2 km increments and 5%, 10%, and 15% of sightings. For the Year 3 data, model fit was best when the furthest 10% of sightings were removed, resulting in a right-truncation at 1.7 km, leaving 39 sightings available for detection function modeling and density estimation. For the Years 1–3 data, model fit was best for both CDS and MCDS methods when the data were left-truncated at 0.2 km and the furthest 5% of sightings were removed, resulting in a right-truncation distance at 2.1 km and leaving 150 observations for final detection function modeling and density estimation.

As recommended by Buckland et al. (2001), the final detection function model was selected from a set of potential models using a combination of model selection and evaluation criteria, including AIC, χ^2, and the coefficient of variation of the resulting estimates. For the Year 3 data, the best-fit model had a uniform key-function with a cosine series expansion. The PSD histogram and fitted model for Year 3 data are shown in Figure 18. The detection function [f(0)] was estimated to be 1.331/km, which results in an effective strip half-width of 0.751 km. For the Years 1–3 data, the CDS best-fit model had a half-normal key-function with a cosine series expansion. The PSD histogram and fitted model are shown in Figure 19. The detection function [f(0)] was estimated to be 1.697/km, which results in an effective strip half-width of 0.589 km.

Model comparisons during the MCDS analysis showed that Beaufort SS (as a non-factor variable) and visibility distance improved model fit more than Beaufort SS (as a factor variable) and the overall sighting conditions ranking variables. The best-fit MCDS model, which included only the Beaufort SS non-factor variable, resulted in a very similar detection function and monthly density estimates compared to the best CDS model. However, fitting additional parameters in the MCDS model resulted in a higher estimated variance than the CDS model, and therefore yielded less precise density estimates. For that reason, the results from the CDS model are provided here as the best estimate of density and abundance for the Years 1–3 combined dataset. Similarly, evaluation of species-specific detection functions for fin whale and humpback whale did not result in meaningful differences in final density estimates or substantial improve the precision of those estimates. Therefore, the global detection function fitted to sightings of all six priority species was also used for these two species.

In Year 3, the pooled density of all priority large whale species averaged across the 12 survey months was 1.742 individuals/1,000 km^2, and abundance was estimated to be 76 whales (CV = 21.22%), representing the average estimated year-round abundance in the entire NYB Survey Area for the priority species (Table 20). After applying multipliers corresponding to the proportion of each priority species among the total identified individuals in Year 3, average annual density and abundance were estimated for each species, as shown in Table 20. Results from Year 1 and Year 2 are also included in Table 20 for reference. For consistency with Year 2 and Year 3 results, the Year 1 results have been revised from the Year 1 report to reflect slight differences in data filtering and density analysis methods. The species proportions were based on the 51 sightings (groups) of 96 individual priority large whale species available for line-transect analysis. Species-specific monthly densities shown in Table 21 were calculated in the same way but using the proportion of identified individuals within each month rather than the whole year, and are shown both with and without the use of g(0) correction factors.

After applying the same species-specific g(0) corrections for detection of whales on the survey line as used by Roberts et al. (2016, 2017), monthly abundance estimates for this study were calculated with those corrections and are shown in Table 22. Also shown in Table 22 are monthly abundance estimates for the NYB Survey Area calculated from data in Roberts et al. (2016) for blue whales, and Roberts et al. (2017) for all other species. Blue whale abundance for the NYB Survey Area from Roberts et al. (2016) was estimated at 0.4 individuals in each month.

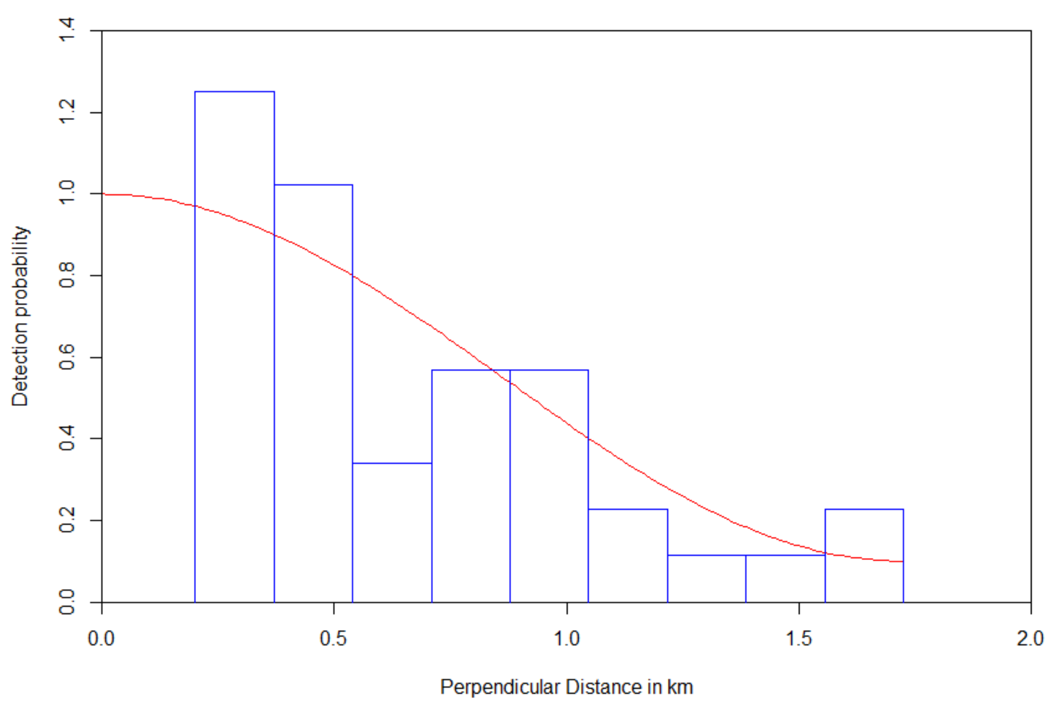

Figure 18. PSD Histogram and Fitted Detection Function (Uniform Key Function with a Cosine Series Expansion) for Priority Large Whale Sightings - Year 3

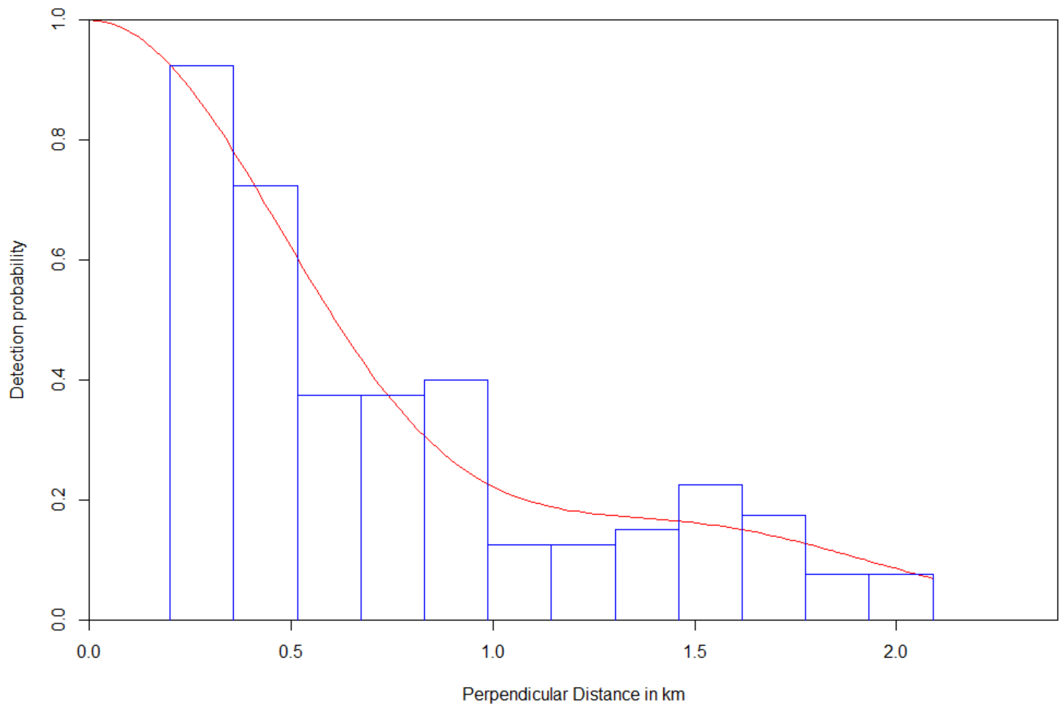

Figure 19. PSD Histogram and Fitted Detection Function (Half-Normal Key Function with a Cosine Series Expansion) for Priority Large Whale Sightings - Years 1–3

TABLE 20. ESTIMATES OF AVERAGE ANNUAL DENSITY AND ABUNDANCE FOR THE SIX PRIORITY LARGE WHALE SPECIES – YEARS 1-3

Common Name	n#	Pro-portion*	Density (Individuals/ 1,000 km^2)	Abundance	95% Confidence Intervals
Blue Whale					
Year 1	1	0.020	0.033	1	1–2
Year 2	0	0	0	0	0–0
Year 3	1	0.011	0.019	1	1–1
Fin Whale					
Year 1	27	0.540	0.895	39	23–65
Year 2	60	0.280	0.658	29	19–43
Year 3	30	0.326	0.568	25	16–37
Humpback Whale					
Year 1	9	0.180	0.298	13	8–22
Year 2	138	0.645	1.513	66	43–100
Year 3	30	0.326	0.568	25	16–37
North Atlantic Right Whale					
Year 1	10	0.200	0.332	14	9–22
Year 2	2	0.009	0.022	1	1–1
Year 3	5	0.054	0.095	4	3–6
Sei Whale					
Year 1	0	0	0	0	0–0
Year 2	1	0.005	0.011	0^	0–1
Year 3	6	0.065	0.114	5	3–7
Sperm Whale					
Year 1	3	0.060	0.099	4	3–7
Year 2	13	0.061	0.143	6	4–9
Year 3	20	0.217	0.379	17	11–25
Total Priority Species					
Year 1	50	1.000	1.658	72	43–120
Year 2	214	1.000	2.347	102	67–155
Year 3	92	1.000	1.742	76	50–114

Notes:

Number of individuals of each species observed while On Effort (available for use in the line-transect analysis).
* Proportion of individuals of species among the total On Effort sightings identified to species.
^ Estimate of 0 results from rounding down the true estimate of 0.48 individuals.

TABLE 21. ESTIMATES OF MONTHLY DENSITY (INDIVIDUALS/1,000 KM^2) FOR THE SIX PRIORITY LARGE WHALE SPECIES - YEAR 3

Month	Blue Whale		Fin Whale		Humpback Whale		North Atlantic Right Whale		Sei Whale		Sperm Whale	
	Uncorr.	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**
January	0	0	0	0	1.547	3.431	0	0	0	0	0.774	4.498
February	0	0	0.831	3.311	0.277	0.614	0	0	0	0	0	0
March	0	0	0.967	3.852	0.322	0.715	0	0	0	0	0.645	3.747
April	0	0	0	0	0	0	0	0	0.695	1.312	0.232	1.347
May	0	0	0.107	0.425	1.387	3.075	0.320	0.958	0	0	0	0
June	0	0	0.340	1.354	0	0	0	0	0	0	1.020	5.929
July	0	0	1.798	7.164	0	0	0	0	0	0	0	0
August	0	0	0.518	2.063	0.345	0.765	0	0	0	0	0.518	3.010
September	0.228	0.560	0.228	0.909	0.912	2.023	0	0	0	0	1.596	9.281
October	0	0	0	0	0.591	1.310	0	0	0	0	0	0
November	0	0	1.203	4.792	1.203	2.667	0	0	0	0	0	0
December	0	0	2.011	8.013	0	0	1.341	4.014	0	0	0	0
Annual Average	**0.019**	**0.047**	**0.568**	**2.263**	**0.568**	**1.259**	**0.095**	**0.283**	**0.114**	**0.214**	**0.379**	**2.201**

Notes:

Corr. = Corrected (with [g0])
NA = Not applicable
Uncorr. = Uncorrected (without [g0])

TABLE 22. ESTIMATES OF MONTHLY ABUNDANCE FOR THE SIX PRIORITY LARGE WHALE SPECIES INCLUDING G(0) CORRECTION FACTORS AND THE PREDICTED ABUNDANCE IN THE NYB FROM ROBERTS ET AL. (2016, 2017) HABITAT-BASED DENSITY MODELS - YEAR 3

Month	Blue Whale		Fin Whale		Humpback Whale		North Atlantic Right Whale		Sei Whale		Sperm Whale	
	Y3	Roberts	Y3	Roberts	Y3	Roberts	Y3	Roberts	Y3	Roberts	Y3	Roberts
January	0	0.4	0	160	149	15	0	17	0	13	196	71
February	0	0.4	143	180	27	19	0	17	0	14	0	149
March	0	0.4	167	236	31	51	0	17	0	14	163	148
April	0	0.4	0	289	0	110	0	27	57	44	58	145
May	0	0.4	19	317	134	162	42	14	0	64	0	115
June	0	0.4	59	345	0	149	0	5	0	36	257	118
July	0	0.4	311	292	0	20	0	2	0	10	0	164
August	0	0.4	90	204	33	8	0	2	0	5	131	159
September	24	0.4	40	273	88	30	0	2	0	5	404	153
October	0	0.4	0	235	58	111	0	1	0	10	0	230
November	0	0.4	209	153	116	76	0	1	0	8	0	62
December	0	0.4	349	159	0	13	175	17	0	9	0	45
Annual Average	**2**	**0.4**	**99**	**237**	**55**	**64**	**12**	**10**	**9**	**19**	**96**	**130**

Notes:

Y3 = Results from Year 3 of this study.
Roberts = Roberts et al. (2016) for blue whale and Roberts et al. (2017) for all other species.

For the combined Years 1–3 dataset, the pooled density of all priority large whale species averaged across the 12 survey months was 2.232 individuals/1,000 km^2, and abundance was estimated to be 97 whales (CV = 16.4%), representing the average estimated year-round abundance in the entire NYB Survey Area for the priority species (Table 23). After applying multipliers corresponding to the proportion of each priority species among the total identified individuals in Years 1–3, average annual density and abundance were estimated for each species, as shown in Table 23. The species proportions were based on the 179 sightings (groups) of 376 individual priority large whale species available for line-transect analysis. Species-specific monthly densities shown in Table 24 were calculated in the same way, but using the proportion of identified individuals within each month, and are shown both with and without the use of g(0) correction factors.

After applying the same species-specific g(0) corrections for detection of whales on the survey line as used by Roberts et al. (2016, 2017), monthly abundance estimates for this study were calculated with those corrections and are shown in Table 25. Also shown in Table 25 are monthly abundance estimates for the NYB Survey Area calculated from data in Roberts et al. (2016) for blue whales and Roberts et al. (2017) for all other species. Blue whale abundance for the NYB Survey Area from Roberts et al. (2016) was estimated at 0.4 individuals in each month. Figure 20 provides a visual comparison of the Years 1–3 monthly abundance estimates from this study for fin, humpback, North Atlantic right, sei, and sperm whales to the monthly abundance estimates from Roberts et al. (2017) as shown in Table 25.

TABLE 23. ESTIMATES OF AVERAGE ANNUAL DENSITY AND ABUNDANCE FOR THE SIX PRIORITY LARGE WHALE SPECIES - YEARS 1–3

Common Name	n#	Pro-portion*	Density (Individuals/ 1,000 km^2)	Abundance	90% Confidence Limits
Blue Whale	2	0.006	0.013	1	0–1
Fin Whale	117	0.329	0.734	32	23–44
Humpback Whale	177	0.497	1.110	48	35–66
North Atlantic Right Whale	17	0.048	0.107	5	3–6
Sei Whale	7	0.020	0.044	2	1–3
Sperm Whale	36	0.101	0.226	10	7–13
Total Priority Species	**356**	**1.000**	**2.232**	**97**	**70–133**

Notes:

Number of individuals of each species observed while On Effort (available for use in the line-transect analysis).
* Proportion of individuals of species among the total On Effort sightings identified to species.

