PROTECTED SPECIES MONITORING IN THE VIRGINIA CAPES OPAREA OFF HATTERAS, NC
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Cape Hatteras Vessel Surveys

Methodology

Study Area

The study area within the Virginia Capes (VACAPES) OPAREA is located east of Cape Hatteras, NC and incorporates a large portion of the Cape Hatteras Special Research Area (CHSRA), designated by NOAA Fisheries. The area is approximately 16000 km^2 in extent and straddles the continental shelf break, including both shelf and pelagic waters (Figure 1). The survey area excludes nearshore coastal waters where the spatial distribution and relative abundance of coastal bottlenose dolphins (*Tursiops truncatus*) has been well established (Torres *et al*. 2003; Torres *et al.* 2005).

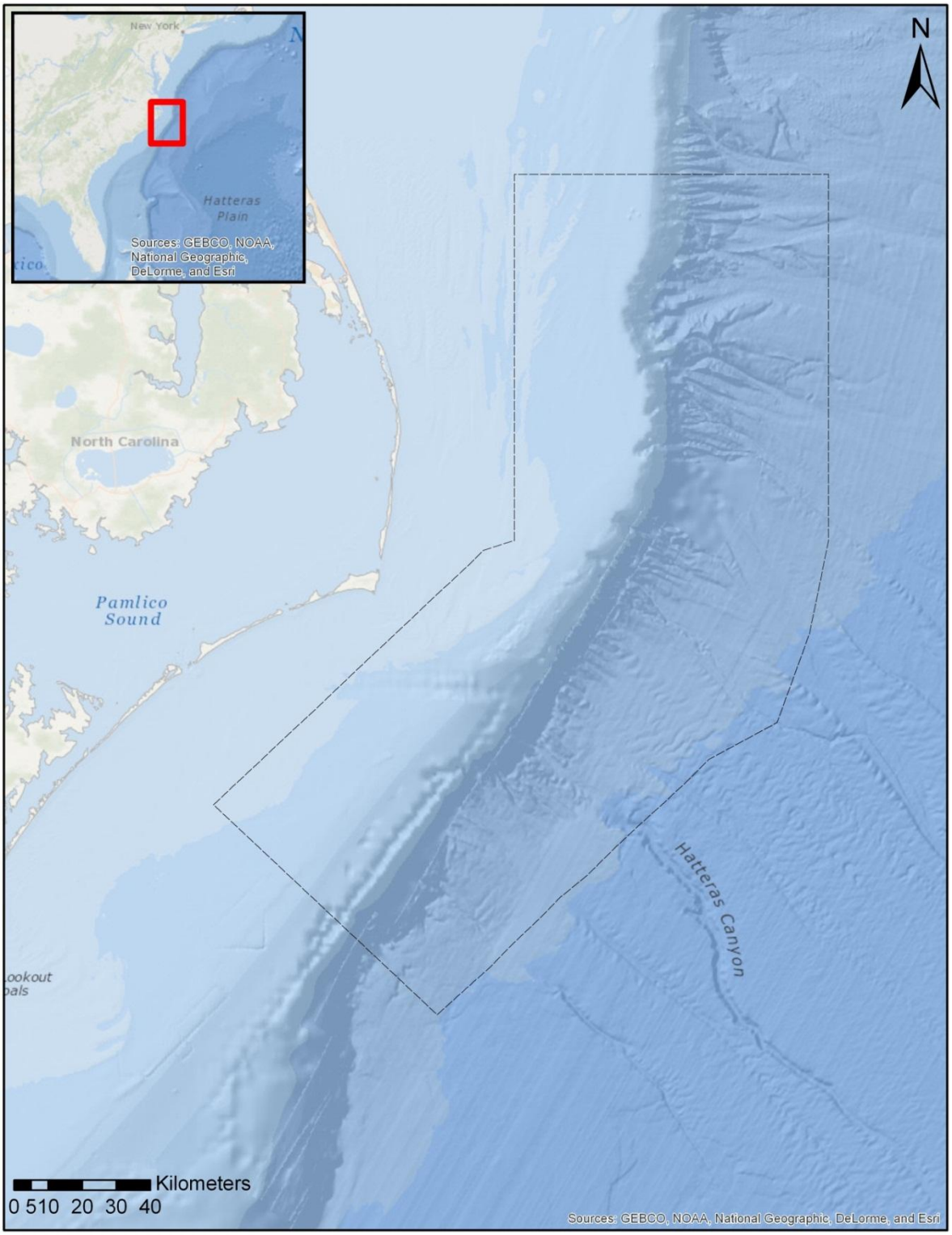

Figure 1. Map of the Cape Hatteras survey area.

Vessel Survey Data Collection

Visual Surveys

Vessel-based survey platforms provide a greater probability of sighting deep-diving species than aerial surveys (Barlow and Gisiner 2006). Shipboard observers are also more likely to be able to confirm species identity, particularly for animals that are difficult to distinguish from the air. Additionally, vessel-based platforms allow for biopsy sampling and photographic identification. Vessel surveys were conducted to address questions of residency and population structure of several cetacean species in the Cape Hatteras study area. Specifically, the objectives of these surveys were to: (1) document the distribution of marine mammals off Cape Hatteras; and (2) collect photo-identification images and biopsy samples from representative cetacean species in this area.

Surveys for cetaceans and other marine megafauna were conducted from a variety of survey platforms including large research vessels, offshore charter fishing vessels and small rigid hull inflatables. The F/V *Sea Creature* and R/V *Cape Hatteras* were used during dedicated AFAST photo-ID and biopsy surveys conducted in February, March and October 2012. Funding for ship time aboard the R/V *Cape*

Figure 2. Vessel survey platforms, the F/V *Hog Wild* (a), and the R/V *SRVx and* R/V *Exocetus* (b).

Hatteras was provided by the Duke/University of North Carolina Oceanographic Consortium (DUNCOC). Additional surveys were conducted from the F/V *Hog Wild*, the R/V *SRVx*, and the R/V *Exocetus* (Figures 2a and b); the F/V *Samanna* and the R/V *Wavelet* were used for a behavioral response study of short-finned pilot whales funded by the Strategic Environmental Research and Development Program (SERDP) conducted during the summer of 2012. Observations were made from the rigid hull inflatable or from the vessels' flying bridge by naked eye and 7x50 binoculars. Two observers (one port and one starboard) scanned constantly from straight ahead to 90° abeam either side of the track. The location, species and behavior of each cetacean group was recorded, along with the location and species for each turtle sighting. Environmental conditions (weather, sea state, depth and sea surface temperature) were recorded at each sighting and whenever sighting conditions changed, using an iPad tablet and a linked GPS unit.

In addition, photo-identification and biopsy techniques were used to examine the use of the Cape Hatteras survey area by individual cetaceans. Thus, whenever possible, photographs of cetaceans for individual photo-identification were obtained; these photographs were also used to confirm species identification at each sighting and to compare identification features with those used by the aerial survey team. Photographs were obtained with Canon or Nikon digital SLRs (equipped with 100-400 mm zoom lenses) in 24-bit color at a resolution of 3072 X 2048 pixels and saved in .jpg format. Remote biopsy sampling methods were employed to collect small skin and blubber samples using a variety of 27 kg – 68 kg pull crossbows, depending on the species and sampling distance. Biopsy samples were obtained with a specialized 2.5 cm stainless biopsy tip attached to a modified bolt, typically fired from the bow of the survey vessel.

Passive Acoustic Monitoring

Three types of passive acoustic monitoring techniques were employed in the Cape Hatteras survey area: a towed hydrophone array, an autonomous glider outfitted with an acoustic recorder, and autonomous bottom-mounted High-frequency Acoustic Recording Packages (HARPs).

Towed array

During the October 2012 survey, a four-element hydrophone array was towed approximately 170 m behind the R/V *Cape Hatteras* to detect the presence of vocalizing cetaceans. Acoustic signals were transmitted to an analog-to-digital converter/mixer (MOTU Traveler, MOTU, Cambridge, MA) sampling at 192 kHz. Continuous recordings were made on laptop computers using *Pamguard 1.11.02* and *Ishmael 1.0* software. Recordings were made the entire time the array was in the water, and monitored in real time by an acoustician.

Seaglider

On 09 October 2012, a buoyancy-driven iRobot Seaglider® was deployed at 35.3638^{o} N, 74.8068^{o} W to collect autonomous passive acoustic recordings of vocalizing cetaceans along the continental shelf break. The glider was outfitted with a digital acoustic monitor (DMON) programmed to make continuous acoustic recordings at a sampling rate of 120 kHz. At each surfacing, the glider transmitted its geographic coordinates and received course instructions from a shore-based pilot via satellite link. During the two-day deployment, the glider completed nine dives to depths up to 900 m, collecting approximately 18 hours of recordings. Due to the strong

current of the Gulf Stream, the glider was unable to maintain position along the shelf break and drifted 63 km to the northeast. The glider was retrieved by the R/V *Cape Hatteras* on 10 October at 35.7881^{o} N, 74.3413^{o} W.

Bottom-mounted Recorders

To collect time-series of acoustic data in the Cape Hatteras survey area, autonomous High-frequency Acoustic Recording Packages (HARPs; Wiggins and Hildebrand 2007) were utilized. The HARP data-logging system includes a 16-bit A/D converter, a hydrophone suspended approximately 12 m above the seafloor, an acoustic release system, ballast weights, and flotation (Figure 3). The data-loggers are capable of sampling up to 200 kHz and can be set to record continuously or on a duty cycle to accommodate variable deployment durations. These instruments combine high and low frequency hydrophone elements to detect the vocalizations of both odontocete and mysticete whales. The units sample at rates high enough to capture the clicks of many odontocetes.

A HARP was deployed at a depth of 950 m at 35.34054^{o} N, 74.85761^{o} W (Site A) on 15 March 2012 and recovered 9 on October 2012 (Table 1, Figure 4), yielding a deployment period of 208 days. Another HARP was subsequently deployed on 9 October 2012 in 970 m of water at 35.34058^{o} N, 74.85590^{o} W (Site A). This instrument is still in the field and is expected to be recovered during spring 2013. Both HARPs were programmed to sample continuously at 200 kHz. Data collection during the initial 2012 Cape Hatteras Site A deployment was limited by an instrument malfunction, which caused recording to stop on 11 April 2012. The deployment

provided a total of 636.75 hours of data over the 28 days the instrument recorded (15 March 2012 – 11 April 2012).

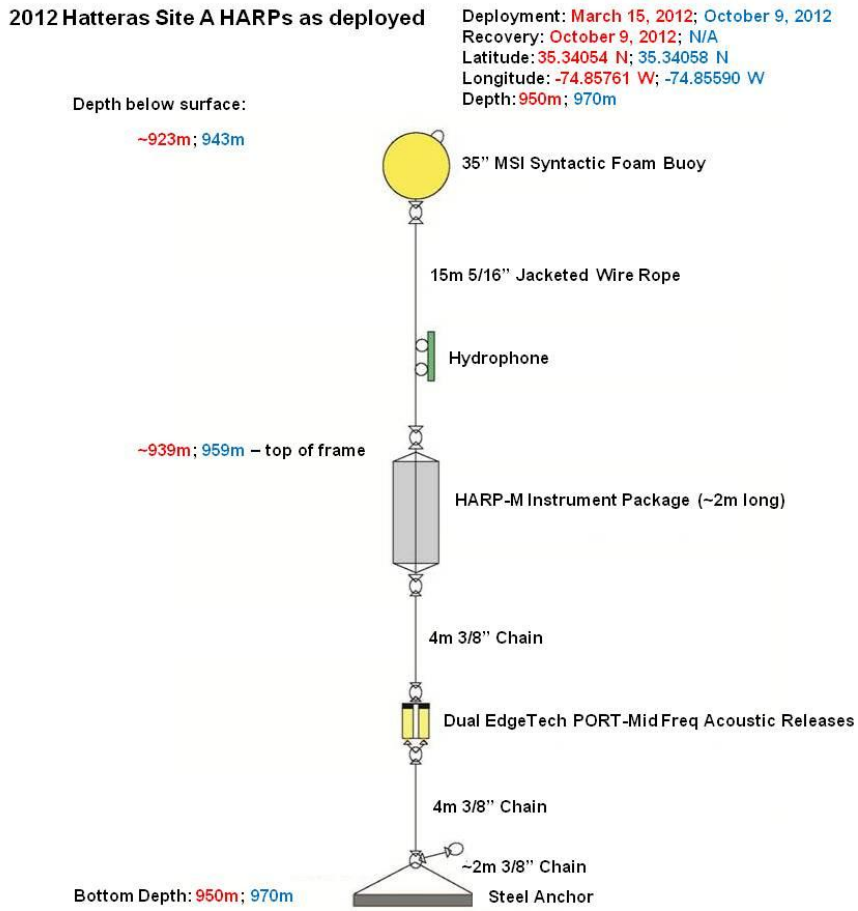

Figure 3. Schematic diagram showing details of 2012 Cape Hatteras Site A HARP deployments. Note that diagram is not drawn to scale.

Table 1. HARP deployments in the Cape Hatteras survey area.

Site	Deployment Date	Retrieval Date	Latitude	Longitude	Depth (m)	Sampling Rate	Duty Cycle	Amount of data
1A	15-Mar-12	9-Oct-12	35.34054	-74.85761	950	200 kHz	Continuous	0.5 TB*
2A	9-Oct-12		35.34060	-74.85590	970	200 kHz	Continuous	

*compressed

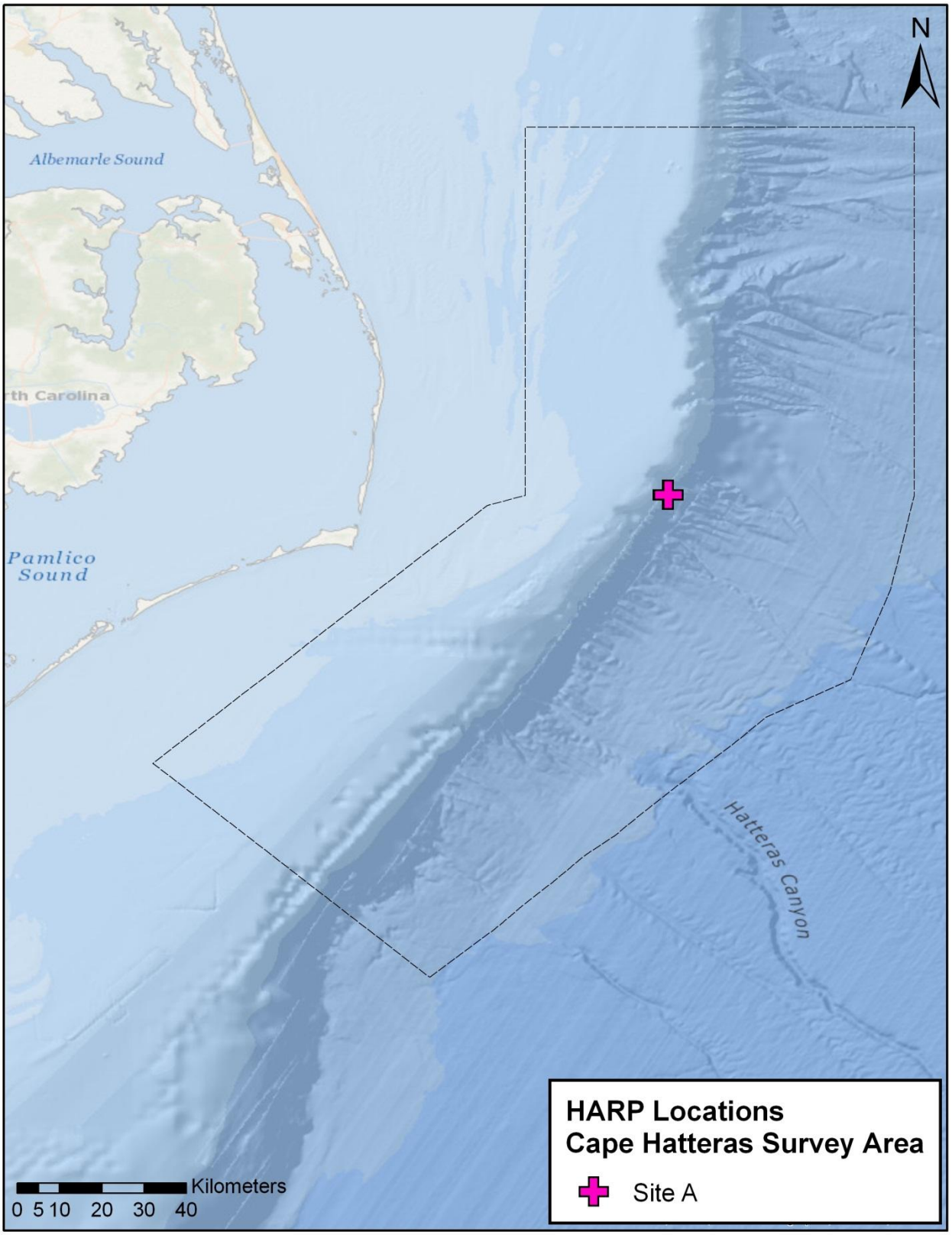

Figure 4. Location of the HARP deployment site in the Cape Hatteras survey area.

