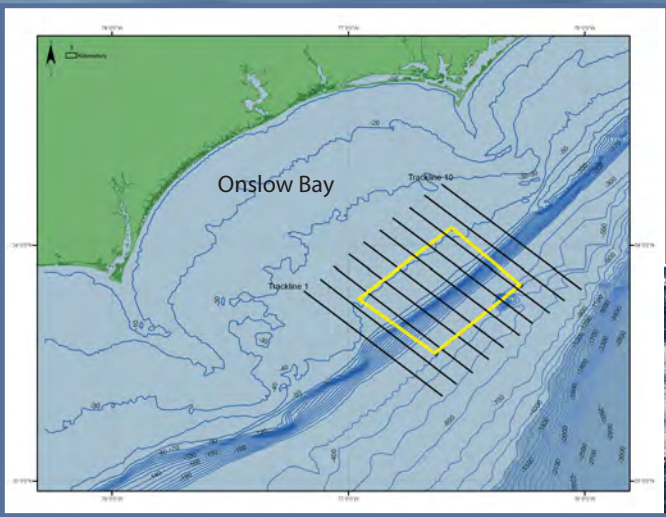
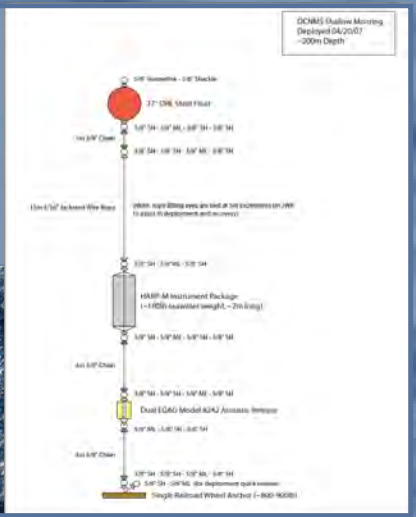
Protected Species Monitoring in the Proposed Undersea Warfare Training Range (USWTR) Onslow Bay, NC

Final Report, Year 1 (June 2007 -June 2008)

October 1, 2008





Executive Summary

This document comprises the first annual progress report to the Department of the Navy on a monitoring program for protected marine species at the proposed site of an Undersea Warfare Training Range (USWTR) in Onslow Bay, North Carolina. The report describes the results of a monitoring program that combines aerial surveys, vessel-based surveys, passive acoustic monitoring and density estimation. As a result of the first year of work, preliminary estimates of the density of marine mammals and sea turtles have been generated from the aerial and ship-based survey efforts. This monitoring program provides important baseline data that will help assess future variation in the density, abundance and distribution of marine mammals, sea turtles and seabirds over time. These baseline data includes species distribution, abundance, density estimates, and some information on seasonal movement and habitat usage patterns specific to Onslow Bay and the proposed USWTR area.

Study Area

The proposed USWTR area in Onslow Bay is 25 nm (46 km) long and 20 nm (37 km) wide. The survey area consisted of a box that extends 20 nm in each direction from the proposed USWTR itself. Ten 40-nm (74- km) long transect lines were established that crossed the survey area, oriented parallel to the short axis of the USWTR boundaries and perpendicular to the primary bathymetric and prevailing oceanographic features influencing the study area. The transect lines were spaced approximately 5 nm (9.3 km) apart. This design yields a total of 400 nm (~740 km) of track line available for surveys; all transect lines were surveyed by both aerial and shipboard platforms.

Aerial Surveys

Personnel from the University of North Carolina at Wilmington carried out aerial surveys of the proposed USWTR site in Onslow Bay. Monthly aerial surveys of designed track lines were flown between June 2007 and June 2008, with a total of 14,387 km surveyed. The goal was to survey the entire USWTR site twice per month. This goal was accomplished for all but four months. Due to inclement weather, in which conditions exceeded Beaufort Sea State (BSS) 3, no surveys were conducted in January 2008, one

survey was flown in December 2007 and February 2008, and 1.4 surveys were flown in March 2008.

Five cetacean species were observed, including: bottlenose dolphins (*Tursiops truncatus*; 33 sightings), spotted dolphins (*Stenella frontalis*; 11 sightings), rough-toothed dolphins (*Steno bredanensis*; 3 sightings), Risso's dolphins (*Grampus griseus*; 3 sightings) and short-finned pilot whales (*Globicephala macrorhynchus*; 3 sightings). In addition, 13 sightings were made of dolphins in which species identity could not be determined with certainty (*i.e*. either *T. truncatus or S. frontalis*, or unidentified delphinids). A total of 268 sea turtles were observed during the study period. Of these, 208 were identified as loggerhead sea turtles (*Caretta caretta*) and the remaining 60 recorded as "unidentified sea turtles". As demonstrated in other aerial survey studies, encounter rates dropped dramatically as BSS increased. In Onslow Bay, as BSS increased from 2 to 3, cetacean sightings decreased from 9.5 to 1.5 per 1000 km surveyed, whereas sea turtle sightings decreased from 36.8 to 8.9 per 1000 km surveyed.

Vessel-Based Surveys and Passive Acoustic Monitoring

Researchers from Duke University conducted vessel-based surveys and passive acoustic monitoring of the proposed USWTR site in Onslow Bay. Observers on surface vessels covered 31 tracklines in approximately 124 hours and 2,300 km of survey effort. Most surveys were conducted in summer; survey effort was limited during winter months due to poor weather conditions. Most (67.5%) survey effort was conducted in Beaufort Sea States 2 and 3. A total of 35 marine mammal sightings were made during vessel surveys (31 while on effort, four while off effort). Four species of cetaceans were observed, including: bottlenose dolphins (24 sightings), Atlantic spotted dolphins (5 sightings), pilot whales (1 sighting), Risso's dolphin (2 sightings). Three sightings of unidentified delphinids were also recorded. In general, bottlenose dolphins, pilot whales and Risso's dolphins were detected in deeper waters than spotted dolphins. No mixed-species groups were observed. Approximately 1000 digital images were taken for species identification and individual recognition purposes. These photographs were instrumental in confirming species identification of sightings made from the aerial platform.

During 13 surveys, a four-element hydrophone array was towed behind the survey vessel. Twelve groups of cetaceans (bottlenose dolphins and spotted dolphins) were detected by the array and also positively identified by the visual observers. These recordings will be used to help identify the species recorded on a bottom-mounted acoustic recording package (see below).

Six hundred seabirds were recorded in approximately 80 hours of dedicated observations between June 2007 and May 2008, yielding a sighting per unit effort (the number of seabirds recorded per hour of effort) between 2.9 and 18.3 per hour. Twenty species of seabird were recorded, with the greatest diversity observed during the month of October. Cory's (*Calonectris diomedea*) and Greater Shearwaters (*Puffinus gravis*) were the species sighted most frequently.

To monitor the occurrence of vocalizing marine mammals, a High Frequency Acoustic Recording Package (HARP) was deployed on two occasions, with the assistance of personnel from the Scripps Institution of Oceanography. The instrument was deployed, recovered and redeployed near the center of the USWTR area, close to the 200-m shelf break. In both deployments the instrument was programmed to record for five-minute periods separated by an inactive interval of five minutes and to record sound at a sample rate of 200 kHz. In an initial analysis of 3.5 months of data from the first HARP deployment, 520 marine mammal vocal events, one mid-frequency sonar event, four probable fish events, and 302 boat events were detected. Analysis of these recordings is ongoing, but at least one species, sperm whales (*Physeter macrocephalus*) was detected by the HARP but not by either the aerial or vessel-based surveys.

Density Estimation

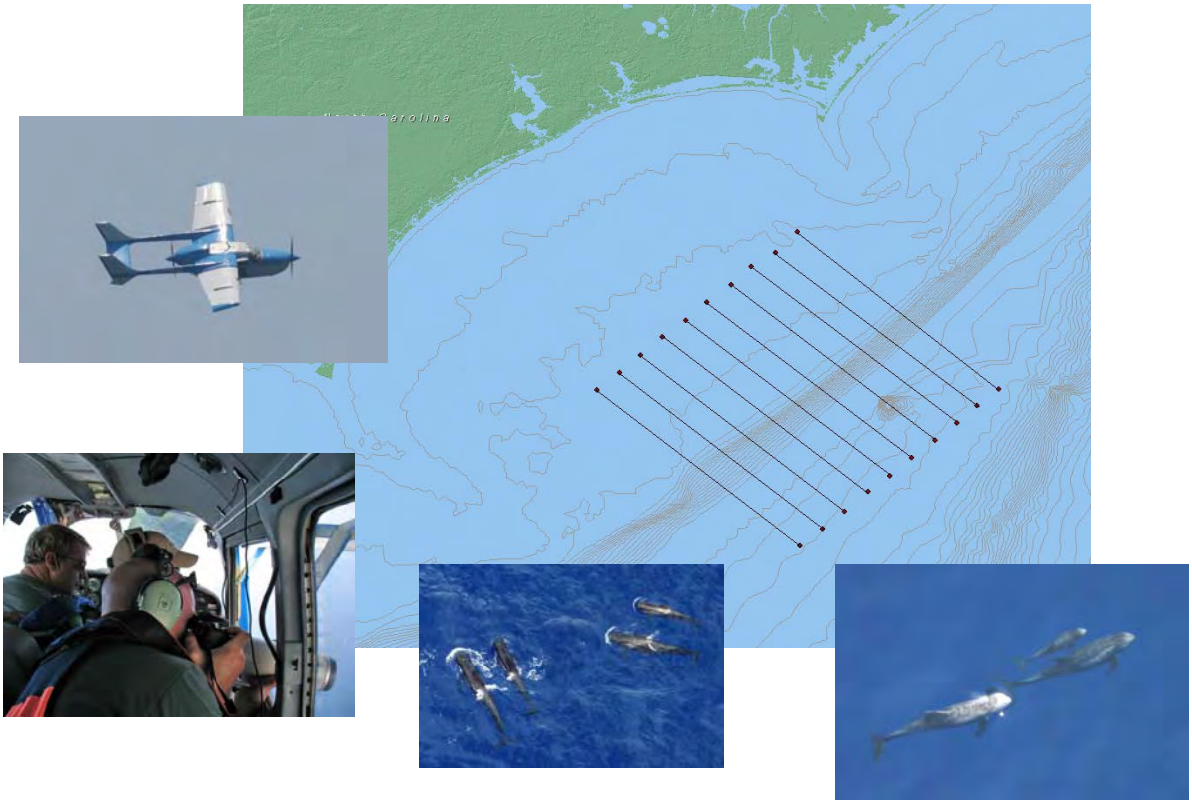
Scientists from the University of St. Andrews conducted analysis of the data from the combined aerial and shipboard surveys of the USWTR from June 2007 through June 2008, together with that of the previous aerial surveys of the UNCW for Onslow Bay conducted in1998/1999. This analysis allowed estimation of approximate surface population sizes of bottlenose dolphins, spotted dolphins, pilot and beaked whales combined, loggerhead turtles, as well as provided some insights into the environmental correlates of the distributions of these animals.

Abundance for the USWTR core region and a surrounding outer area was estimated by first fitting a detection function to the multi-platform survey data and then modelling the resultant estimated densities using a logistic general additive model. The estimated probability of presence was then multiplied by the estimated non-zero density to obtain an estimated overall abundance. Detection functions were not fitted to all of the sightings data owing to a paucity of data (shipboard whale sightings) or oddly distributed data (turtle sightings).

Estimates were made for the USWTR core region and the outer region for June 1998 (extrapolated), June 1999, June 2007 and June 2008 and for each month from July 2007 to June 2008. Estimated bottlenose dolphin numbers varied between 0 (95% CI: 0 – 0, August 2007) to approximately 320 (0 – 2160, January 2008) for the inner region and 0 (0 – 0, August 2007) to *circa* 1140 (930 – 4800, Jan 2008) for the outer region. Estimated spotted dolphin numbers varied from 0 (0 – 00 in 1998 to *circa* 10 (0 – 610) in 2007/2008 in the inner region and 0 (0 – 410, 1998) to 55 (10 – 1400, 2008) in the outer region. Pilot and beaked whale numbers were very low (< 10) throughout the survey period. Estimated loggerhead turtle numbers varied from *circa* 10 (10 – 40, August/September 2007) to 140 (100 – 270, March 2008) in the inner region and 20 (10 – 60, August 2007) to 330 (210 – 500, March 2008) for the outer region. All the above estimates assumed perfect detection on the trackline. There was no evidence of a systematic decline in any species in the last ten years. There was evidence that the abundance of bottlenose dolphins fluctuated with season (perhaps in response to temperature), as did the presence of loggerhead turtles. Spotted dolphins only appeared in the shallower parts of the region.

Given the relatively small number of sightings made during this first year of survey effort, conclusions about the estimated densities of marine mammals and sea turtles in Onslow Bay should be regarded as extremely tentative. Nonetheless it seems reasonable to conclude that the region as a whole has relatively few marine mammals and sea turtles (save perhaps loggerhead turtles). However, the results described here all assume that g(0) (detection probability) is 1.0 on the trackline. This is unlikely to be true, especially for smaller cetaceans, so these values likely underestimate the true abundance of these species in the region.

AERIAL SURVEYS OF THE PROPOSED UNDER SEA WARFARE TRAINING RANGE (USWTR) IN ONSLOW BAY, NORTH CAROLINA, JUNE 2007 TO JUNE 2008



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Executive Summary – Aerial Surveys

This document is an annual progress report to the U.S. Department of the Navy on aerial surveys conducted at the proposed Under Sea Warfare Training Range (USWTR) in Onslow Bay, North Carolina between June 2007 and June 2008. The aerial surveys were carried out by the University of North Carolina Wilmington. The goal was to survey the entire USWTR site twice per month. This goal was accomplished for all but three months. Due to inclement weather, where Beaufort Sea State (BSS) exceeded 3, no surveys were conducted in January 2008, one complete survey was flown in December 2007 and February 2008, and 1.4 surveys were flown in March 2008. A total of 853 cetaceans and 268 sea turtles were observed while on effort in the study area. No right whales (*Eubalena glacialis*) were observed within the site, nor were any other baleen whale species, pinniped or any other marine mammal or sea turtle listed as "Endangered" under the U.S. Endangered Species Act.

Five cetacean species were observed in the survey site including: bottlenose dolphins (*Tursiops truncatus*; 33 sightings of 459 individuals), spotted dolphins (*Stenella frontalis*; 11 sightings of 177 individuals), rough-toothed dolphins (*Steno bredanensis*; 3 sightings of 41 individuals), Risso's dolphins (*Grampus griseus*; 3 sightings of 19 individuals) and short-finned pilot whales (*Globicephala macrorhynchus*; 3 sightings of 53 individuals). In addition, 13 sightings of 104 individuals where species identity could not be established with 100% certainty (*i.e. Tursiops/S. frontalis* or "unidentified delphinids") were made. A total of 268 sea turtles were observed during the study period. Of these, 208 were identified as loggerhead sea turtles (*Caretta caretta*) and the remaining 60 labeled as "unidentified sea turtles". As previously demonstrated in other aerial survey studies, sightings drop off dramatically as the BSS increase. In the present study, as the BSS increased from 2 to 3, cetacean sightings decreased from 9.48 to 1.52 per 1000 km surveyed, whereas sea turtle sightings decreased from 36.8 to 8.9 per 1000 km surveyed.

In addition to cetaceans and sea turtles, several sightings were made of other pelagic marine vertebrates including manta rays, ocean sunfish and sharks. The majority of vessels encountered in the proposed USWTR range were recreational fishing vessels, which were predominately observed shoreward of the 100 fathom depth contour.

Methodology

Survey design and logistics

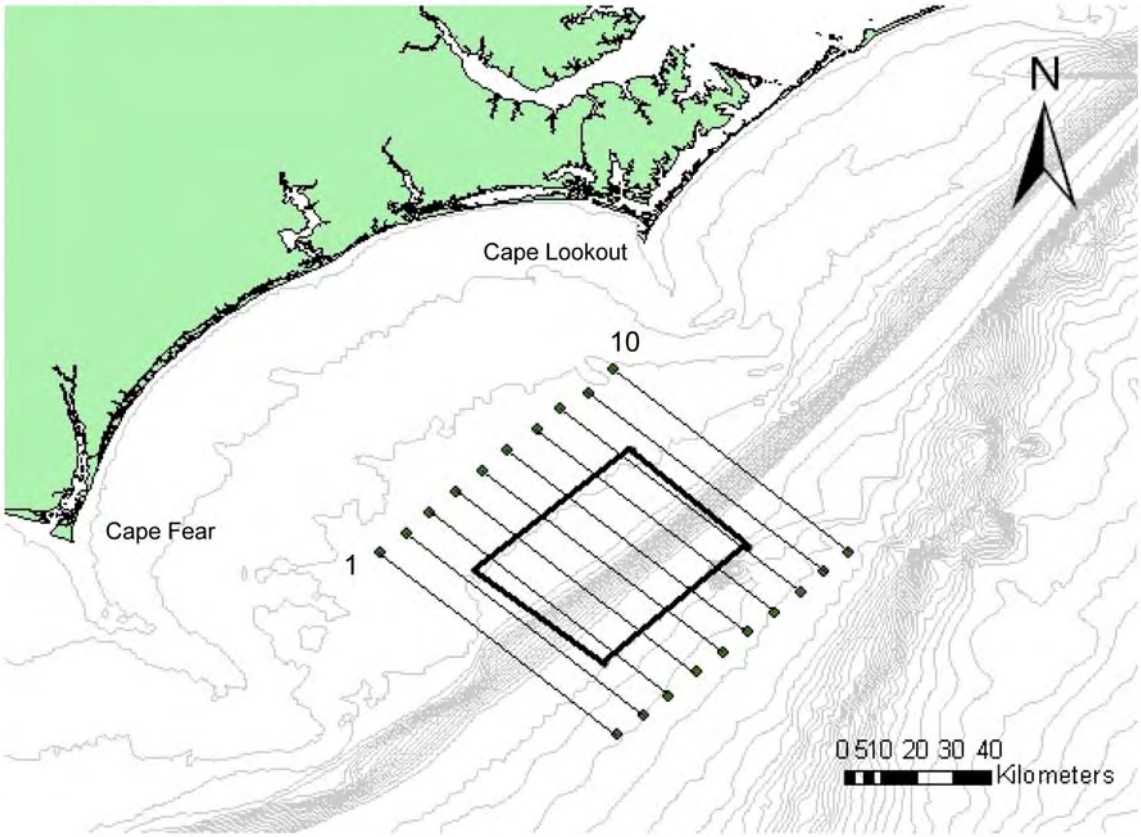
The University of North Carolina Wilmington (UNCW) provided experienced aerial observers and contracted Orion Aviation, Siler City, NC, to provide planes and certified pilots. Surveys were conducted using NOAA – SER Minimum Aircraft and Crew Provisions Guidelines, which require that aircraft are CFR Part 135 certified and that pilots have demonstrated experience working below 1000 ft in support of biological observational studies. Surveys were flown in a Cessna 337 Skymaster, at 305 m altitude and 185 km/hr speed, with a pilot, co-pilot and two observers. Each observer wore a Nomex ® fire retardant suit, a Switlik ® inflatable life jacket, a personal Emergency Positioning Beacon (EPIRB), as well as additional safety equipment. An inflatable life-raft, plane EPIRB, and satellite phone were also onboard at all times.

The survey consisted of ten 74 km long track lines spaced 6.5 km apart, which covered the proposed USWTR site and an 18 km boundary around the site in Onslow Bay (Fig. 1 and Table 1). The corners of the core USWTR site are: N34. 07°/W-76.56° (NW), N33.83°/ W-76.27° (NE), N33.54°/W-76.63° (SW), and N33.77°/W-76.95° (SE). Survey dates were chosen based upon weather and sea conditions, and access to restricted military areas within the site. Because the primary objective of the surveys was to locate and identify to species cetaceans and sea turtles, the sea state and consequent sighting conditions during surveys were key factors that dictated when to initiate and, if necessary, to abort, surveys. Low sea states (*i.e.* winds preferably 5 – 10 knots, but no more than 15 knots and seas maximum 4 feet) were selected to optimize sighting conditions. Sighting rates of small cetaceans drop off to near zero in a Beaufort Sea State (BSS) of 4 or higher, as demonstrated by several previous aerial survey studies (Gómez de Segura *et al*. 2006, DeMaster *et al.* 2001). Once an appropriate weather window was identified, observers from UNCW and Orion Aviation pilots would coordinate to meet at an FBO at the Wilmington, NC airport, from which all the surveys originated.

Table 1. Coordinates for track line end points of the Onslow Bay, NC survey site

	Western End Point		Eastern End Point	
Trackline	Latitude	Longitude	Latitude	Longitude
10	34.2724	-76.6104	33.8157	-76.0252
9	34.2119	-76.6721	33.7679	-76.0870
8	34.1723	-76.7431	33.7154	-76.1456
7	34.1198	-76.8017	33.6653	-76.2104
6	34.0673	-76.8726	33.6152	-76.2783
5	31.0148	-76.9342	33.5626	-76.3399
4	33.9671	-77.0020	33.5149	-76.4047
3	33.9146	-77.0666	33.4575	-76.4724
2	33.8620	-77.1249	33.4074	-76.5370
1	33.8119	-77.1926	33.3596	-76.6017

Figure 1. Survey track lines 1-10 that cover and extend beyond the boundaries of the proposed USWTR site in Onslow Bay, NC.



Data collection

Each side of the plane was monitored by one observer with his own GPS unit, data sheet (see Appendix A), voice recorder, and binoculars, and each was considered an independent strip transect. The start and end of transect lines, changes in environmental variables (*i.e*. cloud cover, BSS, visibility, and glare), and sightings of marine mammals, sea turtles and vessels in the survey area were recorded by each observer throughout the survey (see Appendix B for sighting codes). When a sighting cue was observed, horizontal and vertical angles between the plane and the sighting cue, as well as the break track way point, were recorded. After breaking track, the plane would close on the sighting location and circle above the animal(s) to obtain photographic evidence of species. Initial and final locations of the sighting were recorded so that the distance of the initial sighting from the track line, and any general movements of animal(s), could be calculated. During a marine mammal encounter, the observer on the left side of the plane was the designated data recorder and the right observer took digital photographs to confirm species identification. The cameras used were an F100 Nikon with an 80-400 mm vibration reduction lens, and a Canon 40D with a 100-400 mm image stabilizer lens. The minimum and maximum numbers of animals in each sighting were estimated by both observers in the field and recorded. After photographic and sighting data were collected, the plane returned to the original location on the track line and the survey continued. All data collected during a sighting were recorded on the Sighting Data Sheet (Appendix C).

The plane did not break track for sightings of sea turtles, other marine vertebrates (*e.g*. sharks and rays) or vessels, however, these types of sightings were all recorded and logged.

Data analysis

Upon completion of a daily survey, GPS way points were downloaded to a desktop computer utilizing the GPS Utility software program (GPS Utility Limited, UK) and subsequently transferred into Microsoft ® Excel spread sheets. Observational data (*e.g*. start and stop track line, sightings, and weather conditions) were entered manually into the spread sheet for each GPS way point. All digital images collected during a survey were also downloaded and separated into individual folders for each sighting that

day. The use of digital photography allowed for enlargement of images once in the lab, which enhanced the ability to identify animals to species. For each sighting, a group of best images was selected based on visible diagnostic features. These images were used in conjunction with the preliminary species identification (ID) made in the field, based upon appearance, group size and behavior, to determine species identity. Unless the species identity could be unequivocally established, the designation "unidentified delphinids" or *"Tursiops/Stenella frontalis"* were used. "Unidentified delphinids" was used when delphinids were observed but the species identity of the observed animals could not be established. Unidentifiable species were often the result of high BSS conditions where a clear set of images could not be obtained. *Tursiops/Stenella frontalis* was used when species ID could be narrowed to either of these two morphologically similar species, but exact species could not be diagnosed. Images obtained during a sighting were similarly employed to calculate group numbers, and a best estimate of group size was established based on field observations and images.

All cetaceans encountered during the first year were also reviewed for species ID during two joint meetings of the UNCW and Duke University Marine Lab (DUML) USWTR survey teams. The best images and field notes for each sighting were displayed in chronological order and each team member was asked to record their species ID and the diagnostic characters that they used to make that identification. Each sighting was then discussed to achieve a final species identification. This process allowed for a more rigorous analysis of each sighting and further development of our list of key diagnostic features for each species. If a consensus could not be reached by the group, or if the images did not allow for a species level identification, the sighting was given the label of unidentified delphinid or *Tursiops/Stenella frontalis*. A total of three cetacean sightings were recorded in which no images were collected; all these sightings were labeled unidentified delphinid.

