Aerial Surveys for Protected Marine Species in the Norfolk Canyon Region: 2017 Annual Progress Report

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Cover Photo Credit: (*Balaenoptera physalus*). Photograph collected by the University of North Carolina Wilmington under National Oceanic and Atmospheric Administration scientific permit no. 20527.

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Acronyms and Abbreviations

BSS	Beaufort sea state
km	kilometer(s)
m	meter(s)
SD	standard deviation
U.S.	United States

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1. Introduction

This report forms part of a multi-institutional monitoring project intended to provide information on the species composition, population identity, density, and baseline behavior of marine mammals and sea turtles present in United States (U.S.) Navy range complexes along the U.S. Atlantic Coast. This program began in 2007, with baseline aerial and vessel surveys, as well as a passive acoustic monitoring component in Onslow Bay, North Carolina, and has since expanded to include survey areas off the coasts of Jacksonville, Florida; Cape Hatteras, North Carolina; and Norfolk, Virginia. In Onslow Bay, four years of monitoring yielded a comprehensive picture of the density, distribution, and abundance of marine mammals and sea turtles and provided new insights into residency patterns among pelagic delphinid cetaceans in this region (Read et al. 2014). Nearly nine years of monitoring in Jacksonville have provided similar information on the density and distribution of marine mammals and sea turtles in this area. In Cape Hatteras, over six years of surveys have provided preliminary information on the complex patterns of distribution and diversity of the marine mammals and sea turtles in this exceptionally productive area.

In 2015, to serve the operational needs of the Atlantic Fleet Training and Testing program, survey effort was extended north into Virginia creating the Norfolk Canyon survey area. Three years of aerial surveys at this site have provided preliminary information on the distribution and diversity of cetaceans and sea turtles. The current report builds on this past body of work and describes aerial survey monitoring activities at the Norfolk Canyon study area in 2017.

2. Summary of Norfolk Canyon Aerial Surveys

This document is an annual progress report to the U.S. Department of the Navy on aerial surveys conducted in the Norfolk Canyon study area from January through December 2017. The objective was to conduct two days of effort each month, flying a subset of the 16 tracklines that cover the area.

This year, survey effort occurred in seven of twelve months. Two survey days were achieved in three of the seven months (May, June, and July). A full day of effort occurred in February; partial effort was conducted in January, August, and September. A total of 54 tracklines (3,812.05 kilometers [km]) over 10 days was covered in the Norfolk Canyonsurvey area during this reporting period.

A total of 86 sightings of 7,861 cetaceans was encountered while on-effort during the 10 days of aerial surveys. Nine species of cetaceans were photo-documented while on effort, including common dolphins (*Delphinus delphis*; 23 sightings for 6,080 individuals), common bottlenose dolphins (*Tursiops truncatus*; 17 sightings for 425 individuals), Atlantic spotted dolphins (*Stenella frontalis*; 10 sightings for 469 individuals), Risso's dolphins (*Grampus griseus*; 9 sightings for 102 individuals), striped dolphins (*Stenella coeruleoalba*, 5 sighting of 516 individuals), short-finned pilot whales (*Globicephala macrorhynchus*; 14 sightings for 255 individuals), sperm whales (*Physeter macrocephalus*; 5 sightings for 7 individuals), Cuvier's

beaked whales (*Ziphius cavirostris*; 2 sightings for 5 individuals), and fin whales (*Balaenoptera physalus*, 1 sighting for 2 individuals).

Eight off-effort sightings were also recorded. These include two sightings of striped dolphins (69 individuals), two sightings of humpback whales (*Megaptera novaeangliae*, two individuals), one sighting of common dolphins (225 individuals), one sighting of Risso's dolphins (three individuals), one sighting of a single fin whale, and one sighting of a single sperm whale. These off-effort sightings are included in species sighting maps and tables but are excluded from all other calculations.

One hundred and forty-five sightings of 261 sea turtles were recorded during this survey period. Two hundred and fifty-eight were identified as loggerhead (*Caretta caretta*) and three as leatherback (*Dermochelys coriacea*) turtles. Sea turtles were detected during 8 of 10 survey days, with highest abundances observed in May and June.

While survey conditions were dominated by Beaufort sea state (BSS) 1 to 3, at times surveys were conducted in higher sea states. Other aerial surveys demonstrated that the rate of cetacean sightings is negatively affected by an increase in the BSS (e.g., Gómez de Segura et al. 2006, DeMaster et al. 2001, McAlarney et al. 2013, 2015). Effort-corrected cetacean sightings this year off Norfolk Canyon followed this general trend—sighting rates dropped from 23.4 to 2.1 sightings per 1,000 km as BSS increased from 3 to 4. Sea turtle sightings showed a more dramatic decrease in sighting rate in seas greater than BSS 2.

In addition to cetaceans and sea turtles, other pelagic marine vertebrates (e.g., unidentified sharks, manta rays [*Manta birostris*], cownose rays [*Rhinoptera bonasus*], basking sharks [*Cetorhinus maximus*], and ocean sunfish [*Mola mola*]) were observed. Commercial, military, and recreational vessels were also encountered in the survey area.

All data from this project is made publically available through the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP).

3. Methods

3.1 Survey Design and Logistics

Aerial survey effort was initiated in the waters off Cape Hatteras, North Carolina, in May 2011 to assess the distribution and abundance of offshore cetacean species and sea turtles, complimenting existing surveys in Onslow Bay, North Carolina, and off Jacksonville, Florida. These surveys formed the basis of the U.S. Navy's Atlantic Fleet Training and Testing Monitoring Program, established to document the distribution and abundance of offshore cetacean species and sea turtles could potentially be impacted by naval activities in these areas. In 2015, the survey area was extended north, following the shelf break, into waters offshore of Virginia to include Norfolk Canyon. In 2016, these two areas were designated as separate entities: Cape Hatteras survey area south and Norfolk Canyon survey area north. The 16 tracklines in the Norfolk Canyon survey area include the shallower continental shelf (<100 meters [m]) and deeper, shelf break waters (>1,000 m) and average 74 km long. Designed as

an extension and complement to the work off Cape Hatteras, these two sites create a continuous 16,000-square kilometer survey area over a region of high cetacean diversity (Roberts et al. 2016) (**Figure 1**). Both sites have a large portion of their survey areas that fall within the airspace of the U.S. Navy's Fleet Area Control and Surveillance Facility in Virginia Beach (**Figure 2**). As this is controlled airspace, pilots must contact Virginia Beach the morning of planned survey flights for information on area closures or restriction. Survey plans are modified to avoid interacting with any area activities.

Survey flights originated from the Fixed-base Operator in the Dare County Regional Airport in Manteo, North Carolina, or Landmark Aviation in the Norfolk International Airport in Norfolk, Virginia. Utilizing both airports maximized "on-effort" survey time by decreasing transit time to and from the tracklines surveyed.

A more detailed description of survey methods can be found in the Methodology section in Cummings et al. (2017).

Table 1. Coordinates for trackline end points for the Norfolk Canyon survey area.

Transect Line	Western Waypoint		Eastern Waypoint	
Line Number	Latitude (N)	Longitude (W)	Latitude (N)	Longitude (W)
61	37.321320	75.161133	37.321320	74.333672
60	37.246289	75.161133	37.246384	74.333672
59	37.171448	75.161133	37.171448	74.333672
58	37.096512	75.161133	37.096512	74.333672
57	37.021576	75.161133	37.021576	74.333672
56	36.946640	75.161133	36.946640	74.333672
55	36.871704	75.161133	36.871704	74.333672
54	36.796768	75.161133	36.796768	74.333672
53	36.721897	75.161133	36.721897	74.333672
52	36.646942	75.161133	36.646942	74.333672
51	36.571960	75.161133	36.571960	74.333672
50	36.497024	75.161133	36.497024	74.333672
49	36.422088	75.161133	36.422088	74.333672
48	36.347152	75.161133	36.347152	74.333672
47	36.272216	75.161133	36.272216	74.333672
46	36.197280	75.161133	36.197280	74.333672

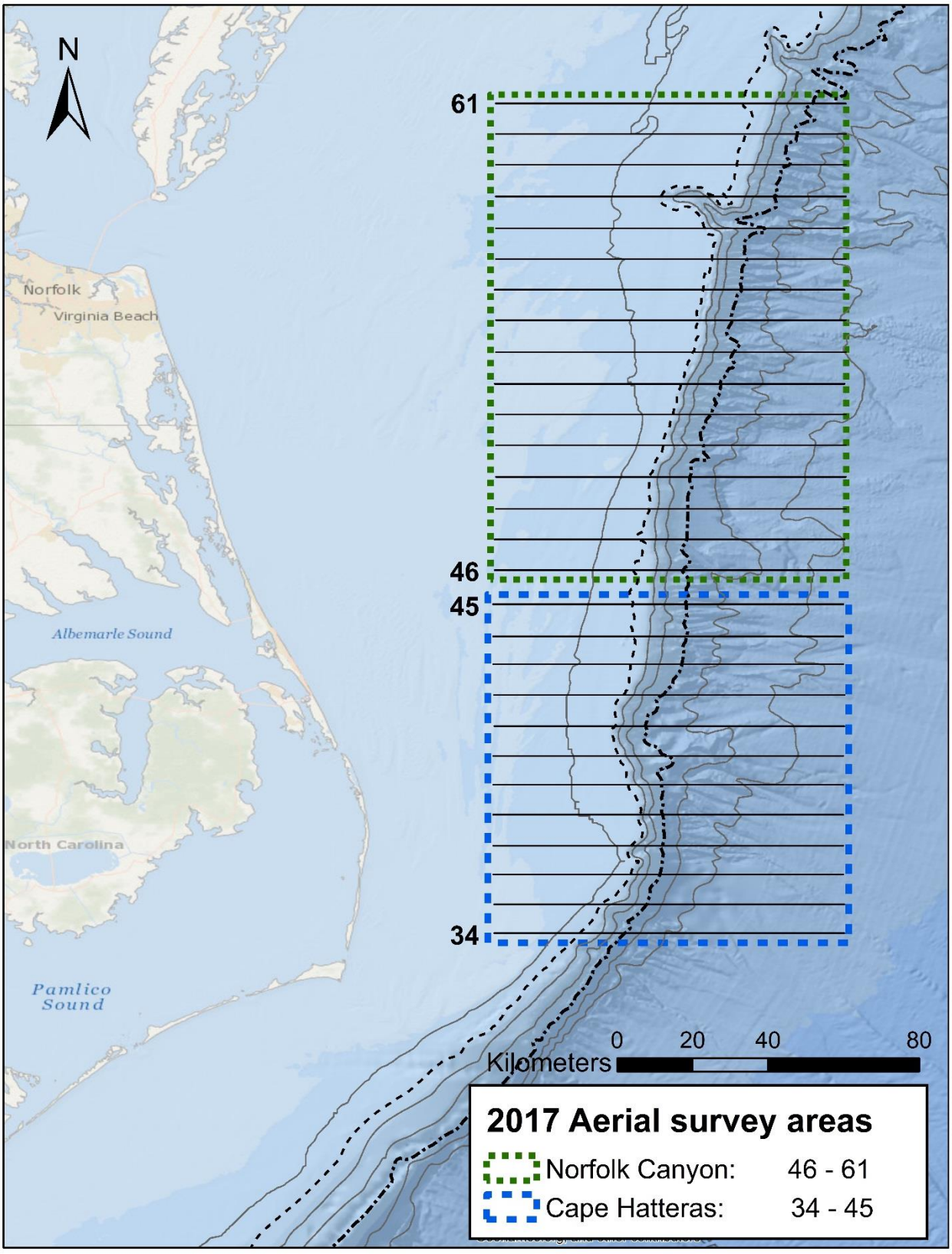

Figure 1. Norfolk Canyon and Cape Hatteras survey areas off the coast of Virginia and North Carolina for the 2017 survey season.

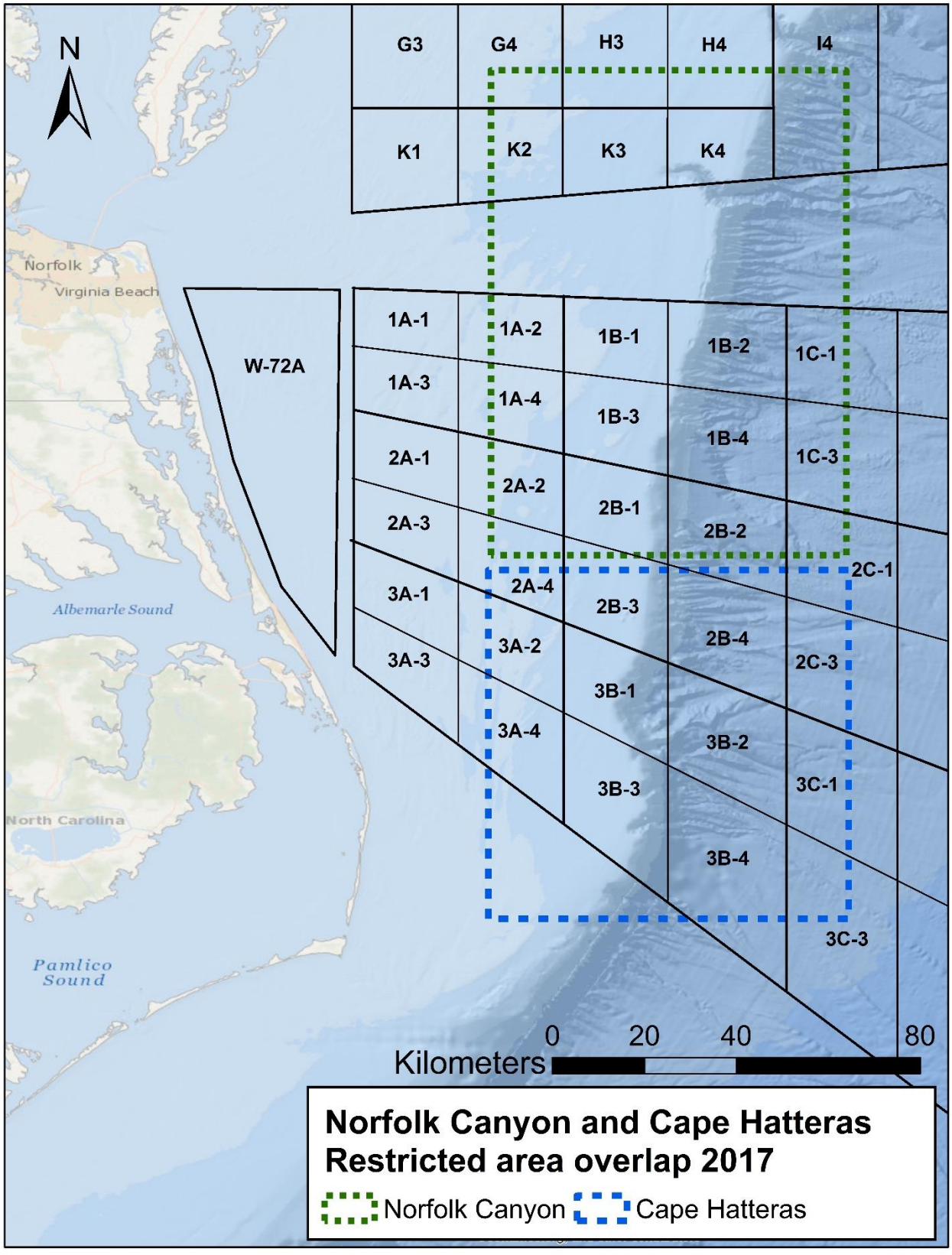

Figure 2. U.S. Navy operational surface grid and restricted warning areas that overlap the Norfolk Canyon and Cape Hatteras survey areas.

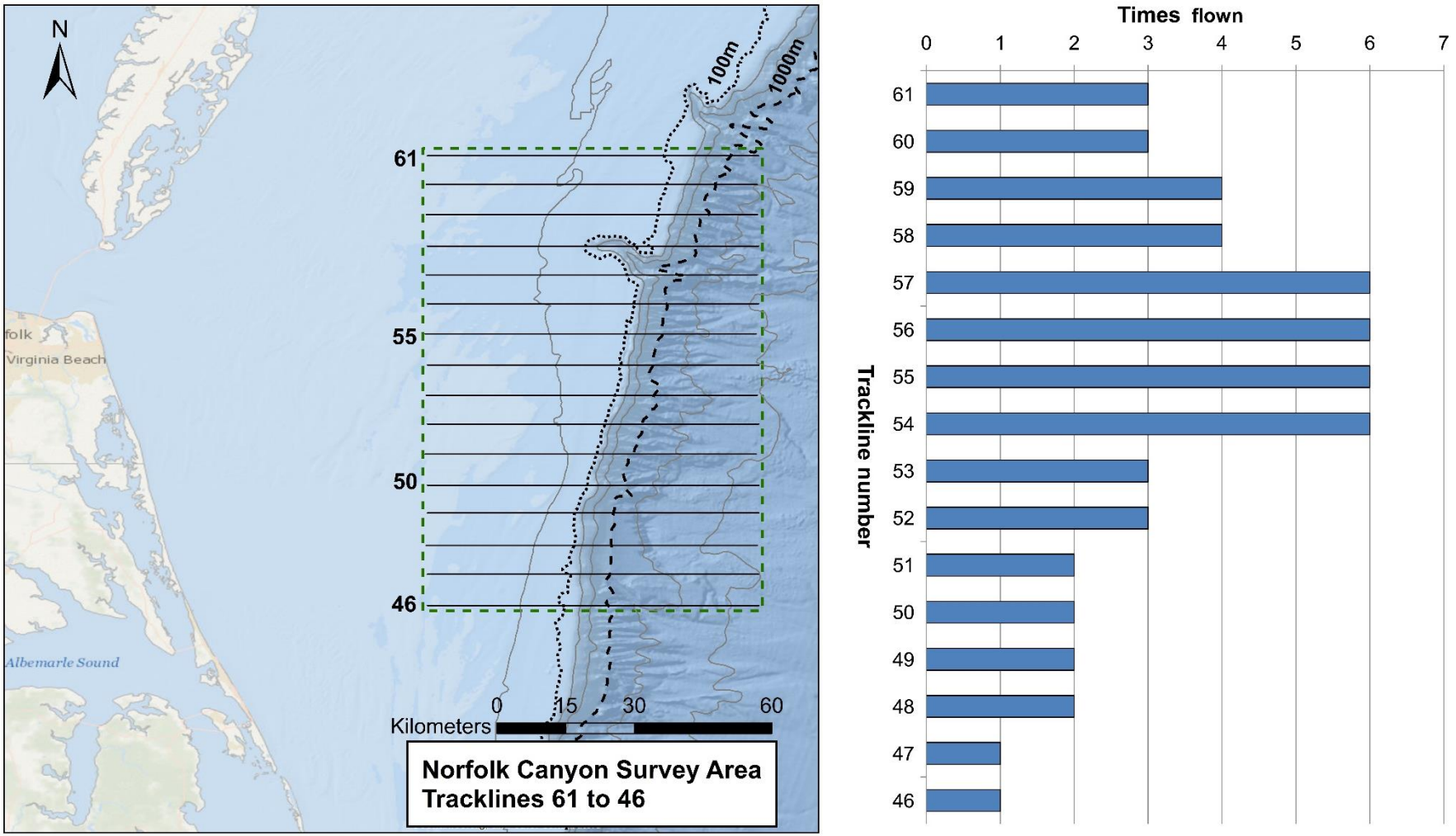

Figure 3. Survey tracklines and realized effort in the Norfolk Canyon survey area for 2017.

4. Results

Fifty-four tracklines totaling 3,812 km were surveyed in 2017 (**Table 2**). Conditions during the 10 survey days ranged from BSS 1 to 5 with greater than 80 percent of effort in sea states of BSS 3 or lower (BSS 1: 453.25 km [11.89 percent], BSS 2: 1,689.05 km [44.31 percent], BSS 3: 981.95 km [25.76 percent], BSS 4: 481.35 km [12.63 percent], BSS 5: 206.45 [5.42 percent]) (**Figures 4a and b**). An average BSS value, weighted by distance flown, was calculated for each month as a way to compare conditions across time (**Figure 4c**).

Table 2. Tracklines, km flown, and Hobbs hours (engine-on time) during aerial surveys of the Norfolk Canyon survey area in 2017. Trackline numbers are listed in the order in which they were flown.