Data Analysis

Vessel survey effort and sighting data were compiled and mapped using *ArcGIS* 10.1 to illustrate the location of effort and sightings within the study area. All vessel sighting data from January 2012 through December 2012 have been posted on the data repository OBIS-SEAMAP (http://seamap.env.duke.edu/).

Acoustic Analysis

Towed Array Analysis

Towed array recordings were analyzed using *Raven 1.4* software to view spectrograms. Ten-minute time bins were scored for presence or absence of odontocete vocalizations, categorized as either whistles/tonal sounds or echolocation clicks/pulsed sounds. The towed array was not sensitive to frequencies below 2 kHz, so mysticete vocalizations were not able to be detected.

Seaglider

Acoustic recordings collected by the glider were analyzed using *Raven* 1.4 software to view spectrograms. During periods when the glider was making course corrections or adjusting its buoyancy (i.e., running internal motors), the acoustic record was unusable due to noise. These intermittent periods of noise lasted from 2 to 290 s. After removing these periods of noise, the remaining recordings were analyzed for cetacean vocalizations. As original signal levels were low, the sound files were amplified by a factor of five to make detections more audible and clearly visible in spectrograms. Sixty-second time bins were scored for presence or absence of odontocete vocalizations, categorized as either whistles/tonal sounds or echolocation clicks/pulsed sounds.

HARP Analysis

HARP data require processing prior to analysis, including backing up data in original format, converting data to wav format, decimating wav data by a factor of 100 to aid in baleen whale detection, and creating long-term spectral averages (LTSAs). New compression code was implemented starting in July 2010 which allowed for greater than two TB of data to be collected after the raw data were decompressed. This amount of data is impractical to analyze manually, so these data were compressed for visual overview by using a *MATLAB*-based acoustic program called Triton (Hildebrand Lab at Scripps Institution of Oceanography, CA) to create LTSAs from the wav files, which allowed for rapid review of the data. LTSAs are effectively compressed spectrograms created using the Welch algorithm (Welch 1967) by coherently averaging 500 spectra created from 2000-point, 0%-overlapped, Hann-windowed data and displaying these averaged spectra sequentially over time.

The data from the first Cape Hatteras Site A HARP deployment were manually scanned for marine mammal vocalizations using the "logger" version of Triton (v1.81.20121030). The effective frequency range of the HARP (10 Hz – 100 kHz) was divided into two parts for this manual review: 10-1000 Hz and 1-100 kHz. The resulting LTSAs had resolutions of 5 s in time and 1 Hz in frequency (for the data decimated by a factor of 100: 10-1000 Hz band) and 5 s in time and 100 Hz in frequency (for the original data: 1-100 kHz band). LTSAs that were decimated by a factor of 100 were inspected for sounds produced by mysticetes. Non-decimated LTSAs were inspected for odontocete whistles and clicks. The presence of vocalizations, assigned to species when possible, was determined in one-minute bins.

Data Storage

All acoustic, visual survey and photographic data are archived on digital media, and backed up on a Duke University network server.

Results

Survey Effort

In February, March and October 2012, 423.9 km were surveyed during approximately 35.2 hours of dedicated marine mammal and sea turtle vessel surveys (Table 2, Figure 5). Sighting conditions were relatively poor during the four-day research cruise aboard the R/V *Cape Hatteras*, with most survey effort conducted in Beaufort Sea State (BSS) 4. An additional 625.5 km and 120.4 hours of effort occurred in May, June, August and September 2012 during the pilot whale behavioral response study (Table 2, Figure 5). Sighting conditions during these latter surveys ranged from excellent to poor (BSS 0 to 5).

Table 2. Dates, kilometers and hours surveyed during vessel surveys in the Cape Hatteras survey area, January 2012 – December 2012. Survey effort between May and September 2012 (shaded in gray) was conducted during the pilot whale behavioral response study.

Date	Sea State	Distance Surveyed (km)	Survey Time (hrs:min)	At Sea Time (hrs:min)	Platform
27-Feb-12	2-4	77.8	5:56	10:15	F/V *Sea Creature*
15-Mar-12	1-3	106.5	6:00	10:32	F/V *Sea Creature*
3-May-12	2-4	40.0	3:37	3:37	R/V *Exocetus*
3-May-12	3-4	34.4	3:14	3:14	R/V *Wavelet*
3-May-12	n/a	n/a	n/a	19:00	R/V *SRVx*
4-May-12	0-1	88.5	9:10	9:10	R/V *Exocetus*
4-May-12	0-2	39.0	9:47	9:47	R/V *Wavelet*
4-May-12	n/a	21.6	6:24	24:00	R/V *SRVx*
12-May-12	2-3	74.9	9:40	10:15	R/V *Exocetus*
12-May-12	2-3	39.6	11:14	11:30	R/V *Wavelet*
12-May-12	n/a	44.4	13:21	24:00	R/V *SRVx*
9-Jun-12	2-4	26.7	4:02	8:37	R/V *Exocetus*
10-Jun-12	2-3	19.2	5:53	10:34	R/V *Exocetus*
11-Jun-12	0-2	25.5	7:36	11:50	R/V *Exocetus*
20-Jun-12	1-3	45.4	6:32	10:25	R/V *Exocetus*
21-Jun-12	3	8.1	1:45	6:36	R/V *Exocetus*
31-Aug-12	3-4	25.2	4:24	9:29	R/V *Exocetus*
31-Aug-12	3-4	39.5	4:24	9:17	F/V *Samanna*
2-Sep-12	0-2	23.3	5:04	10:35	R/V *Exocetus*
2-Sep-12	0-2	30.2	5:04	10:35	F/V *Samanna*
8-Oct-12	4	17.8	1:38	24:00	R/V *Cape Hatteras*
9-Oct-12	4-5	37.5	5:38	24:00	R/V *Cape Hatteras*
10-Oct-12	4	117.4	10:15	24:00	R/V *Cape Hatteras*
11-Oct-12	4-5	66.9	5:47	24:00	R/V *Cape Hatteras*

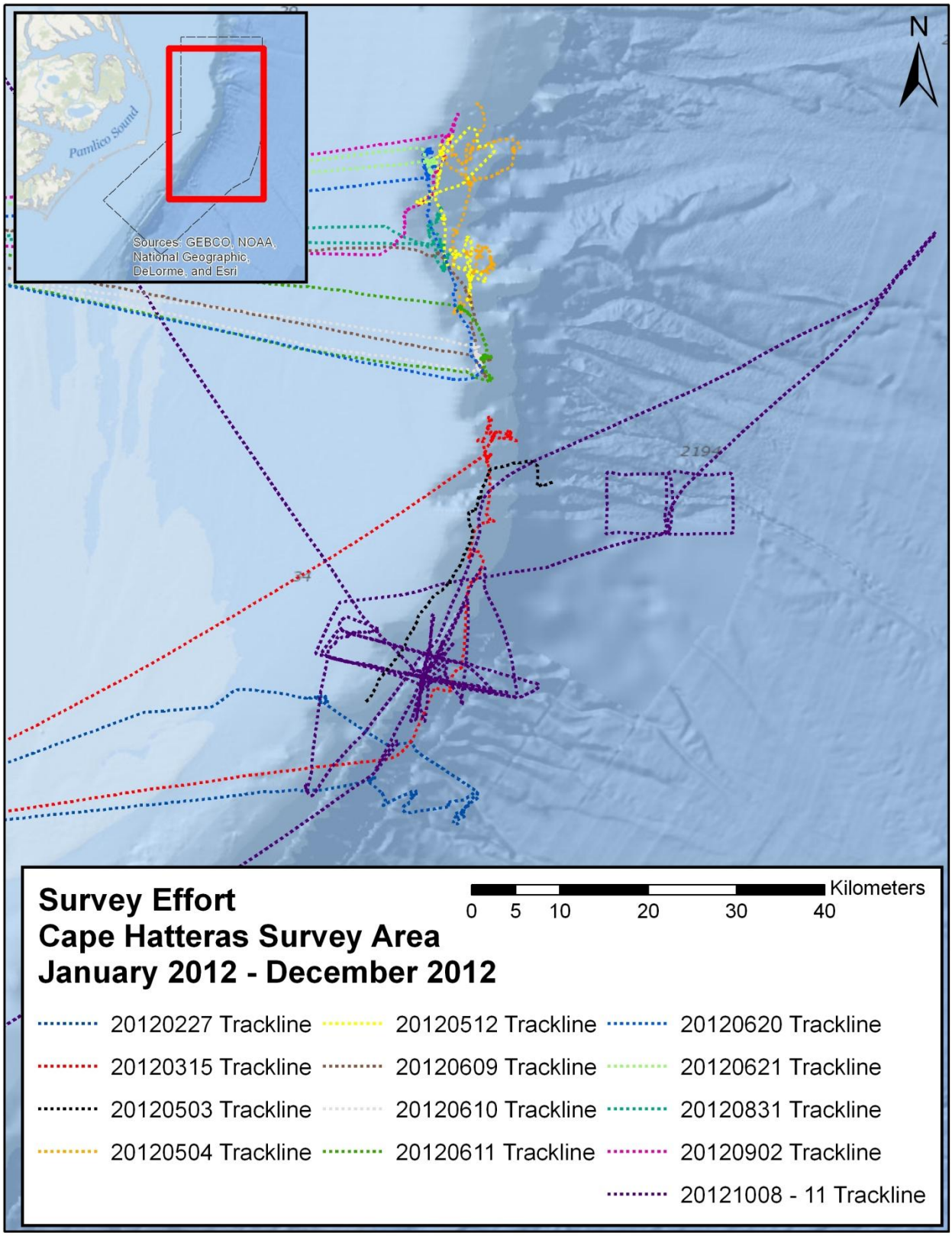

Figure 5. Survey effort in the Cape Hatteras survey area, January 2012 – December 2012.

Sightings

One hundred thirty cetacean sightings, comprising approximately 6200 individuals, were observed during the reporting period. Sightings of species observed in 2012 included: fin whales (*Balaenoptera physalus*; n = 1), common dolphins (*Delphinus delphis*; n = 11), short-finned pilot whales (n = 52), Risso's dolphins (*Grampus griseus*; n = 2), sperm whales (*Physeter macrocephalus*; n = 4), Atlantic spotted dolphins (*Stenella frontalis*; n = 2), bottlenose dolphins (n = 54), Cuvier's beaked whales (*Ziphius cavirostris*; n = 1) and three unidentified delphinids (Tables 3 and 4). No mixed-species groups were observed. In addition, two loggerhead sea turtles (*Caretta caretta*) and one unidentified sea turtle were recorded during vessel surveys in the survey area (Tables 5 and 6).

Table 3. Cetacean sightings from vessel surveys in the Cape Hatteras survey area, January 2012 – December 2012.

Date	Time	Latitude	Longitude	Depth (m)	Temp (C^o)	Species	Group Size	Biopsy Samples	Images
27-Feb-12	8:32	35.32475	-74.97490	102.4	21.3	*T. truncatus*	12	1	101
27-Feb-12	9:43	35.31228	-74.94492	274.3	21.7	*T. truncatus*	25	0	0
27-Feb-12	10:10	35.27835	-74.86606	1584.9	22.8	*P. macrocephalus*	2	0	64
27-Feb-12	11:07	35.19706	-74.82328	2316.5	23.7	*G. macrorhynchus*	30	0	1
27-Feb-12	12:25	35.20783	-74.87241	1981.2	23.6	*P. macrocephalus*	1	0	29
27-Feb-12	12:42	35.22635	-74.86561	no data	no data	*T. truncatus*	5	0	11
27-Feb-12	13:05	35.22117	-74.88532	1828.8	23.6	*P. macrocephalus*	3	0	70
15-Mar-12	9:30	35.33286	-74.83520	1524	24.6	*P. macrocephalus*	1	0	8
15-Mar-12	10:07	35.47135	-74.79906	457.2	24.3	*Z. cavirostris*	2	0	0
15-Mar-12	10:20	35.46951	-74.80684	365.8	24.1	*T. truncatus*	40	0	20
15-Mar-12	11:14	35.56340	-74.78881	274.3	23.1	*D. delphis*	750	0	36
15-Mar-12	11:39	35.60939	-74.78642	365.8	21.3	*T. truncatus*	100	2	138
15-Mar-12	13:27	35.57420	-74.79146	274.3	21.4	*D. delphis*	400	0	59
03-May-12	14:24	35.32082	-74.93017	no data	no data	*T. truncatus*	5	0	0
03-May-12	14:42	35.37069	-74.90216	no data	no data	*T. truncatus*	6	0	0
03-May-12	14:45	35.39150	-74.86758	no data	no data	*T. truncatus*	8	0	0
03-May-12	15:05	35.41724	-74.87065	no data	no data	*T. truncatus*	6	0	0
03-May-12	15:26	35.46554	-74.81459	no data	no data	*T. truncatus*	9	0	0
03-May-12	15:53	35.51108	-74.80909	no data	no data	*T. truncatus*	8	1	7
03-May-12	16:16	35.51998	-74.80069	no data	no data	*T. truncatus*	1	0	0
03-May-12	16:24	35.52789	-74.79877	no data	no data	*T. truncatus*	4	1	13
04-May-12	6:25	35.75758	-74.80231	no data	no data	*G. macrorhynchus*	35	2	16
04-May-12	6:38	35.75997	-74.80291	no data	no data	*G. macrorhynchus*	4	0	186
04-May-12	7:31	35.77239	-74.78662	no data	no data	*G. macrorhynchus*	2	0	9
04-May-12	7:40	35.77897	-74.78685	no data	no data	*G. macrorhynchus*	16	0	46
04-May-12	8:07	35.78198	-74.79107	no data	no data	*G. macrorhynchus*	15	2	2
04-May-12	8:28	35.77750	-74.79748	no data	no data	*G. macrorhynchus*	12	2	31
04-May-12	8:38	35.77391	-74.79969	no data	no data	*G. macrorhynchus*	15	0	67
04-May-12	9:02	35.77903	-74.81185	no data	no data	*G. macrorhynchus*	10	2	41
04-May-12	9:39	35.73380	-74.80877	no data	no data	*T. truncatus*	7	0	23
04-May-12	9:51	35.73409	-74.80820	no data	no data	*T. truncatus*	4	2	27
04-May-12	10:05	35.72094	-74.81472	no data	no data	*T. truncatus*	7	2	49
04-May-12	12:06	35.86798	-74.81832	no data	no data	*G. macrorhynchus*	200	0	54
04-May-12	12:11	35.87120	-74.81889	no data	no data	*G. macrorhynchus*	25	2	76
04-May-12	13:18	35.89091	-74.80133	no data	no data	*T. truncatus*	18	0	0
04-May-12	13:40	35.88188	-74.76211	no data	no data	*D. delphis*	25	1	22
04-May-12	14:30	35.90865	-74.80591	no data	no data	*D. delphis*	75	0	0
04-May-12	14:55	35.85173	-74.80334	no data	no data	*D. delphis*	50	0	5
04-May-12	15:41	35.92730	-74.81920	no data	no data	*T. truncatus*	20	0	4
04-May-12	17:39	35.93250	-74.80820	no data	no data	*B. physalus*	3	0	0

Table 3 cont. Cetacean sightings from vessel surveys in the Cape Hatteras survey area, January 2012– December 2012.