Geographical Information System (GIS) maps of sightings of cetaceans, sea turtles, other marine vertebrates, and vessels within the survey area were created. Positional data were imported from Excel spread sheets into Arc GIS version 9.2 (ESRI®, Redlands, CA), and used to plot sightings.

The distances between the break track waypoint (2.0) and the initial position of each sighting (2.4) was calculated using the online software Scripts Movable Type (http://www.movable-type.co.uk/scripts/latlong.html), which uses the Haversine formula to calculate distances between two geographical reference points. Since there is a bias in estimating the location of a group of mobile marine mammals from a fast moving airplane, the distances calculated between break track and sighting were rounded to 0.1 km. All data obtained during a marine mammal sighting (*e.g.* observational notes, group size, GPS coordinates and image numbers) were summarized in the Sighting Summary Sheet (See Appendices D and E for example and explanation). When all surveys for a month were completed, tables with sightings and effort (see Tables 2 and 3 for examples) were sent to DUML for inclusion in the monthly progress report compiled and sent by DUML to Geo-Marine Inc. (Plano, TX).

Off effort sightings (i.e. "10.0" and sightings made on effort transits to and from the range) were not included in spread sheets used for data analysis.

Table 2. Example of May effort table submitted to Duke University Marine Lab.

Date	Line	Sea State	Miles flown
25-May-08	10	3 to 4	40
25-May-08	9	3 to 4	40
25-May-08	8	3 to 4	40
25-May-08	7	3 to 4	40
25-May-08	6	3 to 4	40
25-May-08	5	3 to 4	40
26-May-08	1	2	40
26-May-08	2	2	40
26-May-08	3	2	40
26-May-08	4	2	40
26-May-08	5	2	40
26-May-08	6	2	40
26-May-08	10	2 to 3	40
26-May-08	9	3	40
26-May-08	8	3	40
26-May-08	7	2 to 3	40
27-May-08	1	2 to 3	40
27-May-08	2	2 to 3	40
27-May-08	3	2 to 3	40
27-May-08	4	2 to 3	40

Table 3. Sighting summary table of USWTR aerial surveys in Onslow Bay for May 2007.

Date	Time	On / Off Effort	Track Line	Latitude	Longitude	Observer	Species	Group Size	Notes
25-May-08	9:52	On Effort	10	34.084476	-76.366981	3	*Caretta caretta*	1	
25-May-08	11:13	On Effort	7	33.966150	-76.600401	3	Chondrichthyes	1	
26-May-08	9:05	On Effort	2	33.474283	-76.632099	3	*Tursiops truncauts*	13	Traveling in groups of 2 or 3
26-May-08	11:00	On Effort	6	33.635981	-76.309018	3	*Tursiops truncauts*	13	One mom / calf pair in group
26-May-08	11:23	On Effort	6	33.842253	-76.600234	3	*Tursiops truncauts*	23	One mom / calf pair in group
26-May-08	14:19	On Effort	10	34.214515	-76.514231	3	*Stenella frontalis*	11	Lots of tactile interactions
26-May-08	15:31	On Effort	8	33.821327	-76.276022	3	*Globicephala macrorhynchus*	9	Widely spaced group
26-May-08	16:06	On Effort	7	33.952922	-76.574205	4	*Tursiops truncauts*	6	Feeding on large school of fish
27-May-08	9:57	On Effort	2	33.515733	-76.689246	3	*Tursiops truncauts*	12	Animal traveling in two groups
27-May-08	10:41	On Effort	3	33.592923	-76.655650	4	*Globicephala macrorhynchus*	12	Two calves and one juvenile
27-May-08	11:13	On Effort	4	33.595927	-76.508913	3	*Grampus griseus*	5	Traveling slowly at the surface

Data storage

All data obtained during a flight (GPS coordinates, voice recordings, digital pictures) and transcribed notes (*e.g.* observations and sightings) are stored electronically in three separate places: on a networked computer hard drive (which is backed up twice a week), an external hard drive, and on separate CDRs or DVDs. Additionally, the original data sheets used in the plane [*i.e.* daily plane log (Appendix F), observer notes and sightings sheets] are stored in binders, as are electronically entered versions of the same and printed forms of all electronic files. All data are stored at UNCW. In addition, all survey data, once edited, are posted online to OBIS SEAMAP (http://seamap.env.duke.edu/).

Results

Two full sets of survey track lines were flown for all months from July 2007 to June 2008 except for December 2007 and February 2008 (10 lines or one full set each month), March 2008 (14 lines), and January (no surveys flown due to weather) for a total of 14,387 km (Table 4). In addition, a preliminary aerial survey consisting of two track lines was conducted in June 2007. Survey conditions ranged from a Beaufort Sea State (BSS) 1 to 4, with the majority of the surveys flown in a BSS 2 or 3 [BSS 1: 556 km (3.9%), BSS 2: 5096 km (35.4%), BSS 3: 6631 km (46.1 %), BSS 4: 2103 km (14.6%)(Fig. 2a – 2c)]. Effort was terminated at BSS greater than 4. The sighting rates dropped off dramatically as BSS increased, with 7 sightings made in a BSS 1 (12.6 sightings/1000 km flown), 49 in a BSS 2 (9.6 sightings/1000 km flown), 10 in a BSS 3 (1.51 sightings/1000 km flown) and zero sightings in a BSS 4 (Fig. 3a - c). The survey conducted on 24 June 2008 illustrates the influence of sea state on sighting rates. Six

lines flown in the morning in a BSS 3 yielded no sightings, whereas four lines flown in a BSS of 2 in the afternoon yielded eight cetacean sightings (Fig. 4).

Table 4. Track lines and km flown during aerial surveys of the proposed USWTR site in Onslow Bay, NC, between June 2007 and June 2008. Track line numbers listed in the order flown. *On March line 8 was flown both in the NW and the SE direction. June 6th, 2008 survey aborted due to low ceiling.

Date	Track Lines Flown (AM)	Track Lines Flown (PM)	Daily Total km flown
26-Jun-2007	10 and 9	none	147.5
17-Jul-2007	10 to 5	4 to 1	723.5
18-Jul-2007	5 to 10	4 to 1	740.0
6-Aug-2007	none	10 to 5	253.5
7-Aug-2007	1 to 6	7 to 10	740.4
8-Aug-2007	4 to 1	none	298.5
24-Sep-2007	1 to 6	10 to 7	743.2
25-Sep-2007	5 to 10	4 to 1	681.0
14-Oct-2007	1 to 6	7 to 10	743.5
15-Oct-2007	1 to 6	7 to 10	756.5
17-Nov-2007	4 and 3	2 and 1	299.5
18-Nov-2007	10 to 5	4 to 1	742.0
19-Nov-2007	10 to 5	none	447.5
12-Dec-2007	6 to 1	none	447.0
12-Dec-2007	10 to 7	none	297.0
25-Feb-2008	10 and 9	1 to 4	446.5
29-Feb-2008	5 to 8	none	294.0
11-Mar-2008	5 to 7	10 to 8*	521.0
13-Mar-2008	1 to 4	10 to 7	594.0
25-Apr-2008	10 to 5	4 to 1	735.0
26-Apr-2008	1 to 4	10 to 5	738.7
25-May-2008	10 to 5	none	448.4
26-May-2008	1 to 6	10 to 7	743.9
27-May-2008	1 to 4	none	295.5
6-Jun-2008	1/2 of 5	none	39.0
24-Jun-2008	5 to 10	4 to 1	738.7
25-Jun-2008	5 to 10	4 to 1	731.8

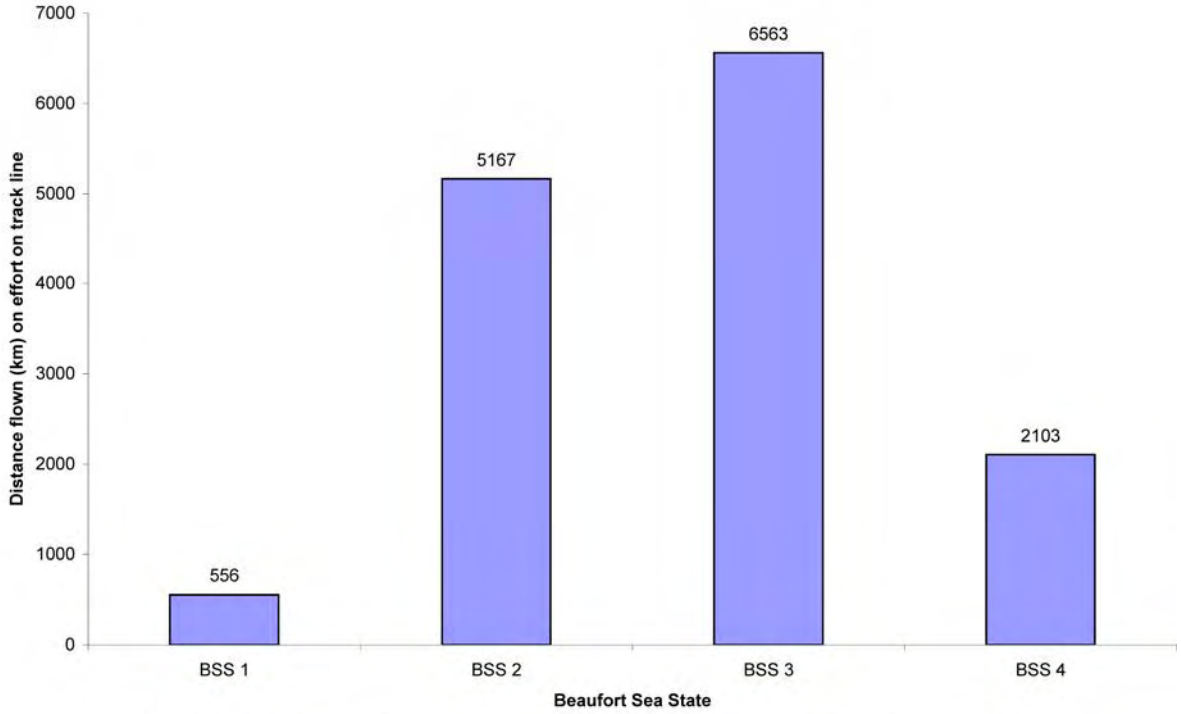


Figure 2a. Total distance surveyed per Beaufort Sea State during the June 2007 - June 2008 UNCW USWTR aerial surveys.

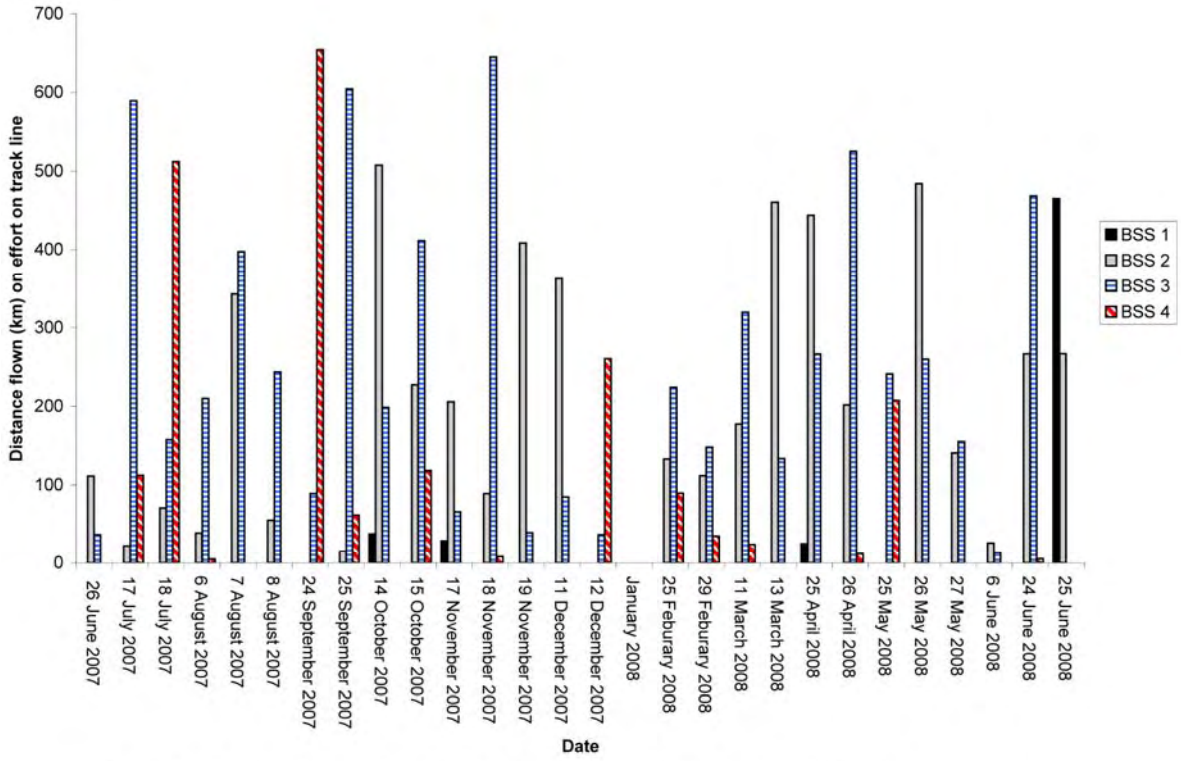


Figure 2b. Effort by Beaufort Sea State for each survey day during the June 2007 - June 2008 UNCW USWTR aerial surveys.

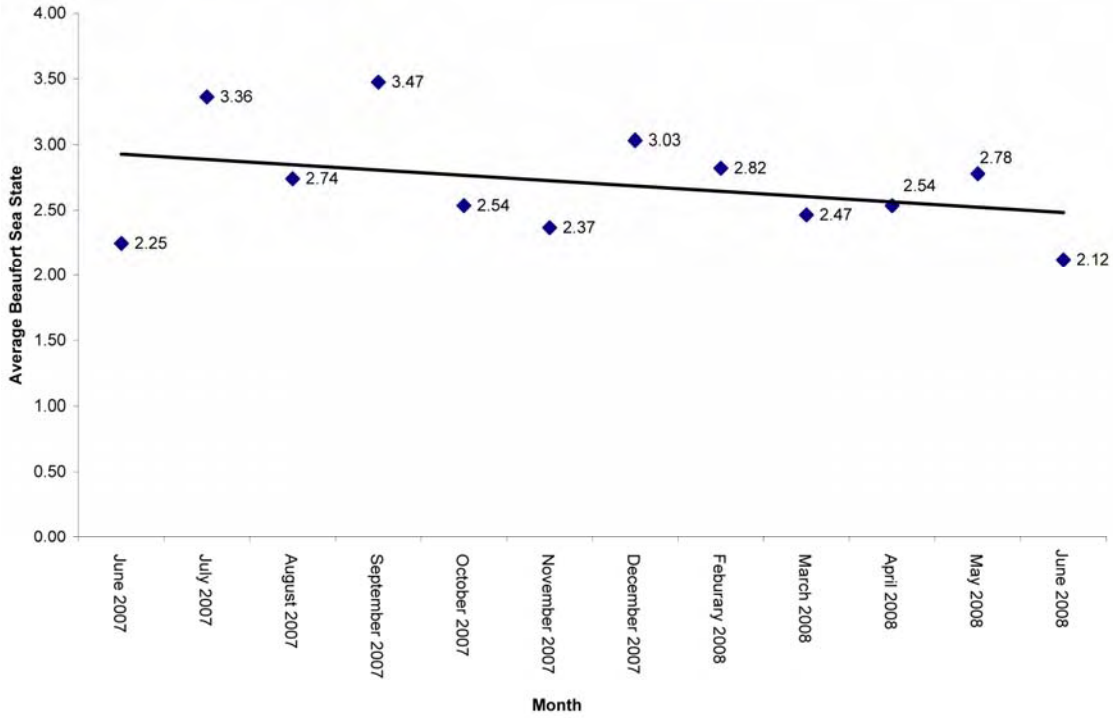


Figure 2c. Average Beaufort Sea State for each month during the June 2007 - June 2008 UNCW USWTR aerial survey in Onslow Bay, NC. Values were calculated using the formula AvgBSS = [(Time @ BSS1 * 1)+(Time @ BSS2 * 2)+……./Total time flown]

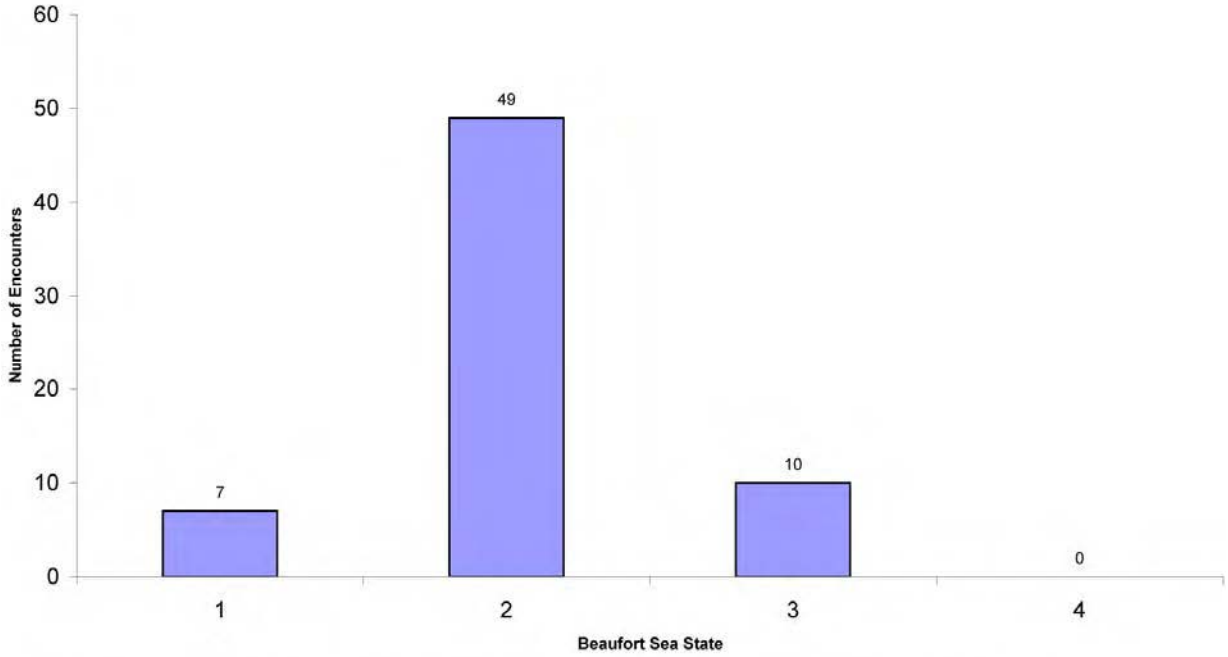


Figure 3a. Total number of cetacean sightings per Beaufort Sea State in the proposed USWR site in Onslow Bay, North Carolina from June 2007 - June 2008.

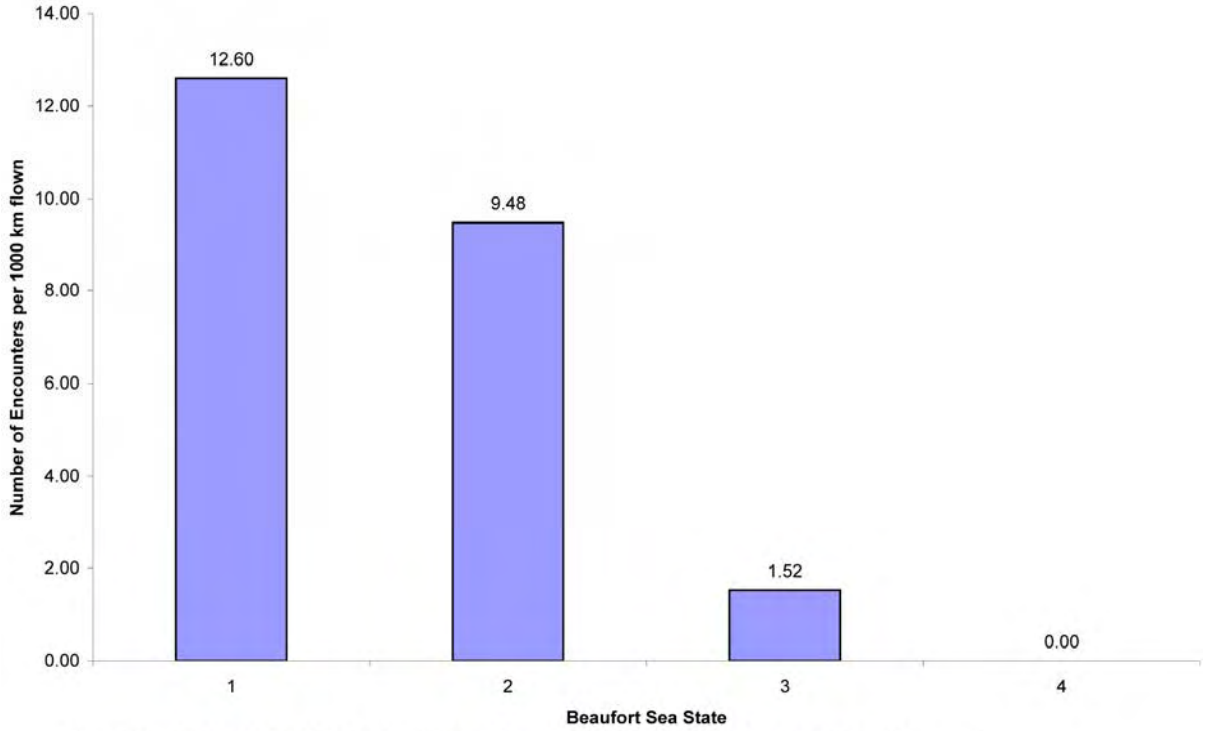


Figure 3b. Cetacean sightings per 1000 km flown by Beaufort sea state from June 2007 - June 2008 in the proposed USWTR site in Onslow Bay, North Carolina.

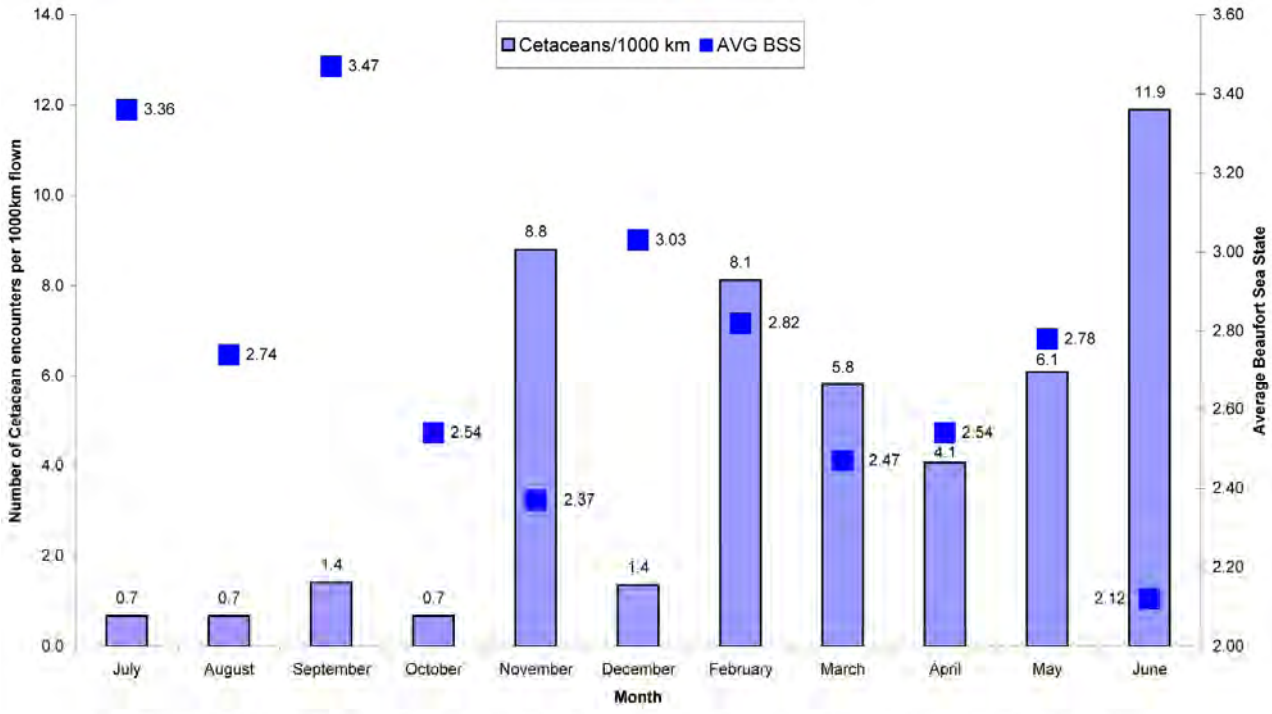


Figure 3c. Cetacean sightings per 1000 km surveyed and the average Beaufort Sea State per month.