Date	Tracklines Flown AM	Tracklines Flown PM	Total km Flown	Hobbs Hours
17-Jan-2017	N/A	54 to 57	191.80	2.6
22-Feb-2017	61 to 58	57 to 54	564.30	6.9
16-May-2017	57 to 54	53 to 52	442.70	6.5
17-May-2017	61 to 58	48 to 51	585.35	6.5
2-Jun-2017	52 to 55	59 to 56	570.60	6.9
26-Jun-2017	N/A	46 to 49	289.80	3.5
17-Jul-2017	N/A	58 to 61	292.25	3.4
18-Jul-2017	57 to 54	N/A	286.85	4.2
23-Aug-2017	50 to 53	N/A	294.75	2.4
5-Sep-2017	N/A	57 to 54	293.65	2.8
10 Days	**54 Tracklines**		**3812.05**	**45.7**

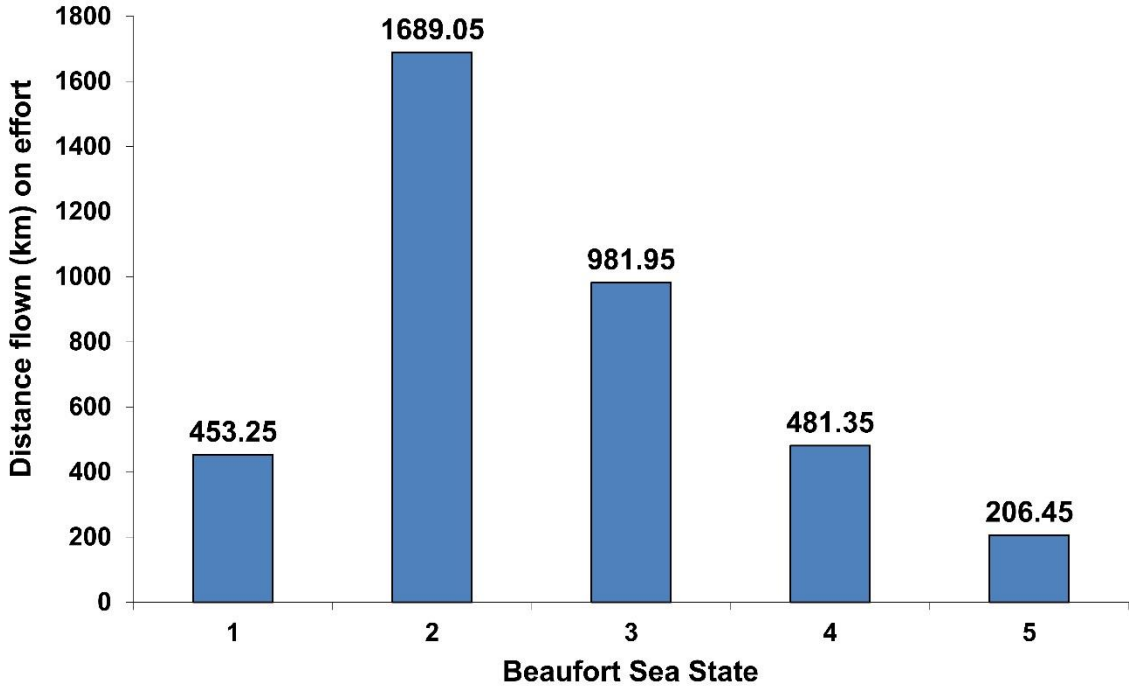

Figure 4a. Total distance surveyed per BSS category during aerial surveys in the Norfolk Canyon survey area in 2017.

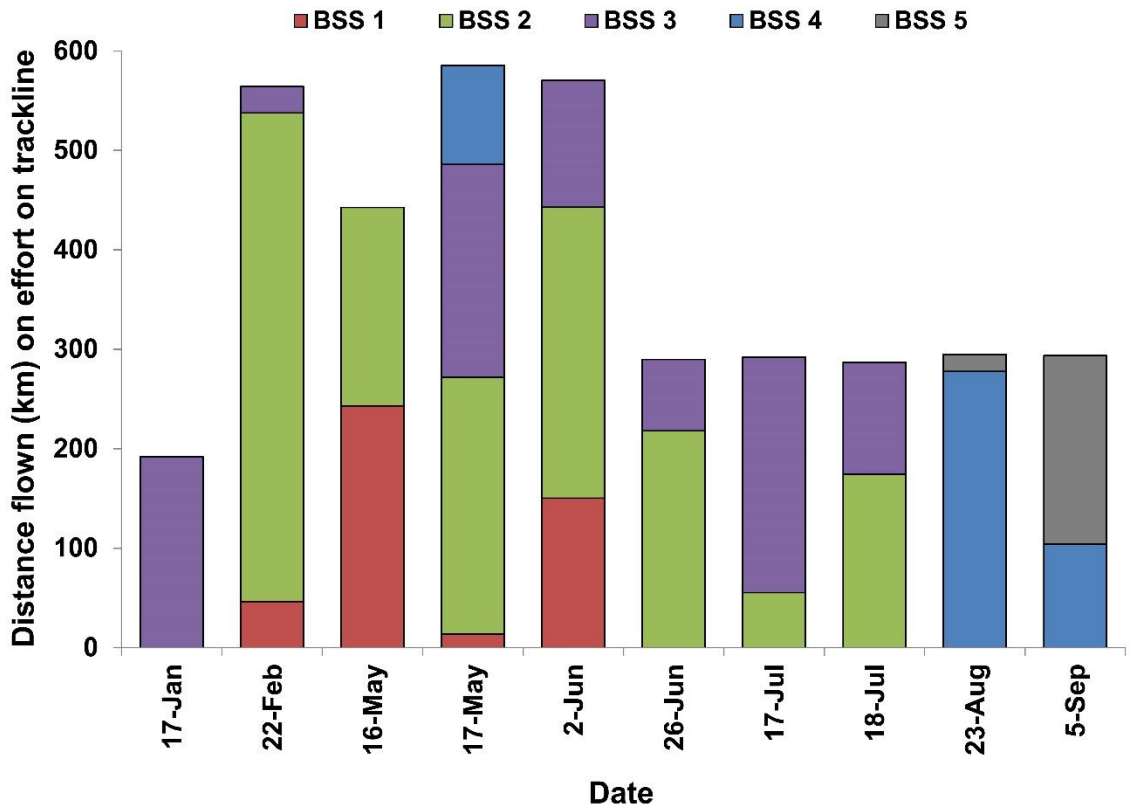

Figure 4b. Effort by BSS category for each survey day during aerial surveys in the Norfolk Canyon survey area in 2017.

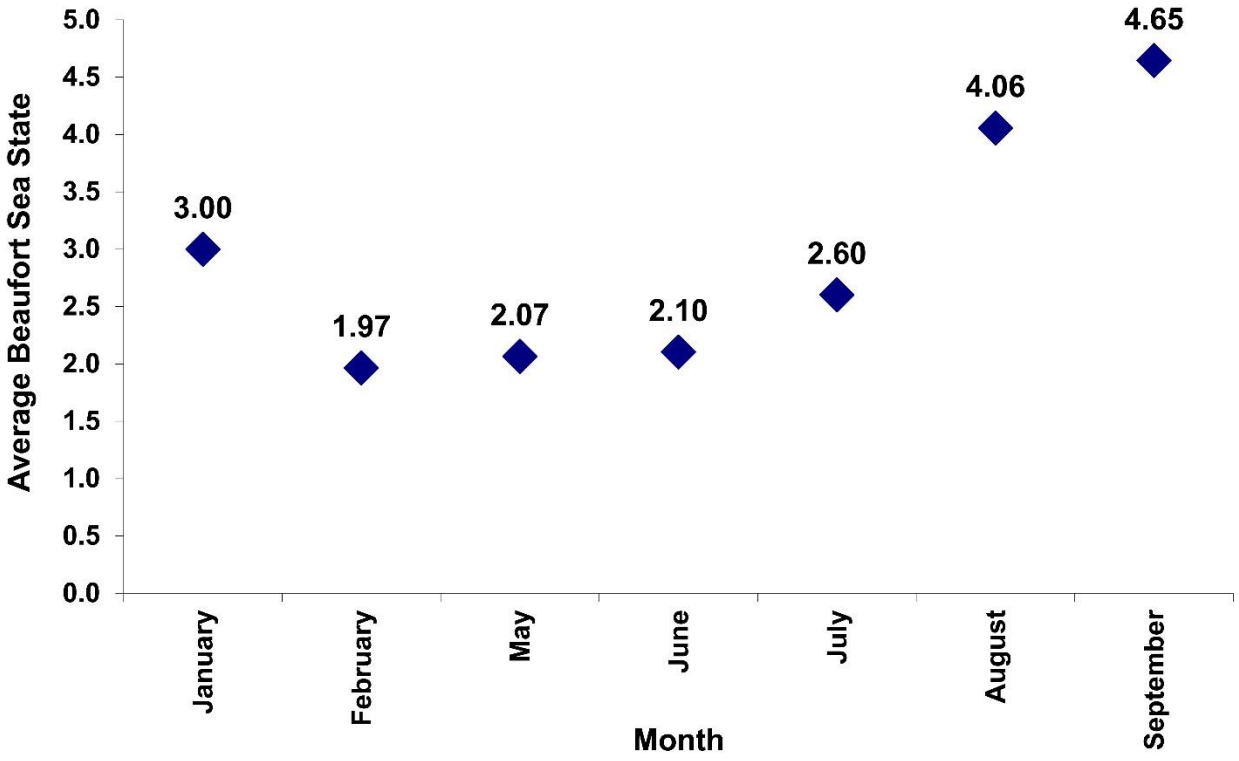

Figure 4c. Average BSS for each month from January to December 2017 during aerial surveys in the Norfolk Canyon survey area in 2017. Values are distance-weighted means.

All but one cetacean sighting occurred in BSS of 3 or less (**Figure 5a**). Cetacean sighting rates decreased as BSS increased, with 30.9 sightings/1,000 km surveyed in BSS 1, 28.4 sightings/1,000 km surveyed in BSS 2, 23.4 sightings/1,000 km surveyed in BSS 3, and 2.1 sightings/1,000 km surveyed in BSS 4 (**Figure 5b**). Sighting rates per month ranged from zero to 39.5 sightings/1,000 km. Sighting rate was highest in June, with 34 sightings recorded over 12 tracklines (**Figure 5c**).

Eighty percent of the sightings occurred within 1.2 km of the trackline (**Figure 6a**). Mean sighting distance for all cetacean sightings was 0.93 km (standard deviation [SD]=0.75). Mean sighting distances across sea states varied by 0.12 km, although variability around these means was high (**Figure 6b**). Average sighting distances are normally calculated after removing outliers, defined as any value in excess of three SD from the mean (mean=0.93 km, SD=0.75, 0.93+[3×0.75]=3.18 km, Outlier > 3.18 km). Two sighting distances were identified as outliers during this reporting period (BSS 1: 3.55 and BSS 4: 4.57 km sighting). The remaining 84 sighting distances are represented in **Figures 6a** and **b**.

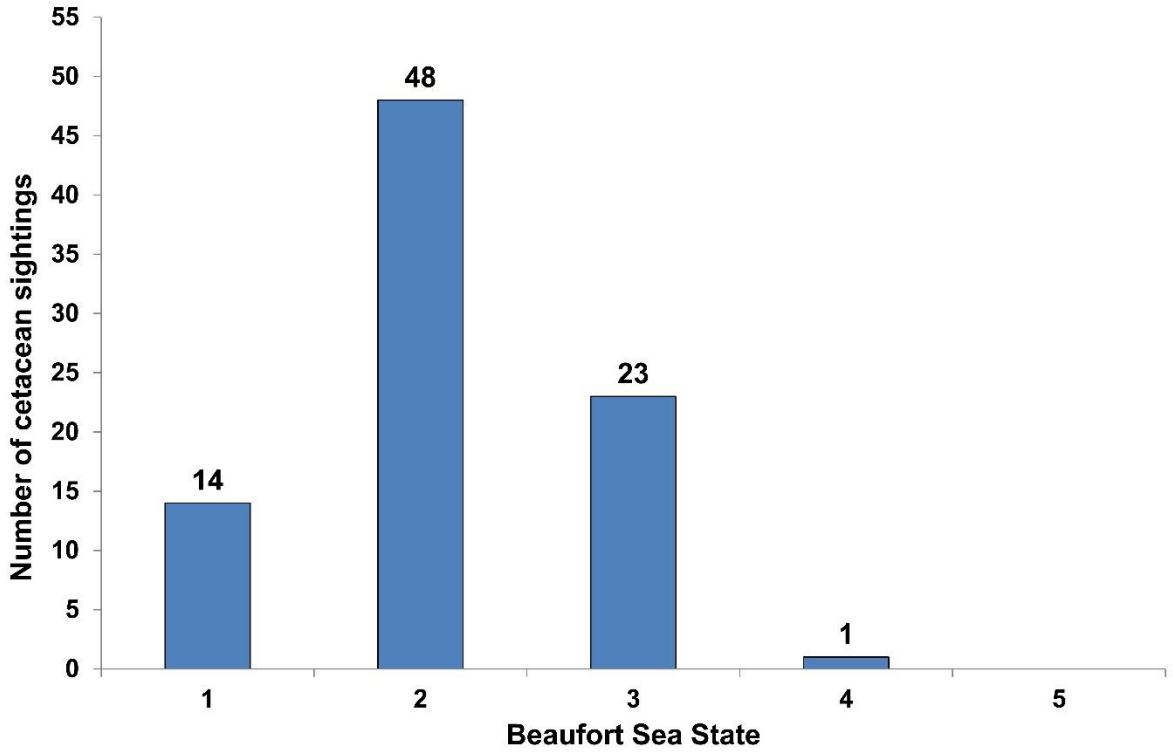

Figure 5a. Number of cetacean sightings per BSS category during aerial surveys in the Norfolk Canyon survey area in 2017.

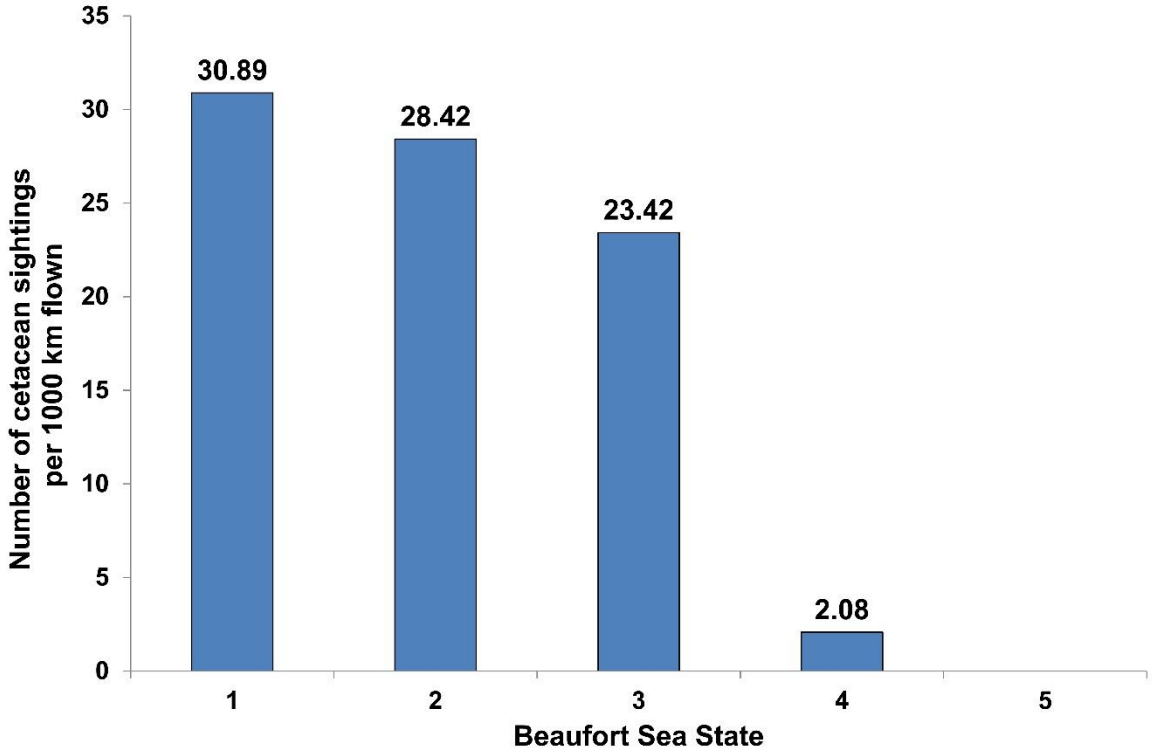

Figure 5b. Cetacean sightings per 1,000 km flown by BSS category during aerial surveys in the Norfolk Canyon survey area in 2017.

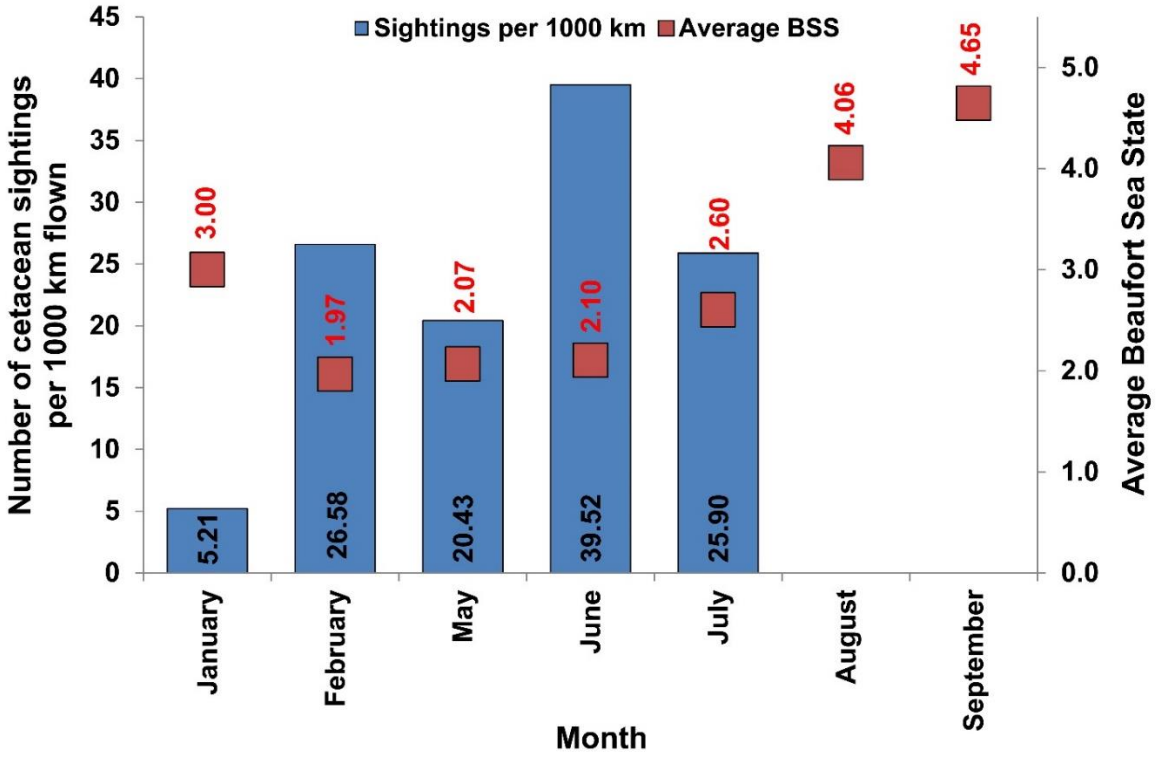

Figure 5c. Cetacean sightings per 1,000 km surveyed and the average BSS per month during aerial surveys in the Norfolk Canyonsurvey area in 2017.

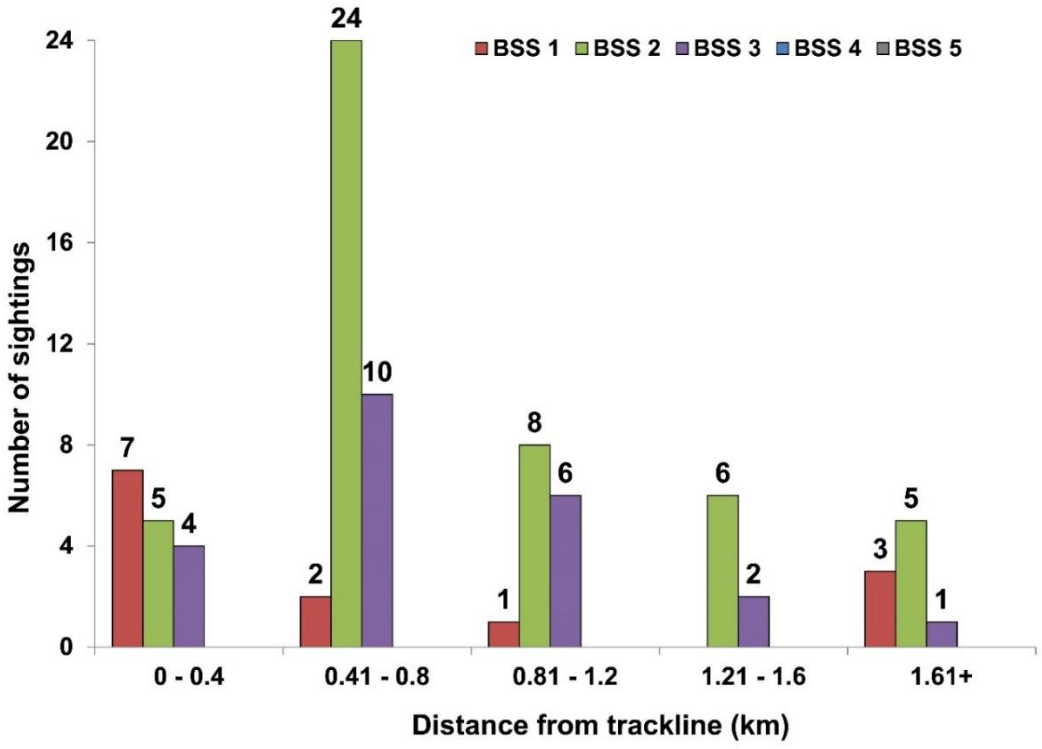

Figure 6a. Sighting distances by BSS category for 84 of 86 on-effort cetacean sightings during aerial surveys in the Norfolk Canyon survey area in 2017.

