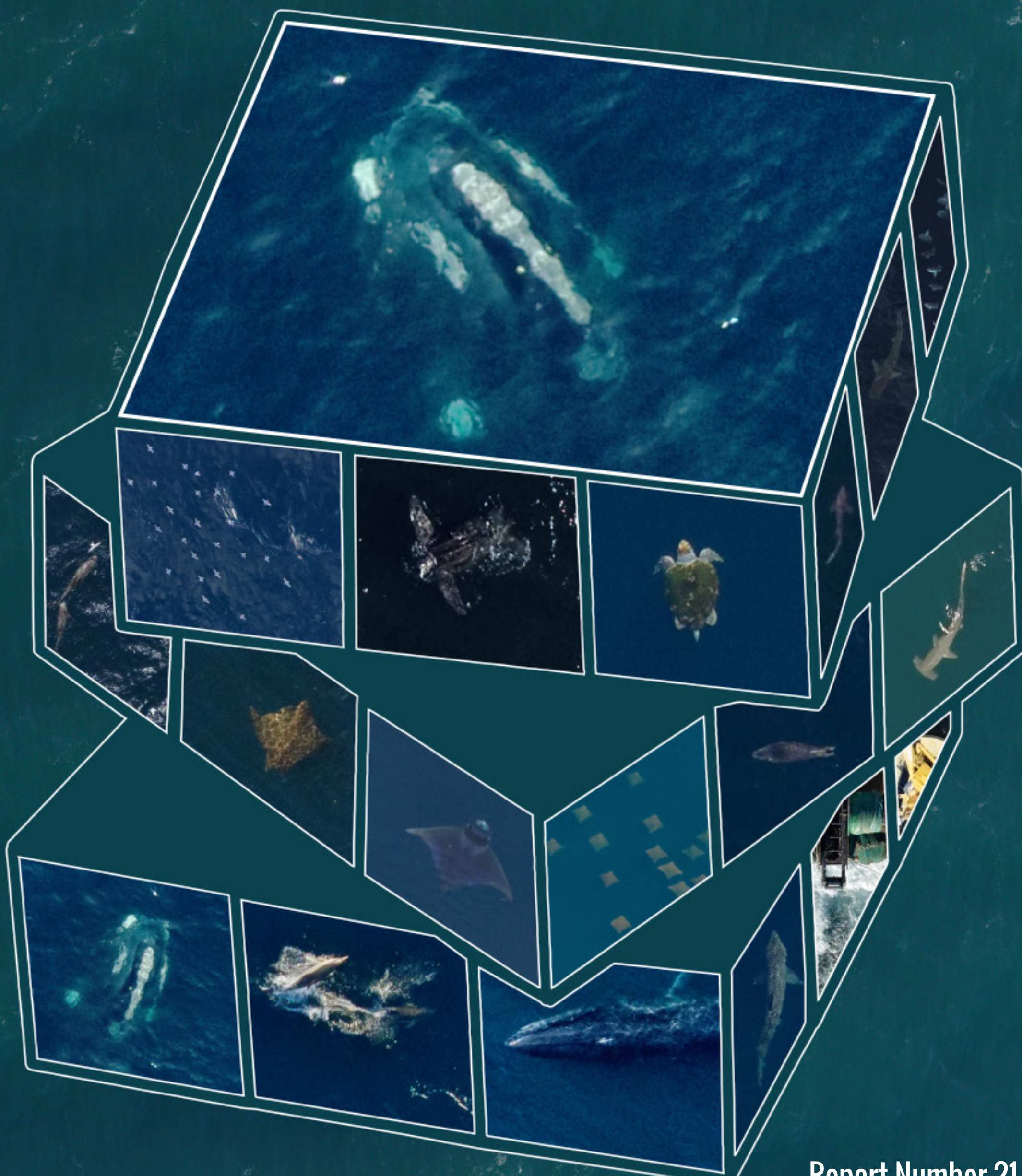
Digital Aerial Baseline Survey of Marine Wildlife in Support of Offshore Wind Energy:

Spatial and Temporal Marine Wildlife Distributions in the New York Offshore Planning Area, Summer 2016–Spring 2019

Final Report | Volume 4: Results (Marine Mammals)



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NORMANDEAU ASSOCIATES ENVIRONMENTAL CONSULTANTS

APEM

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Final Report
Volume 4: Results (Marine Mammals)

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Abstract

NYSERDA tasked Normandeau Associates, Inc., and their teaming partner APEM Ltd. to collect aerial digital imagery over the New York Offshore Planning Area during 12 surveys spaced seasonally over three years between 2016 and 2019. Imagery was captured at a resolution of 1.5 cm at the sea surface and provides information on spatial and temporal abundances of birds, marine mammals, turtles, rays, sharks, large bony fishes, and fish shoals. Spatial patterns were analyzed within distance from shore and water depth zones and reference the proposed Call Areas within the surveyed planning area identified by BOEM at the time of writing. Seasonal density comparisons highlight the differences among zones for each species group. Except for turtles, densities were generally lower in the zone containing the identified BOEM Call Areas. Full Summary and Final Reports can also be found on: remote.normandeau.com. https://remote.normandeau.com/aer_docs.php?pj=6

Keywords

Marine mammals; Birds; Turtles; Rays; Sharks; Aerial Digital Surveys; NYSERDA; Normandeau; APEM; Call Area; Density; Distribution; Abundance; Marine Wildlife; Offshore Wind

Acknowledgments

Normandeau Associates, Inc., and APEM Ltd. would like to thank NYSERDA for this opportunity, which, at the beginning of the project, was the largest survey of its type ever undertaken in the world. During the project, QA/QC protocols were developed that created confidence in data quality, and data sharing platforms evolved that allowed easy information sharing to all.

Normandeau would also like to thank Dr. Greg Skomal, Dr. Robert Kenney, Calusa Horn, Jessica Pate, and Dr. Nick Farmer for their taxonomic expertise and for their interest in the data generated by these surveys. Special thanks to Greg Lampman of NYSERDA for his help and support throughout the project. Normandeau would also like to thank the Project Advisory Committee for their interest and advice throughout the project.

All aerial images were collected by APEM Ltd., and flight height calculation methodology information was provided by APEM Ltd.

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1 Introduction

In support of New York State's commitment to incorporating offshore wind into its energy portfolio, the New York State Energy Research and Development Authority (NYSERDA) embarked on a multi-year ultra-high resolution aerial digital survey of marine resources in a 43,745.20-km^2 (12,754.06-mi^2) offshore planning area (OPA) in 2016. The OPA encompasses the waters of the New York Bight from Long Island southeast to the continental shelf break. Surveys were conducted on a quarterly basis and timed to coincide with periods of abundance of bird and marine species that could be vulnerable to impacts from offshore wind activities.

Each survey collected images covering at least 7% of the OPA. All survey data have been summarized and are freely available at https://remote.normandeau.com/nys_aer_overview.php

This report summarizes the results of the 12 surveys for all marine mammal species. It is volume 4 of five volumes:

- Volume 1: Methods, General Results, Limitations, and Discussion
- Volume 2: Results (Birds)
- Volume 3: Results (Turtles)
- Volume 4: Results (Marine Mammals)
- Volume 5: Results (Sharks and Rays)

2 Results (Marine Mammals)

There were 21 species of marine mammals identified in imagery during surveys of the OPA, representing three species of seals, nine species of whales, and nine species of dolphins (Table 1). Over all 12 surveys, 15,360 individuals were recorded with most encounters in the Summer 2018 survey (Table 2). Example images from each survey are in Appendix A.

Table 1. Marine Mammal Species Identified in Imagery Captured over 12 Surveys in the New York OPA

Common Name	Scientific Name
MARINE MAMMALS	**Mammalia**
Seals	
Gray Seal	*Halichoerus grypus*
Harp Seal	*Pagophilus groenlandicus*
Harbor Seal	*Phoca vitulina*
Whales	
North Atlantic Right Whale [a]	*Eubalaena glacialis*
Blue Whale [a]	*Balaenoptera musculus*
Common Minke Whale	*Balaenoptera acutorostrata*
Fin Whale [a]	*Balaenoptera physalus*
Sei Whale [a]	*Balaenoptera borealis*
Humpback Whale [a]	*Megaptera novaeangliae*
Dwarf Sperm Whale	*Kogia sima*
Pygmy Sperm Whale	*Kogia breviceps*
Sperm Whale a	*Physeter macrocephalus*
Dolphins	
Common Dolphin	*Delphinus delphis*
Short-finned Pilot Whale	*Globicephala macrorhynchus*
Risso's Dolphin	*Grampus griseus*
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*
Rough-toothed Dolphin	*Steno bredanensis*
Atlantic Spotted Dolphin	*Stenella frontalis*
Striped Dolphin	*Stenella coeruleoalba*
Common Bottlenose Dolphin	*Tursiops truncatus*
Harbor Porpoise	*Phocoena phocoena*

[a] Listed under Federal or State Endangered Species Act

Table 2. Raw Numbers of Marine Mammals per Survey Identified in Imagery Captured Over 12 Surveys in the New York OPA

Species	Number in Taxonomic Group	Summer			Fall			Winter			Spring		
		2016	2017	2018	2016	2017	2018	2016–2017	2017–2018	2018–2019	2017	2018	2019
SEAL	**84**	**–**	**2**	**2**	**13**	**1**	**1**	**35**	**5**	**8**	**1**	**7**	**9**
Gray Seal		–	–	–	1	–	–	3	–	–	–	2	–
Harp Seal		–	–	–	–	–	–	–	–	–	1	–	–
Harbor Seal		–	–	–	–	–	–	1	2	–	–	–	1
species unknown		–	2	2	12	1	1	31	3	8	–	5	8
WHALE	**188**	**20**	**11**	**27**	**13**	**16**	**6**	**25**	**9**	**4**	**17**	**23**	**17**
North Atlantic Right Whale [a]		–	–	–	–	–	–	4	–	–	2	–	1
Blue Whale [a]		–	–	–	1	–	–	1	–	–	–	–	–
Common Minke Whale		1	–	5	–	1	–	7	1	–	5	8	2
Fin Whale [a]		10	4	6	5	4	1	5	2	1	1	3	1
Sei Whale [a]		–	1	–	–	–	1	–	–	1	–	6	3
Humpback Whale [a]		–	–	2	1	3	–	2	–	–	5	5	2
Dwarf Sperm Whale		–	2	–	–	–	–	–	–	–	–	–	–
Pygmy Sperm Whale		–	–	–	–	2	–	–	–	–	–	–	1
Sperm Whale [a]		–	3	5	2	–	1	–	–	2	–	–	–
Beaked Whale (unid.)		8	–	–	4	–	3	1	4	–	1	–	5
species unknown		1	1	9	–	6	–	5	2	–	3	1	2
DOLPHIN	**14,857**	**904**	**1,392**	**2,133**	**1,092**	**1,221**	**1,105**	**1,516**	**1,063**	**1,284**	**1,558**	**809**	**780**
Common Dolphin		56	853	1,342	223	563	827	566	504	472	852	229	148
Short-finned Pilot Whale		–	24	–	–	–	–	–	–	–	–	–	–
Pilot Whale (unid.)		102	52	54	9	20	8	–	–	–	29	–	22
Risso's Dolphin		166	140	229	124	37	84	49	57	29	131	164	155
Atlantic White-sided Dolphin		–	–	–	16	–	–	7	2	–	–	–	–
Rough-toothed Dolphin		–	15	–	–	–	–	1	–	–	–	–	–
Atlantic Spotted Dolphin		–	–	–	54	–	–	–	–	–	3	–	2
Striped Dolphin		–	6	75	75	–	–	5	90	270	–	81	4

(continued)

Table 2 continued

Species	Number in Taxonomic Group	Summer			Fall			Winter			Spring		
		2016	2017	2018	2016	2017	2018	2016–2017	2017–2018	2018–2019	2017	2018	2019
Common Bottlenose Dolphin		96	175	116	59	68	1	132	29	74	173	49	122
Common/White-sided Dolphin		–	–	5	–	–	5	16	–	2	4	22	–
Harbor Porpoise		–	–	–	4	–	3	192	27	43	17	85	53
species unknown		484	127	312	528	533	177	548	354	394	349	179	274
UNID. MAMMAL	**231**	**–**	**41**	**3**	**–**	**5**	**9**	**33**	**5**	**10**	**111**	**6**	**8**
species unknown		–	41	3	–	5	9	33	5	10	111	6	8
SEASON TOTAL	**15,360**	**924**	**1,446**	**2,165**	**1,118**	**1,243**	**1,121**	**1,609**	**1,082**	**1,306**	**1,687**	**845**	**814**

[a] Listed as Federal or State Endangered

2.1 Species Identification

Identification rates between marine mammal taxonomic groups varied, with dolphins as the largest group (97%) of mammals found (n=14,857); only 1% were whales (n=188), and 0.5% were seals (n=84). There were 231 unidentified mammals (<2%), which, based on size, were likely either dolphins or seals (Table 3).

For dolphins, 4,609 were not identified to species. These included a species blend of common/white-sided dolphin (n=54), pilot whale unid. (n=296), and unidentified dolphins (n=4,259), which resulted in an identification rate of 31%. Of the 4,259 unidentified dolphins, 3,374 (79%) were significantly submerged (Table 4). Of the 231 unidentified mammals that could have been dolphin or seal, 186 (81%) were significantly submerged. Dolphin identification should consider the physical characters that make each species easy or more difficult to identify. For example, the color and shape characters for Risso's dolphin mean that even when deeply submerged this species is more easily identifiable. Two species of pilot whale are difficult to distinguish, but at the group level are quite distinct. However, the species of smaller beaked dolphins such as common, bottlenose, striped, and spotted are very difficult to tell apart even with clear imagery captured near the surface.

Eighty-four seals were found in imagery across the 12 surveys (Table 3), of which 11 individuals (13%) were identified to species. Nineteen of the remaining 84 (23%) were rated as significantly submerged (Table 4).

Across the 12 surveys, 188 whales were found in the imagery (Table 3). One hundred thirty-two (70%) were identified to species, 26 (14%) were identified as beaked whale (unid.), and 30 (16%) remained as whale-species unknown. Of the 56 unidentified whales, 37 (66%) were significantly submerged (Table 4).

Table 3. Numbers of Marine Mammals Encountered in Each Survey in the New York OPS

Species	Total	Summer			Fall			Winter			Spring		
		2016	2017	2018	2016	2017	2018	2016–2017	2017–2018	2018–2019	2017	2018	2019
SEAL	**84**	**–**	**2**	**2**	**13**	**1**	**1**	**35**	**5**	**8**	**1**	**7**	**9**
Gray Seal	**6**	–	–	–	1	–	–	3	–	–	–	2	–
Harp Seal	**1**	–	–	–	–	–	–	–	–	–	1	–	–
Harbor Seal	**4**	–	–	–	–	–	–	1	2	–	–	–	1
species unknown	**73**	–	2	2	12	1	1	31	3	8	–	5	8
WHALE	**188**	**20**	**11**	**27**	**13**	**16**	**6**	**25**	**9**	**4**	**17**	**23**	**17**
North Atlantic Right Whale [a]	**7**	–	–	–	–	–	–	4	–	–	2	–	1
Blue Whale [a]	**2**	–	–	–	1	–	–	1	–	–	–	–	–
Common Minke Whale	**30**	1	–	5	–	1	–	7	1	–	5	8	2
Fin Whale [a]	**43**	10	4	6	5	4	1	5	2	1	1	3	1
Sei Whale [a]	**12**	–	1	–	–	–	1	–	–	1	–	6	3
Humpback Whale [a]	**20**	–	–	2	1	3	–	2	–	–	5	5	2
Dwarf Sperm Whale	**2**	–	2	–	–	–	–	–	–	–	–	–	–
Pygmy Sperm Whale	**3**	–	–	–	–	2	–	–	–	–	–	–	1
Sperm Whale [a]	**13**	–	3	5	2	–	1	–	–	2	–	–	–
Beaked Whale (unid.)	**26**	8	–	–	4	–	3	1	4	–	1	–	5
species unknown	**30**	1	1	9	–	6	–	5	2	–	3	1	2
DOLPHIN	**14,857**	**904**	**1,392**	**2,133**	**1,092**	**1,221**	**1,105**	**1,516**	**1,063**	**1,284**	**1,558**	**809**	**780**
Common Dolphin	**6,635**	56	853	1,342	223	563	827	566	504	472	852	229	148
Short-finned Pilot Whale	**24**	–	24	–	–	–	–	–	–	–	–	–	–
Pilot Whale (unid.)	**296**	102	52	54	9	20	8	–	–	–	29	–	22
Risso's Dolphin	**1,365**	166	140	229	124	37	84	49	57	29	131	164	155
Atlantic White-sided Dolphin	**25**	–	–	–	16	–	–	7	2	–	–	–	–
Rough-toothed Dolphin	**16**	–	15	–	–	–	–	1	–	–	–	–	–
Atlantic Spotted Dolphin	**59**	–	–	–	54	–	–	–	–	–	3	–	2
Striped Dolphin	**606**	–	6	75	75	–	–	5	90	270	–	81	4

(continued)

Table 3 continued

Species	Total	Summer			Fall			Winter			Spring		
		2016	2017	2018	2016	2017	2018	2016–2017	2017–2018	2018–2019	2017	2018	2019
Common Bottlenose Dolphin	**1,094**	96	175	116	59	68	1	132	29	74	173	49	122
Common/White-sided Dolphin	**54**	–	–	5	–	–	5	16	–	2	4	22	–
Harbor Porpoise	**424**	–	–	–	4	–	3	192	27	43	17	85	53
species unknown	**4,259**	484	127	312	528	533	177	548	354	394	349	179	274
UNID. MAMMAL	**231**	**–**	**41**	**3**	**–**	**5**	**9**	**33**	**5**	**10**	**111**	**6**	**8**
species unknown	**231**	–	41	3	–	5	9	33	5	10	111	6	8
Total	**15,360**	**924**	**1,446**	**2,165**	**1,118**	**1,243**	**1,121**	**1,609**	**1,082**	**1,306**	**1,687**	**845**	**814**

[a] Listed as Federal or State Endangered

Table 4. Numbers of Significantly Submerged Marine Mammals Encountered in Each Survey in the New York OPS

Species	Total	Summer			Fall			Winter			Spring		
		2016	2017	2018	2016	2017	2018	2016–2017	2017–2018	2018–2019	2017	2018	2019
SEAL	**19**	**–**	**1**	**–**	**4**	**–**	**–**	**10**	**1**	**1**	**–**	**–**	**2**
Gray Seal	**–**	–	–	–	–	–	–	–	–	–	–	–	–
Harp Seal	**–**	–	–	–	–	–	–	–	–	–	–	–	–
Harbor Seal	**–**	–	–	–	–	–	–	–	–	–	–	–	–
species unknown	**19**	–	1	–	4	–	–	10	1	1	–	–	2
WHALE	**90**	**4**	**2**	**14**	**4**	**10**	**3**	**16**	**6**	**2**	**6**	**12**	**11**
North Atlantic Right Whale [a]	**3**	–	–	–	–	–	–	3	–	–	–	–	–
Blue Whale [a]	**1**	–	–	–	1	–	–	–	–	–	–	–	–
Common Minke Whale	**13**	–	–	3	–	–	–	3	–	–	1	5	1
Fin Whale [a]	**18**	2	–	4	1	3	1	3	2	1	1	–	–
Sei Whale [a]	**7**	–	–	–	–	–	–	–	–	–	–	4	3
Humpback Whale [a]	**8**	–	–	1	–	2	–	2	–	–	–	2	1
Dwarf Sperm Whale	**–**	–	–	–	–	–	–	–	–	–	–	–	–
Pygmy Sperm Whale	**–**	–	–	–	–	–	–	–	–	–	–	–	–
Sperm Whale [a]	**3**	–	1	–	1	–	–	–	–	1	–	–	–
Beaked Whale (unid.)	**14**	2	–	–	1	–	2	1	2	–	1	–	5
species unknown	**23**	–	1	6	–	5	–	4	2	–	3	1	1
DOLPHIN	**9,837**	**515**	**854**	**1,470**	**524**	**999**	**796**	**1,014**	**704**	**815**	**1,082**	**531**	**533**
Common Dolphin	**4,261**	13	552	889	75	440	585	381	292	244	557	150	83
Short-finned Pilot Whale	**8**	–	8	–	–	–	–	–	–	–	–	–	–
Pilot Whale (unid.)	**191**	78	22	35	–	12	6	–	–	–	21	–	17
Risso's Dolphin	**656**	–	64	159	–	22	65	25	29	19	88	86	99
Atlantic White-sided Dolphin	**14**	–	–	–	11	–	–	2	1	–	–	–	–
Rough-toothed Dolphin	**9**	–	9	–	–	–	–	–	–	–	–	–	–
Atlantic Spotted Dolphin	**40**	–	–	–	37	–	–	–	–	–	2	–	1
Striped Dolphin	**400**	–	5	59	53	–	–	3	56	165	–	58	1

(continued)

Table 4 continued

Species	Total	Summer 2016	Summer 2017	Summer 2018	Fall 2016	Fall 2017	Fall 2018	Winter 2016–2017	Winter 2017–2018	Winter 2018–2019	Spring 2017	Spring 2018	Spring 2019
Common Bottlenose Dolphin	**627**	2	91	71	31	38	1	81	22	57	112	33	88
Common/White-sided Dolphin	**28**	–	–	3	–	–	5	2	–	–	–	18	–
Harbor Porpoise	**229**	–	–	–	2	–	2	111	12	23	15	30	34
species unknown	**3,374**	422	103	254	315	487	132	409	292	307	287	156	210
UNID. MAMMAL	**186**	**–**	**33**	**3**	**–**	**4**	**9**	**25**	**4**	**6**	**90**	**5**	**7**
species unknown	**186**	–	33	3	–	4	9	25	4	6	90	5	7
Total	**10,132**	**519**	**890**	**1,487**	**532**	**1,013**	**808**	**1,065**	**715**	**824**	**1,178**	**548**	**553**

[a] Listed as Federal or State Endangered

Accuracy assessments for marine mammals showed an overall 99.1% accuracy at the species group level and a 95.5% accuracy at the species level. Species group identification accuracy was also high, with whales and dolphins having >99% agreement between initial identification and QC identification and seals having 92.9% agreement (Table 5). There was only one species-specific seal observation while the remaining 13 observations were identified as seal-species unknown. At the species level, identification accuracy was much more variable due to the increasing difficulty of identifying targets at lower taxonomic levels. Whales had nearly consistent 100% initial identification accuracy across all species except for humpback whale (94.7%) and sperm whale (91.7%). Species-specific dolphin identifications were lower than for whales, although still high (>90%) except for Atlantic white-sided dolphin (83.3%). Dolphin species blends had lower identification accuracy, but this is not surprising given that multiple species can be ascribed to these categories, and they are used when species-specific identifications cannot be made (Table 6).

Table 5. Initial Identification Accuracy and QC ID Accuracy for Marine Mammal Species Groups

Species Group	Initial ID Success	QC ID Success	n (initial ID)	n (QC ID)
Seal	92.9%	92.9%	14	14
Whale	100.0%	99.0%	101	102
Dolphin	99.5%	99.9%	2,945	2,932
Unid. Mammal	73.2%	83.3%	41	36
Unknown	NA [a]	0.0%	0	16

[a] An NA value means that no individuals of that species group were identified by the respective observer.

Table 6. Initial Identification Accuracy and QC ID Accuracy for Marine Mammal Species

Species	Initial ID Success	QC ID Success	n (initial ID)	n (QC ID)
Gray Seal	100.0%	100.0%	1	1
Seal-species unknown	92.3%	92.3%	13	13
North Atlantic Right Whale [a]	100.0%	100.0%	7	7
Blue Whale [a]	100.0%	100.0%	2	2
Common Minke Whale	100.0%	100.0%	5	5
Fin Whale [a]	100.0%	100.0%	33	33
Sei Whale [a]	100.0%	100.0%	12	12
Humpback Whale [a]	94.7%	100.0%	19	18
Pygmy Sperm Whale	100.0%	100.0%	2	2
Sperm Whale [a]	91.7%	100.0%	12	11
Beaked Whale (unid.)	100.0%	100.0%	3	3
Whale-species unknown	100.0%	66.7%	6	9
Common Dolphin	97.0%	98.9%	1,375	1,349
Short-finned Pilot Whale	100.0%	100.0%	4	4
Pilot Whale (unid.)	96.0%	96.0%	50	50
Risso's Dolphin	96.6%	98.8%	266	260
Atlantic White-sided Dolphin	83.3%	100.0%	6	5
Rough-toothed Dolphin	100.0%	100.0%	4	4
Atlantic Spotted Dolphin	100.0%	100.0%	12	12
Striped Dolphin	91.4%	84.8%	116	125
Common Bottlenose Dolphin	94.7%	99.0%	208	199
Common/White-sided Dolphin	77.8%	50.0%	9	14
Harbor Porpoise	98.7%	96.2%	76	78
Dolphin-species unknown	94.0%	92.5%	819	832
Unid. Mammal-species unknown	73.2%	83.3%	41	36
unknown object	NA [b]	0.0%	0	12
Blank	NA [b]	0.0%	0	4
needs id	NA [b]	0.0%	0	1

[a] Listed as Federal or State Endangered

[b] An NA value means that no individuals of that species group were identified by the respective observer.

2.2 Species Composition and Density by Survey

During the 12 surveys in the OPA, marine mammal observations included 97% dolphins, 1.5% unidentified mammals, 1% whales, and <1% seals (Table 3).

Seals were the least abundant of the marine mammal species groups consisting of <1% of the total observations (Table 3). Seals were not observed during the Summer 2016 survey; however, there were 0.0006 unidentified seals per km^2 found during both the Summer 2017 and Summer 2018 surveys. Unidentified seals were also observed during all Fall and Winter surveys and during the Spring 2018, Spring 2019, Summer 2017 and Summer 2018 surveys with the highest observance rates of 0.0078 per km^2 during Winter 2016–2017 and 0.0031 per km^2 during Fall 2016 (Table 7). Harp seals were observed during the Spring 2017 survey (0.0003 per km^2) (Table 7). Gray seals were recorded in the Fall 2016 survey (0.0003 per km^2), Winter 2016–2017 survey (0.0008 per km^2), and Spring 2018 survey (0.0006 per km^2) (Table 7). Harbor seals were observed during the Winter 2016–2017, Winter 2017–2018, and Spring 2019 surveys (0.0003, 0.0006, and 0.0003 per km^2, respectively). Most seals (77%) were found during the Fall 2016, Winter 2016–2017, Winter 2018–2019, and Spring 2019 surveys (Table 2, Table 7).

Fin whales were the most abundant whale species during the Summer, Fall 2016, Fall 2017, and Winter 2016–2017 surveys (Table 7). Common minke whales were the most abundant during the Winter 2016–2017 and Spring 2018 surveys (Table 7). Humpback whales had the same density as common minke whales in Spring 2017 and Spring 2019 (0.0015 and 0.0006 per km^2, respectively). Humpback whales were observed less often (0.0016 per km^2) than minke and sei whales in the Spring 2018 survey (0.0026 and 0.0019 per km^2, respectively) and less often than sei whales (0.0010 vs. 0.0006 per km^2) in the Spring 2019 survey (Table 7). North Atlantic right whales were present in the Winter 2016–2017, Spring 2017, and Spring 2019 surveys (0.0010, 0.0006, and 0.0003 per km^2). Blue whales were observed equally during the Fall 2016 and Winter 2016–2017 surveys (0.0003 per km^2). Sperm whales were observed in the Summer 2017, Summer 2018, Fall 2016, Fall 2018, and Winter 2018–2019 surveys; dwarf sperm whales were only present in the Summer 2017 survey; and pygmy sperm whales were only present in the Fall 2017 and Spring 2019 surveys (Table 7). There were at least three species of whales present in each survey and 10 species over all surveys. The maximum number of species (seven) in any survey occurred in the Spring 2019 survey; there were six species in the Winter 2016–2017 survey. Fin whales were present during every survey. The next most frequently occurring species were minke whales (eight surveys), humpbacks (seven surveys), and beaked whales (seven surveys).

Common dolphins were the most frequently encountered species in all surveys except for the Summer 2016 and Spring 2019 surveys, when Risso's dolphins were the most frequently encountered identified dolphins (Table 7). Unknown dolphin species were the most abundant during the Summer 2016 and Fall 2017 surveys. Risso's, common, and common bottlenose dolphins were present for all surveys (Table 7). Rough-toothed dolphins were present in the Winter 2016–2017 and Summer 2017 surveys, and striped dolphins were present in the Summer 2017, Summer 2018, Fall 2016, all Winter surveys, Spring 2018, and Spring 2019 surveys (Table 7).