The mean sighting distance for all cetacean sightings was 0.84 km (SD=0.69) and most sightings were made within 1.2 km of the plane (Fig.5a). The mean sighting distance tended to decrease as BSS increased (Fig. 5b). When plotting average sighting distances, outliers were removed from the data. An outlier was defined as a value in excess of more than three standard deviations from the mean. Three sighting distances which were considered outliers were removed from these calculations (i.e. sighting distances calculated at 3.7, 4.5, and 6.5 km from the trackline).

A reviewer suggested we perform a Hiby fly back or circle back, in which a single plane repeats a segment of track line already flown to obtain duplicate sightings to reduce the coefficient of variation of the results obtained (Hiby, 1999). On 11 March 2008 we performed a modified Hiby flyback in which track line 8 was initially flown west to east and then immediately flown in the east to west in its entirety. Sightings were similar between the initial and the return survey of track line 8 for fishes. Turtles were only observed on one leg (Fig. 6).

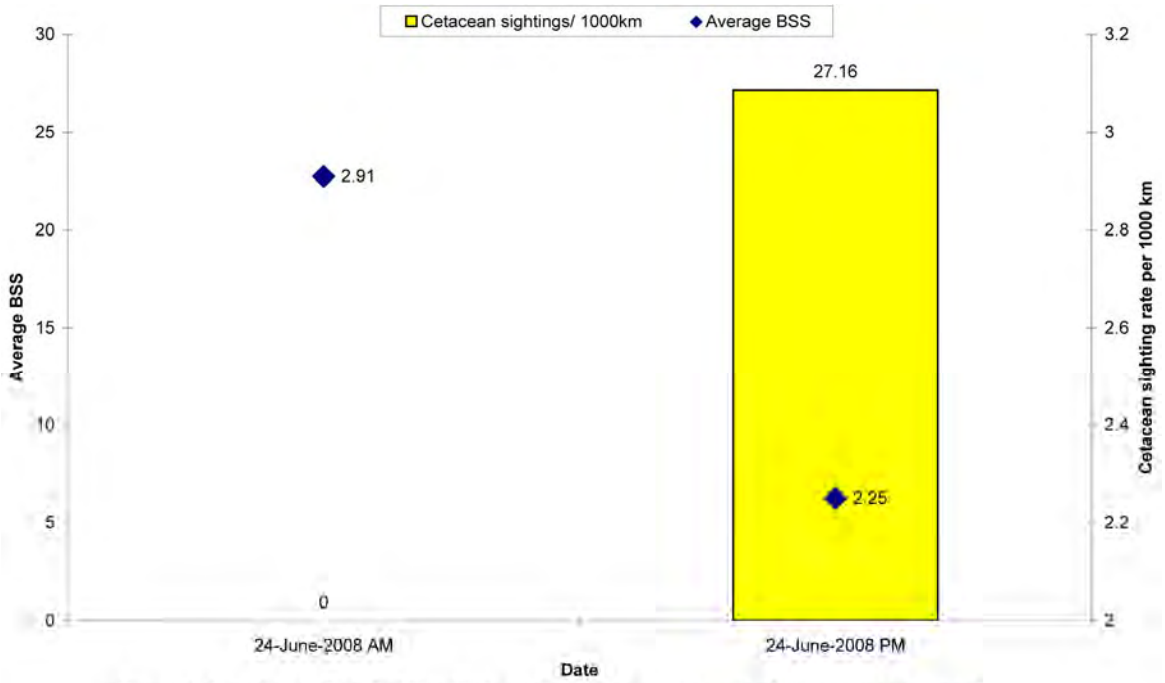


Figure 4. Variation in Beaufort Sea State and cetacean sighting rates between morning and afternoon flights on June 24 2008.

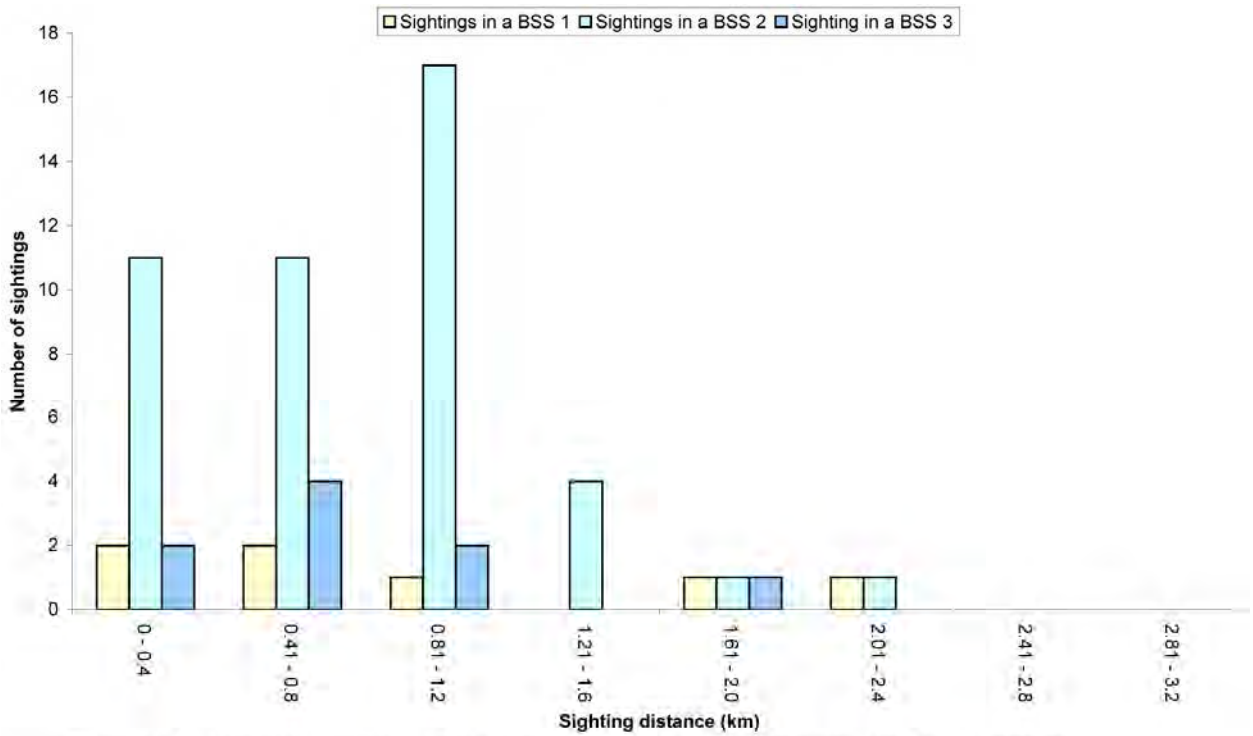


Figure 5a. Cetacean sighting distances by Beaufort Sea State. A total of 61 sightings are graphed (2 outliers removed and 3 delphinid sightings that distance could not be calculated).

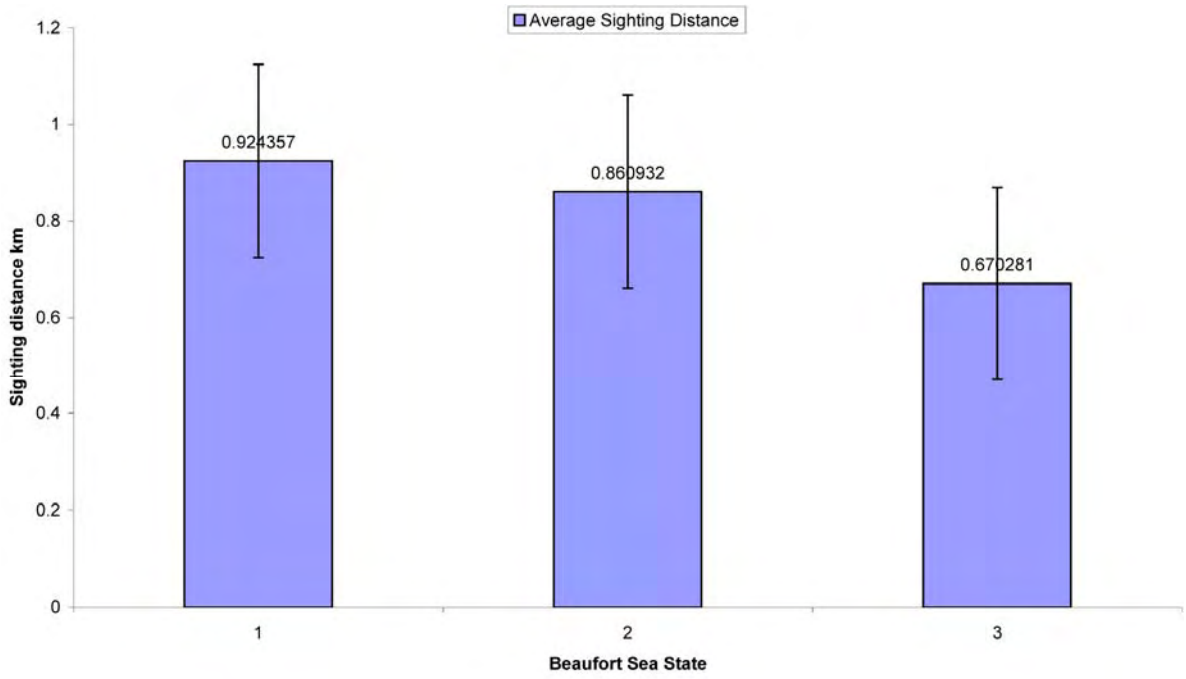


Figure 5b. Mean sighting distance by Beaufort sea state for all cetacean encounters in the Onslow Bay, NC proposed USWTR site.

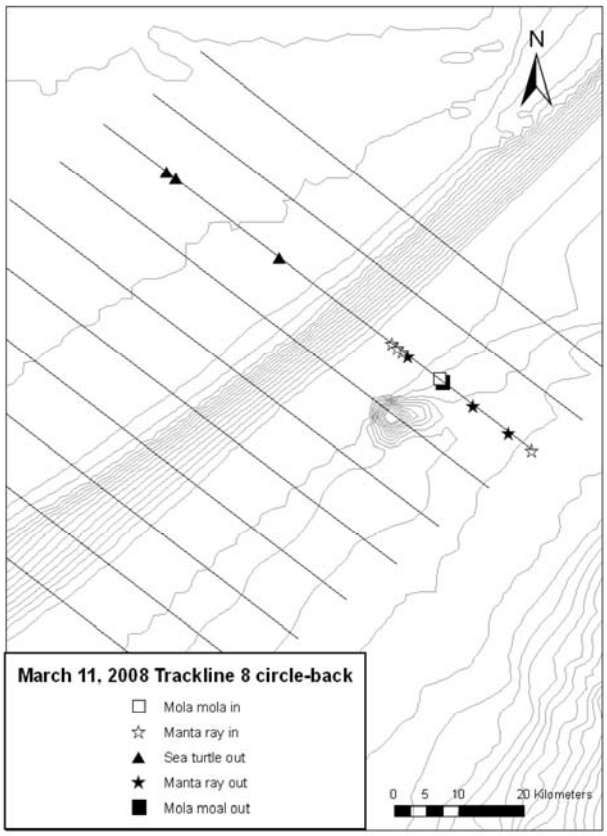


Figure 6. Sightings during circle-back conducted on March 11, 2008.

Marine Mammal Sightings

No pinnipeds, baleen whales, or any odontocete species listed as endangered under the Endangered Species Act were observed in the Onslow Bay survey site during the surveys. Two North Atlantic right whales (*Eubalena glacialis*) were encountered during transit out to the survey site on November 17th, 2007, approximately 47 km southeast from shore and 40 km northwest from the inshore, westernmost boundary of the survey area.

A total of 853 individual cetaceans in 66 sightings were encountered while on effort in the survey area (Table 5). The highest number of sightings occurred in June 2008, followed by November 2007, May 2008, and March 2008. Highest species diversity was also observed in May and June 2008. Sightings for each month are summarized in Appendix 6. Summaries for each individual sighting are in Appendix 7. Species are listed below in order of decreasing number of sightings (*i.e.* most commonly sighted species first). Total number of individuals is based upon the best estimate of group size.

Table 5. Total number of sightings and individuals for each species by month for the Onslow Bay, NC USWTR survey site.

		2007								2008					
		June	July	August	September	October	November	December	January	February	March	April	May	June	Total
Tursiops truncatus	Sightings	1				1	9	1			3	5	5	8	**33**
	# of individuals	80				40	113	1			33	43	67	84	**461**
Stenella frontalis	Sightings				1					4	1		1	4	**11**
	# of individuals				4					68	36		11	58	**177**
Globicephala macrorhynchus	Sightings	1											2		**3**
	# of individuals	32											21		**53**
Steno bredanensis	Sightings											1		2	**3**
	# of individuals											26		14	**40**
Grampus griseus	Sightings												1	2	**3**
	# of individuals												5	15	**20**
Tursiops/ Stenella frontalis	Sightings										1			1	**2**
	# of individuals										3			2	**5**
Unidentified delphinid	Sightings		1	1	1		4			2	1			1	**11**
	# of individuals		6	3	6		56			20	5			1	**97**
	Total sightings	**2**	**1**	**1**	**2**	**1**	**13**	**1**	**0**	**6**	**6**	**6**	**9**	**18**	**66**
	Total individuals	**112**	**6**	**3**	**10**	**40**	**169**	**1**	**0**	**88**	**77**	**69**	**104**	**174**	**853**

Bottlenose dolphins (*Tursiops truncatus*) (Table 6, Fig. 7)

The bottlenose dolphin was the most commonly observed cetacean species during the present study, based both upon number of sightings and number of individuals. This species was observed 33 times for a total of 461 individuals. Group size ranged between 1-80 individuals (mean=14). Bottlenose dolphins were seen in October, November, December, (no survey January), March, April, May, and June. Calves were seen in November, May and June. Based on the distance from shore (*e.g.* greater than 69 km), these bottlenose dolphins were most likely the offshore ecotype (Torres *et al*. 2003). Overall, smaller groups were encountered inshore, and larger groups were seen at and beyond the continental shelf break. During the 1998/1999 aerial survey of the same area, bottlenose dolphins were encountered 17 times for a total of 151 individuals (McLellan *et al*. 1999). Encounters occurred in September, October, November, December, April, and May (McLellan *et al*. 1999). The current best estimate of offshore bottlenose dolphins in the Western Atlantic Ocean, between central Florida and Canada, is 81,588 (CV = 0.17) (NOAA Stock Assessment Report; Waring *et al*. 2007).

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Calf Y/N
26-Jun-07	11:22	13	33.929194	-76.171245	SE	10	1	45	3	60	90	80	N
14-Oct-07	9:33	8	33.483661	-76.759508	SE	1	2	90	2	35	42	40	N
17-Nov-07	10:13	14	33.913005	-76.947197	SE	4	1	90	3	3	4	3	N
17-Nov-07	10:32	20	33.713446	-76.671020	SE	4	2	90	3	16	20	18	N
17-Nov-07	10:41	22	33.686476	-76.604707	SE	4	1	90	3	9	9	9	N
17-Nov-07	11:08	30	33.668959	-76.731080	NW	3	2	60	3	23	25	23	N
18-Nov-07	9:36	15	33.766869	-76.079809	NW	10	3	90	3	2	3	3	N
19-Nov-07	9:46	14	33.689801	-76.496961	SE	5	1	110	3	4	4	4	N
19-Nov-07	9:52	18	33.668711	-76.465009	SE	5	1	100	3	8	10	8	Y
19-Nov-07	10:14	25	33.783959	-76.491535	NW	6	2	90	3	4	6	5	N
19-Nov-07	12:22	80	33.824244	-76.041044	NW	10	3	60	3	37	45	40	N
11-Dec-07	12:57	34	33.768400	-76.875538	NW	3	1	90	3	1	1	1	N
11-Mar-08	10:52	34	33.760469	-76.352189	SE	7	2	90	3	15	16	15	N
13-Mar-08	11:40	26	33.861341	-76.985223	SE	3	3	90	3	4	7	5	N
13-Mar-08	15:50	77	33.784879	-76.257041	NW	8	3	90	3	12	16	13	N
25-Apr-08	10:31	23	34.142246	-76.696676	SE	8	3	90	2	3	3	3	N
25-Apr-08	14:30	62	33.598467	-76.508261	SE	4	1	90	3	10	13	12	N
26-Apr-08	10:54	17	33.623796	-76.544074	NW	4	3	90	3	10	20	15	N
26-Apr-08	11:25	26	33.943435	-76.970047	NW	4	1	110	3	4	4	4	N
26-Apr-08	13:49	41	33.896252	-76.249675	NW	9	2	90	3	8	10	9	N
26-May-08	9:05	12	33.47428	-76.63210	NW	2	2	90	1	12	14	13	N
26-May-08	11:00	38	33.63598	-76.30902	NW	6	1	90	3	12	15	13	Y
26-May-08	11:23	41	33.84225	-76.60023	NW	6	3	80	3	20	25	23	Y
26-May-08	16:06	73	33.95292	-76.57421	NW	7	3	90	3	6	7	6	N
27-May-08	9:57	10	33.515733	-76.689246	NW	2	4	90	3	5	12	12	N
24-Jun-08	14:15	32	33.800619	-76.781757	SE	4	3	120	3	4	7	7	N
24-Jun-08	15:52	59	33.398254	-76.639548	NW	1	2	90	3	25	25	25	N
25-Jun-08	9:48	7	33.584993	-76.363913	SE	5	1	90	3	6	10	9	Y
25-Jun-08	11:15	26	33.941355	-76.457001	NW	8	2	90	3	2	2	2	N
25-Jun-08	12:48	48	34.083751	-76.361075	NW	10	3	90	3	1	1	1	N
25-Jun-08	14:55	61	33.646071	-76.546472	SE	4	4	90	3	13	15	14	N
25-Jun-08	15:55	72	33.541729	-76.695676	SE	2	3	90	3	11	12	11	N
25-Jun-08	16:09	77	33.368079	-76.621439	NW	1	2	45	3	14	16	15	N

Table 6. All *Tursiops truncatus* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

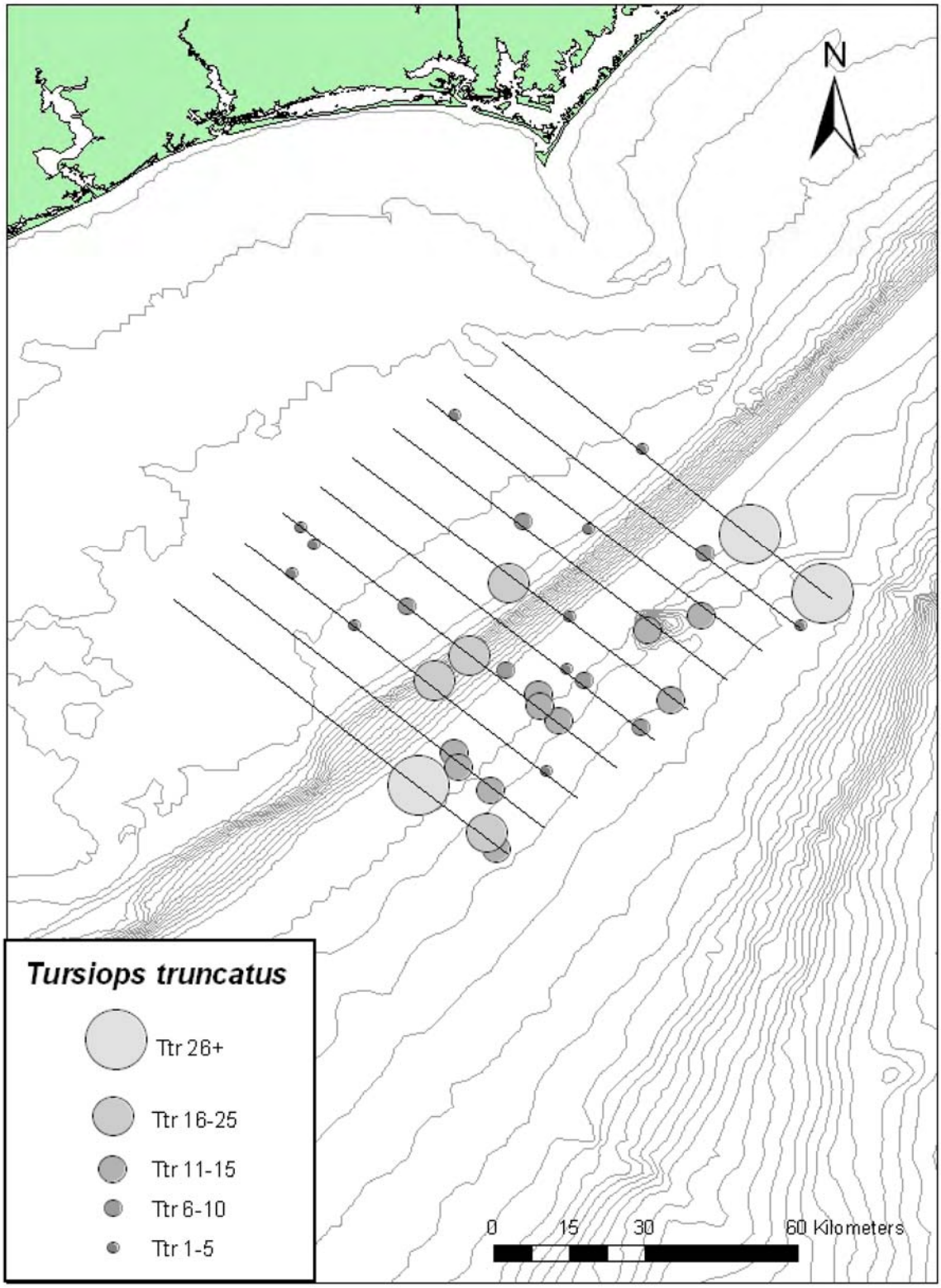


Figure 7. Bottlenose dolphin (*Tursiops truncatus*) sightings indicating group size.

Atlantic spotted dolphins (*Stenella frontalis*) (Table 7, Fig. 8)

The spotted dolphin was the second most commonly encountered species in the survey area. Groups of spotted dolphins were sighted 11 times for a total of 177 individuals. This species was encountered in September, February, March, May, and June. Group size ranged between 4 and 36 (mean group size = 16). Spotted dolphins were exclusively encountered on the shallower, inshore side of the continental shelf break. 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 isobar or in shallower water, and a less spotted and smaller form which occurs further offshore and around islands (Perrin *et al*. 1987, 1994). It is likely, based upon the sighting pattern observed, that the spotted dolphins observed during the present study belong to the continental shelf variety. Spotted dolphins were not recorded during the 1998/1999 aerial surveys of the same area (McLellan *et al*. 1999). The abundance estimate for *S. frontalis* (both inshore and offshore ecotypes) in the western north Atlantic is 50,978 (CV=0.42); the status of the stock(s) is/are unknown (Waring *et al*. 2007).