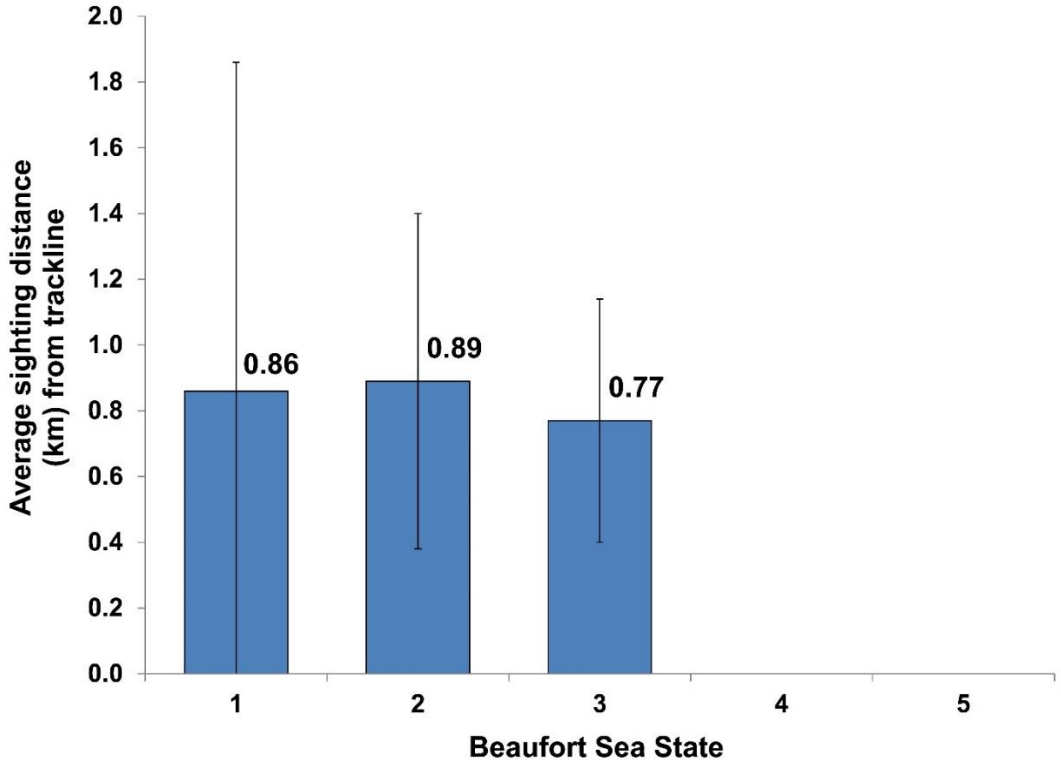

Figure 6b. Average sighting distances by BSS for 84 of 86 on-effort cetacean sightings during aerial surveys in the Norfolk Canyon survey area in 2017. Error bars denote standard deviation for each category.

4.1 Marine Mammal Sightings

A total of 86 sightings of 7,861 individual cetaceans, representing nine species, was observed while on effort during the reporting period (**Table 3, Figure 7**). Summary information follows below for each species individually. Two endangered species, the sperm whale and fin whale, were encountered in the survey area. Six cetacean species had additional sightings that were recorded while off effort. A sighting was considered off-effort if it occurred while transiting to or from the survey area or between tracklines. Any cetaceans the survey team encountered while investigating a separate sighting cue were also labeled off-effort. If two species were seen associated with the same sighting cue both were considered on-effort. The off-effort sightings are included in the tables and maps for each species but are excluded from any calculations. The total number of individuals listed represents the best estimate of group size. Information on individual sighting summaries are in **Appendices A, B, and C**. Daily sightings are summarized in **Appendix D.**

Table 3. Numbers of on-effort sightings and individuals for each species by month for the Norfolk Canyon survey area in 2017.

	Numbers of	Month												Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Delphinus delphis	Sightings		6	-	-	6	10	1	-	-	-	-	-	23
	Individuals		231	-	-	1321	4503	25	-	-	-	-	-	6080
Tursiops truncatus	Sightings	1	3	-	-	5	8		-	-	-	-	-	17
	Individuals	4	40	-	-	167	214		-	-	-	-	-	425
Stenella frontalis	Sightings			-	-	3	6	1	-	-	-	-	-	10
	Individuals			-	-	139	296	34	-	-	-	-	-	469
Grampus griseus	Sightings		1	-	-	3	2	3	-	-	-	-	-	9
	Individuals		11	-	-	21	21	49	-	-	-	-	-	102
Stenella coeruleoalba	Sightings		4	-	-		1		-	-	-	-	-	5
	Individuals		166	-	-		350		-	-	-	-	-	516
Globicephala macrorhynchus	Sightings			-	-	3	3	8	-	-	-	-	-	14
	Individuals			-	-	52	65	138	-	-	-	-	-	255
Physeter macrocephalus	Sightings		1	-	-	1	3		-	-	-	-	-	5
	Individuals		1	-	-	1	5		-	-	-	-	-	7
Ziphius cavirostris	Sightings			-	-		1	1	-	-	-	-	-	2
	Individuals			-	-		1	4	-	-	-	-	-	5
Balaenoptera physalus	Sightings			-	-			1	-	-	-	-	-	1
	Individuals			-	-			2	-	-	-	-	-	2
	Total sightings	**1**	**15**			**20**	**34**	**15**	**0**	**0**				**86**
	Total individuals	**4**	**449**			**1698**	**5455**	**252**	**0**	**0**				**7861**
Caretta caretta	Sightings			-	-	76	50	11	3	2	-	-	-	142
	Individuals			-	-	144	95	14	3	2	-	-	-	258
Dermochelys coriacea	Sightings			-	-	1	2				-	-	-	3
	Individuals			-	-	1	2				-	-	-	3
	Total sightings	**0**	**0**			**77**	**52**	**11**	**3**	**2**				**145**
	Total individuals	**0**	**0**			**145**	**97**	**14**	**3**	**2**				**261**

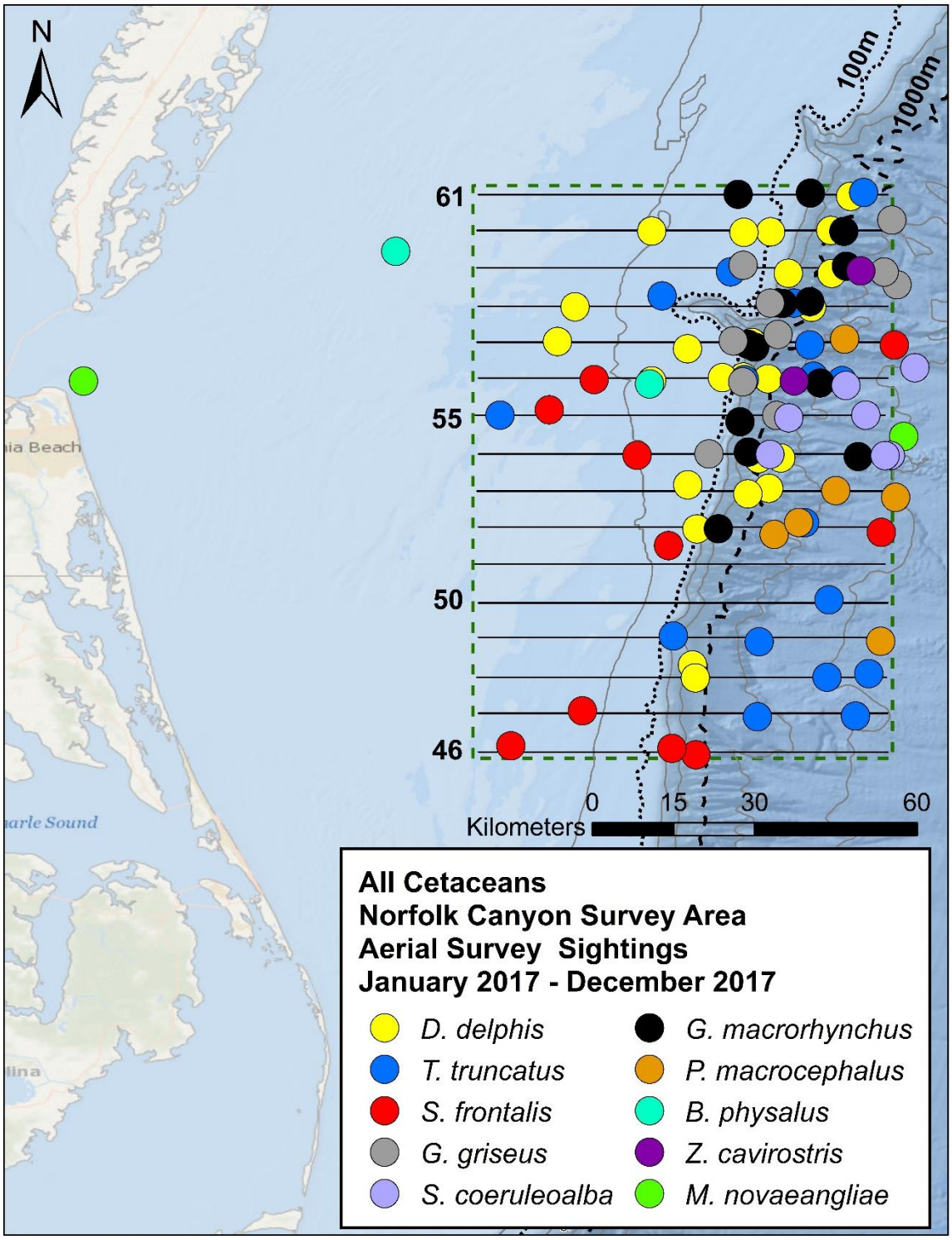

Figure 7. All cetacean sightings during aerial surveys conducted in the Norfolk Canyon survey area in 2017.

4.2 Dolphins

4.2.1 Common dolphin (*Delphinus delphis*)

This species was the most frequently observed and most abundant cetacean in Norfolk Canyon. Twenty-three on-effort sightings of 6,080 individuals (mean group size = 264.35, SD=645.02) were observed, largely inshore of the 1,000-m isobath (**Table 4, Figure 8**). One additional off-effort sighting of 225 individuals occurred while investigating a fin whale. Common dolphin group sizes were highly variable, with the largest groups reaching into the thousands and smaller groups of fewer than 25 animals. The two largest groups occurred in the southern portion of the study area.

Table 4. Common dolphin (*Delphinus delphis*) sightings in the Norfolk Canyon survey area in 2017. Astrick denotes an off-effort sighting.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
22-Feb-2017	10:08:59	14	37.245606	74.571838	60	2	1	60°	80	
22-Feb-2017	10:13:39	18	37.244799	74.625619	60	2	1	90°	72	
22-Feb-2017	10:21:43	22	37.247250	74.811870	60	2	1	90°	35	
22-Feb-2017	11:30:23	37	37.094442	74.966558	58	2	1	100°	10	
22-Feb-2017	14:14:30	49	37.024386	75.002048	57	2	1	90°	11	
22-Feb-2017	15:01:28	67	36.951510	74.669132	56	2	2	90°	23	
16-May-2017	13:22:59	68	36.789623	74.551272	54	1	4	120°	65	
16-May-2017	16:16:58	94	36.716932	74.617957	53	2	3	60°	55	
17-May-2017	10:15:01	16	37.317343	74.410532	61	2	2	90°	70	
17-May-2017	10:30:53	25	37.248565	74.450396	60	2	2	90°	21	
17-May-2017	11:10:01	44	37.162011	74.536073	59	2	3	90°	110	
17-May-2017	14:27:46	70	36.345843	74.723786	48	3	2	90°	1000	
2-Jun-2017	9:28:37	7	36.646538	74.720609	52	1	1	60°	550	
2-Jun-2017	10:00:51	26	36.728511	74.575806	53	1	1	100°	23	
2-Jun-2017	10:09:36	32	36.735270	74.739025	53	2	1	60°	30	
2-Jun-2017	10:52:42	44	36.788326	74.596227	54	3	2	100°	34	
2-Jun-2017	14:21:56	84	37.161871	74.448442	59	2	2	90°	15	
2-Jun-2017	14:38:36	95	37.093578	74.489213	58	3	2	90°	625	
2-Jun-2017	15:21:04	116	37.022378	74.609649	57	1	2	90°	150	
2-Jun-2017	15:57:15	132	36.949456	74.577126	56	1	1	90°	26	
2-Jun-2017	15:58:50	135	36.952824	74.627012	56	1	2	45°	50	
26-Jun-2017	15:20:47	72	36.371793	74.729578	48	2	3	45°	3000	
18-Jul-2017	9:05:47	5	37.009882	74.739644	57	3	2	100°	25	
18-Jul-2017	10:14:53	20	36.944854	74.811928	56	3	2	90°	225	*

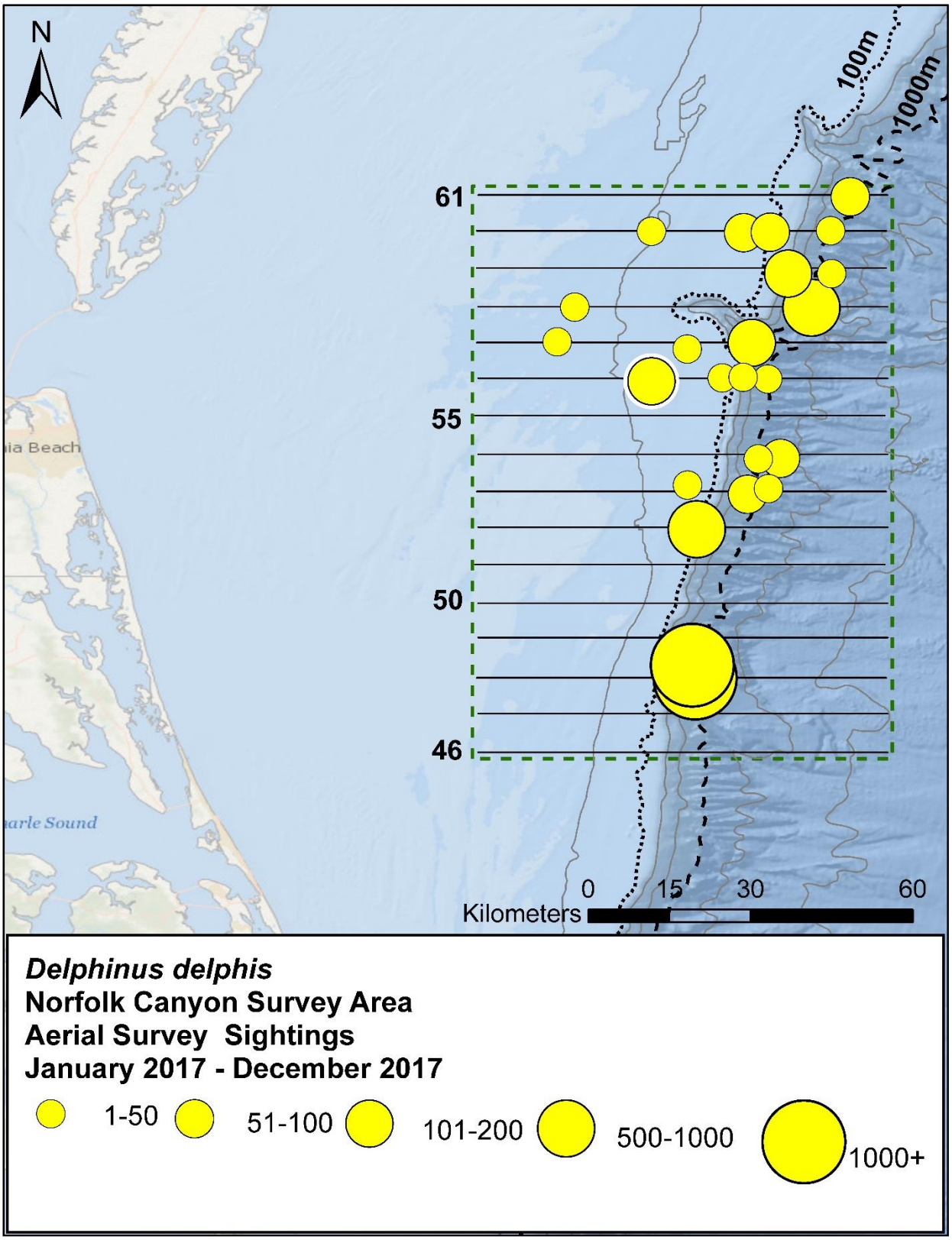

Figure 8. Common dolphin (*Delphinus delphis*) sightings indicating group size. White outline denotes off-effort sighting.

4.2.2 Common bottlenose dolphin (*Tursiops truncatus*)

Seventeen sightings totaling 425 individuals of common bottlenose dolphins were observed in four of the seven months surveyed (**Table 5, Figure 9**). Groups ranged in size between 4 and 60 individuals (mean=25.0, SD=20.1). Fewer sightings and smaller groups occurred in shallower waters, while larger groups were found in deeper waters. The majority of sightings occurred more than 37 km from shore and in waters beyond the 100-m isobath. Based on the distance from shore (i.e., more than 34 km), most of these bottlenose dolphins were likely the offshore ecotype (Torres et al. 2003).

Table 5. Common bottlenose dolphin (*Tursiops truncatus*) sightings in the Norfolk Canyon survey area in 2017..

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
17-Jan-2017	14:15:29	11	36.945538	74.427550	56	3	1	90°	4	
22-Feb-2017	9:53:32	8	37.325240	74.384295	61	2	3	90°	15	
22-Feb-2017	11:13:01	33	37.101920	74.524746	58	2	3	90°	17	
22-Feb-2017	14:55:46	63	36.947423	74.624797	56	2	1	90°	8	
16-May-2017	12:07:45	27	37.017864	74.492676	57	2	2	90°	55	
16-May-2017	12:26:43	39	36.954374	74.485459	56	2	3	60°	20	
16-May-2017	16:48:31	106	36.659091	74.503165	52	2	2	90°	18	
17-May-2017	14:46:16	75	36.354389	74.373560	48	3	3	110°	50	
17-May-2017	15:38:18	90	36.503326	74.454053	50	3	1	90°	24	
2-Jun-2017	11:35:07	60	36.875797	75.117961	55	2	1	60°	6	
2-Jun-2017	14:07:27	76	37.164853	74.652618	59	2	1	90°	10	
2-Jun-2017	14:47:54	100	37.116691	74.790918	58	2	3	45°	8	
26-Jun-2017	14:33:03	56	36.269105	74.400527	47	3	1	100°	25	
26-Jun-2017	14:44:02	60	36.267388	74.598447	47	3	3	110°	60	
26-Jun-2017	15:35:41	76	36.347254	74.458003	48	2	1	90°	40	
26-Jun-2017	16:00:00	86	36.418897	74.595025	49	2	1	90°	60	
26-Jun-2017	16:09:47	90	36.430308	74.768273	49	2	1	90°	5	

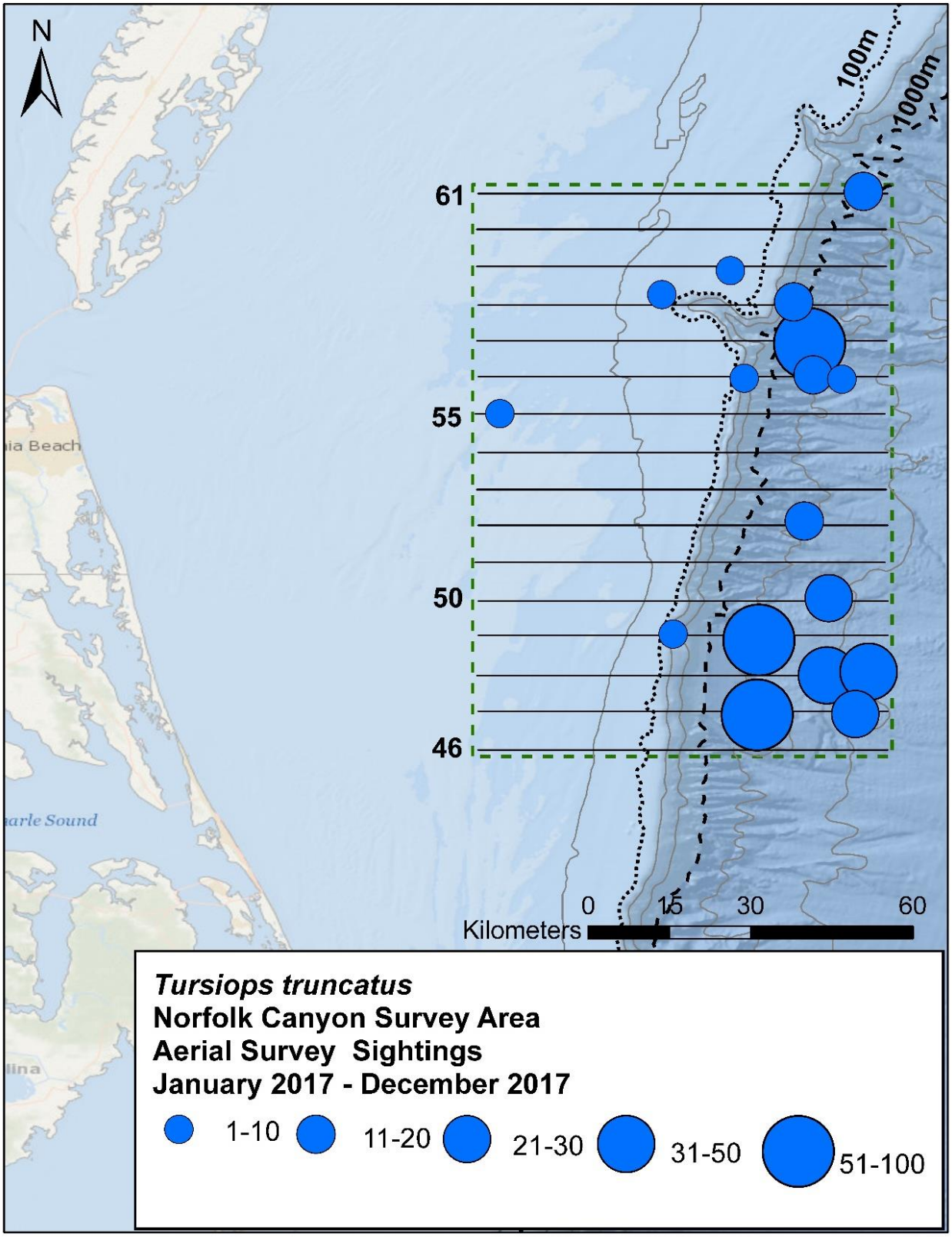

Figure 9. Common bottlenose dolphin (*Tursiops truncatus*) sightings indicating group size.