Table 7. Density (per km^2) and Percent of Total of Marine Mammals Observed in the OPA During the Summer 2016 through Spring 2019 Surveys

Species	Summer						Fall						Winter						Spring						Total
	2016		2017		2018		2016		2017		2018		2016–2017		2017–2018		2018–2019		2017		2018		2019		
	Density	%	Density	%	Density	%	Density	%	Density	%	Density	%	Density	%	Density	%	Density	%	Density	%	Density	%	Density	%	
SEAL	-	-	0.0006	2.38	0.0006	2.38	0.0033	15.48	0.0003	1.19	0.0003	1.19	0.0089	41.67	0.0016	5.95	0.0025	9.52	0.0003	1.19	0.0022	8.33	0.0029	10.71	0.0236
Gray Seal	-	-	-	-	-	-	0.0003	16.67	-	-	-	-	0.0008	50.00	-	-	-	-	-	-	0.0006	33.33	-	-	0.0017
Harp Seal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0003	100.00	-	-	-	-	0.0003
Harbor Seal	-	-	-	-	-	-	-	-	-	-	-	-	0.0003	25.00	0.0006	50.00	-	-	-	-	-	-	0.0003	25.00	0.0012
species unknown	-	-	0.0006	2.74	0.0006	2.74	0.0031	16.44	0.0003	1.37	0.0003	1.37	0.0078	42.47	0.0010	4.11	0.0025	10.96	-	-	0.0016	6.85	0.0025	10.96	0.0205
WHALE	0.0062	10.64	0.0035	5.85	0.0086	14.36	0.0033	6.91	0.0050	8.51	0.0019	3.19	0.0063	13.30	0.0029	4.79	0.0013	2.13	0.0052	9.04	0.0074	12.23	0.0054	9.04	0.0570
North Atlantic Right Whale [a]	-	-	-	-	-	-	-	-	-	-	-	-	0.0010	57.14	-	-	-	-	0.0006	28.57	-	-	0.0003	14.29	0.0019
Blue Whale [a]	-	-	-	-	-	-	0.0003	50.00	-	-	-	-	0.0003	50.00	-	-	-	-	-	-	-	-	-	-	0.0005
Common Minke Whale	0.0003	3.33	-	-	0.0016	16.67	-	-	0.0003	3.33	-	-	0.0018	23.33	0.0003	3.33	-	-	0.0015	16.67	0.0026	26.67	0.0006	6.67	0.0090
Fin Whale [a]	0.0031	23.26	0.0013	9.30	0.0019	13.95	0.0013	11.63	0.0013	9.30	0.0003	2.33	0.0013	11.63	0.0006	4.65	0.0003	2.33	0.0003	2.33	0.0010	6.98	0.0003	2.33	0.0130
Sei Whale [a]	-	-	0.0003	8.33	-	-	-	-	-	-	0.0003	8.33	-	-	-	-	0.0003	8.33	-	-	0.0019	50.00	0.0010	25.00	0.0038
Humpback Whale [a]	-	-	-	-	0.0006	10.00	0.0003	5.00	0.0009	15.00	-	-	0.0005	10.00	-	-	-	-	0.0015	25.00	0.0016	25.00	0.0006	10.00	0.0061
Dwarf Sperm Whale	-	-	0.0006	100.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0006
Pygmy Sperm Whale	-	-	-	-	-	-	-	-	0.0006	66.67	-	-	-	-	-	-	-	-	-	-	-	-	0.0003	33.33	0.0009
Sperm Whale [a]	-	-	0.0010	23.08	0.0016	38.46	0.0005	15.38	-	-	0.0003	7.69	-	-	-	-	0.0006	15.38	-	-	-	-	-	-	0.0040
Beaked Whale (unid.)	0.0025	30.77	-	-	-	-	0.0010	15.38	-	-	0.0009	11.54	0.0003	3.85	0.0013	15.38	-	-	0.0003	3.85	-	-	0.0016	19.23	0.0079
species unknown	0.0003	3.33	0.0003	3.33	0.0029	30.00	-	-	0.0019	20.00	-	-	0.0013	16.67	0.0006	6.67	-	-	0.0009	10.00	0.0003	3.33	0.0006	6.67	0.0091
DOLPHIN	0.2821	6.08	0.4442	9.37	0.6771	14.36	0.2807	7.35	0.3853	8.22	0.3461	7.44	0.3835	10.20	0.3378	7.15	0.4082	8.64	0.4731	10.49	0.2587	5.45	0.2473	5.25	4.5242
Common Dolphin	0.0175	0.84	0.2722	12.86	0.4260	20.23	0.0573	3.36	0.1777	8.49	0.2591	12.46	0.1432	8.53	0.1601	7.60	0.1501	7.11	0.2587	12.84	0.0732	3.45	0.0469	2.23	2.0420
Short-finned Pilot Whale	-	-	0.0077	100.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0077
Pilot Whale (unid.)	0.0318	34.46	0.0166	17.57	0.0171	18.24	0.0023	3.04	0.0063	6.76	0.0025	2.70	-	-	-	-	-	-	0.0088	9.80	-	-	0.0070	7.43	0.0925
Risso's Dolphin	0.0518	12.16	0.0447	10.26	0.0727	16.78	0.0319	9.08	0.0117	2.71	0.0263	6.15	0.0124	3.59	0.0181	4.18	0.0092	2.12	0.0398	9.60	0.0525	12.01	0.0491	11.36	0.4201
Atlantic White-sided Dolphin	-	-	-	-	-	-	0.0041	64.00	-	-	-	-	0.0018	28.00	0.0006	8.00	-	-	-	-	-	-	-	-	0.0065
Rough-toothed Dolphin	-	-	0.0048	93.75	-	-	-	-	-	-	-	-	0.0003	6.25	-	-	-	-	-	-	-	-	-	-	0.0050
Atlantic Spotted Dolphin	-	-	-	-	-	-	0.0139	91.53	-	-	-	-	-	-	-	-	-	-	0.0009	5.08	-	-	0.0006	3.39	0.0154
Striped Dolphin	-	-	0.0019	0.99	0.0238	12.38	0.0193	12.38	-	-	-	-	0.0013	0.83	0.0286	14.85	0.0858	44.55	-	-	0.0259	13.37	0.0013	0.66	0.1879
Common Bottlenose Dolphin	0.0300	8.78	0.0558	16.00	0.0368	10.60	0.0152	5.39	0.0215	6.22	0.0003	0.09	0.0334	12.07	0.0092	2.65	0.0235	6.76	0.0525	15.81	0.0157	4.48	0.0387	11.15	0.3326
Common/White-sided Dolphin	-	-	-	-	0.0016	9.26	-	-	-	-	0.0016	9.26	0.0040	29.63	-	-	0.0006	3.70	0.0012	7.41	0.0070	40.74	-	-	0.0161
Harbor Porpoise	-	-	-	-	-	-	0.0010	0.94	-	-	0.0009	0.71	0.0486	45.28	0.0086	6.37	0.0137	10.14	0.0052	4.01	0.0272	20.05	0.0168	12.50	0.1219
species unknown	0.1511	11.36	0.0405	2.98	0.0990	7.33	0.1357	12.40	0.1682	12.51	0.0554	4.16	0.1386	12.87	0.1125	8.31	0.1253	9.25	0.1060	8.19	0.0572	4.20	0.0869	6.43	1.2765
UNID. MAMMAL	-	-	0.0131	17.75	0.0010	1.30	-	-	0.0016	2.16	0.0028	3.90	0.0083	14.29	0.0016	2.16	0.0032	4.33	0.0337	48.05	0.0019	2.60	0.0025	3.46	0.0697
species unknown	-	-	0.0131	17.75	0.0010	1.30	-	-	0.0016	2.16	0.0028	3.90	0.0083	14.29	0.0016	2.16	0.0032	4.33	0.0337	48.05	0.0019	2.60	0.0025	3.46	0.0697
TOTAL	0.2884	6.02	0.4615	9.41	0.6872	14.10	0.2874	7.28	0.3923	8.09	0.3512	7.30	0.4070	10.48	0.3438	7.04	0.4152	8.50	0.5123	10.98	0.2703	5.50	0.2581	5.30	4.6745

[a] Listed as Federal or State Endangered

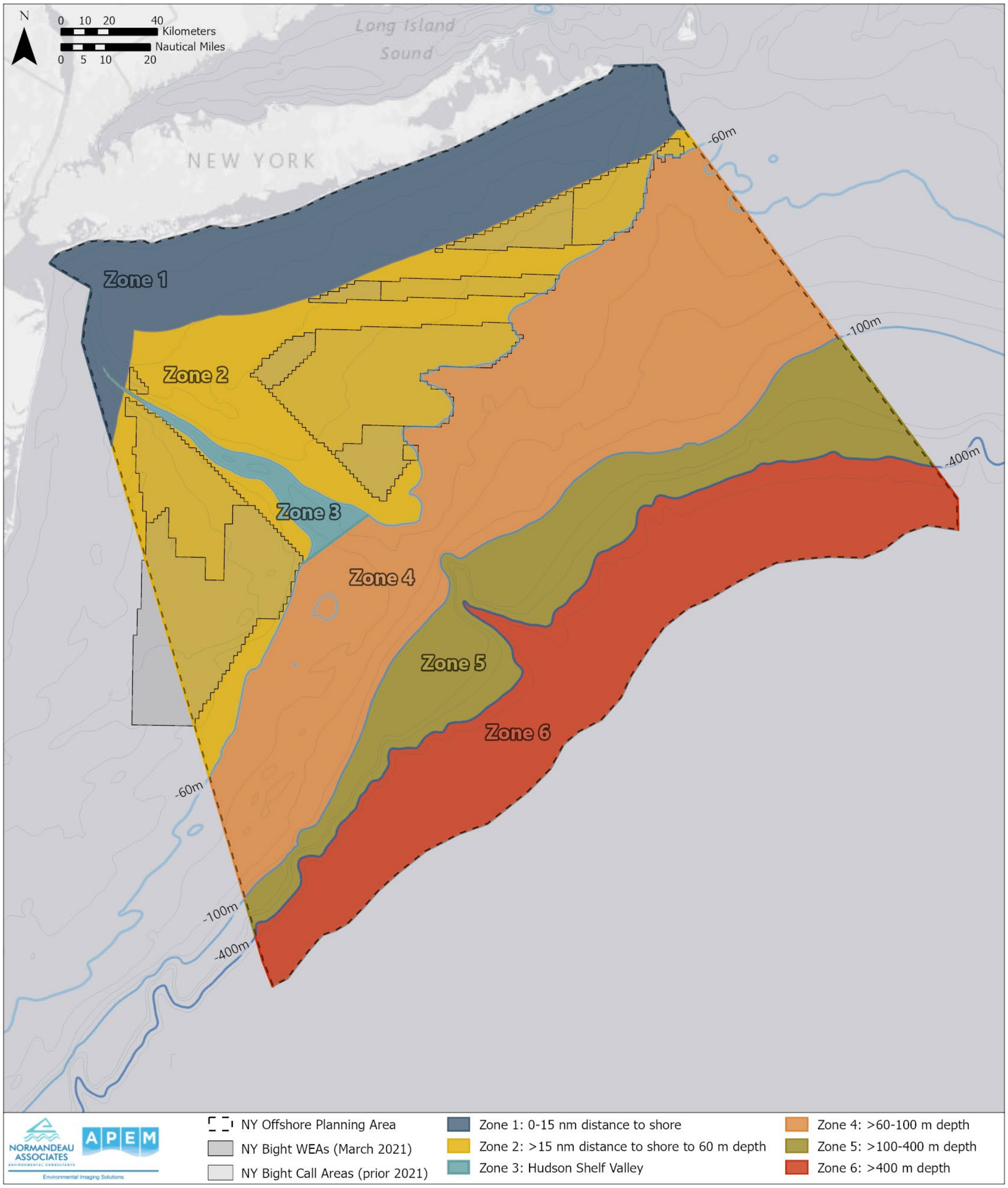
2.3 Spatial Distribution and Direction of Travel

To account for spatial variation more effectively within the OPA, six discrete zones were considered (Figure 1):

- Zone 1: Coastal Zone
- Zone 2: Area for Consideration Zone
- Zone 3: Hudson Shelf Valley Zone
- Zone 4: Shelf Zone
- Zone 5: Shelf Slope Zone
- Zone 6: Shelf Break Zone

Density was quantified for species with 30 or more total observations by dividing the total count of individuals from a species within the strip transect by the strip transect area. Densities are presented as individuals per square kilometer (km^2) surveyed plus or minus standard error of the mean. On the resulting heat maps, density is scaled to the maximum density across all seasons for each taxon. For species with fewer than 30 total observations, a single point map shows the occurrence record spatially and temporally. To gain a deeper understanding of direction of travel, a Rao spacing test is used for species and seasons with greater than 30 occurrences to test the hypothesis that the underlying direction of travel distribution is uniform and report the test statistic as t and the p-value as p where appropriate.

Figure 1. Zones Defined in the Analyses and Location of the Call Areas



2.3.1 Cetaceans

Cetacean analysis followed the protocols laid out in NYSERDA (2017), which reports mammals by underwater auditory frequency groups (see Table 8); therefore, the marine mammals are similarly grouped into these same groups for ease of comparison.

Table 8. Cetaceans Observed from Aerial Digital Surveys Represented in Each Auditory Frequency Group

Defined in Finneran (2016) as cited in NYSERDA (2017).

High-Frequency Cetaceans	Mid-Frequency Cetaceans	Low-Frequency Cetaceans
Dwarf Sperm Whale	Sperm Whale [a]	Blue Whale [a]
Pygmy Sperm Whale	Beaked Whale (unid.)	Common Minke Whale
Harbor Porpoise	Common Dolphin	Fin Whale [a]
	Short-finned Pilot Whale	Sei Whale [a]
	Pilot Whale (unid.)	Humpback Whale [a]
	Risso's Dolphin	North Atlantic Right Whale [a]
	Atlantic White-sided Dolphin	
	Rough-toothed dolphin	
	Atlantic Spotted Dolphin	
	Striped Dolphin	
	Common Bottlenose Dolphin	
	Common/White-sided Dolphin	

[a] Listed as Federal or State Endangered

In total, 15,045 cetaceans were observed. Considering all cetaceans, mean density was relatively homogenous throughout the annual cycle with Summer having the greatest mean density of cetaceans (n=4,487; $\bar{x} = 0.46 \pm 0.07$ individuals/km^2), followed by Fall (n=3,453; $\bar{x} = 0.40 \pm 0.09$ individuals/km^2), Spring (n=3,204; $\bar{x} = 0.39 \pm 0.08$ individuals/km^2), and Winter (n=3,901; $\bar{x} = 0.39 \pm 0.06$ individuals/km^2) (Figure 2, Figure 3). Across all surveys, cetacean density was consistently high within the outer Zones 5 and 6 (Figure 2, Figure 3). During Fall, cetacean density was also high within Zone 3 (Figure 2). Overall cetaceans were more likely to move westerly or easterly throughout the annual cycle. There was a non-uniform distribution of travel directions during Fall ($t = 323.2$, $p < 0.001$), Winter ($t = 326.7$, $p < 0.001$), Spring ($t = 318.5$, $p < 0.001$) and Summer ($t = 328.3$, $p < 0.001$). During Fall, Winter, and Spring surveys cetaceans exhibited a multimodal pattern of travel direction with most individuals traveling east or west, and during Summer there was a pattern of easterly travel (Figure 4).

Figure 2. Spatial Distribution of Cetaceans During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

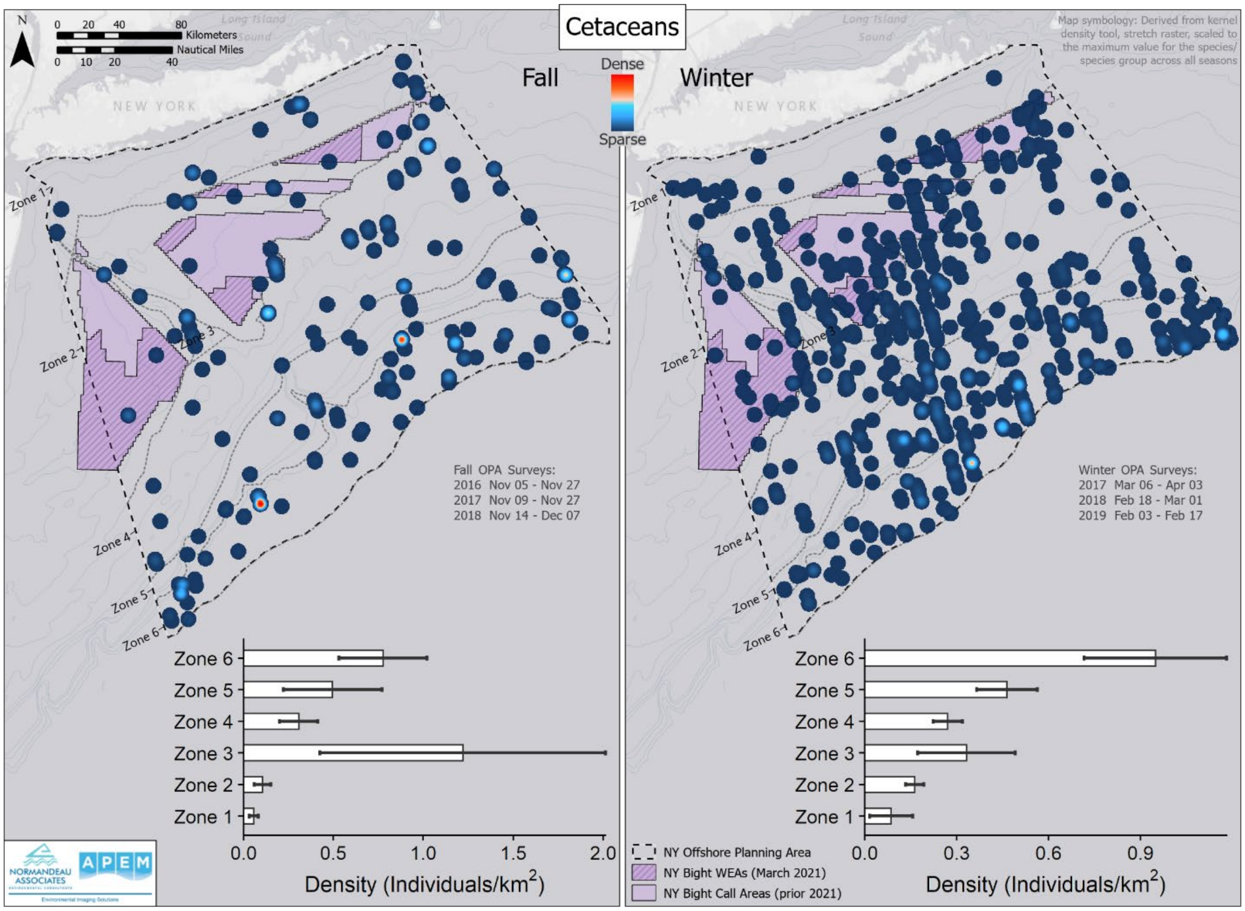


Figure 3. Spatial Distribution of Cetaceans During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

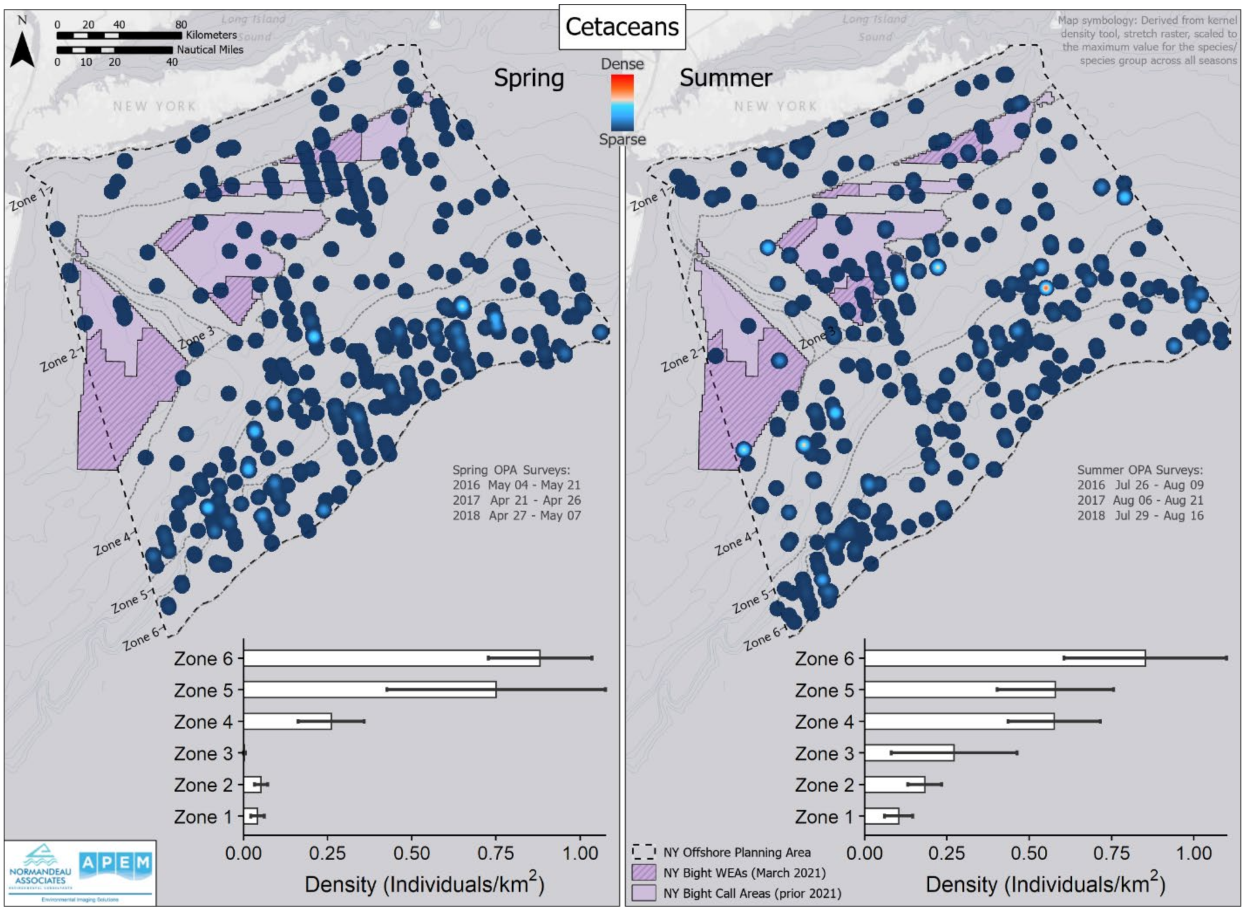
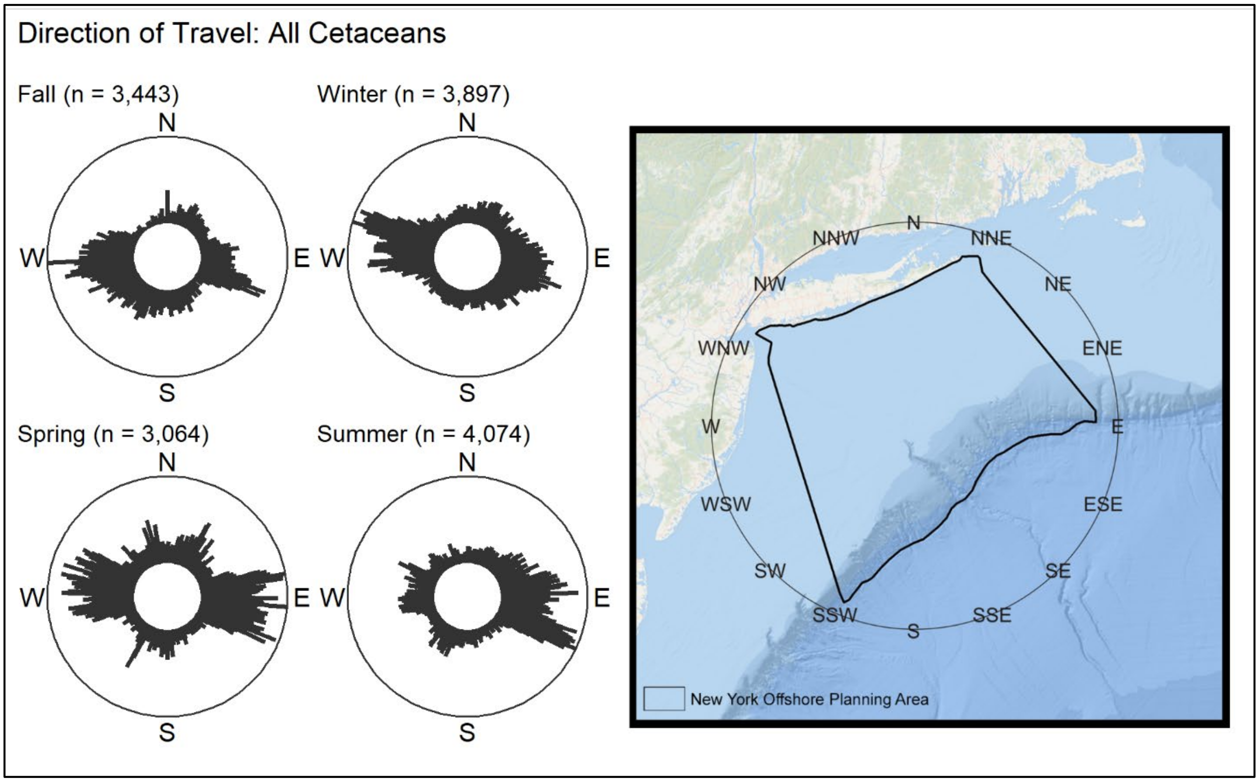


Figure 4. Direction of Travel of All Cetaceans for All Surveys



2.3.1.1 High-frequency Cetaceans

Overall, we observed 429 high-frequency cetaceans, the vast majority of which were harbor porpoise (n=424) followed by dwarf sperm whale (n=2), and pygmy sperm whale (n=3) (Table 2). High-frequency cetacean density was greatest during Winter (n=262; $\bar{x} = 0.02 \pm 0.005$ individuals/km^2), followed by Spring (n=156; $\bar{x} = 0.02 \pm 0.004$ individuals/km^2), with very few individuals being observed during Fall (n=9) and Summer (n=2) surveys (Figure 5, Figure 6). During Winter, mean density was greatest within Zone 2 (n=95; $\bar{x} = 0.05 \pm 0.02$ individuals/km^2) (Figure 5). Density was similarly highest in Zone 2 during Spring surveys (Figure 6). Travel directions were non-uniform and patternless across most seasons except during Winter when travel direction was non-uniform ($t = 208.6$, $p < 0.001$) and individuals traveled to the west or east, a pattern wholly driven by harbor porpoise (Figure 7).

Harbor Porpoise

Patterns of high-frequency cetaceans were driven by harbor porpoise and thus their spatial distribution mirrors that observed when considering all high-frequency cetaceans. Overall 424 harbor porpoise were observed with the greatest density observed during Winter (n=262; $\bar{x} = 0.02 \pm 0.005$ individuals/km^2), followed by Spring (n=155; $\bar{x} = 0.02 \pm 0.005$ individuals/km^2), with few individuals observed during Fall (n=7); none were observed during Summer surveys (Figure 8, Figure 9). During Winter, mean density was greatest within Zone 2 (Figure 8). Density was similarly highest in Zone 2 during Spring surveys (Figure 9). During Winter, travel direction was non-uniform ($t = 208.6$, $p < 0.001$) and individuals traveled in a westerly or easterly direction (Figure 10).

High-frequency Cetaceans with Fewer than 30 Observations

Dwarf sperm whale and pygmy sperm whale were observed on five occasions and in all seasons except Winter (Figure 11). All observations occurred in the outermost edge of Zone 6.

Figure 5. Spatial Distribution of High-frequency Cetaceans During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

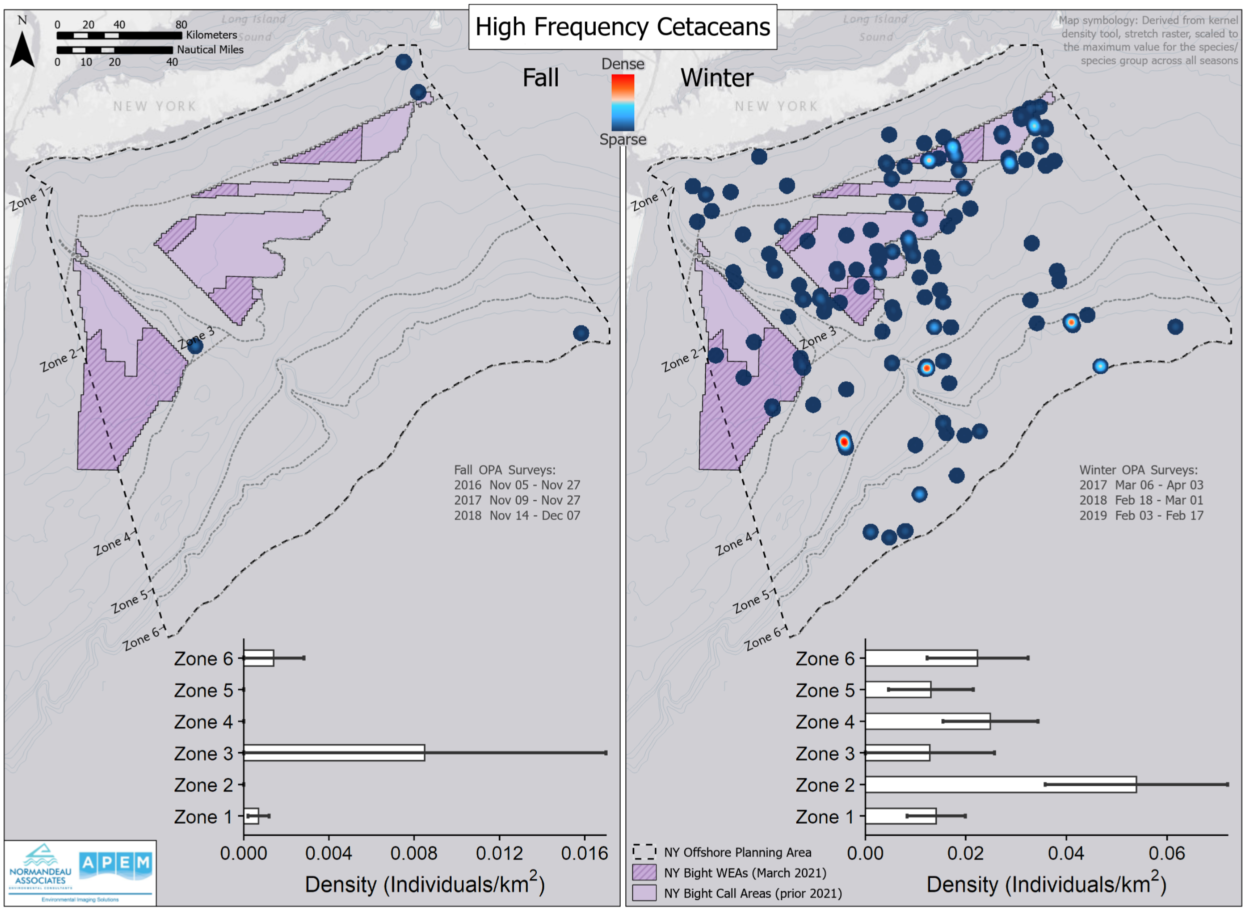


Figure 6. Spatial Distribution of High-frequency Cetaceans During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

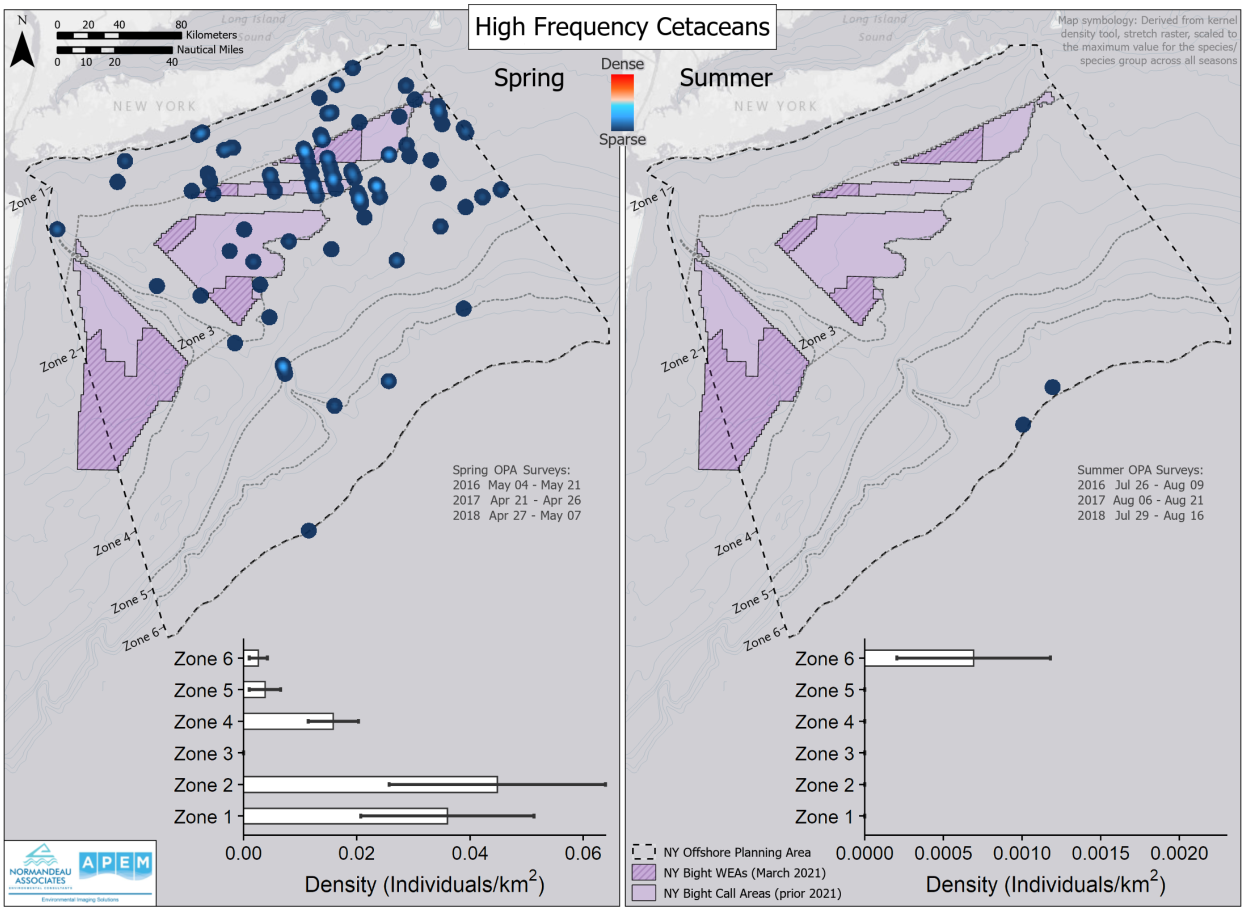


Figure 7. Direction of Travel of High-frequency Cetaceans for All Surveys

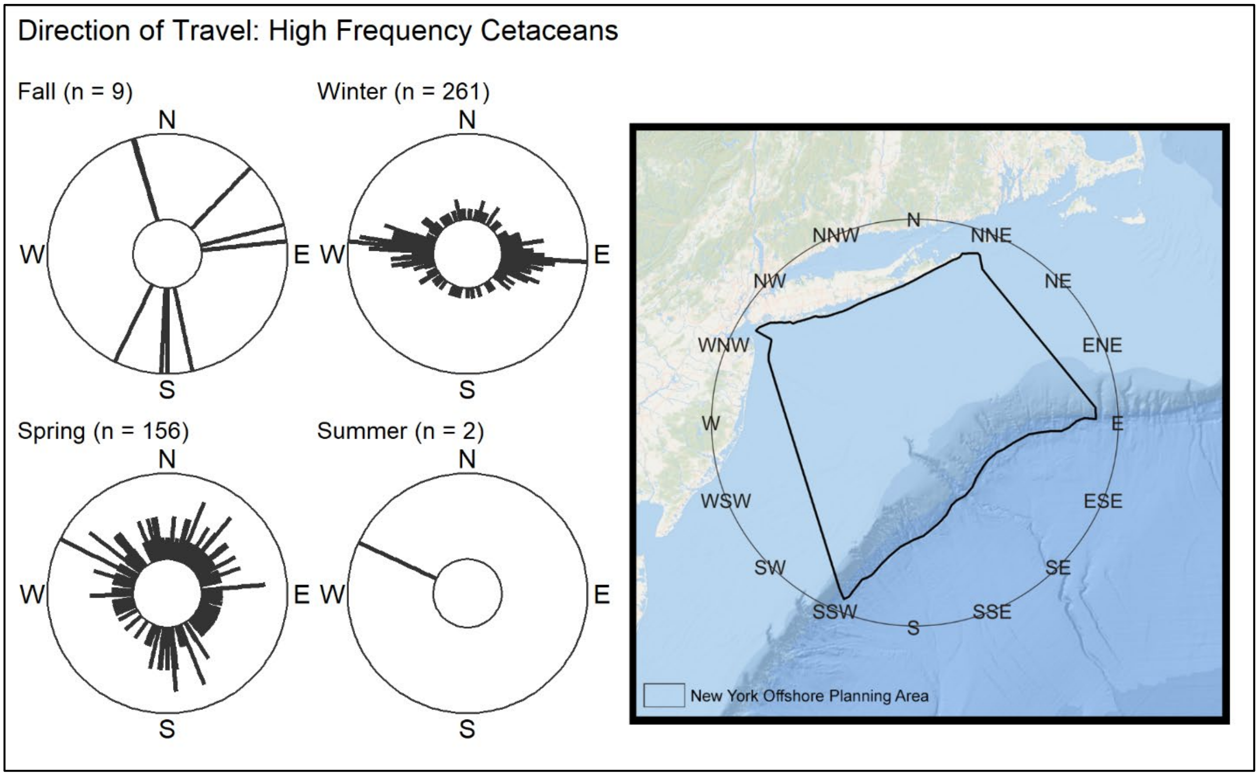


Figure 8. Spatial Distribution of Harbor Porpoise During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