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Calf Y/N
25-Sep-07	11:01	24	34.089353	-76.540134	SE	9	3	100	3	4	4	4	N
29-Feb-08	10:02	5	33.966286	-76.880373	SE	5	2	110	3	7	9	8	N
29-Feb-08	10:18	13	33.812978	-76.653357	SE	5	3	90	3	5	8	7	N
29-Feb-08	11:17	35	34.036700	-76.707461	SE	7	1	100	2	24	30	27	Y
29-Feb-08	11:28	39	33.946793	-76.572190	SE	7	2	90	3	23	29	26	N
11-Mar-08	14:32	63	34.189870	-76.657393	NW	9	3	90	2	30	40	36	N
26-May-08	14:19	53	34.21452	-76.51423	SE	10	3	30	3	11	12	11	N
24-Jun-08	14:00	28	33.937103	-76.964589	SE	4	2	90	3	4	6	5	N
24-Jun-08	14:22	35	33.772186	-76.741641	SE	4	2	90	3	34	37	35	Y
24-Jun-08	16:15	63	33.744705	-77.09179	NW	1	1	90	3	10	10	10	N
25-Jun-08	10:24	15	34.050011	-76.858224	NW	6	2	90	3	8	8	8	Y

Table 7. All *Stenella frontalis* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

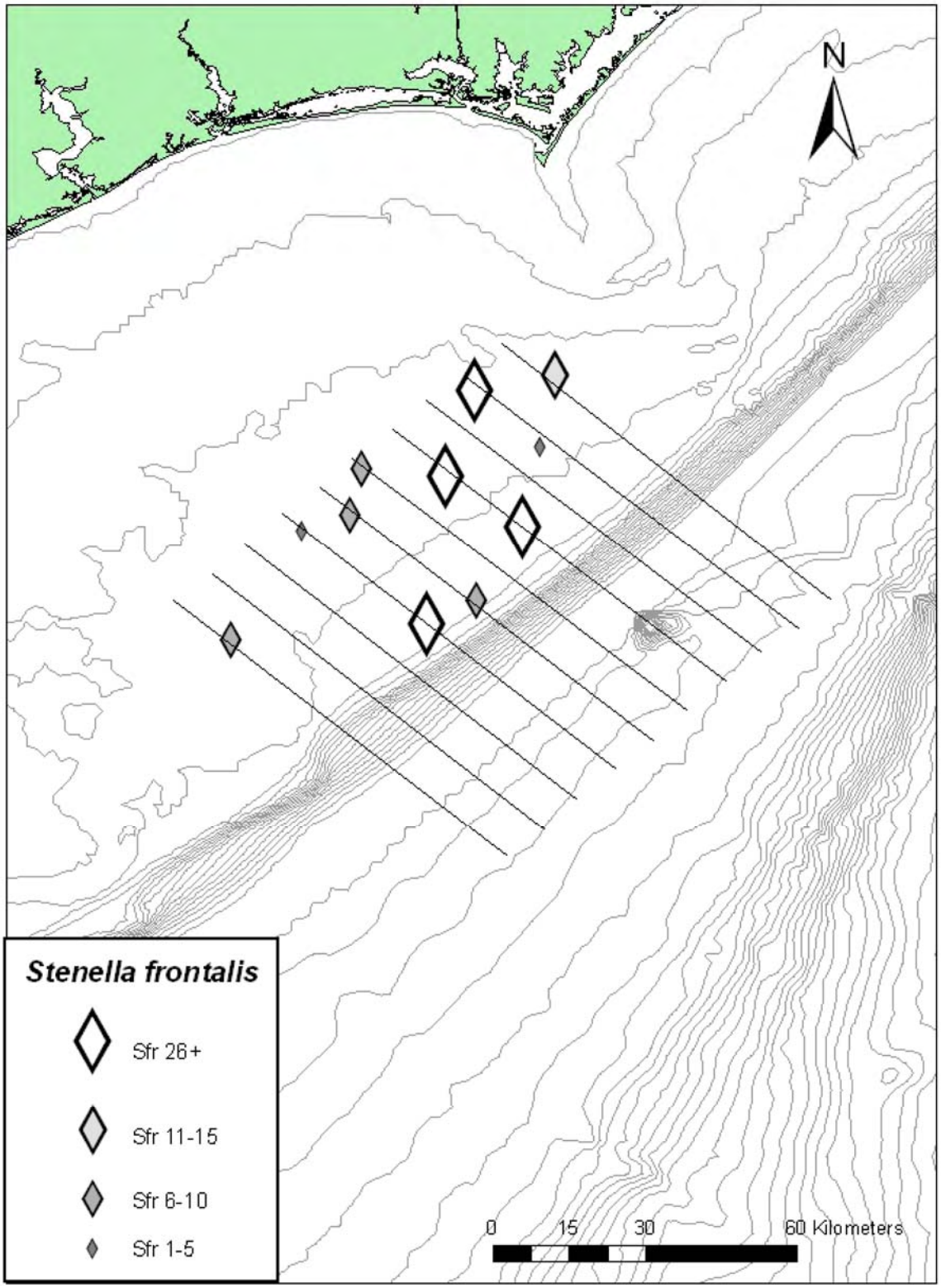


Figure 8. Spotted dolphin (*Stenella frontalis*) sightings indicating group size.

Short-finned pilot whales (*Globicephala macrorhynchus)* (Table 8, Fig. 9)

Short-finned pilot whales were encountered three times, once in June 2007 and twice during May 2008, for a total of 53 individuals. Calves were observed in June 2007 and during one encounter in May 2008. All three sightings of this species were offshore of the continental shelf break. Pilot whales of unidentified species were encountered once during the 1998/1999 aerial surveys, in May 1999 (McLellan *et al*. 1999).

Owing to the difficulty of differentiating short-finned and long-finned pilot whales (*Globicephala melas*) at sea, NMFS reports stock numbers and status as *Globicephala* spp. (Waring *et al*. 2007). The abundance estimate of *Globicephala* spp. (14,411, CV 0.43) is based upon shipboard surveys along the outer continental shelf of the US Atlantic between Florida and Maryland (Waring *et al*. 2007). The status of short-finned pilot whales in the U.S. Atlantic is currently unknown (Waring *et al*. 2007).

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Calf Y/N
26-Jun-07	11:51	20	33.861928	-76.193985	NW	9	3	45	3	28	35	32	Y
26-May-08	15:31	68	33.82133	-76.27602	SE	8	3	90	3	5	12	9	N
27-May-08	10:41	18	33.592923	-76.65565	SE	3	2	90	3	12	12	12	Y

Table 8. All G*lobicephala macrorhynchus* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

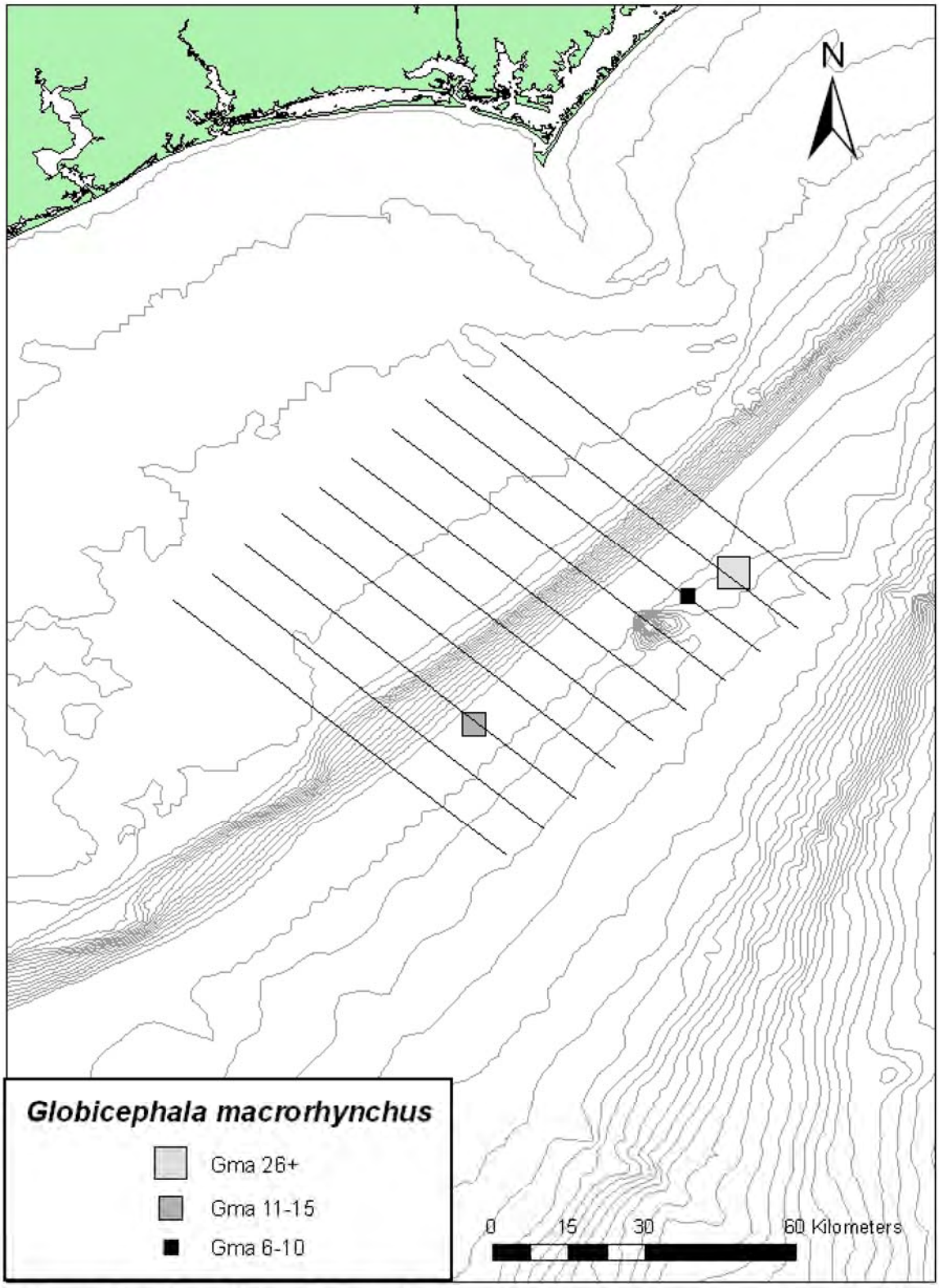


Figure 9. Short finned pilot whales (*Globicephala macrorhynchus*) sightings indicating group size.

Rough-toothed dolphins (*Steno bredanensis*) (Table 9, Fig. 10)

Three groups of rough-toothed dolphins were observed for a total of 40 individuals. One encounter occurred in April 2008 and two in June 2008. The group size ranged from 5 to 26 (mean = 13). A small calf was seen during one of the June sightings. All sightings of this species occurred offshore of the continental shelf break. This species was not observed during the 1998/1999 aerial surveys of the proposed USWTR site (McLellan *et al*. 1999). No stock estimate for *S. bredanensis* in the western north Atlantic is available.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Calf Y/N
25-Apr-08	10:56	29	33.806142	-76.266700	SE	8	3	90	3	24	28	26	N
24-Jun-08	15:34	53	33.516511	-76.66473	SE	2	3	120	4	7	10	9	N
24-Jun-08	14:52	47	33.551987	-76.594555	NW	3	2	60	3	3	5	5	Y

Table 9. All *Steno bredanensis* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

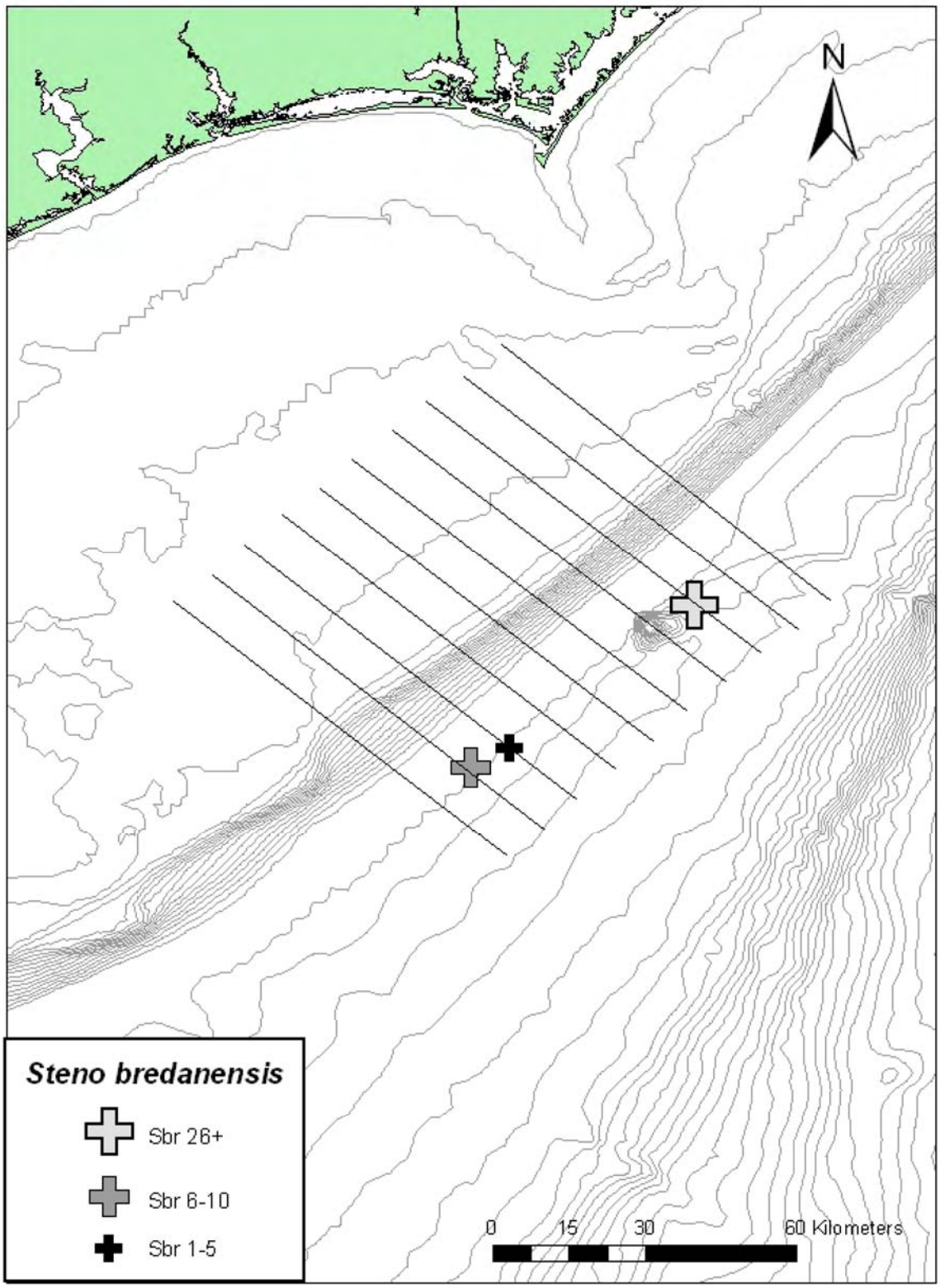


Figure 10. Rough-toothed dolphin (*Steno bredanensis*) sightings indicating group size.

Risso's dolphins *(Grampus griseus)* (Table 10, Fig. 11)

This species was encountered three times, once in May 2008 and twice in June 2008, for a total of 20 individuals. Group sizes for the three encounters were 5, 10, and 5 (average group size = 7). All encounters occurred in waters offshore of the continental shelf break. A very small calf (less than half the length of the associated larger animal) was observed during one of the encounters in June 2008. Risso's dolphins were also seen during the 1998/1999 aerial surveys in May and July (McLellan *et al*. 1999). Risso's dolphins can be found along the mid-Atlantic continental shelf edge year round, with some movement north during spring, summer and fall, and into the mid-Atlantic Bight during winter (Waring *et al*. 2007). The best available estimate for Risso's dolphins based upon results from two US Atlantic surveys conducted in 2004 is 20,479 (CV=0.59) (Waring *et al*. 2007). The status of this species in the western Atlantic is unknown (Waring *et al*. 2007).

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Calf Y/N
27-May-08	11:13	25	33.595927	-76.508913	NW	4	3	90	3	4	5	5	N
25-Jun-08	12:15	45	33.831817	-76.037992	NW	10	1	90	3	8	12	10	Y
25-Jun-08	15:03	64	33.593274	-76.507083	SE	4	2	90	3	5	5	5	Y

Table 10. All *Grampus griseus* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

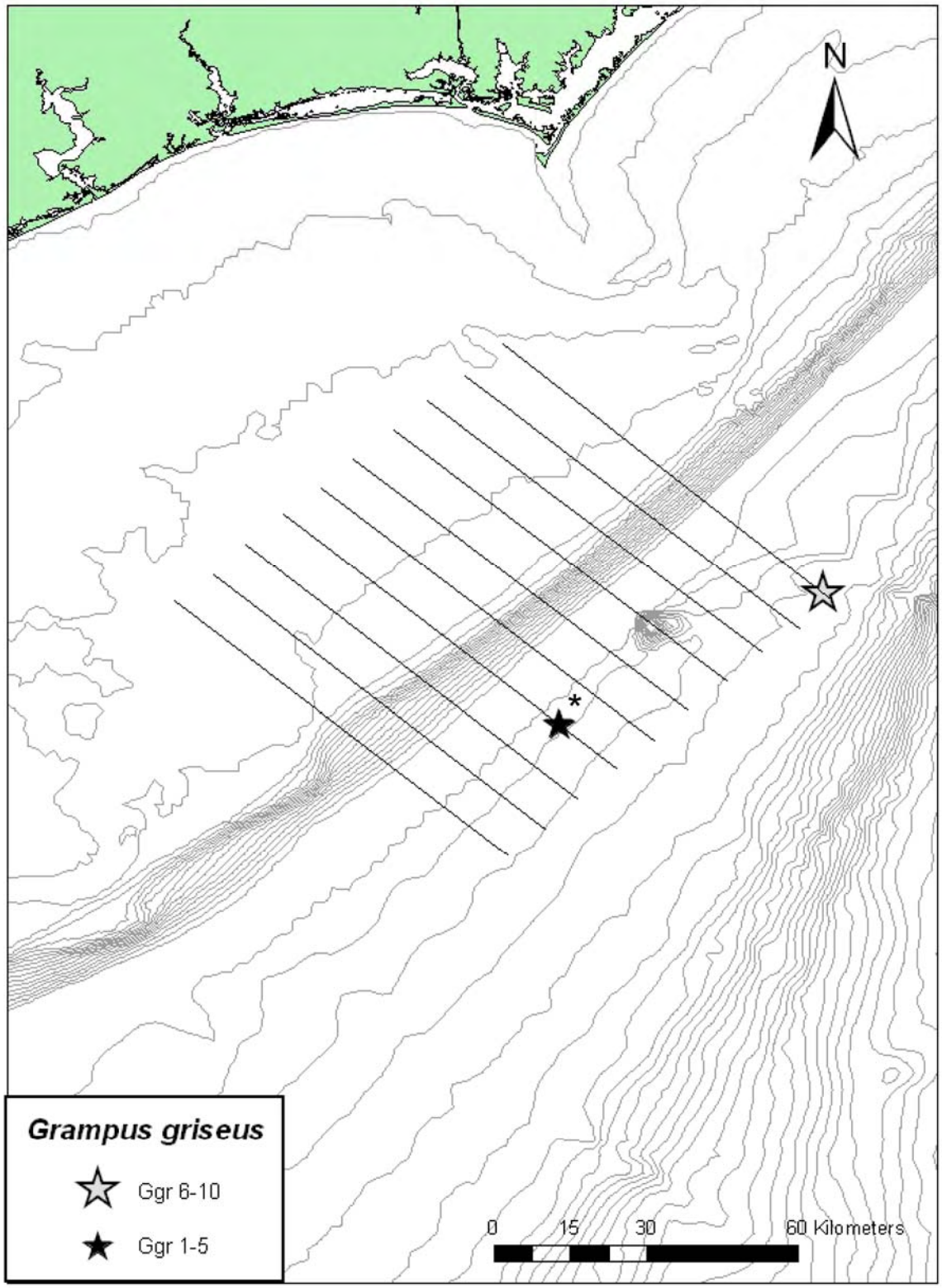


Figure 11. Risso's dolphin (*Grampus griseus*) sightings indicating group size. * Indicates that there are 2 sightings at this location each of 5 animals.

Tursiops/Stenella frontalis (Table 11, Fig. 12)

In two sightings of a total of five individuals, species identity could be narrowed down to *Tursiops truncatus* or *Stenella frontalis*. In these cases, the designation *Tursiops/Stenella frontalis* was used.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Calf Y/N
24-Jun-08	14:48	43	33.507569	-76.532724	NW	3	1	90	3	2	2	2	N
13-Mar-08	11:12	18	33.786004	-77.024951	NW	2	1	90	3	3	3	3	N

Table 11. All *Tursiops/ Stenella frontalis* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

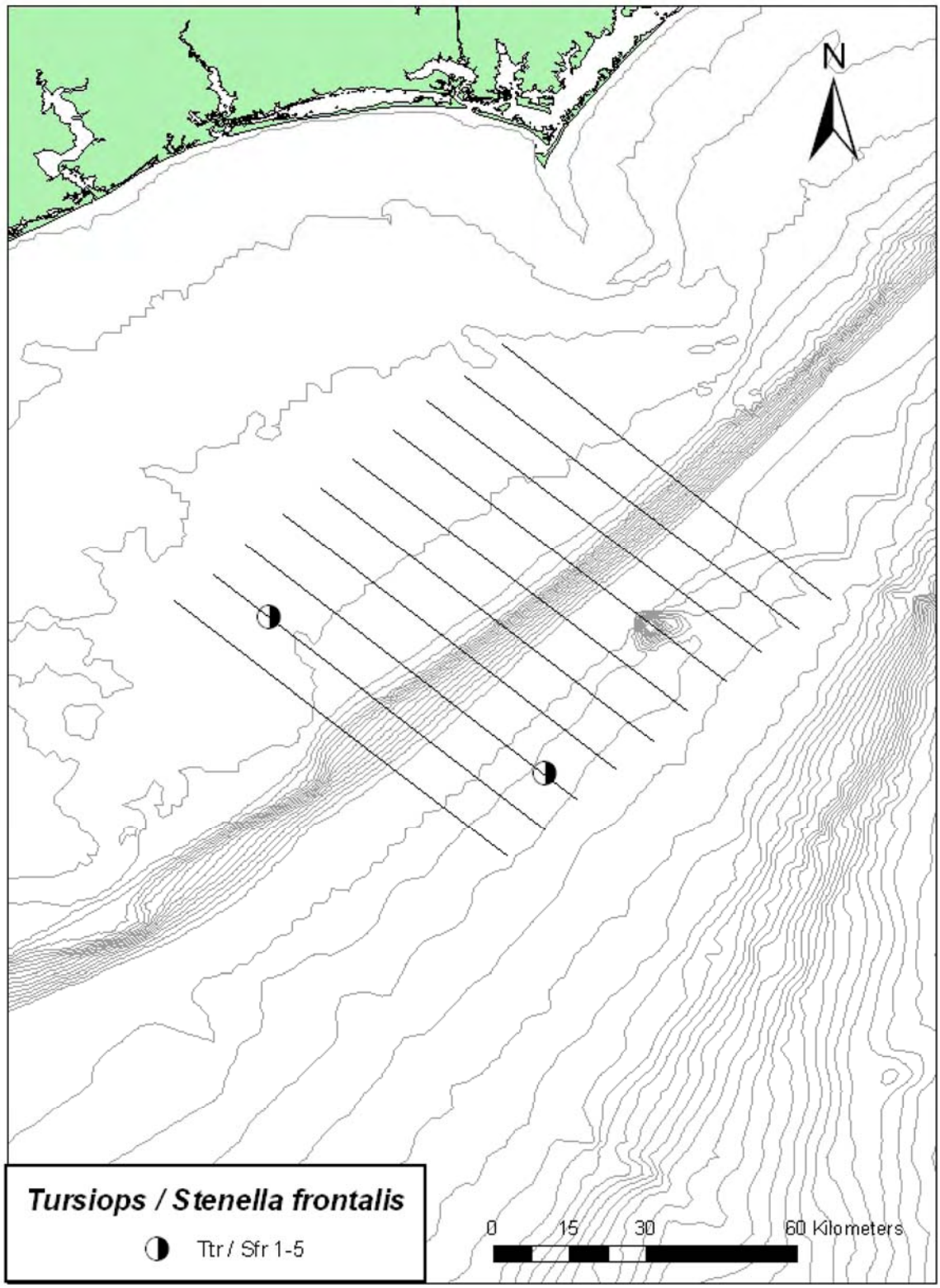


Figure 12. Bottlenose dolphin / Spotted dolphin (*Tursiops / Stenella frontalis*) sightings indicating group size.

Unidentified delphinids (Table 12, Fig. 13)

When no images were obtained or when images obtained during encounters were not of sufficient quality to make an unequivocal species identification, the designation "unidentified delphinids" was used. A total of 97 unidentified delphinids in 11 sightings were recorded. Group size of unidentified delphinids ranged between 1 and 22 (mean=8).