4.2.3 Atlantic spotted dolphin (*Stenella frontalis*)

Ten sightings of 469 individuals were observed while on effort. Group size ranged between 11 and 80 (mean=46.9, SD=25.4) (**Table 6, Figure 10**). There are two distinct forms, or ecotypes, of the Atlantic spotted dolphin in the western North Atlantic: a heavily spotted, larger form that typically occurs on the continental shelf and is most often encountered around the 200-m isobath or shallower, and a less spotted and smaller form that occurs farther offshore and around islands (Perrin et al. 1987, 1994). Examination of photographs collected during each sighting suggests that both ecotypes are present within the survey area.

Table 6. Atlantic spotted dolphin (*Stenella frontalis*) sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
16-May-2017	12:16:14	31	37.017599	74.321996	57	2	3	60°	70	
16-May-2017	16:38:58	102	36.639297	74.348406	52	2	1	110°	29	
17-May-2017	15:57:59	96	36.612695	74.777909	51	4	4	40°	40	
2-Jun-2017	10:32:29	39	36.794866	74.841353	54	3	2	100°	11	
2-Jun-2017	11:26:56	56	36.886698	75.018661	55	2	3	60°	30	
26-Jun-2017	13:39:38	40	36.208914	75.096250	46	2	2	45°	75	
26-Jun-2017	13:57:11	46	36.203757	74.771016	46	2	2	60°	25	
26-Jun-2017	14:05:16	50	36.190680	74.722520	46	2	1	60°	75	
26-Jun-2017	14:53:49	66	36.279404	74.951941	47	2	2	90°	80	
18-Jul-2017	10:23:09	24	36.947743	74.928123	56	3	1	60°	34	

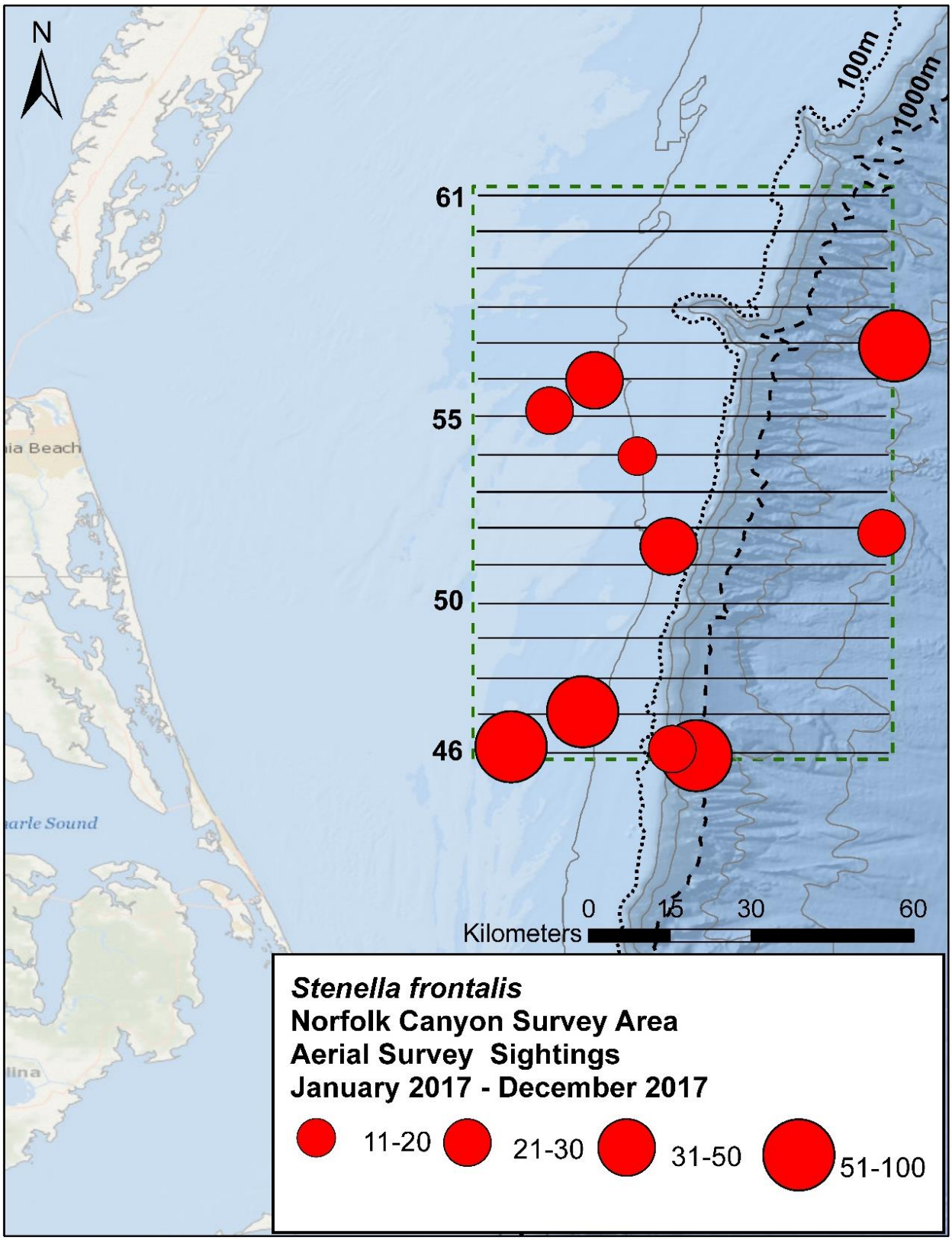

Figure 10. Atlantic spotted dolphin (*Stenella frontalis*) sightings indicating group size.

4.2.4 Risso's dolphin (*Grampus griseus*)

This species was encountered nine times, all in groups of fewer than 30 individuals (mean=11.3, SD=7.3) (**Table 7, Figure 11**). One off-effort sighting of three individuals occurred while transiting between the offshore ends of two tracklines. All sightings occurred near the shelf break or in deeper waters.

Table 7. Risso's dolphin (*Grampus griseus*) sightings in the Norfolk Canyon survey area in 2017. Asterisk denotes an off-effort sighting.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
22-Feb-2017	10:59:36	30	37.139055	74.316688		2	1	90°	3	*
22-Feb-2017	15:36:30	74	36.875276	74.559638	55	2	1	90°	11	
16-May-2017	11:51:23	17	37.025733	74.647110	57	1	2	90°	10	
17-May-2017	10:20:53	13	37.269536	74.327107	61	1	4	90°	3	
17-May-2017	11:41:13	55	37.101961	74.572745	58	3	3	110°	8	
2-Jun-2017	14:14:02	80	37.178378	74.627451	59	2	2	90°	10	
2-Jun-2017	15:35:19	122	37.038796	74.557083	57	1	3	110°	11	
17-Jul-2017	13:55:27	16	37.164574	74.342724	59	3	2	90°	18	
18-Jul-2017	9:50:38	15	36.942979	74.628106	56	3	1	90°	4	
18-Jul-2017	11:43:18	52	36.797772	74.696438	54	3	1	90°	27	

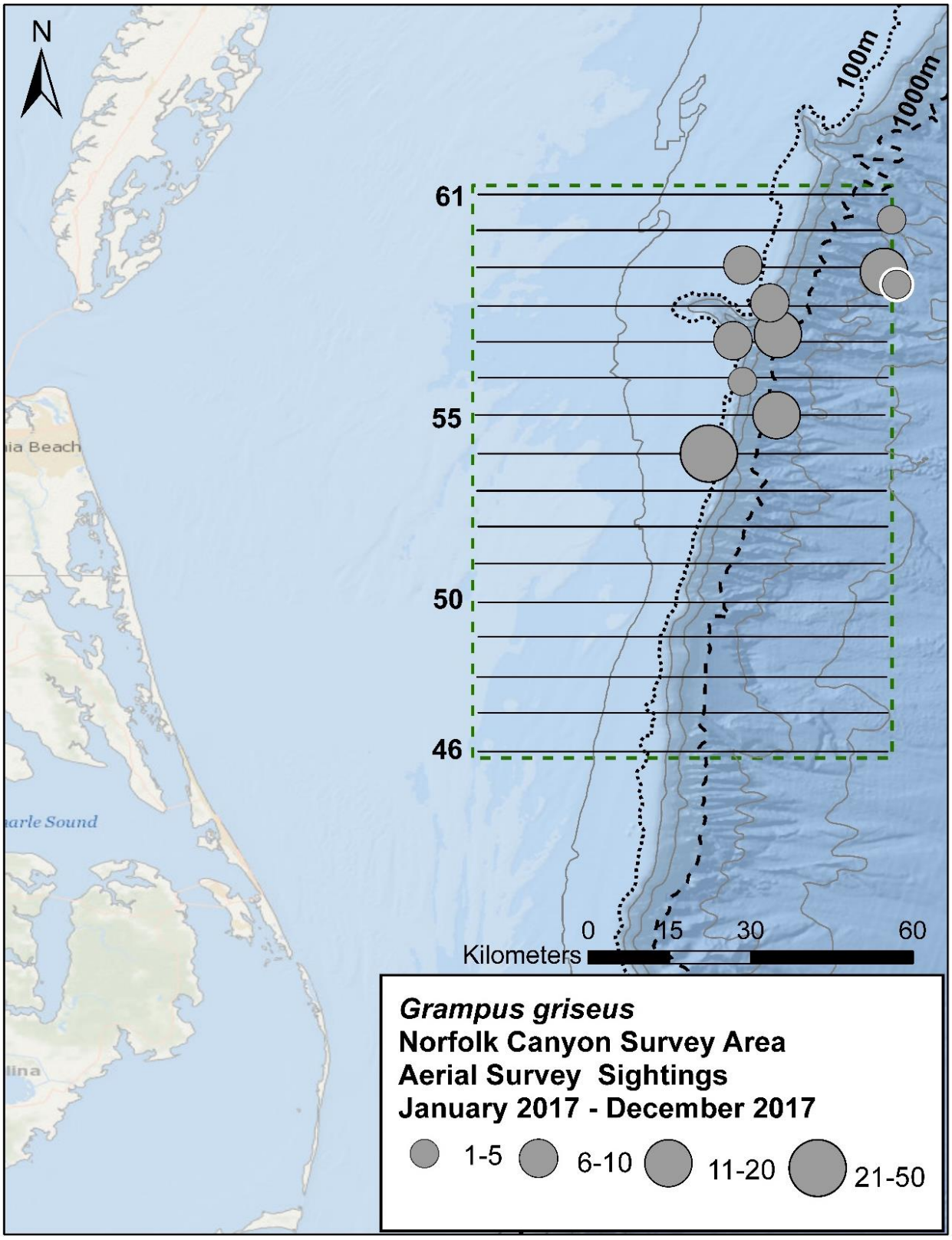

Figure 11. Risso's dolphin (*Grampus griseus*) sightings indicating group size. White outline denotes off-effort sighting.

4.2.5 Striped dolphin (*Stenella coeruleoalba*)

Five on-effort sightings, representing 516 individuals, were observed beyond the 1,000-m isobath (**Table 8, Figure 12**). Two off-effort sightings were seen in transit between the offshore ends of tracklines. The majority of groups were of fewer than 50 individuals, although a larger group of 350 individuals was observed.

Table 8. Striped dolphin (*Stenella coeruleoalba*) sightings in the Norfolk Canyon survey area in 2017. Asterisk denotes off-effort sightings.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
17-Jan-2017	14:32:53	16	36.971435	74.280467			1	90°	35	*
22-Feb-2017	14:45:59	59	36.935613	74.419922	56	2	3	90°	80	
22-Feb-2017	15:39:46	78	36.870464	74.535308	55	2	1	75°	50	
22-Feb-2017	15:48:16	82	36.875880	74.379820	55	2	1	90°	13	
22-Feb-2017	16:02:44	63	36.794544	74.329968		2	2	90°	34	*
22-Feb-2017	16:14:49	91	36.796836	74.573036	54	2	1	75°	23	
2-Jun-2017	11:05:16	48	36.794384	74.340732	54	2	2	60°	350	

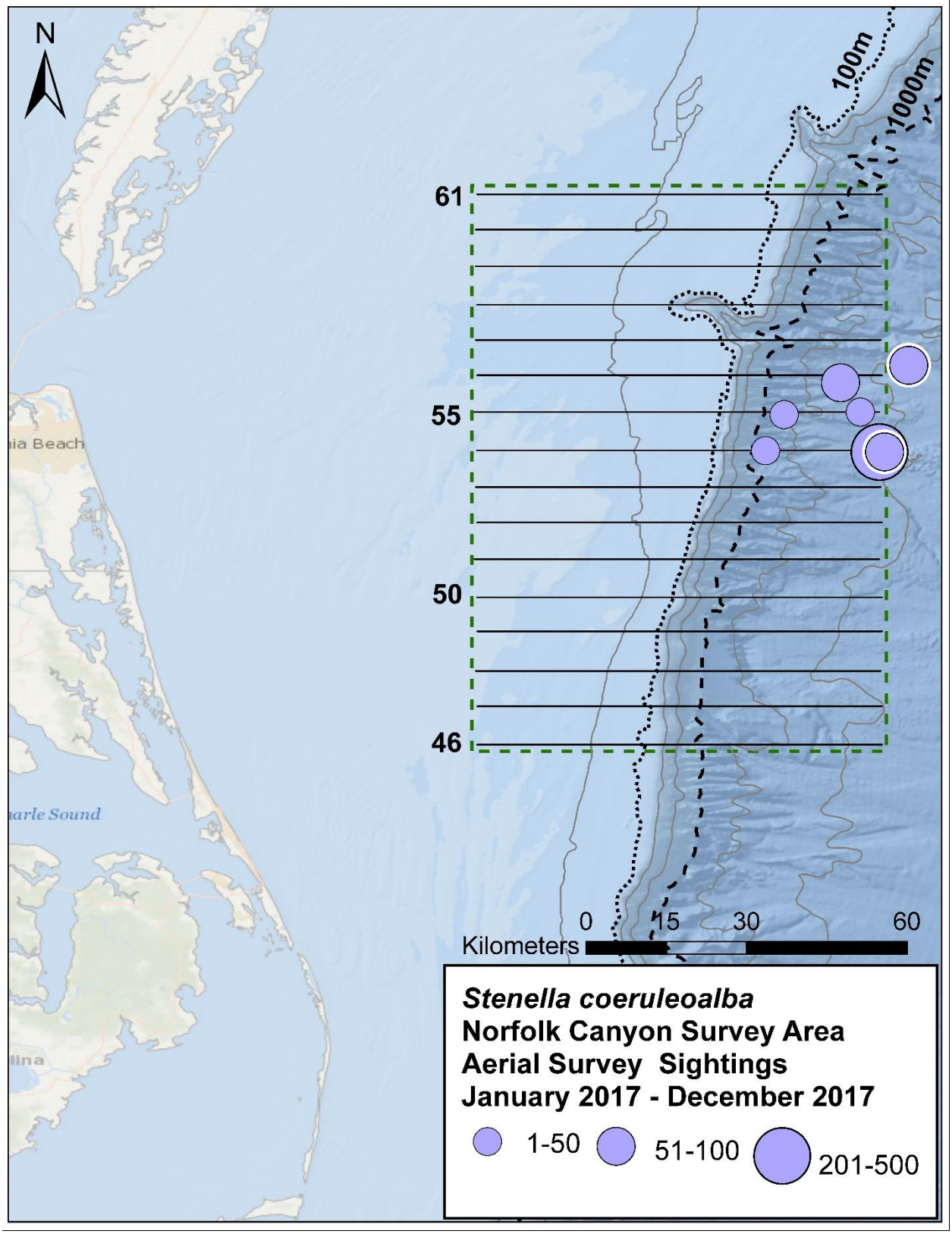

Figure 12. Striped dolphin (*Stenella coeruleoalba*) sightings indicating group size. White outline denotes off-effort sightings.

4.3 Whales

4.3.1 Short-finned pilot whale (*Globicephala macrorhynchus*)

This species was observed 14 times for a total of 255 individuals, and was seen in 3 of the 7 months in which surveys were conducted. Group sizes ranged from 2 to 50 individuals (mean=18.21, SD=14.42) (**Table 9**). Sightings of pilot whales in the western North Atlantic occur primarily near the continental shelf break (Waring et al. 2014), and sightings in the Cape Hatteras survey area followed this pattern. Pilot whales were observed beyond the 100-m isobath into waters greater than 2,000 m in bottom depth (**Figure 13**).