TABLE 24. ESTIMATES OF MONTHLY DENSITY (INDIVIDUALS/1,000 KM^2) FOR THE SIX PRIORITY LARGE WHALE SPECIES - YEARS 1–3

	Blue Whale		Fin Whale		Humpback Whale		North Atlantic Right Whale		Sei Whale		Sperm Whale	
Month	**Uncorr.**	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**	**Uncorr**	**Corr.**
January	0	0	0.285	1.137	0.856	1.899	0	0	0	0	0.143	0.830
February	0.073	0.178	0.436	1.736	0.218	0.483	0	0	0	0	0	0
March	0	0	0.809	3.225	0.405	0.897	0.304	0.909	0	0	0.405	2.353
April	0	0	0.167	0.666	0.167	0.371	0.501	1.501	0.585	1.104	0.585	3.401
May	0	0	1.363	5.429	1.103	2.446	0.195	0.583	0	0	0	0
June	0	0	0.950	3.784	4.849	10.751	0	0	0	0	0.150	0.872
July	0	0	2.733	10.888	0.841	1.864	0	0	0	0	0.315	1.833
August	0	0	1.114	4.437	0.506	1.122	0	0	0	0	1.012	5.886
September	0.052	0.127	0.258	1.026	1.339	2.970	0	0	0	0	0.361	2.097
October	0	0	0.412	1.643	0.412	0.914	0	0	0	0	0	0
November	0	0	0.639	2.546	0.426	0.945	0.213	0.638	0	0	0	0
December	0	0	0.933	3.717	0.133	0.296	0.400	1.197	0	0	0.133	0.775
Annual Average	**0.013**	**0.031**	**0.734**	**2.923**	**1.110**	**2.461**	**0.107**	**0.319**	**0.044**	**0.083**	**0.226**	**1.312**

Notes:

Corr. = Corrected (with [g0])
NA = Not applicable
Uncorr. = Uncorrected (without [g0])

TABLE 25. ESTIMATES OF MONTHLY ABUNDANCE FOR THE SIX PRIORITY LARGE WHALE SPECIES INCLUDING G(0) CORRECTION FACTORS AND THE PREDICTED ABUNDANCE IN THE NYB FROM ROBERTS ET AL. (2016, 2017) HABITAT-BASED DENSITY MODELS - YEARS 1–3

Month	Blue Whale		Fin Whale		Humpback Whale		North Atlantic Right Whale		Sei Whale		Sperm Whale	
	Y1-3	Roberts	Y1-3	Roberts	Y1-3	Roberts	Y1-3	Roberts	Y1-3	Roberts	Y1-3	Roberts
January	0	0.4	50	160	83	15	0	17	0	13	36	71
February	8	0.4	76	180	21	19	0	17	0	14	0	149
March	0	0.4	141	236	39	51	40	17	0	14	103	148
April	0	0.4	29	289	16	110	65	27	48	44	148	145
May	0	0.4	237	317	107	162	25	14	0	64	0	115
June	0	0.4	164	345	466	149	0	5	0	36	38	118
July	0	0.4	473	292	81	20	0	2	0	10	80	164
August	0	0.4	192	204	49	8	0	2	0	5	255	159
September	5	0.4	44	273	129	30	0	2	0	5	91	153
October	0	0.4	72	235	40	111	0	1	0	10	0	230
November	0	0.4	112	153	41	76	28	1	0	8	0	62
December	0	0.4	160	159	13	13	52	17	0	9	33	45
Annual Average	**1**	**0.4**	**127**	**237**	**107**	**64**	**14**	**10**	**4**	**19**	**57**	**130**

Notes:

Y1-3 = Results from Years 1–3 of this study.
Roberts = Roberts et al. (2016) for blue whale and Roberts et al. (2017) for all other species.

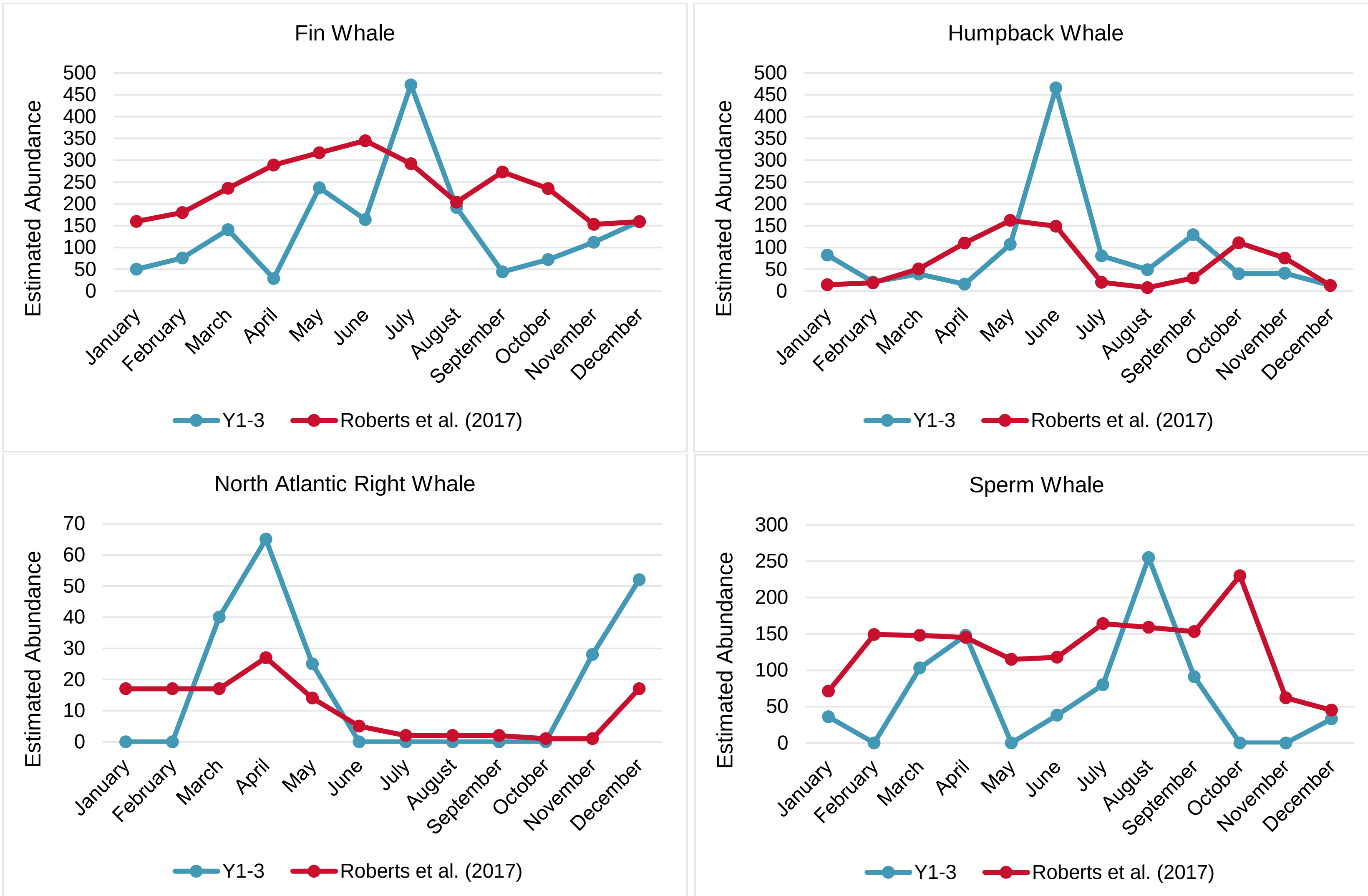

Figure 20. Monthly Abundance Estimates of Four Priority Large Whale Species from this Study Compared to Monthly Abundance Estimates from Roberts et al. (2017) Data

3.3 OTHER MARINE MAMMAL SPECIES

In addition to the priority large whale species, 10 other types of marine mammal (cetaceans and pinnipeds) sightings were recorded (Table 26). Figure 21 shows sighting rates for other marine mammal species (grouped, using pooled data) for Years 1–3 and Figure 22 shows sighting rates for other marine mammal species by species and season. A total of 980 sightings (estimated 23,244 individuals) were recorded. Of these sightings, 39% (384 sightings, estimated 7,249 individuals) were identified to species and the remaining 61% (596 sightings, estimated 15,995 individuals) were unidentified. The most frequently recorded other marine mammal was the unidentified dolphin (493 groups; estimated 12,974 individuals), followed by Risso's dolphin (*Grampus griseus*) (232 groups; estimated 2,462 individuals). Additionally, there were 39 groups (estimated 45 individuals) of minke whales (*B. acutorostrata*), 39 groups (estimated 385 individuals) of bottlenose dolphin (*Tursiops truncatus*), 51 groups (estimated 3,867 individuals) of common dolphin, 20 groups (estimated 472 individuals) of pilot whales (*Globicephala* sp.), 1 group (estimated 2 individuals) of Cuvier's beaked whale (*Ziphius cavirostris*), and 2 groups (estimated 16 individuals) of harbor porpoise (*Phocoena phocoena)* (Figure 22 and Table 26). Sighting rates for all other marine mammals pooled were highest during summer (367.86 marine mammals/1,000 km effort), followed by fall (115.14 marine mammals/1,000 km effort) (Table 22, Figure 22). Sighting rates were lowest during spring and winter (105.32 and 77.27 marine mammals/1,000 km effort, respectively) (Figure 22 and Table 27). Figures 23 through 26 show sighting rates across Years 1–3 by season for the following species: Risso's dolphin, common dolphin, pilot whale, and bottlenose dolphin. For information on sightings and mapped locations by monthly survey, refer to the individual monthly survey reports submitted to NYSDEC. Figures 90 and 91 show non-priority marine mammals sighting locations by Year 3 (Figure 90) and then across Years 1–3 (Figure 91).

TABLE 26. SIGHTINGS OF OTHER MARINE MAMMAL SPECIES - YEARS 1–3

Common Name	Year 1			Year 2			Year 3			Years 1–3		
	Number	Group Size		Number	Group Size		Number	Group Size		Number	Group Size	
	Groups (Indiv.)	Mean (S.D.)	Range	Groups (Indiv.)	Mean (S.D.)	Range	Groups (Indiv.)	Mean (S.D.)	Range	Groups (Indiv.)	Mean (S.D.)	Range
Bottlenose Dolphin	15 (144)	9.6 (9.2)	1-35	6 (107)	17.8 (18.6)	2-50	18 (134)	7.4 (6.5)	1-25	39 (385)	9.9 (10.4)	1-50
Common Dolphin	30 (2,713)	90.4 (126.4)	2-500	5 (657)	131.4 (262.1)	2-600	16 (497)	31.1 (37.9)	3-150	51 (3,867)	75.8 (127.6)	2-600
Cuvier's Beaked Whale	1 (2)	2 (NA)	2-2	-	-	-	-	-	-	1 (2)	2 (NA)	2-2
Delphinus/Tursiops/Stenella	28 (699)	25.0 (21.2)	1-80	38 (1,994)	52.5 (129.2)	2-800	4 (226)	56.5 (53.7)	1-120	70 (2,919)	41.7 (97.2)	1-800
Harbor Porpoise	-	-	-	-	-	-	2 (16)	8.0 (7.1)	3-13	2 (16)	8 (7.1)	3-13
Minke Whale	9 (9)	1 (0)	1-1	23 (28)	1.2 (0.5)	1-3	7 (8)	1.1 (0.4)	1-2	39 (45)	1.2 (0.4)	1-3
Pilot Whale	8 (279)	34.9 (33.1)	3-110	1 (2)	2 (NA)	2-2	11 (191)	17.4 (15.2)	3-50	20 (472)	23.6 (25.0)	2-110
Risso's Dolphin	96 (788)	8.2 (9.8)	1-55	67 (820)	12.2 (11.2)	1-50	69 (854)	12.4 (17.6)	1-110	232 (2,462)	10.6 (13.1)	1-110
Tursiops/Grampus	1 (1)	1 (NA)	1-1	-	-	-	-	-	-	1 (1)	1 (NA)	1-1
Tursiops/Lagenorhynchus	-	-	-	1 (1)	1 (NA)	1-1	3 (15)	5.0 (3.6)	2-9	4 (16)	4.0 (3.6)	1-9
Unidentified Beaked Whale	3 (8)	2.7 (2.1)	1-5	-	-	-	1 (5)	5.0 (NA)	5-5	4 (13)	3.3 (2.1)	1-5
Unidentified Cetacean	2 (2)	1 (0)	1-1	11 (54)	4.9 (7.2)	1-24	7 (12)	1.7 (1.5)	1-5	20 (68)	3.4 (5.6)	1-24
Unidentified Dolphin	126 (3,108)	24.7 (45.7)	1-300	120 (4,300)	35.8 (52.9)	1-300	247 (5,566)	22.5 (40.8)	1-300	493 (12,974)	26.3 (45.5)	1-300
Unidentified Seal	-	-	-	1 (1)	1 (NA)	1-1	1 (1)	1 (NA)	1-1	2 (2)	1 (0)	1-1
Unidentified Whale	2 (2)	1 (0)	1-1	-	-	-	-	-	-	2 (2)	1.0 (0)	1-1
Other Marine Mammals Total	**321 (7,755)**			**273 (7,964)**			**386 (7,525)**			**980 (23,244)**		

Notes:

Indiv. = Individual
NA = Not applicable
S.D. = Standard deviation

TABLE 27. OTHER MARINE MAMMAL SPECIES SIGHTING RATES BY SEASON - YEARS 1–3

Common Name	Spring	Summer	Fall	Winter	All Seasons
Bottlenose Dolphin	0.35	5.42	4.39	0.60	2.74
Common Dolphin	17.17	59.49	10.86	24.45	27.55
Cuvier's Beaked Whale	0.06	0	0	0	0.01
Delphinus/Tursiops/Stenella	13.32	46.24	10.84	13.74	20.80
Harbor Porpoise	0	0.09	0	0.39	0.11
Minke Whale	0.29	0.84	0.11	0.06	0.32
Pilot Whale	0.06	7.31	5.76	0	3.36
Risso's Dolphin	16.07	33.83	15.60	4.57	17.54
Tursiops/Grampus	0	0	0	0.03	0.01
Tursiops/Lagenorhynchus	0.03	0.44	0	0	0.11
Unidentified Beaked Whale	0	0	0.16	0.21	0.09
Unidentified Cetacean	1.68	0.20	0.08	0	0.48
Unidentified Dolphin	56.26	213.97	67.75	33.17	92.43
Unidentified Seal	0.03	0.03	0	0	0.01
Unidentified Whale	0	0	0	0.06	0.01
Other Marine Mammals Total	**105.32**	**367.86**	**115.54**	**77.27**	**165.59**

Notes:

Sighting rates are based on number of marine mammals (i.e., individuals).
Pooled observation effort by season includes Transect, Cross-leg, Transit, and Circling Efforts; does not include Overland Effort.