Date	Time	Latitude	Longitude	Depth (m)	Temp (C^o)	Species	Group Size	Biopsy Samples	Images
12-May-12	6:25	35.74843	-74.79619	no data	no data	*S. frontalis*	80	0	0
12-May-12	6:40	35.71658	-74.80292	no data	no data	*G. macrorhynchus*	225	3	214
12-May-12	7:21	35.73322	-74.80705	no data	no data	*G. macrorhynchus*	15	0	0
12-May-12	7:27	35.73501	-74.80724	no data	no data	*G. macrorhynchus*	18	0	22
12-May-12	7:29	35.73337	-74.80549	no data	no data	*D. delphis*	90	0	0
12-May-12	7:40	35.74128	-74.80586	no data	no data	*G. macrorhynchus*	5	0	0
12-May-12	7:49	35.74329	-74.80684	no data	no data	*G. macrorhynchus*	12	0	5
12-May-12	8:11	35.75157	-74.80600	no data	no data	*G. macrorhynchus*	50	0	33
12-May-12	8:47	35.76180	-74.81129	no data	no data	*G. macrorhynchus*	4	0	22
12-May-12	9:13	35.77386	-74.82154	no data	no data	*G. macrorhynchus*	9	1	8
12-May-12	9:24	35.77905	-74.82572	no data	no data	*G. macrorhynchus*	20	2	15
12-May-12	9:48	35.78925	-74.80994	no data	no data	*G. macrorhynchus*	12	2	25
12-May-12	10:36	35.81605	-74.83760	no data	no data	*D. delphis*	10	0	0
12-May-12	10:43	35.76249	-74.81832	no data	no data	*T. truncatus*	1	0	0
12-May-12	11:29	35.81415	-74.83582	no data	no data	*D. delphis*	40	2	14
12-May-12	11:32	35.82182	-74.84522	no data	no data	*T. truncatus*	3	0	0
12-May-12	13:33	35.82878	-74.84924	no data	no data	*D. delphis*	500	0	16
12-May-12	15:33	35.83531	-74.84611	no data	no data	*D. delphis*	30	0	0
12-May-12	15:40	35.83111	-74.84867	no data	no data	*D. delphis*	400	2	12
12-May-12	15:53	35.82910	-74.84933	no data	no data	*G. macrorhynchus*	100	2	66
12-May-12	16:21	35.82927	-74.85794	no data	no data	*G. macrorhynchus*	12	2	37
12-May-12	16:33	35.82852	-74.86164	no data	no data	*G. macrorhynchus*	15	0	26
12-May-12	16:48	35.83122	-74.85789	no data	no data	*G. macrorhynchus*	80	1	23
09-Jun-12	7:50	35.77431	-74.84212	no data	no data	*T. truncatus*	125	0	0
09-Jun-12	8:26	35.67017	-74.80161	no data	no data	*G. macrorhynchus*	500	0	215
09-Jun-12	8:29	35.70654	-74.80683	no data	no data	*T. truncatus*	15	0	0
09-Jun-12	10:19	35.66924	-74.79764	no data	no data	*T. truncatus*	25	0	4
10-Jun-12	7:55	35.66504	-74.79563	no data	no data	*T. truncatus*	200	0	0
10-Jun-12	7:58	35.66462	-74.79564	no data	no data	*G. macrorhynchus*	350	2	178
11-Jun-12	7:36	35.65376	-74.80552	no data	no data	*G. macrorhynchus*	400	2	678
11-Jun-12	8:59	35.65407	-74.78836	no data	no data	*T. truncatus*	50	0	0
20-Jun-12	7:44	35.64840	-74.82772	no data	no data	*T. truncatus*	7	0	0
20-Jun-12	7:48	35.64935	-74.81069	no data	no data	*T. truncatus*	5	0	0
20-Jun-12	8:02	35.67620	-74.80597	no data	no data	*T. truncatus*	20	0	0
20-Jun-12	8:21	35.73983	-74.82216	no data	no data	*T. truncatus*	12	0	0
20-Jun-12	8:50	35.86422	-74.84343	no data	no data	*G. macrorhynchus*	75	2	551
20-Jun-12	10:07	35.86083	-74.75019	1097.3	22.8	*S. frontalis*	6	0	0
20-Jun-12	10:21	35.88327	-74.84688	no data	no data	*T. truncatus*	30	0	9
20-Jun-12	13:44	35.85953	-74.85173	no data	no data	*T. truncatus*	6	0	0
21-Jun-12	8:03	35.85997	-74.84825	no data	no data	*T. truncatus*	4	0	0
21-Jun-12	8:05	35.85887	-74.84655	no data	no data	*G. macrorhynchus*	150	0	26

Table 3 cont. Cetacean sightings from vessel surveys in the Cape Hatteras survey area, January 2012– December 2012.

Date	Time	Latitude	Longitude	Depth (m)	Temp (C^o)	Species	Group Size	Biopsy Samples	Images
21-Jun-12	8:07	35.84684	-74.84924	no data	no data	*G. macrorhynchus*	21	0	0
21-Jun-12	9:24	35.87041	-74.84398	no data	no data	*T. truncatus*	10	0	0
31-Aug-12	8:28	35.78733	-74.84516	350	25.7	*G. macrorhynchus*	14	0	39
31-Aug-12	9:25	35.77604	-74.83273	no data	no data	*G. macrorhynchus*	17	0	24
31-Aug-12	9:42	35.78505	-74.84220	no data	no data	*G. griseus*	5	0	20
31-Aug-12	10:03	35.78636	-74.83774	no data	no data	*G. macrorhynchus*	15	0	9
31-Aug-12	10:48	35.76120	-74.83438	no data	25.5	*G. macrorhynchus*	20	1	78
31-Aug-12	10:56	35.74551	-74.83189	no data	no data	*G. griseus*	3	0	2
31-Aug-12	11:53	35.74080	-74.83125	no data	no data	*G. macrorhynchus*	6	0	9
02-Sep-12	8:06	35.78594	-74.88399	no data	no data	*T. truncatus*	14	1	0
02-Sep-12	8:24	35.79807	-74.87353	no data	no data	*G. macrorhynchus*	225	3	267
02-Sep-12	8:52	35.81287	-74.86696	193.9	27.6	*G. macrorhynchus*	4	0	19
02-Sep-12	10:15	35.84562	-74.84350	no data	no data	*T. truncatus*	1	0	0
02-Sep-12	12:00	35.89090	-74.83536	no data	no data	*T. truncatus*	12	0	0
02-Sep-12	12:43	35.89307	-74.83549	415.1	28.2	*G. macrorhynchus*	19	0	87
08-Oct-12	11:15	35.45194	-74.94609	no data	no data	*T. truncatus*	12	0	10
08-Oct-12	11:39	35.39599	-74.90475	55.7	26.3	*T. truncatus*	2	0	0
08-Oct-12	12:00	35.36881	-74.87709	419.7	27.1	*T. truncatus*	2	0	1
08-Oct-12*	7:54	35.33761	-74.85473	no data	no data	*G. macrorhynchus*	8	0	0
08-Oct-12*	8:35	35.34404	-74.85093	no data	no data	*G. macrorhynchus*	3	0	0
09-Oct-12	11:28	35.36068	-74.92671	no data	24.4	*T. truncatus*	3	0	0
09-Oct-12	11:45	35.36710	-74.95118	no data	24.3	*T. truncatus*	2	0	0
09-Oct-12	16:37	35.38323	-74.89640	424	28.3	*T. truncatus*	6	0	15
09-Oct-12	16:50	35.37670	-74.87507	823	28.3	*T. truncatus*	5	0	0
09-Oct-12	17:26	35.36183	-74.81441	1375	28.5	*T. truncatus*	3	0	0
10-Oct-12	14:23	35.62675	-74.60406	1800	27.9	*G. macrorhynchus*	5	0	1
10-Oct-12	15:08	35.57437	-74.72291	1240	27.8	*T. truncatus*	5	0	22
10-Oct-12	15:21	35.55620	-74.76113	893	27.4	Unid. delphinid	unk.	0	0
10-Oct-12	15:23	35.54815	-74.76916	893	27.3	*G. macrorhynchus*	4	0	0
10-Oct-12	15:29	35.54639	-74.77627	709.7	24.6	*G. macrorhynchus*	12	0	0
10-Oct-12	15:38	35.52861	-74.79305	709	24.6	*T. truncatus*	3	0	0
10-Oct-12	16:25	35.47683	-74.80213	423.6	27.8	*T. truncatus*	6	0	0
10-Oct-12	16:54	35.43871	-74.81992	427	27.7	Unid. delphinid	4	0	0
10-Oct-12	17:04	35.42656	-74.82314	372	27.6	*T. truncatus*	4	0	0
10-Oct-12	17:14	35.40975	-74.82988	445.8	27.5	*T. truncatus*	4	0	0
10-Oct-12	17:27	35.39687	-74.83501	542	27.5	*T. truncatus*	6	0	45
10-Oct-12	18:08	35.36393	-74.86160	400	27.5	*T. truncatus*	30	0	5
10-Oct-12	18:15	35.33082	-74.88398	400	27.5	Unid. delphinid	8	0	0
10-Oct-12	18:29	35.32835	-74.88594	416	27.9	*T. truncatus*	10	0	40
11-Oct-12	12:43	35.42895	-74.81044	no data	no data	*G. macrorhynchus*	8	0	0
11-Oct-12	13:01	35.40689	-74.82105	no data	no data	*G. macrorhynchus*	6	0	0

Table 3 cont. Cetacean sightings from vessel surveys in the Cape Hatteras survey area, January 2012– December 2012.

Date	Time	Latitude	Longitude	Depth (m)	Temp (C^o)	Species	Group Size	Biopsy Samples	Images
11-Oct-12	13:07	35.39958	-74.82483	no data	no data	*G. macrorhynchus*	6	0	0
11-Oct-12	13:49	35.35058	-74.85211	no data	no data	*G. macrorhynchus*	5	0	0
11-Oct-12	15:00	35.26578	-74.89597	no data	no data	*G. macrorhynchus*	4	0	0
11-Oct-12	15:11	35.25268	-74.90347	no data	no data	*G. macrorhynchus*	4	0	0
11-Oct-12	16:15	35.27635	-74.88658	no data	no data	*G. macrorhynchus*	5	0	0
11-Oct-12	16:24	35.27287	-74.88509	1400	27.2	*G. macrorhynchus*	12	0	4
11-Oct-12	17:16	35.18276	-74.99826	500	no data	*T. truncatus*	15	0	0
11-Oct-12	18:38	35.06367	-75.17264	no data	no data	*T. truncatus*	6	0	0
*off effort									

Table 4. Number of sightings and mean group size for each species observed during all vessel surveys in the Cape Hatteras survey area.

	Sightings			
Species	**2009**	**2011**	**2012**	**Mean Group Size**
Balaenoptera physalus	0	0	1	1.0±0.0
Delphinus delphis	0	6	11	183.5±212.4
Globicephala macrorhynchus	9	33	52	39.7±83.4
Grampus griseus	1	2	2	10.8±13.3
Physeter macrocephalus	0	1	4	1.6±0.9
Stenella frontalis	0	8	2	66.8±88.1
Stenella/Delphinus mix	0	1	0	85.0±0.0
Tursiops truncatus	23	27	54	17.8±27.9
Tursiops/Stenella mix	0	1	0	100.0±0.0
Ziphius cavirostris	0	3	1	2.0±0.8
Unid. delphinid	1	0	3	4.7±3.1
Total:	**34**	**82**	**130**	

Table 5. Sea turtle sightings made from vessel surveys in the Cape Hatteras survey area, January 2012 – December 2012.

Date	Time	Latitude	Longitude	Depth (m)	Temp (C^o)	Species	Group Size
15-Mar-12	13:24	35.57758	-74.79057	274.3	21.3	Unid. sea turtle	1
03-May-12	3:01	35.41730	-74.85256	no data	no data	*Caretta caretta*	1
09-Oct-12	10:58	35.34830	-74.88319	no data	no data	*Caretta caretta*	1

Table 6. Number of sea turtle sightings and mean group size for each species observed during all vessel surveys in the Cape Hatteras survey area.

	Sightings			
Species	**2009**	**2011**	**2012**	**Mean Group Size**
Caretta caretta	2	0	2	1.0±0.0
Unid. sea turtle	0	0	1	1.0±0.0
Total:	**2**	**0**	**3**	

Distributions and Habitat Associations of Cetaceans and Sea Turtles

The distribution of marine mammals and sea turtle sightings is presented in Figures 6 through 16. Short-finned pilot whales and bottlenose dolphins were encountered along the entire shelf break, whereas common dolphins and sperm whales were observed more frequently in the northern and southern ranges of the survey area, respectively. Sea turtles were observed on three occasions along the shelf break (Figure 16).

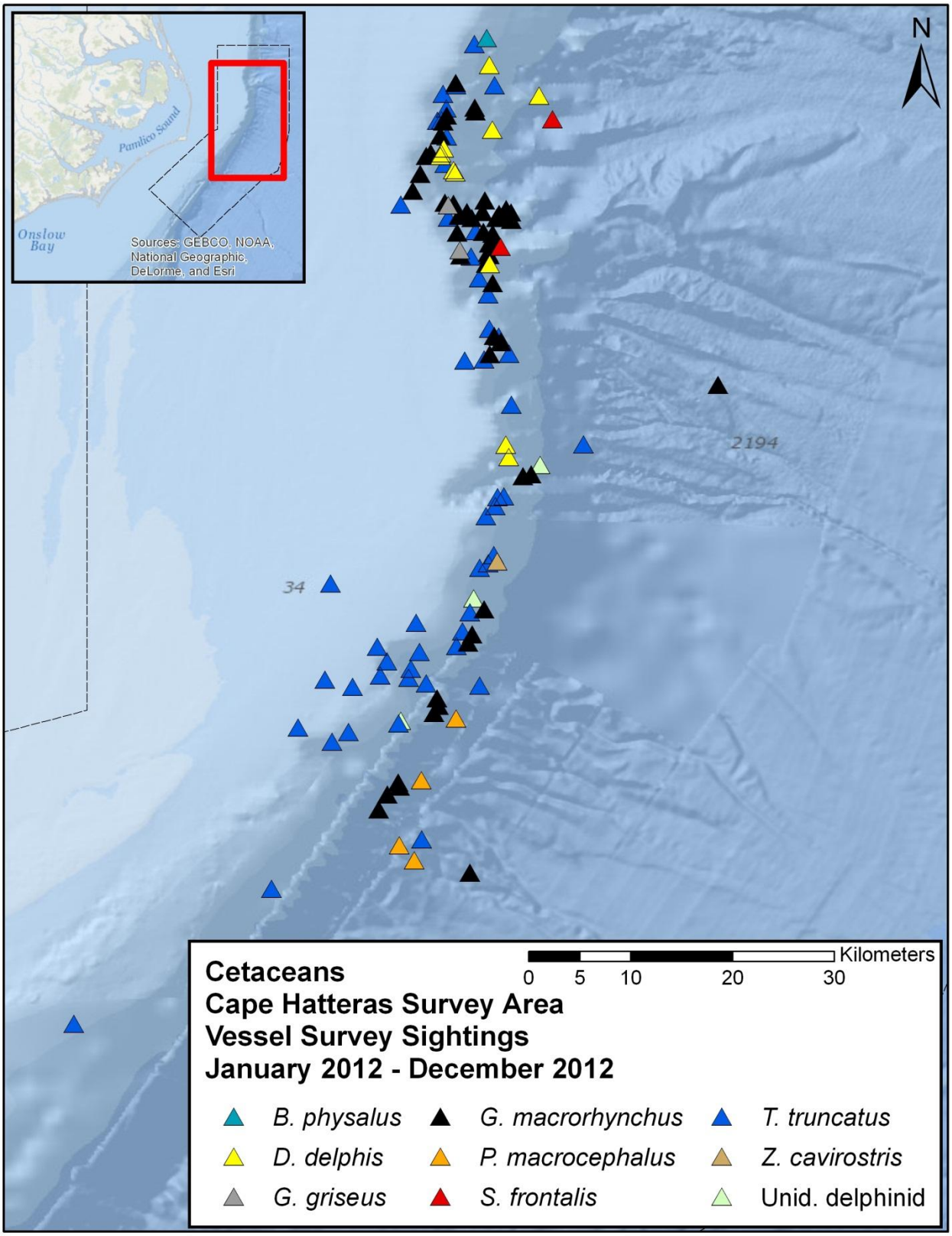

Figure 6. Distribution of all cetacean sightings made during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