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Calf Y/N
18-Jul-07	10:06	23	33.883485	-76.373307	NW	8	1	90	3	4	7	6	N
7-Aug-07	11:07	21	33.705724	-76.394329	NW	6	3	30	3	2	4	3	N
25-Sep-07	10:43	21	34.159464	-76.597856	SE	9	1	90	3	5	7	6	N
19-Nov-07	9:34	10	33.761658	-76.603021	SE	5	3	90	3	14	23	20	Y
19-Nov-07	10:29	30	33.916486	-76.681417	NW	6	2	80	3	11	12	11	N
19-Nov-07	11:10	44	33.804399	-76.385545	SE	7	2	120	3	22	25	22	N
19-Nov-07	11:47	66	34.134283	-76.692483	NW	8	2	90	3	3	3	3	N
25-Feb-08	14:06	48	33.671971	-76.995668	SE	1	2	110	3	6	9	7	N
25-Feb-08	14:45	57	33.721963	-76.944112	NW	2	1	90	3	11	15	13	N
11-Mar-08	14:08	57	34.072139	-76.473937	NW	9	3	90	3	5	7	5	N
25-Jun-08	11:54	30	34.022289	-76.418861	SE	9	3	90	3	1	1	1	N

Table 12. All unidentified delphinid sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

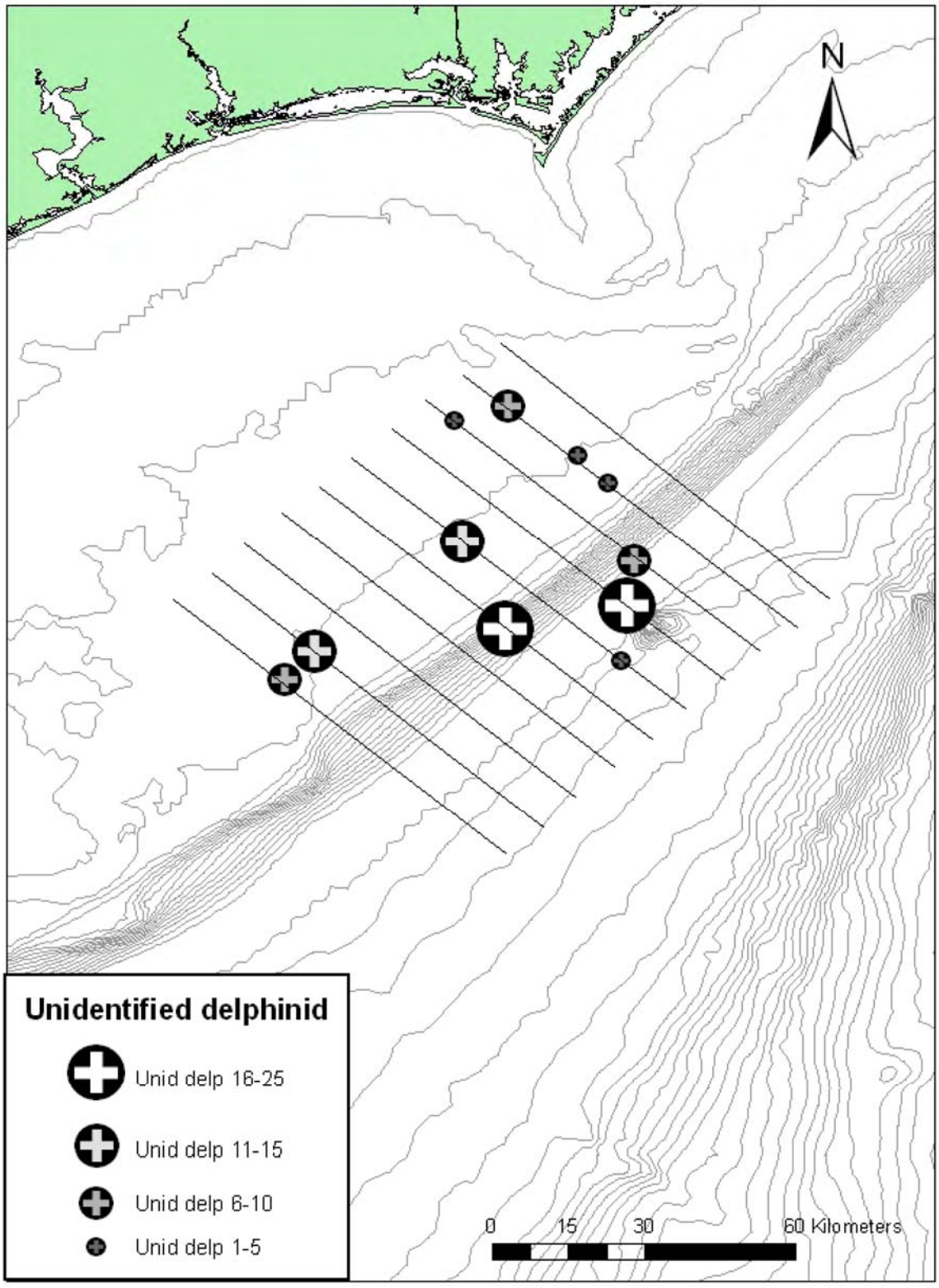


Figure 13. Unidentified delphinid sightings indicating group size.

Sea Turtle Sightings (Tables 13 and 14, Figs. 14 and 15a-c)

The most common sea turtle off the North Carolina coast is the loggerhead sea turtle (*Caretta caretta),* a species that nests along the NC coast and is listed as threatened under the US Endangered Species Act (National Marine Fisheries Service and U.S. Fish and Wildlife Service 2008). Other sea turtle species present in the mid-Atlantic are the green (*Chelonia mydas*), leather back (*Dermochelys coriacea),* hawksbill *(Eretmochelys imbricata),* and Kemps Ridley (*Lepidochelys kempii)* (National Marine Fisheries Service and U.S. Fish and Wildlife Service 1991, 1992a, 1992b, 1993). A total of 268 sea turtles were seen in the survey area between June 2007 and June 2008. Of these, 208 were identified as loggerhead sea turtles and the remaining 60 labeled as "unidentified sea turtles". Hence, the only sea turtle species positively identified in the study area was the loggerhead turtle. In contrast to the 1998/1999 surveys, no leatherback sea turtles were seen (McLellan *et al*. 1999). Sea turtles were seen during all months surveyed except in August 2007, although abundance fluctuated throughout the year. The lowest densities were observed between July and October (0.0 to 3.5 sea turtles /1000 km) and the highest densities occurred between November and March (35.9 to 63.7 sea turtles /1000 km). The majority of sea turtles were observed shoreward of the continental shelf break. As expected, sea turtle sightings were strongly correlated with Beaufort Sea State.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
26-Jun-07	10:49	12	34.198552	-76.515018	SE	10	3	90	3	1	1	1
26-Jun-07	11:06	16	34.158743	-76.479518	SE	10	1	90	3	1	1	1
26-Jun-07	11:10	18	34.136318	-76.436727	SE	10	2	90	3	1	1	1
26-Jun-07	11:39	16	33.887715	-76.117205	SE	10	3	90	3	1	1	1
26-Jun-07	12:10	23	33.948014	-76.319892	NW	9	2	90	3	1	1	1
26-Jun-07	12:16	25	34.051203	-76.459225	NW	9	2	30	3	1	1	1
26-Jun-07	12:21	26	34.154647	-76.592118	NW	9	3	30	3	1	1	1
26-Jun-07	12:24	28	34.208053	-76.665405	NW	9	3	60	3	1	1	1
26-Jun-07	12:17	28	34.069589	-76.483684	NW	9	3	60	3	1	1	1
26-Jun-07	12:21	30	34.157549	-76.595846	NW	9	4	90	3	1	1	1
18-Jul-07	8:50	6	33.783169	-76.628061	SE	5	1	90	3	1	1	1
24-Sep-07	9:40	6	33.726151	-77.078952	SE	1	3	90	3	1	1	1
24-Sep-07	9:56	7	33.419931	-76.677856	SE	1	2	100	3	2	2	2
24-Sep-07	10:31	15	33.868707	-77.009495	SE	3	1	90	3	1	1	1
25-Sep-07	14:56	42	33.481771	-76.507232	NW	3	2	90	3	1	1	1
14-Oct-07	15:26	49	34.073449	-76.613081	NW	8	1	90	3	1	1	1
14-Oct-07	15:38	46	34.152089	-76.592553	SE	9	1	90	3	1	1	1
17-Nov-07	10:03	7	33.916902	-76.936368	SE	4	3	90	3	1	1	1
17-Nov-07	10:25	17	33.840586	-76.834218	SE	4	1	90	3	1	1	1
17-Nov-07	10:25	18	33.838469	-76.831379	SE	4	1	90	3	1	1	1
17-Nov-07	10:49	15	33.607221	-76.525800	SE	4	2	90	3	1	1	1
17-Nov-07	10:53	16	33.518437	-76.407462	SE	4	2	60	3	1	1	1
17-Nov-07	11:12	21	33.713736	-76.803719	NW	3	4	60	3	1	1	1
17-Nov-07	11:18	34	33.834663	-76.969675	NW	3	3	90	3	1	1	1
17-Nov-07	11:20	36	33.845537	-76.975936	NW	3	1	90	3	1	1	1
17-Nov-07	11:20	24	33.851705	-76.984646	NW	3	1	90	3	1	1	1
17-Nov-07	11:23	25	33.899050	-77.047241	NW	3	3	60	3	1	1	1
17-Nov-07	15:00	41	33.478111	-76.629145	SE	2	1	60	3	1	1	1
17-Nov-07	15:23	44	33.656229	-76.987350	NW	1	1	90	3	1	1	1
18-Nov-07	10:01	18	34.114387	-76.542791	NW	9	3	90	3	1	1	1
18-Nov-07	10:01	19	34.121617	-76.552489	NW	9	2	60	3	1	1	1
18-Nov-07	11:35	38	33.852760	-76.586283	SE	6	1	60	3	1	1	1
18-Nov-07	11:43	39	33.692515	-76.379708	SE	6	2	90	3	1	1	1
18-Nov-07	9:20	11	34.028677	-76.295084	SE	10	2, 3	90	3	2	2	2
19-Nov-07	9:23	5	33.956730	-76.857000	SE	5	2	100	3	1	1	1
19-Nov-07	9:24	6	33.933040	-76.826040	SE	5	2	90	3	1	1	1
19-Nov-07	9:27	8	33.873515	-76.748801	SE	5	1	100	3	1	1	1
19-Nov-07	10:07	18	33.657321	-76.331965	NW	6	3	90	3	1	1	1
19-Nov-07	10:41	24	34.001463	-76.789518	NW	6	2	90	3	1	1	1
19-Nov-07	10:43	26	34.038649	-76.837006	NW	6	3	90	3	1	1	1
19-Nov-07	10:43	25	34.028100	-76.822347	NW	6	2	90	3	2	2	2

Table 13. All *Caretta caretta* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
19-Nov-07	10:48	29	34.104149	-76.782757	SE	7	3	90	3	1	1	1
19-Nov-07	10:50	30	34.060311	-76.714242	SE	7	3	90	3	1	1	1
19-Nov-07	11:29	40	33.829620	-76.287666	NW	8	2	60	3	1	1	1
19-Nov-07	11:44	44	34.100959	-76.648564	NW	8	1	60	3	1	1	1
19-Nov-07	11:44	43	34.089744	-76.633873	NW	8	2	60	3	1	1	1
19-Nov-07	11:45	45	34.119055	-76.673604	NW	8	3	60	3	2	2	2
19-Nov-07	12:43	56	34.173875	-76.483219	NW	10	2	60	3	1	1	1
11-Dec-07	11:21	5	33.978966	-76.754569	SE	6	2	90	3	1	1	1
11-Dec-07	11:22	6	33.960016	-76.728545	SE	6	3	90	3	1	1	1
11-Dec-07	12:01	14	33.902819	-76.784864	NW	5	2	45	3	1	1	1
11-Dec-07	12:02	15	33.922376	-76.808914	NW	5	1	45	3	1	1	1
11-Dec-07	12:03	16	33.949767	-76.847100	NW	5	1	90	3	1	1	1
11-Dec-07	12:04	17	33.978302	-76.886442	NW	5	2	45	3	1	1	1
11-Dec-07	12:10	20	33.950338	-76.983337	SE	4	2	90	3	1	1	1
11-Dec-07	12:11	21	33.924820	-76.945994	SE	4	3	45	3	1	1	1
11-Dec-07	12:15	23	33.848555	-76.844525	SE	4	1	90	3	1	1	1
11-Dec-07	12:19	24	33.763228	-76.732795	SE	4	3	60	3	1	1	1
11-Dec-07	13:11	39	33.819721	-77.071867	SE	2	2	30	3	1	1	1
11-Dec-07	13:14	40	33.760561	-76.993192	SE	2	1	60	3	1	1	1
11-Dec-07	13:30	43	33.429349	-76.566824	SE	2	2	90	3	1	1	1
11-Dec-07	13:36	46	33.399423	-76.652542	NW	1	3	90	3	1	1	1
11-Dec-07	13:46	47	33.608441	-76.926040	NW	1	2	90	3	1	1	1
11-Dec-07	11:56	12	33.817022	-76.673977	NW	5	2	45	3	1	1	1
25-Feb-08	14:00	46	33.715809	-77.067712	SE	1	4	45	3	1	1	1
25-Feb-08	14:10	51	33.643969	-76.968326	SE	1	3	90	3	1	1	1
25-Feb-08	14:11	52	33.627420	-76.947433	SE	1	1	45	3	1	1	1
25-Feb-08	14:12	53	33.595705	-76.907372	SE	1	2	90	3	1	1	1
25-Feb-08	14:13	46	33.593514	-76.904367	SE	1	3	90	3	1	1	1
25-Feb-08	14:44	56	33.704444	-76.921813	NW	2	2	60	3	1	1	1
25-Feb-08	14:50	59	33.739632	-76.968623	NW	2	3	110	3	1	1	1
25-Feb-08	14:51	60	33.755905	-76.989600	NW	2	2	90	3	1	1	1
25-Feb-08	15:08	66	33.757079	-76.859000	SE	3	2	90	3	1	1	1
25-Feb-08	15:09	67	33.742300	-76.839083	SE	3	1	90	3	1	1	1
25-Feb-08	15:10	68	33.726409	-76.817917	SE	3	2	60	3	1	1	1
25-Feb-08	15:10	69	33.714628	-76.802946	SE	3	3	60	3	1	1	1
25-Feb-08	10:28	17	34.065983	-76.478760	NW	9	1	90	3	1	1	1
25-Feb-08	10:31	18	34.123859	-76.555769	NW	9	1	90	3	1	1	1
25-Feb-08	10:32	19	34.145283	-76.581694	NW	9	1	90	3	1	1	1
25-Feb-08	14:13	55	33.577871	-76.883429	SE	1	2	60	3	1	1	1
25-Feb-08	14:14	56	33.569219	-76.872214	SE	1	1	90	3	1	1	1
25-Feb-08	14:40	50	33.628072	-76.820910	NW	2	3	90	3	1	1	1
25-Feb-08	14:41	52	33.658245	-76.860604	NW	2	2	90	3	1	1	1

Table 13. All *Caretta caretta* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
25-Feb-08	14:41	51	33.649988	-76.848940	NW	2	2	100	3	1	1	1
25-Feb-08	14:42	54	33.674872	-76.883280	NW	2	1	90	3	1	1	1
25-Feb-08	14:42	53	33.664185	-76.868832	NW	2	2	90	3	1	1	1
25-Feb-08	15:40	70	33.760220	-76.729413	NW	4	2	90	3	1	1	1
25-Feb-08	15:41	71	33.782826	-76.757457	NW	4	2	90	3	1	1	1
25-Feb-08	15:47	72	33.898225	-76.912265	NW	4	1	90	3	2	2	2
25-Feb-08	15:49	74	33.921513	-76.946091	NW	4	3	90	3	1	1	1
25-Feb-08	15:50	75	33.952259	-76.984478	NW	4	2	90	3	1	1	1
25-Feb-08	15:51	76	33.962391	-76.998089	NW	4	2	90	3	1	1	1
25-Feb-08	9:58	10	34.021468	-76.290208	SE	10	2	90	3	1	1	1
29-Feb-08	10:59	25	33.877073	-76.620831	NW	6	1	90	3	1	1	1
29-Feb-08	11:13	23	34.096821	-76.771226	SE	7	3	90	3	1	1	1
29-Feb-08	11:26	37	33.992578	-76.634189	SE	7	2	80	2	1	1	1
29-Feb-08	12:10	49	34.016537	-76.537436	NW	8	3	90	3	1	1	1
29-Feb-08	12:13	50	34.090298	-76.636591	NW	8	1	60	2	1	1	1
29-Feb-08	12:16	41	34.137058	-76.694589	NW	8	1	60	3	1	1	1
29-Feb-08	10:11	9	33.910327	-76.794532	SE	5	3	100	3	1	1	1
29-Feb-08	10:14	10	33.862294	-76.733044	SE	5	4	120	3	1	1	1
29-Feb-08	10:15	11	33.849216	-76.716228	SE	5	2	90	3	1	1	1
29-Feb-08	10:28	9	33.759112	-76.595593	SE	5	1	90	3	1	1	1
29-Feb-08	10:59	18	33.880426	-76.625538	NW	6	3	60	3	1	1	1
29-Feb-08	11:01	19	33.929577	-76.689812	NW	6	2	90	3	1	1	1
29-Feb-08	11:04	27	33.987516	-76.768835	NW	6	1	50	3	1	1	1
29-Feb-08	11:43	30	33.865893	-76.468958	SE	7	3	90	3	1	1	1
29-Feb-08	12:07	37	33.960908	-76.467848	NW	8	3	90	3	1	1	1
29-Feb-08	12:13	39	34.072722	-76.612207	NW	8	2	60	3	1	1	1
11-Mar-08	14:25	60	34.101760	-76.527062	NW	9	2	90	3	1	1	1
11-Mar-08	14:26	34	34.128998	-76.563323	NW	9	1	90	3	1	1	1
11-Mar-08	14:45	68	34.106415	-76.656342	SE	8	1	90	3	1	1	1
11-Mar-08	14:46	39	34.097235	-76.644374	SE	8	3	90	3	1	1	1
11-Mar-08	14:51	69	33.987838	-76.500356	SE	8	2	90	3	1	1	1
11-Mar-08	10:19	28	33.941895	-76.706830	NW	6	2	90	3	1	1	1
13-Mar-08	10:29	3	33.690528	-77.034445	SE	1	2	90	3	1	1	1
13-Mar-08	10:30	4	33.666827	-77.002034	SE	1	2	80	3	1	1	1
13-Mar-08	10:30	4	33.670405	-77.007007	SE	1	3	90	3	1	1	1
13-Mar-08	10:30	5	33.660947	-76.994096	SE	1	4	90	3	1	1	1
13-Mar-08	10:32	5	33.640002	-76.965591	SE	1	2	90	3	1	1	1
13-Mar-08	10:35	8	33.577643	-76.885553	SE	1	2	90	3	1	1	1
13-Mar-08	11:04	10	33.638187	-76.832356	NW	2	2	60	3	1	1	1
13-Mar-08	11:07	14	33.696147	-76.907157	NW	2	2	90	3	1	1	1
13-Mar-08	11:08	15	33.715254	-76.931251	NW	2	1	60	3	1	1	1
13-Mar-08	11:08	14	33.725537	-76.943865	NW	2	3	45	3	2	2	2

Table 13. All *Caretta caretta* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
13-Mar-08	11:09	15	33.738198	-76.961708	NW	2	3	45	3	2	2	2
13-Mar-08	11:10	16	33.758592	-76.991068	NW	2	1	90	3	1	1	1
13-Mar-08	11:10	16	33.763760	-76.997739	NW	2	2	45	3	1	1	1
13-Mar-08	11:28	19	33.822268	-77.072626	NW	2	1	60	3	1	1	1
13-Mar-08	11:35	24	33.894190	-77.039983	SE	3	3	120	3	1	1	1
13-Mar-08	11:54	31	33.818510	-76.941352	SE	3	1	90	3	1	1	1
13-Mar-08	11:56	32	33.762967	-76.868429	SE	3	3	70	3	1	1	1
13-Mar-08	11:57	33	33.745760	-76.846872	SE	3	2	90	3	1	1	1
13-Mar-08	11:58	34	33.731587	-76.828109	SE	3	2	90	3	1	1	1
13-Mar-08	11:58	24	33.731335	-76.827821	SE	3	3	45	3	1	1	1
13-Mar-08	11:59	35	33.721446	-76.814439	SE	3	3	80	3	1	1	1
13-Mar-08	11:59	36	33.713228	-76.803469	SE	3	3	90	3	1	1	1
13-Mar-08	11:59	25	33.720685	-76.813442	SE	3	2	90	3	1	1	1
13-Mar-08	11:59	26	33.711992	-76.801866	SE	3	2	90	3	3	3	3
13-Mar-08	12:00	37	33.705982	-76.793862	SE	3	3	90	3	1	1	1
13-Mar-08	12:35	46	33.757093	-76.721320	NW	4	3	90	3	1	1	1
13-Mar-08	12:35	47	33.767341	-76.734565	NW	4	3	80	3	1	1	1
13-Mar-08	12:36	48	33.777541	-76.748227	NW	4	3	90	3	1	1	1
13-Mar-08	12:36	51	33.790214	-76.765515	NW	4	2	120	3	1	1	1
13-Mar-08	12:36	34	33.788117	-76.762402	NW	4	2	60	3	2	2	2
13-Mar-08	12:36	33	33.776304	-76.746537	NW	4	1	90	3	2	2	2
13-Mar-08	12:36	49	33.782877	-76.755154	NW	4	2	100	3	3	3	3
13-Mar-08	12:37	52	33.799393	-76.779584	NW	4	2	90	3	1	1	1
13-Mar-08	12:37	36	33.808073	-76.791050	NW	4	2	90	3	1	1	1
13-Mar-08	12:37	35	33.801156	-76.781997	NW	4	3	45	3	3	3	3
13-Mar-08	12:38	38	33.815803	-76.800762	NW	4	2	60	3	1	1	1
13-Mar-08	12:39	53	33.843327	-76.835880	NW	4	2	90	3	1	1	1
13-Mar-08	12:41	54	33.869286	-76.871837	NW	4	2	90	3	1	1	1
13-Mar-08	12:42	55	33.903207	-76.916701	NW	4	2	90	3	1	1	1
13-Mar-08	12:43	56	33.923307	-76.943257	NW	4	1	90	3	1	1	1
13-Mar-08	14:37	62	34.084271	-76.369455	SE	10	3	90	3	1	1	1
13-Mar-08	16:13	64	33.828254	-76.421067	NW	7	1	90	3	1	1	1
13-Mar-08	15:35	73	34.050852	-76.583907	SE	8	2	90	3	1	1	1
13-Mar-08	16:17	66	33.908466	-76.525853	NW	7	1	60	3	2	2	2
13-Mar-08	16:18	67	33.920770	-76.541856	NW	7	1	90	3	1	1	1
25-Apr-08	15:16	68	33.699603	-76.913412	SE	2	2	90	3	1	1	1
25-Apr-08	9:30	6	34.226247	-76.550562	SE	10	2	90	3	1	1	1
25-Apr-08	9:31	7	34.202171	-76.519496	SE	10	3	100	3	1	1	1
25-Apr-08	12:29	45	33.978820	-76.886837	NW	5	2	90	3	3	3	3
25-Apr-08	12:30	46	34.006749	-76.923791	NW	5	1	90	3	1	1	1
25-Apr-08	14:05	55	33.963843	-76.997228	SE	4	2	60	3	4	4	4
25-Apr-08	14:07	57	33.912055	-76.928270	SE	4	1	90	3	1	1	1

Table 13. All *Caretta caretta* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
25-Apr-08	14:11	51	33.841318	-76.834407	SE	4	3	100	3	1	1	1
25-Apr-08	14:56	60	33.742811	-76.842367	NW	3	1	90	3	1	1	1
25-Apr-08	15:02	63	33.848403	-76.980264	NW	3	1	90	3	1	1	1
25-Apr-08	15:04	65	33.900994	-77.049010	NW	3	1	90		1	1	1
25-Apr-08	15:11	73	33.805849	-77.051328	SE	2	3	60	3	1	1	1
25-Apr-08	15:22	77	33.586656	-76.767691	SE	2	2	60	3	1	1	1
25-Apr-08	15:53	75	33.716171	-77.067002	NW	1	3	100	3	1	1	1
25-Apr-08	15:54	76	33.737397	-77.094942	NW	1	2	90	3	1	1	1
25-Apr-08	10:11	13	34.073360	-76.489050	NW	9	2	45	3	1	1	1
25-Apr-08	10:12	14	34.092997	-76.514980	NW	9	1	45	3	1	1	1
25-Apr-08	10:21	19	34.151728	-76.592705	NW	9	2	90	3	1	1	1
26-Apr-08	9:40	4	33.571828	-76.877501	SE	1	3	45	3	1	1	1
26-Apr-08	11:22	19	33.927167	-76.949187	NW	4	1	90	3	1	1	1
26-Apr-08	14:05	39	34.109861	-76.537195	NW	9	3	60	3	1	1	1
25-May-08	9:52	3	34.084476	-76.366981	SE	10	3	90	3	1	1	1
25-Jun-08	11:24	22	34.030124	-76.557663	NW	8	1	90	3	1	1	1
25-Jun-08	11:28	23	34.119785	-76.674444	NW	8	3	90	3	1	1	1
25-Jun-08	11:30	24	34.141838	-76.706209	NW	8	2	90	3	1	1	1
25-Jun-08	12:57	40	34.227066	-76.547078	NW	10	2	60	3	1	1	1
25-Jun-08	14:43	47	33.864234	-76.864912	SE	4	2	30	3	1	1	1
25-Jun-08	15:40	57	33.821112	-77.071023	SE	2	2	90	3	1	1	1