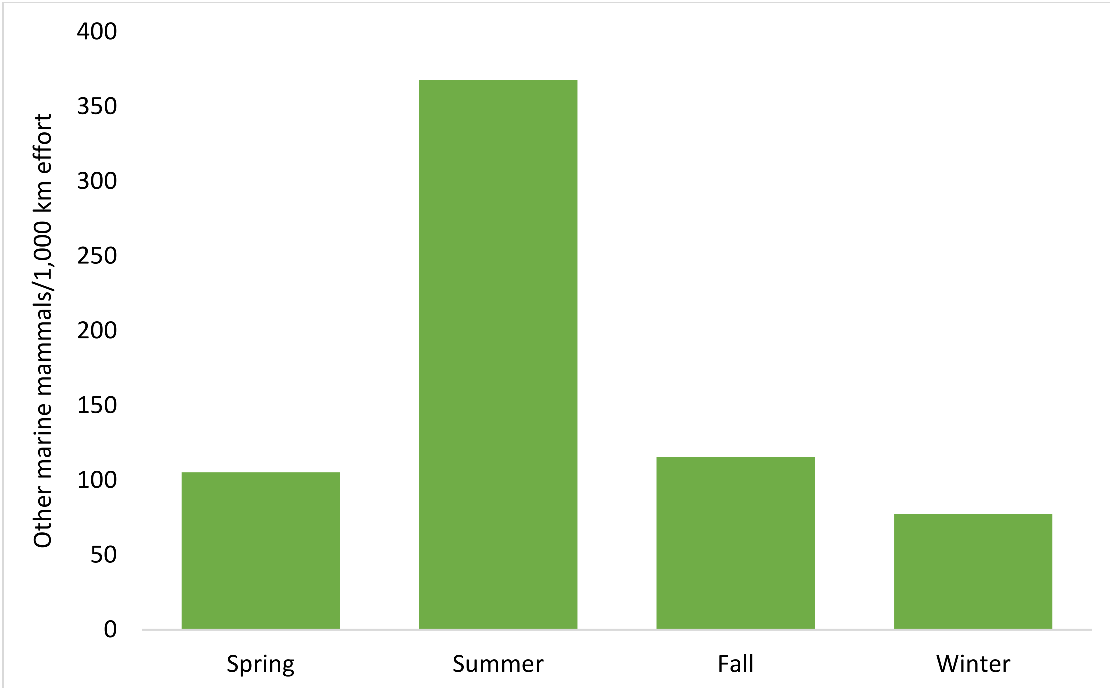

Figure 21. Sighting Rates for Other Marine Mammal Species (Pooled) - Years 1–3

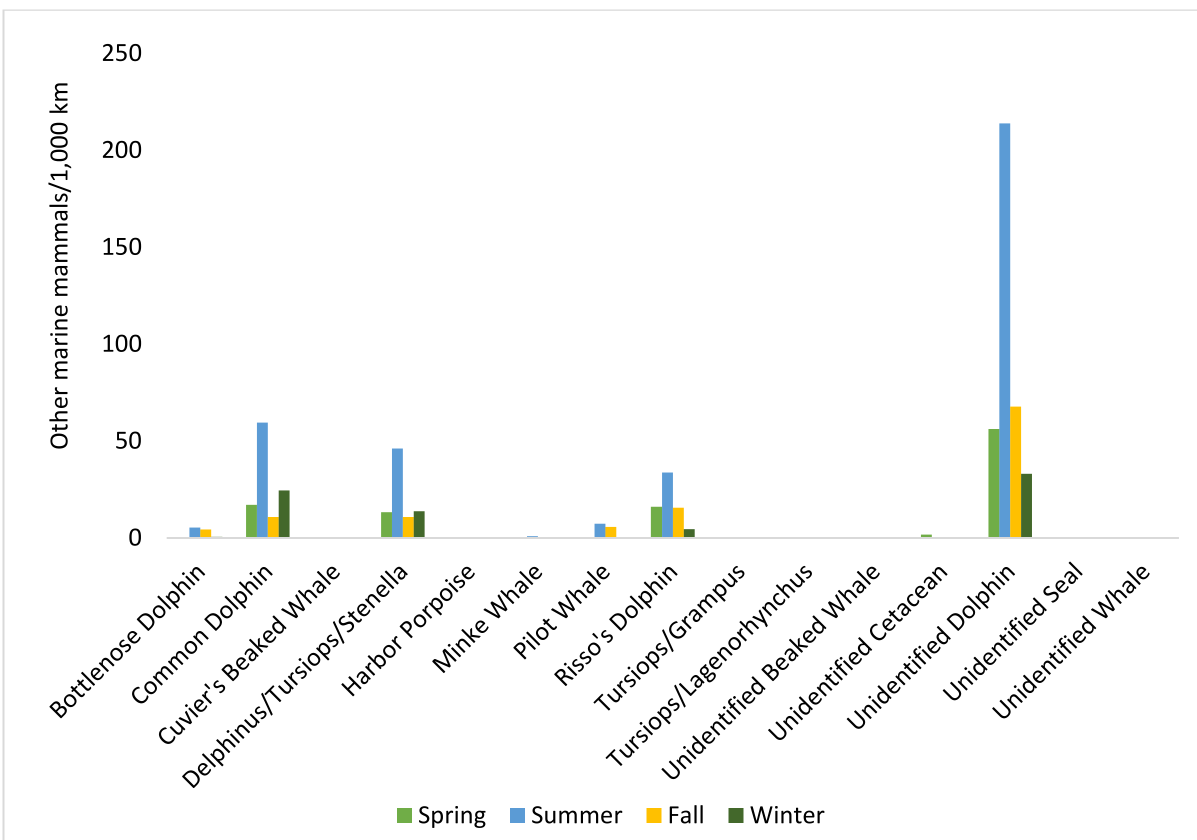

Figure 22. Sighting Rates by Species and Season for Other Marine Mammals

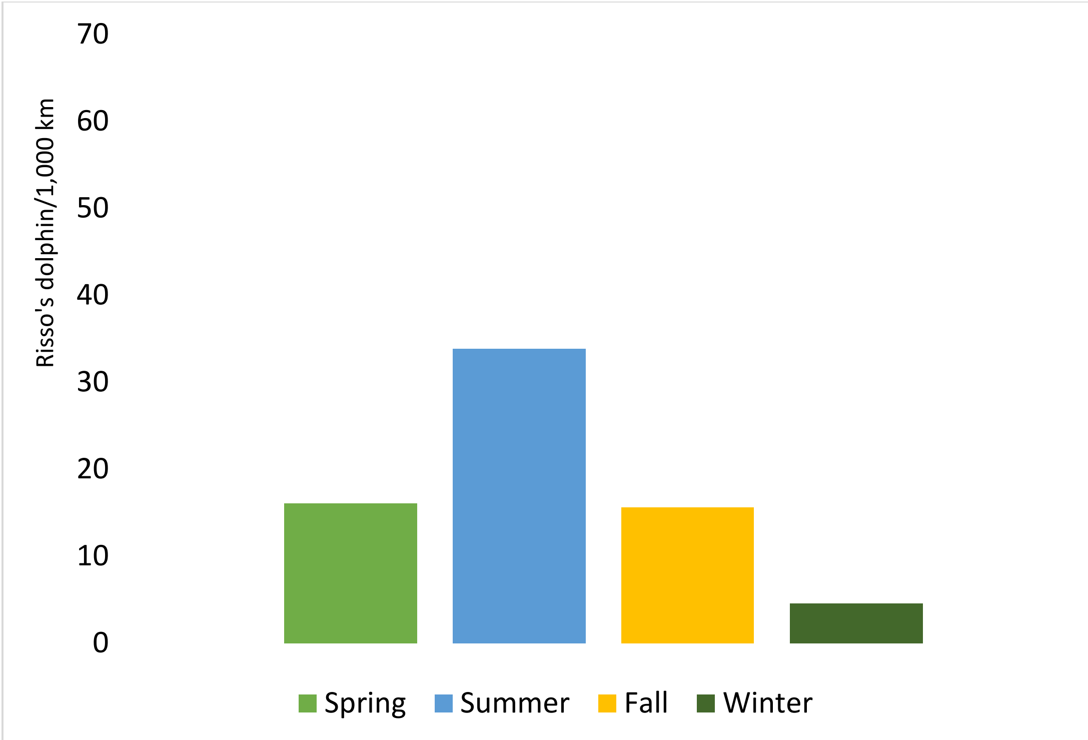

Figure 23. Sighting Rates by Species and Season for Risso's Dolphin - Years 1–3

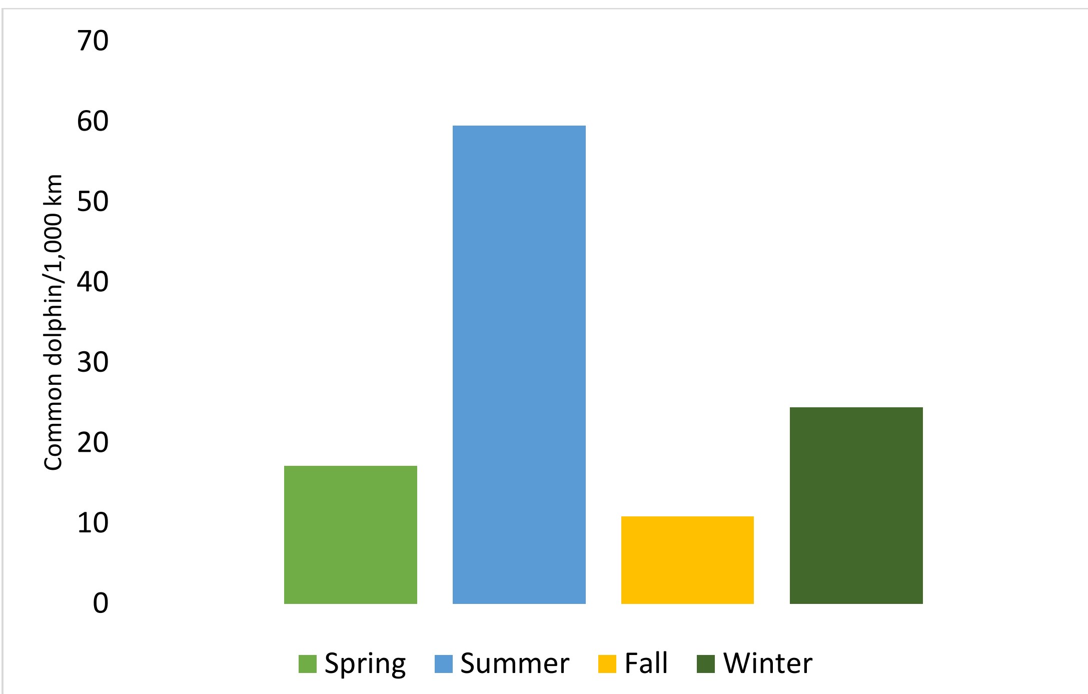

Figure 24. Sighting Rates by Species and Season for Common Dolphin - Years 1–3

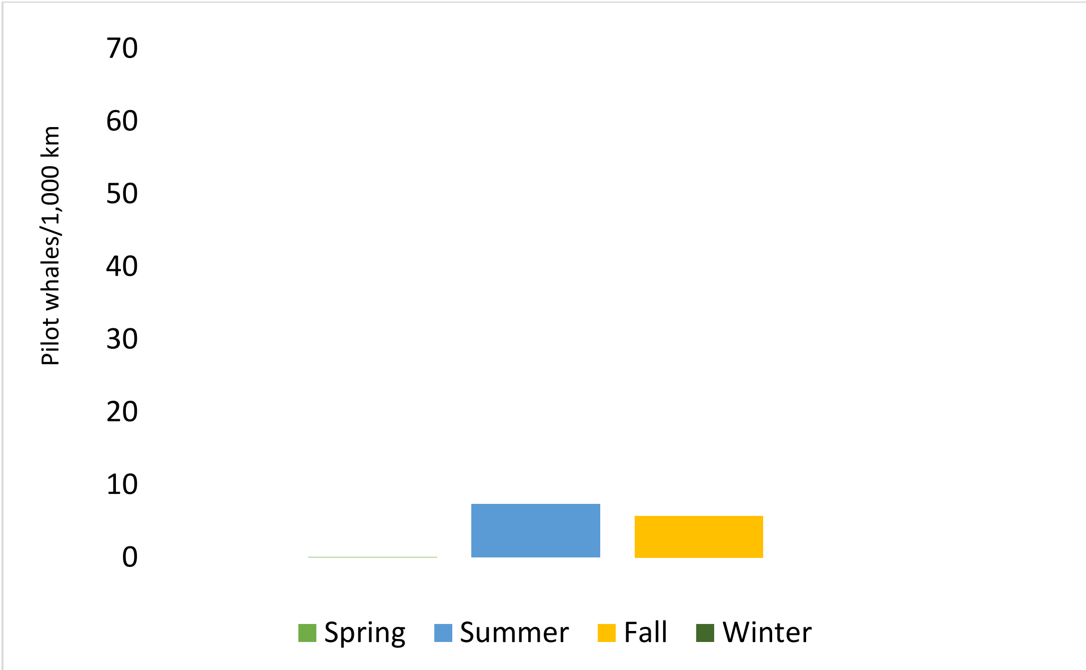

Figure 25. Sighting Rates for Pilot Whale by Species and Season - Years 1–3

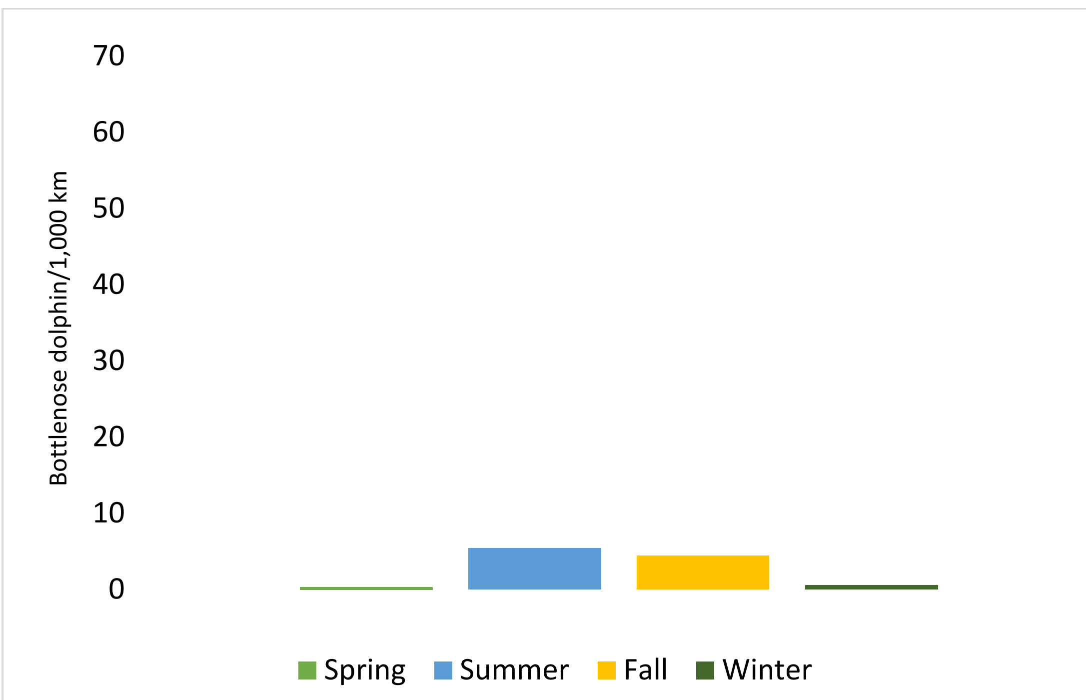

Figure 26. Sighting Rates for Bottlenose Dolphin by Species and Season - Years 1–3

3.4 SEA TURTLES

A total of 474 sea turtle sightings of an estimated 557 individual sea turtles (Tables 6 and 28) were recorded during Years 1–3 combined. Of these sightings, 50 groups totaling 54 individuals were identified to species, including one Kemp's ridley sea, 37 leatherback sea turtles, and 16 loggerhead sea turtles. The remaining 424 sightings (503 individuals) were of unidentified sea turtles. For information on sightings and mapped locations by monthly survey, refer to the individual monthly survey reports submitted to NYSDEC. Sea turtle sightings rates for all sea turtles were highest during summer (10.75 sea turtles /1,000 km effort), followed by fall (4.65 sea turtles/1,000 km effort). Sighting rates were lowest during spring and winter (0.30 and 0.03 sea turtles/1,000 km effort, respectively) (Figure 27 and Table 29). Figures 92 and 93 show sea turtle sighting locations by Year 3 (Figure 92) and then across Years 1–3 (Figure 93).