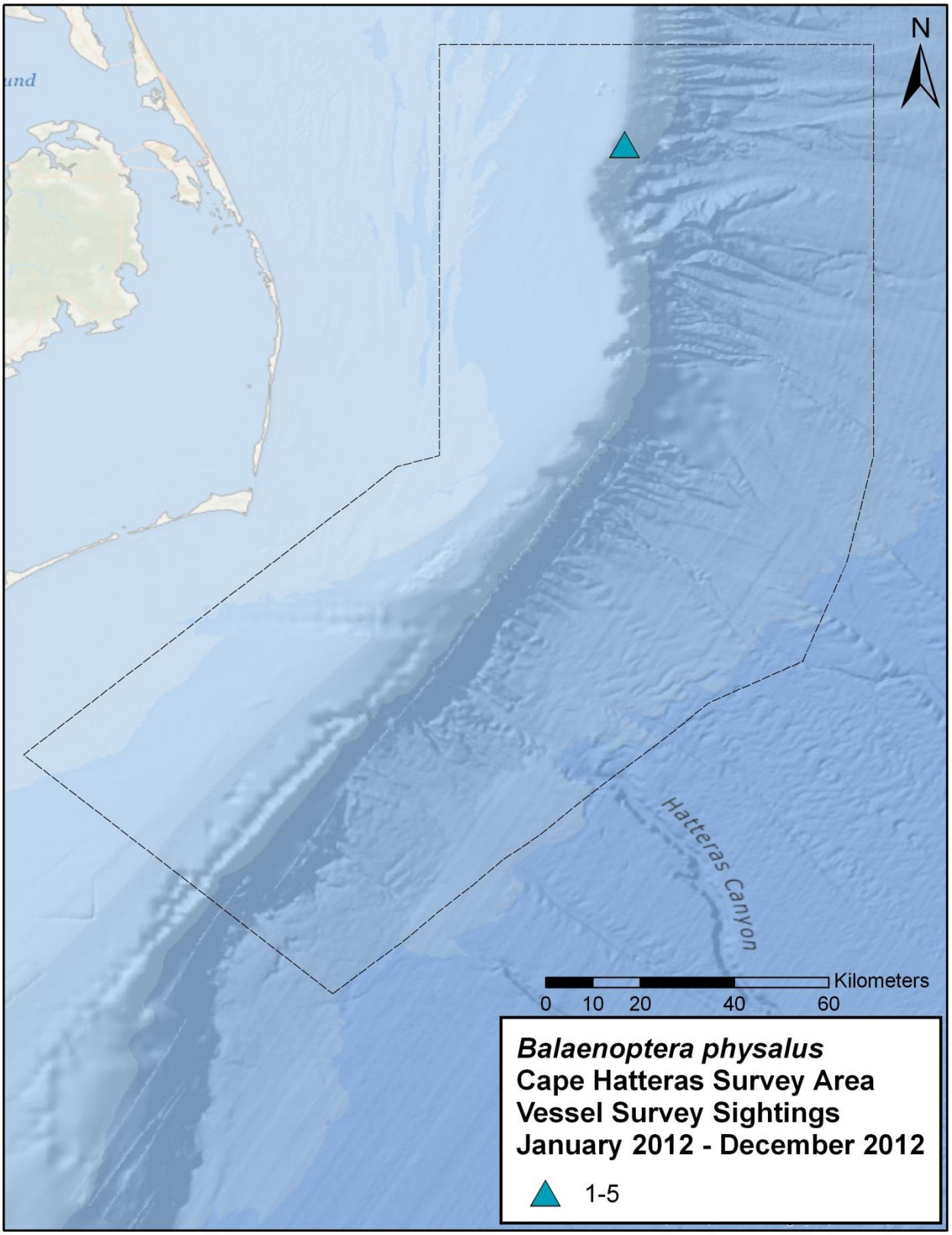

Figure 7. Distribution of fin whale sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

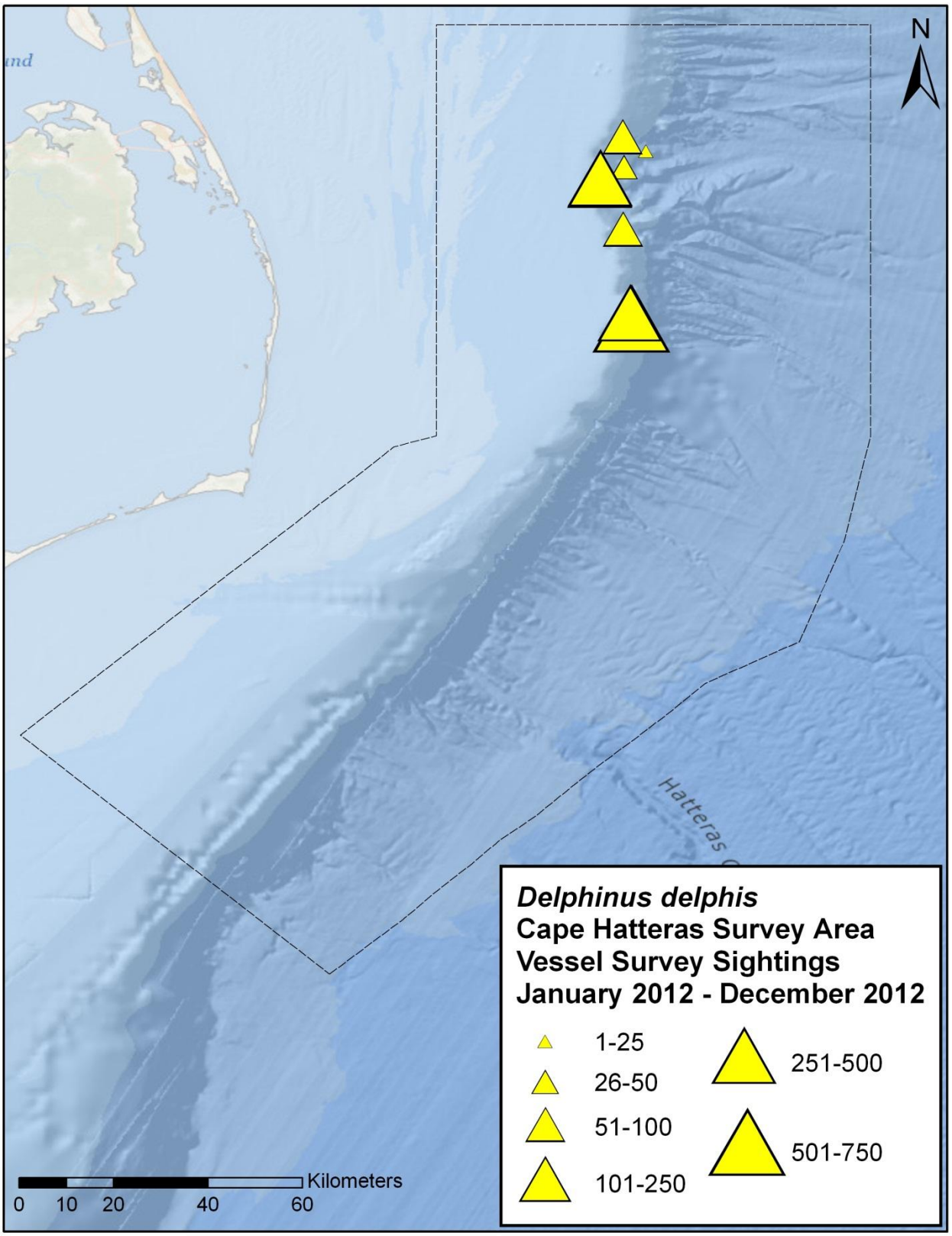

Figure 8. Distribution of common dolphin sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

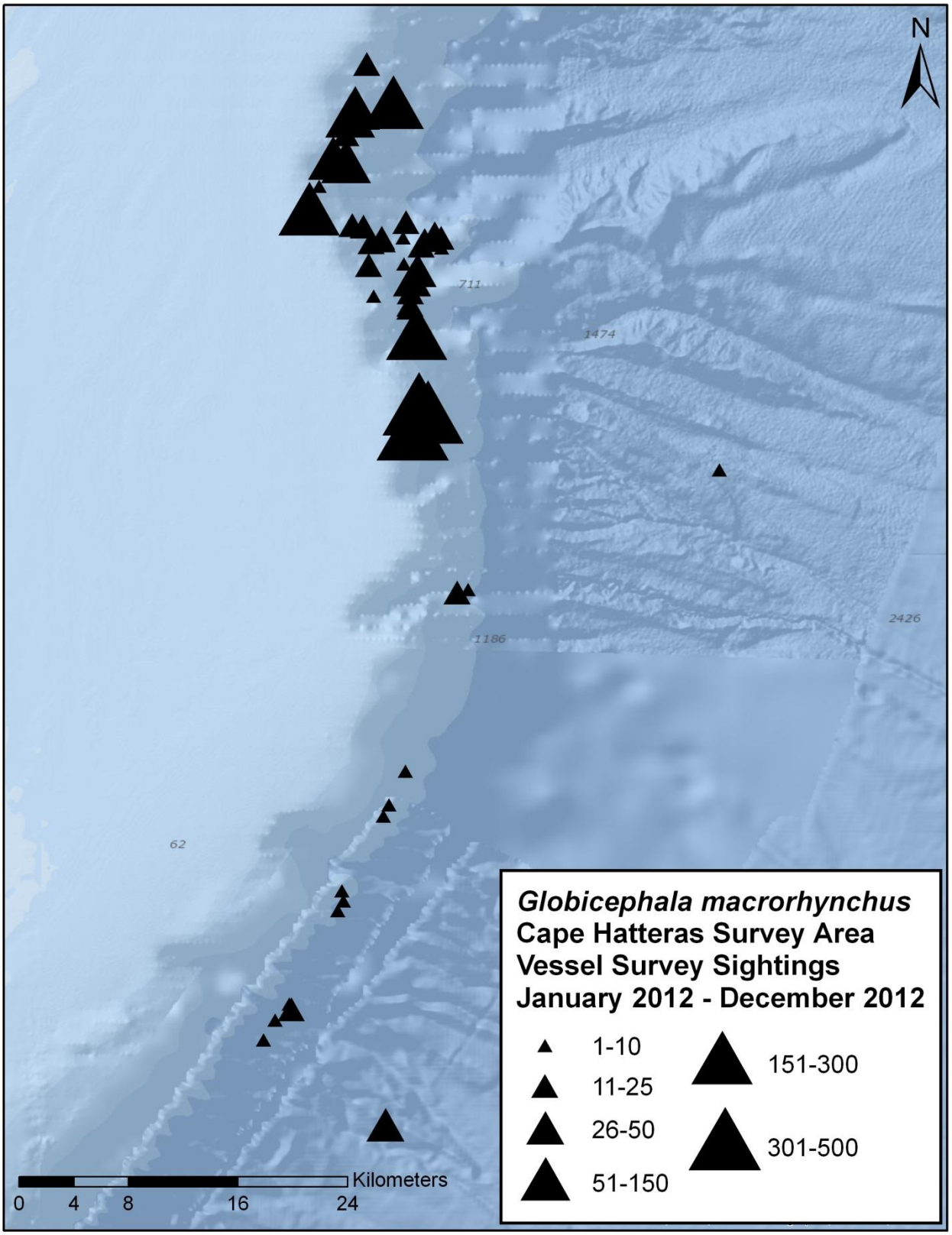

Figure 9. Distribution of short-finned pilot whale sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

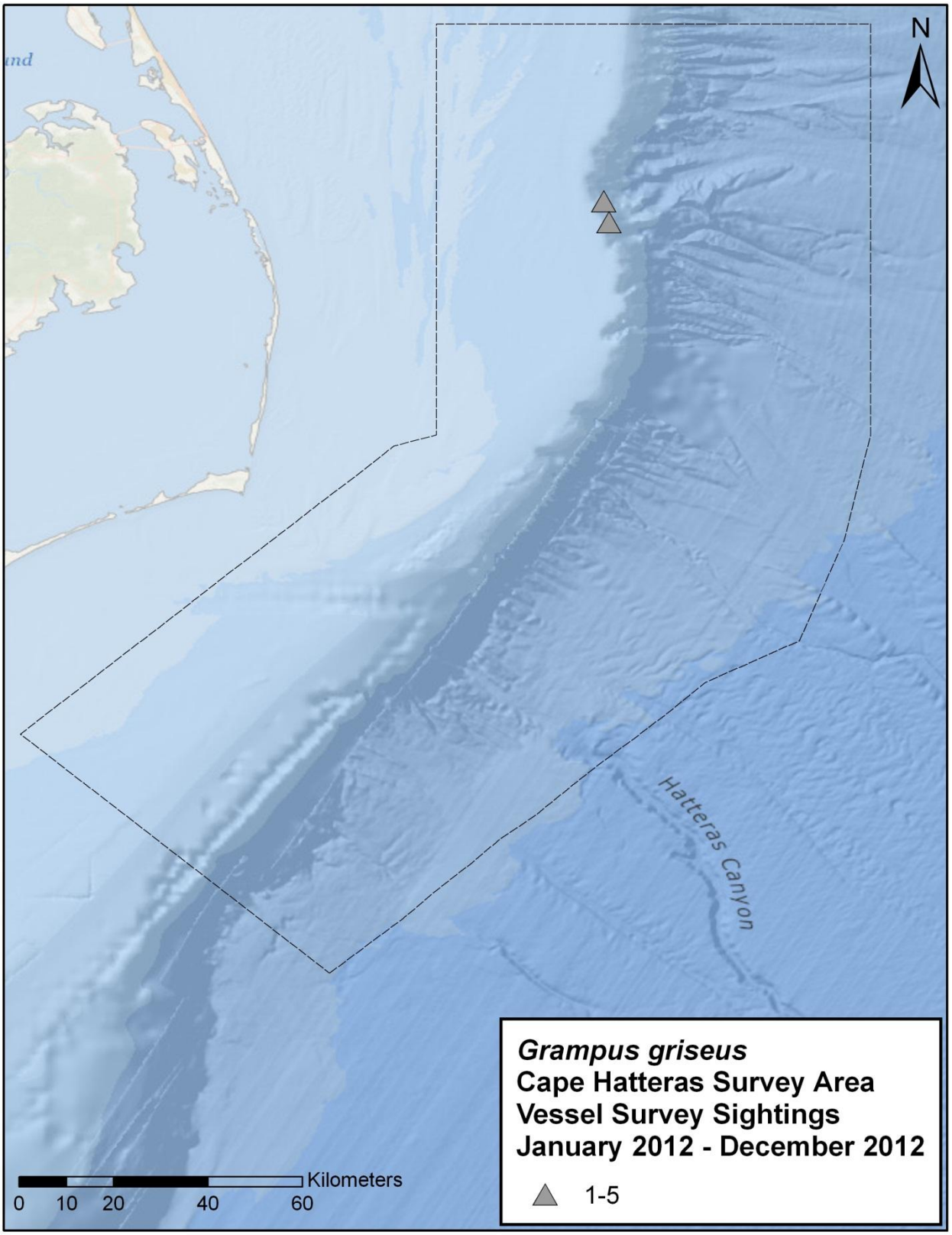

Figure 10. Distribution of Risso's dolphin sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

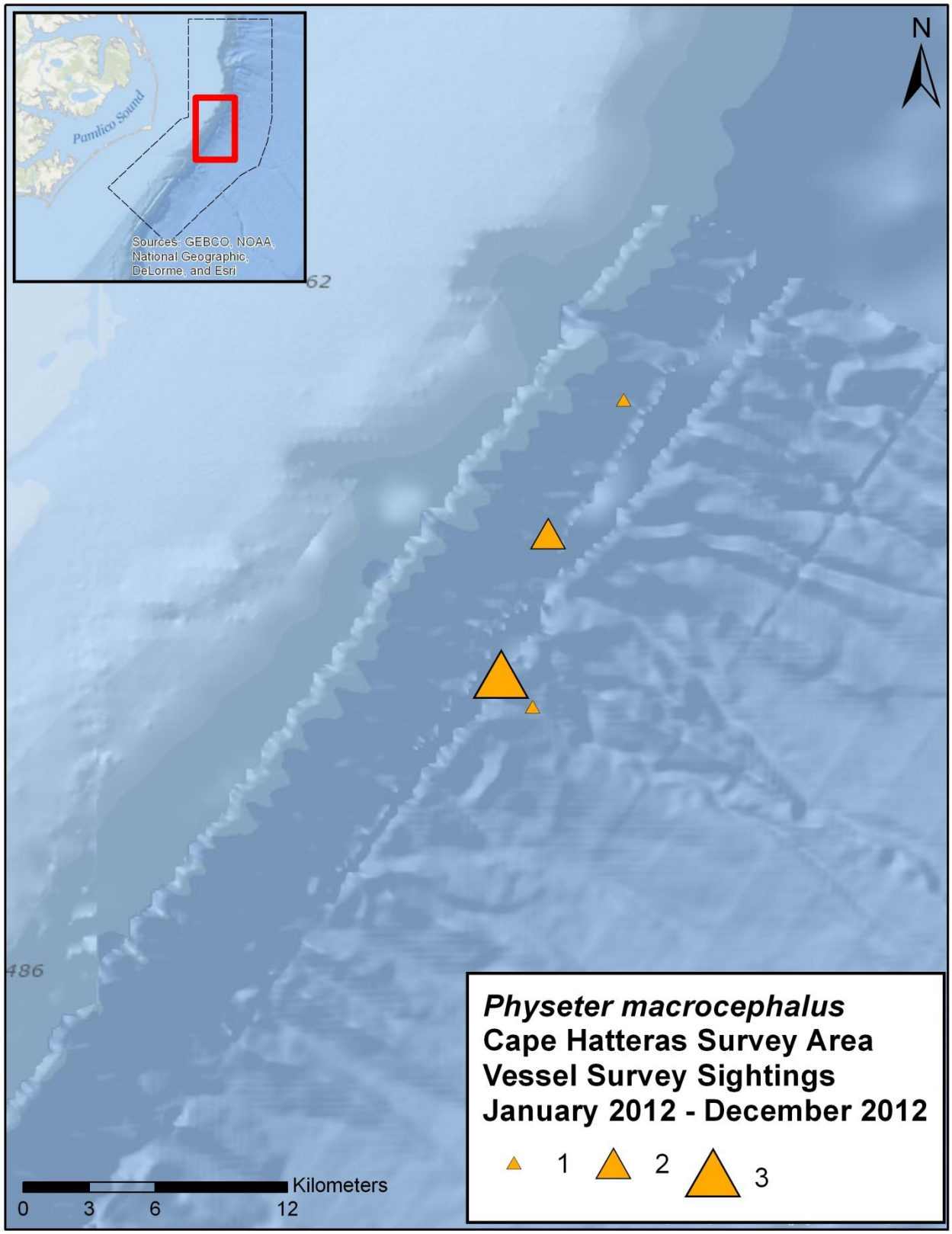

Figure 11. Distribution of sperm whale sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