Table 9. Short-finned pilot whale (*Globicephala macrorhynchus)* sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
16-May-2017	11:57:50	21	37.019087	74.617708	57	1	1	120°	35	
17-May-2017	9:58:25	8	37.321342	74.637513	61	3	1	100°	5	
17-May-2017	11:34:00	51	37.102313	74.556557	58	3	1	100°	12	
2-Jun-2017	9:34:48	11	36.646762	74.677272	52	1	1	90°	11	
2-Jun-2017	14:25:55	88	37.176352	74.418834	59	2	3	90°	4	
2-Jun-2017	15:22:55	117	37.012923	74.603863	57	1	2	90°	50	
17-Jul-2017	13:35:04	5	37.101322	74.547438	58	3	1	90°	20	
17-Jul-2017	13:42:32	10	37.104991	74.492848	58	2	1	90°	30	
17-Jul-2017	14:51:25	29	37.246753	74.424033	60	3	1	90°	2	
17-Jul-2017	15:11:13	35	37.324013	74.491516	61	2	1	90°	18	
18-Jul-2017	9:33:48	11	36.940942	74.471711	56	3	2	100°	11	
18-Jul-2017	10:53:34	36	36.862665	74.633620	55	3	3	90°	10	
18-Jul-2017	11:09:51	43	36.792276	74.395035	54	2	3	90°	10	
18-Jul-2017	11:32:34	48	36.801575	74.616820	54	2	1	90°	37	

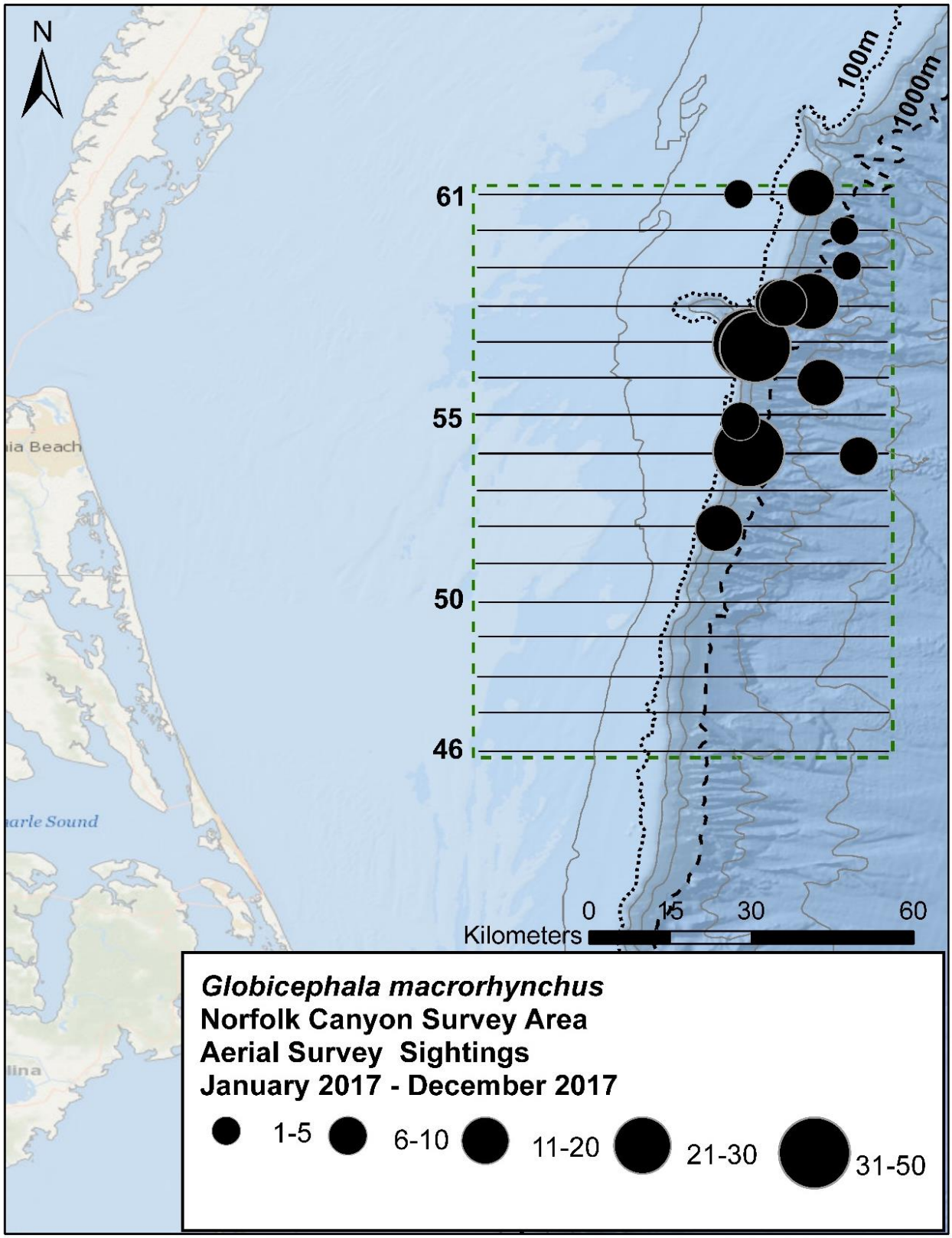

Figure 13. Short-finned pilot whale (*Globicephala macrorhynchus*) sightings indicating group size.

4.3.2 Sperm whale (*Physeter macrocephalus*)

Sperm whales were observed on-effort a total of five times either as singles or as pairs. One off-effort sighting between tracklines was also recorded. All sightings occurred beyond the 1,000-m isobath in the southern portion of the Norfolk Canyon, Virginia survey area (**Table 10, Figure 14**).

Table 10. Sperm whale (*Physeter macrocephalus*) sightings in the Norfolk Canyon survey area in 2017. Asterisk denotes an off-effort sighting.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
22-Feb-2017	14:32:20	53	37.029393	74.422474	57	2	3	90°	1	
16-May-2017	16:31:05	99	36.709882	74.319606			2	45°	1	*
16-May-2017	16:52:22	107	36.659468	74.515129	52	2	2	90°	1	
2-Jun-2017	9:39:02	15	36.635234	74.564609	52	1	2	90°	1	
2-Jun-2017	9:55:42	22	36.723578	74.440239	53	1	1	90°	2	
26-Jun-2017	15:50:13	82	36.419763	74.349716	49	2	2	90°	2	

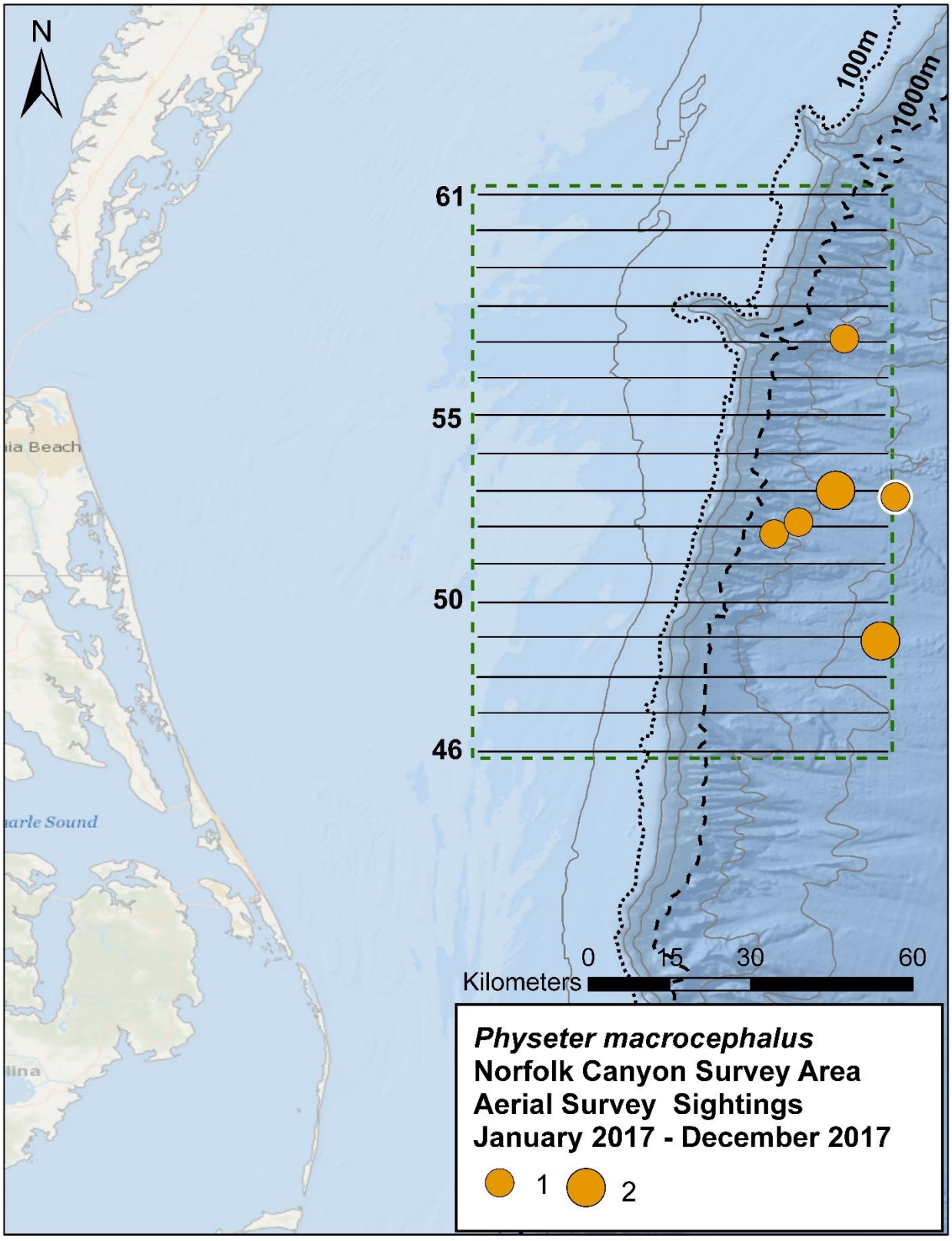

Figure 14. Sperm whale (*Physeter macrocephalus*) sightings indicating group size. White outline denotes an off-effort sighting.

4.3.3 Cuvier's beaked whale (*Ziphius cavirostris*)

Two sightings, a group of four and a single individual, of this species were observed beyond the 1000-m isobath around the submarine canyon that gives this site its name in the northern portion of the survey area.(**Table 11, Figure 15**). Photo-documentation of all beaked whales continues to better define characteristic of each species, as well as building catalog images of distinctive scarring patterns used for individual animal ID (Waples et al. 2017).

Table 11. Cuvier's beaked whale (*Ziphius cavirostris*) sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
2-Jun-2017	15:53:31	129	36.944845	74.524152	56	3	2	90°	1	
17-Jul-2017	14:03:15	20	37.166828	74.389711	59	2	1	60°	4	

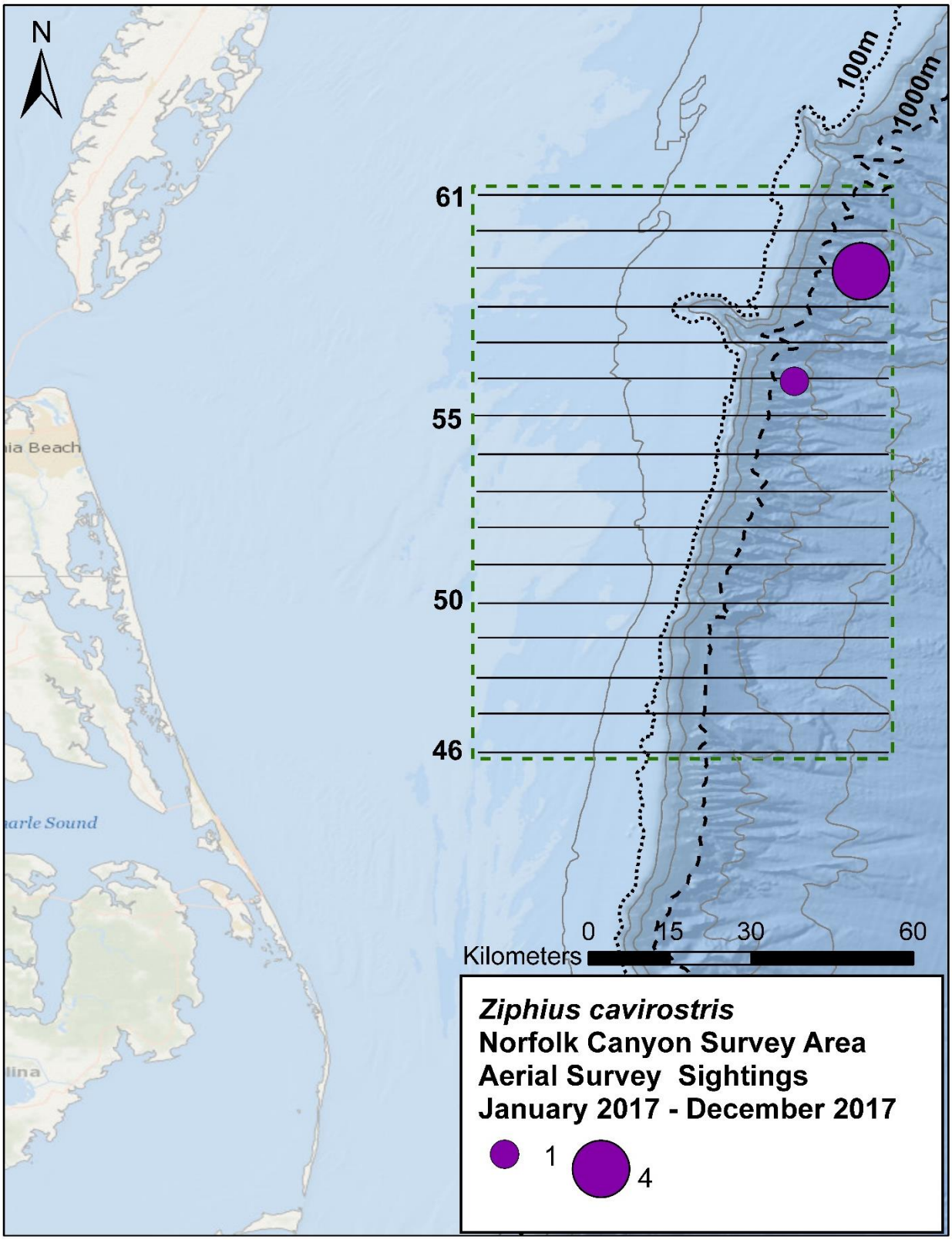

Figure 15. Cuvier's beaked whale (*Ziphius cavirostris*) sightings indicating group size.

4.3.4 Fin whale (*Balaenoptera physalus*)

Fin whales were observed both within the survey area and while transiting to the site (**Table 12, Figure 16**). Both encounters were of larger, presumably adult animals. In previous years fin whales have been observed with healed or recent propeller injuries. No such injuries were observed on individuals photographed this year.

Table 12. Fin whale (*Balaenoptera physalus*) sightings in the Norfolk Canyon survey area in 2017. Asterisk denotes an off-effort sighting.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
22-Feb-2017	9:19:34	3	37.206358	-75.328456		2	1	90°	1	*
18-Jul-2017	10:03:43	19	36.938781	-74.816419	56	3	2	90°	2	

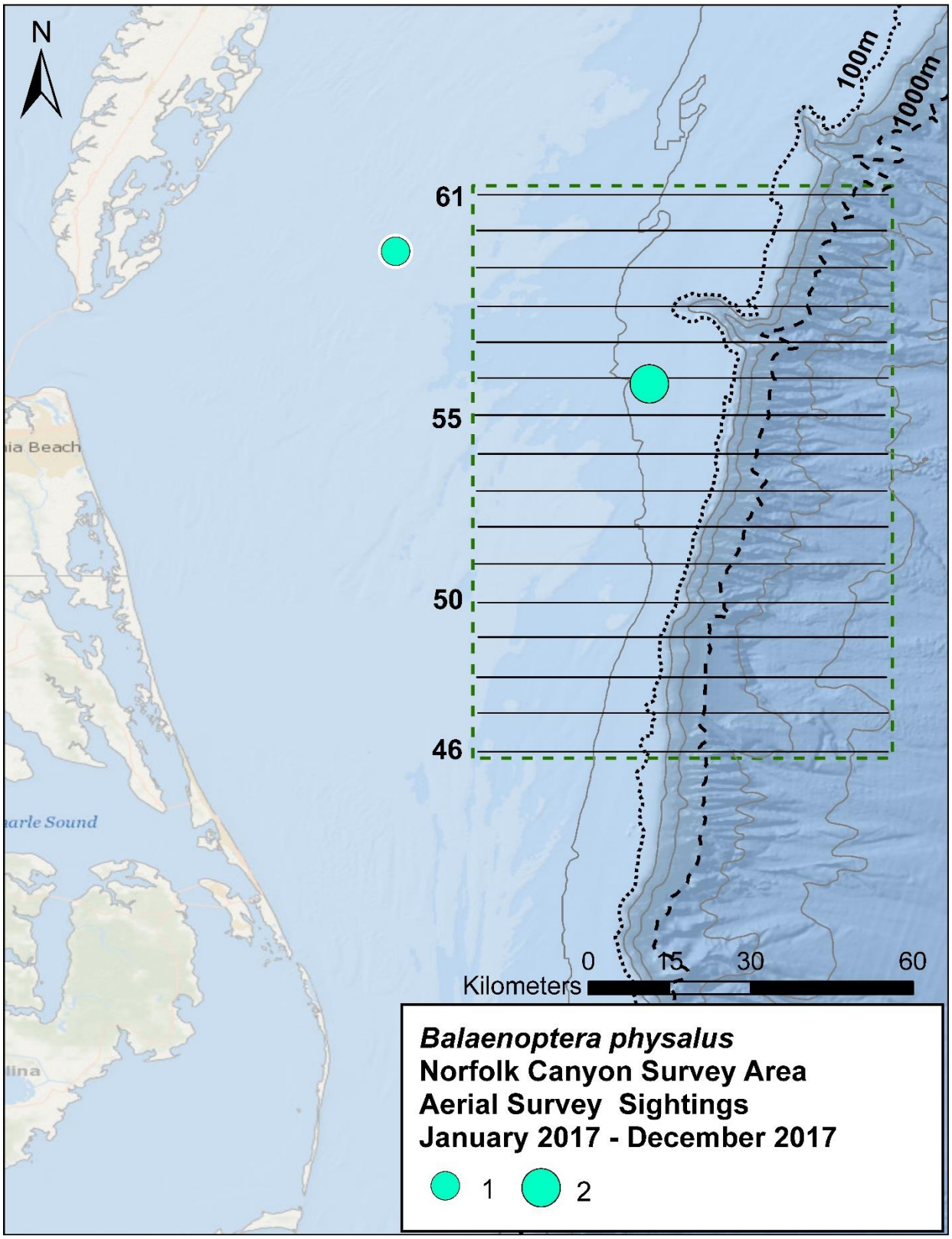

Figure 16. Fin whale (*Balaenoptera physalus*) sightings indicating group size. White outline denotes an off-effort sighting.

4.3.5 Humpback whale (*Megaptera novaeangliae*)

Humpback whales were observed over the inshore waters near the mouth of the Chesapeake Bay and also offshore of the Norfolk Canyon survey area (**Table 13, Figure 17**). Both were off-effort sightings of single individuals. Multiple images were taken of the offshore animal, which was heavily scarred and was observed with ventral pleats distended, indicative of feeding. Since this species has been the focus of current and past photo-identification work, all efforts were made to document any features that could aid in identifying the individual. Images collected from this sighting were passed to teams responsible for maintaining the Atlantic Humpback whale catalog.

Table 13. Humpback whale (*Megaptera novaeangliae*) sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
22-Feb-2017	13:51:42	46	36.944739	75.959004		2	2	90°	1	*
22-Feb-2017	15:52:48	86	36.832800	74.303134		2	1	90°	1	*

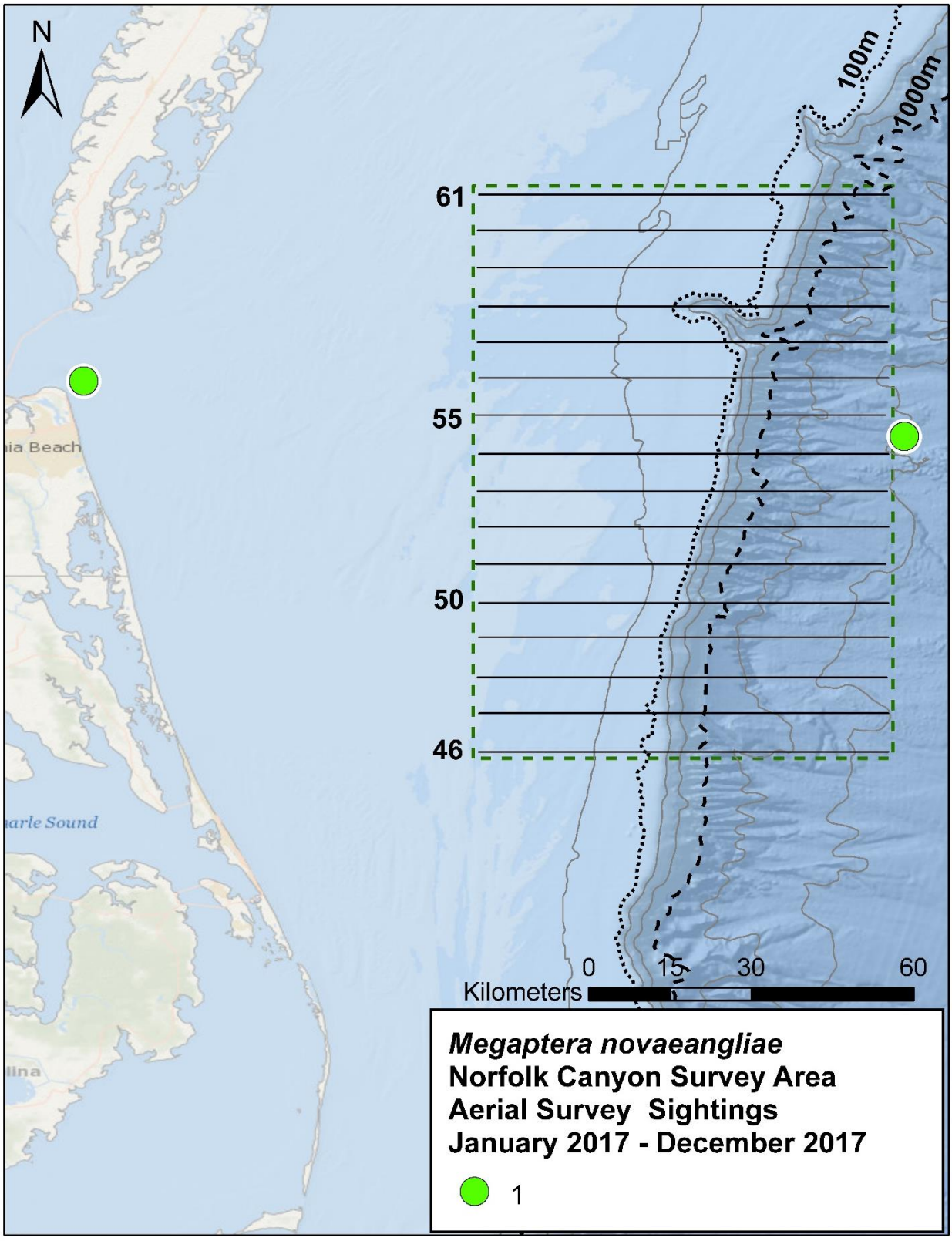

Figure 17. Humpback whale (*Megaptera novaeangliae*) sightings indicating group size. White outline denotes an off-effort sighting.