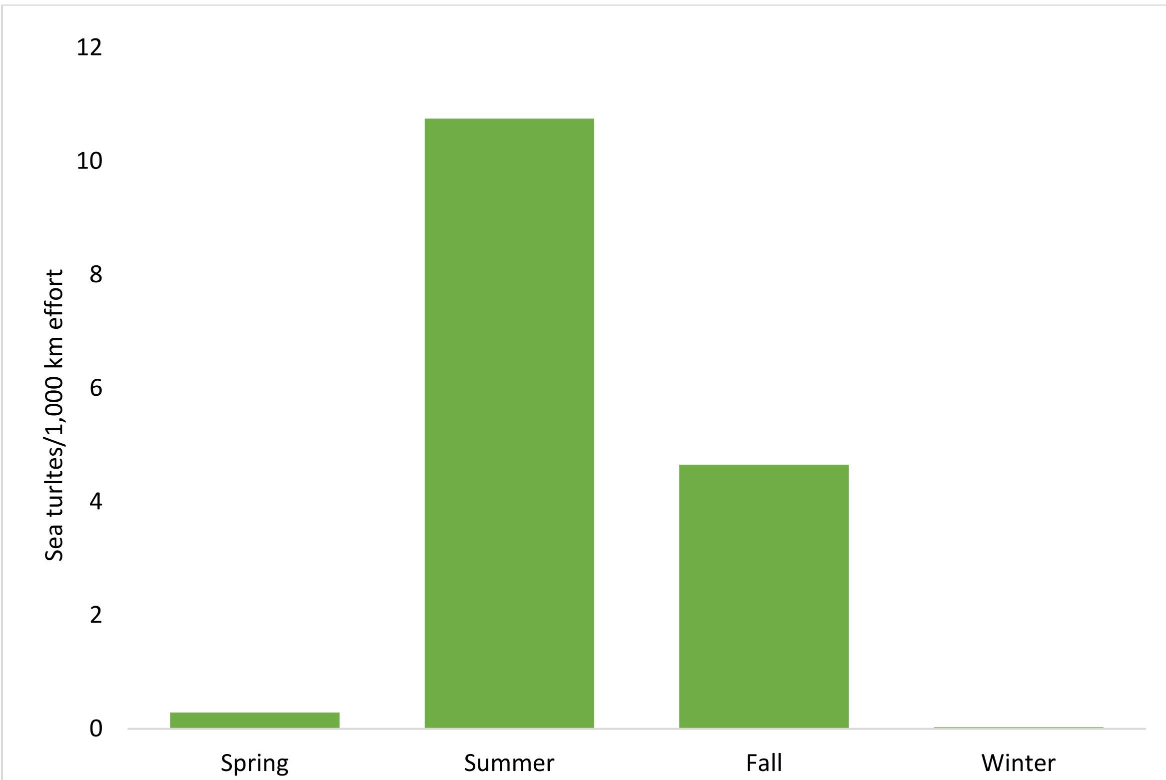

Figure 27. Sighting Rates for All Sea Turtles - Years 1–3

TABLE 28. SEA TURTLE SIGHTINGS - YEARS 1–3

Common Name	Year 1			Year 2			Year 3			Years 1–3		
	Number	Group Size		Number	Group Size		Number	Group Size		Number	Group Size	
	Groups (Indiv.)	Mean (S.D.)	Range	Groups (Indiv.)	Mean (S.D.)	Range	Groups (Indiv.)	Mean (S.D.)	Range	Groups (Indiv.)	Mean (S.D.)	Range
Kemp's Ridley Sea Turtle				1 (1)	1 (NA)	1-1				1 (1)	1 (NA)	1-1
Leatherback Sea Turtle	7 (7)	1 (0)	1-1	18 (20)	1.1 (0.3)	1-2	9 (10)	1.1 (0.3)	1-2	34 (37)	1.1 (0.3)	1-2
Loggerhead Sea Turtle	1 (1)	1 (NA)	1-1	7 (7)	1 (0)	1-1	7 (8)	1.1 (0.4)	1-2	15 (16)	1.1 (0.3)	1-2
Unidentified Sea Turtle	215 (248)	1.2 (0.5)	1-5	88 (118)	1.3 (0.9)	1-7	121 (137)	1.1 (0.5)	1-4	424 (503)	1.2 (0.6)	1-7
Total	**223 (256)**			**114 (146)**			**137 (155)**			**474 (557)**		

Notes:

Indiv. = Individuals
NA = Not applicable
S.D. = Standard deviation

TABLE 29. SEA TURTLE SIGHTING RATES BY SEASON – YEARS 1-3

Common Name	Spring	Summer	Fall	Winter	Total
Kemp's Ridley Sea Turtle	0	0.03	0	0	0.01
Leatherback Sea Turtle	0.06	0.55	0.42	0	0.26
Loggerhead Sea Turtle	0	0.15	0.29	0	0.11
Unidentified Sea Turtle	0.23	10.02	3.94	0.03	3.58
Total	**0.29**	**10.75**	**4.66**	**0.03**	**3.97**

Notes:

Sighting rates are based on number of sea turtles (i.e., individuals).
Pooled observation effort by season includes Transect, Cross-leg, Transit, Random, and Circling Efforts, does not include Overland Effort.

3.5 STRANDING AND ENTANGLEMENT REPORTS

3.5.1 Year 1

During Year 1, no sightings of dead, injured, stranded, or entangled marine mammals or sea turtles were recorded. On December 4, 2017, others reported an entangled humpback whale off Long Island, New York. The Marine Animal Entanglement Response from Center for Coastal Studies (CCS) and USCG Jones Beach set out to attempt a disentanglement of the whale, but after searching the area for multiple hours, the whale was not sighted. The December 2017 aerial survey was in progress and the survey team was alerted of the possible entangled animal; however, the survey team did not observe the animal.

3.5.2 Year 2

Dead Dolphin (April 2018)

One sighting of a dead dolphin (*Tursiops truncatus* or *Lagenorhynchus sp*.) occurred during the April 2018 survey (Photographs 1 and 2). On April 10, 2018, at 18:42:46 EDT, a carcass was observed while transiting between Lines 1 and 2 on the offshore (southern) end of the lines. The sighting was cued based on the presence of birds near the carcass. The position of the sighting was 38.787° N and 73.018° W, 135 km (72 nm) offshore. The survey team circled the carcass to confirm species and take photographs. The carcass appeared to be recently deceased with minimal decomposition. Although the age was unknown, the dolphin appeared to be an adult. The sex of the carcass is unknown. Photographs were sent to species identification specialist, Dr. Tom Jefferson of NOAA Fisheries SWFSC for identification. The photographs were identified and confirmed as either *Tursiops truncatus* or *Lagenorhynchus sp*. (Dr. Tom Jefferson, pers. comm.). Photographs of the carcass are shown below. Ann Zoidis (PM, Tetra Tech) reported the event to the NOAA NEFCS Stranding Hotline on April 10, 2018, at 19:00 EDT.

Photograph 1. Dead Dolphin (*Tursiops truncatus* or *Lagenorhynchus sp*.)
Observed April 10, 2018
Photo credit: Kate Lomac-MacNair (Tetra Tech)

Photograph 2. Dead Dolphin (*Tursiops truncatus* or *Lagenorhynchus sp*.)
Observed April 10, 2018
Photo credit: Kate Lomac-MacNair (Tetra Tech)

Entangled Sperm Whale (June 2018)

One sighting of an entangled sperm whale occurred during the June 2018 survey (Photographs 3 and 4). On June 16, 2018, at 11:03 am EDT, an entangled sperm whale was sighted on Line 14 on the offshore (southern) end of the line. The animal was approximately 167 km (90 nm) from shore at 39.770° N and 70.995° W. Upon first sighting the animal, the survey team suspected it was a carcass because there were no visible respirations (blows) while circling the animal two to three times. The head was positioned up, with the tail down in the water. There was what appeared to be a large dark mass (possibly a ghost net) next to the head near the jaw and photographs showed a large plastic tote near the animal's mouth. The survey team circled for approximately 20 minutes for photographs and relayed information about the entanglement to Ann Zoidis (PM, Tetra Tech) via satellite phone. The event was classified as an entanglement based on behavior observed during the sighting, and the consistent presence of the black mass and tote by the animal's head. Ann Zoidis reported the event to the NOAA NEFCS Stranding Hotline on June 16, 2018, at 9:36 am EDT. Ann Zoidis uploaded 80 photographs of the sighting to the NOAA representative, David Morin, and to the NYSDEC Technical PM promptly after reporting the sighting, for review by NOAA's team of experts.

Photograph 3. Entangled Sperm Whale (*Physeter macrocephalus*)
Observed June 16, 2018
Photo credit: Kate Lomac-MacNair (Tetra Tech)

Photograph 4. Entangled Sperm Whale (*Physeter macrocephalus*)
Observed June 16, 2018
Photo credit: Kate Lomac-MacNair (Tetra Tech)

3.5.3 Year 3

Dead Humpback Whale (July 2019)

One sighting of a dead humpback whale occurred during the July 2019 survey (Photographs 5 and 6). The carcass was observed on July 24th at 13:54 at 40.995° N and 71.759° W, 11.5 km (6.2 nm) offshore on Line 15. Kate Lomac-MacNair (PI, Tetra Tech) of the aerial survey team contacted Ann Zoidis (PM, Tetra Tech) via satellite phone and text from the plane to confer. Subsequently, Ann Zoidis contacted NOAA Fisheries regional response program and spoke to the New York Coordinator and relayed the information. NYSDEC contacted Atlantic Marine Conservation Society (AMCS) stranding responders and Rob DiGiovanni, Chief Scientist and lead at AMCS. Shortly thereafter, Ann Zoidis received a call from AMCS asking for photographs. Ann Zoidis uploaded all photographs of the carcass to the AMCS SharePoint site and to the NYSDEC Technical PM on the NYSDEC SharePoint site on the evening of July 24th. On July 25th, NYSDEC, AMCS, and Ann Zoidis coordinated to investigate options of searching for the dead humpback. The survey team agreed to assist in searching for the carcass however AMCS reporting finding the whale carcass drifting west approximately 3 miles off of Montauk, midday on July 25th, so the Tetra Tech survey team did not alter the July 25th survey flight route.

Photograph 5. Dead Humpback Whale (*Megaptera novaeangliae*)
Observed July 24, 2019
Photo credit: Darren Ireland (LGL)

Photograph 6. Dead Humpback Whale (*Megaptera novaeangliae*)
Observed July 24, 2019
Photo credit: Darren Ireland (LGL)

Dead Humpback Whale (February 2020)

There was one sighting of a dead humpback whale during the February 2020 survey (Photographs 7 and 8). On February 15, 2020, at 14:08:43 EST, a carcass was observed while flying Line 7. The sighting was cued based on the presence of birds near the carcass. The position of the sighting was 39.593° N and 72.410° W, 131 km (71 nm) offshore on Line 7. The survey team circled the carcass to confirm species and collect photographs. The dead animal was observed floating on its back with its head lowered in the water, and what appeared to be an internal organ protruding from its throat. One pectoral fin was observed floating perpendicular to the body, with the other pectoral fin oriented toward the sea floor. The carcass appeared bloated and the unsubmerged flesh showed signs of sun bleaching and decay. Birds were perched on the carcass. No clear signs of entanglement or cause of death were observed. The survey team circled for approximately 8 minutes. Mitch Poster (Tetra Tech, observer survey team) reported the event to the NOAA NEFSC Stranding Hotline on February 15, 2020 at 16:49 EST. On February 15, 2020 at 16:59 EST, Mitch Poster received a return call from a NOAA representative and relayed the species, number of individuals, time, and location of the sighting, as well as the following details: no clear signs of entanglement or cause of death observed; the animal was oriented toward the east but was not moving due to calm wind and wave conditions during the sighting; the animal was floating on its back with its head lowered in the water and what appeared to be an internal organ protruding from its throat; one of the animal's pectoral fins was oriented perpendicular to the animal while the other was oriented toward the sea floor; the animal appeared to be bloated; and there were birds perched on the animal. Mike Ferrif (Data Manager, Tetra Tech) sent 18 photographs of the sighting to the NOAA representative and to the NYSDEC Technical PM promptly after reporting the sighting.

Photograph 7. Dead Humpback Whale (*Megaptera novaengliae*)
Observed February 15, 2020
Photo credit: Darren Ireland (LGL)

Photograph 8. Dead Humpback Whale (*Megaptera novaengliae*)
Observed February 15, 2020
Photo credit: Darren Ireland (LGL)

Dead Dolphin (February 2020)

There was one sighting of a dead dolphin (*Delphinus/Tursiops/Stenella*) during the February 2020 survey (Photograph 9). On February 15, 2020, at 15:13:30 EST, a carcass was observed while flying Line 6. The position of the sighting was 39.778° N and 72.840° W, 99 km (53 nm) offshore. No birds were observed in the area near the carcass. The survey team circled the carcass to attempt to confirm species and take photographs. The carcass appeared to be recently deceased with minimal decomposition. No clear signs of entanglement or cause of death were observed. The survey team circled for approximately 6 minutes. Mitch Poster (Tetra Tech, observer survey team) reported the event to the NOAA NEFCS Stranding hotline on February 15, 2020 at 16:49 EST. On February 15, 2020 at 16:59 EST, Mitch Poster received a return call from a NOAA representative and relayed the species, number of individuals, time, and location of the sighting, as well as the following details: no clear signs of entanglement or cause of death observed; the animal was floating on its back; it was pale in color, and there were no clear signs of decay. Ann Zoidis (PM, Tetra Tech) sent 10 photographs of the sighting to the NOAA representative and to the NYSDEC Technical PM promptly after reporting the sighting. Photographs of the dolphin carcass were submitted to species identification specialist, Dr. Tom Jefferson of NOAA Fisheries SWFSC on February 17, 2020 who confirmed the carcass to a collective species group category and confirmed it to be *Delphinus/Tursiops/Stenella* species (Dr. Tom Jefferson, pers. comm.). Photographs of the carcass are shown below.

Photograph 9. Dead Dolphin (*Delphinus/Tursiops/Stenella* Sp.)
Observed February 15, 2020
Photo credit: Darren Ireland (LGL)

3.6 OTHER MARINE SPECIES SIGHTINGS

In addition to the other marine mammal species described in Section 3.3, 12 other types of marine species sightings (Table 30) were recorded. To focus observation efforts on searching for priority large whale species, details on these sightings were collected opportunistically and limited to date, time, species, group size (when possible), and location of the plane (latitude/longitude; no declination angle was recorded). Additional sighting details were sometimes voice recorded (e.g., estimated body length and coloration, behavior, group size). Hot keys on the laptop running the software Mysticetus were used to mark the locations of these sightings when it would not interfere significantly with priority observation efforts (e.g., in areas where all sightings were relatively low); Mysticetus automatically generated date, time, and GPS position when a sighting hot key was used. The sightings consist of those for which locations were noted using the computer in the field and thus should be considered minimum numbers of sightings. Figures 94 and 95 show other marine species sighting locations by Year 3 (Figure 94) and then across Years 1–3 (Figure 95).

TABLE 30. SIGHTINGS OF OTHER MARINE SPECIES: YEARS 1–3

Common Name	Groups	Total Individuals	Mean Group Size	S.D.	Minimum Group Size	Maximum Group Size
Atlantic Manta Ray	29	51	1.8	1.9	1	10
Basking Shark	220	998	4.5	11.6	1	130
Blue Shark	1	1	1.0	NA	1	1
Fish School	315*	NA	NA	NA	NA	NA
Great White Shark	5	7	1.4	0.5	1	2
Hammerhead Shark	45	84	1.9	2.4	1	15
Ocean Sunfish	363	410	1.1	0.5	1	6
Other	24	112	4.7	13.2	1	60
Small Ray	11	2,228	202.5	348.9	6	1,200
Unidentified Ray	83	8,331	100.4	239.2	1	1,500
Unidentified Shark	176	747	4.2	30.3	1	400
Whale Shark	8	11	1.4	1.1	1	4
Other Marine Species Total	**1,280**	**12,980**				

Notes:

*Estimated individuals were not calculated for fish schools.
NA = Not applicable
S.D. = Standard deviation

4.0 DISCUSSION

This 3-year NYB large whale line transect aerial monitoring survey provides the most intensive and extensive year-round, visual observation-based results ever conducted in New York State (NYS) and adjacent U.S. Exclusive Economic Zone (EEZ) offshore waters. These results provide important comprehensive insights into seasonal patterns and inter-annual variation of the six focal large whale species, as well as their density, abundance, and general distribution within the study area. Importantly, the study area included active shipping lanes and locations of likely future offshore energy development, and as such, provide a basis for future evaluations of impacts or mitigations needed.

The following subsections discuss findings for each of the six priority species of large whales and, where feasible, integrate the survey findings with the findings of other similarly focused surveys in the same or adjacent east coast regions. For several decades, the National Marine Fisheries Service (NMFS) has been conducting systematic aerial or vessel-based surveys and passive acoustic monitoring studies for marine mammals and sea turtles along the East Coast of the U.S. (AMAPPS surveys I and II). Recently, a few other publications have presented findings for coastal or offshore waters within the U.S. EEZ, using various visual, acoustic, or aerial methodologies, or some combination thereof (see review in Roberts et al. 2016, 2017 and Hayes et al. 2019, or other published studies [e.g., CETAP 1982; Clark et al. 2010; DiGiovanni and DePerte 2013; Muirhead et al. 2015; Kraus et al. 2016; Whitt et al. 2013, 2015; Palka et al. 2017; NOAA Fisheries 2018, 2019; Davis et al. 2017; Stone et al. 2017; New York State Energy Research and Development Authority {NYSERDA} 2018; Brown et al. 2017, 2019; Estabrook et al. 2019]).