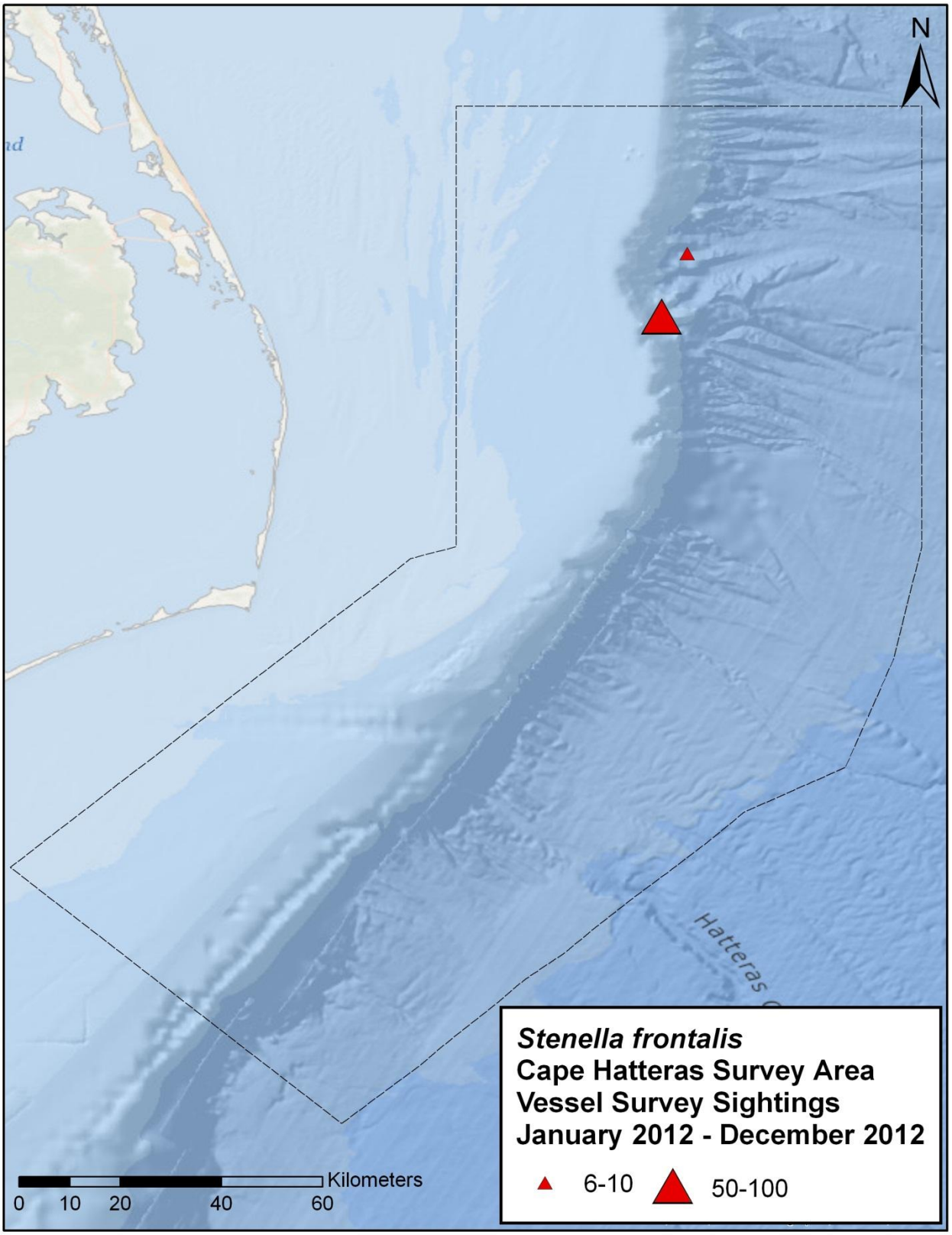

Figure 12. Distribution of Atlantic spotted dolphin sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

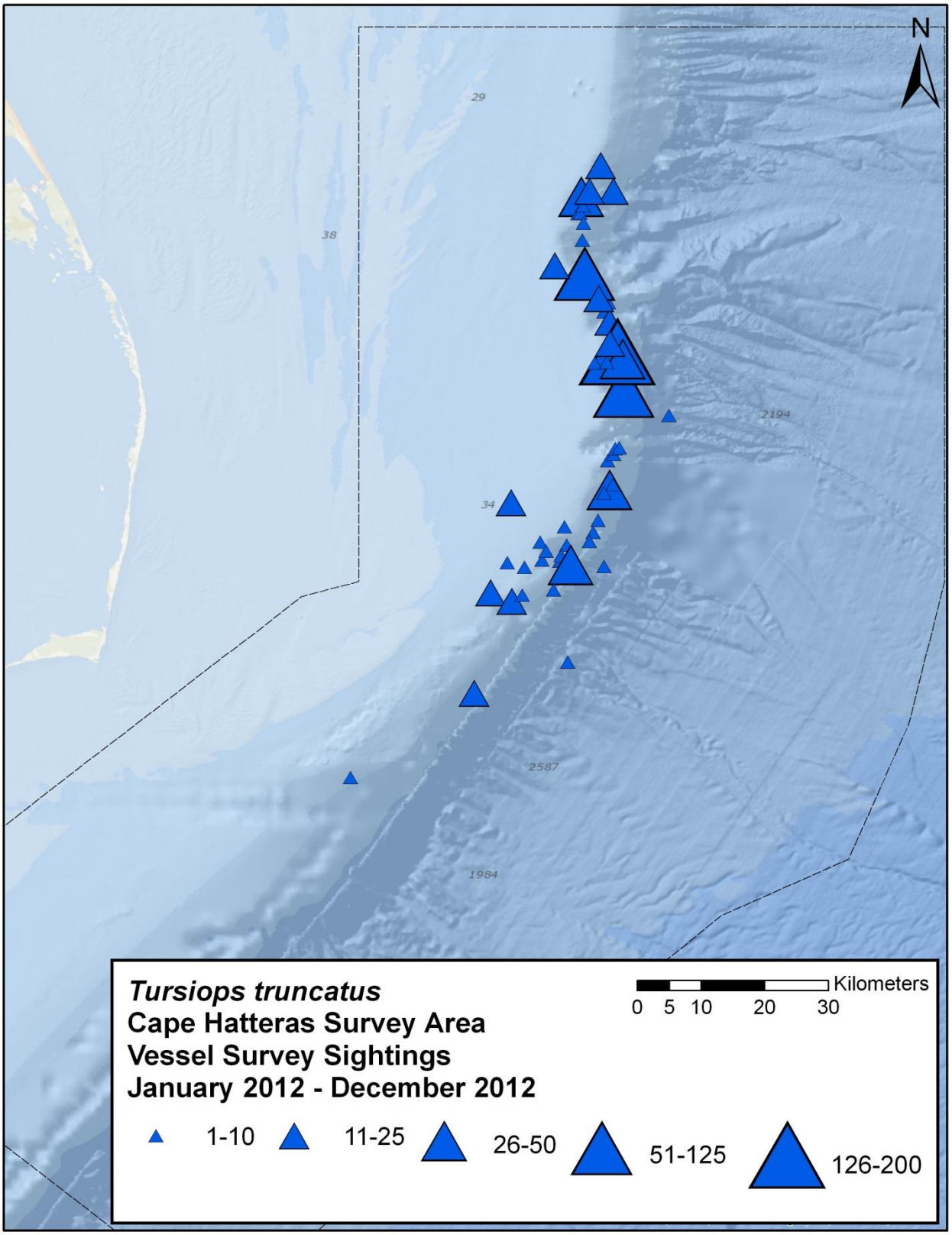

Figure 13. Distribution of bottlenose dolphin sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

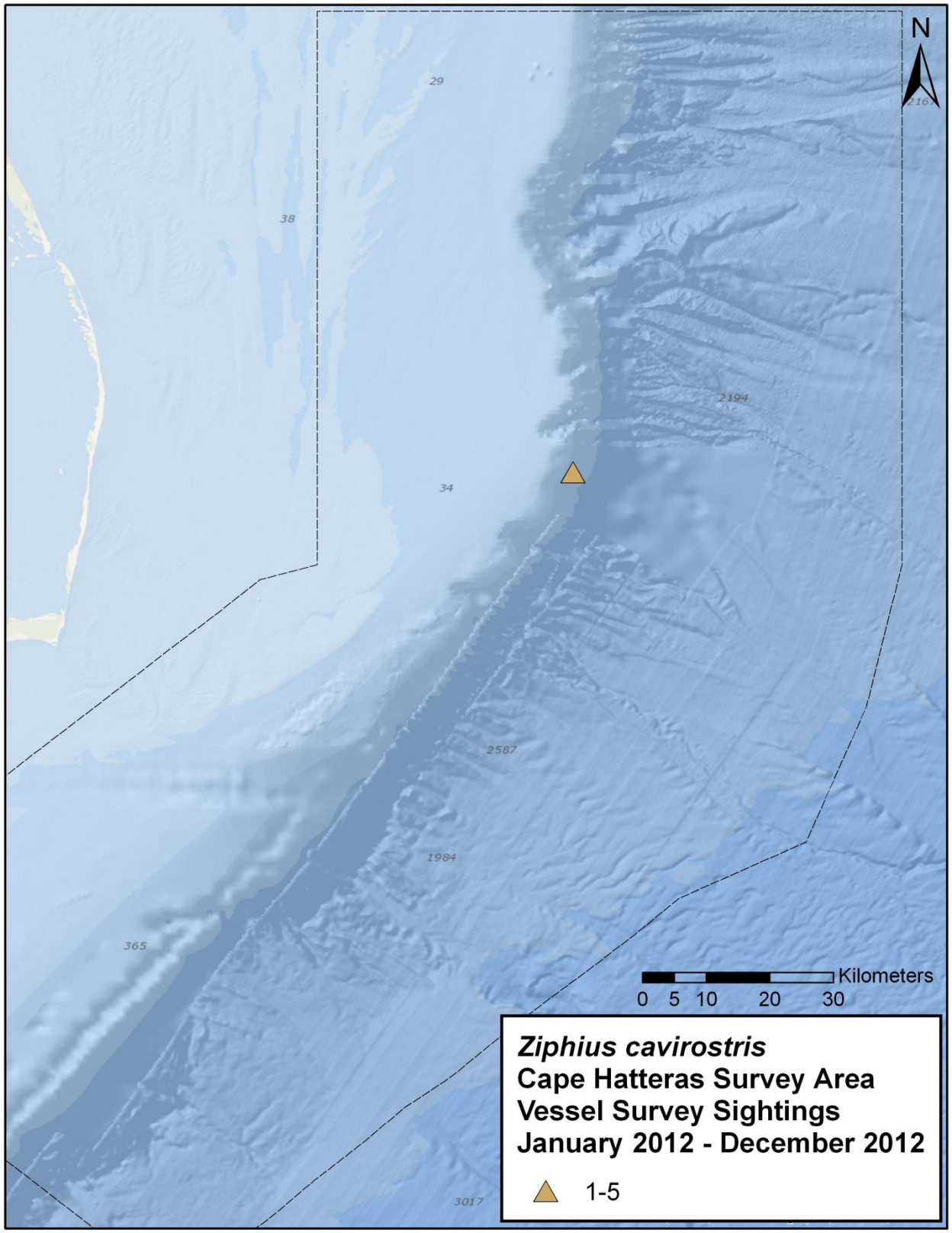

Figure 14. Distribution of Cuvier's beaked whale sightings indicating group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

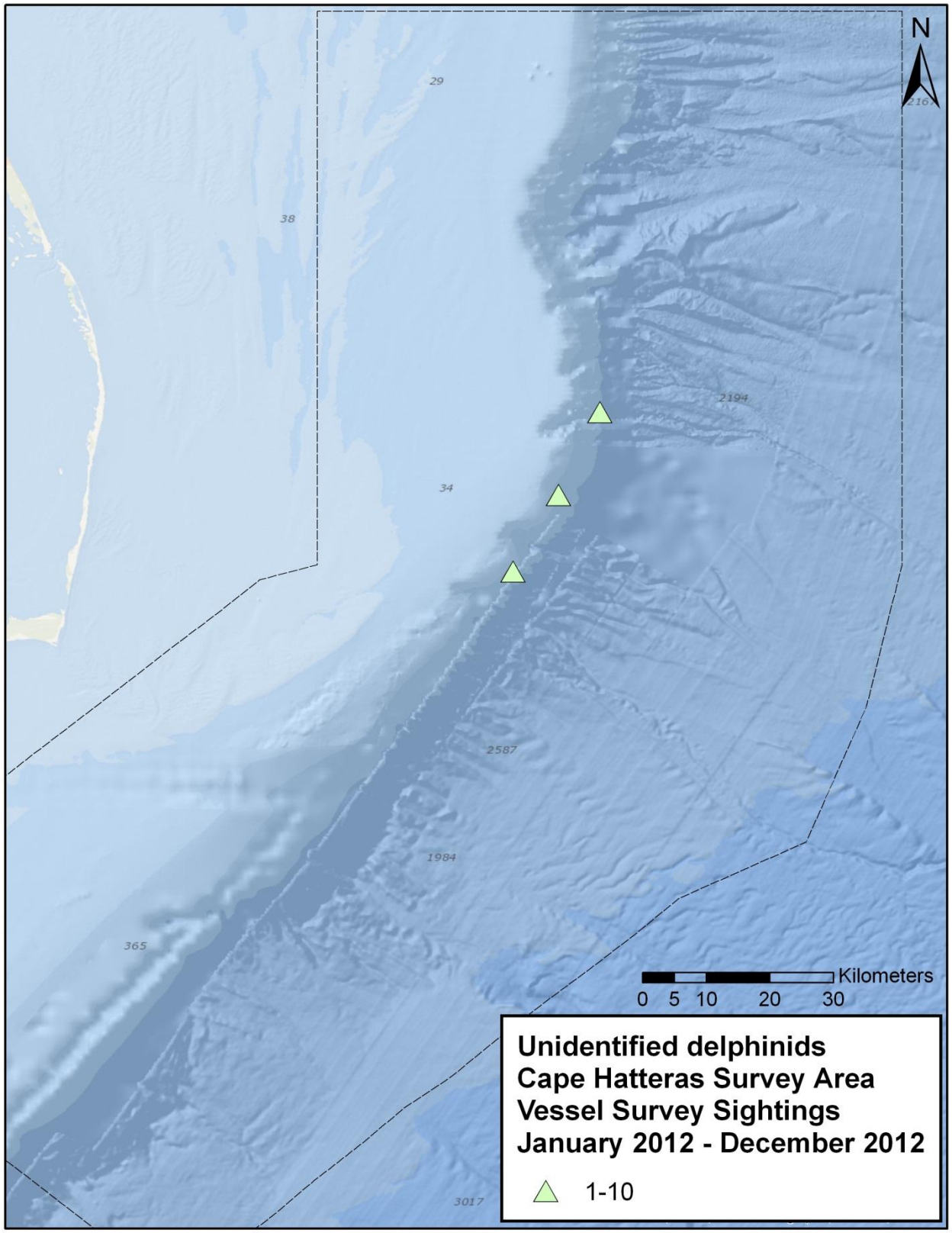

Figure 15. Distribution of unidentified delphinid sightings indication group size observed during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