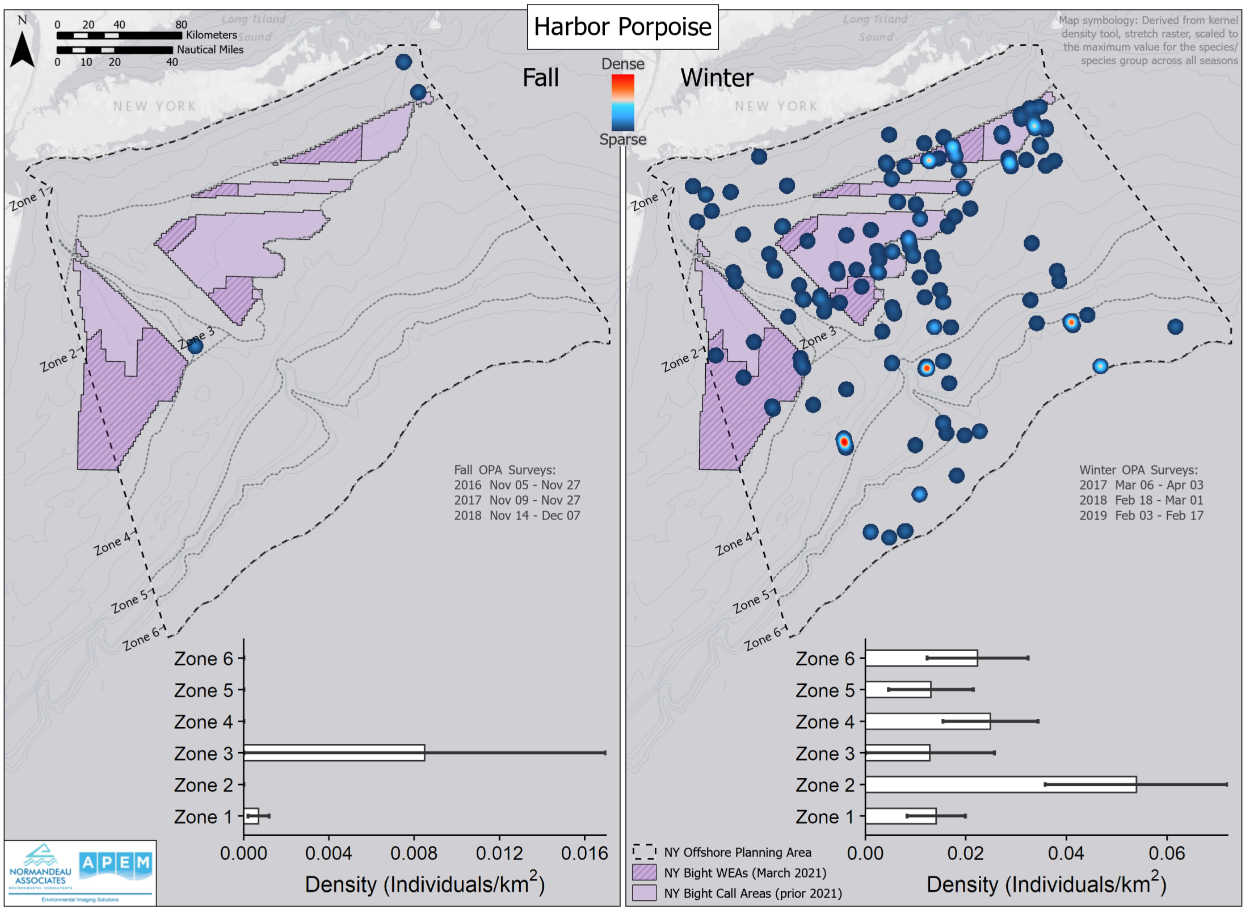


Figure 9. Spatial Distribution of Harbor Porpoise During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

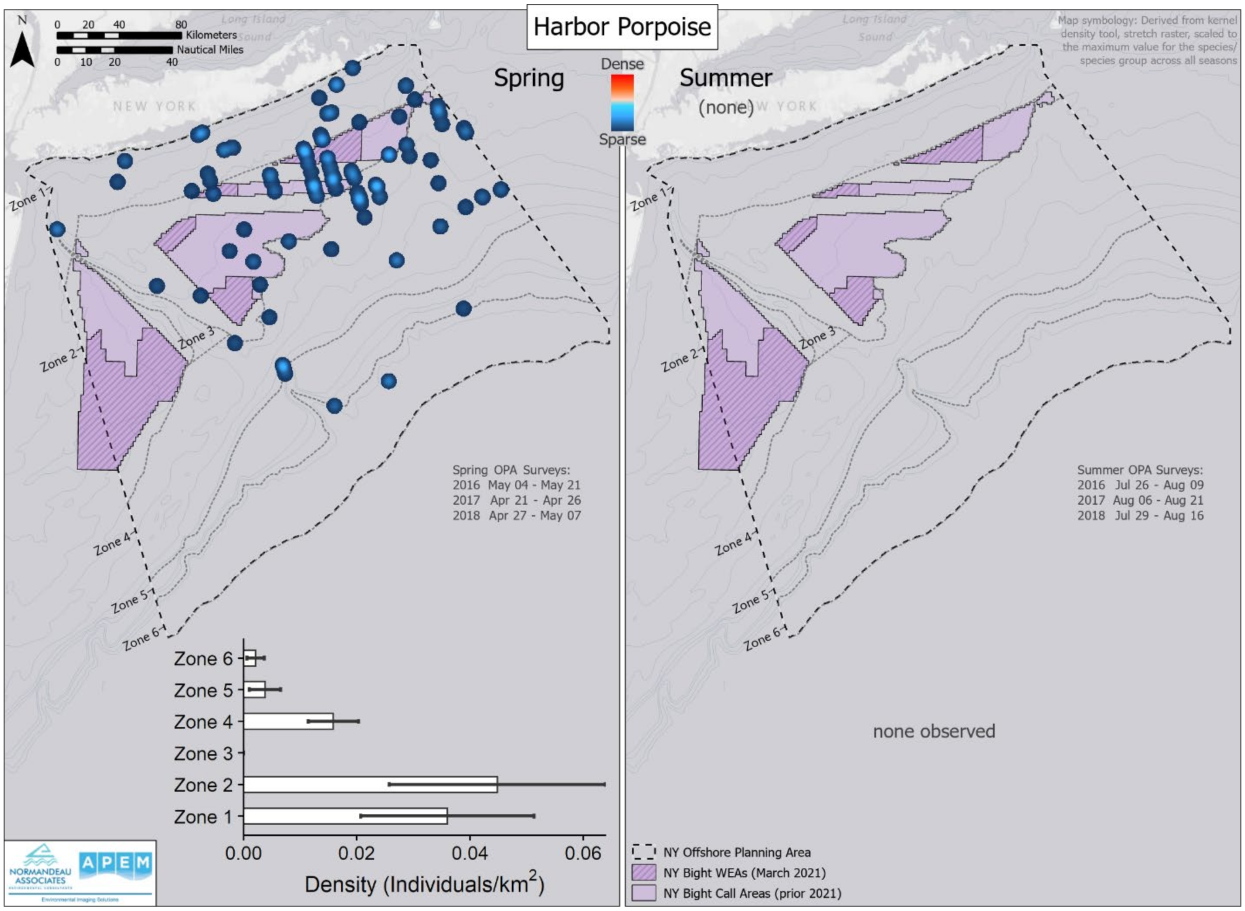


Figure 10. Direction of Travel of Harbor Porpoise for All Surveys

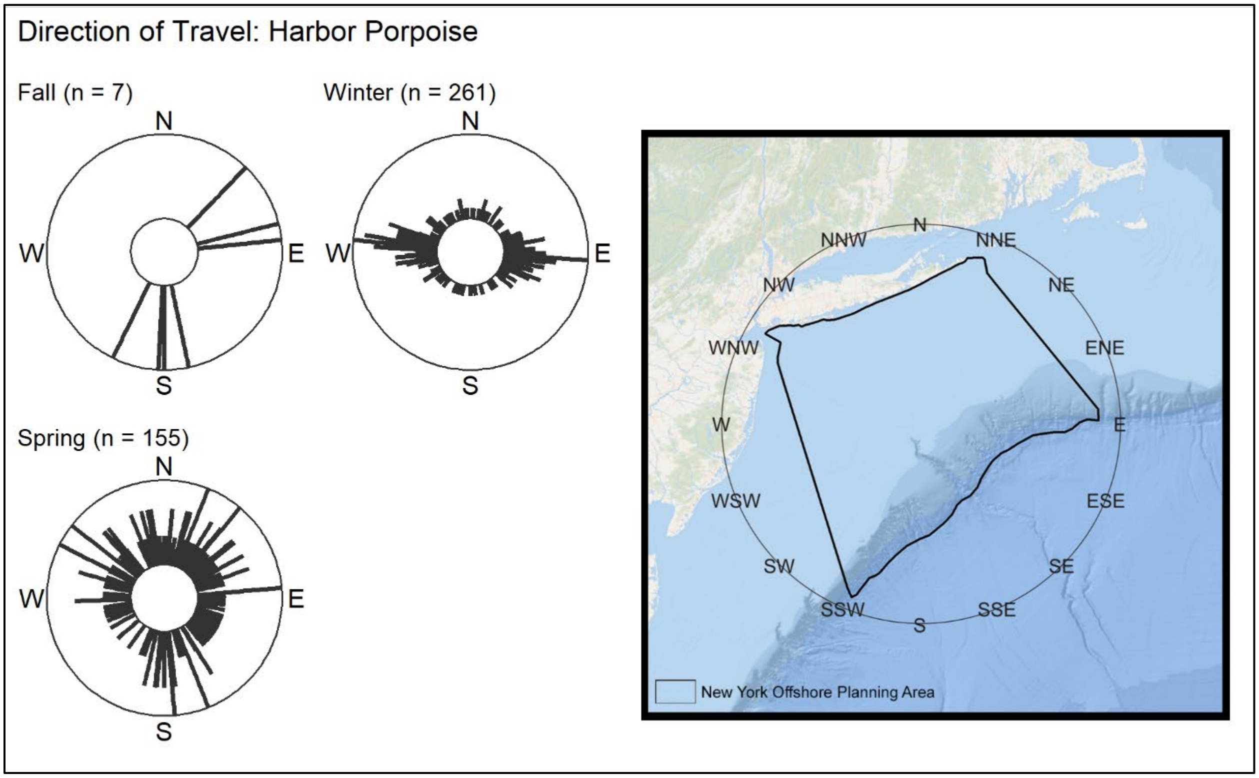
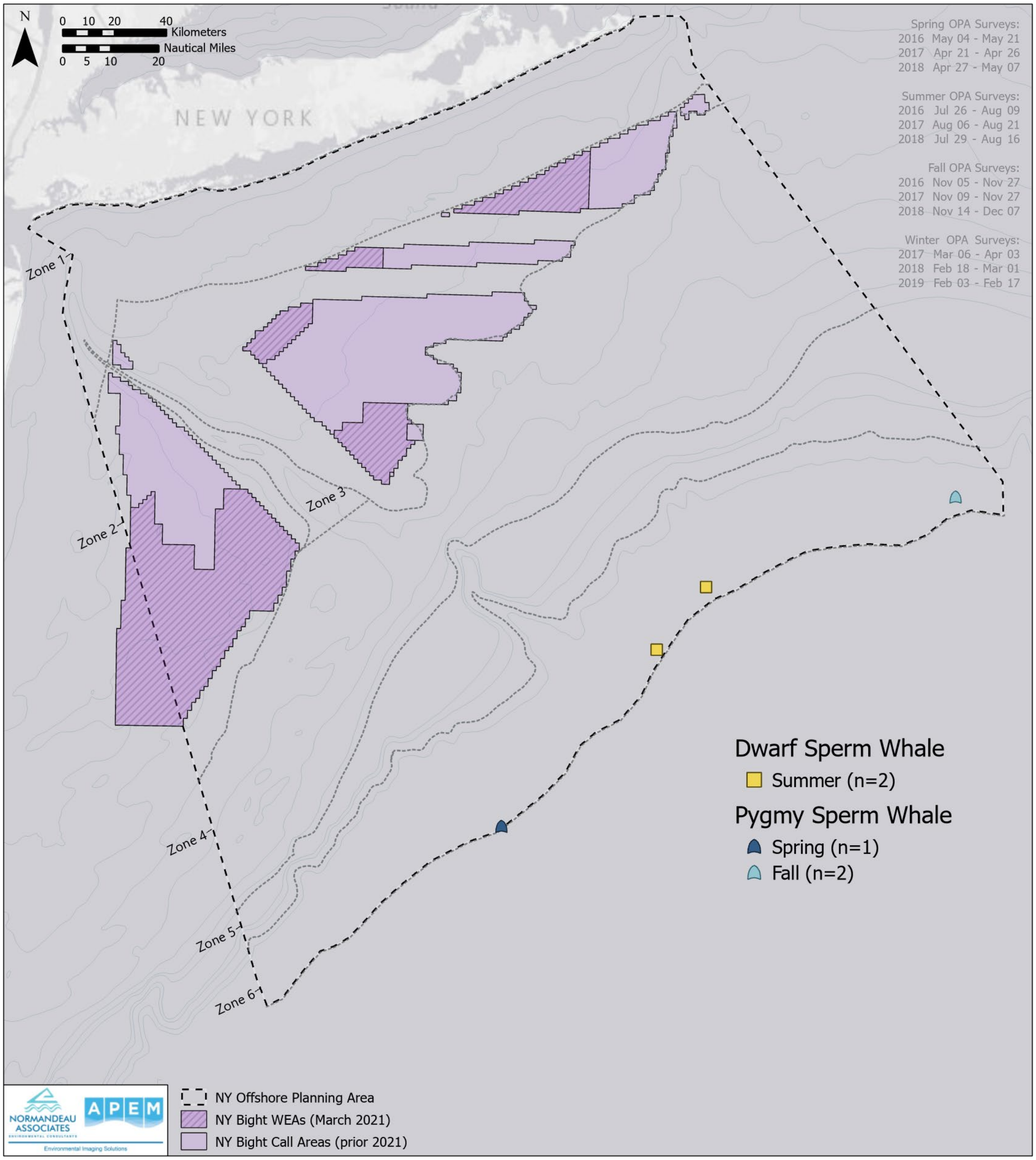


Figure 11. Spatial Distribution of High-frequency Cetacean Species with Fewer than 30 Occurrences Across All Surveys

The Fall pygmy sperm whale sighting of two individuals was of an adult and calf.



2.3.1.2 Mid-frequency Cetaceans

Mid-frequency cetaceans (n=14,896) were the most observed group of cetaceans, including the abundant dolphin group (Table 8). In total 13 sperm whales, 26 beaked whales, and 10,099 dolphins of nine species were observed (Table 2). Dolphins therefore drove spatial and temporal patterns of mid-frequency cetacean but also drove patterns when considering all cetaceans together. Mid-frequency cetacean density was relatively homogenous throughout the annual cycle. Density was greatest during Summer (n=4,445; $\bar{x} = 0.41 \pm 0.06$ individuals/km^2), followed by Fall (n=3,453; $\bar{x} = 0.40 \pm 0.09$ individuals/km^2), Spring (n=3,153; $\bar{x} = 0.39 \pm 0.07$ individuals/km^2), and Winter (n=3,870; $\bar{x} = 0.39 \pm 0.06$ individuals/km^2) (Figure 12, Figure 13). Across all surveys, cetacean density was consistently above the average of the OPA within the outer Zones 5 and 6 (Figure 12, Figure 13). During Fall, cetacean density was also high within Zone 3 (Figure 12). Overall mid-frequency cetaceans were more likely to move in a west or east direction throughout the annual cycle. There was a non-uniform distribution of travel directions during Fall ($t = 323.2$, $p < 0.001$), Winter ($t = 326.7$, $p < 0.001$), Spring ($t = 318.5$, $p < 0.001$) and Summer ($t = 328.3$, $p < 0.001$). During Fall surveys individuals exhibited a slight preference for west–southwest travel directions and west during Winter (Figure 14). During Spring surveys mid-frequency cetaceans exhibited a multimodal pattern of travel direction with most individuals traveling east or west; during Summer there was a pattern of travel to the east (Figure 14).

Pilot Whale (Unid.)

In total 296 pilot whales (unid.) were observed throughout the OPA with the greatest density observed during Summer (n=208; $\bar{x} = 0.05 \pm 0.03$ individuals/km^2), followed by Spring (n=51; $\bar{x} = 0.008 \pm 0.005$ individuals/km^2), and Fall (n=37; $\bar{x} = 0.004 \pm 0.002$ individuals/km^2); none were observed during Winter surveys (Figure 15, Figure 16). During all three seasons that pilot whales (unid.) were observed, individuals were isolated to the outer Zones 5 and 6. During Fall, travel direction was non-uniform ($t = 212.9$, $p < 0.001$) and individuals were infrequently observed traveling north. Travel direction was also non-uniform during Spring surveys ($t = 240.6$, $p < 0.001$) when the predominant direction of travel was to the east and northeast (Figure 17).

Common Dolphin

Common dolphins were among the most frequently observed species in the OPA (n=6,635) with 2,251 observed during Summer; 1,613 during Fall; 1,542 during Winter; and 1,229 during Spring. During Fall and Winter density was greatest within Zone 3, during Summer density was greatest within Zone 4 (n=1,473; $\bar{x} = 0.41 \pm 0.13$ individuals/km^2), and during Spring outer Zones 5 and 6 had the greatest mean density estimates (Figure 18, Figure 19). Common dolphins had a non-uniform distribution of travel directions during Fall ($t = 284.9$, $p < 0.001$), Winter ($t = 281.6$, $p < 0.001$), Spring ($t = 275.1$, $p < 0.001$), and Summer ($t = 302.6$, $p < 0.001$) (Figure 20). During Winter, common dolphins exhibited a pattern of travel to the west, during Spring individuals were observed traveling predominantly west or east ($t = 275.1$, $p < 0.001$), and during Summer most individuals headed to the east (Figure 20).

Risso's Dolphin

Risso's dolphin density was greatest during Summer surveys (n=535; $\bar{x} = 0.07 \pm 0.02$ individuals/km^2), followed by Spring (n=450; $\bar{x} = 0.05 \pm 0.01$ individuals/km^2), Fall (n=245; $\bar{x} = 0.03 \pm 0.02$ individuals/km^2), and Winter (n=135; $\bar{x} = 0.02 \pm 0.004$ individuals/km^2) (Figure 21, Figure 22). Observations were isolated to the outer zones with Zone 6 having the greatest density across all seasons (Figure 21, Figure 22). Risso's dolphins exhibited non-uniform distributions of travel direction during Fall ($t = 302.6$, $p < 0.001$) when there was a slight pattern of travel to the southwest and east and non-uniform distributions of travel direction during Summer ($t = 302.6$, $p < 0.001$) when individuals exhibited a traveling bias toward the southeast and southwest. During Winter ($t = 302.6$, $p < 0.001$), and Spring ($t = 302.6$, $p < 0.001$) travel direction was non-uniform and did not exhibit a clear pattern of travel (Figure 23).

Atlantic Spotted Dolphin

Nearly 92% of Atlantic spotted dolphins were observed during Fall (n=54; $\bar{x} = 0.009 \pm 0.008$ individuals/km^2), the rest were observed during Spring (n=5; $\bar{x} < 0.001$ individuals/km^2) (Figure 24). During Fall surveys, all 54 Atlantic spotted dolphins were observed in Zone 6 resulting in a zone density of $\bar{x} = 0.05 \pm 0.04$ individuals/km^2; however, variance was high because most sightings occurred within a single transect along the southern tip of the OPA (Figure 24). Direction of travel was non-uniform during the Fall ($t = 268.0$, $p < 0.001$) with most individuals traveling east, and all five individuals observed during the Spring traveled to the southeast (Figure 25).

Striped Dolphin

Striped dolphins were one of the few marine mammal species observed with the greater density estimates during Winter (n=365; $\bar{x}$ = 0.04 ± 0.02 individuals/km^2) than during Fall (n=75; $\bar{x}$ = 0.01 ± 0.01 individuals/km^2), Spring (n=85; $\bar{x}$ = 0.01 ± 0.01 individuals/km^2), and Summer (n=37; $\bar{x}$ = 0.007 ± 0.006 individuals/km^2) (Figure 26, Figure 27). During Winter all observations were isolated to Zone 6 where density was $\bar{x}$ = 0.18 ± 0.1 (Figure 28), and across all seasons striped dolphins were never observed outside of the outer Zones 4, 5, and 6. Direction of travel was non-uniform and unimodal during Fall ($t = 305.6$, $p < 0.001$) and Spring ($t = 279.1$, $p < 0.001$) (Figure 28). During Fall, striped dolphin traveled to the southeast, and during Spring individuals were observed traveling south. Travel direction was non-uniform during Winter ($t = 305.6$, $p < 0.001$) and Summer ($t = 211.9$, $p < 0.001$) and was biased to the east (Figure 28).

Common Bottlenose Dolphin

Common bottlenose dolphins were most frequently observed during Summer (n=387) and Spring (n=344) in the OPA, followed by Winter (n=235) and Fall (n =128) (Figure 29, Figure 30). Across all seasons and zones, mean density was greatest in Zone 5 during Spring surveys (Figure 30). During Summer, density was relatively homogenous across zones compared to other seasons, although density was above average within the outer Zones 4, 5, and 6 (Figure 30). Summer was the only season that common bottlenose dolphins were observed within Zone 1 (i.e., individuals observed near-shore) likely the Northern Migratory Coastal Stock, which differs from the offshore stock that occur in the outer zones. Direction of travel was non-uniform and biased to the southeast during Spring ($t = 183.3$, $p < 0.001$), Summer ($t = 189.8$, $p < 0.001$), and Fall ($t = 205.1$, $p < 0.001$). During Winter ($t = 200.7$, $p < 0.001$) travel direction was non-uniform and biased toward the northeast and southeast (Figure 31).

Common/Atlantic White-sided Dolphin

Of the 54 individuals observed in the common/Atlantic white-sided dolphin species group, most were observed in the Spring 2018 (n=22) and Winter 2016–2017 (n=16) surveys. Other observations were in Summer 2018 (n=5), Fall 2018 (n=5), Winter 2018–2019 (n=2), and Spring 2017 (n=4) (Table 3). Across all seasons and zones, mean density was greatest in Zone 4 during Fall (n=5; $\bar{x}$ = 0.002 ± 0.002 individuals/km^2), Winter (n=18; $\bar{x}$ = 0.001 ± 0.0007 individuals/km^2), and Summer (n=5; $\bar{x}$ < 0.001 individuals/km^2) surveys (Figure 32, Figure 33). During Spring (n=26; $\bar{x}$ = 0.005 ± 0.004 individuals/km^2), density was greatest in Zone 6 (Figure 33). Direction of travel was biased toward the east and west during Spring and Winter (Figure 34).

Mid-frequency Cetaceans with Fewer than 30 Observations

Twelve sperm whales and 26 beaked whales (unid.) were observed in Zone 6 across all seasons. One additional sperm whale was observed in Zone 1 during Winter (Figure 35).

Figure 12. Spatial Distribution of Mid-frequency Cetaceans During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

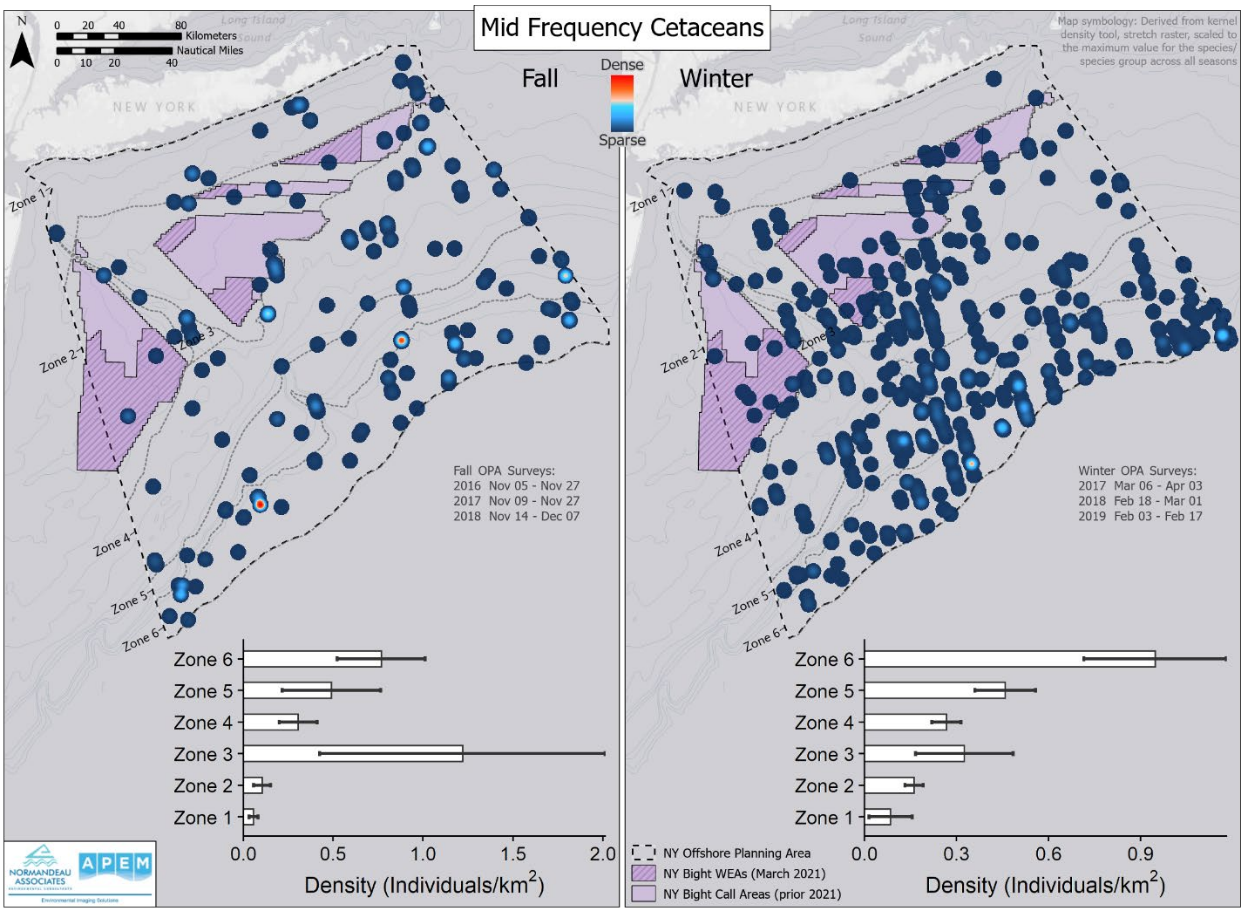


Figure 13. Spatial Distribution of Mid-frequency Cetaceans During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