Several of these studies spatially overlapped portions of this NYB visual aerial survey (CETAP 1982; DiGiovanni and DePerte 2013; Muirhead et al. 2015; Whitt et al. 2013, 2015; Palka et al. 2017; NYSERDA 2018; Brown et al. 2017, 2019; NOAA Fisheries 2018, 2019; and Estabrook et al. 2019). However, none were systematic line-transect visual observer surveys of the entire NY OPA, which this study provides. Some study areas covered only coastal waters, such as Whitt et al. (2015), which took place within 37 km (20 nm) of the coast of New Jersey, and Brown et al. (2017, 2019), which occurred in coastal waters of New Jersey and New York.

4.1 SIX PRIORITY LARGE WHALE SPECIES

Results from the full 3-year survey period are discussed with a focus on multi-year findings, year-to-year comparisons where possible, and in the context of a review of literature focused on other historical and recent systematic studies conducted in northwestern Atlantic Ocean waters within the U.S. EEZ that encompasses the NYB Survey Area.

In general, based on a review of available literature, results followed expected species-specific and seasonal patterns of density, relative abundance, and distribution. Results by each species of priority large whale are discussed in the context of reported expected versus observed patterns and numbers, recognizing that the combined 3-year survey sample sizes for most of the study species are small, and inter-annual variability was observed.

Discussions below are focused on sightings identified to species; only 10% (31 of the total 318 large whale sightings) were not identified to species. Estimated densities were prorated, and overall sighting rates were adjusted to account for these unidentified whales (Section 2.5.2).

4.1.1 Blue Whale

Over the 3-year survey, a total of 3 sightings (5 individuals) of blue whales were recorded during Years 1 and 3. During Year 1, two sightings of 4 individuals were recorded (Appendix B, Photograph B-1), no blue whale sightings were recorded during Year 2, and 1 individual was recorded during Year 3 (Figure 65). A possible blue whale (identified as a blue/fin/sei) was seen during January 2017 (Year 1), June 2018 (Year 2), and July 2019 (Year 3).

Seasonally, sighting rates for blue whales were highest during winter (0.12 whales/1,000 km effort), followed by fall (0.03 whales/1,000 km effort). No blue whales were recorded during spring or summer. Unlike previous August/summer sightings of blue whales off the U.S. East Coast, both of the Year 1 confirmed blue whale sightings occurred during winter, in January and February. The Year 3 sighting, however, occurred in fall (early September). The Year 3 sighting of the blue whale in September is more consistent with previous August sightings off the U.S. East Coast. Winter detections of blue whales are consistent with acoustic monitoring in the study area in 2017–2018, when the percent daily acoustic presence in fall and winter was 2–4%, and there were no acoustic detections in spring or summer (Estabrook et al. 2019). Previous acoustic recording efforts in this region also showed generally low overall presence of blue whales (11% of all recording days), with higher daily presence in winter (24%) than spring (9%), and none in the fall (Muirhead et al. 2018). Winter is believed to be the breeding/calving period for blue whales in the western Atlantic (Jefferson et al. 2015), though actual breeding/calving areas have not been documented.

Blue whales are considered rare in U.S. EEZ waters of the northwestern Atlantic Ocean encompassing the NYB Survey Area (Jefferson et al. 2015; Waring et al. 2010). This area has been proposed as the southernmost extent of the species' feeding range in the region (CETAP 1982; Wenzel et al. 1988). Most of what is known about the blue whale in the northwestern Atlantic comes from long-term photo-identification studies in the Gulf of St. Lawrence, Canada, where animals regularly feed from spring through fall (Waring et al. 2015). However, acoustic recordings of blue whales have been made from Atlantic sub-tropical waters through much of the North Atlantic, particularly in offshore waters (Waring et al. 2015; Muirhead et al. 2018; Estabrook et al. 2019). They were not sighted or detected in Whitt et al. (2015). Estabrook et al. (2019) reported acoustic detections between November and February, with a peak daily presence in February. NYSERDA (2018) raw data reported digital captures of blue whales in fall and winter during their first year of study in 2016–2017. Muirhead et al. (2018) reported that blue whales were never detected in the New York Harbor area but were detected on 11% (28 of the 258) of days recorded in the NYB study area, which extended from the coast of Long Island to the continental shelf break, mainly in winter and spring. No blue whales were sighted in the AMAPPS II 2018 NYB survey (NOAA Fisheries 2018, 2019).

With respect to distribution across habitat zones (Section 3.2.3), blue whale occurrence was highest in the plain followed by the slope (Figure 84). No blue whales were recorded in the nearshore or shelf habitats. Blue whale presence in the plain was only recorded during winter, while presence in the slope was only recorded during fall.

Compared to other baleen whale species, blue whales tend to be seen more frequently alone or in smaller mean group sizes. All blue whales recorded were exhibiting Rest/Slow Travel or Medium Travel behaviors.

4.1.2 Fin Whale

Previous studies have shown the fin whale to be the most commonly documented large whale species in U.S. Atlantic EEZ waters where it occurs year-round, though residency periods of individuals are little known (Whitt et al. 2015; Hayes et al. 2019). Waters off New England provide important spring–fall feeding grounds for fin whales; however, calving and wintering areas remain unknown (Hayes et al. 2019).

The fin whale was the second most commonly seen large whale species and was observed during all three years, all four seasons, and all 12 survey months (Appendix B, Photographs B-3 through B-6). Over the three survey years, 124 sightings (207 individuals) of fin whales were recorded. Seasonally, sighting rates for fin whales were approximately three times higher during summer. Probable foraging was recorded during spring, summer, and fall. Years 1–3 density and abundance estimates were highest in July when feeding behavior was observed, especially in Year 2, and as many as 473 individuals (CV 28%) may have been present in the Survey Area on average (Table 23). Monthly abundance estimates from Years 1–3 data showed greater variation than predicted abundances from Roberts et al. (2017), but the overall seasonal trends were similar to Robert's data as shown in Figure 20. However, the average annual abundance estimated from the three years was about half that predicted by Roberts et al. (2017; Table 23). Nonetheless, despite fewer fin whale observations than humpback whales, the average annual abundance estimate for fin whales, once corrected for availability bias (g[0]) (127), was slightly larger than that of humpback whales (107; Table 22).

Fin whales are frequently sighted or detected in other studies in the same area. Whitt et al. (2015) saw them in all seasons and Estabrook et al. (2019) detected them in all seasons and every month, with the most detections in January. NYSERDA (2018) raw data reported digital captures of fin whales in all seasons during their study years (2016–2017). AMAPPS (NOAA Fisheries 2018) sighted them both nearshore and offshore of the NY OPA study area. Fin whales (and humpback whales) were the most frequently detected large whale during the AMAPPS spring 2019 aerial survey (NOAA Fisheries 2019).

Both historical and more recent studies within the U.S. Atlantic EEZ found relative abundance and density of fin whales to be highest during spring, lower during summer and fall, and lowest during winter (e.g., Edwards et al. 2015; Whitt et al. 2015; Kraus et al. 2016 Hayes et al. 2017; Stone et al. 2017). Conversely, acoustic recordings in the NYB from Oct 2017 through July 2018 showed the lowest daily presence of fin whales in spring (28% of days versus 43–46% of days in the other three seasons; Estabrook et al. 2019). One potential explanation is they may not be calling as much in the spring for behavioral reasons (summer feeding vs. winter behaviors). In an acoustic study from fall 2008 through spring 2009, fin whales were detected on all recording days off Long Island and at the highest rate (58% of days) during the winter (Muirhead et al. 2018); however, no recording effort occurred during summer. Hayes et al. (2019) also mentions documentation of fin whale recordings from areas including the NYB. The results from this study are generally more consistent with other visual observation studies. Differences in results between the two observational methods may result from seasonal differences in calling behavior and/or surfacing behavior.

During Year 1, fin whales were commonly observed engaged in Probable Foraging behavior, but only during spring (Appendix B, Photograph B-2). A peak in numbers and foraging activity during spring is consistent with year-round systematic studies reported off the adjacent New Jersey and Connecticut-Massachusetts-Rhode Island waters (Whitt et al. 2015; Stone et al. 2017). In Year 2, on multiple days in June and July 2018, feeding aggregations of fin whales were sighted, in all cases in proximity to large groups of feeding humpback whales. On two consecutive survey days in June (June 14 and 15), 16 groups with a combined estimated count of over 50 fin whales were observed foraging. In July, on three consecutive survey days (July 9, 10, and 11), 18 groups with a combined estimated count of over 25 fin whales were observed foraging. In Year 3, fin whales were recorded engaged in probable foraging during June (Appendix B, Photograph B-4) and November. The foraging event in June was part of a mixed-species association with dolphin species. The higher sighting rates observed in spring and summer months, along with observed feeding activity, indicate the NYB should be considered part of the species' seasonal feeding grounds in some years. Whitt et al. (2015) also noted a mixed-species aggregation of fin whales and humpback whales in mid-September 2008 in their nearshore study area off New Jersey.

Fin whales were found in all four habitat classes with the highest presence in the shelf and slope (Figure 85), however, sighting rates were still relatively high in both the nearshore and plain habitats. AMAPPS summer–fall surveys found fin whales over shelf and slope waters up to 2,000 m deep off New York (NOAA Fisheries 2019). Similarly, during the survey, fin whale occurrence in summer was highest in the shelf and slope; during fall, it was highest in the shelf and plain habitats. During spring, fin whale occurrence was highest in the plain and slope and during winter fin whale occurrence was highest in the nearshore and slope. Kraus et al. (2016) found fin whale relative abundance was farther offshore in spring and in nearshore waters during summer. NYSERDA (2018) reported distributions similar to those reported in this study in their first year of surveys (summer 2016 through spring 2017).

4.1.3 Humpback Whale

Humpback whales are known to feed and migrate during spring through fall along the U.S. East Coast, with most animals migrating south to more tropical waters (e.g., the West Indies) during winter for breeding and calving (Katona and Beard 1990; Stevick et al. 1998; Hayes et al. 2019). However, humpbacks have also been documented year-round in waters off the U.S. East Coast (Clapham et al. 1993; Swingle et al. 1993; Hayes et al. 2019). In the Massachusetts Bay area, humpbacks have been acoustically detected nearly year-round, peaking from March through May, and again from September through December (Clark and Clapham 2004; Vu et al. 2012; Murray et al. 2014). Humpback whales were the most common large whale sighted during the 2018 and 2019 AMAPPS aerial surveys (NOAA Fisheries 2018, 2019). Recent studies in the New York-New Jersey Harbor Estuary (NYNJHE) reported numerous sightings of humpback whales from an inshore study area adjacent to the northwest portion of the NY OPA (Brown et al, 2017, 2019) and documented a recent increase in humpback whale sightings. The Brown et al. (2017, 2019) study area covered a portion of both our transit and transect survey area (north end of Lines 4–6; Figure 72). Many sightings occurred in the shipping channels and close to shore, where the potential for ship strike collisions with humpback whales is higher.

A total of 111 sightings (279 individuals) of humpback whales were recorded and were spread across all three years of this survey. Seasonally, sighting rates for humpback whales were highest during summer (4.40 whales/1,000 km effort), followed by fall (1.45 whales/1,000 km effort), and lowest during winter (1.16 whales/1,000 km effort) and spring (0.98 whales/km effort).

During Year 1, the humpback whale was the most commonly seen large whale species and was observed during 8 of the 12 survey months and during all four seasons. Relative abundance by season (based on sighting rates) peaked during spring and was similarly high during winter. Probable Foraging and Mill behaviors were observed among 23 of the total 36 individuals observed. Several relatively large aggregations (compared to other whale species observed) of up to eight whales were seen scattered across several square kilometers, also indicative of foraging.

During Year 2, humpback whales were again the most commonly seen large whale species and observed during all four seasons and 11 of the 12 survey months except January. In June 2018 on two consecutive survey days (June 14 and 15), a total of 16 groups with a combined estimate count of approximately 100 humpback whales were observed foraging (Appendix B, Photographs B-8 and B-9), with one event spanning approximately 5 km (~3 nm) with approximately 9 animals in the group exhibiting cooperative and bubble-net feeding. In July 2018 on three consecutive survey days (July 9, 10, and 11), a total of 8 groups with a combined estimated count of over 11 humpback whales were observed foraging.

During Year 3, the humpback whale was again the most commonly recorded large whale species and observed during all four seasons and 11 of the 12 months (except February). Probable Foraging, including bubble-net feeding groups and mixed-species associations with fin whales, minke whales, and common dolphins was observed in June (Appendix B, Photograph B-13). Probable Foraging was also recorded in May (Appendix B, Photographs B-10 through B-12) and July (Appendix B, Photograph B-14).

Some of these humpback groups were observed in mixed-species aggregations (a behavior also noted in Whitt et al. [2015] in mid-September 2008) with fin whales, minke whales, and common dolphins. Sighting rates and abundance estimates peaked during summer, corresponding with large feeding aggregations during June and July, slightly later than the April–June peak predicted by Roberts et al. (2017). The relatively large numbers of humpback whales engaged in feeding activity indicates NYB waters are likely important habitat for humpback whales and should be considered part of the species' summer feeding grounds. Humpback whale densities decreased somewhat in the fall but remained consistently present in the study area through early winter. This pattern is consistent with trends in the Roberts et al. (2017) predictions, although the annual average abundance predicted from our data was approximately twice that predicted by Roberts et al. (2017), which is opposite of the findings of this study for fin whales. Differences between the monthly abundance estimates and the predictions of Roberts et al. (2017) are not surprising given the Roberts et al. (2017) predictions are based on many different surveys across multiple years, which effectively smooths out the interannual variation observed in any given year.

These findings are consistent with studies indicating this species, including lunge-feeding individuals, has been increasing in nearshore coastal waters off New York and New Jersey, particularly during spring through fall (Whitt et al. 2015; Hayes et al. 2019). For example, numbers have been sufficient in recent years during late spring through early fall to support a growing whale watch industry in Long Island Sound and near the coast of Long Island, where humpbacks have frequently been observed feeding on large schools of fish, including menhaden (Pierre-Louis 2017).

Humpback whales are frequently sighted or detected in other studies in the same area. Whitt et al. (2015) saw them in all seasons with highest numbers in winter. Estabrook et al. (2019) detected them in all seasons and every month, with the lowest sighting in October and highest in February and May. NYSERDA (2018) raw data reported digital aerial captures of humpback whales in all seasons except summer during study years (2016–2017). Acoustic monitoring in 2017–2018 showed consistent presence of humpback whales in the study area, but daily acoustic presence was twice as high in winter and spring compared to summer and fall. During the course of surveys of this study (Years 1–3), humpback whale sighting rates were highest during summer and fall and lowest during spring and winter. Additionally, sighting rates were substantially higher during Year 2 than Year 1 and 3, suggesting potentially high levels of interannual variability. Continued annual monitoring would be necessary to more fully understand such variation.

With respect to distribution, humpback whales were recorded in all four habitat classes, with the highest occurrence in the nearshore and shelf habitats (Figure 86). Sighting rates were lower in the slope and plain habitats. During summer, fall, and winter, humpback whale presence was highest in the nearshore and shelf. During spring, it was highest in the shelf and slope. The only occurrence of humpback whale in the plain occurred during winter. These results are more consistent with the summer–fall 2016 and 2017 AMAPPS surveys (Palka et al. 2017; NOAA Fisheries 2018, 2019), where humpback whales off New England were seen across the entire continental shelf and only rarely beyond the shelf edge. NYSERDA (2018) reported distributions similar to those reported in this study.

During Year 3 on two different occasions, dead humpback whales were observed; the first during July 2019 and the second during February 2020. Since January 2016, elevated humpback whale mortalities have occurred along the Atlantic coast from Maine through Florida. NOAA has declared these collective mortality events as Unusual Mortality Events (UME). It was not possible to determine the cause of death for the two humpback carcasses recorded during Year 3.