4.4 Sea Turtles

There were 145 sightings, totaling 261 individuals, of two sea turtle species during the reporting period (see **Tables 14** and **15** and **Figures 19** and **20** in **Sections 4.4.1 and 4.4.2**, respectively). Sighting rates were negatively correlated with BSS, with rates sharply declining as BSS increased (**Figures 18a, 18b**). Ninety-two percent of all sea turtle sightings occurred in the months of May and June (**Figure 18c**). Loggerhead sea turtles represented the majority (>99 percent) of sea turtles sighted. The only other sea turtle species identified in the Norfolk Canyon survey area was the leatherback sea turtle (0.2 percent of total sea turtles sighted).

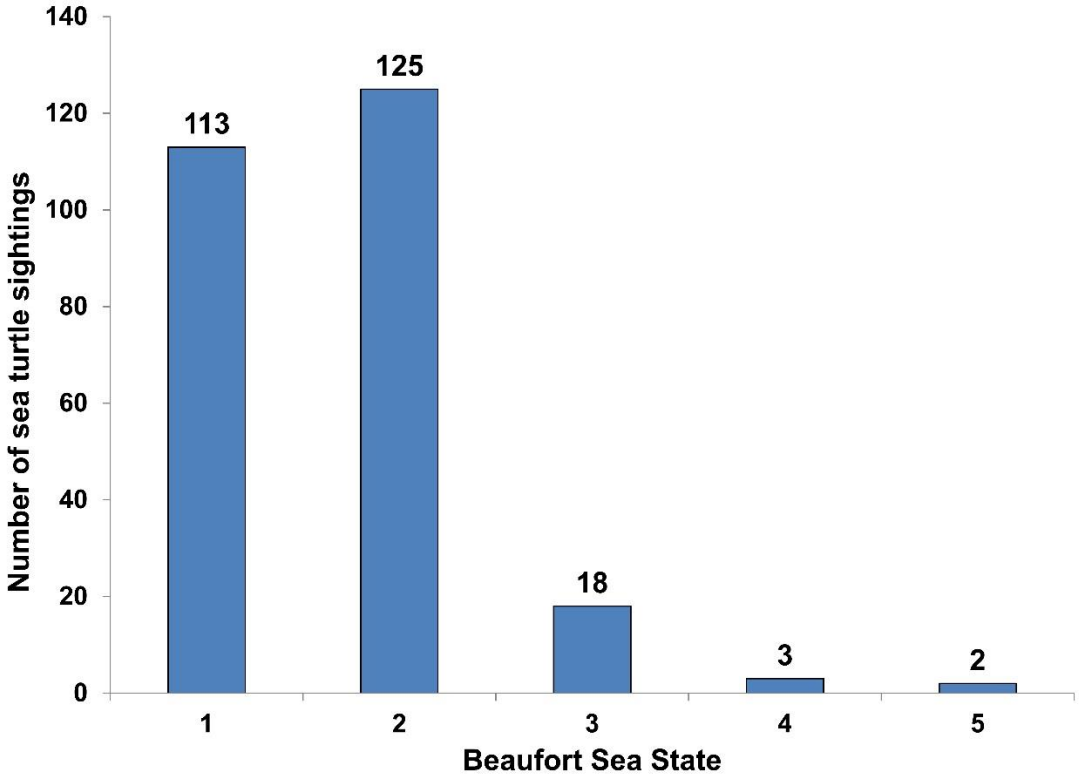

Figure 18a. Total number of sea turtle sightings by BSS category in the Norfolk Canyon survey area in 2017.

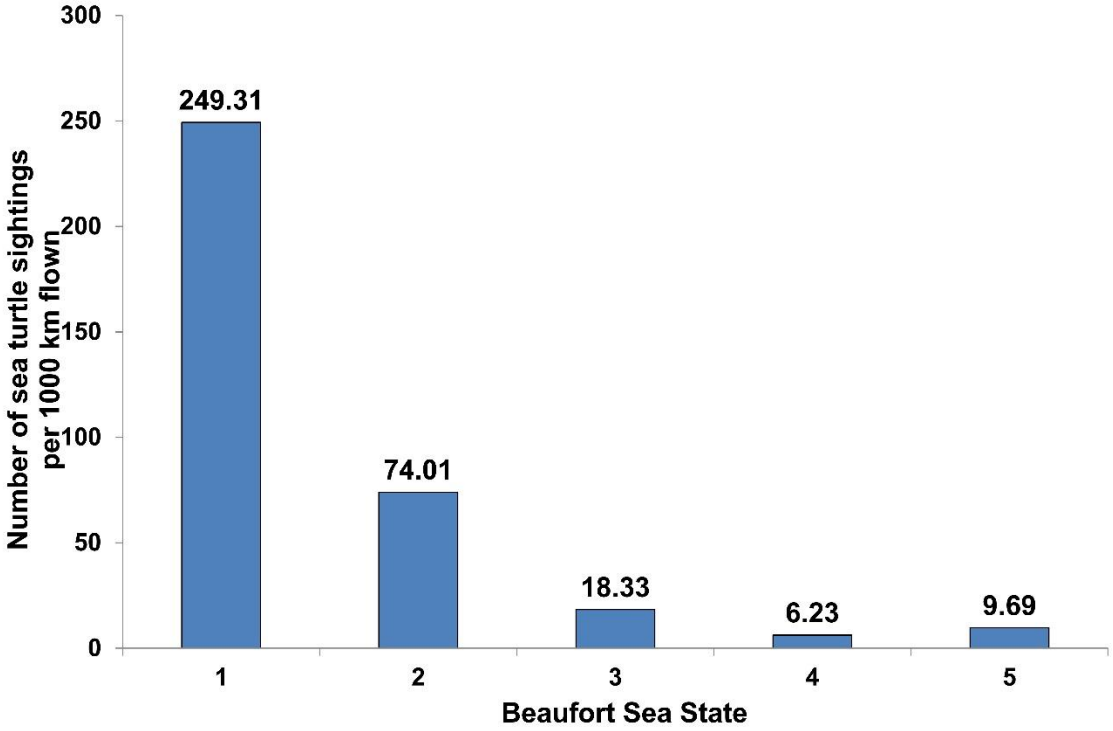

Figure 18b. Sea turtle sightings per 1,000 km flown by BSS category in the Norfolk Canyon survey area in 2017.

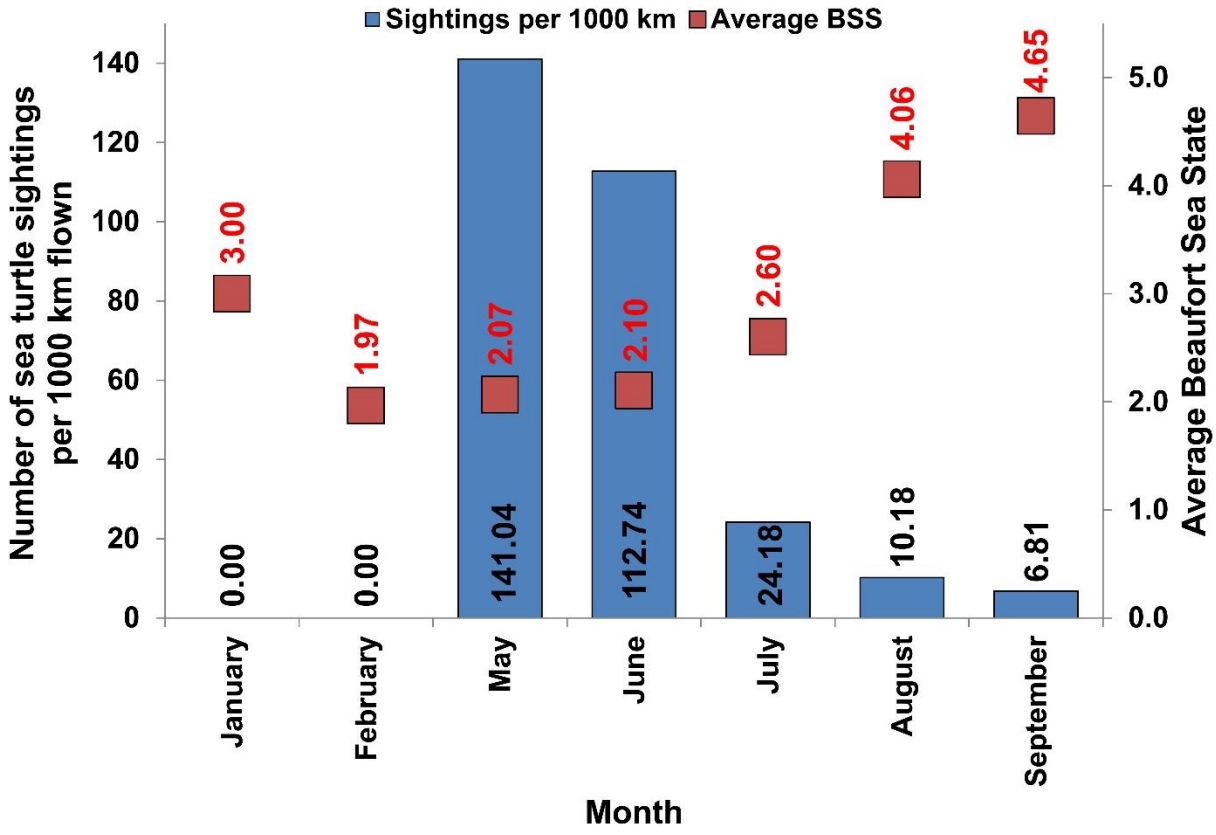

Figure 18c. Sea turtle sightings per 1,000 km surveyed and the average BSS per month in the Norfolk Canyon survey area in 2017.

4.4.1 Loggerhead sea turtle (*Caretta caretta*)

Sightings of loggerhead sea turtles occurred in 5 of 7 months surveyed, for a total of 258 animals (**Table 14, Figure 19**). The majority of sightings occurred inside the 50-m isobath with few in deeper waters.

Table 14. Loggerhead sea turtle (*Caretta caretta)* sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
16-May-2017	11:34:45	6	37.022433	75.152167	57	1	2	90°	2	
16-May-2017	11:34:53	5	37.022760	75.146694	57	1	1	90°	2	
16-May-2017	11:35:19	6	37.023695	75.128436	57	1	2	90°	1	
16-May-2017	11:35:28	7	37.024217	75.122724	57	1	1	100°	1	
16-May-2017	11:35:32	8	37.024533	75.119591	57	1	1	80°	1	
16-May-2017	11:35:47	7	37.025428	75.109658	57	1	2	90°	3	
16-May-2017	11:36:39	8	37.025202	75.073604	57	1	1	90°	2	
16-May-2017	11:37:04	9	37.023755	75.055949	57	1	3	90°	1	
16-May-2017	11:38:11	10	37.021233	75.011549	57	1	3	100°	2	
16-May-2017	11:38:50	11	37.020596	74.985930	57	1	1	90°	2	
16-May-2017	11:39:17	9	37.020756	74.968792	57	1	1	90°	2	
16-May-2017	11:40:38	10	37.023417	74.917572	57	1	2	90°	2	
16-May-2017	11:40:57	12	37.023532	74.904791	57	1	1	100°	2	
16-May-2017	11:42:18	13	37.023821	74.850989	57	1	2	90°	1	
16-May-2017	12:28:51	25	36.945984	74.492498	56	2	3	90°	2	
16-May-2017	12:40:06	44	36.946322	74.909920	56	1	2	90°	1	
16-May-2017	12:40:54	45	36.946717	74.940190	56	1	1	80°	1	
16-May-2017	12:40:57	26	36.946824	74.941857	56	2	2	90°	2	
16-May-2017	12:42:04	46	36.946659	74.984218	56	1	1	100°	2	
16-May-2017	12:42:06	27	36.946769	74.985537	56	2	2	90°	3	
16-May-2017	12:42:37	47	36.947091	75.005486	56	1	3	90°	2	
16-May-2017	12:43:16	28	36.947593	75.030236	56	2	2	90°	2	
16-May-2017	12:43:24	48	36.947620	75.035826	56	1	1	90°	2	
16-May-2017	12:43:51	29	36.948035	75.052981	56	2	1	90°	1	
16-May-2017	12:44:36	30	36.948803	75.081167	56	2	2	90°	1	
16-May-2017	12:44:49	49	36.948968	75.089656	56	1	3	110°	1	
16-May-2017	12:45:51	50	36.949086	75.129116	56	1	1	90°	2	
16-May-2017	12:46:35	51	36.948162	75.156037	56	1	2	70°	2	
16-May-2017	12:50:27	54	36.872303	75.119618	55	1	2	90°	3	

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
16-May-2017	12:51:04	34	36.872553	75.094648	55	2	2	90°	1	
16-May-2017	12:51:40	55	36.872622	75.070654	55	1	2	90°	2	
16-May-2017	12:52:02	56	36.873622	75.055672	55	1	2	90°	1	
16-May-2017	12:52:18	57	36.874200	75.044345	55	1	3	90°	1	
16-May-2017	12:52:46	58	36.875364	75.024824	55	1	1	110°	1	
16-May-2017	12:53:24	59	36.875810	74.997621	55	1	2	90°	1	
16-May-2017	12:53:39	35	36.875856	74.987657	55	2	2	90°	2	
16-May-2017	12:55:34	60	36.874589	74.907855	55	1	3	90°	3	
16-May-2017	13:02:05	38	36.873389	74.756825	55	2	2	90°	1	
16-May-2017	13:29:32	45	36.795434	74.663597	54	1	2	90°	1	
16-May-2017	13:41:12	73	36.798399	74.838811	54	1	2	90°	1	
16-May-2017	13:42:29	48	36.797665	74.889618	54	1	2	90°	2	
16-May-2017	13:43:32	75	36.797419	74.931534	54	1	1	90°	2	
16-May-2017	13:43:48	49	36.797326	74.942148	54	1	2	90°	2	
16-May-2017	13:43:58	76	36.797303	74.948717	54	1	2	100°	2	
16-May-2017	13:45:29	77	36.796347	75.008773	54	1	3	90°	1	
16-May-2017	13:45:54	78	36.795909	75.025802	54	1	1	90°	1	
16-May-2017	13:46:08	79	36.795675	75.035011	54	1	2	90°	1	
16-May-2017	13:46:45	80	36.794951	75.059401	54	1	3	60°	1	
16-May-2017	13:47:39	81	36.794564	75.095948	54	1	1	80°	1	
16-May-2017	13:48:04	51	36.794812	75.112519	54	1	2	90°	2	
16-May-2017	13:48:32	82	36.795406	75.131071	54	1	2	90°	2	
16-May-2017	16:03:20	56	36.722846	75.142659	53	1	2	90°	3	
16-May-2017	16:03:53	87	36.722668	75.119676	53	2	1	90°	1	
16-May-2017	16:04:10	57	36.723578	75.107802	53	1	2	90°	2	
16-May-2017	16:04:19	88	36.724051	75.101757	53	2	1	90°	1	
16-May-2017	16:04:45	89	36.724321	75.082773	53	2	2	60°	3	
16-May-2017	16:04:48	58	36.724259	75.080676	53	1	1	90°	1	
16-May-2017	16:05:33	59	36.723560	75.048827	53	1	2	90°	1	
16-May-2017	16:06:22	90	36.722973	75.014186	53	2	2	90°	2	
16-May-2017	16:07:28	60	36.722422	74.970468	53	1	2	90°	2	
16-May-2017	16:08:09	61	36.722241	74.942921	53	1	1	90°	1	
16-May-2017	16:08:40	62	36.722324	74.922291	53	1	1	90°	2	
16-May-2017	16:09:08	91	36.722401	74.903386	53	2	1	80°	3	
16-May-2017	16:15:47	92	36.723478	74.636056	53	2	1	90°	1	
16-May-2017	17:04:29	73	36.648095	74.858067	52	1	1	90°	1	

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
16-May-2017	17:07:23	75	36.647428	74.969103	52	1	2	90°	1	
16-May-2017	17:07:46	110	36.647503	74.983640	52	2	1	90°	1	
16-May-2017	17:09:41	111	36.647490	75.057051	52	2	2	90°	2	
16-May-2017	17:10:34	76	36.646617	75.090284	52	1	1	90°	1	
16-May-2017	17:12:20	77	36.645962	75.158708	52	1	3	90°	2	
17-May-2017	9:43:04	3	37.323154	75.102374	61	3	1	90°	1	
17-May-2017	9:46:31	4	37.323028	74.954764	61	3	3	90°	1	
17-May-2017	9:49:36	5	37.322607	74.828859	61	3	2	90°	2	
17-May-2017	10:44:39	32	37.246799	74.919769	60	3	2	90°	1	
17-May-2017	10:45:00	18	37.246632	74.932960	60	2	1	90°	1	
17-May-2017	10:45:36	33	37.246552	74.954895	60	3	2	90°	1	
17-May-2017	10:45:54	19	37.246652	74.965930	60	2	1	90°	1	
17-May-2017	10:56:06	36	37.173950	75.068559	59	3	2	90°	1	
17-May-2017	10:57:26	37	37.175183	75.014113	59	3	2	90°	1	
17-May-2017	10:58:38	38	37.174722	74.966066	59	3	2	90°	2	
17-May-2017	10:59:39	39	37.173810	74.925257	59	3	1	90°	1	
17-May-2017	11:49:43	32	37.096075	74.848232	58	2	2	90°	1	
17-May-2017	11:54:36	60	37.098354	75.033998	58	2	1	90°	1	
17-May-2017	14:16:39	65	36.345158	75.145341	48	2	2	90°	4	
17-May-2017	14:17:55	66	36.348190	75.094560	48	2	2	90°	2	
17-May-2017	14:19:21	67	36.350074	75.037680	48	2	2	90°	1	
17-May-2017	14:19:57	39	36.349418	75.013310	48	2	2	100°	1	
17-May-2017	15:11:11	50	36.419597	74.998659	49	2	2	90°	1	
17-May-2017	15:14:20	51	36.423425	75.123242	49	2	2	90°	3	
17-May-2017	15:19:23	85	36.497288	75.097762	50	2	2	90°	1	
17-May-2017	16:06:01	99	36.571245	74.877170	51	3	3	90°	2	
2-Jun-2017	9:18:10	3	36.645202	75.072400	52	2	1	90°	1	
2-Jun-2017	9:18:43	3	36.645197	75.052950	52	2	2	90°	1	
2-Jun-2017	9:20:39	4	36.645315	74.982766	52	2	1	60°	1	
2-Jun-2017	10:30:20	37	36.795034	74.919401	54	3	2	90°	1	
2-Jun-2017	11:22:47	37	36.874664	74.893952	55	2	2	90°	1	
2-Jun-2017	11:22:54	54	36.874638	74.899252	55	2	2	90°	2	
2-Jun-2017	11:31:20	40	36.874458	75.096304	55	2	1	90°	3	
2-Jun-2017	13:54:28	69	37.169708	75.104818	59	1	2	90°	1	
2-Jun-2017	13:55:00	70	37.169719	75.083506	59	1	2	90°	2	
2-Jun-2017	13:55:33	46	37.169765	75.061855	59	2	1	90°	1	