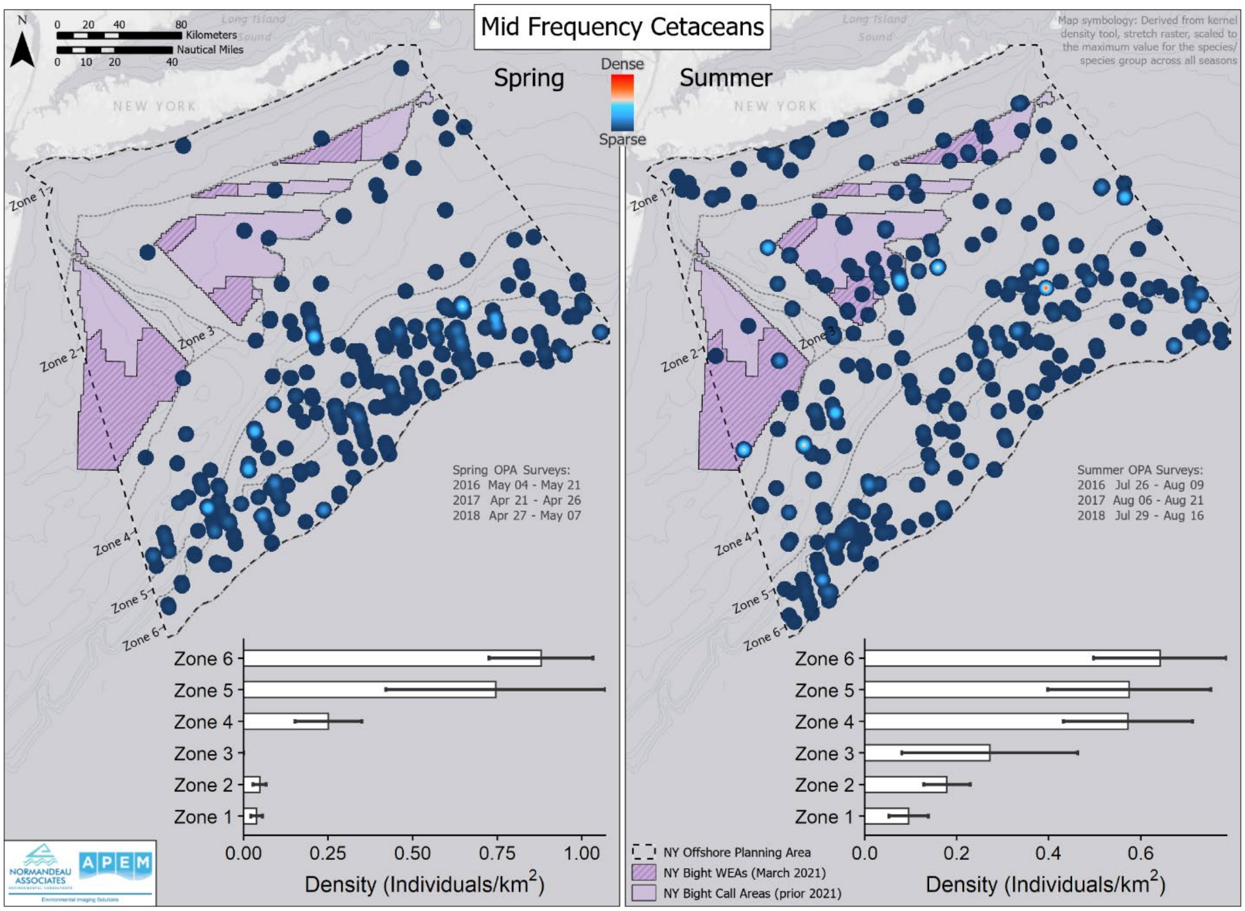


Figure 14. Direction of Travel of Mid-frequency Cetaceans for All Surveys

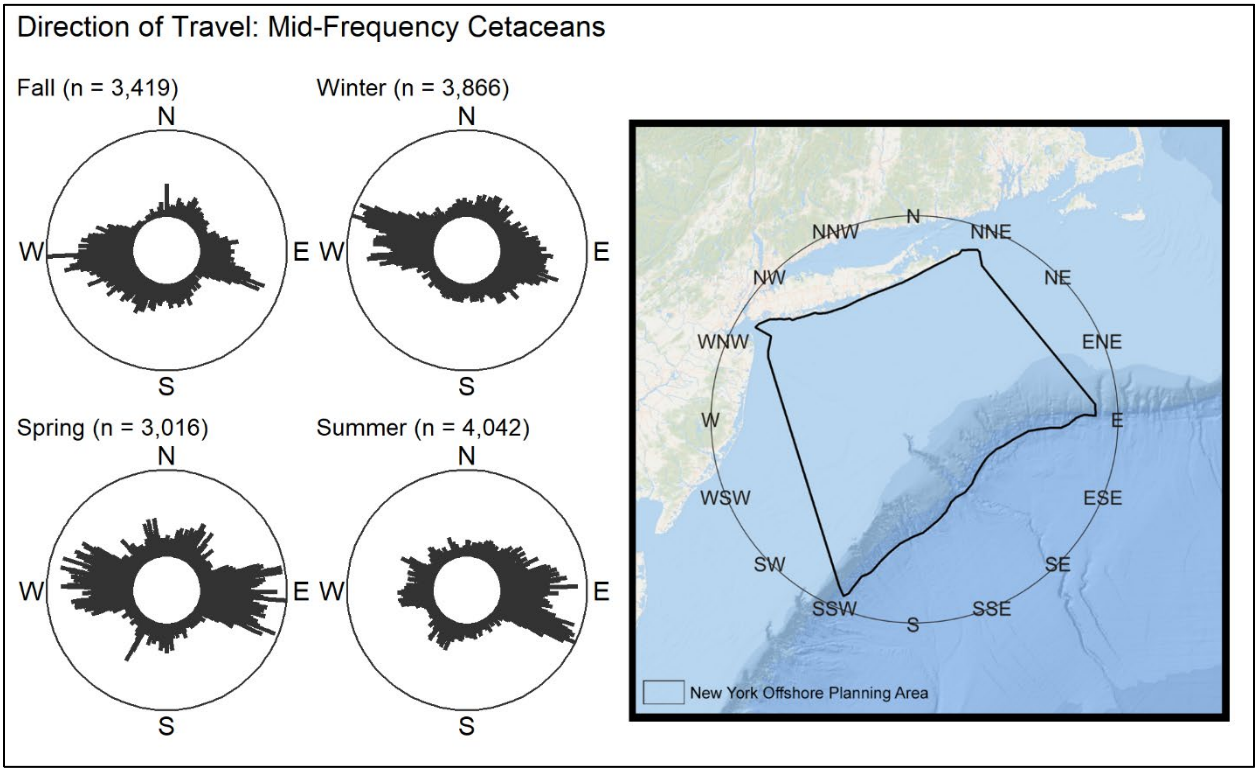


Figure 15. Spatial Distribution of Pilot Whales (Unid.) During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

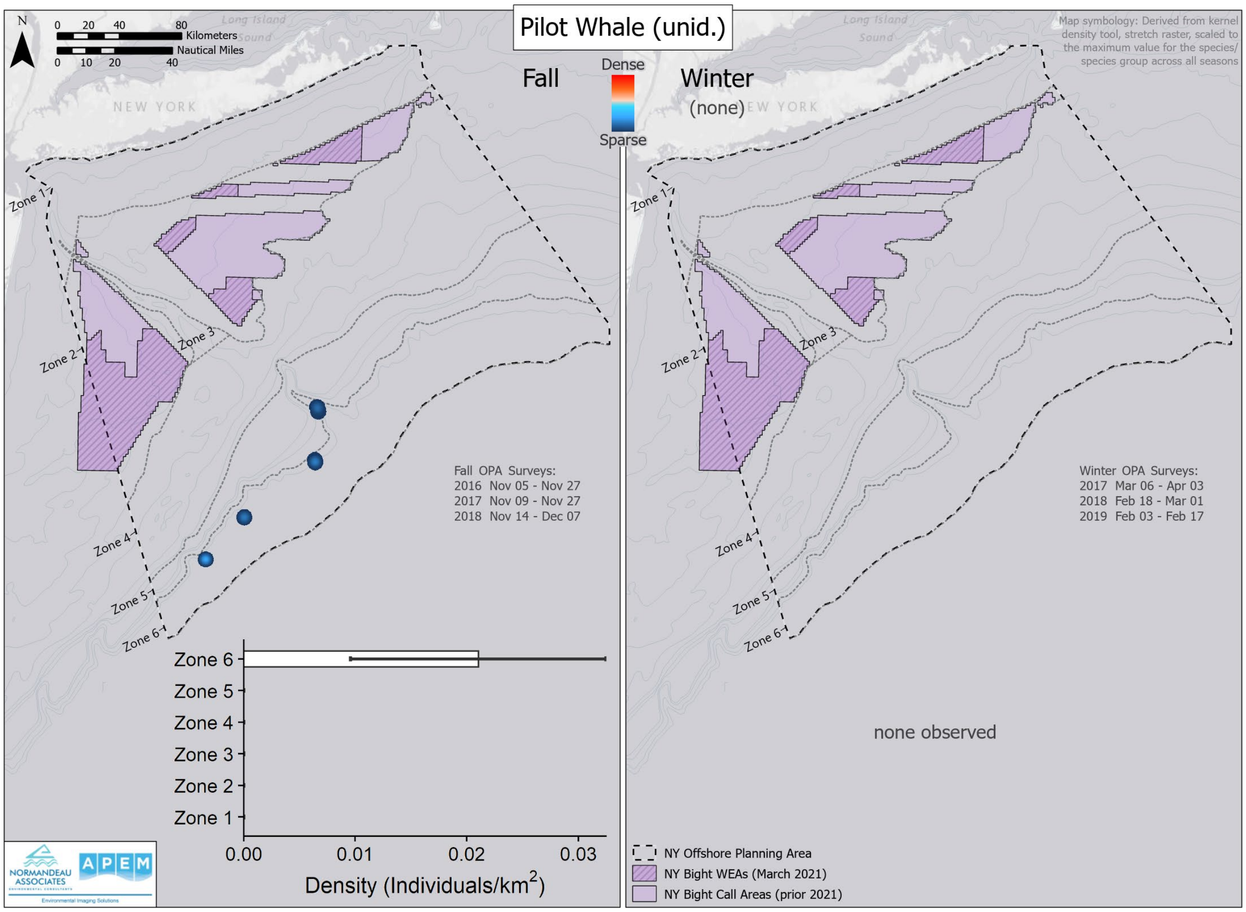


Figure 16. Spatial Distribution of Pilot Whales (Unid.) During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

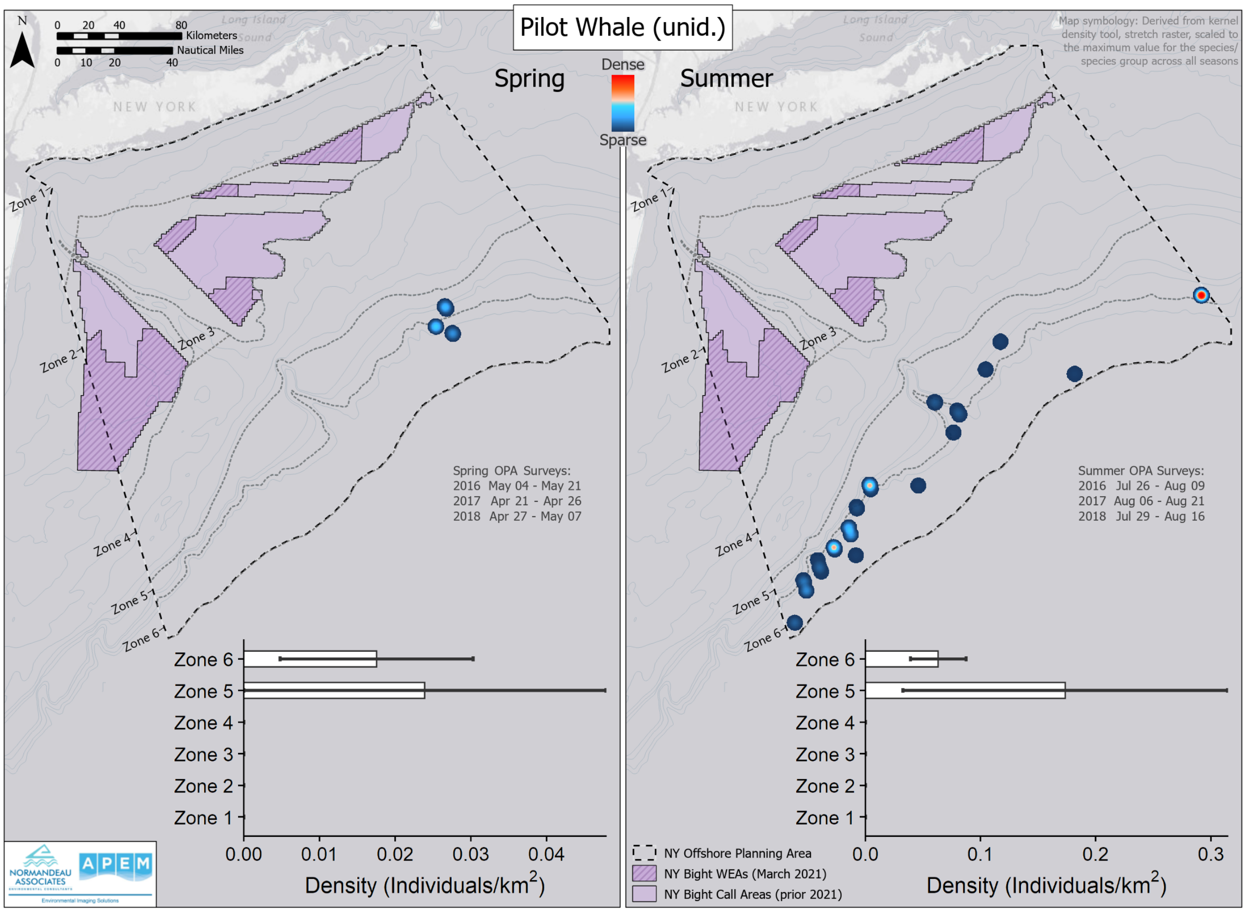


Figure 17. Direction of Travel of Pilot Whales (unid.) for All Surveys

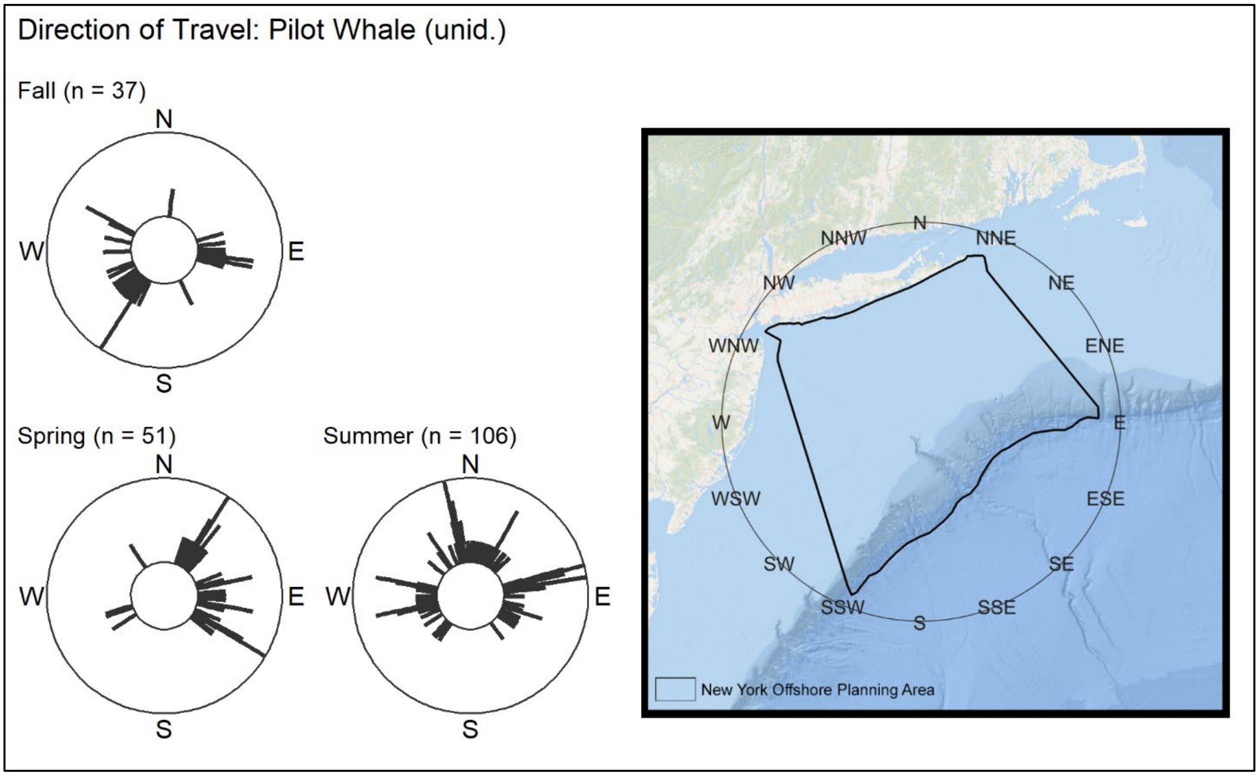


Figure 18. Spatial Distribution of Common Dolphins During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

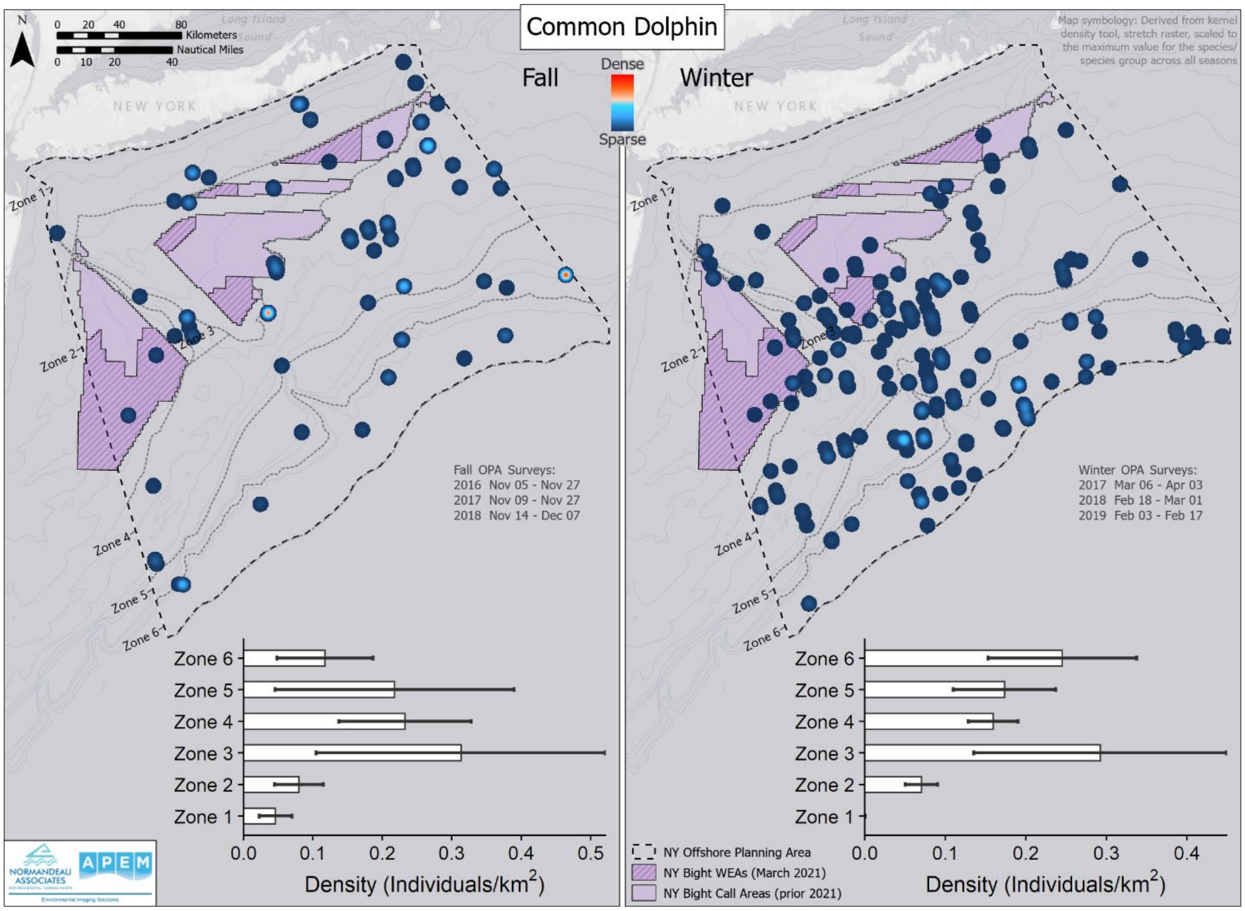


Figure 19. Spatial Distribution of Common Dolphins During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

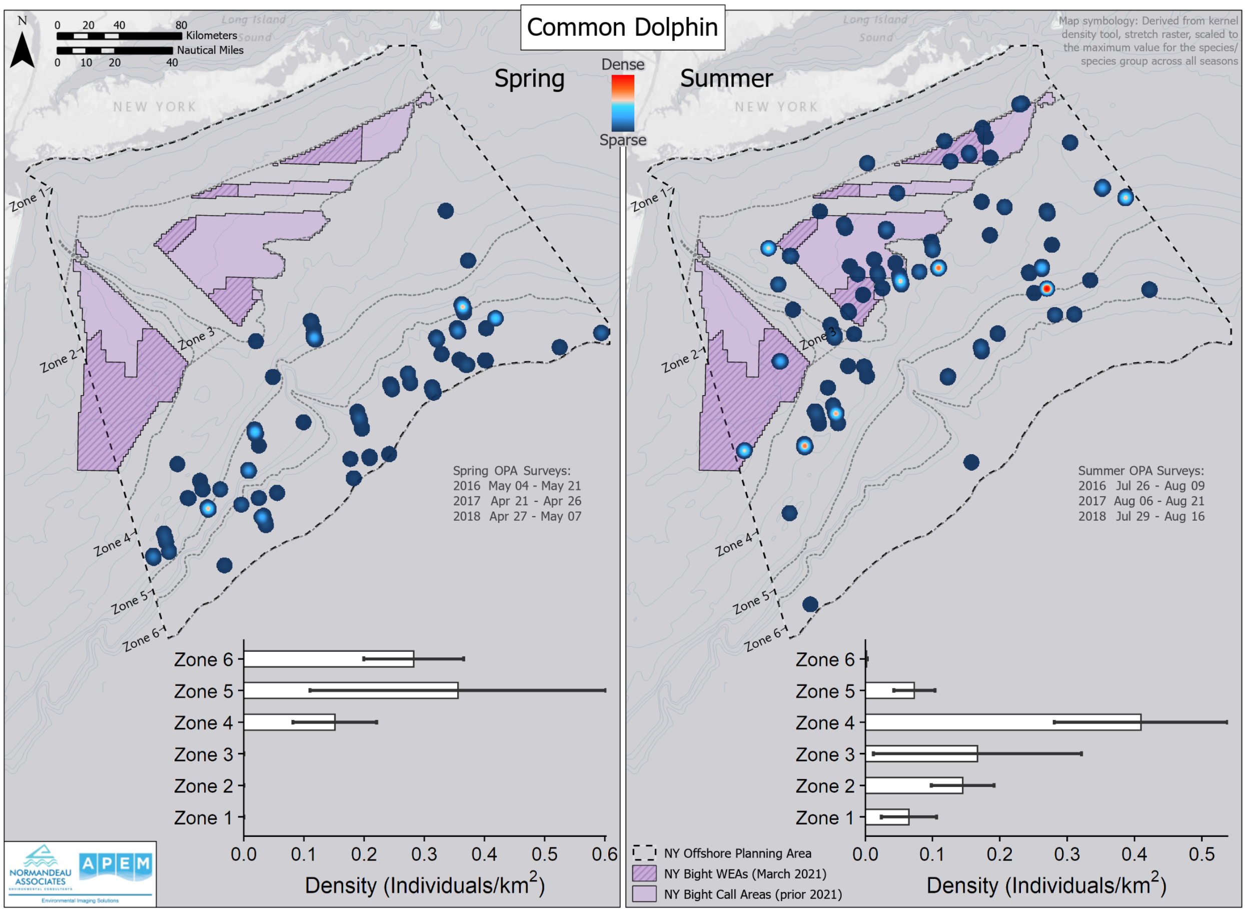


Figure 20. Direction of Travel of Common Dolphins for All Surveys

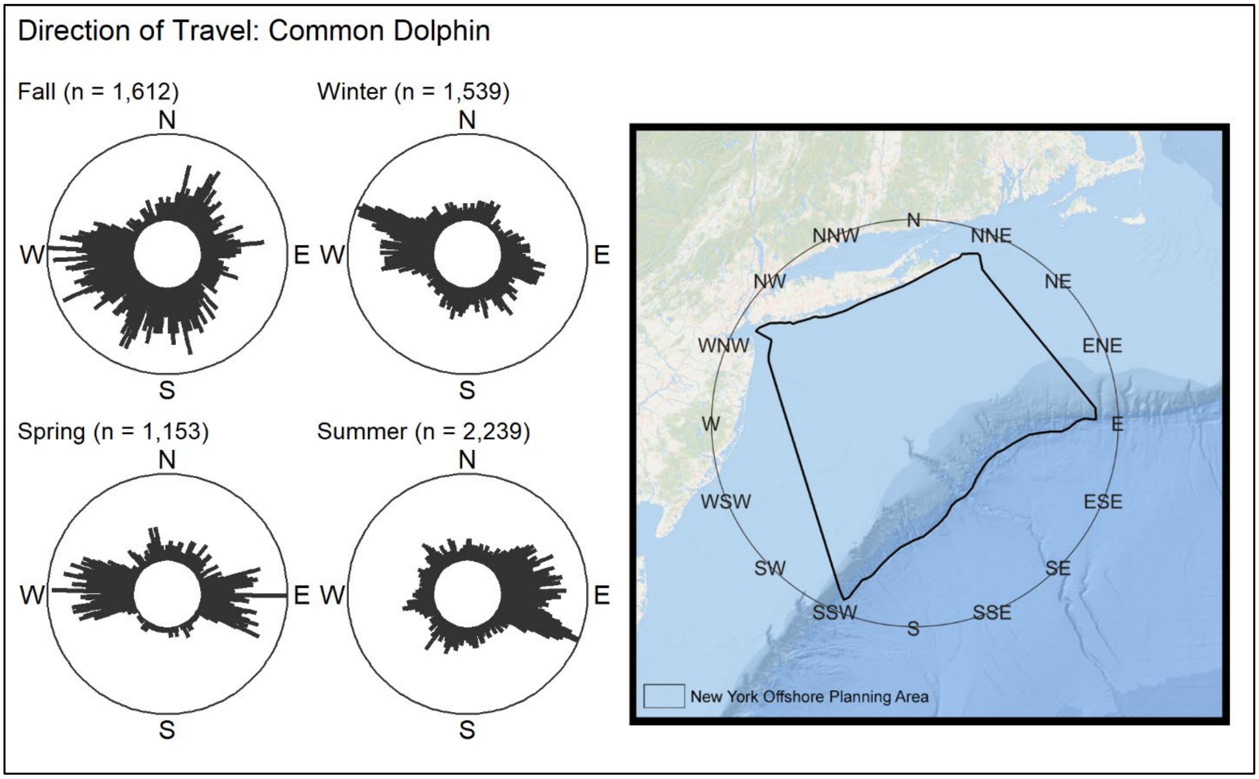


Figure 21. Spatial Distribution of Risso's Dolphins During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

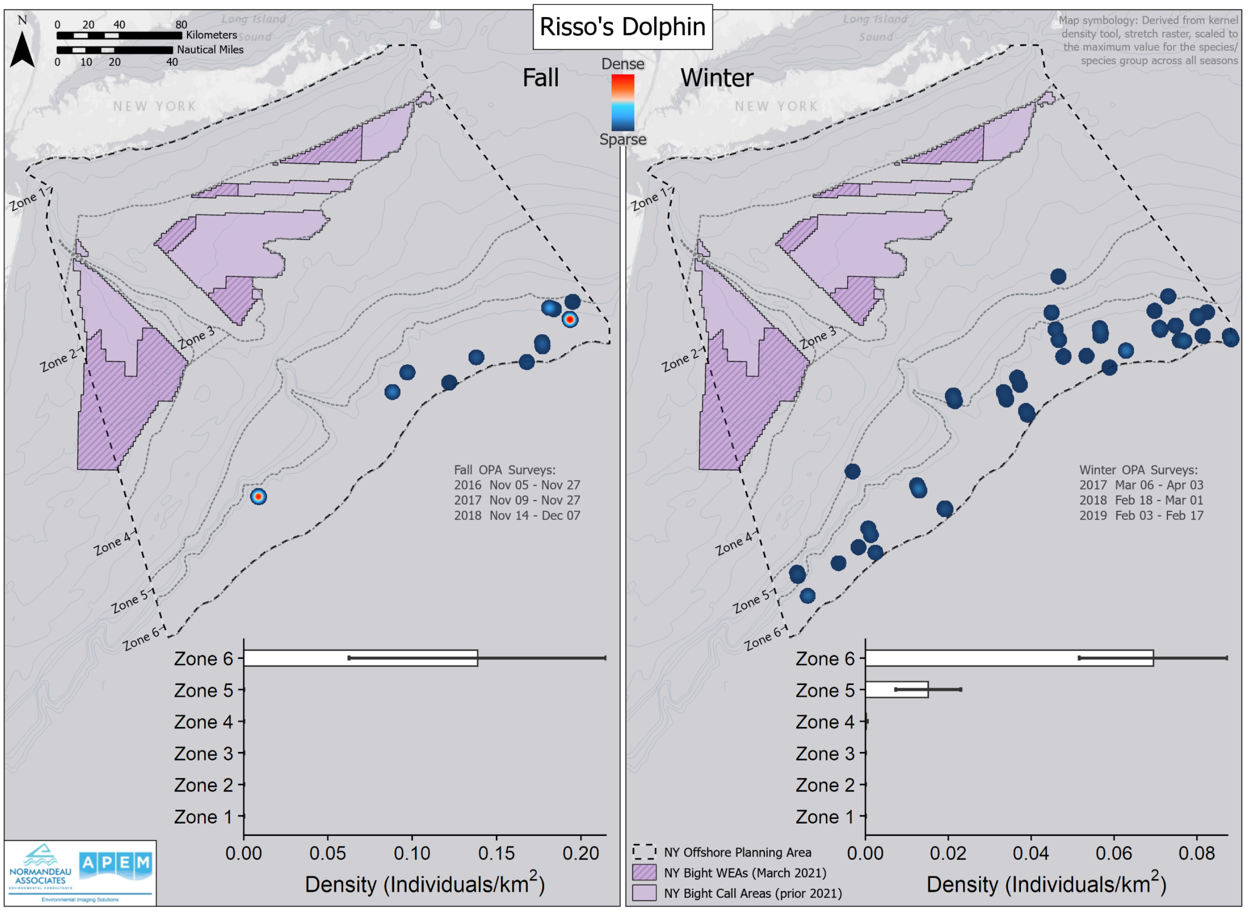


Figure 22. Spatial Distribution of Risso's Dolphins During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

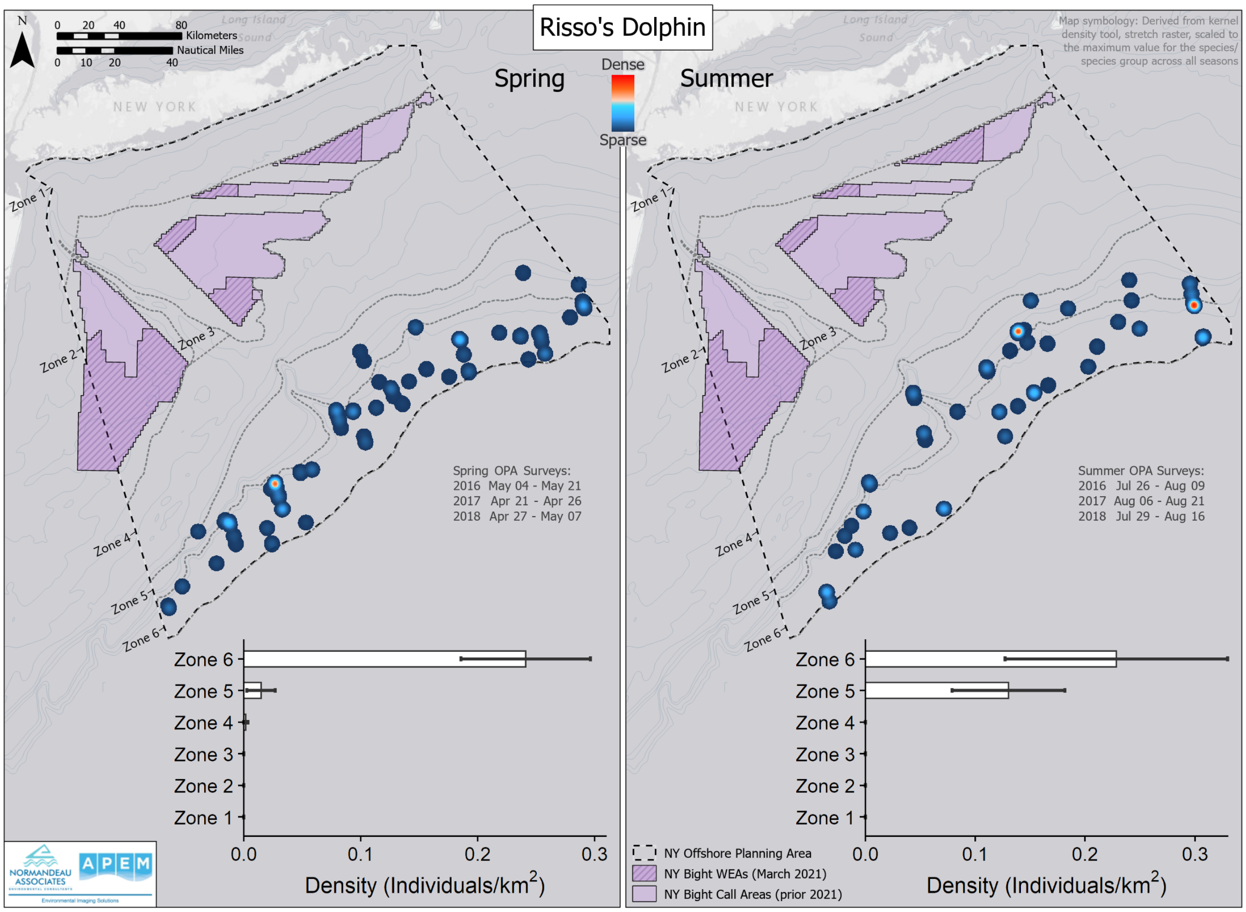


Figure 23. Direction of Travel of Risso's Dolphin for All Surveys

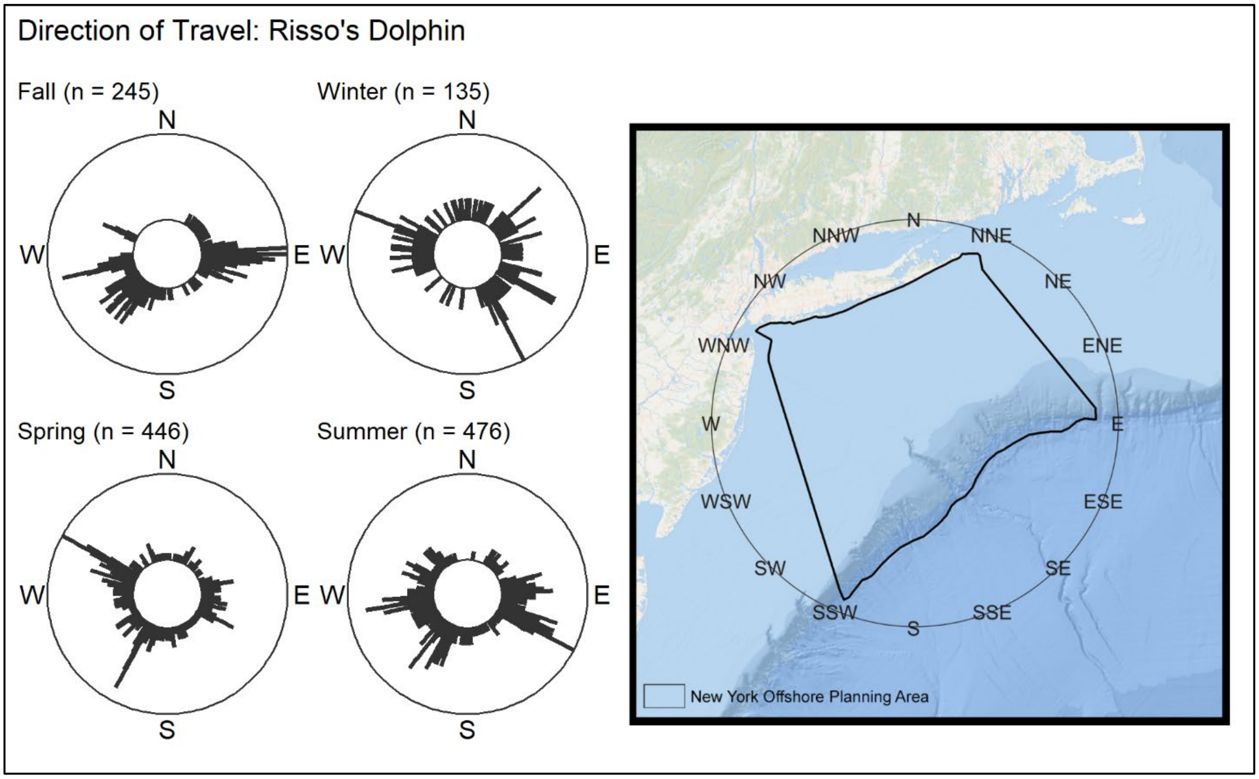


Figure 24. Spatial Distribution of Atlantic Spotted Dolphin During Fall and Spring by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