4.1.4 North Atlantic Right Whale

Years 1–3 survey findings supplement what is currently known about distribution and habitat use patterns of the endangered North Atlantic right whale in waters off New York. North Atlantic right whale presence is relatively well described for their spring–fall feeding grounds primarily north and east of the Survey Area, and during the winter calving/breeding period when small numbers are usually found off Florida and Georgia (e.g., Kraus et al. 1986; Hayes et al. 2019). However, the distribution of most of the population during winter remains unclear (Hayes et al. 2019) and several recent studies suggest spatio-temporal habitat use patterns may be changing (Meyer-Gutbrod et al. 2018; Hayes et al. 2018; Davies et al. 2017, 2019; Gowan et al. 2019; Simard et al. 2019).

Based on current data, the North Atlantic right whale is expected to migrate through waters off New York primarily during spring and fall, en route to and returning from feeding and breeding/calving regions (Hayes et al. 2019). This species has been acoustically detected year-round in U.S. East Coast waters (Davis et al. 2017); however, large whale vocalizations can be detected hundreds of miles away, so detection of sounds within the NY OPA does not necessarily mean that whales were present within the NY OPA. Extensive bi-monthly aerial surveys in the Massachusetts and Rhode Island Wind Areas during 2011–2015 found this species present consistently each year during winter and spring, from December through May, where they were observed feeding (Leiter et al. 2017). Whitt et al. (2013, 2015) reported visual sightings in all seasons but summer, and acoustic detections of this species during all four seasons in New Jersey waters within approximately 40 km of shore, based on year-round shipboard and aerial surveys spanning February 2008 through December 2009 (the survey area is approximately 50–100 km [27–54 nm] southwest of the NYB Survey Area).

Over the three survey years, 15 sightings (24 individuals) of North Atlantic right whales were documented and sightings were recorded in all three years. Sighting rates for North Atlantic right whales were highest during spring (0.41 whales/1,000 km effort), followed by winter (0.24 whales/1,000 km effort). North Atlantic right whales were observed in 5 of 12 months, primarily from November to May, with a continuous lack of sightings from June through October. Abundance estimates corrected for detection bias (g[0]) estimated 25-65 whales may have been present in March—April while 28—52 whales may have been present in November—December (23). A sample of North Atlantic right whale photographs are found in Appendix B, Photographs B-15 through B-18.

In all three survey years, no North Atlantic right whales were recorded during summer and only one individual recorded during fall (Year 1). All other sightings occurred during winter and spring. Both the seasonal trends and relative scale of abundance estimates from the survey data correspond reasonably well with trends and monthly abundance estimates for the survey area from Roberts et al. (2017); although the lack of sightings in this survey from January and February yielded abundance estimates of zero while Roberts et al. (2017) predicted 17 individual North Atlantic right whales present in those months (Figure 20). It is not unexpected that actual survey results from just three years would produce monthly estimates with greater variability than those predicted by habitat-based models built on many years of survey data.

Years 1–3 results are similar to results reported by Whitt et al. (2013, 2015) for their study area off New Jersey, adjacent to Lines 1–4 of this survey (Figure 2). Whitt et al. (2013, 2015) reported sightings in every season except summer, and acoustic detections were made year-round. NYSERDA (2018) also reported digital aerial sightings of North Atlantic right whales in winter and spring of the first year of study (summer 2016 through spring 2017). The report does not provide coefficients of variation, though it does describe their methodology for assigning taxonomy. The 2018 AMAPPS II survey, which occurred in our fall and winter seasons in the NY OPA, did not have any North Atlantic right whale sightings (NOAA Fisheries 2018); however, the spring 2019 AMAPPS survey detected right whales offshore near the 100 m depth contour (NOAA Fisheries 2019).

Peak North Atlantic right whale sighting rates in early spring followed by no sightings during summer also fits with the later spring peak of feeding by North Atlantic right whales further north, off Massachusetts and Rhode Island (Kraus et al. 2016; Leiter et al. 2017), as well as results of AMAPPS shipboard and aerial surveys in the region (e.g., NOAA Fisheries 2018, 2019). This trend is also consistent with acoustic monitoring off New Jersey in 2008–2009 (Muirhead et al. 2017), who reported higher rates of North Atlantic right whale acoustic detections in spring than fall or winter. No data collection took place during summer months in that study, so a lack of detections during that period cannot be confirmed (Muirhead et al. 2017).

Acoustic monitoring in the NYB study area, funded by NYSDEC and conducted from October 2017 through July 2018, reported detections of North Atlantic right whale calls in all seasons and all months (Estabrook et al. 2019). Fairly consistent with our visual results, the percent of days in each month for which North Atlantic right whale calls were detected were higher in fall, winter, and spring, and nearly absent in summer. The highest rates of acoustic detections were recorded in the fall, while the highest rates of aerial detections in this three year survey occurred in the spring, although seasons were defined slightly differently across the two studies (Estabrook et al. 2019). In a large analysis of multiple acoustic datasets over a 10-year period, Davis et al. (2017) found year-round acoustic presence of North Atlantic right whales in the NYB region, with the lowest rates of call detections in the summer, and highest rates in the late winter and spring. Inter-annual variation, or perhaps seasonal differences in vocalization rates and surfacing times may explain some differences in results from acoustic and aerial monitoring efforts, but further research and analysis would be necessary to confirm.

With respect to behavior, the North Atlantic right whales were most frequently observed exhibiting Rest/Slow Travel behavior. A noteworthy behavioral event occurred during Year 3 (December 2019) between two North Atlantic right whales exhibiting possible socio-sexual behaviors. Body contact was observed several times, including belly-to-belly contact while rolling with pectoral fins out of the water, head-to-body contact, and head-to-head contact. The behavior may have been mating or courtship behavior during migration to their southern breeding/calving grounds, something not previously recorded in the NYB.

With respect to spatial distribution, North Atlantic right whale sightings from Years 1–3 occurred in the nearshore, shelf, and plain habitats (Figure 87). There were no North Atlantic right whales recorded in the slope habitat. Seasonally, during spring they were observed in the nearshore, shelf, and plain habitats. During fall they were only recorded on the shelf and during winter they were in both the nearshore and shelf habitats. These sightings do not appear consistently distributed relative to other geographic or oceanographic features. No apparent behavioral patterns were readily evident.

Photo-identification photographs (and associated metadata) of the North Atlantic right whale taken during Years 1–3 were submitted by Tetra Tech for further analysis to the North Atlantic right whale catalog managed by the NEAQ. Appendix A contains detailed text and tabular summaries (Table A-1) of North Atlantic right whale sighting and photographic information. The text provides detail on Year 3 North Atlantic right whale sightings and an overview of Year 1 and 2 results (more detailed results from Years 1 and 2 are found in previous Annual Reports [Tetra Tech and SES 2018; Tetra Tech and LGL 2019]). Table A-1 contains a tally of photographic findings received from the NEAQ North Atlantic right whale group following our photographic data submittals. The table also provides the total North Atlantic right whale sightings successfully photographed in Years 1–3: three in Year 1; four in Year 2; and two in Year 3. Finally, Table A-1 includes details on the total number of photographs submitted and associated frame numbers, photo counts from each sighting, and total number of animals successfully identified in post-processing and consequently included in the North Atlantic Right Whale Catalogue (http://rwcatalog.neaq.org/#/). Information on North Atlantic right whale identification name, age, gender, marks, etc. are also included where available in Appendix A.

Based on recent sightings of large numbers of North Atlantic right whales in the summer months in the Gulf of St. Lawrence and other northern areas where they were previously considered rare, there is evidence of a growing trend hypothesis that the North Atlantic right whale population may be shifting its ranges further north in the summer months likely due to changes in prey availability and the search for more prey in the north (Meyer-Gutbrod et al. 2018; Hayes et al. 2018; Davies et al. 2017, 2019; Gowan et al. 2019; Simard et al. 2019). Studies are underway to assess if they may be shifting areas in parallel to changes in the distribution of their main prey species, the planktonic copepod *Calanus finmarchicus*. Warmer waters have been shown to affect which species of copepods may be present and that typical species can be replaced by those of poorer nutritional value (Richardson et al. 2020). Changes in prey may be a result of rapidly warming east coast waters including in the Gulf of Maine (Pershing et al. 2015). Shifting prey distributions over time may result in some changes to the current occurrence trends and timing of North Atlantic right whales in the NYB.

North Atlantic right whales are especially vulnerable to any habitat-based changes. They are federally-listed as critically endangered, are subject to ship strike deaths, and have a specialized feeding preference for copepods (Baumgartner et al. 2003). In addition, NOAA Fisheries has declared a North Atlantic right whale UME, defined as a significant die-off with an unusual number of mortalities for a species. The current North Atlantic right whale UME has been ongoing since 2017 and continues through 2020.

4.1.5 Sei Whale

Over the three survey years, a total of 2 sightings (7 individuals) of sei whales were recorded, one each in Years 2 and 3. Seasonally, sei whales were only recorded during spring (0.20 whales/1,000 km effort).

During Year 2, a single sei whale was observed during spring, on April 11, 2018 (Figure 77). A single sei whale was also reported from a Navy aerial survey in the Norfolk Canyon study area off the coast of Virginia on April 11, 2018, approximately 400 km (216 nm) away (Department of the Navy [DoN] 2018). During Year 3, one group (6 individuals) was sighted in April. The sei whale during Year 2 was observed exhibiting Rest/Slow Travel behavior (Appendix B, Photographs B-20 and B-21) and the sei whales during Year 3 were observed exhibiting Mill and possible socio-sexual behaviors. During the Year 3 sighting, individuals were observed rolling on their sides, presenting bellies in close proximity, rapid movements and directional changes. The behavior this group was exhibiting may have been mating or courtship behavior. Consistent with Year 2 and 3 survey results, acoustic recordings from October 2017 through July 2018 in the study area showed relatively low acoustic presence of sei whales in fall and winter (4–5%), with the highest presence in the spring (19% of days) and none in July (Estabrook et al. 2019).

Documented sei whale sightings along the U.S. Atlantic Coast are relatively uncommon compared to other baleen whales and were not reported in some of the area-specific papers reviewed for this study, though they can be difficult to differentiate from fin whales (Jefferson et al. 2015; Hayes et al. 2019). Highest reported numbers in U.S. East Coast waters occur during spring and summer, primarily in the Gulf of Maine and Georges Bank, and into more northern waters. Roberts et al. (2017) predicted a relatively low abundance of sei whales throughout the year in the survey area, with the highest abundance estimates from April through June, corresponding with the April sightings in Year 2 and 3.

Sei whale distribution was highest in the shelf followed by the slope and were not recorded in the nearshore or plain habitats (Figure 88). Sei whales are believed to associate closely with deeper waters compared to other baleen whales off the U.S. Atlantic Coast and are typically reported along the continental shelf region (Hain et al. 1985). However, they also occur in shallower waters likely in association with prey (Hayes et al. 2017). The sei whale sighting during Year 2 of this survey was recorded in approximately 54 m water depth and the sei whale sighting occurring during Year 3 was recorded in approximately 380 m water depth. Whitt et al. (2015) and NYSERDA (2018) reported no sei whale sightings. Estabrook et al. (2019) detected sei whales between November and February. No sei whales were sighted in the NYB during the AMAPPS II 2018 or 2019 aerial surveys (NOAA Fisheries 2018, 2019).

4.1.6 Sperm Whale

Sperm whales in the U.S. Atlantic EEZ are associated primarily with deeper offshore waters over the continental shelf edge, over the continental slope, and over deeper mid-ocean regions (Wong and Whitehead 2014; Waring et al. 2015), with occasional forays into shelf waters off New England (CETAP 1982; Scott and Sadvoe 1997; Kenney and Vigness-Raposa 2010). Seasonal sex-age segregation occurs among this species, with females and young remaining together in long-term group formations while inhabiting primarily tropical and sub-tropical waters. Mature males range considerably farther north to feed, particularly during summer, then travel south to breed with females during winter (Jefferson et al. 2015; Waring et al. 2015). Past systematic surveys in the U.S. Atlantic EEZ have documented mixed schools of females with calves as well as single large adults (Waring et al. 2015), which are likely males based on what is known about the species' social behavior. However, survey data for this species during winter in the U.S. Atlantic EEZ are notably sparse (Waring et al. 2015).

Over the three survey years, sperm whales were recorded in all three years, for a total of 32 sightings (72 individuals). Seasonally, sighting rates for sperm whales were highest during summer (1.28 whales/1,000 km effort), followed by spring (0.35 whales/1,000 km effort), and lowest during fall (0.26 whales/1,000 km effort) and winter (0.18 whales/km effort).

Sperm whales were recorded during all seasons and all months except May and November. Seasonally, sperm whales were most frequent during summer followed by spring. Year 1 resulted in seven sightings (7 individuals) of sperm whales across all four seasons. During Year 2, a total of nine sightings (23 individuals) occurred across all seasons except fall (Appendix B, Photographs B-21 and B-22). During Year 3, a total of 16 sightings (42 individuals) occurred across all seasons (Figures 79 through 81; Appendix B, Photographs B-23 through B-25). Over the three years, sperm whales were recorded during all months except May and November. Roberts et al. (2017) predicted year-round presence of sperm whales in the survey area, with approximately 100–200 individuals present from February through October and less than 100 individuals from November through January. The long dive durations relative to surface intervals results in a large g(0) correction factor that produces the relatively high abundance estimates in the months when sperm whales were observed.

All Year 1 sightings consisted of single animals engaged in Travel behavior. Given the social patterns of this species where mature single whales tend to be males, the single adult sperm whales observed were likely single males. During Year 2 and 3, larger groups were recorded ranging from 1 to 7 total individuals and were observed exhibiting Rest/Slow Travel and Mill behaviors, possibly resting between foraging dives. Several mother/calf pairs and potential nursing were observed and photographed. Additionally, a noteworthy behavioral event occurred during Year 3 (September 2019) within a group of five sperm whales exhibiting possible socio-sexual behaviors. Body contact, including belly-to-belly, was observed along with rapid movements, changes in direction and close proximity between individuals. This behavioral event was unusual relative to most previous sperm whale behaviors observed during this survey, suggestive of mating or courtship behavior.

In June of Year 2, a single sperm whale was recorded as entangled approximately 167 km (90 nm) from shore. Based on review of photographs and observations made by the survey team, the sperm whale appeared entangled in fishing net with a large plastic tote semi-submerged near the animal's mouth (Section 3.5.2).

Stanistreet et al. (2018) recorded sperm whale sounds year-round on the continental slope between North Carolina and Georges Bank, off southern New England. They noted distinct seasonal patterns, with a winter peak off North Carolina followed by a spring peak in waters off southern

New England. This seasonal trend was apparent in the Year 2 results where density and abundance estimates were highest in spring and summer, and lowest in fall.

Consistent with the distribution pattern typical of this species, all 32 sperm whale sightings in Years 1–3 were made over offshore, deeper waters. Sperm whale distribution was highest in plain habitat, followed by slope; no sperm whales were recorded in the nearshore or shelf habitats. Additionally, sperm whales were recorded in the deeper waters of Hudson Canyon (Figures 80, 81, and 89). During spring, sperm whales were only recorded in slope habitat. During summer, sperm whales occurred in both the slope and plain, but were higher in in the plain habitat. During fall and winter, sperm whales occurred in both the slope and plain but were higher in the slope habitat. Summer–fall AMAPPS surveys in 2016 (Palka et al. 2017) documented numerous sperm whales over the continental slope and deeper waters off New York, including in areas overlapping the offshore portions of the Years 1–3 survey transect lines, as well as one sighting on the shelf south of Massachusetts. Whitt et al. (2013, 2015) did not observe sperm whales in their survey area, which was in nearshore waters only 37 km (20 nm) offshore, about 50–100 km (27–54 nm) southwest of the NYB Survey Area off New Jersey during 2008–2009; their survey area only encompassed shelf waters. NYSERDA (2018) reported raw digital captures only in the fall with one on the shelf edge. Estabrook et al. (2019) had no detections.