Table 13. All *Caretta caretta* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
17-Jul-07	9:23	13	34.137272	-76.698453	SE	8	1	80	3	1	1	1
18-Nov-07	11:05	30	33.971949	-76.605786	NW	7	1	90	3	1	1	1
18-Nov-07	11:21	33	34.114596	-76.797563	NW	7	1	90	3	1	1	1
18-Nov-07	10:01	19	34.118188	-76.547824	NW	9	3	100	3	2	2	2
18-Nov-07	10:06	21	34.210804	-76.670548	NW	9	1	90	3	1	1	1
18-Nov-07	10:25	25	33.988466	-76.498948	SE	8	1	90	3	1	1	1
19-Nov-07	10:06	23	33.631831	-76.300344	NW	6	2	100	3	1	1	1
19-Nov-07	10:25	28	33.845835	-76.583383	NW	6	1	90	3	1	1	1
19-Nov-07	11:03	43	33.928928	-76.550851	SE	7	2	50	3	1	1	1
19-Nov-07	11:39	61	33.986705	-76.497194	NW	8	3	90	3	1	1	1
19-Nov-07	11:42	62	34.060781	-76.596606	NW	8	2	90	3	1	1	1
19-Nov-07	11:44	63	34.085720	-76.628691	NW	8	1	90	3	1	1	1
19-Nov-07	11:44	64	34.093141	-76.638238	NW	8	3	90	3	1	1	1
19-Nov-07	12:01	71	34.134669	-76.566239	SE	9	1	90	3	1	1	1
19-Nov-07	12:02	50	34.113337	-76.536738	SE	9	3	120	3	1	1	1
19-Nov-07	12:04	74	34.089472	-76.504803	SE	9	2	130	3	1	1	1
19-Nov-07	12:04	75	34.077454	-76.488677	SE	9	2	90	3	1	1	1
19-Nov-07	12:45	86	34.217612	-76.540934	NW	10	3	90	3	1	1	1
19-Nov-07	10:43	35	34.026617	-76.820152	NW	6	1	90	3	1	1	1
19-Nov-07	10:43	36	34.037068	-76.834922	NW	6	2	90	3	1	1	1
11-Dec-07	11:20	14	33.999740	-76.783103	SE	6	1	90	3	1	1	1
11-Dec-07	11:21	15	33.994008	-76.775170	SE	6	2	90	3	1	1	1
11-Dec-07	11:23	16	33.944754	-76.707362	SE	6	2	90	3	1	1	1
11-Dec-07	11:59	23	33.876332	-76.751658	NW	5	2	110	3	1	1	1
11-Dec-07	12:02	24	33.933258	-76.824034	NW	5	1	70	3	1	1	1
11-Dec-07	12:03	25	33.946295	-76.842407	NW	5	2	90	3	1	1	1
11-Dec-07	12:04	26	33.961291	-76.863156	NW	5	2	90	3	1	1	1
11-Dec-07	12:10	29	33.963326	-77.001498	SE	4	1	90	3	1	1	1
11-Dec-07	12:14	22	33.880464	-76.886076	SE	4	3	90	3	1	1	1
11-Dec-07	12:48	35	33.712732	-76.802921	NW	3	1	90	3	2	2	2
11-Dec-07	12:48	34	33.711655	-76.801515	NW	3	2	90	3	2	2	2
11-Dec-07	12:59	39	33.773844	-76.884149	NW	3	2	90	3	1	1	1
11-Dec-07	13:01	40	33.817619	-76.938246	NW	3	1	90	3	1	1	1
11-Dec-07	13:14	43	33.762471	-76.995615	SE	2	2	90	3	1	1	1
11-Dec-07	13:45	49	33.582341	-76.891415	NW	1	3	90	3	1	1	1
11-Dec-07	13:46	51	33.606924	-76.924000	NW	1	1	100	3	1	1	1
11-Dec-07	13:46	50	33.596768	-76.910756	NW	1	2	90	3	1	1	1
11-Dec-07	13:47	52	33.628461	-76.951878	NW	1	3	110	3	1	1	1
11-Dec-07	13:48	53	33.635656	-76.961371	NW	1	1	90	3	1	1	1
11-Dec-07	13:54	54	33.778799	-77.147813	NW	1	1	100	3	1	1	1
11-Dec-07	13:55	55	33.787924	-77.160951	NW	1	1	100	3	1	1	1
11-Dec-07	11:57	21	33.831360	-76.692843	NW	5	2	100	3	1	1	1

Table 14. All sea turtle sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
29-Feb-08	10:58	17	33.861495	-76.599101	NW	6	4	90	3	1	1	1
29-Feb-08	12:08	38	33.987571	-76.500696	NW	8	4	90	3	1	1	1
13-Mar-08	11:07	13	33.700427	-76.912456	NW	2	3	90	3	1	1	1
13-Mar-08	12:39	39	33.840675	-76.832206	NW	4	2	45	3	1	1	1
25-Apr-08	15:10	72	33.833348	-77.087089	SE	2	1	90	3	1	1	1
25-Apr-08	10:20	18	34.135162	-76.570719	NW	9	1	90	3	1	1	1
24-Jun-08	15:18	40	33.808172	-77.050635	SE	2	2	90	3	1	1	1
24-Jun-08	16:24	48	33.788085	-77.159783	NW	1	2	3	3	1	1	1
24-Jun-08	15:18	40	33.808172	-77.050635	SE	2	2	90	3	1	1	1
24-Jun-08	16:24	48	33.788085	-77.159783	NW	1	1	90	3	1	1	1
25-Jun-08	11:24	22	34.030124	-76.557663	NW	8	1	90	3	1	1	1
25-Jun-08	11:28	23	34.119785	-76.674444	NW	8	3	90	3	1	1	1
25-Jun-08	11:30	24	34.141838	-76.706209	NW	8	2	90	3	1	1	1
25-Jun-08	12:57	40	34.227066	-76.547078	NW	10	2	60	3	1	1	1
25-Jun-08	14:43	47	33.864234	-76.864912	SE	4	2	30	3	1	1	1
25-Jun-08	15:40	57	33.821112	-77.071023	SE	2	2	90	3	1	1	1
25-Jun-08	10:15	13	33.917010	-76.677743	NW	6	2	90	3	1	1	1
25-Jun-08	11:31	28	34.165043	-76.738923	NW	8	3	70	3	1	1	1
25-Jun-08	11:47	34	34.156079	-76.594370	SE	9	3	90	3	1	1	1
25-Jun-08	11:48	35	34.138573	-76.570716	SE	9	2	90	3	1	1	1
25-Jun-08	12:54	50	34.170840	-76.475191	NW	10	2	90	3	1	1	1
25-Jun-08	12:57	51	34.221733	-76.539953	NW	10	2	90	3	1	1	1
25-Jun-08	15:52	70	33.582281	-76.761493	SE	2	3	90	3	1	1	1

Table 14. All sea turtle sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

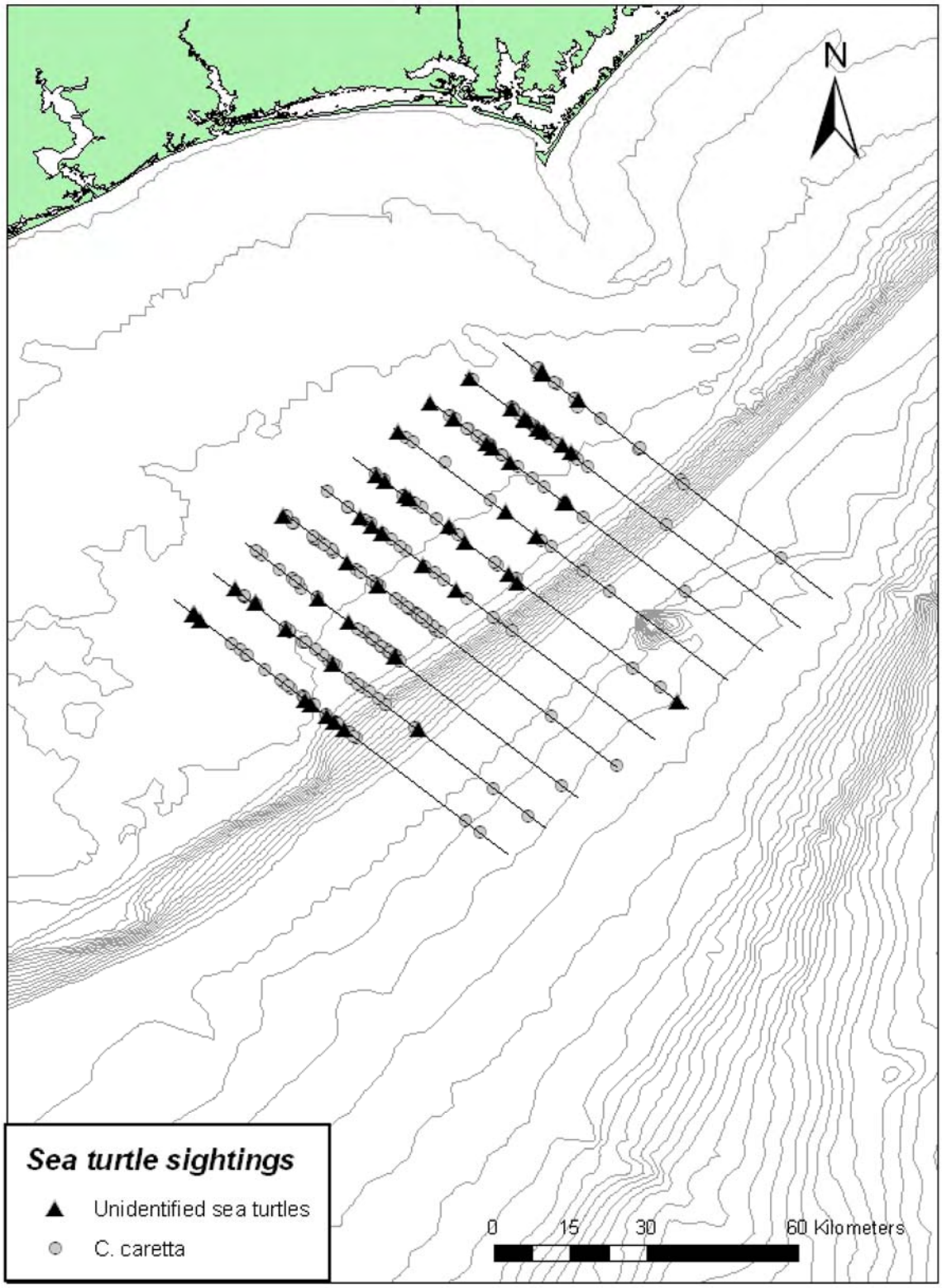


Figure 14. Unidentified sea turtle and loggerhead sea turtle sightings.

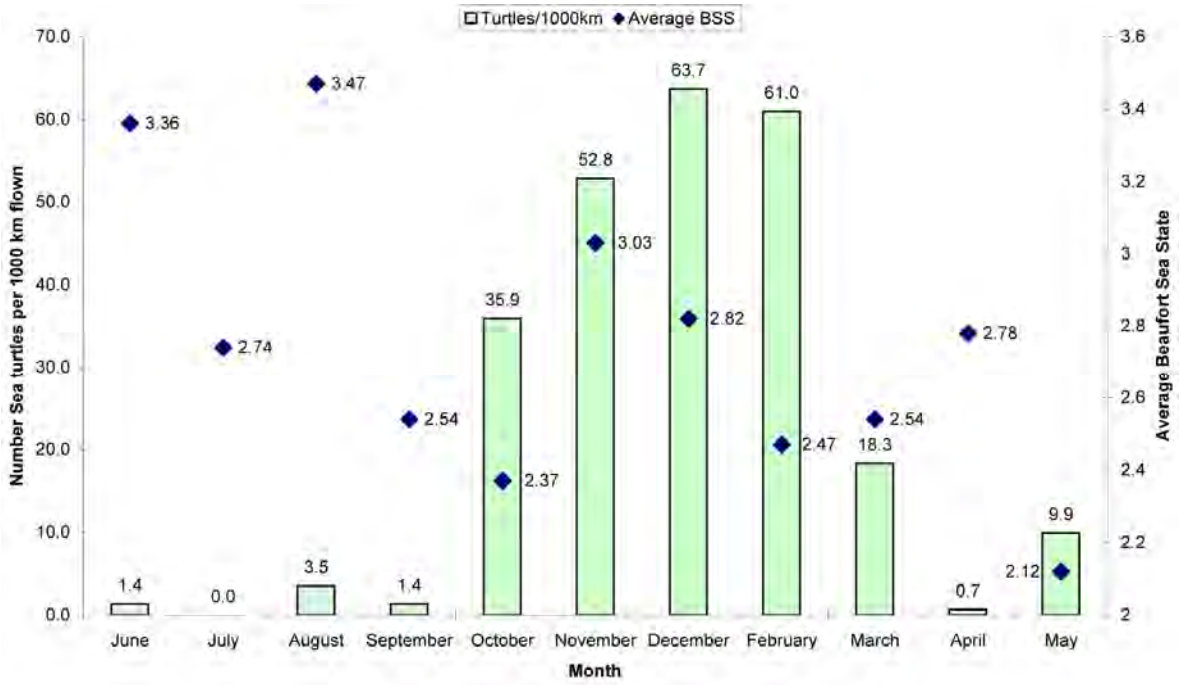


Figure 15a. Number of sea turtles seen per 1000 km flown during aerial surveys conducted at the proposed USWTR site in Onslow Bay, NC between June 2007 and June 2008.

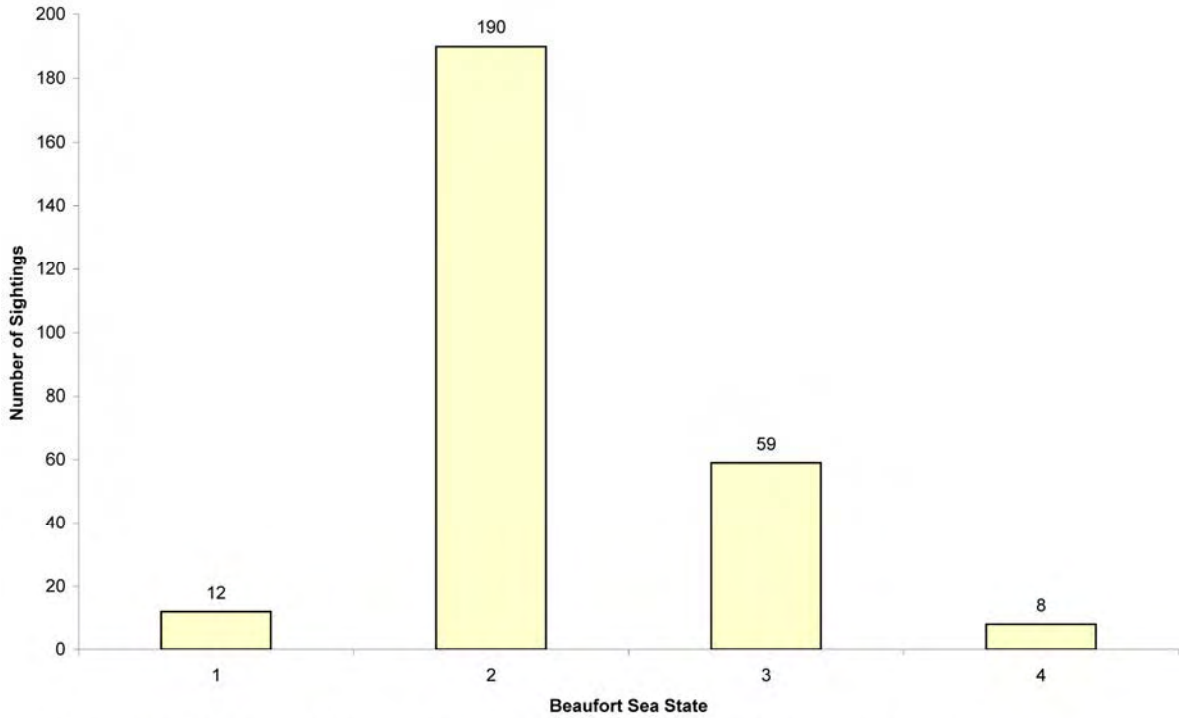


Figure 15b . Total number of sea turtle sightings by Beaufort Sea State in the proposed USWTR site in Onslow Bay, North Carolina during June 2007 - June 2008.

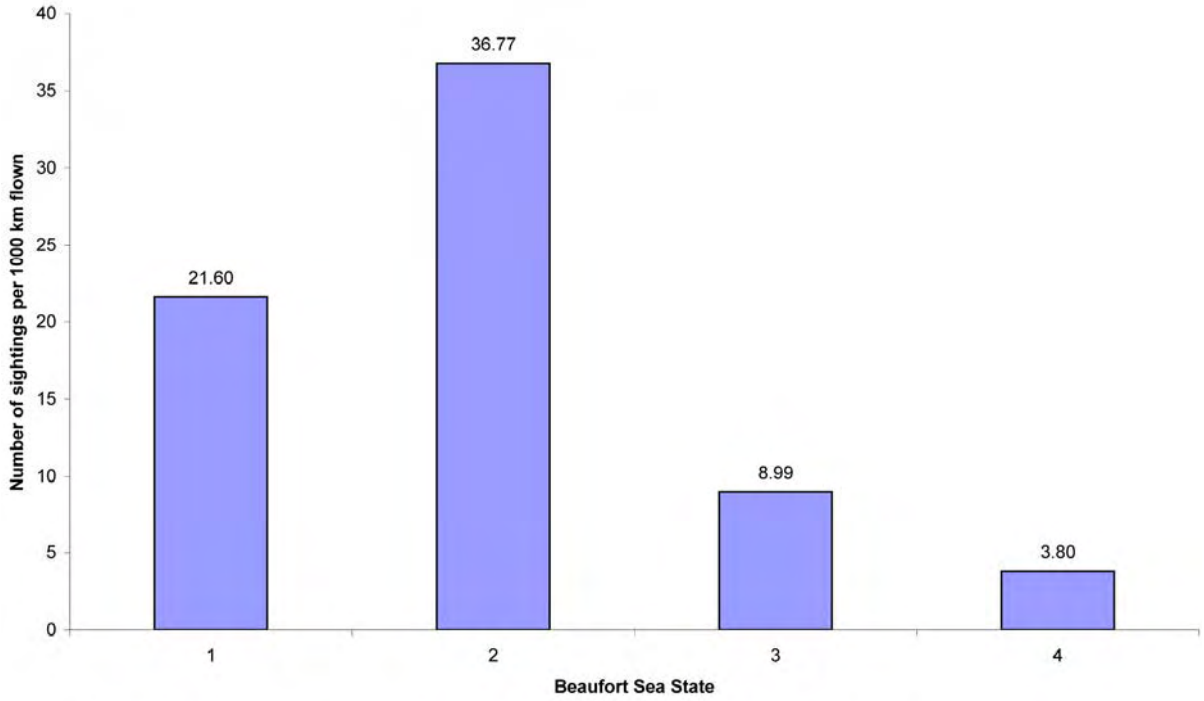


Figure 15C. Turtle sightings per 1000 km flown by Beaufort Sea State from June 2007 - June 2008 in the proposed USWTR site in Onslow Bay, North Carolina.

Other Marine Vertebrate Sightings (Fig. 16)

Chondrichtian fishes

Sharks were observed 12 times throughout the survey period; hammerhead sharks (*Sphyrna* spp.) were the most commonly sighted species (n=9) (Table 15).

Manta rays (*Manta birostris*), were observed 16 times. The majority of sightings (n=12) occurred during the March surveys (Table 16).

Other

Ocean sunfish (*Mola mola*) were encountered six times with no discernable spatial or temporal trends (Table 17).

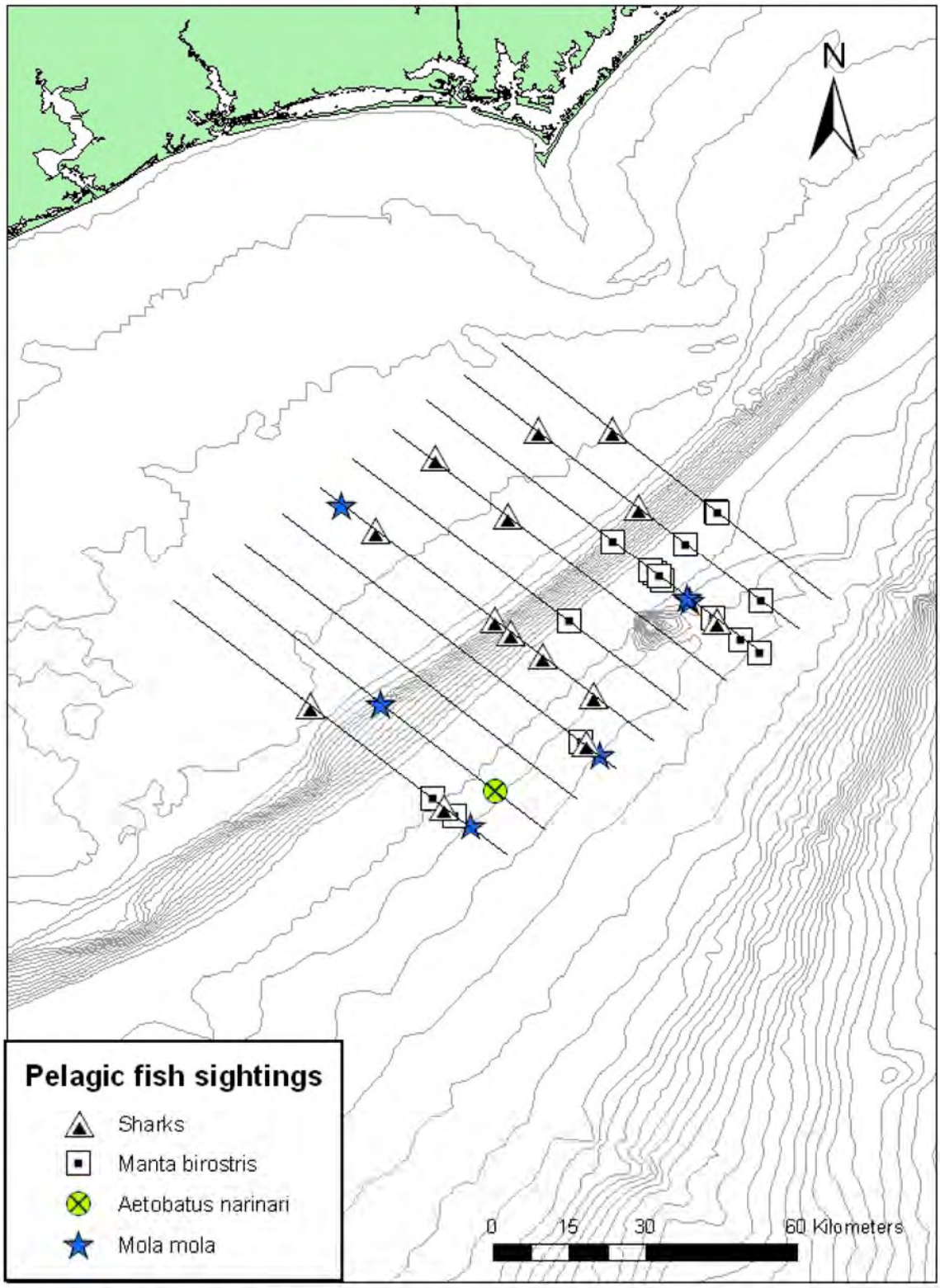


Figure 16. Pelagic fish species sightings observed in Onslow Bay, NC USWTR proposed location.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
19-Nov-07	9:31	7	33.779074	-76.622973	SE	5	1	90	3	1	1	1
19-Nov-07	10:50	39	34.069181	-76.728993	SE	7	1	90	3	2	2	2
19-Nov-07	12:02	72	34.120057	-76.545933	SE	9	1	90	3	1	1	1
11-Dec-07	13:38	48	33.445632	-76.713235	NW	1	2	90	3	1	1	1
25-Feb-08	10:24	15	33.982593	-76.366774	NW	9	2	90	3	1	1	1
29-Feb-08	10:10	6	33.940335	-76.835061	SE	5	3	90	3	1	1	1
11-Mar-08	9:52	23	33.715483	-76.537974	SE	5	2	90	3	1	1	1
13-Mar-08	10:32	6	33.628617	-76.950755	SE	1	3	90	3	1	1	1
25-Apr-08	12:17	41	33.757103	-76.594525	NW	5	1	90	3	2	2	2
25-May-08	11:13	18	33.96615	-76.600401	NW	7	1	90	3	1	1	1
25-Jun-08	9:44	6	33.646379	-76.446961	SE	5	3	90	3	1	1	1
25-Jun-08	15:07	52	33.559897	-76.461445	SE	4	1	90	3	1	1	1