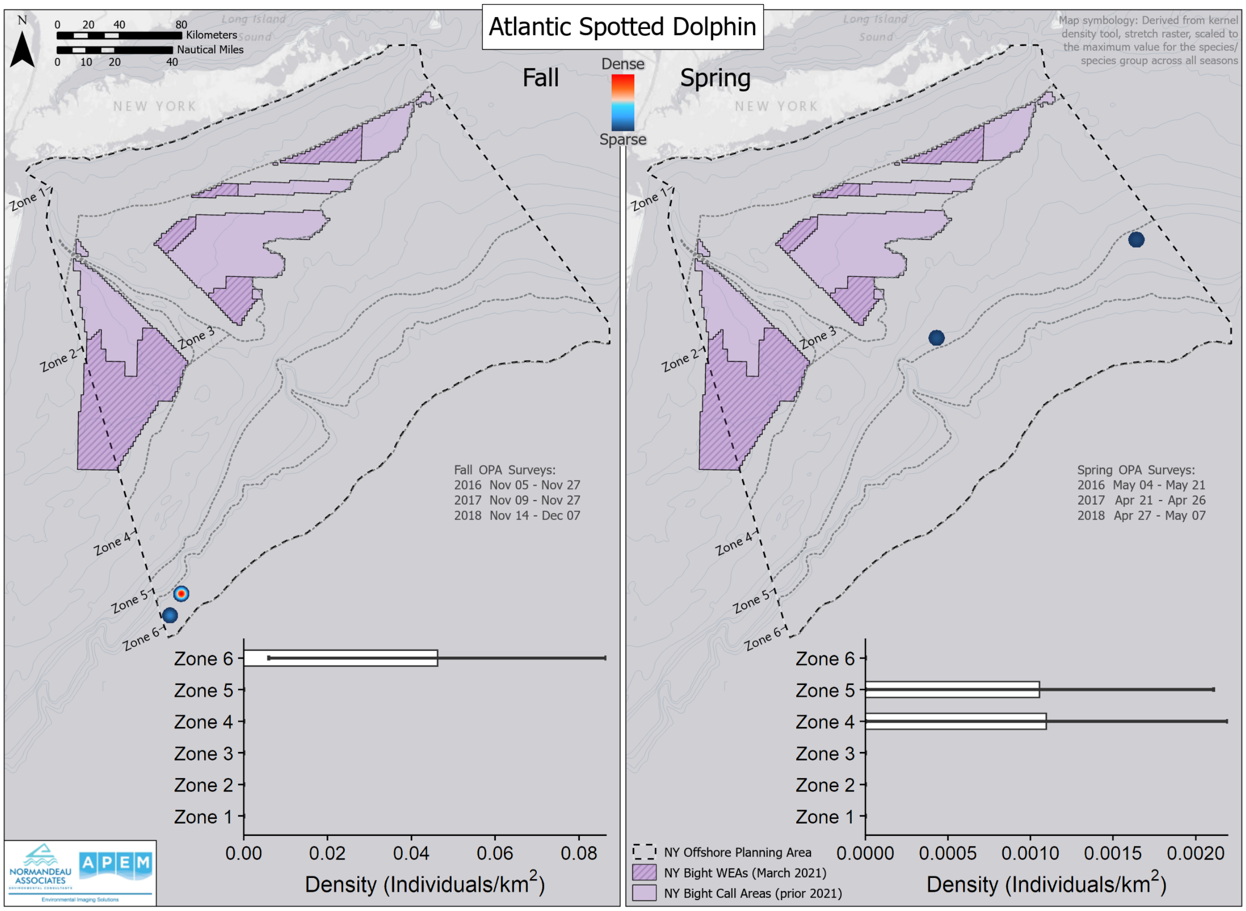


Figure 25. Direction of Travel of the Atlantic Spotted Dolphin for All Surveys

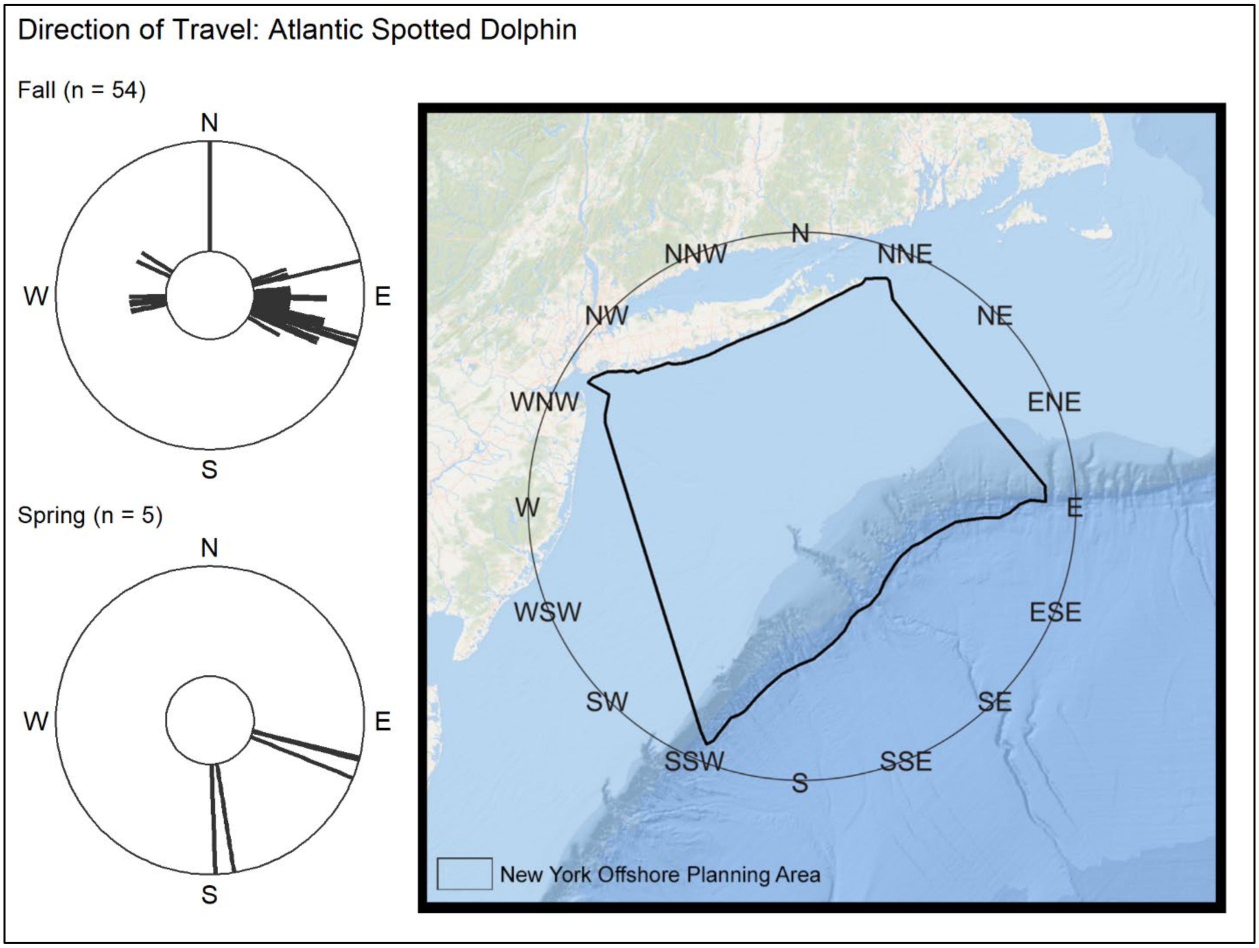


Figure 26. Spatial Distribution of Striped Dolphins During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

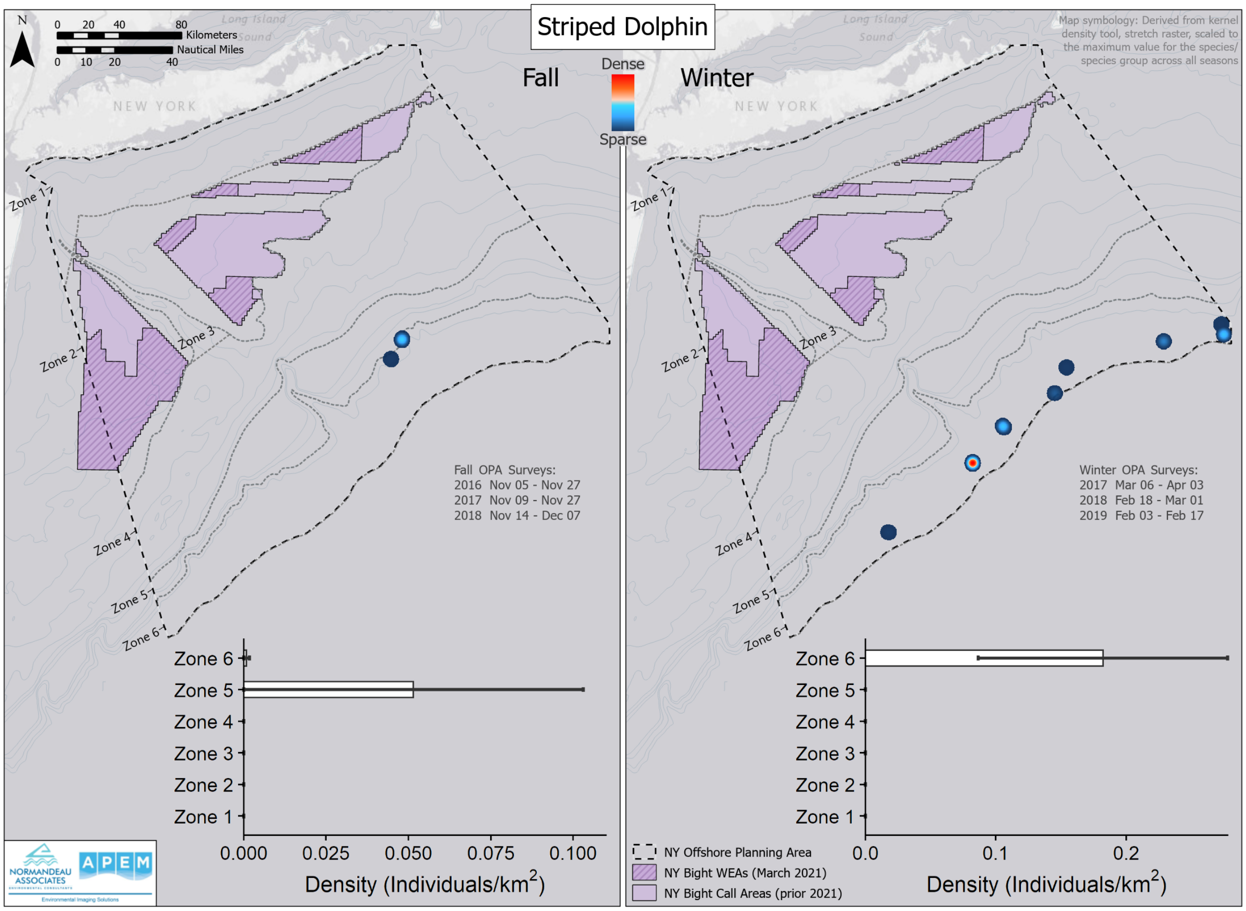


Figure 27. Spatial Distribution of Striped Dolphins During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

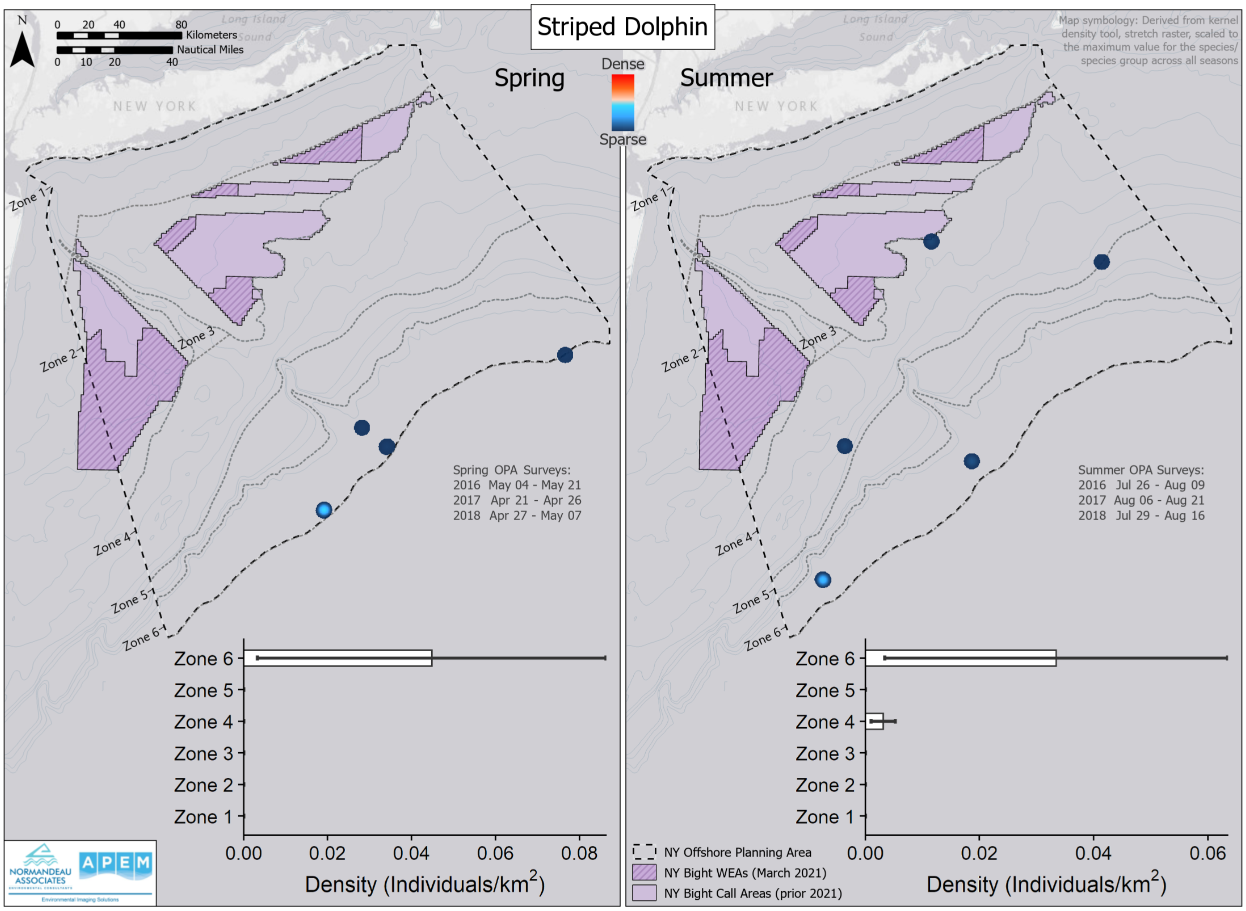


Figure 28. Direction of Travel of Striped Dolphin for All Surveys

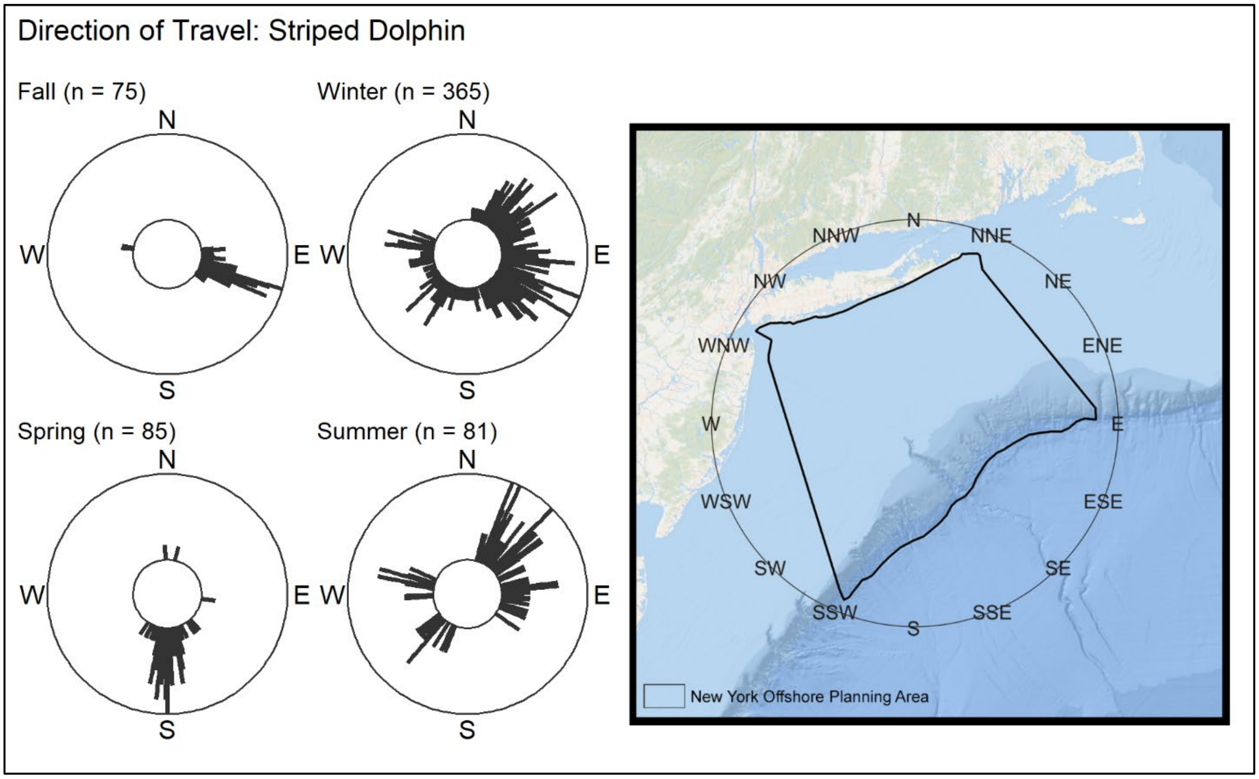


Figure 29. Spatial Distribution of Common Bottlenose Dolphins During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

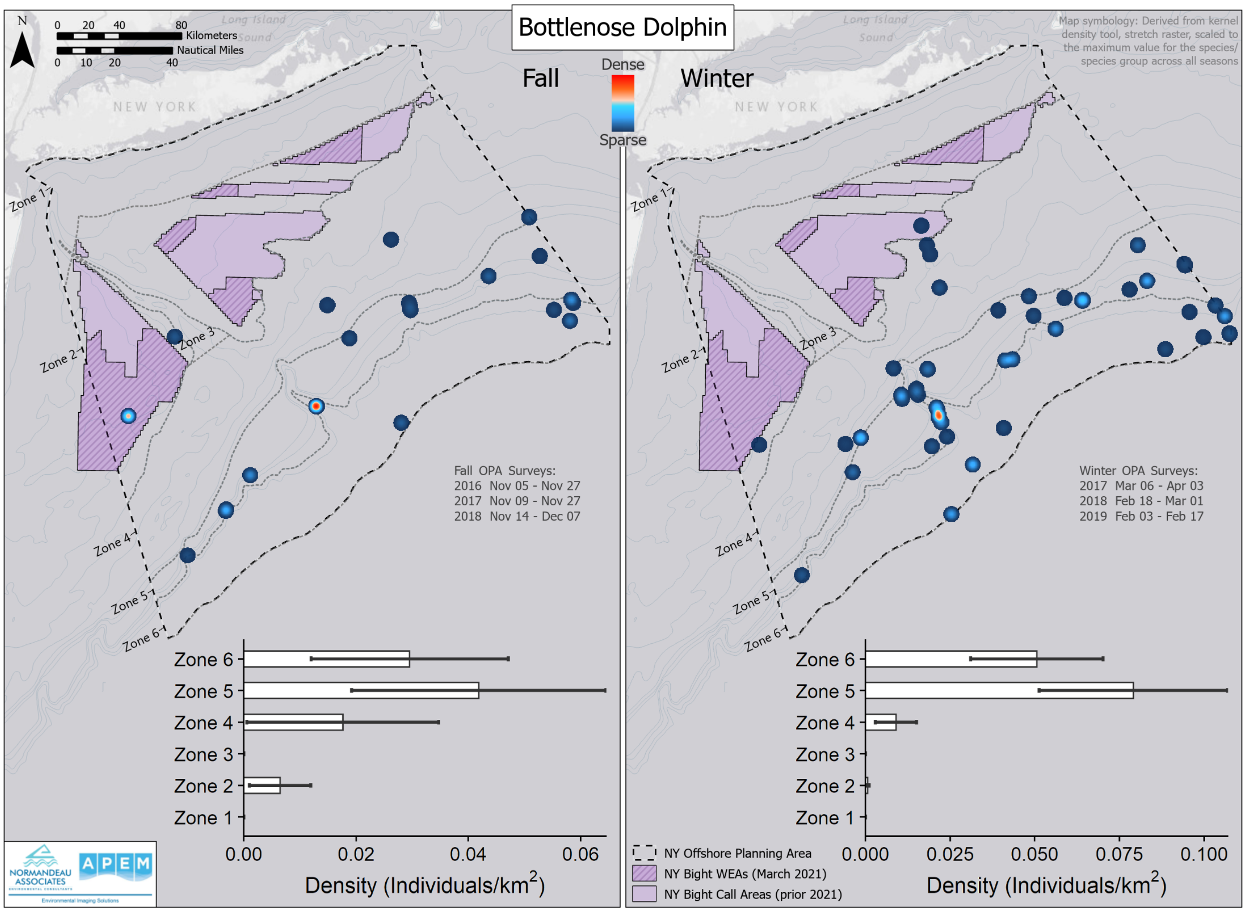


Figure 30. Spatial Distribution of Common Bottlenose Dolphins During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

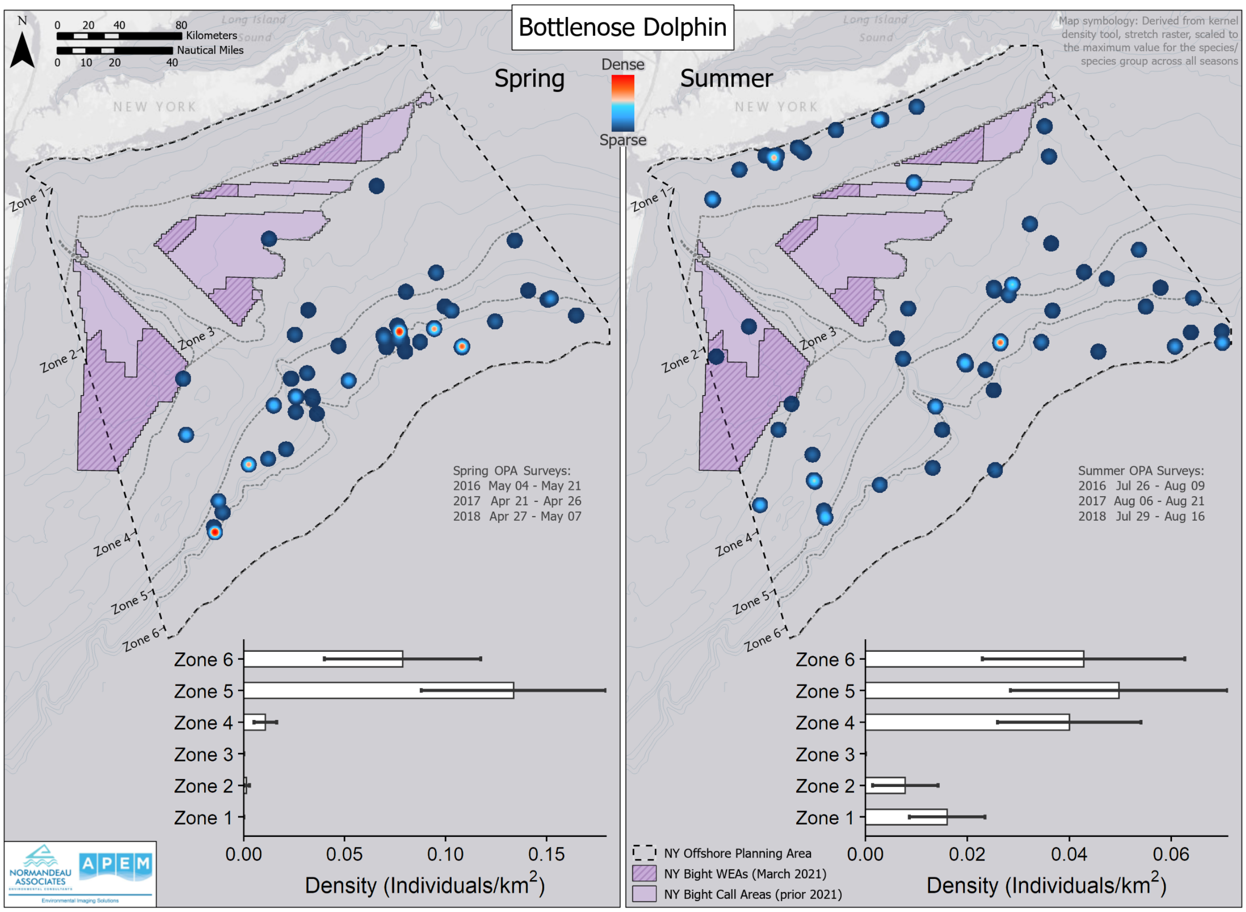


Figure 31. Direction of Travel of Common Bottlenose Dolphins for All Surveys

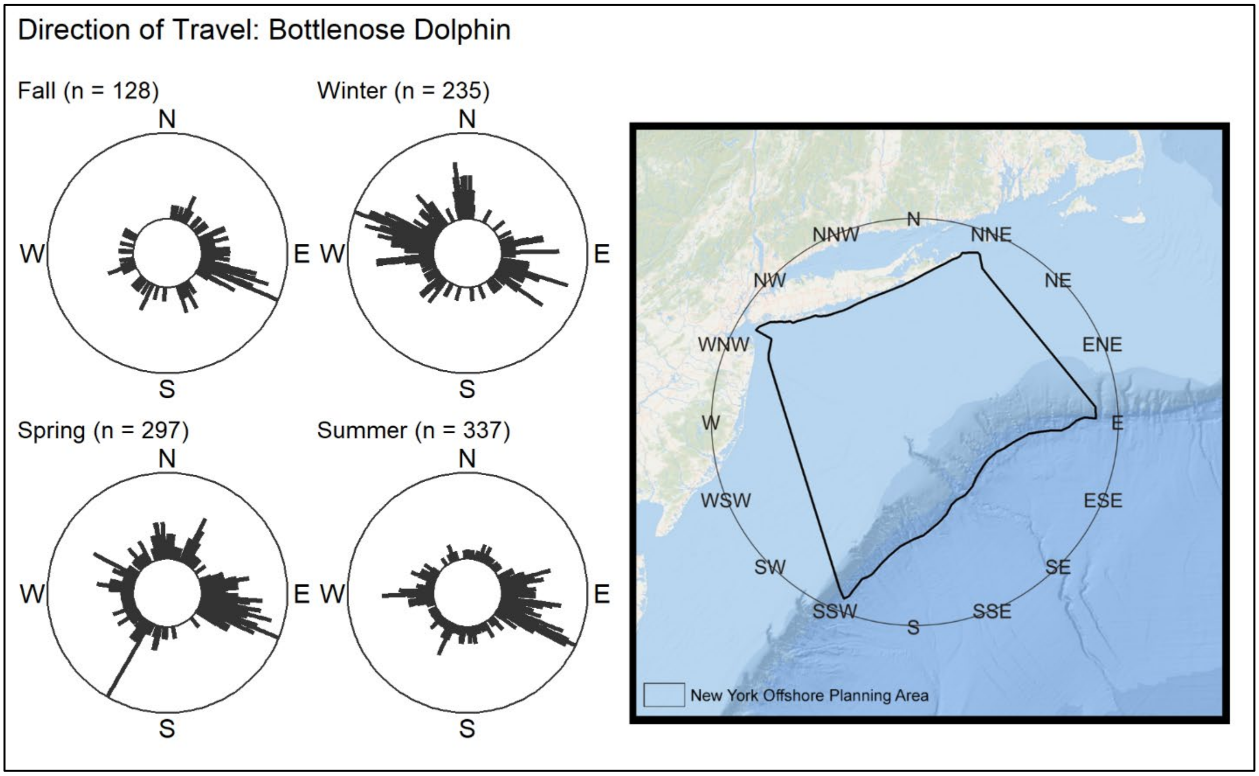


Figure 32. Spatial Distribution of Common/Atlantic White-sided Dolphins During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