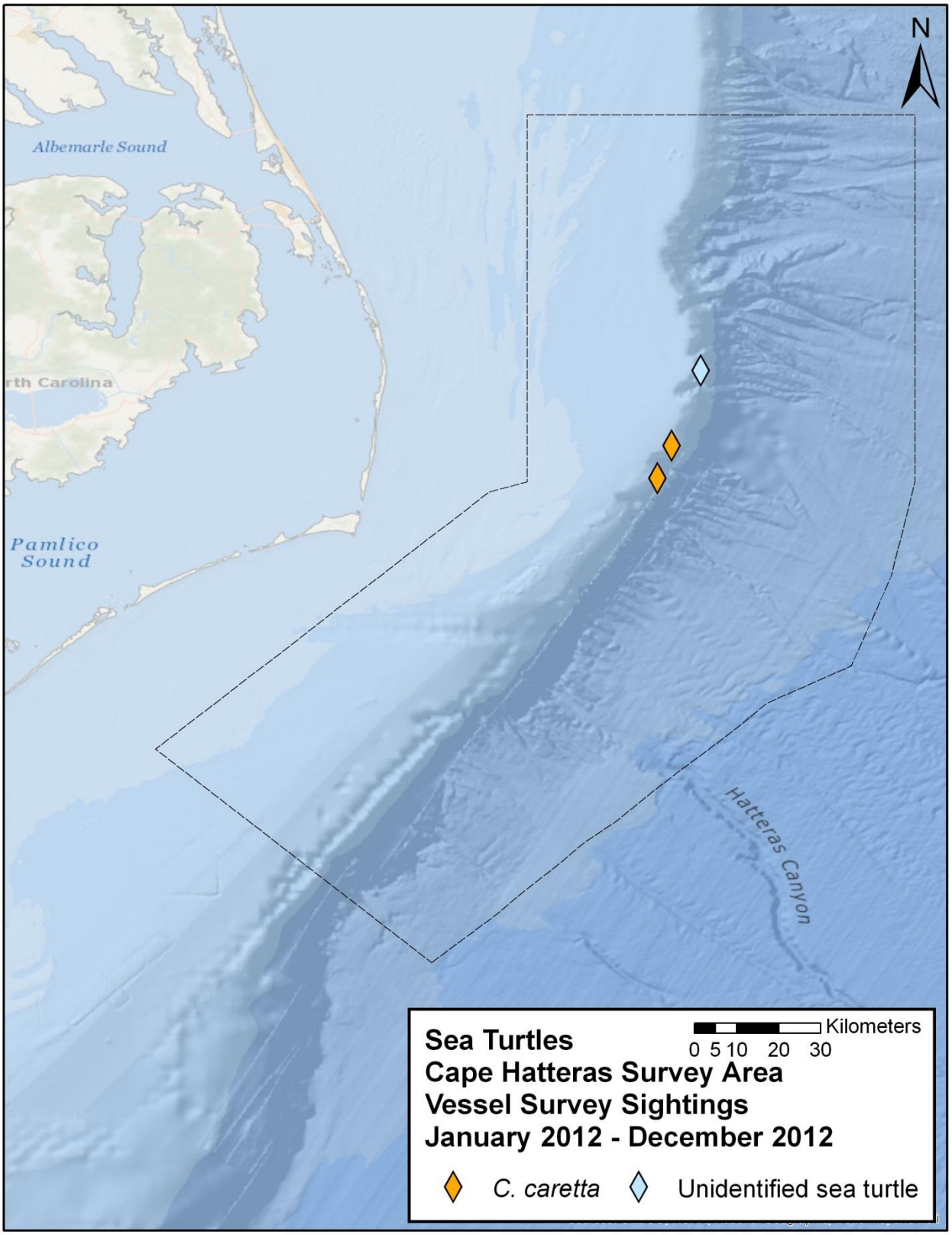

Figure 16. Distribution of sea turtle sightings made during vessel surveys in the Cape Hatteras survey area, January 2012 - December 2012.

Seasonality of Effort and Sightings

Pilot whales and bottlenose dolphins were the cetacean species most frequently observed off Cape Hatteras and were recorded during six of the seven months surveyed in 2012 (Table 3, Figure 17). Pilot whales, bottlenose dolphins and Risso's dolphins have been observed in all three years of survey effort off Cape Hatteras (including the limited survey effort conducted in 2009). Common dolphins were the third most commonly observed cetacean in 2012 and occurred in large groups (Table 4), but were encountered on only two survey days in the spring (Figure 17). Sperm whales and Cuvier's beaked whales were seen in both 2011 and 2012, but only in winter months (Tables 3 and 4, Figure 17). Common dolphins, sperm whales, Atlantic spotted dolphins and Cuvier's beaked whales were recorded in both 2011 and 2012. Sightings of sea turtles observed in each month of survey effort are depicted in Figure 18.

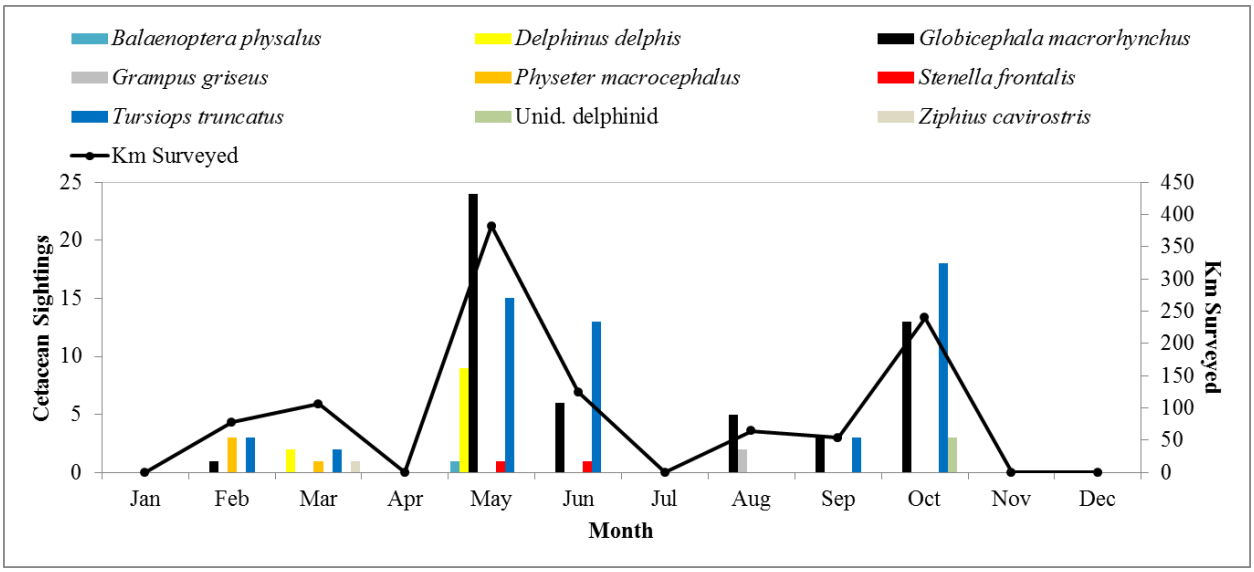

Figure 17. Number of cetacean sightings by month and effort (kilometers surveyed) for vessel surveys conducted in the Cape Hatteras survey area, January 2012 - December 2012.

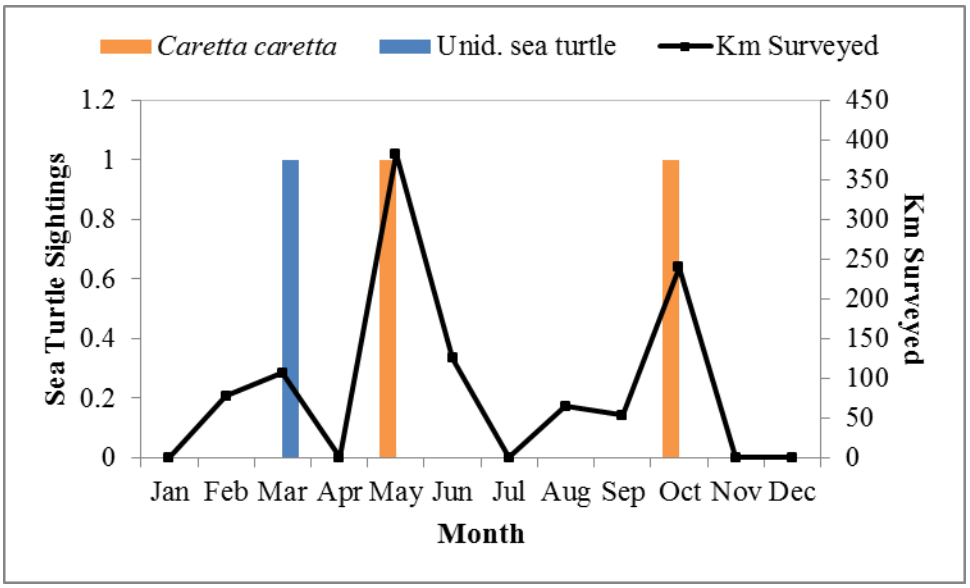

Figure 18. Number of sea turtle sightings by month and effort (kilometers surveyed) for vessel surveys conducted in the Cape Hatteras survey area, January 2012 - December 2012.

Biopsy Sampling

A total of 48 biopsy samples were collected from common dolphins (n = 5), pilot whales (n = 33), and bottlenose dolphins (n = 10) during vessel surveys in the Cape Hatteras survey area in 2012 (Table 7, Figure 19). Skin samples will be analyzed for sex, population structure and ecotype (for bottlenose dolphins) in the coming months. Voucher specimens of these samples will be archived with the Southeast Fisheries Science Center in Lafayette, LA.

Table 7. Biopsy samples collected in the Cape Hatteras survey area, January 2012 – December 2012.

Date	Time	Latitude	Longitude	Species	Sample #
27-Feb-12	9:07	35.32565	-74.95434	*T. truncatus*	ZTS-12-017
15-Mar-12	11:43	35.60738	-74.78570	*T. truncatus*	ZTS-12-018
15-Mar-12	11:55	35.59564	-74.78589	*T. truncatus*	ZTS-12-019
3-May-12	16:29	35.52964	-74.79842	*T. truncatus*	ASF-12-001
3-May-12	15:55	35.51199	-74.80915	*T. truncatus*	AJR-12-001
4-May-12	10:48	35.80625	-74.82287	*G. macrorhynchus*	DMW-12-003
4-May-12	10:56	35.80745	-74.82513	*G. macrorhynchus*	AJR-12-002
4-May-12	9:56	35.73668	-74.80759	*T. truncatus*	ASF-12-005
4-May-12	9:57	35.73619	-74.80826	*T. truncatus*	ASF-12-006
4-May-12	10:23	35.71665	-74.81758	*T. truncatus*	DWJ-12-005
4-May-12	10:42	35.71770	-74.82387	*T. truncatus*	DWJ-12-006
4-May-12	13:18	35.88414	-74.80476	*G. macrorhynchus*	ASF-12-007
4-May-12	13:21	35.88541	-74.80557	*G. macrorhynchus*	ASF-12-008
4-May-12	13:43	35.88314	-74.76342	*D. delphis*	DWJ-12-007
4-May-12	6:40	35.76007	-74.79821	*G. macrorhynchus*	DWJ-12-001
4-May-12	8:03	35.78338	-74.79190	*G. macrorhynchus*	DWJ-12-002
4-May-12	8:33	35.77425	-74.79953	*G. macrorhynchus*	ASF-12-002
4-May-12	8:35	35.77460	-74.79988	*G. macrorhynchus*	ASF-12-003
4-May-12	9:07	35.77925	-74.81310	*G. macrorhynchus*	DWJ-12-003
4-May-12	9:11	35.78006	-74.81227	*G. macrorhynchus*	DWJ-12-004
12-May-12	11:31	35.81242	-74.83441	*D. delphis*	DWJ-12-010
12-May-12	11:36	35.81386	-74.83308	*D. delphis*	DWJ-12-011
12-May-12	15:45	35.82757	-74.85163	*D. delphis*	DWJ-12-012
12-May-12	15:48	35.82890	-74.84965	*D. delphis*	DWJ-12-013
12-May-12	15:56	35.82943	-74.84890	*G. macrorhynchus*	ASF-12-012
12-May-12	15:59	35.82955	-74.84869	*G. macrorhynchus*	ASF-12-013
12-May-12	16:23	35.82953	-74.85886	*G. macrorhynchus*	DWJ-12-014
12-May-12	16:29	35.82831	-74.85901	*G. macrorhynchus*	DWJ-12-015
12-May-12	16:53	35.83246	-74.85738	*G. macrorhynchus*	ASF-12-014
12-May-12	9:17	35.77638	-74.82158	*G. macrorhynchus*	ASF-12-009
12-May-12	9:26	35.78000	-74.82639	*G. macrorhynchus*	ASF-12-010
12-May-12	9:29	35.78094	-74.82723	*G. macrorhynchus*	ASF-12-011
12-May-12	9:52	35.79140	-74.81110	*G. macrorhynchus*	DWJ-12-008
12-May-12	9:54	35.79263	-74.81215	*G. macrorhynchus*	DWJ-12-009
12-May-12	13:02	35.81615	-74.85230	*G. macrorhynchus*	DMW-12-004
12-May-12	16:43	35.86056	-74.84271	*G. macrorhynchus*	ZTS-12-025
12-May-12	19:07	35.89589	-74.82608	*G. macrorhynchus*	HJF-12-011

Table 7 cont. Biopsy samples collected in the Cape Hatteras survey area, January 2012 – December 2012.

Date	Time	Latitude	Longitude	Species	Sample #
10-Jun-12	12:28	35.68119	-74.80234	*G. macrorhynchus*	ZTS-12-027
10-Jun-12	13:44	35.68210	-74.80244	*G. macrorhynchus*	ZTS-12-028
11-Jun-12	14:20	35.72237	-74.81664	*G. macrorhynchus*	HJF-12-012
11-Jun-12	14:45	35.72331	-74.81794	*G. macrorhynchus*	HJF-12-013
20-Jun-12	13:09	35.87769	-74.85482	*G. macrorhynchus*	ZTS-12-029
20-Jun-12	13:29	35.86564	-74.85274	*G. macrorhynchus*	ZTS-12-030
31-Aug-12	12:43	35.78429	-74.83548	*G. macrorhynchus*	DMW-12-011
2-Sep-12	8:13	35.78793	-74.88362	*T. truncatus*	ZTS-12-041
2-Sep-12	12:31	35.89796	-74.82880	*G. macrorhynchus*	ZTS-12-042
2-Sep-12	12:39	35.90362	-74.82632	*G. macrorhynchus*	ZTS-12-043
2-Sep-12	12:50	35.91158	-74.82343	*G. macrorhynchus*	ZTS-12-044

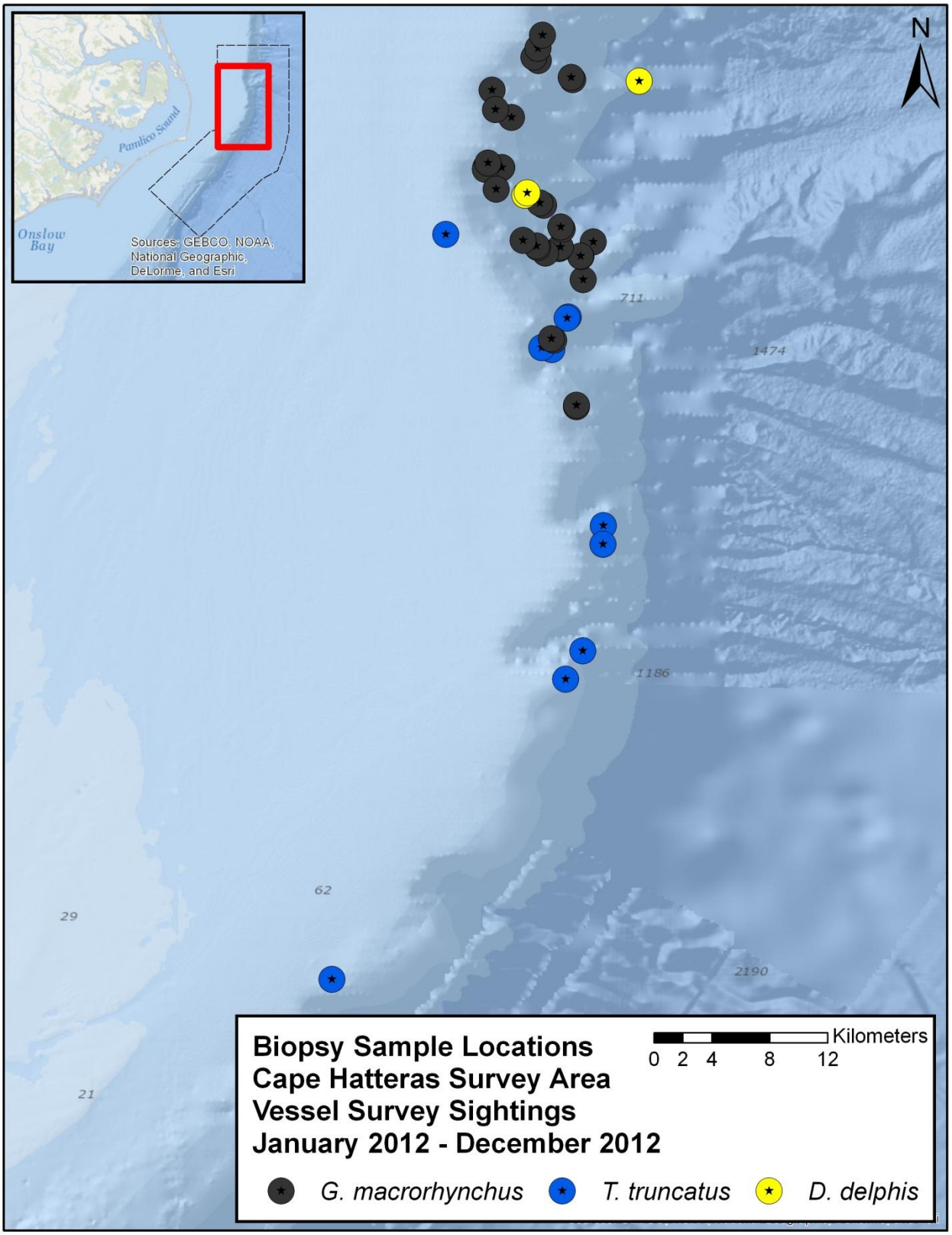

Figure 19. Locations of biopsy samples collected in the Cape Hatteras survey area, January 2012 – December 2012.