Table 15. All shark sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #	Comments
24-Sep-07	15:56	14	33.918773	-76.411349	SE	8	2	90	3	1	1	1	Manta Ray
25-Sep-07	9:21	10	33.777154	-76.489689	NW	6	2	90	3	1	1	1	Manta Ray
15-Oct-07	9:00	9	33.476036	-76.620023	NW	2	1	90	3	1	1	1	Spotted Eagle Ray
11-Dec-07	12:29	26	33.563070	-76.467683	SE	4	2	60	3	1	1	1	Manta Ray
11-Mar-08	13:57	30	33.915239	-76.280784	NW	9	2	90	3	1	1	1	Manta Ray
11-Mar-08	14:58	70	33.850148	-76.322100	SE	8	1	90	3	1	1	1	Manta Ray
11-Mar-08	15:02	73	33.781697	-76.231406	SE	8	2	60	3	1	1	1	Manta Ray
11-Mar-08	15:04	74	33.744428	-76.182765	SE	8	2	60	3	1	1	1	Manta Ray
11-Mar-08	15:07	45	33.720514	-76.150117	NW	8	1	90	3	1	1	1	Manta Ray
11-Mar-08	15:15	77	33.861743	-76.335525	NW	8	2	90	3	1	1	1	Manta Ray
11-Mar-08	15:15	48	33.868505	-76.344256	NW	8	1	80	3	1	1	1	Manta Ray
11-Mar-08	15:15	47	33.857030	-76.329143	NW	8	3	90	3	1	1	1	Manta Ray
13-Mar-08	10:41	7	33.462454	-76.733200	SE	1	2	90	3	1	1	1	Manta Ray
13-Mar-08	14:43	65	33.974459	-76.227783	SE	10	2	90	3	1	1	1	Manta Ray
13-Mar-08	14:43	46	33.971680	-76.224445	SE	10	2	90	3	1	1	1	Manta Ray
13-Mar-08	15:05	52	33.813835	-76.147014	NW	9	3	90	3	1	1	1	Manta Ray
25-Jun-08	16:16	66	33.430343	-76.693036	NW	1	1	90	3	1	1	1	Manta Ray

Table 16. All ray sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Sighting Cue	Min #	Max #	Best #
8-Aug-07	10:13	15	33.411883	-76.664571	NW	1	2	90	3	1	1	1
11-Dec-07	12:05	27	33.984582	-76.895008	NW	5	3	90	3	1	1	1
11-Mar-08	15:00	72	33.814097	-76.274118	SE	8	2	60	3	1	1	1
11-Mar-08	15:13	46	33.819542	-76.278470	NW	8	2	90	3	1	1	1
13-Mar-08	12:22	43	33.538583	-76.434512	NW	4	3	100	3	1	1	1
25-Apr-08	15:20	76	33.631182	-76.824754	SE	2	1	90	3	1	1	1

Table 17. All *Mola mola* sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Vessel Sightings

Commercial (Table 18, Fig. 17)

A total of 57 commercial vessels were seen during the study. This category includes tankers, container/cargo vessels, and car carriers.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
17-Jul-07	8:35	7	34.163089	-76.465062	SE	10	5	45	1	Large Container Vessel Heading South
17-Jul-07	9:14	16	34.131651	-76.568242	NW	9	5	45	1	Large Contianer Vessel (possible resight)
17-Jul-07	10:08	19	34.074873	-76.745012	NW	7	2	90	1	Container vessel, 0.5 NM off
17-Jul-07	13:03	37	33.815690	-76.800494	SE	4	4	90	1	Large tanker, ~ 4 NM off
17-Jul-07	13:36	44	33.734081	-76.830549	NW	3	3	45	1	Transport vessel heading south
6-Aug-07	12:38	10	34.160002	-76.466282	SE	10	4	90	1	Container vessel ~1.5 miles off
6-Aug-07	13:05	19	33.909795	-76.271022	NW	9	4	30	1	Conatiner vessel heading south
6-Aug-07	13:37	25	33.883304	-76.365213	SE	8	4	45	1	Resight of large cargo vessel on line 9
6-Aug-07	14:49	38	33.789122	-76.636289	NW	5	5	45	1	Conatiner vessel ~1.5 - 2 miles off
24-Sep-07	9:55	9	33.433266	-76.696337	SE	1	3	45	1	Car carrier 3.5 nm, heading N
24-Sep-07	10:15	12	33.653157	-76.853828	NW	2	4	80	1	Container vessel, 4 nm off
25-Sep-07	8:51	4	33.921644	-76.808241	SE	5	3	110	1	Container vessel, 2 NM off
25-Sep-07	8:54	6	33.860589	-76.723806	SE	5	1	45	1	Container vessel on track line
25-Sep-07	8:57	5	33.799134	-76.643618	SE	5	3	100	1	Freighter, ~ 2 NM off
25-Sep-07	10:18	14	33.935540	-76.431647	NW	8	3	90	1	Container vessel, 2.5 NM off
25-Sep-07	14:37	38	33.767156	-76.733429	SE	4	4	30	1	Commercial transport vessel: RORO
25-Sep-07	15:22	56	33.815327	-76.988273	NW	3	4	90	1	Container vessel, 3 NM off
14-Oct-07	9:16	7	33.744909	-77.110551	SE	1	5	80	1	Unid medium sized vessel ~ 4 miles off
14-Oct-07	10:02	11	33.683243	-76.893646	NW	2	4	90	1	Tanker heading south ~ 4 miles off
14-Oct-07	10:58	22	33.873086	-76.877594	NW	4	3	90	1	Conatiner vessel ~ 2 miles off
15-Oct-07	13:55	44	33.961245	-76.599022	SE	7	3	90	2	Ocean tug and tow ~3.5 miles off
15-Oct-07	14:18	50	33.805262	-76.259113	NW	8	4	90	1	Large tanker ~3.5 miles off
15-Oct-07	14:56	57	33.913173	-76.278233	SE	9	4	90	1	Container vessel ~ 4 miles off
17-Nov-07	11:06	28	33.664156	-76.738450	NW	3	3	90	1	Tanker, ~2.5 NM off
17-Nov-07	11:14	32	33.739619	-76.839638	NW	3	3	90	1	Container vessel 3 NM off
17-Nov-07	14:57	40	33.548434	-76.717855	SE	2	5	30	1	Container vessel ~1.5 miles off
18-Nov-07	9:19	11	34.054119	-76.327538	SE	10	4	90	1	Container vessel, ~3 NM off
18-Nov-07	11:39	38	33.766328	-76.478141	SE	6	3	90	3	Tug, barge and third vessel ~ 2.5 NM off
18-Nov-07	15:36	52	33.759589	-76.865459	NW	3	4	45	1	Container vessel , ~1mile off
18-Nov-07	16:16	57	33.451887	-76.721871	NW	1	4	30	1	Container vessel heading north
19-Nov-07	9:30	6	33.810310	-76.664391	SE	5	4	90	1	Container vessel, 3 NM off
19-Nov-07	9:32	8	33.770066	-76.611010	SE	5	4	90	1	Container vessel, 3.5 NM off
19-Nov-07	10:25	21	33.850875	-76.590502	NW	6	4	60	1	Transport vessel stationary
19-Nov-07	12:41	84	34.131168	-76.426563	NW	10	3	90	2	Tug and barge, ~ 1.5 NM off
25-Feb-08	10:23	14	33.977955	-76.360265	NW	9	3	90	1	Container vessel 3 NM off
25-Feb-08	10:29	17	34.085899	-76.506323	NW	9	3	90	1	Container vessel, ~5 NM
11-Mar-08	10:32	31	34.058266	-76.718650	SE	7	3	45	2	Tug and barge
11-Mar-08	10:38	14	33.935371	-76.561714	SE	7	4	110	1	Container vessel, ~1 3/4 miles off
11-Mar-08	13:57	55	33.896805	-76.257795	NW	9	3	30	1	Large container vessel
11-Mar-08	15:23	79	34.018460	-76.541758	NW	8	4	30	1	Large container vessel
13-Mar-08	11:52	30	33.839642	-76.967066	SE	3	4	80	2	Tug and barge
13-Mar-08	14:44	47	33.952484	-76.198122	SE	10	2	30	1	Container vessel stationary
25-Apr-08	12:00	36	33.670443	-76.350071	SE	6	3	80	1	Container vessel

Table 18. All commercial vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
25-Apr-08	14:58	62	33.780995	-76.892178	NW	3	1	70	1	Container vessel
25-Apr-08	15:13	74	33.773450	-77.009268	SE	2	5	45	1	Research boat
25-Apr-08	15:14	75	33.746507	-76.974308	SE	2	5	60	1	Transport/ cargo vessel
26-Apr-08	10:26	10	33.822235	-76.945419	SE	3	5	45	1	Large research vessel
25-May-08	10:09	7	33.774146	-76.099131	NW	9	3	45	1	Large cargo vessel
26-May-08	8:35	3	33.771146	-77.138047	SE	1	2	30	2	Tug and barge
26-May-08	9:40	20	33.85642	-76.99182	SE	3	1	90	2	Tug and barge
26-May-08	10:20	23	33.873287	-76.875076	NW	4	4	30	2	Tug and barge resight
26-May-08	10:31	26	33.951996	-76.850759	SE	5	3	45	1	Tug and barge resight
26-May-08	14:43	59	33.85382	-76.07484	SE	10	3	90	1	Yacht
24-Jun-08	11:24	17	34.167813	-76.611538	SE	9	3	90	1	Large vessel
24-Jun-08	11:28	18	34.079963	-76.494669	SE	9	3	90	1	Container vessel
24-Jun-08	15:27	41	33.619519	-76.808501	SE	2	45	1	1	Container vessel
25-Jun-08	10:12	11	33.869459	-76.614478	NW	6	120	4	1	Container vessel
25-Jun-08	11:45	28	34.202044	-76.660157	SE	9	4	30	1	Cargo vessel
25-Jun-08	11:51	37	34.076816	-76.490015	SE	9	150	1	2	Tug and barge

Table 18. All commercial vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

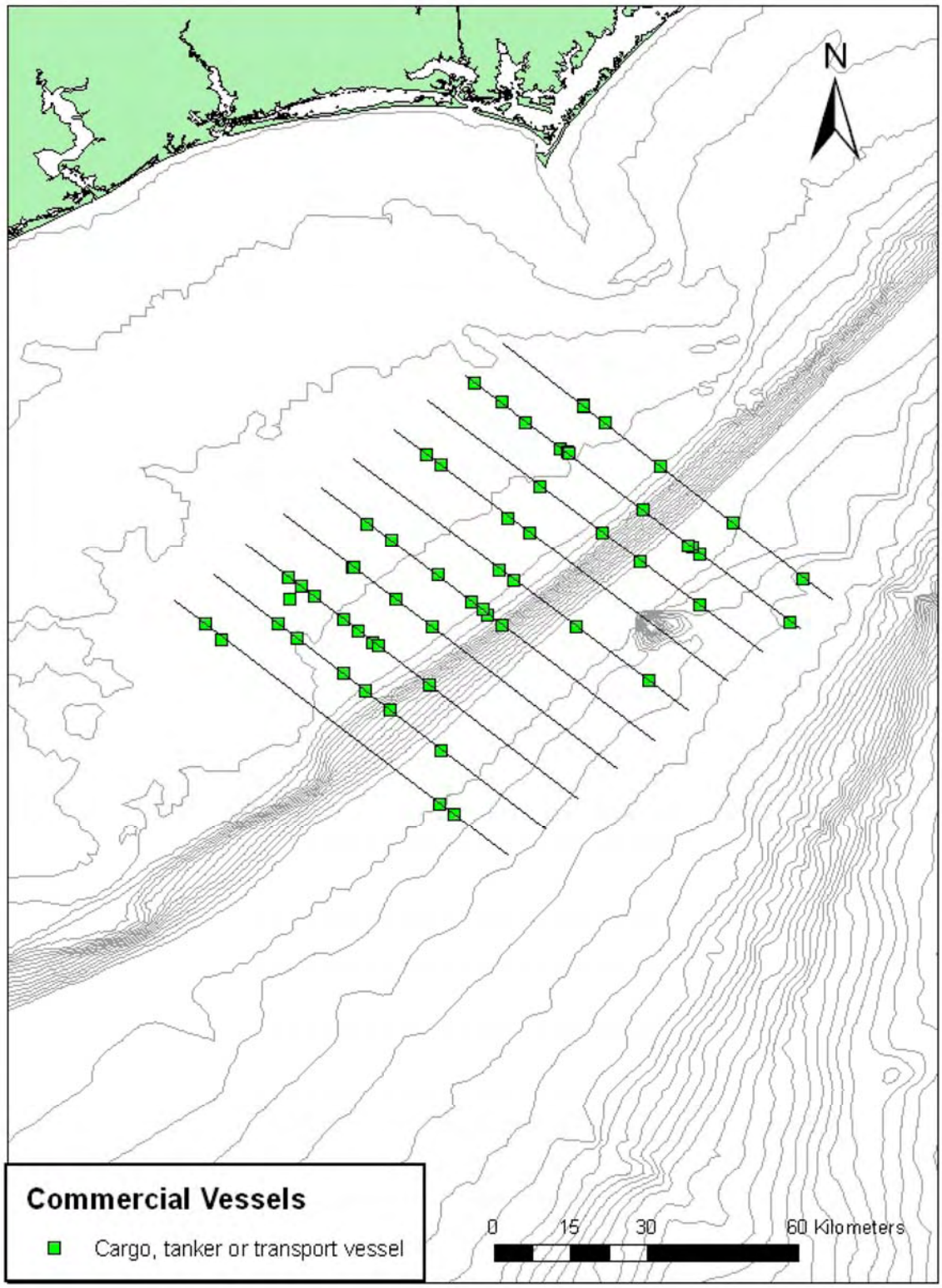


Figure 17. Location of Commercial vessels observed in Onslow Bay, NC USWTR proposed location.

Military (Table 19, Fig. 18)

Six U.S. Navy vessels were observed in the study site.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
26-Jun-07	11:11	10	34.124544	-76.420892	SE	10	4	30	1	Military vessel, ~ 1/2 - 1 mile off
18-Nov-07	10:16	23	34.172512	-76.739990	NW	9	4	90	1	Navy vessel, ~ 4 NM off, stationary
11-Dec-07	13:20	42	33.621663	-76.814648	SE	2	5	90	1	Navy frigate ~2 miles off
13-Mar-08	12:05	38	33.593884	-76.650770	SE	3	4	60	2	Aircraft carrier and tanker
13-Mar-08	15:04	51	33.802262	-76.133573	NW	9	4	30	1	Military tanker
25-Apr-08	14:20	53	33.656682	-76.590546	SE	4	4	90	1	Navy vessel

Table 19. All military vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

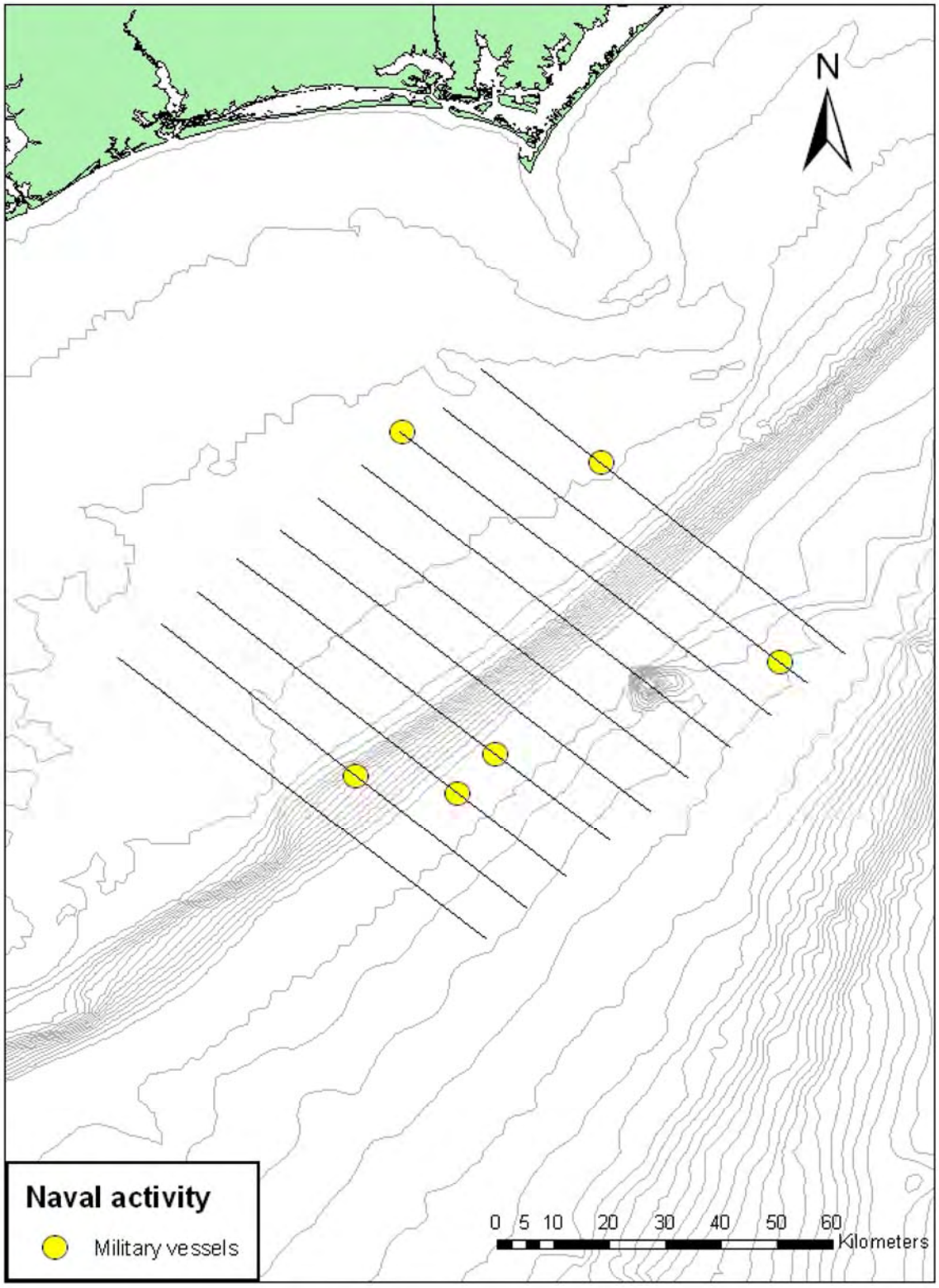


Figure 18. Location of Naval vessels observed in the Onslow Bay NC USWTR proposed location.

Recreational (Table 20, Fig. 19)

The most commonly sighted type of vessel in the survey area were recreational fishing vessels (n=334), with the majority of sightings occurring at or shoreward of the continental shelf break.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
26-Jun-07	10:47	10	34.244672	-76.573145	SE	10	3	90	1	Fishing vessel, ~ 3 NM off
26-Jun-07	10:48	11	34.219190	-76.539714	SE	10	2	90	1	Recreational vessel, ~ 400 m off
26-Jun-07	11:13	19	34.079172	-76.360674	SE	10	3	120	1	Small fishing vessel, ~ 500 m off
26-Jun-07	12:13	26	33.991028	-76.377964	NW	9	2	75	1	Head boat, 2 NM off track line
26-Jun-07	12:13	24	33.996445	-76.384962	NW	9	2	30	1	1 Recreational vessel 60ft, gear out
26-Jun-07	12:14	27	34.011907	-76.406309	NW	9	2	85	1	Fishing vessel, ~ 2/3 NM off
26-Jun-07	12:21	27	34.165695	-76.608122	NW	9	4	60	1	Recreational vessel ~ 1/2 mile off
17-Jul-07	8:31	5	34.267309	-76.579856	SE	10	4	45	1	Commercial fishing vessel, ~ 3/4 mile off
17-Jul-07	9:13	15	34.120066	-76.551848	NW	9	3	30	1	Commercial fishing vessel ~1 mile off
17-Jul-07	10:06	18	34.029459	-76.685393	NW	7	3	90	1	17 foot sportfishing vessel, ~ 1.0 NM off
17-Jul-07	10:25	26	33.831504	-76.560904	SE	6	3	45	1	Commercial fishing vessel ~1/2 mile off
17-Jul-07	12:58	36	33.922335	-76.941578	SE	4	2	30	1	Recreational fishing vessel ~200m off
17-Jul-07	13:34	43	33.692554	-76.775909	NW	3	2	45	1	Commercial fishing vessel ~1/2 mile off
17-Jul-07	13:58	45	33.667330	-76.870410	SE	2	2	90	2	2 sport fishing vessels, 0.75 and 2 NM
18-Jul-07	9:19	15	33.926358	-76.686413	NW	6	1	60	1	~200m off
18-Jul-07	9:36	19	33.971490	-76.608240	SE	7	3	90	1	Small sport fishing vessel, 3 NM off
18-Jul-07	9:41	20	33.870871	-76.478091	SE	7	3	100	1	Small sport fishing vessel, 1.5 NM off
18-Jul-07	10:57	39	34.031992	-76.300644	NW	10	3	90	1	Small sport fishing vessel, 1.5 NM off
18-Jul-07	10:58	40	34.044508	-76.315991	NW	10	2	90	1	Small sport fishing vessel, 500 m off
18-Jul-07	11:03	42	34.165599	-76.470186	NW	10	3	90	1	Small sport fishing vessel, 2.0 NM off
18-Jul-07	14:01	54	33.664496	-76.867985	SE	2	3	90	1	Sport fishing vessel, ~1.75 NM off
18-Jul-07	14:31	57	33.632676	-76.959681	NW	1	2	90	1	Fishing vessel, anchored, ~1.25 NM off
6-Aug-07	12:40	12	34.127540	-76.423425	SE	10	2	130	1	Small sport fishing vessel ~ 3/4 NM off
6-Aug-07	13:04	18	33.892911	-76.250656	NW	9	3	30	1	Recreational fishing vessel, ~3/4 mile off
6-Aug-07	13:07	17	33.954071	-76.329252	NW	9	2	150	1	Sport fishing vessel, ~ 1/2 mile off
6-Aug-07	13:10	20	34.005759	-76.397894	NW	9	4	45	2	2 Commercial fishing vessels
6-Aug-07	13:15	21	34.123883	-76.554898	NW	9	4	60	1	Fishing vessel, stationary ~3/4 mile off
6-Aug-07	13:17	22	34.159095	-76.601344	NW	9	4	60	2	2 Commercial fishing vessels, stationary
6-Aug-07	13:34	21	34.143629	-76.580861	SE	8	3	100	1	Aport fishing vessel, ~1.5 mile off
6-Aug-07	14:48	37	33.776769	-76.620641	NW	5	4	45	1	Recreational fishing vessel ~1 mile off
6-Aug-07	14:51	35	33.835007	-76.695666	NW	5	3	100	1	Sport fishing vessel, ~ 2 NM off
7-Aug-07	10:45	20	33.868864	-76.731489	SE	5	3	90	1	Sport fishing vessel, ~ 2 NM off
7-Aug-07	14:00	32	33.991371	-76.631464	SE	7	4	90	1	Small recrational vessel ~3/4 miles off
7-Aug-07	14:00	33	33.978255	-76.615234	SE	7	3	60	1	Headboat stationary ~ 1/2 mile off
7-Aug-07	14:04	35	33.893234	-76.511857	SE	7	1	90	1	Fishing vessel on track line
7-Aug-07	14:05	36	33.872032	-76.482031	SE	7	1	90	1	Sport fishing vessel
7-Aug-07	14:50	43	34.043319	-76.439008	SE	9	4	60	1	Recreational fishing vessel heading NW
8-Aug-07	9:53	11	33.743713	-76.972664	SE	2	3	90	1	Sport fishing vessel, ~ 1.75 miles off
24-Sep-07	10:31	13	33.862263	-76.998902	SE	3	4	60	1	Commercial fishing vessel, ~ 1/2 mile off
24-Sep-07	11:17	18	33.935103	-76.957816	NW	4	3	85	1	Unidentified vessel, 2 NM off
24-Sep-07	14:49	3	34.142197	-76.442316	SE	10	1	45	1	Commercial fishing vessel