4.2 Unusual or Rare Marine Mammal Sightings

There were some relatively unusual or historically rare sightings of marine mammals made during Years 1–3; these were the sightings of blue whales, possible blue whales (coded as a blue/fin/sei whale), and sei whales. Sightings for these species are detailed in Section 3.2.1 and Tables 10 through 13. Both the blue and sei whale are historically considered rare for the NYB. They were not observed in some of the past or recent studies occurring in proximity to this study area (CETAP 1982; Whitt et al. 2015; NOAA Fisheries 2018); however, sei whales were observed by DiGiovanni and DePerte (2013), and both increasingly noted in acoustic detection studies. Blue whales were detected between November and February at all acoustic detection sites at least some of the time, and sei whales were most commonly detected in March through May by all sensors (Estabrook et al. 2019).

4.3 Other Marine Mammal Species

Other confirmed marine mammal species recorded during the survey included Risso’s dolphin, minke whales, bottlenose dolphin, common dolphin, Cuvier’s beaked whale, harbor porpoise, and pilot whales (Figure 91). Overall, the Years 1–3 survey results support the general historical seasonal abundance patterns of delphinids in the NYB: the highest relative numbers were seen during summer and fall, with fewer sightings during winter and spring (Hayes et al. 2019). Since the survey effort was focused on large whale species, only brief, limited, and opportunistic circling of other marine mammals was conducted when warranted based on real-time factors such as weather, survey time, and novelty of species. Thus, given the relatively high survey altitude of 305 m (1,001 ft) and the brief period these species were in view while flying by, only a small number of delphinids were confidently identified to species based on identifiable characteristics such as white/gray coloration of Risso’s dolphin and body shape and color of pilot whales.

More sightings of Risso's dolphins were recorded during Year 1 (96 sightings, 788 individuals) than other years; however, sighting numbers were similar during Years 2 and 3 (67 sightings, 820 individuals and 69 sightings, 854 individuals, respectively). Overall, Risso's dolphin where most frequent during summer months, followed by spring and fall. Similarly, fewer pilot whales were recorded during Year 2 (1 sighting, 2 individuals) than Year 1 (8 sightings, 279 individuals), yet Year 3 had the highest number of pilot whales (11 sightings, 191 individuals). Pilot whales were most frequent during summer and fall; there were no sightings during winter and only a handful during spring months. These findings are opposite to those found for the priority large whale species. More minke whales were recorded during Year 2 (23 sightings, 28 individuals) than Year 1 (9 sightings, 9 individuals), similar to the findings for the priority large whale species. Harbor porpoise were recorded during Year 3 (2 sightings, 16 individuals) and not recorded during Year 1 or 2. Of the total of 980 sightings (estimated 23,244 individuals) recorded, 39% (384 sightings, estimated 7,249 individuals) were identified to species and the remaining 61% (596 sightings, estimated 15,995 individuals) were not identified to species.

4.4 SEA TURTLES

Four species of sea turtles are considered likely to occur in the NYB: the green, (Atlantic) Kemp's ridley, leatherback and loggerhead sea turtles. A fifth species, the hawksbill, is considered rare, though can occur (New York State Department of State [NYSDOS] 2013). Sea turtles in NYB waters are historically most common from late spring through summer/early fall (NOAA Fisheries 2020). During seasons of warmer water, sea turtles are commonly found off Long Island, including in Long Island Sound and the eastern bays of Long Island.

Overall, the Years 1–3 survey results support the historical seasonal abundance patterns of sea turtles in the NYB; the highest relative numbers were seen during summer and fall, with very few sightings during spring and winter (NOAA Fisheries 2020). Since the survey effort was focused on large whale species, no circling of sea turtles was conducted to confirm species. Thus, given the relatively high survey altitude of 305 m (1,001 ft) and the brief period small turtles would have been in view while flying by, only a small number of large sea turtles were confidently identified to species. Sea turtle sightings are shown on Figure 93.

Of the four species considered likely to occur in the NYB, three were identified during the Years 1–3 surveys: Kemp's ridley (1 individual during Year 2), leatherback (34 sightings, 37 individuals recorded during all survey years), and loggerhead (15 sightings, 16 individuals recorded during all survey years).

4.5 OTHER SIGHTINGS

Opportunistic sightings of species other than priority large whales and sea turtles (e.g., sharks, rays, fish) were collected though are not discussed in detail. Monthly reports submitted to NYSDEC provide further details on these sightings, including minimum numbers of groups and individuals by species or highest taxonomic order. Figure 95 shows other marine species sightings.

5.0 CONCLUSION

This comprehensive final report summarizes results of 3 years of systematic aerial surveys of marine mammals and sea turtles focused on six priority large whale species. Results from Years 1–3 provide insight into the occurrence, relative abundance, behavior, and density and abundance of observed species. Additionally, comparisons between years and seasons offer an indication of the extent of inter-annual and seasonal variation that may be present in the NYB. Appendix D provides recommendations for future research and cover additional analyses of existing data, and, suggestions for additional data collection to address long-term or reginal monitoring goals.

Overall, for the priority large whales sighted for Years 1–3 combined, sighting rates were highest for humpback whales, followed by fin whales, sperm whales, North Atlantic right whales, sei whales, and blue whales. Seasonally, pooled sighting rates were highest during summer, followed by spring, and lowest during fall and winter.

Annual sighting rates for all priority large whale species varied between Year 1, Year 2, and Year 3, and by species. For all priority large whales pooled, annual sighting rates were highest in Year 2, followed by Year 3, and lowest in Year 1. Year 2 sighting rates were nearly twice as high as Year 3 and over 3.5 times as high as Year 1. The higher values in Year 2 were primarily driven by a large number of sightings of humpback and fin whales in the summer season. The large differences in sighting rates of these species between years shows interannual variation in the NYB may be relatively high. Since many of the fin and humpback whales sighted in the summer of Year 2 were observed showing feeding behaviors, this variation was likely driven by differences in food availability between the years.

Blue whales: Blue whales were recorded during Year 1 and Year 3, but not in Year 2. From the Years 1–3 pooled data, the average annual density for the survey area was 0.031 individuals/1,000 km^2. Blue whales were most frequently observed exhibiting Rest/Slow Travel behavior followed by Medium Travel behavior. Blue whales were recorded only during fall (September) and winter (January and February) with none during spring or summer months. Sighting rates were highest during winter followed by fall. Blue whale presence was highest in the plain followed by the slope. No blue whales were recorded in the nearshore or shelf habitats. Blue whales are considered rare in U.S. EEZ waters of the northwestern Atlantic Ocean which includes the NYB Survey Area (Jefferson et al. 2015; Waring et al. 2010). This area has been proposed as the southernmost extent of the species' feeding range in the region (CETAP 1982; Wenzel et al. 1988).

Fin whales: Fin whales were recorded in all 3 years and sighting rates were highest during Year 2 followed by Year 3, and lowest during Year 1. From the Years 1–3 pooled data, the average annual density for the survey area was 2.923 individuals/1,000 km^2. Fin whales were recorded in all four seasons and all months. Sighting rates for fin whales were highest during summer followed by spring, winter, and fall. Fin whales were observed most frequently exhibiting Rest/Slow Travel behavior followed by Probable Foraging. Probable Foraging behavior occurred during spring (March and May), summer (June and July) and fall (November); however, several notable foraging events occurred during June and July in Year 2 where lunge-feeding behaviors were recorded. On two occasions, fin whales were observed in a mixed-species association feeding with common dolphin. The higher sighting rates observed in spring and summer months, along with likely feeding activity, indicates that the NYB should likely be considered part of the species' seasonal feeding grounds, at least in some years. Fin whales were recorded in all four habitat classes with the highest presence in the shelf and slope and relatively high in both the nearshore and plain habitats.

Humpback whales: The humpback whale was the most frequently observed large whale species in all 3 years and was observed during all four seasons and all 12 survey months. From the Years 1–3 pooled data, the average annual density for the survey area was 2.461 individuals/1,000 km^2. Sighting rates and abundance estimates peaked during summer, corresponding with large feeding aggregations. Several notable foraging events occurred during June and July in both Year 2 and 3 when large bubble-net feeding was recorded. Humpback whales were most frequently observed exhibiting Probable Foraging behavior followed by Rest/Slow Travel and Mill. Similar to fin whales, the higher sighting rates observed in the summer months, along with foraging activity observed, indicates that the NYB should likely be considered part of the species' seasonal feeding grounds, at least in some years. These findings are consistent with studies indicating this species, including lunge-feeding individuals, has been increasing in nearshore coastal waters off New York and New Jersey, particularly during spring through fall (Whitt et al. 2015; Hayes et al. 2017). Humpback whales were recorded in all four habitat classes with the highest occurrence in the nearshore and shelf habitats. Distribution varied by season; during summer, fall, and winter humpback whale presence was highest in the nearshore and shelf habitats whereas during spring it was highest in the shelf and slope. The only occurrence of humpback whale in the plain occurred during winter.

North Atlantic right whales: North Atlantic right whales were recorded in all 3 years and sighting rates were highest during Year 1, followed by Year 3, and lowest during Year 2. From the Years 1–3 pooled data, the average annual density for the survey area was 0.319 individuals/1,000 km^2. Sighting rates for North Atlantic right whales were highest during spring, followed by winter and fall. No North Atlantic right whale sightings occurred during summer months. Peak North Atlantic right whale sighting rate in early spring followed by no sightings during summer is consistent with the later spring peak of feeding North Atlantic right whales further north, off Massachusetts and Rhode Island (Kraus et al. 2016; Leiter et al. 2017), as well as results of AMAPPS shipboard and aerial surveys in the region (Palka et al. 2017). This trend is also consistent with acoustic monitoring off New Jersey in 2008–2009 (Muirhead et al. 2017) which reported higher rates of North Atlantic right whale acoustic detections in spring than fall or winter. North Atlantic right whales were recorded in nearshore, slope, and plain habitat classes with the highest occurrence in the slope followed by the nearshore habitat. Overall, North Atlantic right whales were most frequently observed exhibiting Rest/Slow Travel behavior.

Sei whales: Sei whales were recorded during Year 2 and 3, both in the spring. From the Years 1–3 pooled data, the average annual density for the survey area was 0.083 individuals/1,000 km^2. Distribution was highest in the shelf followed by the slope. Sei whales were not recorded in the nearshore or plain habitats. The sei whale during Year 2 was observed exhibiting Rest/Slow Travel behavior and the sei whales during Year 3 were observed exhibiting Mill behavior. Documented sei whale sightings along the U.S. Atlantic Coast are relatively uncommon compared to other baleen whales and were not reported in some of the area-specific papers reviewed for this study, though they are difficult to differentiate from fin whales (Jefferson et al. 2015; Hayes et al. 2017).

Sperm whales: Sperm whales were recorded during all years with sighting rates highest during Year 3, followed by Year 2, and lowest during Year 1. From the Years 1–3 pooled data, the average annual density for the survey area was 1.312 individuals/1,000 km^2. Sperm whales were recorded during all seasons and all months except May and November. Sighting rates for sperm whales were highest during summer, followed by spring, fall, and then winter. Consistent with the distribution pattern typical of this species, distribution was highest in the plain followed by the shelf. Sperm whales were not recorded in the nearshore or shelf habitats. Roberts et al. (2017) predicted relatively consistent monthly abundance estimates for sperm whales within the study area. Results from this study are less consistent month-to-month, likely because of the long periods this species spends underwater (and therefore not available for detection by aerial surveys), combined with the relatively low amount of survey effort in areas of deep water where sperm whales occur. Sperm whales were most frequently observed exhibiting Rest/Slow Travel behavior, followed by Medium Travel, Mill, and Surface-Active Mill.

Overall, the findings for the six priority large whale species show humpback and fin whales are more common than the other four species, while sperm and North Atlantic right whales are consistently present, but in lower numbers. Sei and blue whales appear to be relatively rare within the NYB. Combined, the six species have an annual average density of 6.268 individuals/1,000 km^2 within the survey area. These findings, including trends in seasonal occurrence of these species, are generally consistent with expectations based on past research in the region. However, the results also show there can be substantial interannual variability in the abundance, distribution, and behavior of large whales in the NYB.

6.0 LITERATURE CITED

Akaike, H. 1974. "A new look at the statistical model identification." *IEEE Transactions on Automatic Control*. Vol. 19(6), pp. 716–723.

Baumgartner, M.F., T.V. Cole, R.G Campbell,G.J. Teegarden,and E.G. Durbin. 2003. "Associations between North Atlantic right whales and their prey, *Calanus finmarchicus*, over diel and tidal time scales." *Marine Ecology Progress Series*. Vol. 264, pp.155–166.

Brown, D.M., P.L. Sieswerda, and E.C.M. Parsons. .2019. "Potential encounters between humpback whales (Megaptera novaeangliae) and vessels in the New York Bight apex, USA." *Marine Policy*, 106, p.103527.

Brown, D.M., J. Robbins, P.L. Sieswerda, R. Schoelkopf, and E.C.M. Parsons.. 2018. "Humpback whale (*Megaptera novaeangliae*) sightings in the New York-New Jersey Harbor Estuary." *Marine Mammal Science*, 34(1), pp.250-257.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. *Introduction to Distance Sampling*. Oxford University Press, Oxford, UK.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J. L. Laake, D. L. Borchers and L. Thomas. 2004. (editors). *Advanced Distance Sampling*. Oxford University Press.

Carretta, J.V., M.S. Lowry, C.E. Stinchcomb, M.S. Lynn, R.E. Cosgrove. 2000. "Distribution and abundance of marine mammals at San Clemente Island and surrounding offshore waters: results from aerial and ground surveys in 1998 and 1999." Administrative Report LJ-00-02, available from Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA, USA, 92038. 44 p.

Cetacean and Turtle Assessment Program (CETAP). 1982. "A characterization of marine mammals and turtles in the mid- and North Atlantic areas of the U.S. outer continental shelf." Final Report Ref. No. AA551-CT8-48 to the Bureau of Land Management, U.S. Department of the Interior, Washington, D.C.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy, and S. Pittman. 1993. "Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine." *Canadian Journal of Zoology*. Vol. 71, pp. 440–443.

Clark, C.W. and P.J. Clapham. 2004. "Acoustic monitoring on a humpback whale *(Megaptera novaeangliae)* feeding ground shows continual singing into late spring." *Proceedings of the Royal Society Biological Sciences*. Vol. 271, pp. 1051–1057.

Clark, C.W., M.W. Brown, and P. Corkeron. 2010. "Visual and acoustic surveys for North Atlantic right whales, *Eubalaena glacialis,* in Cape Cod Bay, Massachusetts, 2001–2005: Management implications." *Marine Mammal Science*. Vol. 26, pp. 837–854.

Davies, K.T., M.W. Brown, P.K. Hamilton, A.R. Knowlton, C.T. Taggart, and A.S. Vanderlaan. 2019. "Variation in North Atlantic right whale Eubalaena glacialis occurrence in the Bay of Fundy, Canada, over three decades." *Endangered Species Research*, *39*, pp.159-171.

Davis, G.E., M.F. Baumgartner, J.M. Bonnell, J. Bell, C. Berchok, J.B. Thornton, S. Brault, G. Buchanan, R.A. Charif, D. Cholewiak and C.W. Clark. 2017. "Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (*Eubalaena glacialis*) from 2004 to 2014." *Scientific Reports.* Vol. 7(1), p.13460.

Department of the Navy (DoN). 2018. "U.S. Navy Blue whales and sei whales and right whales - OH MY!!!" U.S. Navy Marine Species Monitoring blog. Available at: https://www.navymarinespeciesmonitoring.us/blog/blue-whales-and-sei-whales-and-right-whales-oh-my/.

DiGiovanni Jr., R. A., and A. DePerte. 2013. "Marine mammal abundance survey for North Atlantic Right Whales in the New York Bight and the Mid-Atlantic Region (Revised)." Riverhead Foundation for Marine Research and Preservation, Riverhead, New York.

Edwards, E.F., C. Hall, T.J. Moore, C. Sheredy, and J.V. Redfern. 2015. "Global distribution of fin whales *(Balaenoptera physalus)* in the post-whaling era (1980–2012)." *Mammal Review*. Vol. 45, pp. 197–214.

ESRI. 2017. ArcGIS Desktop: Release 10.6.1. Environmental Systems Research Institute. Redlands, California.