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
2-Jun-2017	13:55:58	71	37.169762	75.045746	59	1	2	90°	2	
2-Jun-2017	13:57:02	47	37.170041	75.003294	59	2	1	90°	4	
2-Jun-2017	13:57:26	72	37.169908	74.987431	59	1	2	90°	2	
2-Jun-2017	13:57:55	48	37.170244	74.969001	59	2	1	60°	2	
2-Jun-2017	13:58:14	74	37.169956	74.956154	59	2	2	90°	2	
2-Jun-2017	14:46:04	61	37.099541	74.741990	58	2	1	90°	1	
2-Jun-2017	14:52:40	64	37.099484	74.890266	58	2	1	90°	2	
2-Jun-2017	14:54:06	65	37.099210	74.945428	58	2	1	90°	2	
2-Jun-2017	14:54:33	103	37.099129	74.962790	58	1	2	90°	2	
2-Jun-2017	14:55:56	66	37.099045	75.016041	58	2	2	90°	4	
2-Jun-2017	14:56:00	104	37.099009	75.018794	58	1	2	90°	2	
2-Jun-2017	14:56:44	67	37.098989	75.046567	58	2	1	90°	6	
2-Jun-2017	14:57:57	105	37.098947	75.093141	58	1	2	90°	1	
2-Jun-2017	14:58:57	68	37.096758	75.131517	58	2	1	90°	1	
2-Jun-2017	15:04:41	108	37.019618	75.084010	57	1	2	90°	2	
2-Jun-2017	15:05:57	109	37.019766	75.037539	57	1	2	90°	1	
2-Jun-2017	15:06:35	72	37.019784	75.014593	57	2	1	90°	2	
2-Jun-2017	15:06:51	110	37.019867	75.004479	57	1	2	90°	2	
2-Jun-2017	15:07:34	73	37.019860	74.978720	57	2	1	60°	3	
2-Jun-2017	15:08:25	74	37.019956	74.947816	57	2	1	90°	3	
2-Jun-2017	15:09:02	111	37.019924	74.925492	57	1	1	90°	1	
2-Jun-2017	15:09:35	112	37.019924	74.905473	57	1	2	90°	2	
2-Jun-2017	15:10:25	113	37.020036	74.874579	57	1	1	90°	1	
2-Jun-2017	15:11:06	114	37.020054	74.850025	57	1	1	90°	1	
2-Jun-2017	16:08:08	140	36.949295	74.896528	56	1	2	90°	2	
2-Jun-2017	16:09:06	90	36.949236	74.933211	56	2	1	90°	1	
2-Jun-2017	16:10:56	91	36.949181	75.003962	56	2	2	90°	4	
2-Jun-2017	16:11:04	141	36.949120	75.008693	56	1	2	90°	2	
2-Jun-2017	16:11:57	142	36.949057	75.042635	56	1	2	90°	2	
2-Jun-2017	16:12:15	92	36.949024	75.054412	56	2	1	90°	3	
2-Jun-2017	16:13:31	93	36.948910	75.103479	56	2	1	90°	4	
2-Jun-2017	16:14:23	94	36.947782	75.136854	56	2	1	90°	3	
26-Jun-2017	13:46:44	43	36.197331	75.067832	46	2	2	90°	1	
26-Jun-2017	13:47:57	44	36.197484	75.024494	46	2	1	90°	1	
26-Jun-2017	15:01:26	44	36.272358	75.022514	47	2	2	90°	1	
26-Jun-2017	15:09:48	47	36.347271	75.093737	48	2	1	90°	1	

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
26-Jun-2017	15:10:44	48	36.347662	75.062151	48	2	2	90°	1	
26-Jun-2017	15:13:00	49	36.347837	74.980708	48	2	2	90°	1	
26-Jun-2017	16:17:23	64	36.421508	74.984018	49	2	2	90°	2	
26-Jun-2017	16:18:05	93	36.421527	75.013309	49	2	2	90°	1	
17-Jul-2017	14:23:40	13	37.171521	74.983511	59	3	2	90°	1	
17-Jul-2017	14:35:11	27	37.247829	74.980585	60	3	1	90°	1	
17-Jul-2017	15:28:40	23	37.321387	75.087958	61	3	2	90°	1	
18-Jul-2017	10:29:06	16	36.946993	74.989259	56	2	1	90°	3	
18-Jul-2017	10:30:22	17	36.946525	75.042025	56	2	1	90°	2	
18-Jul-2017	10:32:04	27	36.946296	75.110966	56	3	2	90°	1	
18-Jul-2017	10:40:06	30	36.872486	75.006048	55	2	2	90°	1	
18-Jul-2017	10:41:43	31	36.872814	74.942220	55	2	3	90°	1	
18-Jul-2017	11:48:38	55	36.796737	74.899831	54	2	2	90°	1	
18-Jul-2017	11:51:19	35	36.796703	75.005516	54	2	1	90°	1	
18-Jul-2017	11:54:53	56	36.796179	75.144152	54	2	2	90°	1	
23-Aug-2017	10:16:30	12	36.728419	74.806938	53	4	1	90°	1	
23-Aug-2017	10:17:42	13	36.728256	74.852166	53	4	2	90°	1	
23-Aug-2017	10:19:33	14	36.727147	74.921152	53	4	2	90°	1	
5-Sep-2017	16:08:04	12	36.799260	74.924389	54	5	1	90°	1	
5-Sep-2017	16:14:17	14	36.798697	75.148134	54	5	2	90°	1	

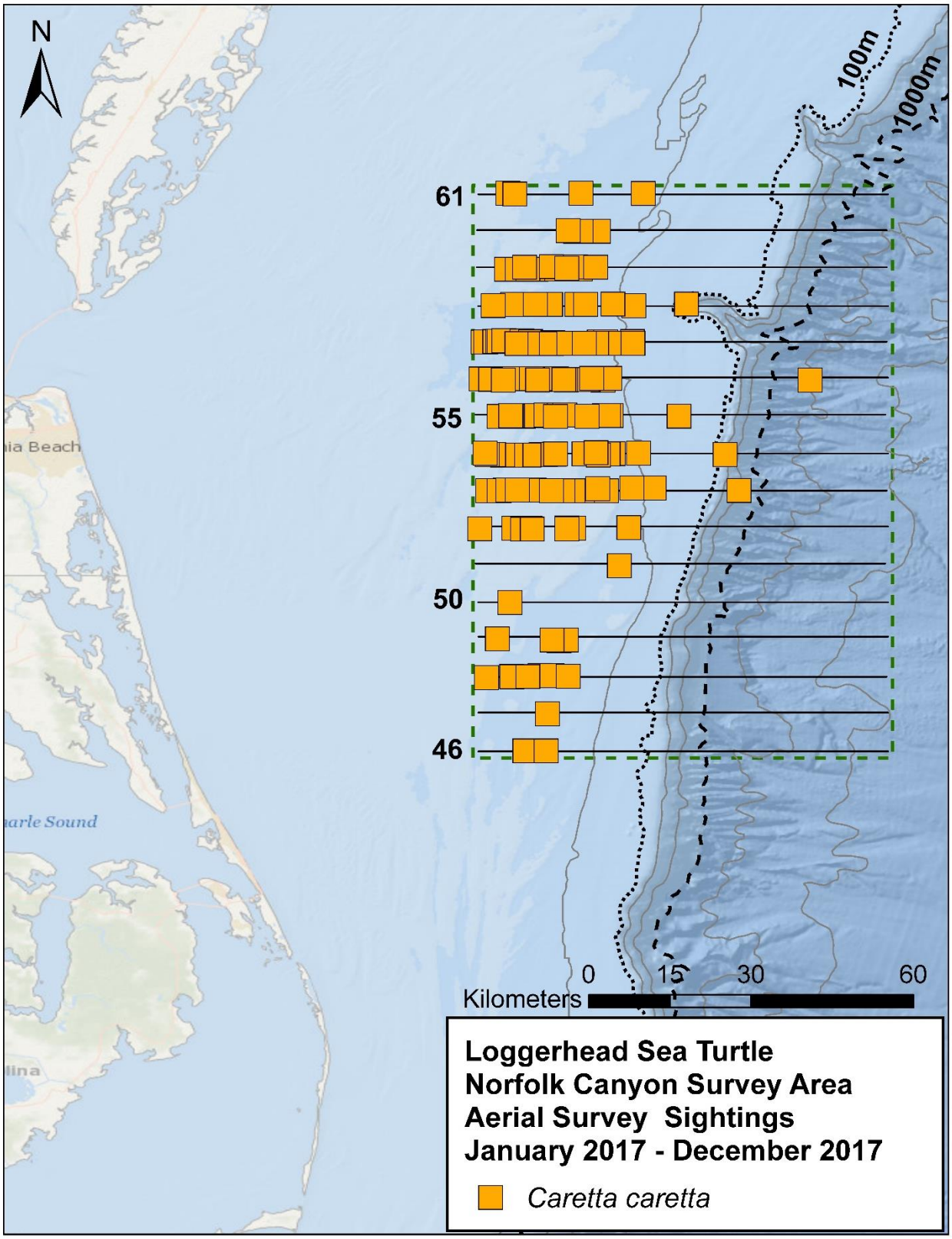

Figure 19. Loggerhead sea turtle (*Caretta caretta*) sightings.

4.4.2 Leatherback sea turtle (*Dermochelys coriacea*)

Three sightings of lone leatherback sea turtles were observed in the northern portion of the study area from the inshore waters out to beyond the 1,500-m isobath (**Table 15, Figure 20**).

Table 15. Leatherback sea turtle (*Dermochelys coriacea)* sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
16-May-2017	13:11:06	39	36.870580	74.404699	55	2	2	90°	1	
2-Jun-2017	14:05:46	49	37.170552	74.675127	59	2	1	90°	1	
2-Jun-2017	15:03:49	71	37.019651	75.116241	57	2	1	90°	1	

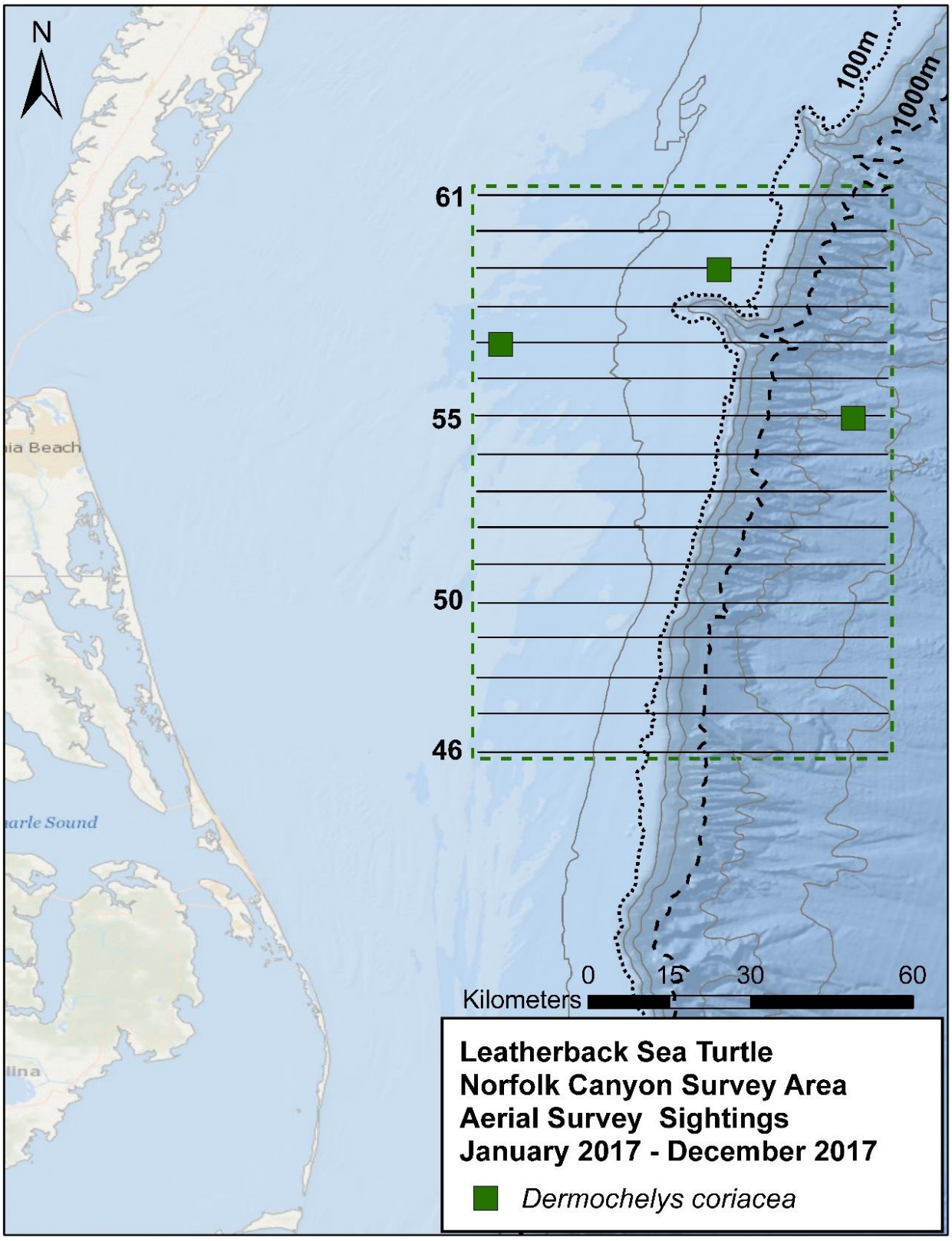

Figure 20. Leatherback sea turtle (*Dermochelys coriacea)* sightings.

4.5 Other Marine Vertebrate Sightings

4.5.1 Chondrichthyan fishes

One unidentified hammerhead shark (*Sphyrna* sp.) was recorded during the reporting period. Two species of rays were identified: 155 cownose rays and six manta rays. Basking sharks were present in high numbers during the month of May, both in shallow and deeper waters. All sightings are represented in **Table 16** and **Figure 21**.

Table 16. Chondrichthyan fish sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Comments
16-May-2017	11:44:41	11	37.023268	74.754756	57	1	3	90°	1	Basking shark
16-May-2017	13:42:14	74	36.797810	74.880166	54	1	1	110°	1	Basking shark
17-May-2017	17:05:15	74	36.647976	74.887493	52	1	2	90°	1	Basking shark
17-May-2017	10:12:03	8	37.323524	74.422921	61	1	2	60°	2	Basking shark
17-May-2017	10:19:00	12	37.291923	74.330249	61	1	2	90°	1	Basking shark
17-May-2017	12:56:15	36	36.873640	74.879598	55	2	1	90°	1	Basking shark
17-May-2017	10:05:17	6	37.326311	74.508661	61	2	4	80°	3	Basking shark
17-May-2017	10:10:34	14	37.322166	74.482672	61	2	3	90°	2	Basking shark
17-May-2017	10:06:33	12	37.332260	74.512717	61	3	3	90°	3	Basking shark
17-May-2017	10:42:10	31	37.247867	74.828169	60	3	3	90°	1	Basking shark
2-Jun-2017	16:03:41	88	36.949318	74.726334	56	2	1	90°	6	Hammerhead
2-Jun-2017	10:05:12	21	36.727103	74.636035	53	1	2	90°	1	Manta ray
2-Jun-2017	10:05:35	29	36.727268	74.651017	53	1	2	60°	2	Manta ray
2-Jun-2017	11:11:14	35	36.864118	74.411767	55	2	1	90°	2	Manta ray
2-Jun-2017	9:19:32	4	36.645193	75.023569	52	2	2	90°	45	Cownose ray
2-Jun-2017	9:22:13	5	36.645261	74.924390	52	2	1	60°	50	Cownose ray
26-Jun-2017	16:15:57	63	36.421801	74.925569	49	2	1	90°	1	Manta ray
5-Sep-2017	15:30:36	12	36.869638	75.033207	55	4	1	90°	60	Cownose ray

4.5.2 Other fishes

Twelve ocean sunfish were recorded, with the majority offshore of the 100-m isobath (**Table 17, Figure 21**).

Table 17. Ocean sunfish (*Mola mola)* sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Off Effort
17-Jan-2017	14:45:58	17	37.021841	74.566356	57	3	1	90°	1	
22-Feb-2017	9:50:18	4	37.320786	74.479567	61	2	1	90°	1	
22-Feb-2017	10:00:22	9	37.240618	74.360372	60	2	1	90°	1	
22-Feb-2017	10:02:03	10	37.240174	74.420649	60	2	2	90°	2	
22-Feb-2017	10:02:42	11	37.240071	74.443269	60	2	1	90°	1	
22-Feb-2017	10:04:14	12	37.240693	74.498518	60	2	2	90°	1	
22-Feb-2017	10:53:51	27	37.171064	74.503086	59	2	2	90°	1	
22-Feb-2017	15:33:42	72	36.877137	74.639917	55	2	2	90°	1	
22-Feb-2017	16:08:24	89	36.792616	74.414006	54	2	1	90°	1	
16-May-2017	13:28:25	44	36.794520	74.623674	54	1	1	90°	1	
17-May-2017	14:17:42	38	36.346856	75.102812	48	2	2	90°	1	

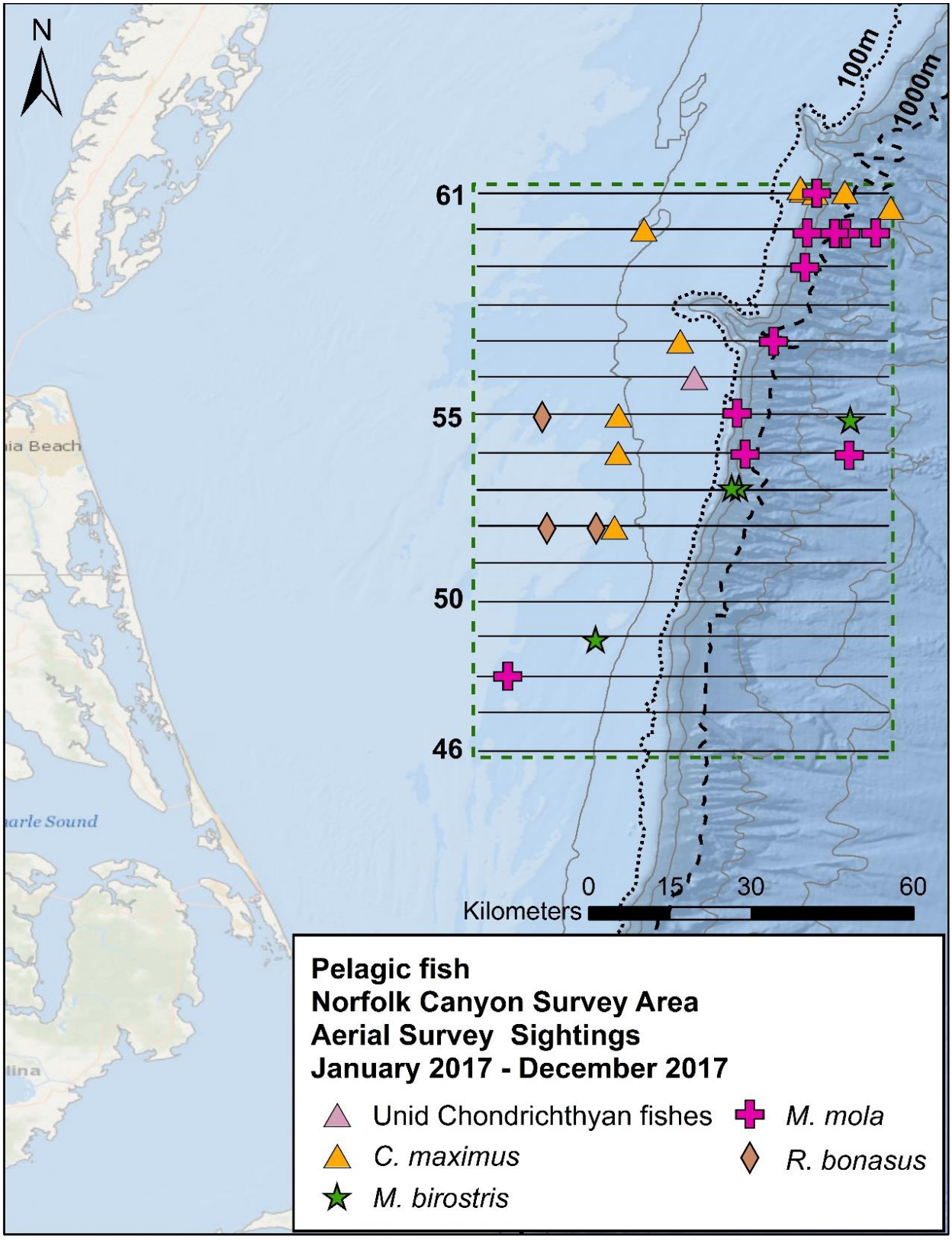

Figure 21. Pelagic fish sightings: unidentified chondrichthyan fish, manta ray (*Manta birostris*), cownose ray (*Rhinoptera bonasus),* ocean sunfish (*Mola mola*).

4.6 Vessel Sightings

4.6.1 Commercial

A total of 23 commercial vessels (e.g., cargo, tankers, car carriers, and commercial fishing vessels) was observed in the survey area (**Table 18, Figure 22**).