Photographic Effort

In total, 4111 digital images were taken during effort in the Cape Hatteras study area in 2012 for species identification and 2635 were analyzed for individual recognition (Table 8). Every attempt was made to photograph all animals encountered, both to validate species identification and to develop photo-identification catalogs for cetacean species in the Cape Hatteras survey area.

Images of newly identified dolphins were added to existing photo-identification catalogs in the Cape Hatteras survey area (Table 8). Photo-identification is now complete for all sightings made in February and March 2012. Although no matches were made in 2012, twenty-seven bottlenose dolphins were added to the catalog (Table 8). One sperm whale was matched to another individual photographed earlier on the same day.

One hundred seventeen short-finned pilot whales photographed in 2012 were compared to the existing Cape Hatteras catalog for this species (Table 8) and a number of these pilot whales were matched (Table 9, Figure 20). Pilot whale 7-019 was observed on 09 and 10 June 2012; this animal was first photographed on 04 September 2006. Gm-12-162a was also seen on 04 September 2006 and subsequently photographed and biopsied on 30 May 2008 before being photographed again on 09 and 10 June 2012. Genetic analysis determined that this individual was a male. Pilot whale 6-006 was photographed and biopsied on 24 August 2007 and photographed again on 11 June 2012; genetic analysis determined that this individual was also a male. Three pilot whales photographed in 2012 were tagged in 2011: 1-002 tagged on 27 May 2011; 7-009 tagged on 29 May 2011; and 6-001 tagged on 14 June 2011. All three of these

individuals were photographed on 12 May 2012. Our photo-identification results demonstrate that at least some of the short-fined pilot whales in this area are present over multiple years and may be resident to the area (Figure 20).

The catalogs of short-finned pilot whales in the Cape Hatteras (n = 136) and Onslow Bay (n = 16) survey areas were compared, but no matches were found between the two sites.

Table 8. Summary of photo-id effort and number of biopsy samples collected in the Cape Hatteras survey area, January 2012 – December 2012. Note that number of sightings reflects photo-ID analysis completed for sightings in 2012 only and not the total number of sightings from previous effort.

Species	Images	Sightings	Catalog Size (2009-2012)	Number of Matches (2009-2012)	Number of Biopsy Samples (2012)
Delphinus delphis	95	2	5	0	5
Globicephala macrorhynchus	2107	9	136	14	33
Grampus griseus	0	0	1	0	0
Physeter macrocephalus	163	4	1	1	0
Tursiops truncatus	270	28	78	0	10

Table 9. Photo-identification matches of short-finned pilot whales observed during focal follows in 2012 and during previous research effort in the CHSRA. Note that only images obtained from tagged or biopsied animals in previous years were compared to animals photographed in 2012.

Whale ID	2006	2007	2008	2010	2011	2012
1-002					X	X
6-001					X	X
6-006		X				X
7-009					X	X
7-019	X					X
Gm_12_162	X		X			X

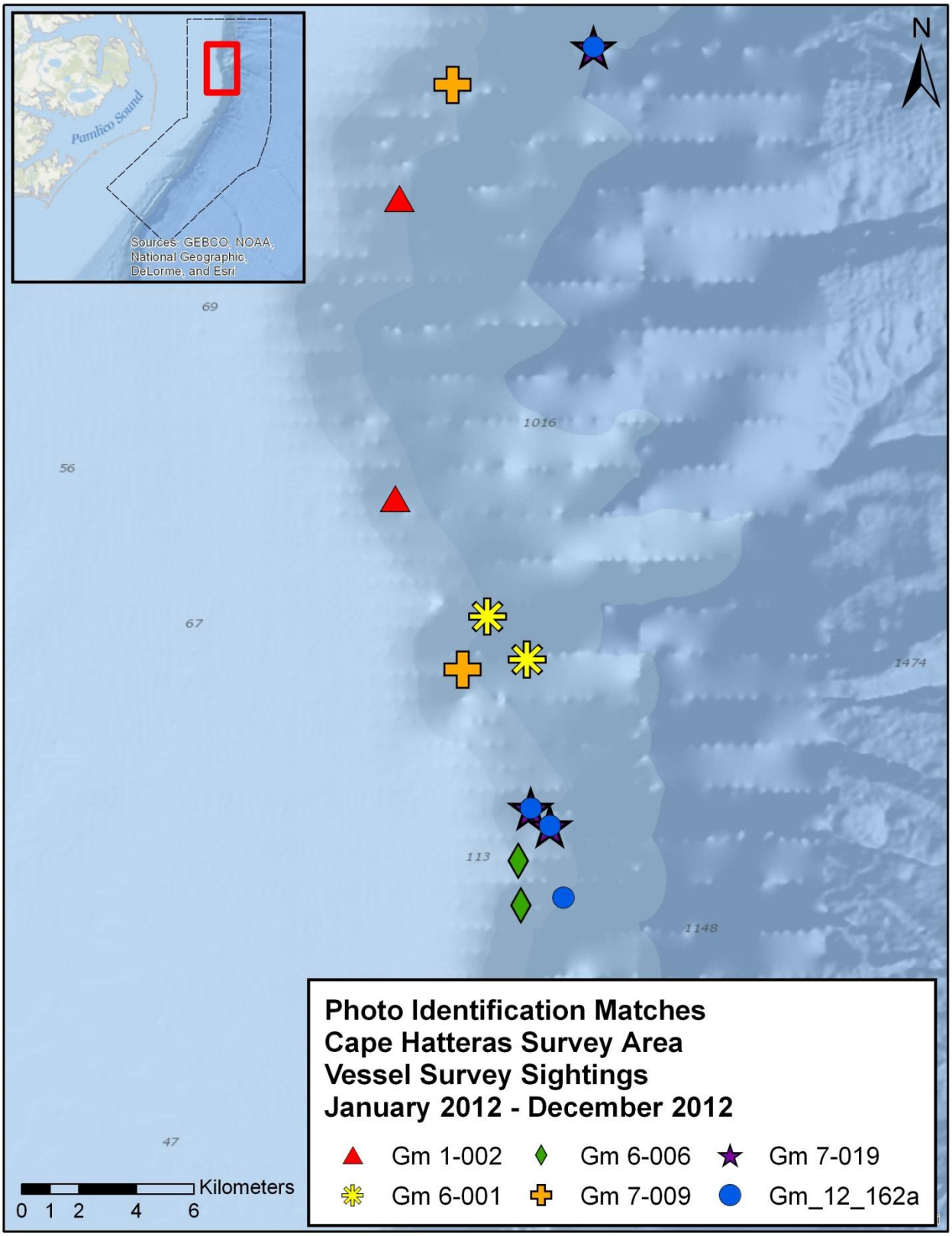

Figure 20. Photo-identification matches of short-finned pilot whales observed in the Cape Hatteras survey area.

Passive Acoustic Monitoring

Towed Array Analysis

Acoustic surveys were conducted during three days of vessel surveys in the Cape Hatteras study area, resulting in 33.8 hours of recordings between 09 October 2012 and 11 October 2012. Whistles were detected during 23.2 hours, making up 68.5% of the total recording time. Clicks were detected during 19 hours, making up 56.2% of the total recording time (Table 10). Species confirmation for these acoustic detections was not possible due to high sea states that prevented positive visual identification of the animals present in the area, but the species present and recorded included pilot whales and bottlenose dolphins. Additionally, there was a single acoustic detection of sperm whale clicks on 11 October 2012, from 11:41-12:00 EDT (Table 10).

Table 10. Summary of odontocete vocalizations detected in acoustic recordings collected during towed hydrophone array deployments in the Cape Hatteras study area, October 2012.

Species	Call type	Total detection duration (h)	Percent of total recording time
Unid. odontocete	Whistles	23.2	68.5
Unid. odontocete	Clicks	19.0	56.2
Physeter macrocephalus	Clicks	0.3	0.88

Seaglider Analysis

During a two-day deployment from 09-10 October 2012, approximately 18 hours of passive acoustic recordings were collected by the autonomous glider. After removing periods that were unusable due to internal glider noise, which made up approximately 10% of the total recording time, the remaining 16.6 hours were analyzed for cetacean vocalizations. Whistles were detected

during 12.9 hours, making up 78.6% of the total recording time. Clicks were detected during 8.0 hours, making up 48.8% of the total recording time (Table 11).

Table 11. Summary of odontocete vocalizations detected in acoustic recordings collected during an autonomous seaglider deployment in the Cape Hatteras study area, October 2012.

Species	Call type	Total detection duration (h)	Percent of total recording time
Unid. odontocete	Whistles	12.9	78.6
Unid. odontocete	Clicks	8.0	48.8
Unid. odontocete	All (whistles & clicks)	13.5	81.5

Harp Analysis

Underwater ambient noise during the 2012 Hatteras (Site A) HARP deployment is shown in Figure 21. Table 12 summarizes the detected and identified marine mammal vocalizations for this deployment. Figures 22-28 show the daily occurrence patterns for the different marine mammal groups (classified to species when possible).

Mysticete vocalizations detected during the deployment consisted of fin whale 20 Hz pulses and minke whale pulse trains. No blue, sei, humpback, or North Atlantic right whale vocalizations were identified. Fin whales were present in approximately half the recording days (Figure 22), based on occurrence of visibly distinct 20 Hz pulses. However, this represents a minimum estimate of fin whale vocal activity, since increased energy in the 20 Hz band was often observed, likely due to distant calling fin whales. Periods of increased energy without distinct pulses were not included in the fin whale occurrence summary and figures, but are reflected by a peak in ambient noise at 20 Hz (Figure 21). Minke whale pulse trains, including speed-up, slow-

down, and regular type pulse trains, were present in all recording days except for 11 April 2012 (Figure 23). Slow-down pulse trains occurred most frequently.

Detected odontocete vocalizations included clicks, whistles, and burst-pulses (Figures 24-28). Most of these detections were assigned to the unidentified odontocete category. These vocalizations were present nearly continuously throughout the deployment, and consisted of overlapping detections of multiple groups and species (Figure 24). Clicks produced by Kogia spp. were detected once during the deployment, on 27 March 2012 (Figure 25). Sperm whales were present throughout the deployment, with detections on all but two days (10 -11 April 2012) (Figure 26). Risso's dolphins were detected twice, on 16 March 2012 and 30 March 2012 (Figure 27). There were eleven detections of beaked whale clicks on separate days throughout the deployment (Figure 28), summarized in Table 13. Using custom *Matlab* scripts, spectral characteristics of clicks from these vocal events were measured and compared with known beaked whale species templates. Each vocal event was tentatively identified as either *Mesoplodon europaeus* (8 events) or *Ziphius cavirostris* (3 events).

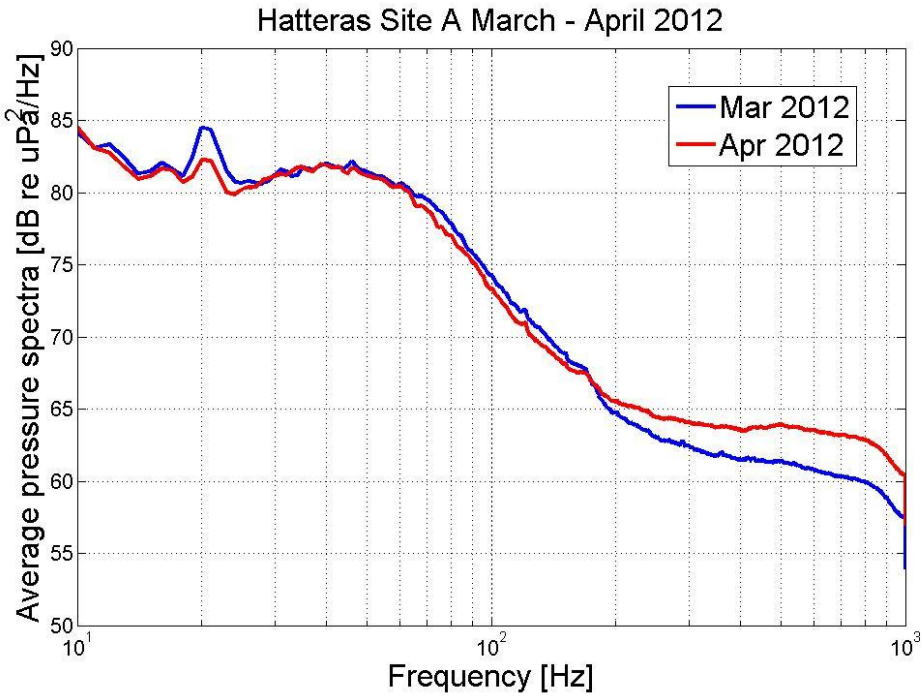

Figure 21. Monthly averages of ambient noise at Cape Hatteras Site A for March – April 2012.

Table 12. Summary of detections of marine mammal vocalizations at Site A for March – April 2012.

Species	**Call type**	**Total duration of vocalizations (hours)**	**Percent of recording duration**	**Days with vocalizations**	**Percent of recording days**
Fin whale	20 Hz	45.13	7.09	14	50.00
Minke whale	pulse train (slow-down, speed-up, regular)	51.5	8.10	27	96.43
Unidentified odontocete	clicks/whistles/ burst-pulses	491.57	77.20	28	100
Kogia spp.	clicks	0.1	0.02	1	3.57
Sperm whale	clicks	65.27	10.25	26	92.86
Risso's dolphins	clicks	2.47	0.39	2	7.14
Beaked whale spp.	clicks	1.77	0.28	11	39.29

Table 13. Summary of detected beaked whale click events, including duration of each event and tentative species identification based on spectral characteristics of clicks.