ESRI. 2020. World Ocean Basemap. ESRI, GEBCO, NOAA, Garmin, HERE, and other contributors. Digital Data. Updated January 2020. http://goto.arcgisonline.com/maps/Ocean/World_Ocean_Base

Estabrook, B.J., D.V. Harris, K.B. Hodge, D.P. Salisbury, D. Ponirakis, J. Zeh, S.E. Parks, A.N. Rice. 2019. "Year 1 Annual Survey Report for New York Bight Whale Monitoring Passive Acoustic Surveys October 2017– July 2018." Contract C009925. New York State Department of Environmental Conservation. East Setauket, NY.

Gowan, T.A., J.G. Ortega-Ortiz, J.A. Hostetler, P.K. Hamilton, A.R. Knowlton, K.A. Jackson, R.C. George, C.R. Taylor, and P.J. Naessig.. 2019. "Temporal and demographic variation in partial migration of the North Atlantic right whale." *Scientific reports*, *9*(1), pp.1-11.

Hayes, S.A., S. Gardner, L.P. Garrison, A. Henry, and L. Leandro.. 2018. North Atlantic Right Whales-Evaluating their Recovery Challenges in 2018. NOAA Technical Memorandum NMFS- NE-247. September 2018. 30 p.

Hayes S.A., E. Josephson, K. Maze-Foley, P.E. Rosel. 2019. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2018. Published June 2019. NOAA Tech Memo NMFS-NE 258; 291 p.

Heide-Jorgensen, M.P., K.L. Laidre, R.G. Hansen, M.L. Burt, M. Simon, D.L. Borchers, J. Hansen, K. Harding, M. Rasmussen, R. Dietz, and J. Teilmann. 2012. “Rate of increase and current abundance of humpback whales in West Greenland.” *Journal of Cetacean Research and Management*. Vol 12: pp. 1–14.

Jefferson, T.A., M.A. Smultea and C.E Bacon. 2014. “Southern California Bight marine mammal density and abundance from aerial surveys, 2008–2013.” *Journal of Marine Animals and Their Ecology*. Vol. 7(2), pp. 14–30.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2015. *Marine mammals of the world: a comprehensive guide to their identification (2nd edition).* Elsevier/Academic Press, San Diego, California.

Katona, S.K. and J.A. Beard. 1990. “Population size, migrations and feeding aggregations of the humpback whale *(Megaptera novaeangliae)* in the western North Atlantic Ocean.” Report of the International Whaling Commission. Vol. 12, pp. 295–306.

Kenney, R.D and K.J. Vigness-Raposa. 2010. *Marine mammals and sea turtles of Narragansett Bay, Block Island Sound, Rhode Island Sound, and nearby waters: an analysis of existing data for the Rhode Island Ocean Special Area Management Plan. Ocean SAMP, Vol 2*. Rhode Island Coastal Resources Management Council, Wakefield, Rhode Island.

Kraus, S.D., J.H. Prescott, A.R. Knowlton, and G.S. Stone. 1986. “Migration and calving of right whales *(Eubalaena glacialis)* in the western North Atlantic.” International Whaling Commission. Vol. 10, pp. 139–144.

Kraus, S.D., S. Leiter, K. Stone, B. Wikgren, C. Mayo, P. Hughes, R.D. Kenney, C.W. Clark, A. N. Rice, B. Estabrook and J. Tielens. 2016. “Northeast Large Pelagic Survey Collaborative Aerial and Acoustic Surveys for Large Whales and Sea Turtles.” U.S. Department of the Interior, Bureau of Ocean Energy Management, Sterling, Virginia. OCS Study BOEM 2016-054. 117 pp. + appendices.

Lafortuna, C.L., M. Jahoda, A. Azzellino, F. Saibene, A. Colombini. 2003. “Locomotor behaviours and respiratory pattern of the Mediterranean fin whale (*Balaenoptera physalus*).” *European Journal of Applied Physiology*. Vol. 90, pp. 387–395.

Leiter, S.M., K.M. Stone, J.L. Thompson, C.M. Accardo, B.C. Wikgren, M.A. Zani, T.V.N. Cole, R.D. Kenney, C.A. Mayo, and S.D. Kraus. 2017. "North Atlantic right whale *Eubalaena glacialis* occurrence in offshore wind energy areas near Massachusetts and Rhode Island, USA." *Endangered Species Research* Vol. 34, pp. 45–59.

Meyer-Gutbrod, E. L., C. H. Greene, P.J. Sullivan, and A.J. Pershing. 2015. Climate-associated changes in prey availability drive reproductive dynamics of the North Atlantic right whale population. *Marine Ecology Progress Series*. Vol. 535, pp. 243–258.

Muirhead, C.A., A.M. Warde, I.S. Biedron, A. Nicole Mihnovets, C.W. Clark, A.N. Rice. 2018. “Seasonal acoustic occurrence of blue, fin, and North Atlantic right whales in the New York Bight.” *Aquatic Conservation: Marine and Freshwater Ecosystems*. Vol. 28, pp. 744–753.

Murray, A., A. Rice, and C. Clark. 2014. “Extended seasonal occurrence of humpback whales in Massachusetts Bay.” *Journal Marine Biological Association of the U.K*. Vol. 94, pp. 1117–1125.

Natural Earth. 2018. Natural Earth 200-meter Bathymetry Polygon Shapefile, 2018. Digital Data. Downloaded April 18. 2018. http://www.naturalearthdata.com/downloads/10m-physical-vectors/10m-bathymetry/

New York State (NYS). 2014. New York State Geographic Information Gateway. Offshore Planning Area – NY. Digital Data. Downloaded April 13, 2018. http://opdgig.dos.ny.gov/#/search/browse

NYS. 2018. New York State Office of Information Technology Services GIS Program Office (GPO). New York State Civil Boundaries. April 2018. Digital Data. Downloaded April 13, 2018. http://gis.ny.gov/gisdata/inventories/details.cfm?DSID=927

National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2010. National Centers for Environmental Information. 2010. Northeast Atlantic and Southeast Atlantic Coastal Relief Models. Modified September 2010. Digital Data. Downloaded March 19, 2019. https://www.ngdc.noaa.gov/mgg/coastal/crm.html

NOAA. 2013. Office of Coast Survey. U.S. Maritime Limits and Boundaries. Digital data. Downloaded April 13, 2018. https://nauticalcharts.noaa.gov/data/us-maritime-limits-and-boundaries.html#access-digital-dataState Offshore Planning Area.

NOAA. 2015. Office of Coast Survey. Shipping Fairways, Lanes, and Zones for U.S. Waters. December 4. Digital Data. Downloaded April 13, 2018. https://nauticalcharts.noaa.gov/data/gis-data-and-services.html#enc-direct-to-gis.

NOAA Fisheries. 2016. “Northeast Aerial AMAPPS Survey Data Collection Procedures, 15 Aug – 28 Oct 2016.” Report by the Northeast Fisheries Science Center and Southeast Fisheries Science Center.

NOAA Fisheries. 2018. Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Water of the Western North Atlantic Ocean – AMAPPS II. US Dept. of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region, Washington, DC. 120 pp. Available online at: https://www.fisheries.noaa.gov/resource/publication-database/atlantic-marine-assessment-program-protected-species.

NOAA Fisheries. 2019. Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Water of the Western North Atlantic Ocean – AMAPPS II. Draft Report. In Press.

NOAA Fisheries. 2020. Species Directory, Sea Turtles. Available at: https://www.fisheries.noaa.gov/sea-turtles.

New York State Energy Research and Development Authority (NYSERDA). 2018. Digital aerial baseline survey of marine wildlife in support of offshore wind energy. First Annual Report. Summer 2016 through spring 2017. October. 133 pp.

New York State Department of State (NYSDOS). 2013. Offshore Atlantic Ocean Study. Available online at: http://docs.dos.ny.gov/communitieswaterfronts/ocean_docs/NYSDOS_Offshore_Atlantic_Ocean_Study.pdf

Palka, D. 2005. "Aerial surveys in the northwest Atlantic: estimation of g (0)." In *European Cetacean Society's 18th Annual Conference, Estimation of g (0) in Line-transect Surveys of Cetaceans, ECS Newsletter No*. 44. April. pp. 14–9.

Palka, D.L. 2006. "Summer Abundance Estimates of Cetaceans in U.S. North Atlantic Navy Operating Areas." U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document. 06-03: 41 p.

Palka, D.L., S. Chavez-Rosales, E. Josephson, D. Cholewiak, H.L. Haas, L. Garrison, M. Jones, D. Sigourney, G. Waring (retired), M. Jech, E. Broughton, M. Soldevilla, G. Davis, A. DeAngelis, C.R. Sasso, M.V.Winton, R.J. Smolowitz, G. Fay, E. LaBrecque, J.B. Leiness, Dettloff, M. Warden, K. Murray, and C. Orphanides. 2017. "Atlantic Marine Assessment Program for Protected Species: 2010–2014." U.S. Department of the Interior, Bureau of Ocean Energy Management, Atlantic OCS Region. Washington, D.C. OCS Study BOEM 2017-071. 211 pp.

Pershing A.J., M.A. Alexander, C.M. Hernandez, L.A. Kerr, A. Le Bris, K.E. Mills, J.A. Nye, N.R. Record, H.A. Scannell, J.D. Scott, G.D. Sherwood. 2015. "Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery." *Science*. November. 13;350(6262):809–12.

Pierre-Louis, K. 2017. "Why Whales are Back in New York City." *Popular Science*. June 7. Available at: https://www.popsci.com/new-york-city-whales#page-4.

R Core Team. 2018. R: A language and environment for statistical computing. R foundation for statistical computing. Vienna, Austria. https://www.R-project.org.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, L.P. Garrison, K.D. Mullin, T.V. Cole, C.B. Khan and W.A. McLellan. 2016. "Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico." *Scientific Reports*. Vol. 6, No. 22615, 12 pp.

Roberts, J.J., L. Mannocci, P.N. Halpin. 2017. "Final Project Report: Marine Species Density Data Gap Assessments and Update for the AFTT Study Area, 2016-2017 (Option Year 1). Document version 1.4." Report prepared for Naval Facilities Engineering Command, Atlantic by the Duke University Marine Geospatial Ecology Lab, Durham, North Carolina.

Rowlett, R. and the University of North Carolina at Chapel Hill. 2001. Beaufort Scale.

Scott, T.M. and S.S. Sadove. 1997. "Sperm whale *(Physeter macrocephalus)* sightings in the shallow shelf waters off Long Island, New York." *Marine Mammal Science.* Vol. 13, pp. 317–321.

Simard, Y., N. Roy, S. Giard, and F. Aulanier. 2019. "North Atlantic right whale shift to the Gulf of St. Lawrence in 2015, revealed by long-term passive acoustics." *Endangered Species Research*, *40*, pp.271-284.

Stanistreet, J.E., D.P. Nowacek, J.T. Bell, D.M. Cholewiak, J.A. Hildebrand, L.E. Hodge, S.M. Van Parijs, and A.J. Read. 2018. "Spatial and seasonal patterns in acoustic detections of sperm whales *Physeter macrocephalus* along the continental slope in the western North Atlantic Ocean." *Endangered Species Research*. Vol. 35, pp. 1–13.

Stevick, P., N. Øien, and D.K. Mattila. 1998. "Migration of a humpback whale between Norway and the West Indies." *Marine Mammal Science*. Vol. 14, pp. 162–166.

Stone, K.M., S.M. Leiter, R.D. Kenney, B.C. Wikgren, J.L. Thompson, J.K. Taylor, and S.D. Kraus. 2017. "Distribution and abundance of cetaceans in a wind energy development area offshore of Massachusetts and Rhode Island." *Journal of Coastal Conservation*. Vol. 21, pp. 527–543.

Swingle, W.M., S.G. Barco, T.D. Pitchford, W.A. McClellan, and D. Pabst. 1993. "Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia." *Marine Mammal Science.* Vol. 9, pp. 309–315.

Tetra Tech, Inc. (Tetra Tech). 2017. "Survey Plan for New York Bight Whale Monitoring Aerial Surveys." Technical report prepared by Tetra Tech and Smultea Sciences under Tetra Tech contract. March. Prepared for New York State Department of Environmental Conservation, Division of Marine Resources. March 30, 2017.

Tetra Tech and SES. 2018. "Year 1 Annual Survey Report for New York Bight Whale Monitoring Aerial Surveys March 2017 – February 2018." Technical report prepared by Tetra Tech and Smultea Sciences under Tetra Tech contract C009926. 159 pp. + appendices. Prepared for New York State Department of Environmental Conservation, Division of Marine Resources, East Setauket, NY. May 10, 2018. Available online at: https://www.dec.ny.gov/docs/fish_marine_pdf/mmaeran1.pdf

Tetra Tech and LGL. 2019. Year 2 Annual Survey Report for New York Bight Whale Monitoring Aerial Surveys, March 2018 – February 2019. Technical report prepared by Tetra Tech, Inc. and LGL Ecological Research Associates, Inc. 115 pp. + appendices. Prepared for New York State Department of Environmental Conservation, Division of Marine Resources, East Setauket, NY. May 15, 2019. Available online at: https://www.dec.ny.gov/docs/fish_marine_pdf/mmaeran2.pdf

Thomas, L., S.T. Buckland, E.A. Rexstad, J.L. Laake, S. Strindberg, S.L. Hedley, J.R.B. Bishop, T.A. Marques, and K.P. Burnham. 2010. "Distance software: design and analysis of distance sampling surveys for estimating population size." *Journal of Applied Ecology*. Vol. 47, pp. 5–14.

U.S. Bureau of Ocean Energy Management (BOEM). 2019. Renewable Energy Leases and Planning Areas. Digital Data. Downloaded April 24, 2019. https://www.boem.gov/Renewable-Energy-GIS-Data/

U.S. Census Bureau (USCB). 2017. U.S. Census Bureau Cartographic Boundary Shapefiles – States. Digital Data. Downloaded April 18, 2018. https://www.census.gov/geo/maps-data/data/cbf/cbf_state.html

U.S. Department of the Interior (DOI). 2017. Department of the Interior Data Catalog. Outer Continental Shelf Submerged Lands Act Boundary – Atlantic Region NAD83. December 12, 2017. Digital Data. Downloaded April 13, 2018. https://catalog.data.gov/dataset/outer-continental-shelf-submerged-lands-act-boundary-atlantic-region-nad83

Vu, E.T., D. Risch, C.W. Clark, and S. Gaylord. 2012. "Humpback whale *(Megaptera novaeangliae)* song occurs extensively on feeding grounds in the western North Atlantic Ocean." *Aquatic Biology*. Vol. 14, pp. 175–183.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel. 2010. *U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 2010*. NOAA Technical Memorandum NMFS-NE 219: 1–606. Available at: http://spo.nwr.noaa.gov/tm.htm

Waring, G.T., E. Josephson, K. Maze-Foley, P.E. Rosel, editors. 2015. *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2014*. NOAA Technical Memorandum NMFS NE 231; 361 p. doi: 10.7289/V5TQ5ZH0.

Watwood, S.L., P.J.O. Miller, M. Johnson, P.T. Madsen, P.L. Tyack. 2006. "Deep-diving foraging behaviour of sperm whales (*Physeter macrocephalus*)." *Journal of Animal Ecology*. Vol. 75, pp. 814–825.

Wenzel, F., Mattila, D.K. and Clapham, P.J. 1988. "*Balaenoptera musculus* in the Gulf of Maine." *Marine Mammal Science*. Vol. 4:172–175

Whitt, A.D., K. Dudzinski, and J.R. Laliberte. 2013. "North Atlantic right whale distribution and seasonal occurrence in nearshore waters off New Jersey, USA and implications for management." *Endangered Species Research*. Vol. 20, pp. 50–69.

Whitt, A., J.A. Powell, A.G. Richardson, and J.R. Bosyk. 2015. "Abundance and distribution of marine mammals in nearshore waters off New Jersey, USA." *J. Cetacean Research Management*. Vol. 15, pp. 45–59.

Wong, S.N. and H. Whitehead. 2014. "Seasonal occurrence of sperm whales *(Physeter macrocephalus)* around Kelvin Seamount in the Sargasso Sea in relation to oceanographic processes." *Deep Sea Research Part I: Oceanographic Research Papers*. Vol. 91, pp. 10–16.

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