Table 18. Commercial vessel sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Comments
17-Jan-2017	13:57:20	6	36.876169	74.600944	55	3	2	90°	1	Commercial fishing vessel
22-Feb-2017	9:37:54	6	37.322371	74.998015	61	2	2	60°	1	Cargo vessel
16-May-2017	12:23:36	36	36.945249	74.405207	56	2	4	80°	1	Cargo vessel
16-May-2017	13:05:51	63	36.872306	74.607876	55	1	2	60°	1	Cargo vessel
16-May-2017	13:16:44	66	36.795064	74.373649	54	1	2	40°	1	Cargo vessel
16-May-2017	13:45:08	50	36.796657	74.995366	54	1	4	60°	1	Cargo vessel
17-May-2017	14:36:13	73	36.349635	74.614989	48	3	3	90°	1	Cruise ship
17-May-2017	14:57:59	47	36.421967	74.481827	49	3	4	40°	1	Cruise ship
2-Jun-2017	14:36:26	93	37.099101	74.462830	58	3	1	90°	2	Tug and Barge
2-Jun-2017	16:02:23	87	36.949203	74.676187	56	2	3	90°	1	Tanker
2-Jun-2017	16:07:26	89	36.949356	74.869564	56	2	3	45°	1	Car carrier
26-Jun-2017	14:46:32	63	36.271859	74.658032	47	2	3	90°	1	Cargo vessel
17-Jul-2017	14:13:36	24	37.171586	74.581034	59	3	1	45°	1	Cargo vessel
17-Jul-2017	14:36:27	16	37.248047	74.928400	60	3	2	60°	1	Cargo vessel
17-Jul-2017	15:17:21	38	37.321539	74.631712	61	2	1	45°	1	Cargo vessel
18-Jul-2017	10:37:39	20	36.867968	75.100848	55	2	4	90°	1	Tanker
18-Jul-2017	11:47:23	33	36.796952	74.851500	54	2	4	90°	1	Tanker
23-Aug-2017	10:11:14	11	36.724389	74.612260	53	4	3	60°	1	Commercial fishing vessel
5-Sep-2017	15:12:12	6	36.949497	74.724636	56	5	3	90°	1	Tanker
5-Sep-2017	15:21:55	9	36.948945	75.085040	56	4	3	90°	1	Tanker
5-Sep-2017	16:11:05	13	36.798903	75.031477	54	5	3	60°	1	Cargo vessel
5-Sep-2017	16:12:42	15	36.798794	75.090393	54	5	4	60°	1	Car carrier

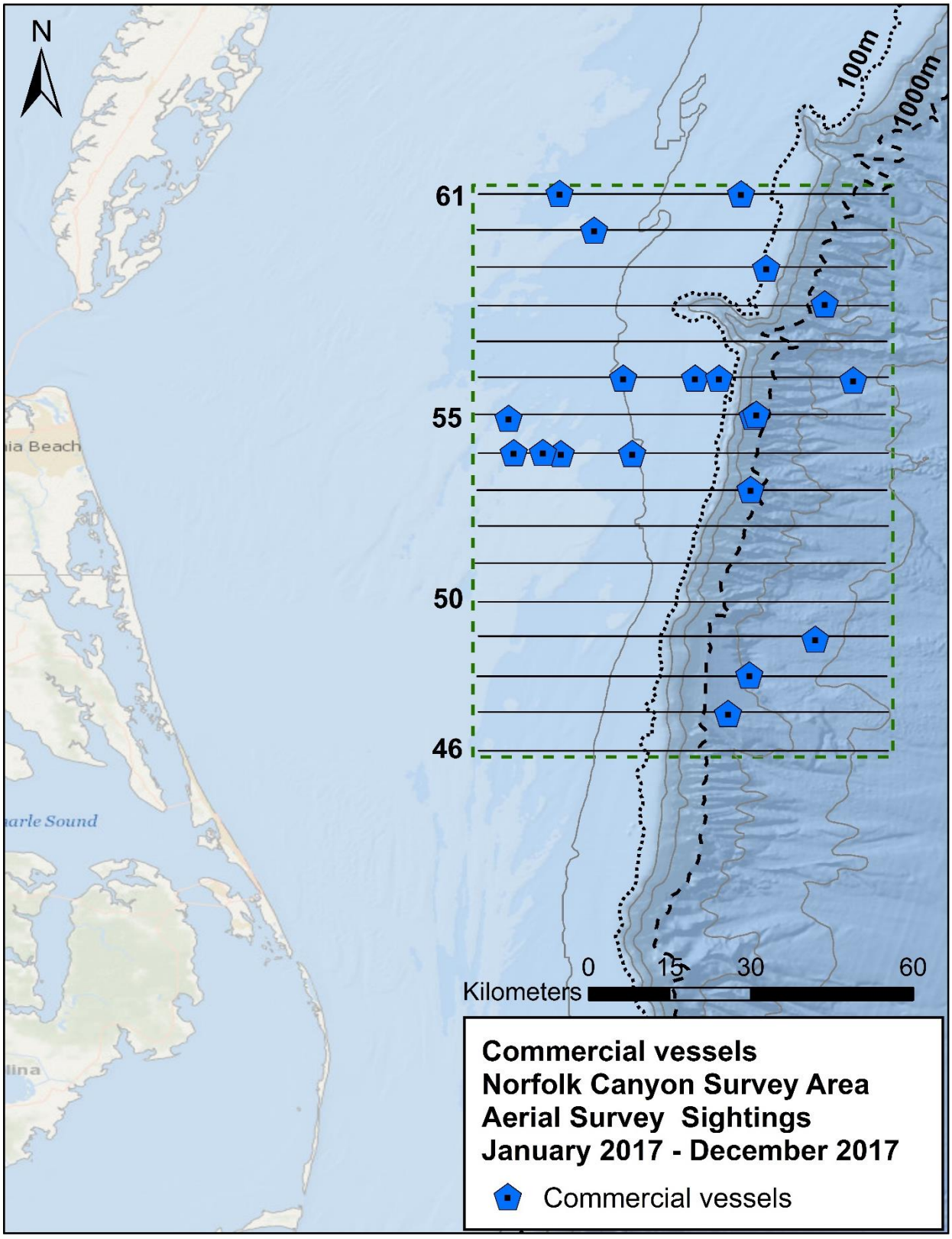

Figure 22. Commercial vessel sightings.

4.6.2 Military Vessels

Six military vessels were observed at the survey area (**Table 19, Figure 23**).

Table 19. Military vessel sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Comments
22-Feb-2017	14:20:40	41	37.020844	74.852626	57	2	4	45°	1	Military vessel
22-Feb-2017	15:24:48	54	36.884431	74.988286	55	2	3	45°	1	Military vessel
22-Feb-2017	16:27:38	95	36.791478	74.950888	54	2	3	30°	1	Military vessel
22-Feb-2017	16:33:11	67	36.790853	75.152245	54	2	1	45°	1	Military vessel
16-May-2017	12:32:09	42	36.948261	74.607234	56	2	4	60°	1	Military vessel
2-Jun-2017	11:13:56	36	36.857478	74.524571	55	2	3	45°	1	Military vessel

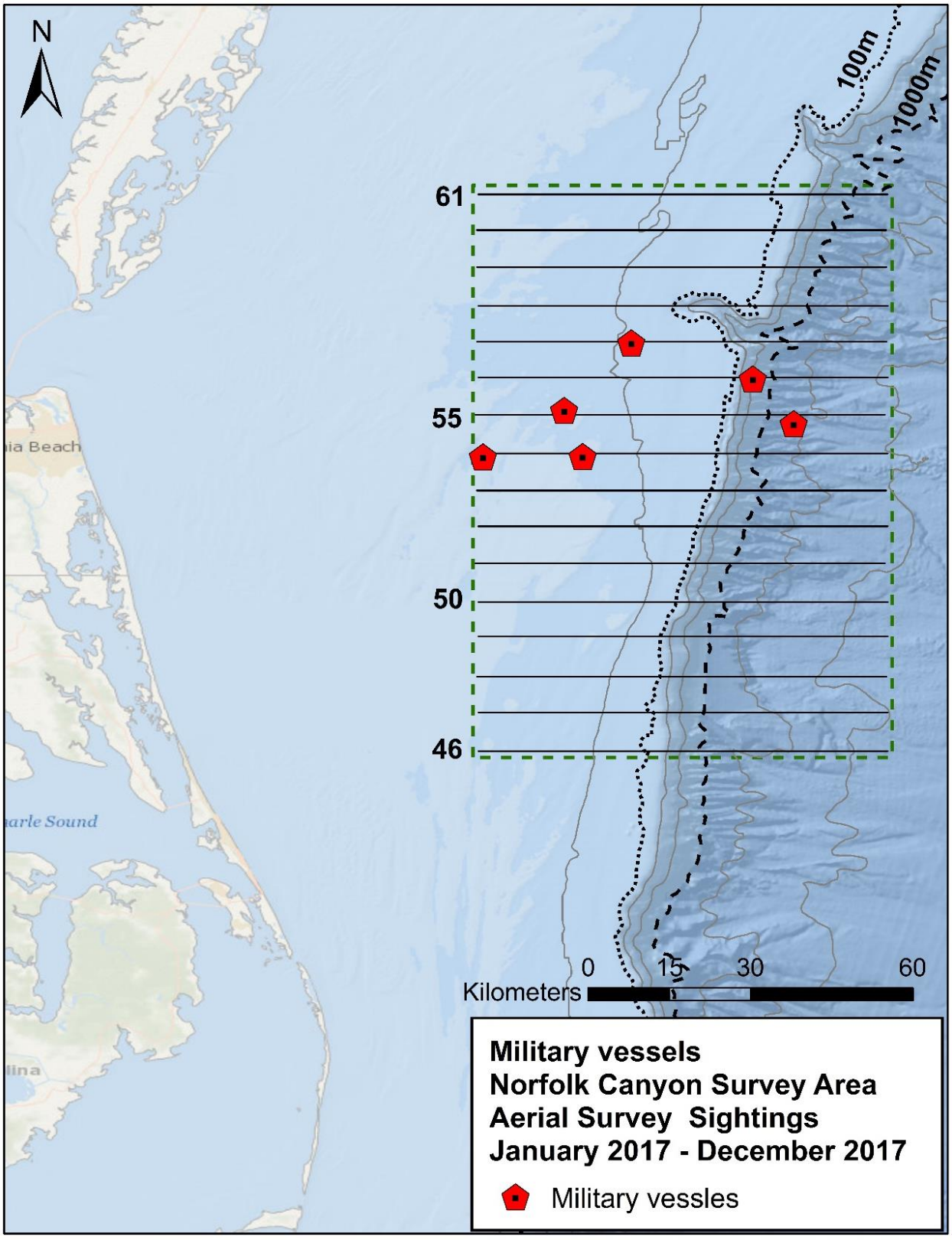

Figure 23. Military vessel sightings.

4.6.3 Other Vessels

A total of 19 other vessels were recorded in the survey area and all categorized as recreational sport-fishing vessels (**Table 20, Figure 24**).

Table 20. Other vessel sightings in the Norfolk Canyon survey area in 2017.

Date	Time	Waypoint	Latitude (N)	Longitude (W)	Track Number	BSS	Angle out	Degree Forward	Best Number	Comments
17-Jan-2017	14:05:53	9	36.945857	74.693290	56	3	2	90°	1	Recreational fishing vessel
22-Feb-2017	15:27:04	55	36.882653	74.899919	55	2	2	60°	1	Recreational fishing vessel
16-May-2017	12:03:09	16	37.019929	74.600418	57	2	2	90°	2	Recreational fishing vessels
16-May-2017	12:04:08	25	37.022237	74.563241	57	2	2	90°	5	Recreational fishing vessels
16-May-2017	12:04:33	17	37.022414	74.547713	57	2	2	90°	1	Recreational fishing vessel
16-May-2017	12:24:14	37	36.944415	74.429004	56	2	3	100°	1	Recreational fishing vessel
2-Jun-2017	9:52:16	15	36.725090	74.425775	53	1	3	90°	1	Recreational fishing vessel
2-Jun-2017	9:56:38	18	36.720424	74.462148	53	1	3	90°	1	Recreational fishing vessel
26-Jun-2017	14:49:25	64	36.271578	74.776306	47	2	1	90°	1	Recreational fishing vessel
26-Jun-2017	14:49:31	40	36.271682	74.780516	47	3	1	90°	1	Recreational fishing vessel
26-Jun-2017	15:17:41	50	36.347694	74.810551	48	2	3	90°	1	Recreational fishing vessel
17-Jul-2017	13:30:17	3	37.097903	74.643135	58	3	2	90°	1	Recreational fishing vessel
18-Jul-2017	11:48:33	34	36.796743	74.896530	54	2	1	45°	1	Recreational fishing vessel
5-Sep-2017	15:16:27	7	36.949305	74.879685	56	5	1	90°	1	Recreational fishing vessel

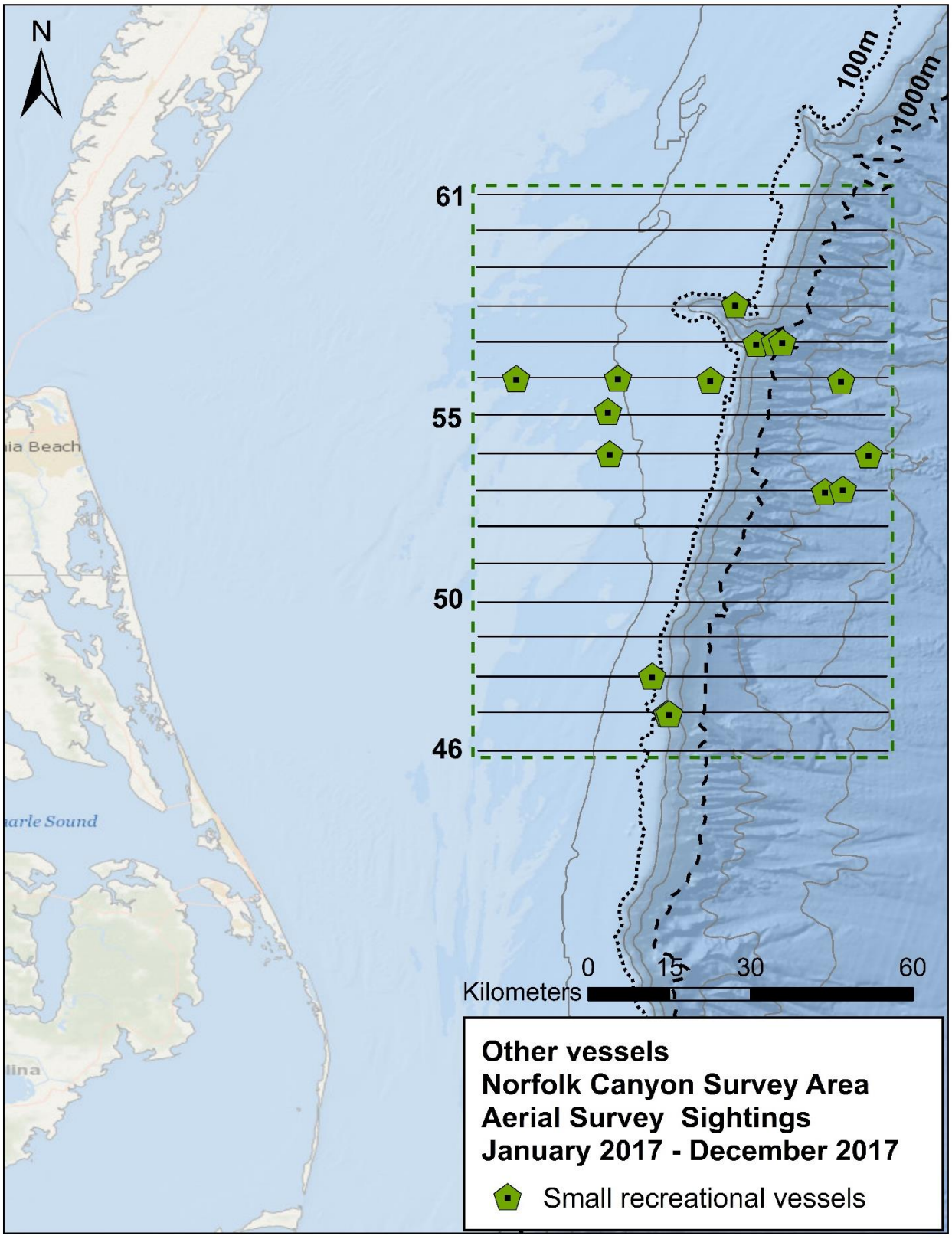

Figure 24. Other vessel sightings.

5. Acknowledgements

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A

Aerial Survey Data Sheet

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Appendix A

AERIAL SURVEY DATA SHEET

Date:_____ **Observer Side:**_____ **GPS#:**_____ **Page**__ **of**___

Pilot/Co-Pilot_____ **Observers Left/Right:**_____ **Hobbs:**_____

Time	Waypoint #	Event	Heading	Track #	Observer R / L	Visibility	BSS	Cloud	Glare L	Glare R	Vertical Angle	Horizontal degree	Sighting Cue	Species	Reliability	Min #	Max #	Best Est	Comments

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B

Event Codes and Species List

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Codes for Variables on USWTR Aerial Survey Data Sheet

Date: Month, Day, Year

Track#: opportunistic track line=99

Event:

1.1 = On effort/on track
1.2 = Off effort

3.1 = Change in environmental conditions

10.0 = Opportunistic sighting(s)
PF = Preflight
XB = Cross Beach
WU = Wheels Up
WD = Wheels Down
TE = Transit Leg on Effort

2.0 = Sighting-breaking track/off effort (real time)
2.3 = Vessel sighting

2.4 = Sighting of marine mammal (real location)
2.41 = Location of Sighting Cue, No Animals sighted
2.42 = Break from sighting

2.7 = Sighting of sea turtle (real location)
2.8 = Sighting of large vessel (Military, commercial, etc.)
2.9 = Unidentified sighting, requires comments

Confidence of cue
1 = definite
2 = probable
3 = possible/unsure

Beaufort Sea State:
0 = slick, calm, mirror-like
1 = small waves
2 = whitecaps 0-33%, waves 1-2 feet
3 = whitecaps 33-50%, waves 2-3 feet
4 = whitecaps 50-65%, waves 3-5 feet
5 = whitecaps >65%, waves >5 feet
6 = too rough too survey

Cloud Cover:
01 = clear
02 = partly cloudy
03 = continuous layer of clouds
04 = rain
05 = haze
99 = other, requires comments

Glare
0 = No glare
1 = 0-25 %
2 = 25 -50 %
3 = >50%

Visibility:
1 = clear to horizon
2 = half the distance to the horizon
3 = less than half the distance to the horizon

Sighting Cues:
1 = Blow
2 = Splash
3 = Body Part
4 = Breach
5 = Other (needs comments)

Vertical Angle is given in rough increments of 20 degrees with 1 being directly on the trackline and 4 being anything outside of survey wide to horizon

Horizontal Angle is given assuming the nose of the plane is 0 degrees and directly off the wing is 90 degrees – measurements are taken from 1-180 on each side of the plane.

Species List for Aerial Surveys		
Common Name	**Scientific Name**	**Species Code**
Cetaceans		
North Atlantic right whale	*Eubalaena glacialis*	Egl
Minke whale	*Balaenoptera acutorostrata*	Bac
sei whale	*Balaenoptera borealis*	Bbo
fin whale	*Balaenoptera physalus*	Bph
Brydes whale	*Balaenoptera edeni*	Bed
humpback whale	*Megaptera novaeangliae*	Mno
unidentified balaenopterid	Family *Balaenopteridae*	BALA
sperm whale	*Physeter macrocephalus*	Pma
pygmy sperm whale	*Kogia breviceps*	Kbr
dwarf sperm whale	*Kogia sima*	Ksi
unidentified Kogia	*Kogia* spp.	KOGI
Northern bottlenose whale	*Hyperoodon ampullatus*	Ham
Cuvier's beaked whale	*Ziphius cavirostris*	Zca
Mesoplodon beaked whale	Genus *Mesoplodon*	MESO
unidentified beaked whale	Family *Ziphiidae*	ZIPH
harbor porpoise	*Phocoena phocoena*	Pph
killer whale	*Orcinus orca*	Oor
melon-headed whale	*Peponocephala electra*	Pel
pygmy killer whale	*Feresa attenuata*	Fat
false killer whale	*Pseudorca crassidens*	Pcr
Risso's dolphin	*Grampus griseus*	Ggr
long-finned pilot whale	*Globicephala melas*	Gme
short-finned pilot whale	*Globicephala macrorhynchus*	Gma
unidentified pilot whale	Genus *Globicephala*	GLOB
rough-toothed dolphin	*Steno bredanensis*	Sbr
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Lac
Fraser's dolphin	*Lagenodelphis hosei*	Lho
common dolphin	*Delphinus delphis*	Dde
bottlenose dolphin	*Tursiops truncatus*	Ttr
spotted dolphin	*Stenella frontalis*	Sfr
striped dolphin	*Stenella coeruleoalba*	Sco
spinner dolphin	*Stenella longirostris*	Scl
unidentified *Stenella*	Genus *Stenella*	STEN
unidentified delphinid	Family *Delphinidae*	DELP
unidentified cetacean		CETA
Pinnipeds		
gray seal	*Halichoerus grypus*	Hgr
harbor seal	*Phoca vitulina*	Pvi
harp seal	*Phoca groenlandica*	Pgr
hooded seal	*Cystophora cristata*	Ccr
unidentified phocid	Family *Phocidae*	PHOC
Sea Turtles		
loggerhead	*Caretta caretta*	Cca
leatherback	*Dermochelys coriacea*	Dco
green	*Chelonia mydas*	Cmy
Kemp's ridley	*Lepidochelys kempii*	Lke
hawksbill	*Eretmochelys imbricata*	Eim
unidentified sea turtle		TURT
Other interesting sightings		
ocean sunfish	*Mola mola*	Mmo
basking shark	*Cetorhinus maximus*	Cma
whale shark	*Rhincodon typus*	Rty
manta ray	*Manta birostris*	Mbi
cownose rays	*Rhinoptera bonasus*	Rbo