Date & Time (GMT)	Duration (h:min)	Tentative species ID
3/15/12 19:04	00:08	*M. europaeus*
3/18/12 17:38	00:04	*M. europaeus*
3/20/12 18:34	00:12	*M. europaeus*
3/21/12 18:45	00:18	*M. europaeus*
3/25/12 07:09	00:06	*M. europaeus*
3/27/12 09:57	00:11	*Z. cavirostris*
3/28/12 15:45	00:05	*M. europaeus*
3/30/12 11:06	00:06	*M. europaeus*
4/5/12 03:25	00:06	*Z. cavirostris*
4/6/12 08:00	00:08	*Z. cavirostris*
4/11/12 00:46	00:11	*M. europaeus*

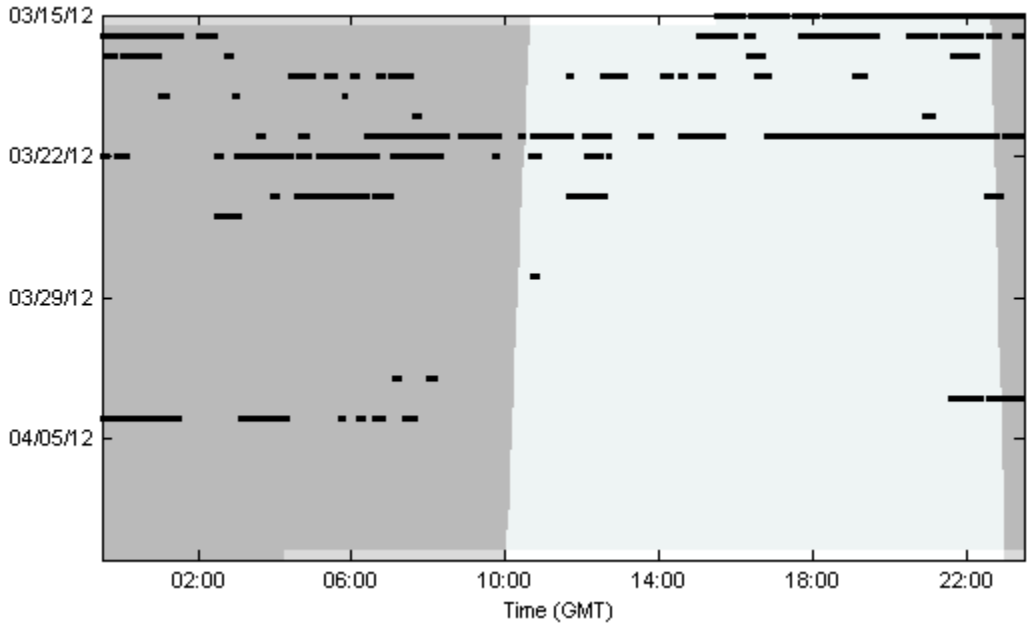

Figure 22. Fin whale 20 Hz pulse detections (black bars) for the 2012 Cape Hatteras Site A deployment. Shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

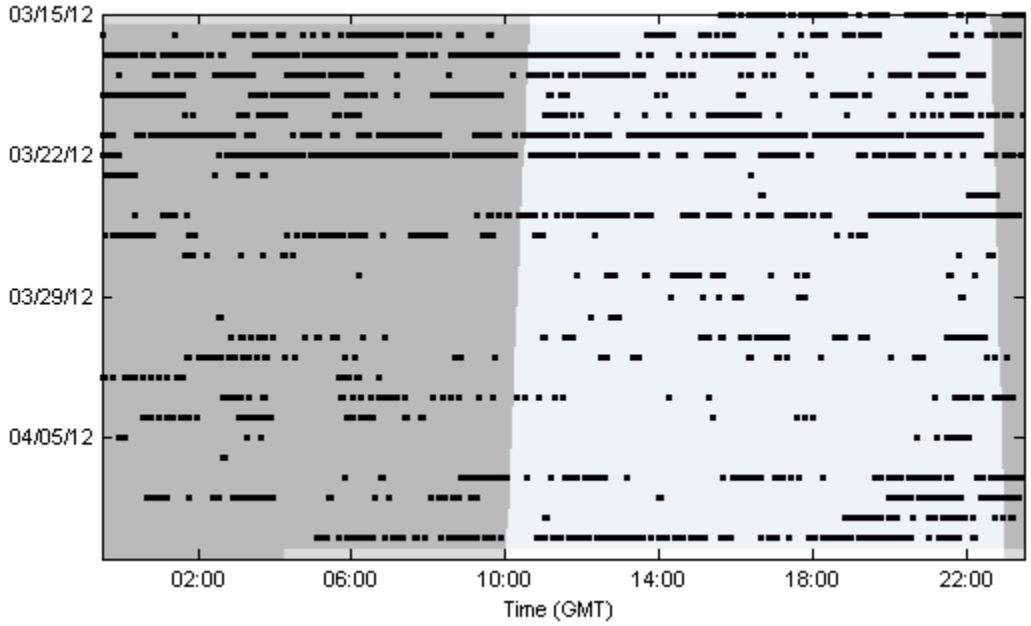

Figure 23. Minke whale pulse train detections (black bars) for the 2012 Cape Hatteras Site A deployment. Shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

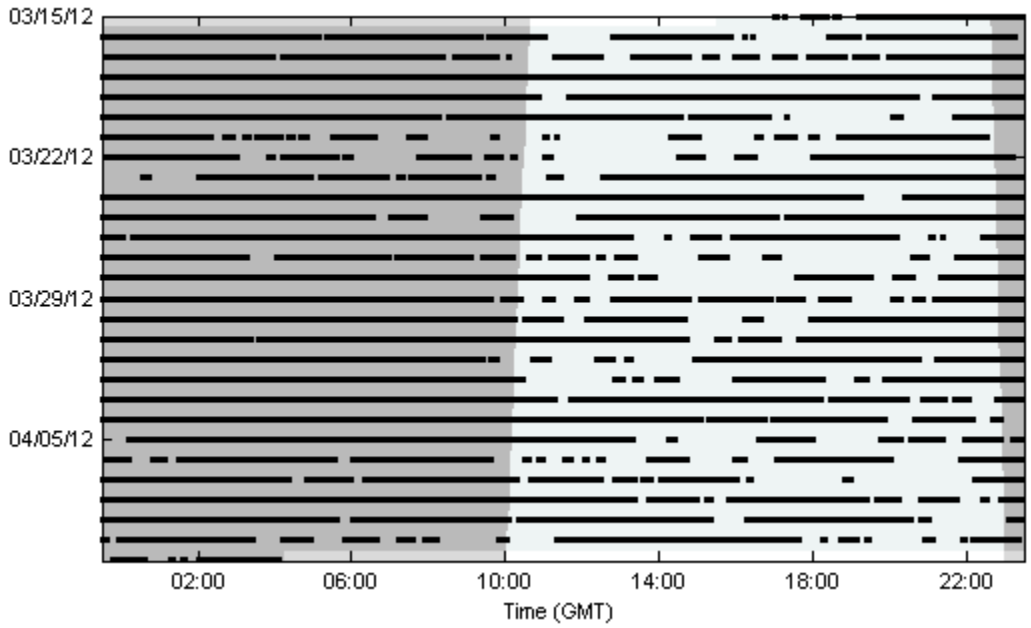

Figure 24. Unidentified odontocete vocalization detections (black bars) for the 2012 Cape Hatteras Site A deployment. Shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

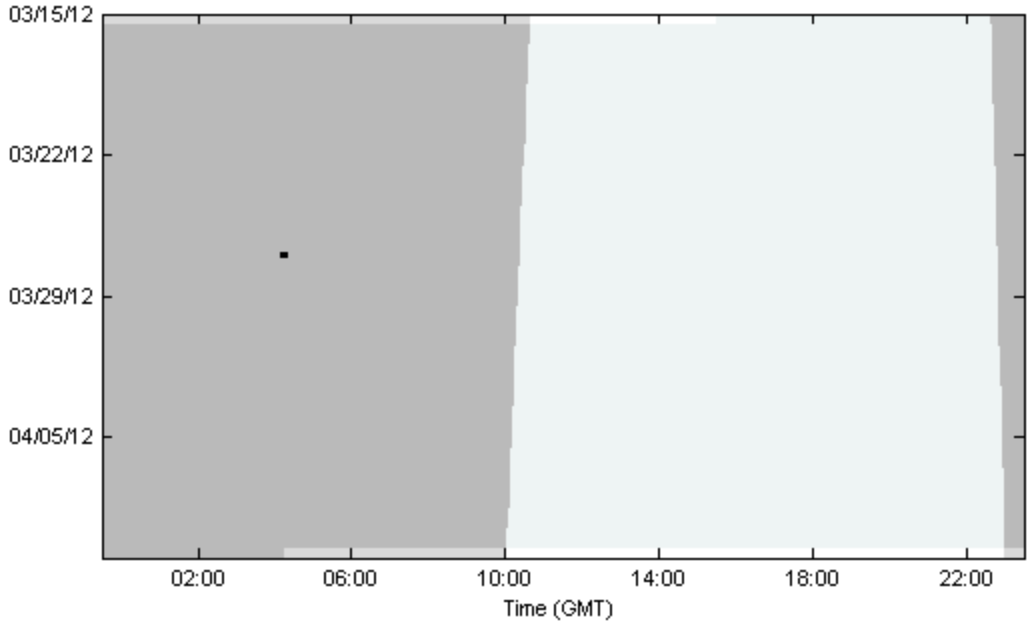

Figure 25. Kogia spp. click detections (black bars) for the 2012 Cape Hatteras Site A deployment. Shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

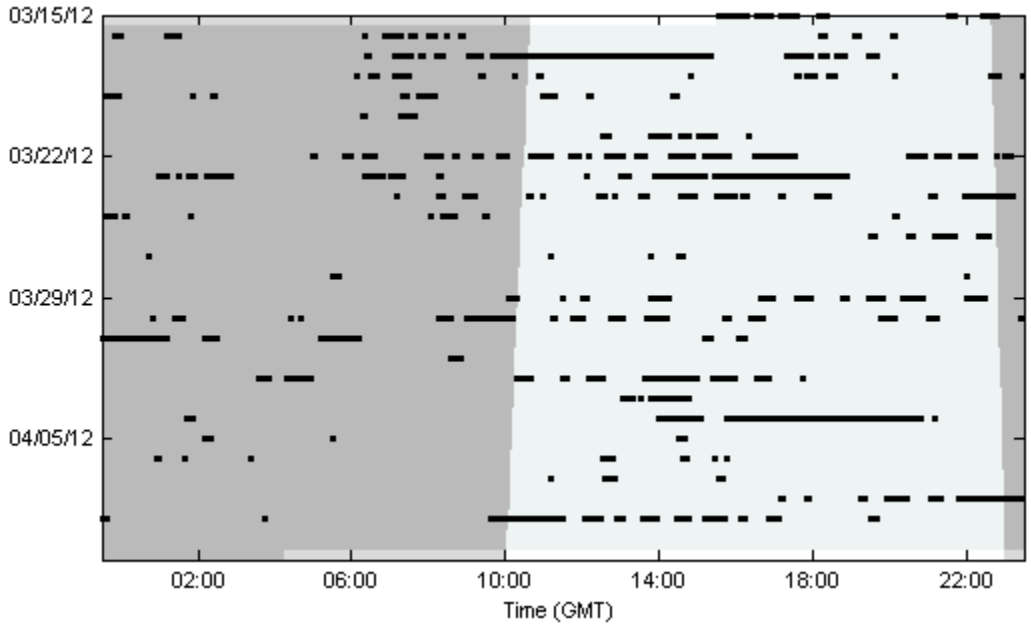

Figure 26. Sperm whale click detections (black bars) for the 2012 Cape Hatteras Site A deployment. Shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

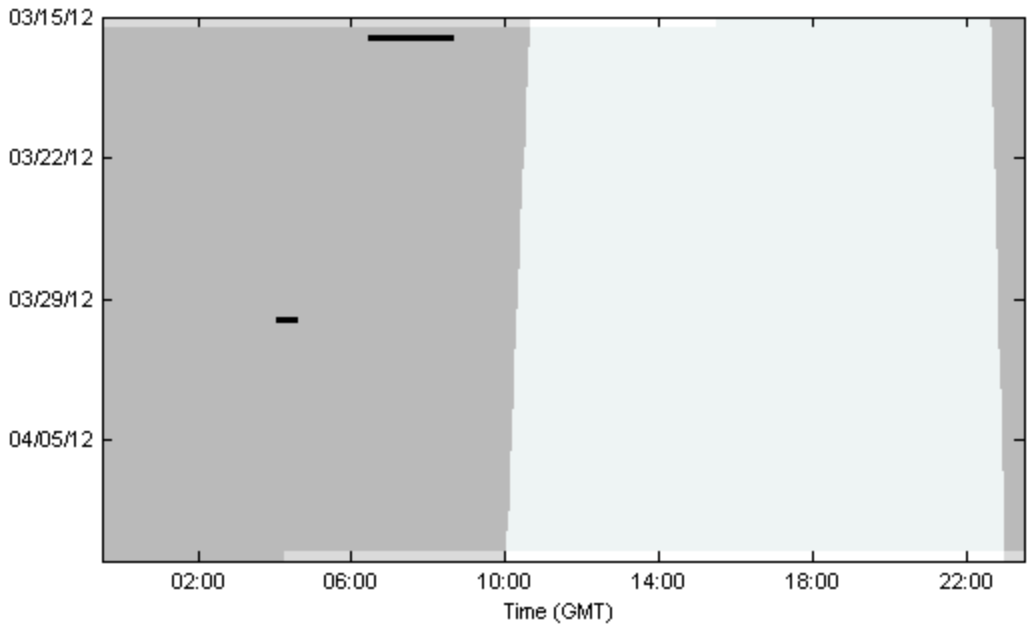

Figure 27. Risso's dolphin click detections (black bars) for the 2012 Cape Hatteras Site A deployment. Shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

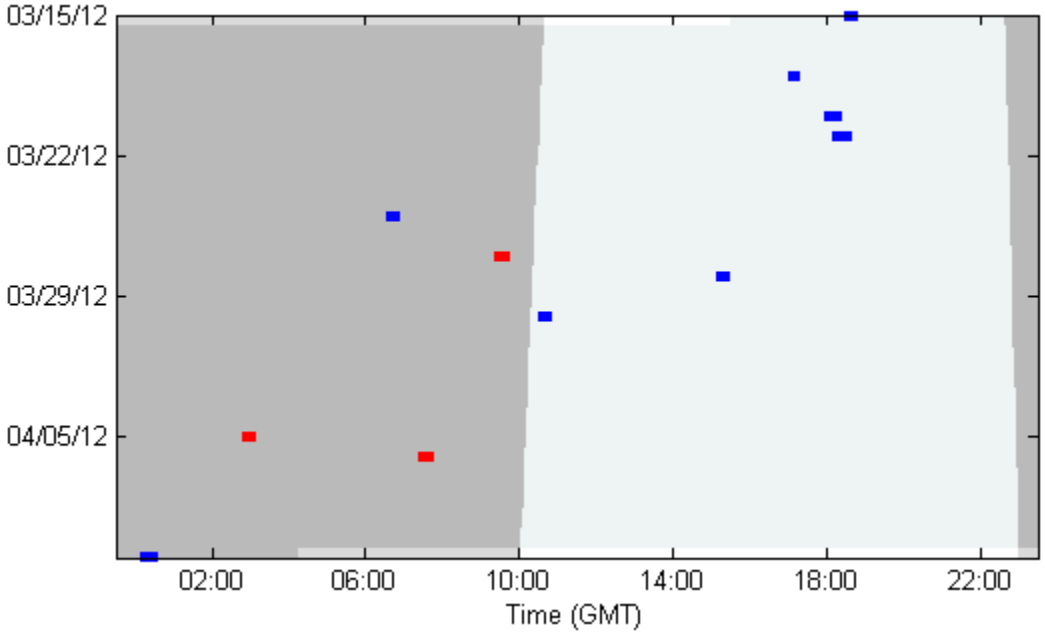

Figure 28. Beaked whale click detections for the 2012 Cape Hatteras Site A deployment. Colors indicate tentative species identification: *M. europaeus* (blue) and *Z. cavirostris* (red). Shading indicates periods of darkness, determined from the U.S. Naval Observatory (http://aa.usno.navy.mil).

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Literature Cited

Barlow, J. and R. Gisiner. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management, 7: 239-249.

Torres, L.G., Rosel, P.E., D'Agrosa, C. and Read, A.J. 2003. Improving management of overlapping bottlenose dolphin ecotypes through spatial analysis and genetics. Marine Mammal Science. 19(3):502-14.

Torres, L.G., McLellan, W.A., Meagher, E. and D. Ann Pabst. 2005. Seasonal distribution and relative abundance of bottlenose dolphins, *Tursiops truncatus*, along the US mid-Atlantic Coast. Journal of Cetacean Research and Management, 7(2): 153-161.

Welch, P.D. 1967. The use of fast Fourier transform for the estimation of power spectra: A method based on time averaging over short, modified periodograms: IEEE Transactions on Audio Electroacoustics, AU-15, pp. 70-73.

Wiggins, S.M. and J.A. Hildebrand. 2007. High-frequency Acoustic Recording Package (HARP) for broad-band, long-term marine mammal monitoring. International Symposium on Underwater Technology 2007 and Workshop on Scientific Use of Submarine Cables and Related Technologies 2007 (Institute of Electrical and Electronics Engineers, Tokyo, Japan), pp. 551-557.