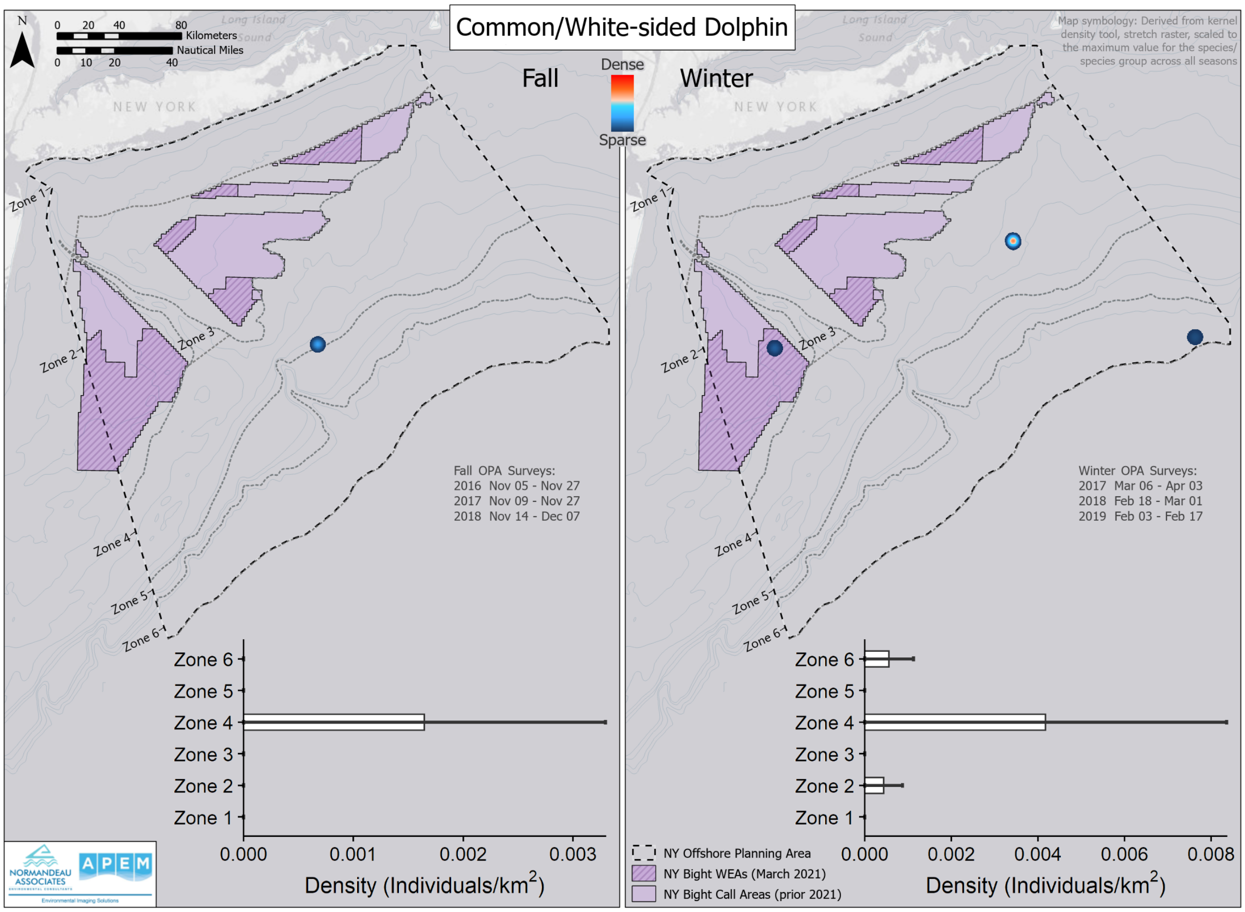


Figure 33. Spatial Distribution of Common/White-sided Dolphins During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

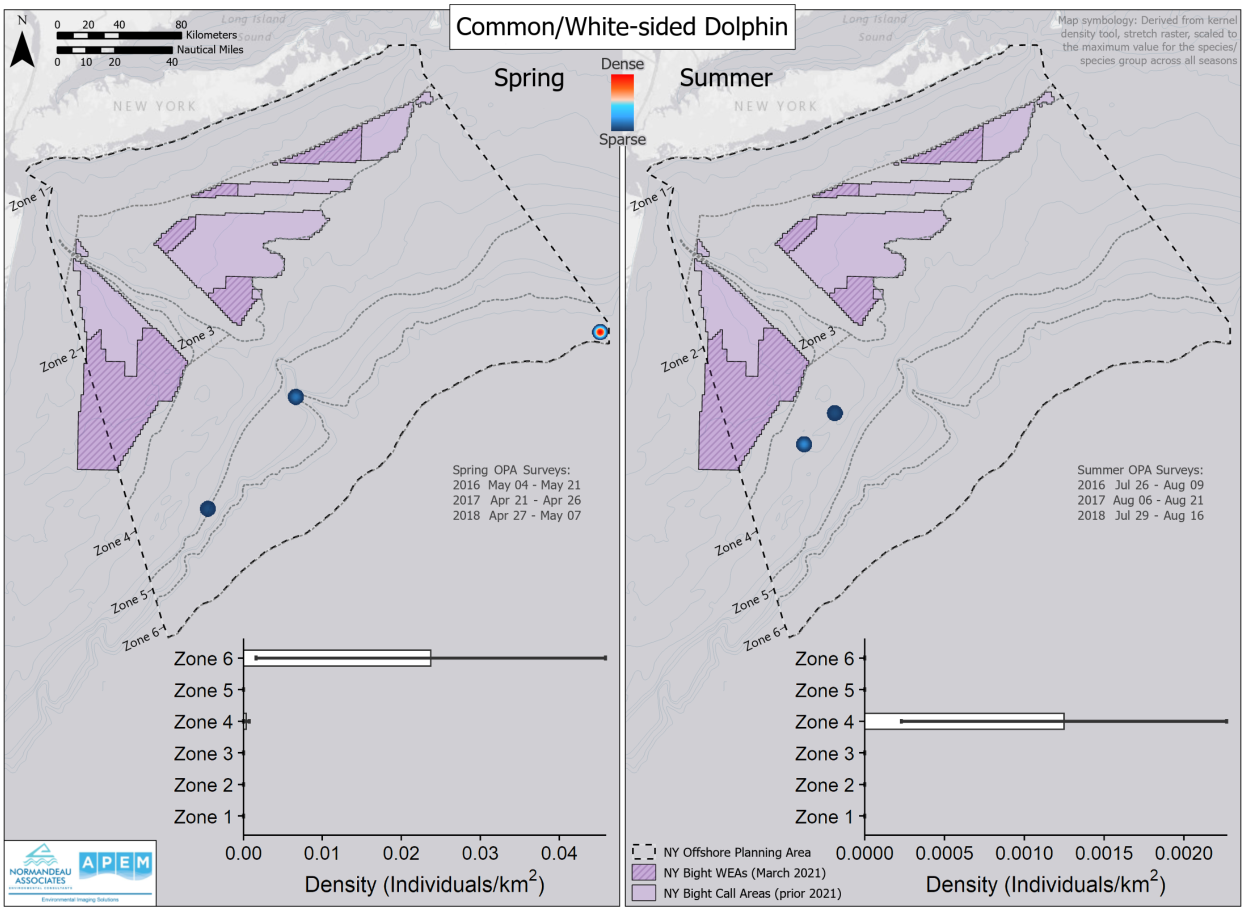


Figure 34. Direction of Travel of Common/White-sided Dolphins for All Surveys

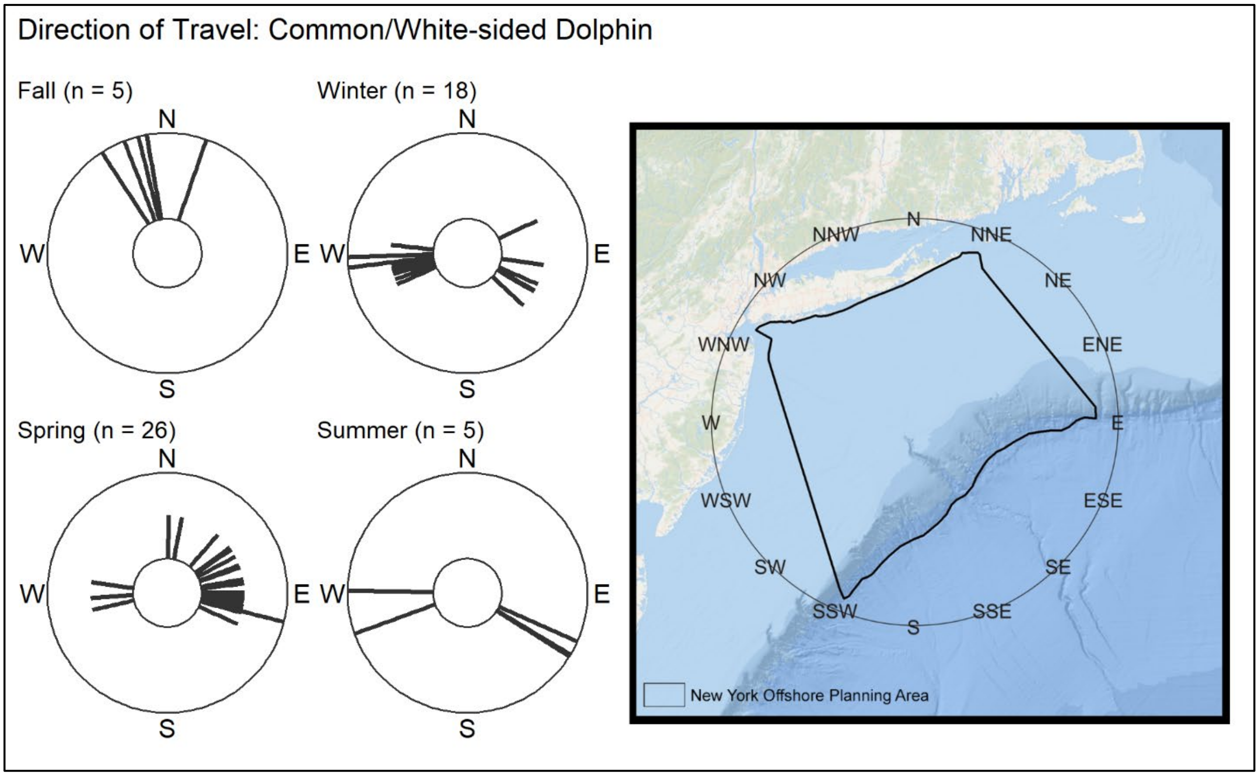
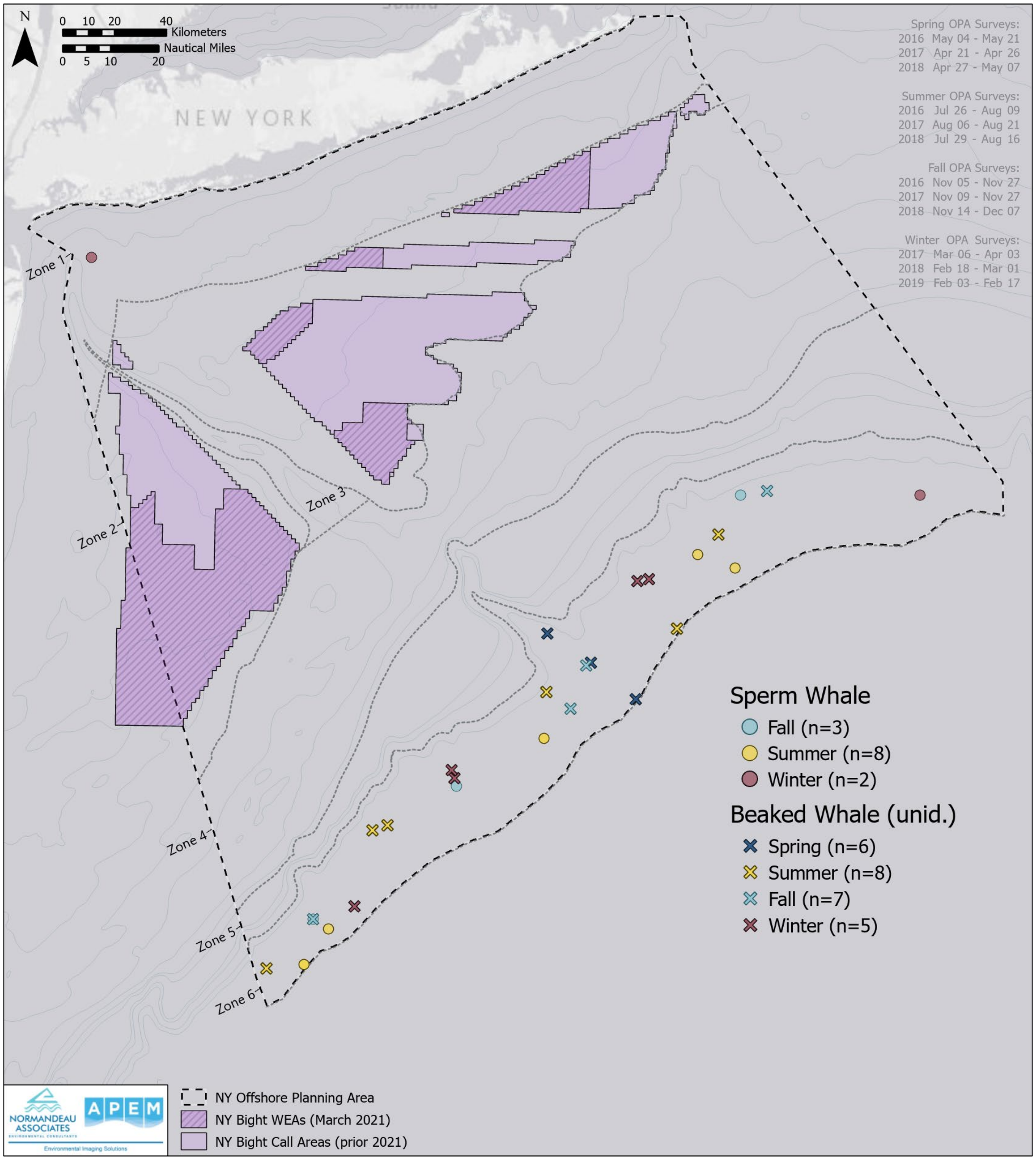


Figure 35. Spatial Distribution of Mid-frequency Cetacean Species with Fewer than 30 Occurrences Across All Surveys



2.3.1.3 Low-frequency Cetaceans

The low-frequency cetacean group includes all baleen whales: common minke whale (n=30), fin whale (n=43), sei whale (n=12), humpback whale (n=20), and North Atlantic right whale (n=7) (Table 2, Figure 36, Figure 37). Overall, low-frequency cetacean density was greatest during Spring (n=44; $\bar{x}$ = 0.004 individuals/km^2), followed by Summer (n=28; $\bar{x}$ = 0.003 individuals/km^2), with Winter and Fall having the same estimated density of $\bar{x}$ = 0.002 individuals/km^2 (Figure 36, Figure 37). During Fall and Winter low-frequency cetaceans concentrated in the outer zones (Figure 36). During Spring, Zone 4 had the greatest density (n=22; $\bar{x}$ = 0.01 ± 0.003 individuals/km^2), and during Summer, Zone 1 had the greatest density (Figure 37). Across all seasons, low-frequency cetacean observations were low and exhibited no prominent patterns of travel (Figure 38).

Fin Whale

Fin whale (n=43) density was overall low with the greatest density observed during Summer (n=20; $\bar{x}$ = 0.003 individuals/km^2), followed by Fall (n=10), Winter (n=8), and Spring (n=5) (Table 2, Figure 39, Figure 40). During Summer, fin whale distribution was relatively even across zones. Overall, observations were low in any season making it difficult to discern patterns of direction of travel; however, during Summer fin whales were observed traveling either to the northwest or southeast (Figure 41).

Common Minke Whale

Estimated mean common minke whale density was low across all seasons and zones (Figure 42, Figure 43). It was greatest during Spring (n=15), followed by Winter, Summer, and Fall when only one common minke whale was observed (Table 2). Common minke whales concentrated within Zone 4 during Winter and Spring (Figure 42, Figure 43). Overall observations were low in any season making it difficult to discern patterns of direction of travel (Figure 44).

Low-frequency Cetaceans with Fewer than 30 Observations

North Atlantic right whale (n=7), blue whale (n=2), sei whale (n=12), and humpback whale (n=20) were distributed throughout the OPA and across all seasons (Table 2, Figure 45).

Figure 36. Spatial Distribution of Low-frequency Cetaceans During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

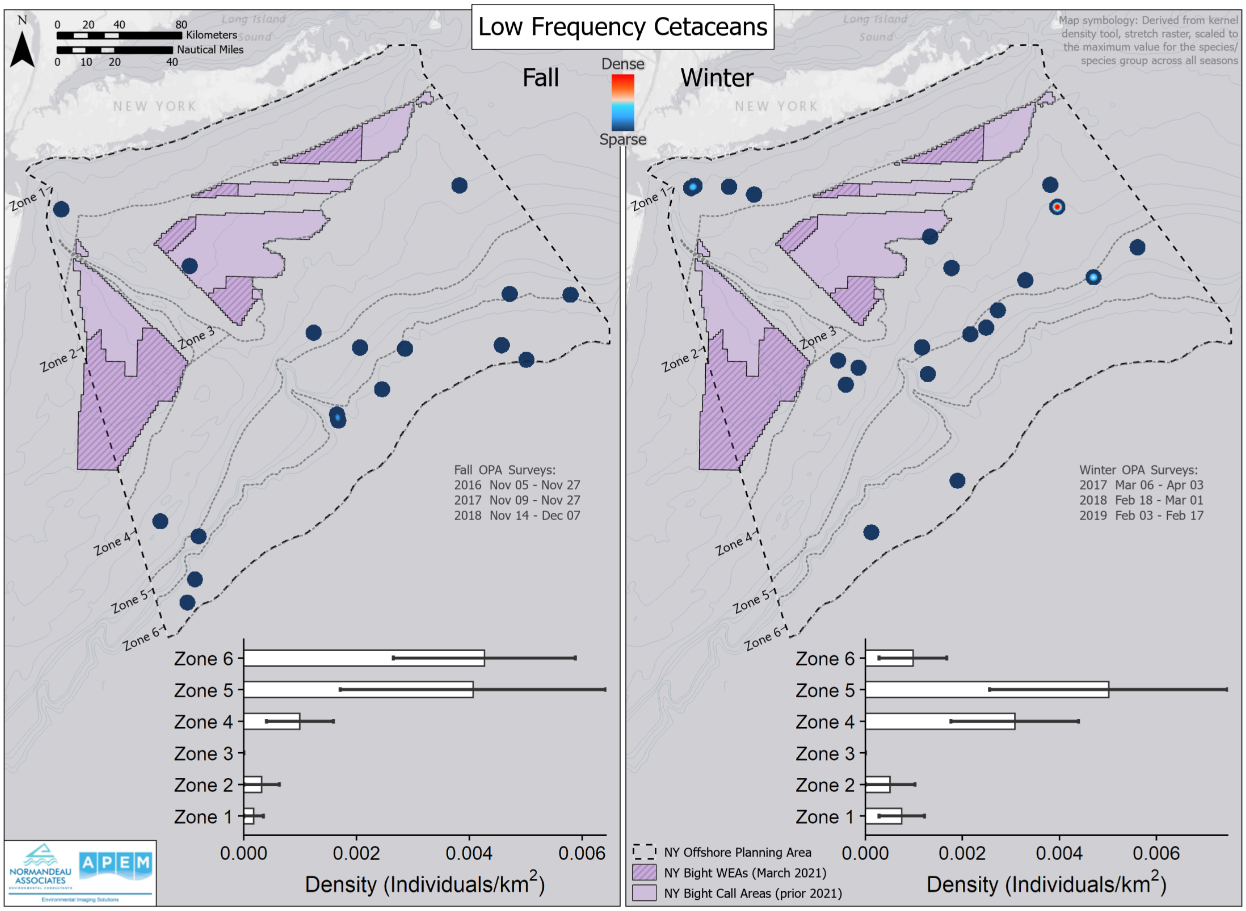


Figure 37. Spatial Distribution of Low-frequency Cetaceans During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

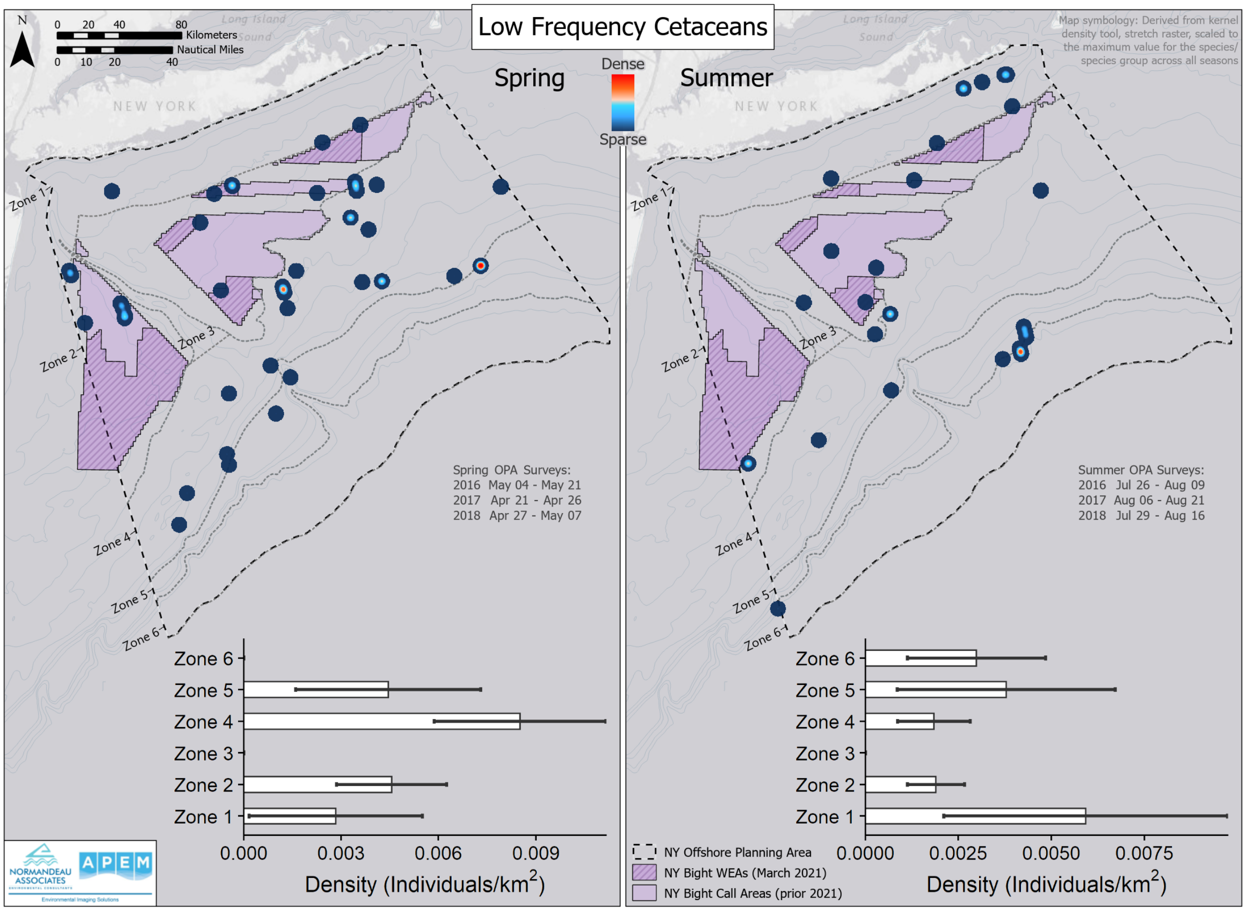


Figure 38. Direction of Travel of Low-frequency Cetaceans for All Surveys

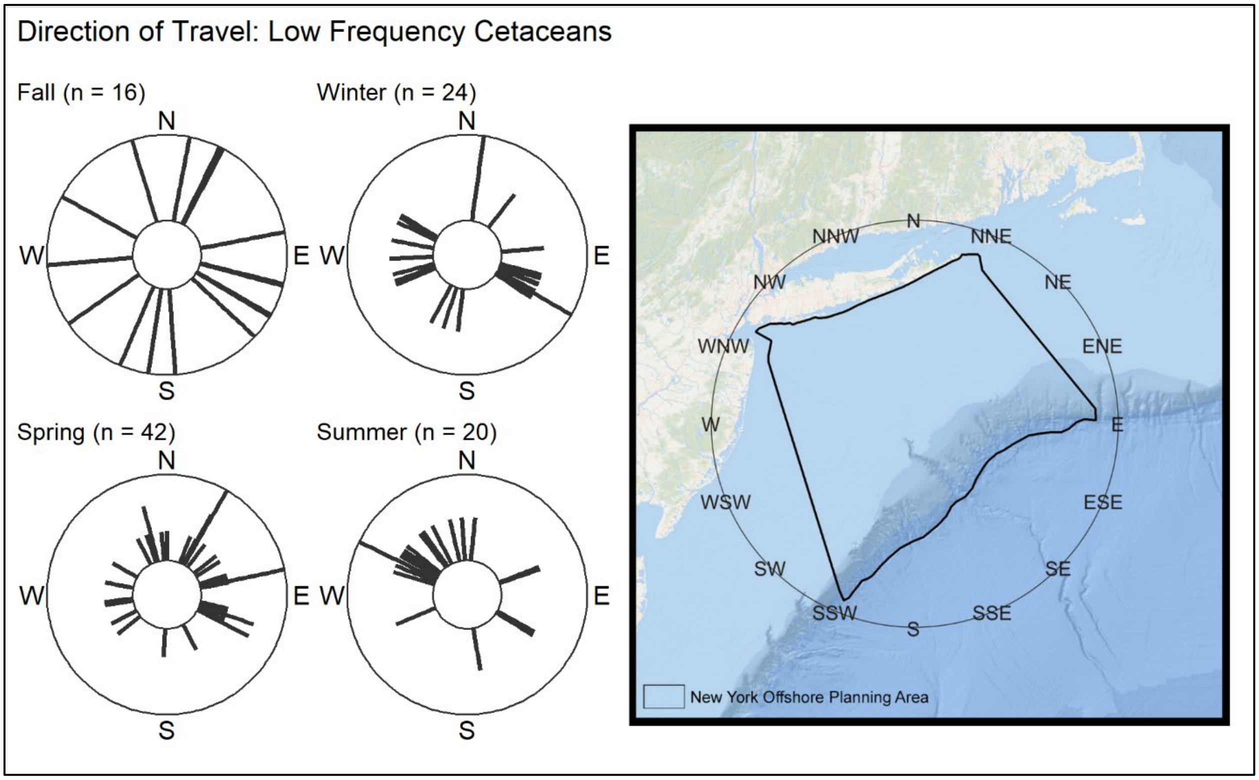


Figure 39. Spatial Distribution of Fin Whales During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

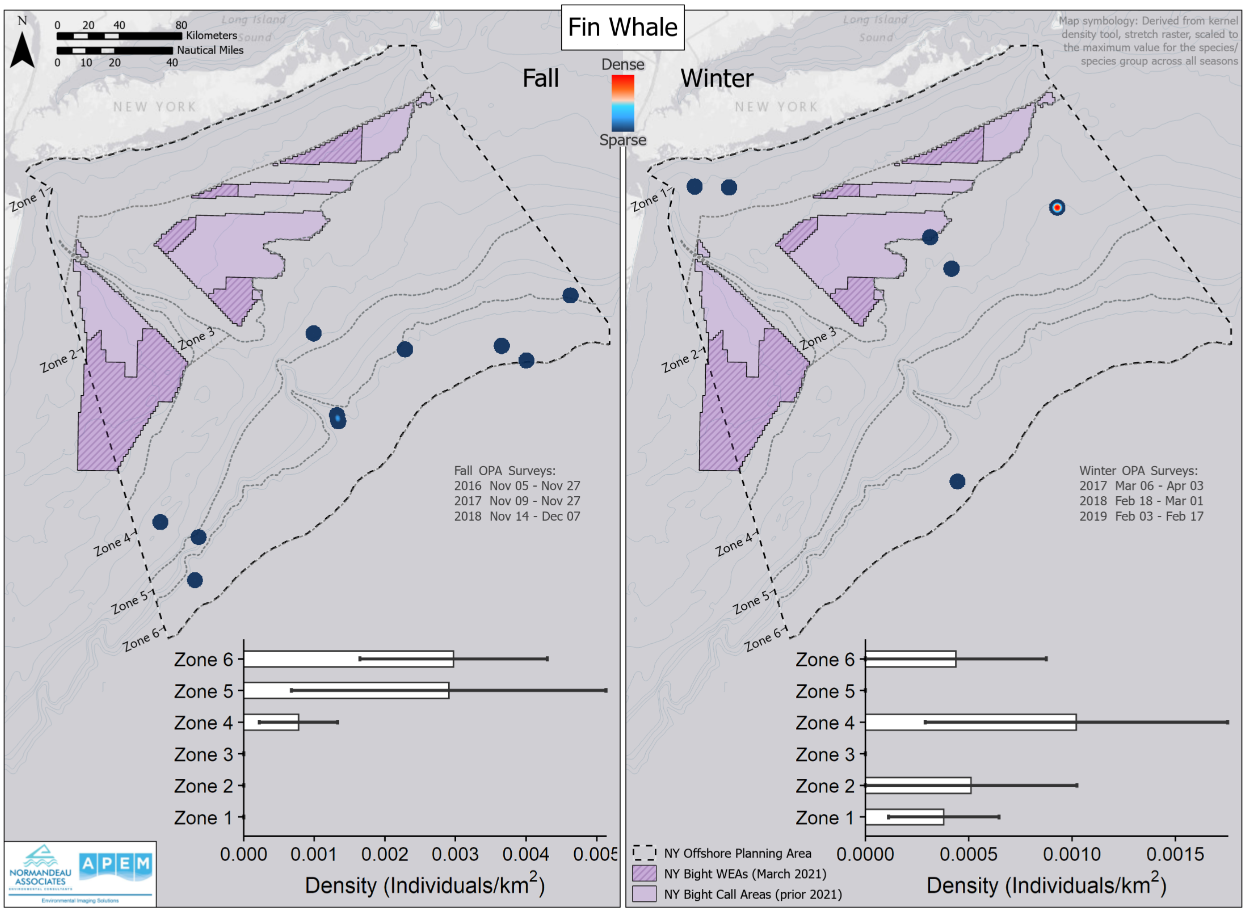


Figure 40. Spatial Distribution of Fin Whales During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

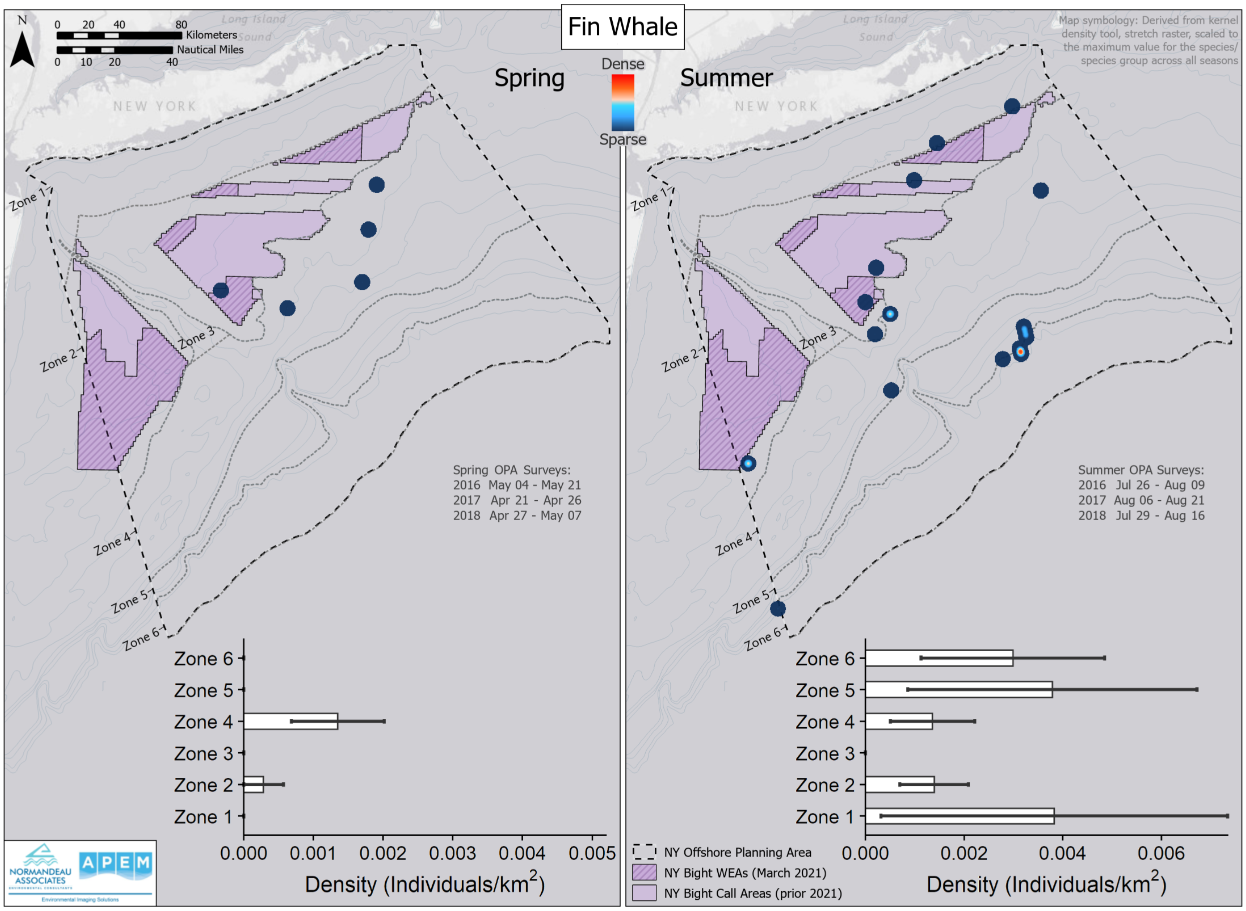


Figure 41. Direction of Travel of Fin Whales for All Surveys

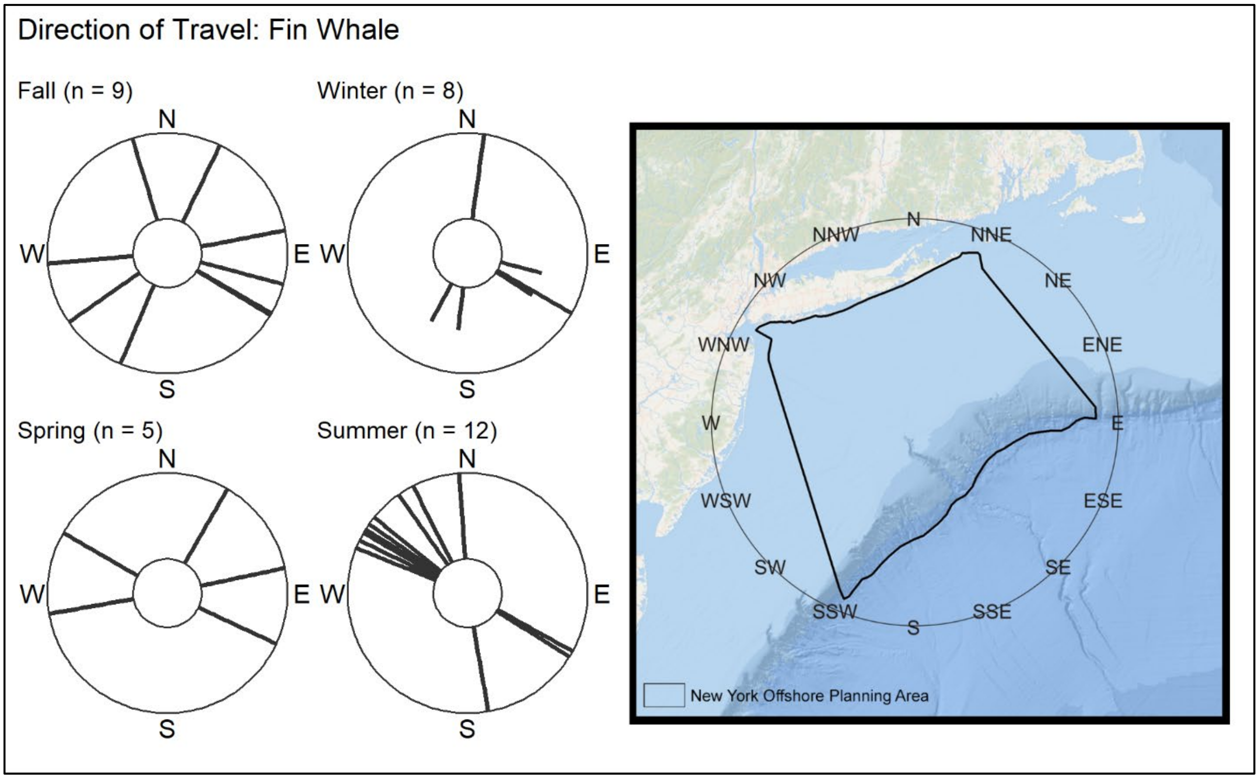


Figure 42. Spatial Distribution of Common Minke Whales During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

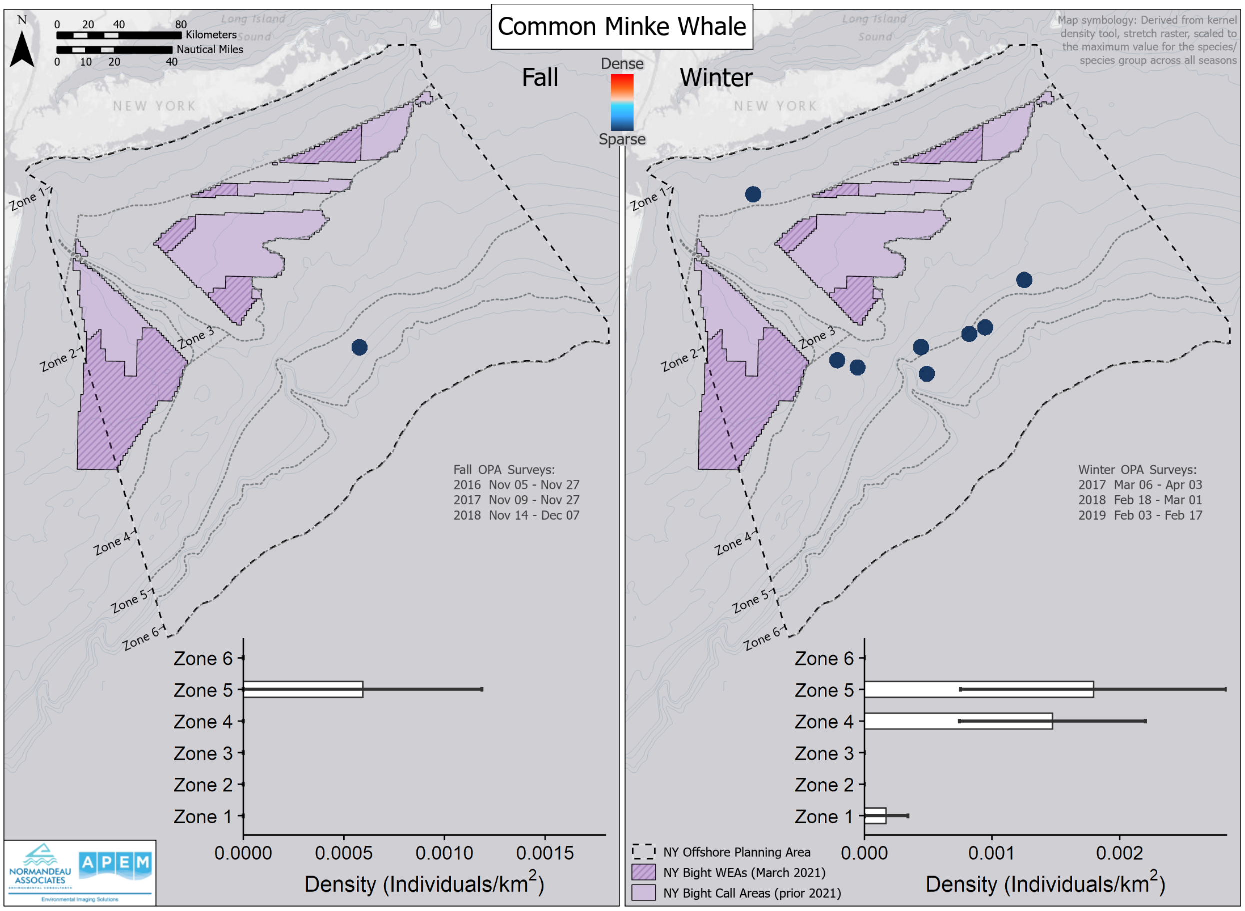


Figure 43. Spatial Distribution of Common Minke Whales During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

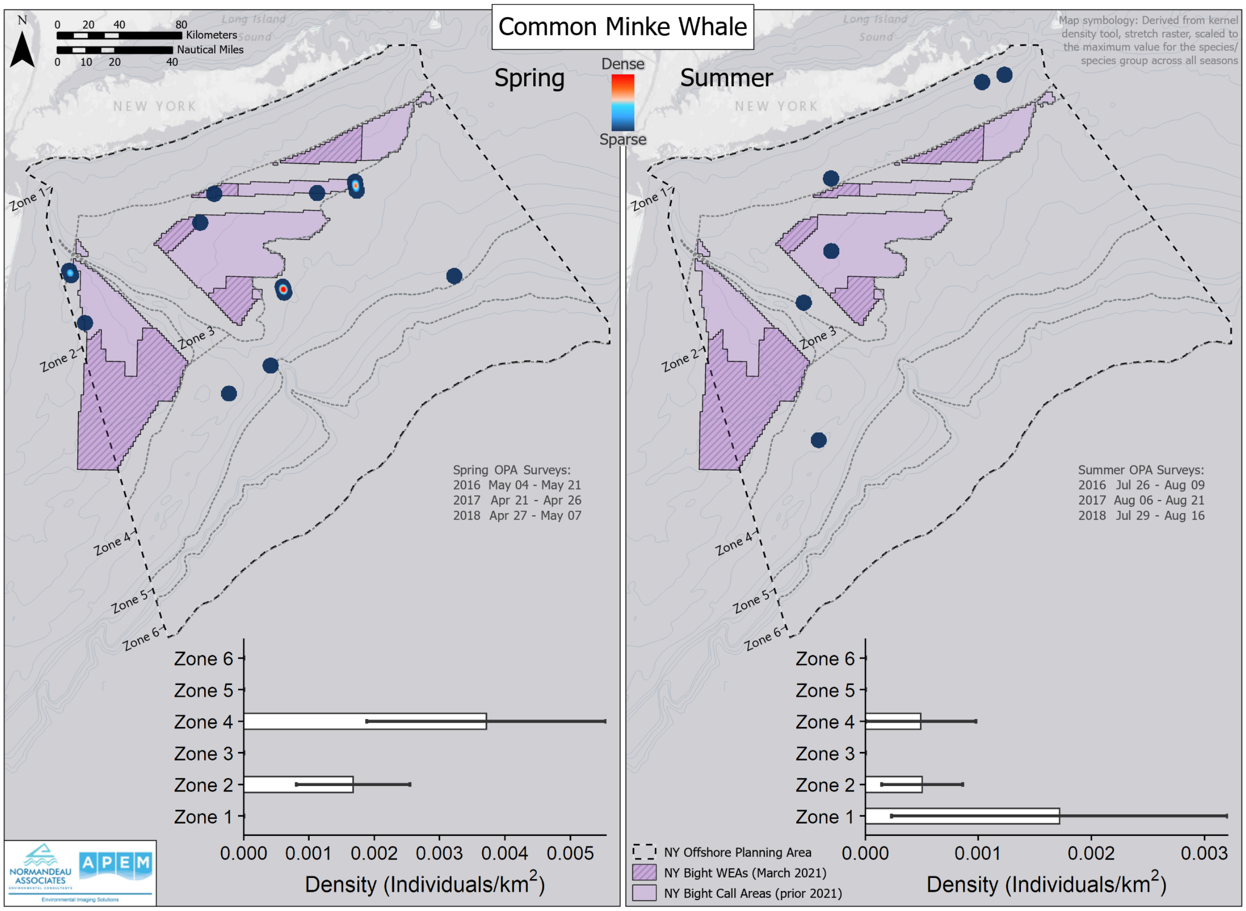


Figure 44. Direction of Travel of Common Minke Whales for All Surveys

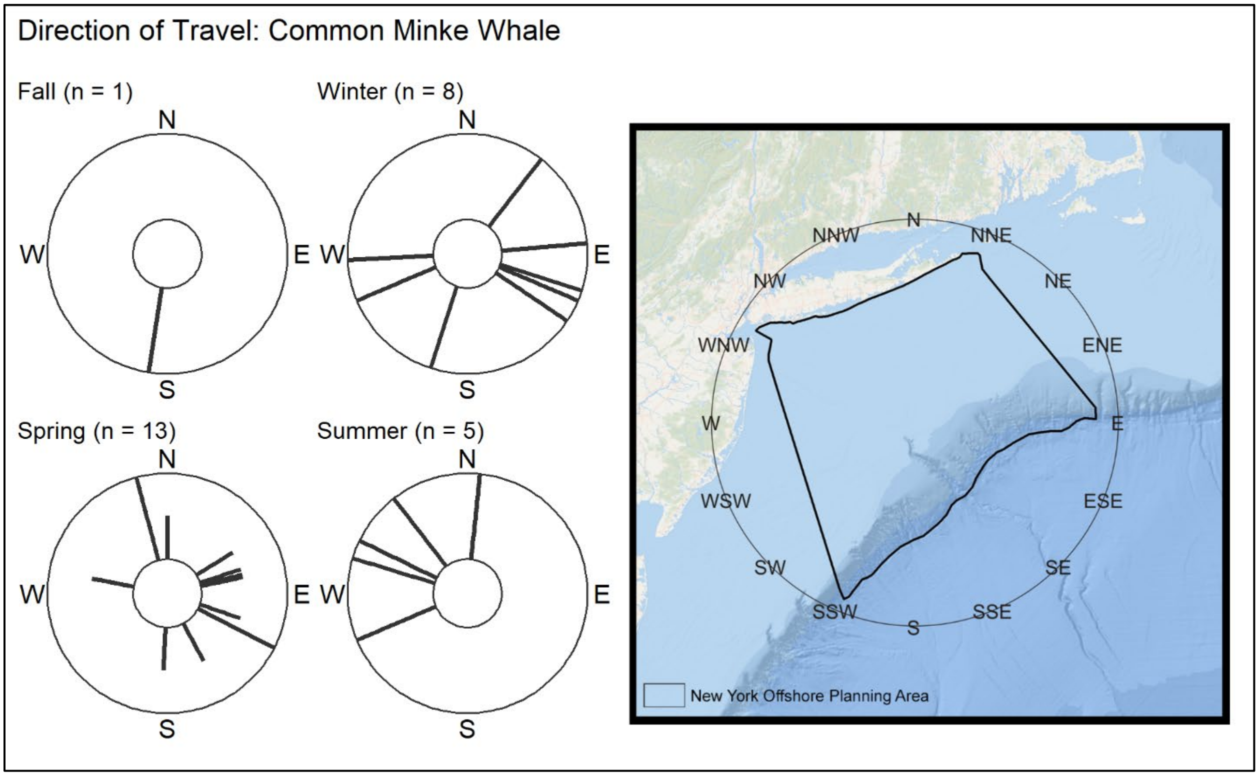
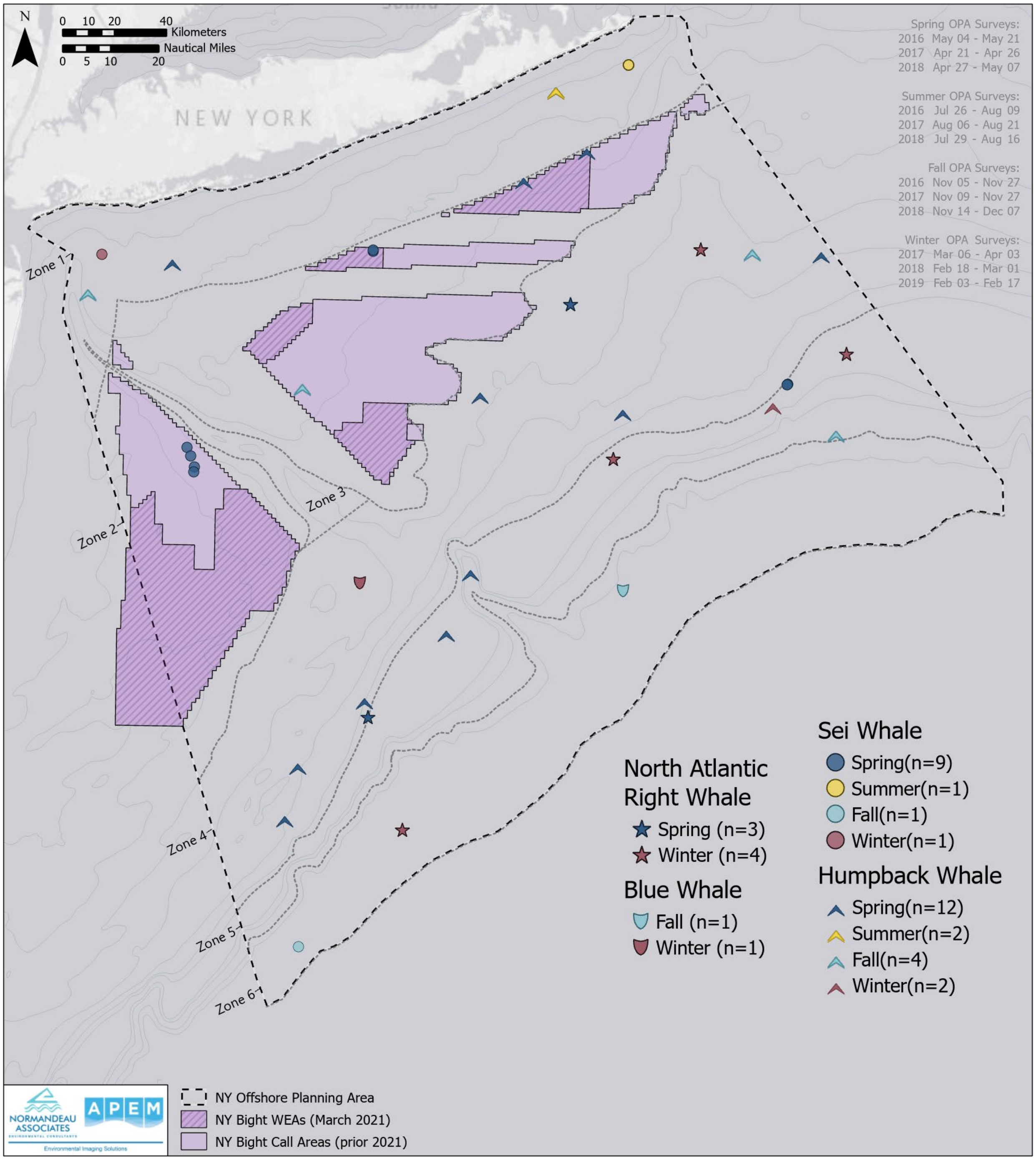


Figure 45. Spatial Distribution of Low-frequency Cetacean Species with Fewer than 30 Occurrences Across All Surveys



2.3.2 Seals

Seals were classified as gray seal (n=6), harbor seal (n=4), harp seal (n=1), and seal-species unknown (n=73) (Table 2). Pinniped density was over three times greater in Winter (n=48; $\bar{x}$ = 0.006 seals/km^2) than observed in Spring (n=17; $\bar{x}$ = 0.002 seals/km^2), Fall (n=15; $\bar{x}$ = 0.002 seals/km^2), and Summer (n=4; $\bar{x}$ < 0.001 seals/km^2) (Figure 46, Figure 47). During Winter, density was greatest within Zones 1 and 4 (Figure 46). During Winter, when seals were most abundant, travel direction was non-uniform (t = 143.5, p < 0.001) but otherwise had no pattern (Figure 48).

Gray seals, harbor seals, and harp seals were observed within all zones except Zone 3. Further, gray seals, harbor seals, and harp seals were never observed during Summer surveys (Figure 49).

Figure 46. Spatial Distribution of Seals During Fall and Winter by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

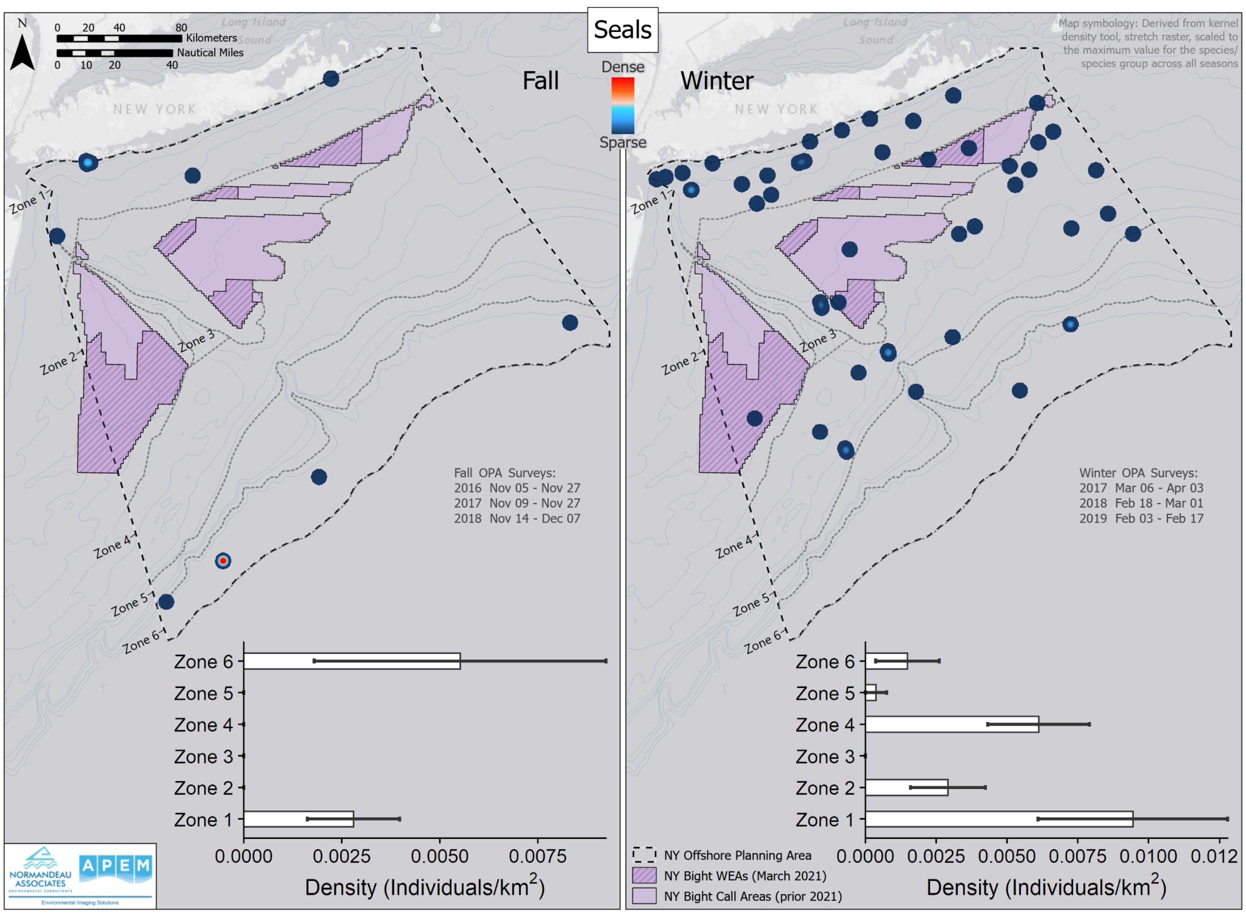


Figure 47. Spatial Distribution of Seals During Spring and Summer by Zone and Proximity to Call Areas

Heat map density maximum is scaled to the maximum density for the species/species group across all seasons. Inset figure shows estimated densities within each Zone ± standard error of the mean.

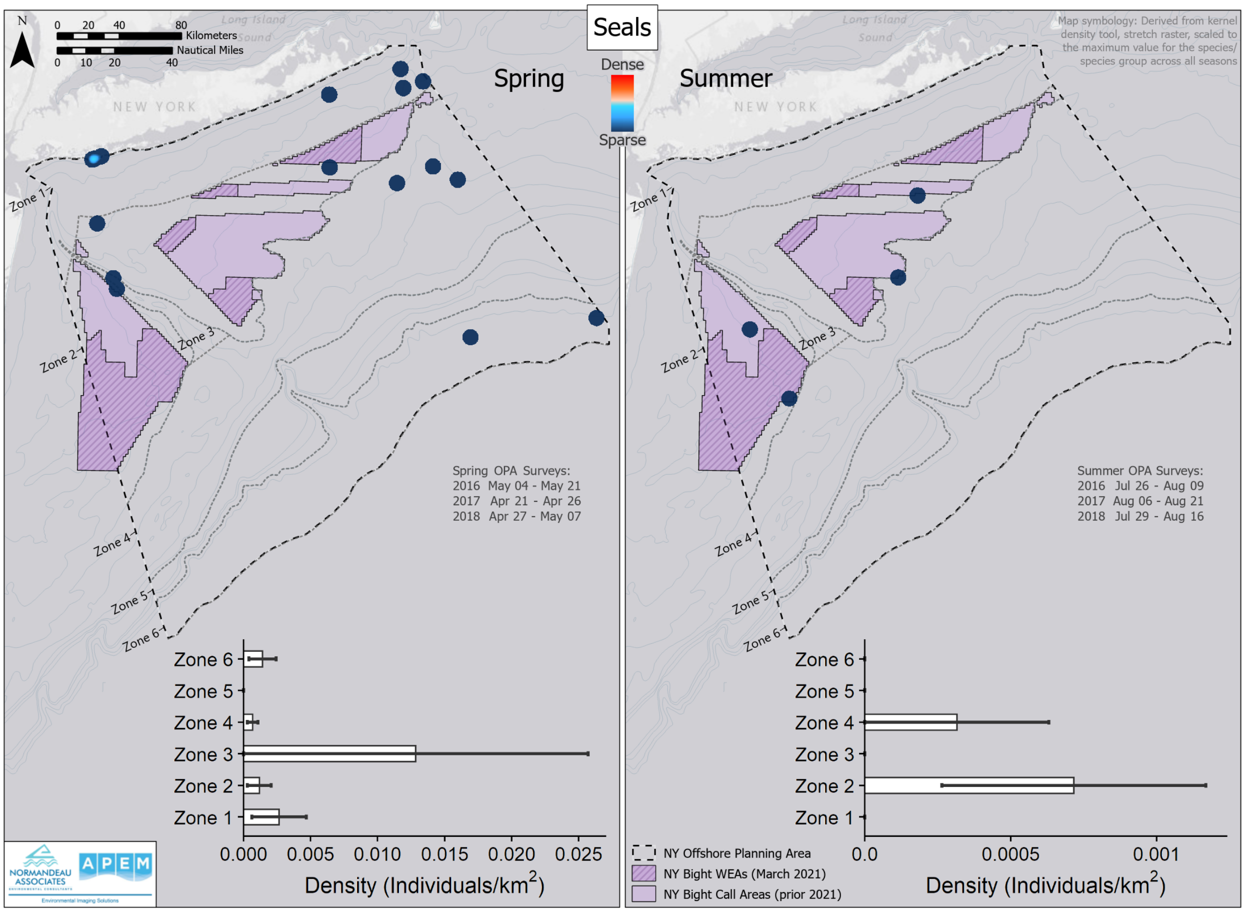


Figure 48. Direction of Travel of Seals for All Surveys

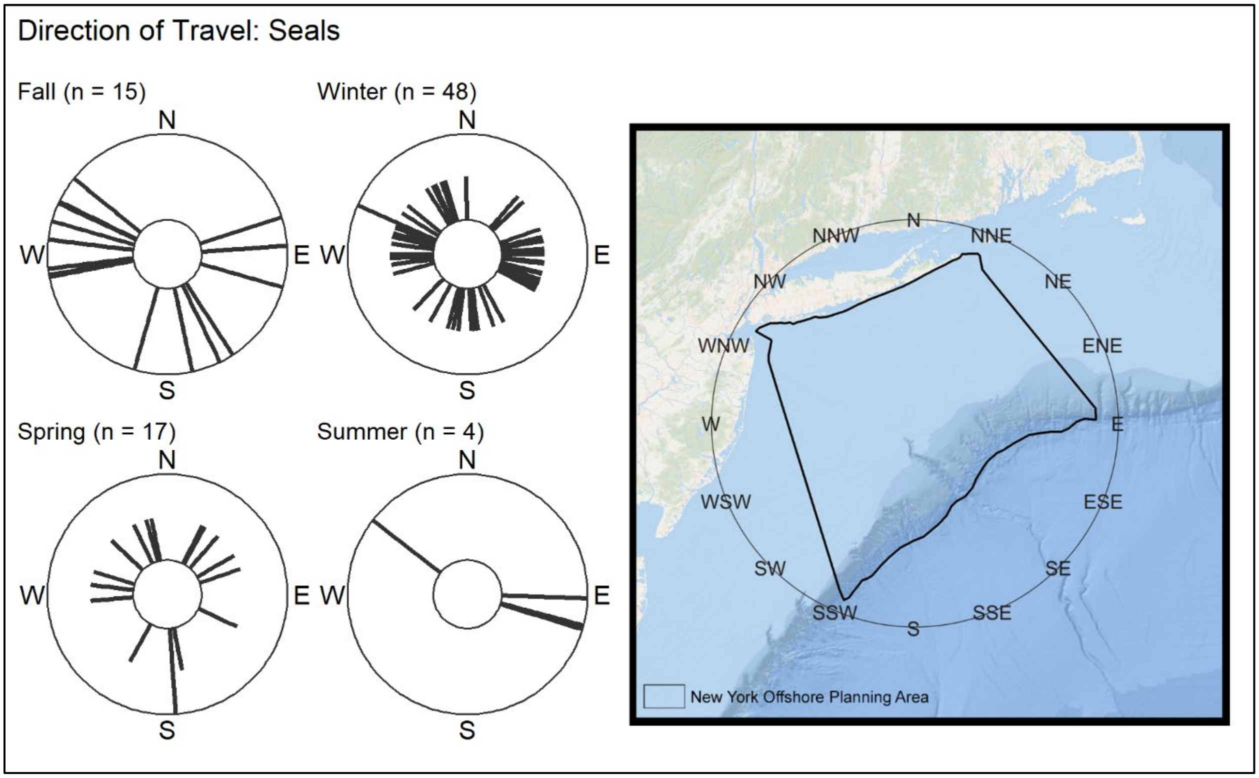
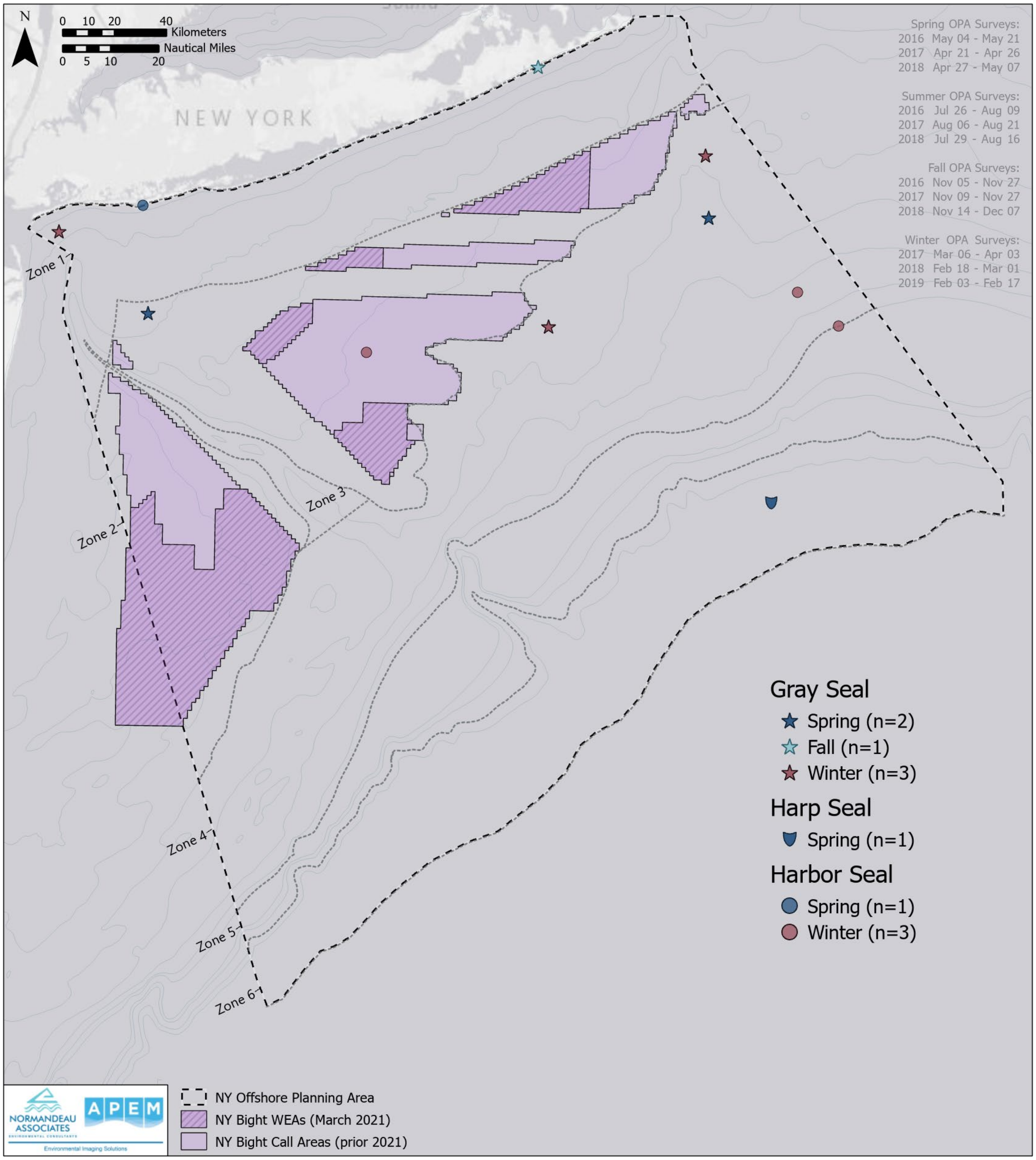


Figure 49. Spatial Distribution of Seal Species with Fewer than 30 Occurrences Across All Surveys



3 References

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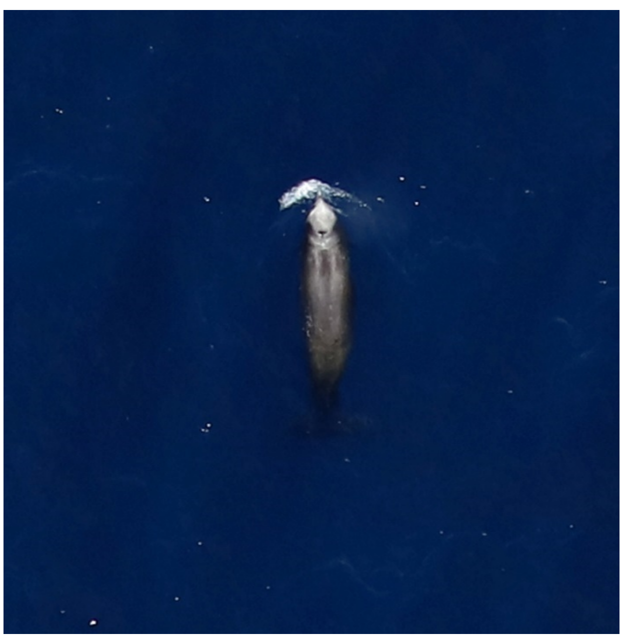
Appendix A. Representative Marine Mammal Images from Each Survey

Summer 2016

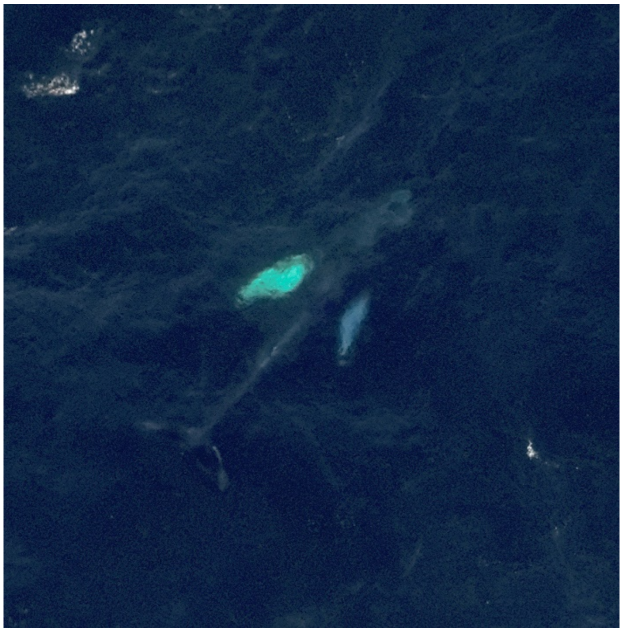

Fin Whale

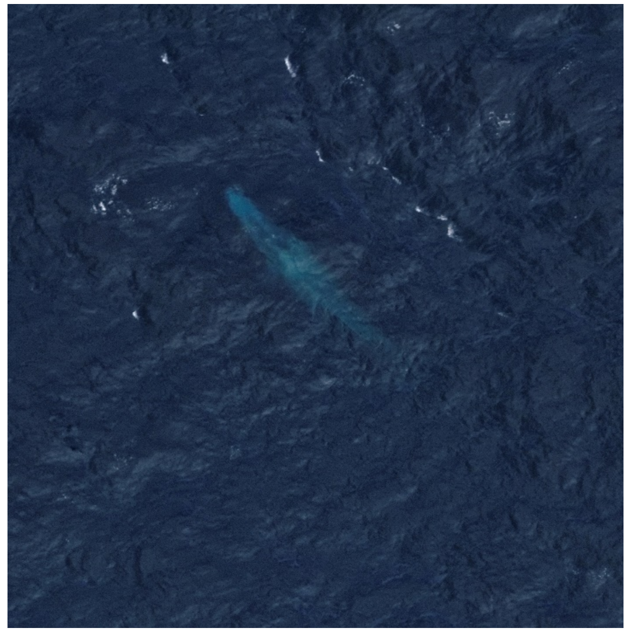

Pilot Whale (unid.)

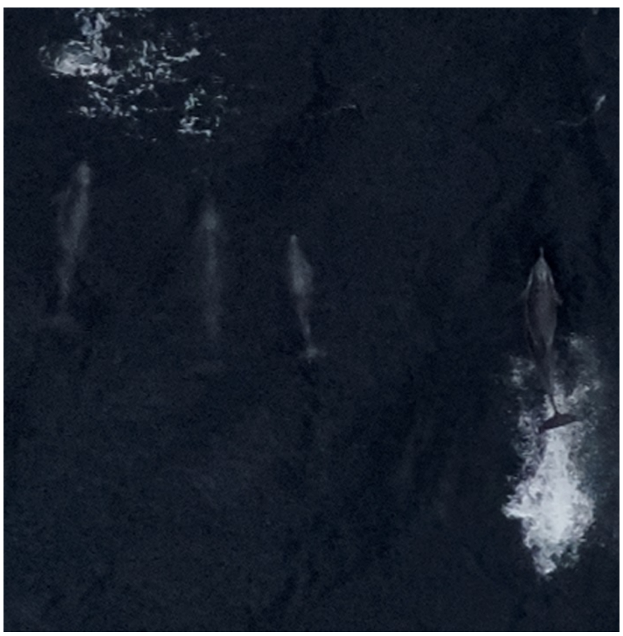

Beaked Whale (unid.)


Risso’s Dolphin

Fall 2016

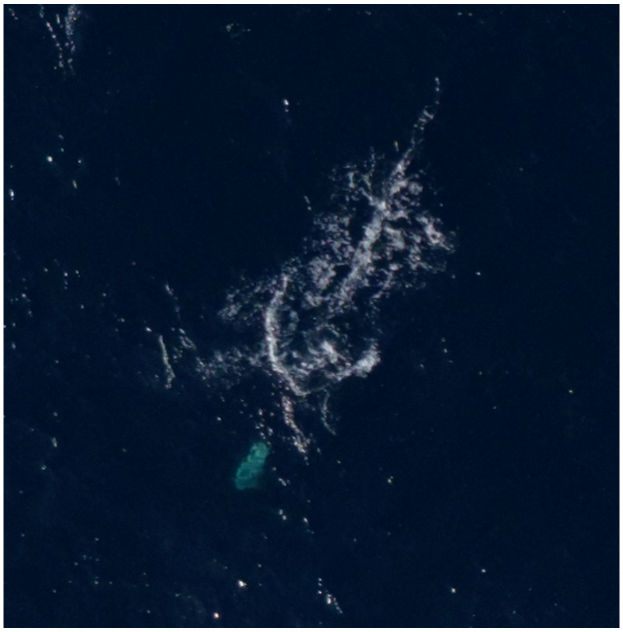

Humpback Whale

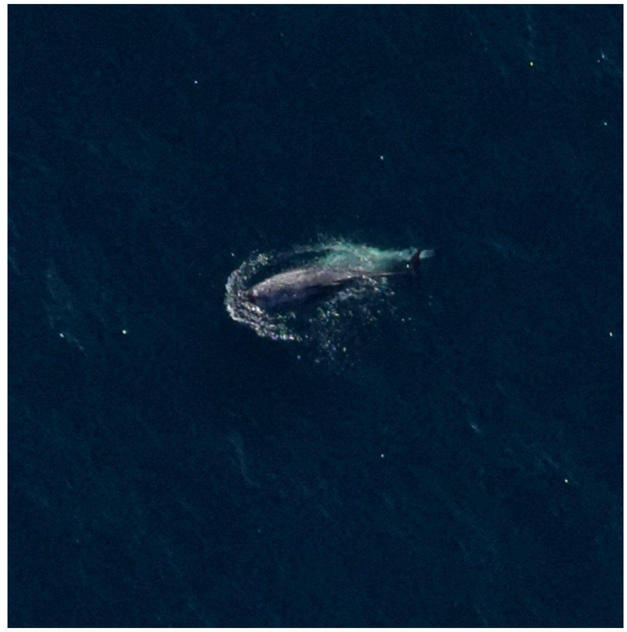

Blue Whale

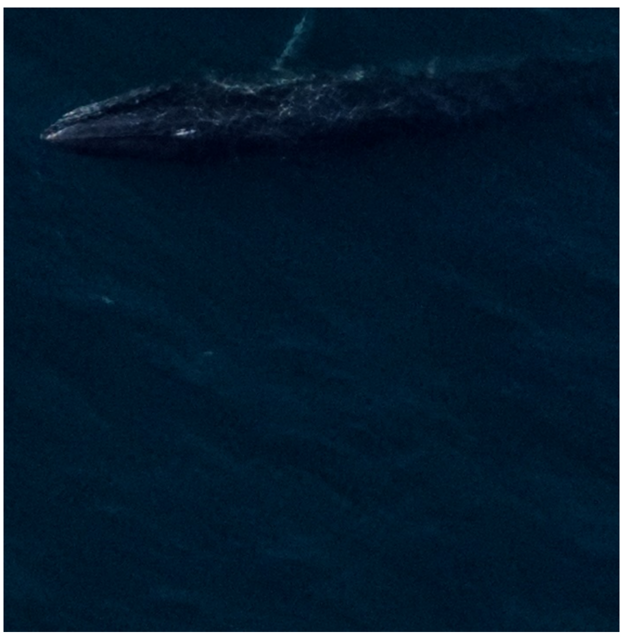

Striped Dolphin


Common Dolphin

Winter 2016–2017

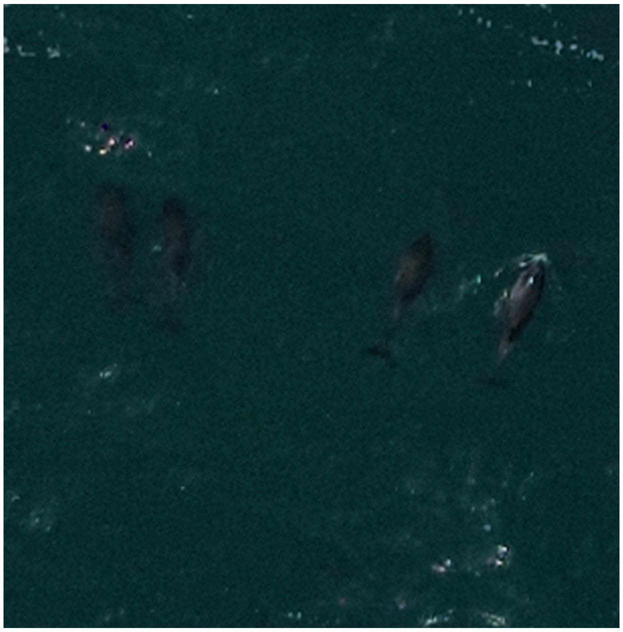

North Atlantic Right Whale


Risso's Dolphin

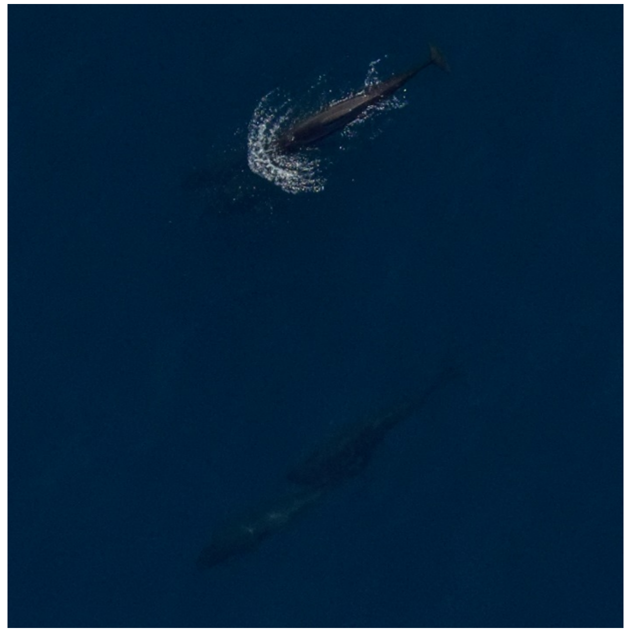

Fin Whale


Harbor Seal

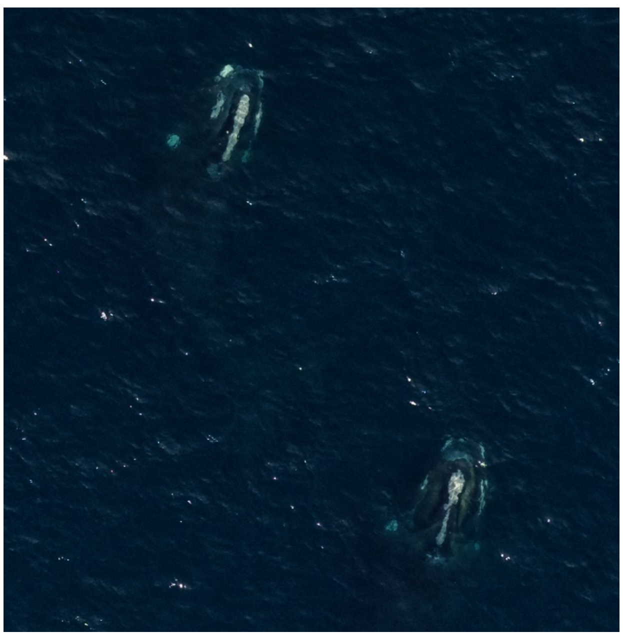
Spring 2017



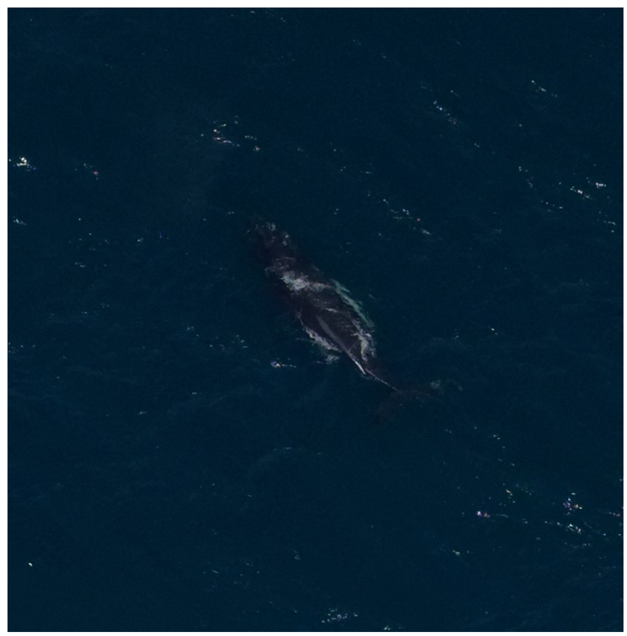
Harbor Porpoise



Pilot Whale (unid.)



North Atlantic Right Whale

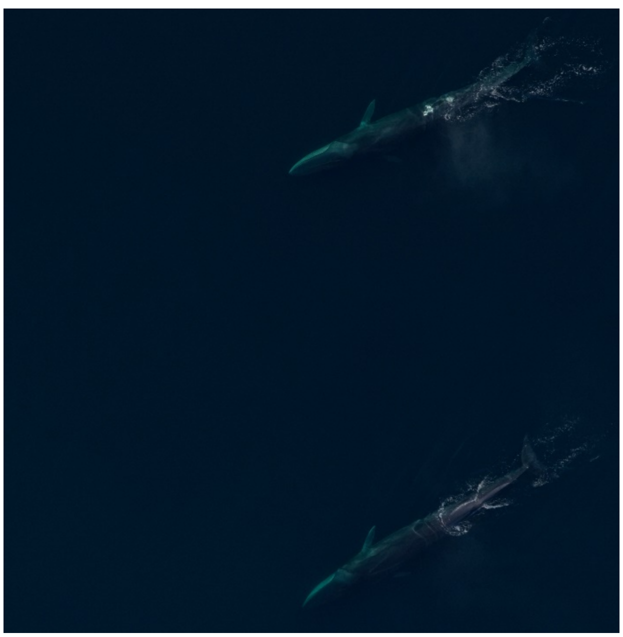


Humpback Whale

Summer 2017


Sei Whale


Common Dolphin

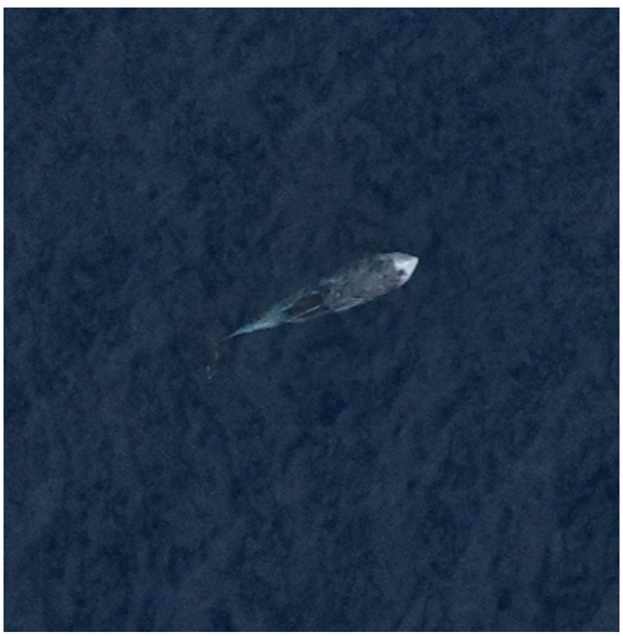

Fin Whale


Short-finned Pilot Whale

Fall 2017


Fin Whale

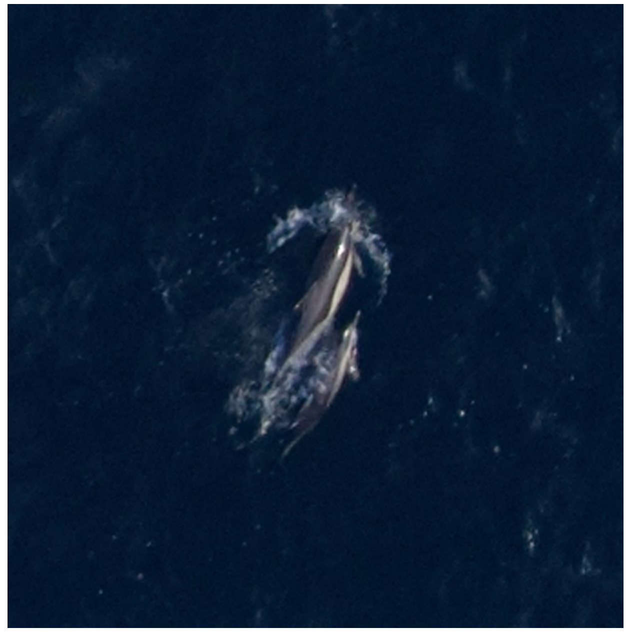

Humpback Whale


Risso’s Dolphin


Pygmy Sperm Whale (with calf)

Winter 2017–2018

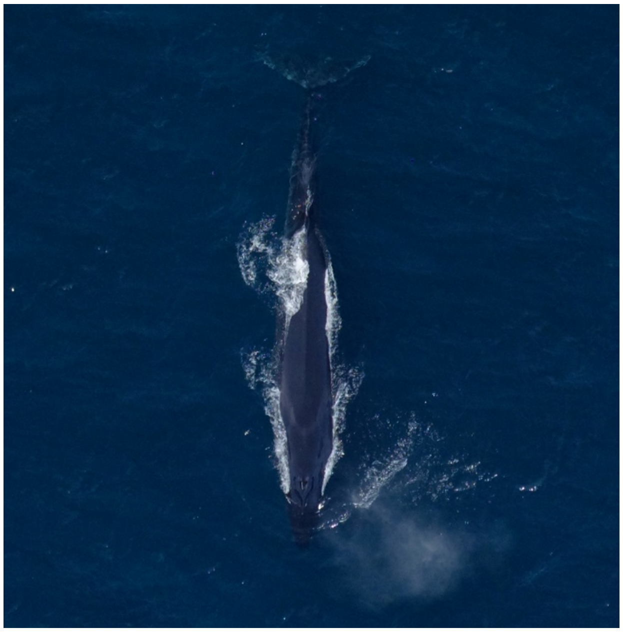

Common Minke Whale


Common Dolphin (with juvenile)


Harbor Seal

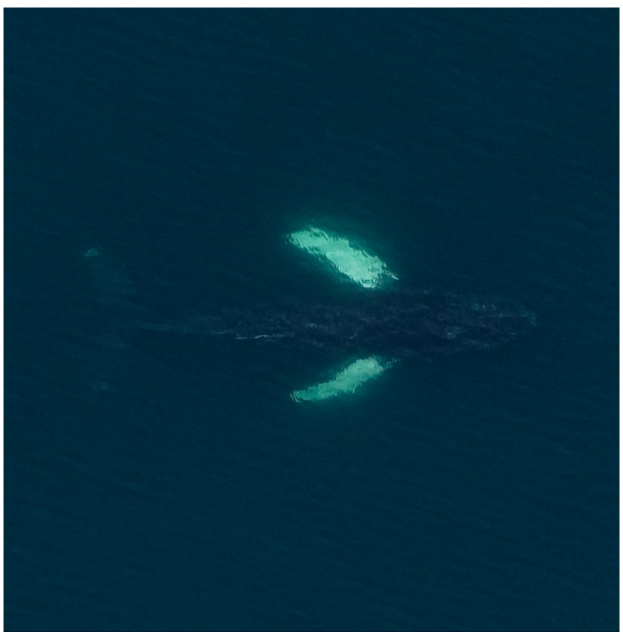

Fin Whale

Spring 2018

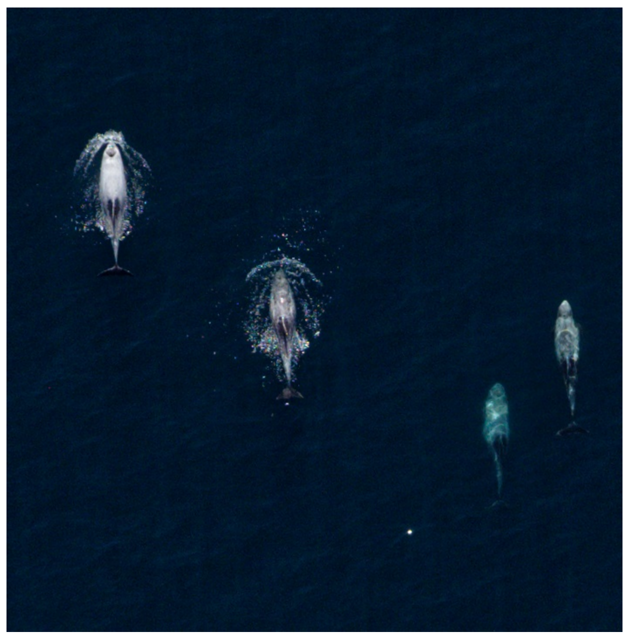


Sei Whale

Seal-Species Unknown



Humpback Whale

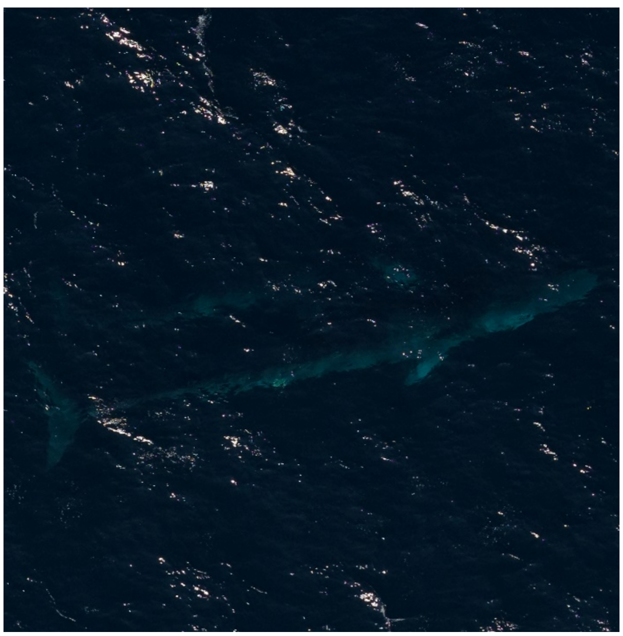


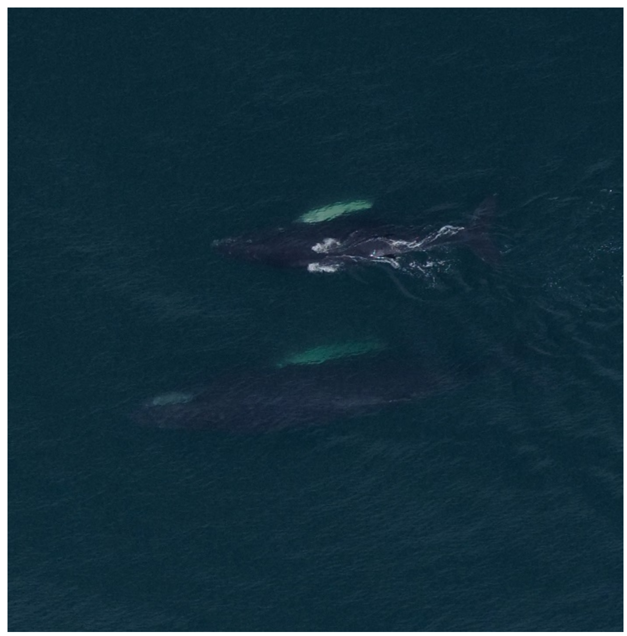
Risso’s Dolphin

Summer 2018


Striped Dolphin


Sperm Whale (with calf)

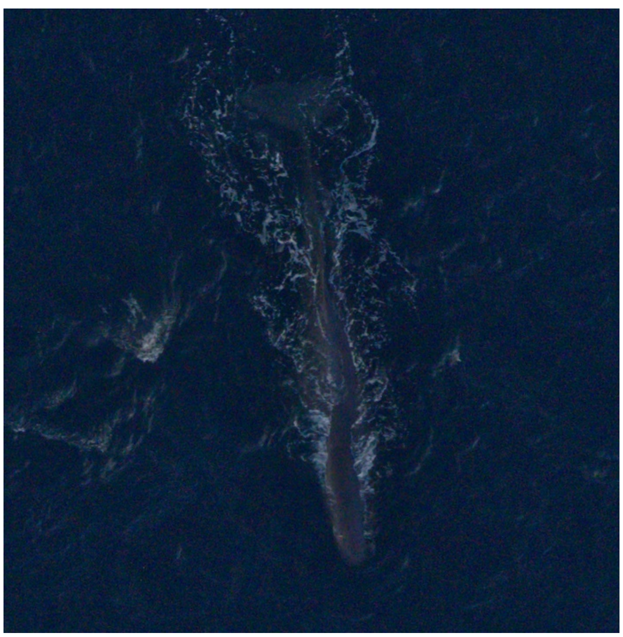

Fin Whale (with calf)


Humpback Whale (yearling)

Fall 2018

Sei Whale

Risso's Dolphin



Sperm Whale

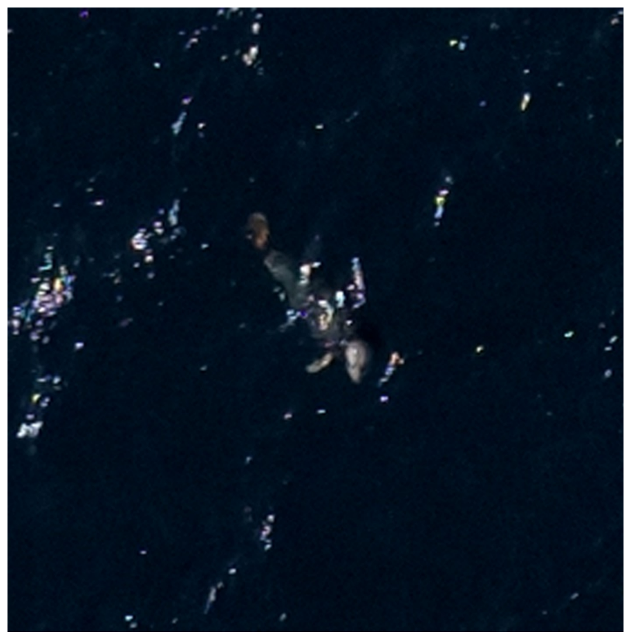
Common Dolphin

Winter 2018–2019

Striped Dolphin (with calf)

Sperm Whale

Harbor Porpoise

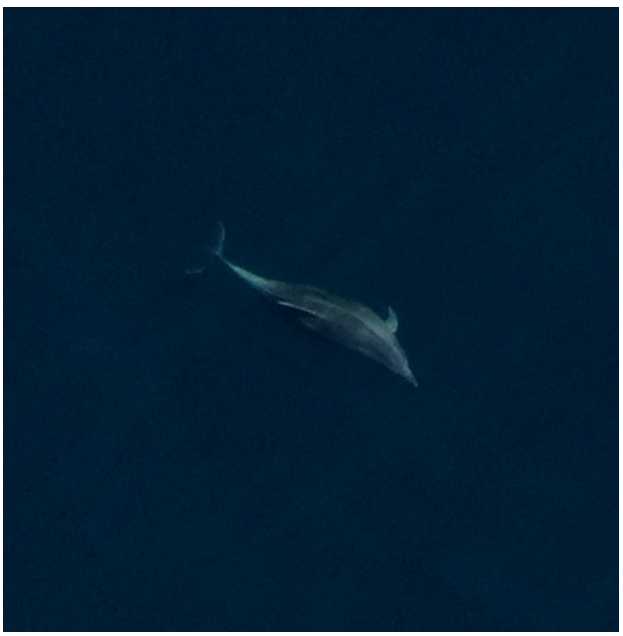


Seal-Species Unknown

Spring 2019


Humpback Whale


Common Bottlenose Dolphins


Common Bottlenose Dolphin


Harbor Porpoise

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