Table 20. All fishing vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
24-Sep-07	14:50	30	34.121424	-76.416458	SE	10	2	90	1	Small recreational fishing vessel, 2 NM off
24-Sep-07	14:52	31	34.087002	-76.373357	SE	10	3	80	2	2 recreational fishing vessels, ~ 2 NM off
24-Sep-07	15:28	11	33.975756	-76.359291	NW	9	3	45	1	Stationanry fishing vessel
24-Sep-07	15:32	34	34.041586	-76.449855	NW	9	3	90	1	Headboat ~ 3 NM off
25-Sep-07	8:55	7	33.839758	-76.696130	SE	5	5	90	1	Recreational fishing vessel ~ 1.5 miles off
25-Sep-07	9:52	14	33.875500	-76.483890	SE	7	2	60	1	Recreational fishing vessel ~300 m off
25-Sep-07	11:19	25	33.984730	-76.378347	SE	9	4	60	1	Commercial fishing vessel ~1/5 mile off
25-Sep-07	11:20	26	33.974368	-76.364214	SE	9	3	90	1	Recreational fishing vessel, ~ 1.5 NM off
25-Sep-07	11:43	29	33.995897	-76.253990	NW	10	3	100	1	Recreational fishing vessel, ~ 1.5 NM off
25-Sep-07	11:55	28	34.251255	-76.592719	NW	10	4	90	1	Commercial fishing vessel, ~ 1/5 mile off
25-Sep-07	14:35	46	33.798573	-76.775632	SE	4	1	90	1	Recreational fishing vessel, anchored
25-Sep-07	14:39	47	33.730426	-76.688823	SE	4	3	90	3	3 recreational fishing vessel,~ 2-3 NM off
14-Oct-07	9:59	13	33.627829	-76.822557	NW	2	3	90	1	Headboat
14-Oct-07	10:06	12	33.768509	-77.004988	NW	2	3	90	1	Recreational fishing vessel ~ 3 miles off
14-Oct-07	10:07	13	33.786821	-77.028580	NW	2	3	90	1	Recreational fishing vessel ~ 2 miles off
14-Oct-07	10:08	14	33.813609	-77.063177	NW	2	3	90	1	Small vessel
14-Oct-07	10:18	17	33.847997	-76.975520	SE	3	2	90	1	Small vessel
14-Oct-07	10:22	18	33.754821	-76.856458	SE	3	1	90	1	Large headboat
14-Oct-07	10:26	19	33.675526	-76.759837	SE	3	3	90	5	Small vessels
14-Oct-07	10:51	22	33.727175	-76.683448	NW	4	3	90	2	Hatteras vessels
14-Oct-07	10:51	20	33.727309	-76.683810	NW	4	4	90	1	Recreational fishing vessel ~ 2 miles off
14-Oct-07	10:51	19	33.718828	-76.672490	NW	4	3	90	2	2 Recreational fishing vessels ~300m off
14-Oct-07	10:59	23	33.880935	-76.888324	NW	4	3	90	1	Head boat ~ 2.5 miles off
14-Oct-07	11:42	29	33.818193	-76.539023	NW	6	3	90	1	Recreational vessel ~ 2 miles off
14-Oct-07	14:48	37	33.986762	-76.627193	SE	7	3	90	3	Fishing vessel
14-Oct-07	14:52	38	33.914604	-76.528939	SE	7	2	90	1	Fishing vessel
14-Oct-07	14:53	40	33.888439	-76.496570	SE	7	1	90	1	Recreational fishing vessel stationary
14-Oct-07	14:54	39	33.872339	-76.477630	SE	7	3	90	3	Fishing vessel
14-Oct-07	15:19	45	33.924132	-76.422679	NW	8	3	90	1	Recreational fishing vessel ~ 2miles off
14-Oct-07	15:21	46	33.976921	-76.484028	NW	8	3	90	1	Recreational fishing vessel ~ 2miles off
14-Oct-07	15:22	47	33.981867	-76.491726	NW	8	2	90	1	Recreational fishing vessel ~ 1.5 mile off
14-Oct-07	15:25	48	34.041652	-76.572455	NW	8	2	90	1	Headboat ~ 3/4 miles off trackline
14-Oct-07	15:29	50	34.125504	-76.681264	NW	8	3	90	2	2 Sport fishing vessel ~ 2.5 miles off
14-Oct-07	15:45	53	34.022906	-76.420746	SE	9	3	90	2	2 fishing vessels (1 and 1.5 miles off)
14-Oct-07	15:46	47	33.994003	-76.383432	SE	9	2	90	1	Fishing vessel
14-Oct-07	16:14	58	34.068075	-76.346431	NW	10	3	90	1	Sport fishing vessel ~2 miles off
14-Oct-07	16:22	60	34.218854	-76.540777	NW	10	3	90	3	3 sport fishing vessels ~ 3 miles off
15-Oct-07	8:30	4	33.811788	-77.190716	SE	1	2	90	1	Small vessel
15-Oct-07	8:31	7	33.789118	-77.162718	SE	1	3	90	1	Recreational fishing vessel ~2 miles off
15-Oct-07	8:35	5	33.726939	-77.078909	SE	1	2	90	1	Small vessel
15-Oct-07	9:27	14	33.845900	-76.970280	SE	3	3	90	1	Small vessel
15-Oct-07	10:02	18	33.757720	-76.726587	NW	4	4	90	3	Large vessels

Table 20. All fishing vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
15-Oct-07	10:07	19	33.876672	-76.889745	NW	4	2	90	1	Recreational fishing vessel ~3/4 miles off
15-Oct-07	10:51	31	33.816949	-76.541147	NW	6	3	90	2	2 Recreational fishing vessel
15-Oct-07	10:52	32	33.849101	-76.581621	NW	6	3	90	1	Recreational fishing vessel ~2 miles off
15-Oct-07	10:58	27	33.962576	-76.734049	NW	6	2	90	1	Hatteras boat
15-Oct-07	13:54	43	33.988985	-76.634419	SE	7	3	90	1	Sports fishing vessel ~3 miles off trackline
15-Oct-07	13:57	35	33.920142	-76.541383	SE	7	3	90	3	Small vessels
15-Oct-07	14:00	46	33.871428	-76.474880	SE	7	1	90	1	Passed over fishing vessel
15-Oct-07	14:25	51	33.947154	-76.447124	NW	8	2	90	2	2 recreational fishing vessels ~1 mile off
15-Oct-07	14:30	52	34.037844	-76.565580	NW	8	3	90	1	Fishing vessel ~1.5 miles off
15-Oct-07	14:48	56	34.066152	-76.476875	SE	9	2	90	1	Recreational fishing vessel ~1.5 miles off
15-Oct-07	14:51	40	34.004433	-76.395177	SE	9	2	90	1	Small vessel
15-Oct-07	15:27	61	34.247962	-76.576353	NW	10	3	90	1	Sports fishing vessel ~ 2miles off
18-Nov-07	9:10	10	34.237677	-76.559812	SE	10	3	90	1	Fishing vessel
18-Nov-07	10:04	20	34.172587	-76.621002	NW	9	3	90	1	Headboat, 2 NM off
18-Nov-07	11:06	31	33.978828	-76.615242	NW	7	4	100	1	Sport fishing, ~ 1 NM off stationary
18-Nov-07	11:32	37	33.914119	-76.671784	SE	6	4	60	1	Stationary recreational fishing vessel
18-Nov-07	11:32	36	33.913944	-76.671552	SE	6	3	90	1	Headboat ~ 1.75 NM off, stationary
18-Nov-07	15:56	62	33.668112	-76.871934	SE	2	3	90	1	Sailing vessel, ~ 1.75 NM off
19-Nov-07	11:04	34	33.904767	-76.521150	SE	7	3	60	1	Recreational fishing vessel
19-Nov-07	11:05	35	33.877133	-76.485115	SE	7	2	60	1	Stationary Recreational fishing vessel
19-Nov-07	12:08	76	33.977666	-76.363153	SE	9	3	90	1	Recreational vessel, ~2.5 NM off
19-Nov-07	12:47	87	34.248820	-76.579081	NW	10	2	80	1	Sport fishing vessel, ~0.5 NM off
11-Dec-07	12:13	30	33.897262	-76.907786	SE	4	4	90	1	Small recreational vessel, 2.5 NM off
11-Dec-07	12:21	25	33.730095	-76.688251	SE	4	4	60	1	Recreational fishing vessel stationary
11-Dec-07	12:36	29	33.456405	-76.471972	NW	3	3	30	1	Staionary recreational fishing vessel
11-Dec-07	13:20	41	33.635364	-76.832863	SE	2	5	90	1	Stationary recreational fishing
25-Feb-08	9:51	9	34.176539	-76.485178	SE	10	4	3	1	Recreational fishing vessel
25-Feb-08	13:57	45	33.762250	-77.128517	SE	1	3	90	1	Recreational fisherman
25-Feb-08	14:51	61	33.764180	-76.999938	NW	2	4	90	1	Recreational fishing vessel
25-Feb-08	15:48	73	33.905370	-76.923209	NW	4	4	90	1	Recreational fishing vessel
29-Feb-08	10:38	19	33.562342	-76.338956	SE	5	4	60	1	Recreational fishing vessel
29-Feb-08	11:07	29	34.043021	-76.838591	NW	6	2	90	1	Recreational fishing vessel
29-Feb-08	11:24	26	34.013892	-76.662347	SE	7	3	90	1	Tug and Barge
11-Mar-08	9:44	5	33.878659	-76.754109	SE	5	4	110	1	Small Recreational fishing vessel
11-Mar-08	9:49	22	33.770859	-76.611372	SE	5	3	90	1	Commercial fishing vessel
11-Mar-08	10:12	9	33.791571	-76.508419	NW	6	4	120	1	1 1/4 miles off trackline
11-Mar-08	10:13	10	33.811962	-76.534551	NW	6	4	90	1	Recreational vessel ~2 miles off
11-Mar-08	10:14	27	33.829816	-76.558607	NW	6	4	45	1	Recreational fishing vessel ~ 1 mile off
11-Mar-08	10:35	13	34.009566	-76.653544	SE	7	3	100	1	Recreational vessel ~1 mile off
11-Mar-08	10:40	32	33.892748	-76.503556	SE	7	4	90	1	Stationary recreational fishing vessel
11-Mar-08	10:40	15	33.891742	-76.502400	SE	7	3	90	1	Recreational fishing vessel

Table 20. All fishing vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
11-Mar-08	13:34	25	34.043946	-76.316582	SE	10	4	3	1	Recreational fishing vessel
11-Mar-08	13:42	50	33.890850	-76.120605	SE	10	2	90	1	Commercial fishing vessel
11-Mar-08	14:01	31	33.989109	-76.376014	NW	9	3	2	1	Recreational fishing vessel
11-Mar-08	14:03	33	34.015532	-76.410432	NW	9	4	2	1	Recreational fishing vessel
11-Mar-08	14:26	61	34.112919	-76.541914	NW	9	2	90	1	Recreational fishing vessel
11-Mar-08	14:42	38	34.158606	-76.725740	SE	8	4	1	1	Recreational fishing vessel
11-Mar-08	14:53	41	33.951972	-76.454552	SE	8	3	90	1	Recreational fishing vessel
11-Mar-08	15:18	50	33.927193	-76.421275	NW	8	3	1	1	Recreational fishing vessel
11-Mar-08	15:28	51	34.113747	-76.665677	NW	8	3	4	1	Recreational fishing vessel
11-Mar-08	15:30	80	34.149875	-76.713433	NW	8	4	60	1	Recreational fishing vessel
13-Mar-08	10:33	6	33.611073	-76.929433	SE	1	4	90	1	Recreational fishing vessel
13-Mar-08	10:34	7	33.595774	-76.911092	SE	1	3	80	1	Recreational fishing vessel
13-Mar-08	11:03	12	33.631086	-76.823306	NW	2	3	75	1	Recreational fishing vessel
13-Mar-08	11:05	12	33.667029	-76.869367	NW	2	3	30	1	Recreational fishing vessel
13-Mar-08	11:05	11	33.653905	-76.852671	NW	2	4	45	1	Commercial fishing vessel
13-Mar-08	11:06	13	33.674007	-76.878753	NW	2	4	90	1	Recreational fishing vessel
13-Mar-08	11:52	29	33.846360	-76.977698	SE	3	2	90	1	Recreational fishing vessel
13-Mar-08	12:36	50	33.789197	-76.764003	NW	4	3	90	1	Recreational fishing vessel
13-Mar-08	12:38	37	33.814529	-76.799151	NW	4	3	45	1	Recreational fishing vessel
13-Mar-08	14:30	44	34.217625	-76.539520	SE	10	3	30	1	Recreational fishing vessel
13-Mar-08	14:40	63	34.031276	-76.301735	SE	10	1	90	1	Recreational fishing vessel
13-Mar-08	14:40	64	34.018722	-76.285432	SE	10	3	110	1	Recreational fishing vessel
13-Mar-08	15:14	69	33.995730	-76.383551	NW	9	4	90	1	Recreational fishing vessel
13-Mar-08	15:14	53	33.986402	-76.371040	NW	9	2	60	1	Recreational fishing vessel
13-Mar-08	15:15	70	34.009959	-76.402875	NW	9	3	90	1	Recreational fishing vessel
13-Mar-08	15:39	74	33.977627	-76.487445	SE	8	2	90	1	Small Commercial fishing vessel
13-Mar-08	15:41	58	33.947801	-76.447570	SE	8	1	45	1	Recreational fishing vessel
13-Mar-08	15:42	59	33.932509	-76.427725	SE	8	4	45	1	Recreational fishing vessel
13-Mar-08	16:21	83	33.978472	-76.616680	NW	7	2	90	1	Recreational fishing vessel
25-Apr-08	9:27	3	34.270468	-76.606513	SE	10	3	45	1	Recreational fishing vessel
25-Apr-08	9:28	5	34.253006	-76.585106	SE	10	2	100	1	Recreational fishing vessel
25-Apr-08	9:41	5	34.005452	-76.266806	SE	10	4	45	1	Recreational fishing vessel
25-Apr-08	10:04	14	33.947924	-76.323134	NW	9	3	60	2	Two recreational fishing vessels
25-Apr-08	10:48	26	33.934234	-76.430213	SE	8	3	45	1	Commercial fishing vessel
25-Apr-08	10:49	27	33.920588	-76.412144	SE	8	4	60	1	Recreational fishing vessel
25-Apr-08	10:49	24	33.920286	-76.411804	SE	8	3	60	1	Recreational fishing vessel
25-Apr-08	11:22	31	33.854108	-76.454840	NW	7	4	60	4	Four recreational fishing vessels
25-Apr-08	11:23	41	33.867119	-76.471973	NW	7	3	45	1	Recreational fishing vessel
25-Apr-08	11:35	32	34.096520	-76.771453	NW	7	3	80	1	Recreational fishing vessel
25-Apr-08	11:52	44	33.831822	-76.561443	SE	6	3	60	1	Recreational fishing vessel
25-Apr-08	11:52	35	33.836238	-76.567317	SE	6	4	90	1	Recreational fishing vessel
25-Apr-08	11:53	45	33.812798	-76.536533	SE	6	2	45	1	Recreational fishing vessel

Table 20. All fishing vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
25-Apr-08	12:18	43	33.784292	-76.630322	NW	5	3	70	1	Recreational fishing vessel
25-Apr-08	12:24	50	33.897052	-76.778688	NW	5	4	45	1	Recreational fishing vessel
25-Apr-08	12:25	44	33.918491	-76.806987	NW	5	3	45	1	Recreational fishing vessel
25-Apr-08	14:06	56	33.945673	-76.972998	SE	4	1	60	1	Recreational fishing vessel
25-Apr-08	14:16	58	33.730142	-76.687392	SE	4	4	90	1	Recreational fishing vessel
25-Apr-08	14:16	52	33.733233	-76.691441	SE	4	2	80	4	Four recreational fishing vessels
25-Apr-08	14:22	55	33.620979	-76.544014	SE	4	3	90	2	Recreational fishing vessels
25-Apr-08	14:53	69	33.671032	-76.749026	NW	3	3	60	1	Recreational fishing vessels
25-Apr-08	14:57	61	33.762963	-76.868556	NW	3	2	60	1	Recreational fishing vessel
25-Apr-08	15:02	64	33.856511	-76.990834	NW	3	3	90	1	Recreational fishing vessel
25-Apr-08	15:19	69	33.640277	-76.836556	SE	2	2	80	1	Recreational fishing vessel
26-Apr-08	9:35	3	33.681631	-77.021151	SE	1	4	90	1	Recreational fishing vessel
26-Apr-08	10:24	11	33.867035	-77.004079	SE	3	3	90	2	Recreational fishing vessels
26-Apr-08	10:24	9	33.852878	-76.985466	SE	3	1	60	1	Recreational fishing vessel
26-Apr-08	10:25	12	33.838854	-76.967226	SE	3	2	45	1	Recreational fishing vessel
26-Apr-08	10:34	11	33.667052	-76.743331	SE	3	2	0	1	Recreational fishing vessel
26-Apr-08	11:10	21	33.691064	-76.636700	NW	4	1	90	1	Recreational fishing vessel
26-Apr-08	11:10	16	33.690637	-76.636114	NW	4	2	45	1	Recreationl fishing vessel
26-Apr-08	11:11	22	33.711877	-76.664236	NW	4	4	60	1	Recreational fishing vessel
26-Apr-08	11:11	17	33.712163	-76.664578	NW	4	1	45	1	Recreationl fishing vessel
26-Apr-08	11:18	24	33.845573	-76.840835	NW	4	2	90	1	Recreational fishing vessel
26-Apr-08	11:20	18	33.891248	-76.901442	NW	4	1	90	1	Stationary recreational fishing vessel
26-Apr-08	13:25	33	34.107549	-76.397735	SE	10	1	90	1	Recreational fishing vessel
26-Apr-08	13:26	34	34.096137	-76.382956	SE	10	2	45	2	Two recreational fishing vessels
26-Apr-08	13:29	35	34.034919	-76.304454	SE	10	3	30	1	Recreational fishing vessel
26-Apr-08	13:29	26	34.034280	-76.303645	SE	10	4	60	1	Recreational fishing vessel
26-Apr-08	13:30	27	34.014620	-76.278693	SE	10	3	90	1	Recreational fishing vessel
26-Apr-08	13:32	36	33.967640	-76.218440	SE	10	4	90	1	Recreational fishing vessel
26-Apr-08	13:57	45	33.949933	-76.326067	NW	9	4	90	1	Recreational fishing vessel
26-Apr-08	13:58	46	33.965731	-76.346932	NW	9	2	60	1	Recreational fishing vessel
26-Apr-08	13:59	47	33.982810	-76.369527	NW	9	3	60	1	Recreational fishing vessel
26-Apr-08	13:59	36	33.978975	-76.364365	NW	9	1	45	1	Recreational fishing vessel
26-Apr-08	14:00	37	33.996795	-76.387871	NW	9	5	60	1	Recreational fishing vessel
26-Apr-08	14:05	48	34.111829	-76.539840	NW	9	1	80	1	Head boat anchored
26-Apr-08	14:23	51	33.950066	-76.450786	SE	8	3	70	1	Recreational fishing vessel
26-Apr-08	14:26	52	33.888715	-76.370540	SE	8	1	90	1	Recreational fishing vessel
26-Apr-08	15:06	60	33.977141	-76.752888	SE	6	3	30	1	Recreational fishing vessel
26-Apr-08	15:09	61	33.923480	-76.682089	SE	6	2	90	1	Recreational fishing vessel
26-Apr-08	15:12	62	33.850299	-76.585676	SE	6	3	60	1	Recreational fishing vessel
26-Apr-08	15:40	67	33.859896	-76.729903	NW	5	4	60	1	Recreational fishing vessel
25-May-08	9:51	4	34.109852	-76.399853	SE	10	4	60	1	Recreational fishing vessel
25-May-08	10:13	8	33.844213	-76.187116	NW	9	3	90	1	Recreational fishing vessel

Table 20. All fishing vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

Date	Time	Way Point	Latitude	Longitude-1	Heading	Track Number	Angle out	Degree Forward	Best #	Comments
26-May-08	15:17	57	34.072254	-76.610876	SE	8	1	60	1	Recreational fishing vessel
26-May-08	15:22	58	33.980721	-76.492015	SE	8	3	30	2	Recreational fishing vessel
26-May-08	15:26	59	33.895324	-76.381290	SE	8	2	45	1	Recreational fishing vessel
27-May-08	9:32	4	33.649237	-76.980501	SE	1	4	45	1	Recreational fishing vessel ~200m off
27-May-08	11:33	20	33.813598	-76.797694	NW	4	2	90	1	Recreational fishing vessel
24-Jun-08	10:19	6	33.919611	-76.679065	NW	6	45	3	1	Sailing vessel
24-Jun-08	10:36	9	33.992606	-76.635817	SE	7	100	4	1	Recreational fishing vessel
24-Jun-08	10:42	10	33.882690	-76.493237	SE	7	90	4	1	Recreational fishing vessel
24-Jun-08	10:50	11	33.712926	-76.272021	SE	7	70	3	1	Head boat
24-Jun-08	11:15	17	34.103057	-76.651772	NW	8	90	1	1	Recreational fishing vessel
24-Jun-08	12:07	21	34.226897	-76.553544	NW	10	2	45	1	Recreational fishing vessel
24-Jun-08	12:09	22	34.264817	-76.600080	NW	10	2	45	1	Recreational fishing vessel
25-Jun-08	9:29	3	33.942266	-76.833045	SE	5	45	2	1	Recreational fishing vessel
25-Jun-08	9:33	3	33.860613	-76.728798	SE	5	5	60	1	Recreational fishing vessel
25-Jun-08	10:40	19	34.028028	-76.681291	SE	7	90	2	1	Recreational fishing vessel
25-Jun-08	10:40	20	34.014335	-76.663604	SE	7	90	2	2	2 recreational fishing vessels
25-Jun-08	10:47	21	33.884286	-76.489791	SE	7	45	1	1	Recreational fishing vessel
25-Jun-08	11:46	33	34.173875	-76.618006	SE	9	100	2	1	Unidentified vessel (dive boat?)
25-Jun-08	11:50	36	34.104337	-76.525562	SE	9	100	2	1	Recreational fishing vessel
25-Jun-08	11:52	29	34.068556	-76.479370	SE	9	3	60	1	Recreational fishing vessel
25-Jun-08	12:57	52	34.230605	-76.551700	NW	10	120	3	1	Recreational fishing vessel
25-Jun-08	12:58	53	34.245909	-76.570117	NW	10	110	3	3	3 recreational fishing vessels
25-Jun-08	12:59	41	34.272554	-76.606153	NW	10	3	60	1	Recreational fishing vessel
25-Jun-08	14:40	58	33.906189	-76.920889	SE	4	90	1	1	Recreational fishing vessel
25-Jun-08	14:42	46	33.884001	-76.891471	SE	4	3	45	1	Recreational fishing vessel
25-Jun-08	14:43	59	33.848977	-76.844841	SE	4	120	3	1	Recreational fishing vessel
25-Jun-08	15:46	58	33.710026	-76.926794	SE	2	2	30	1	Recreational fishing vessel
25-Jun-08	15:51	59	33.600248	-76.786104	SE	2	1	45	1	Sailboat
25-Jun-08	16:28	67	33.680552	-77.018734	NW	1	2	60	1	Recreational fishing vessel

Table 20. All fishing vessel sightings in the proposed USWTR site in Onslow Bay, NC for surveys conducted from June 2007 to June 2008.

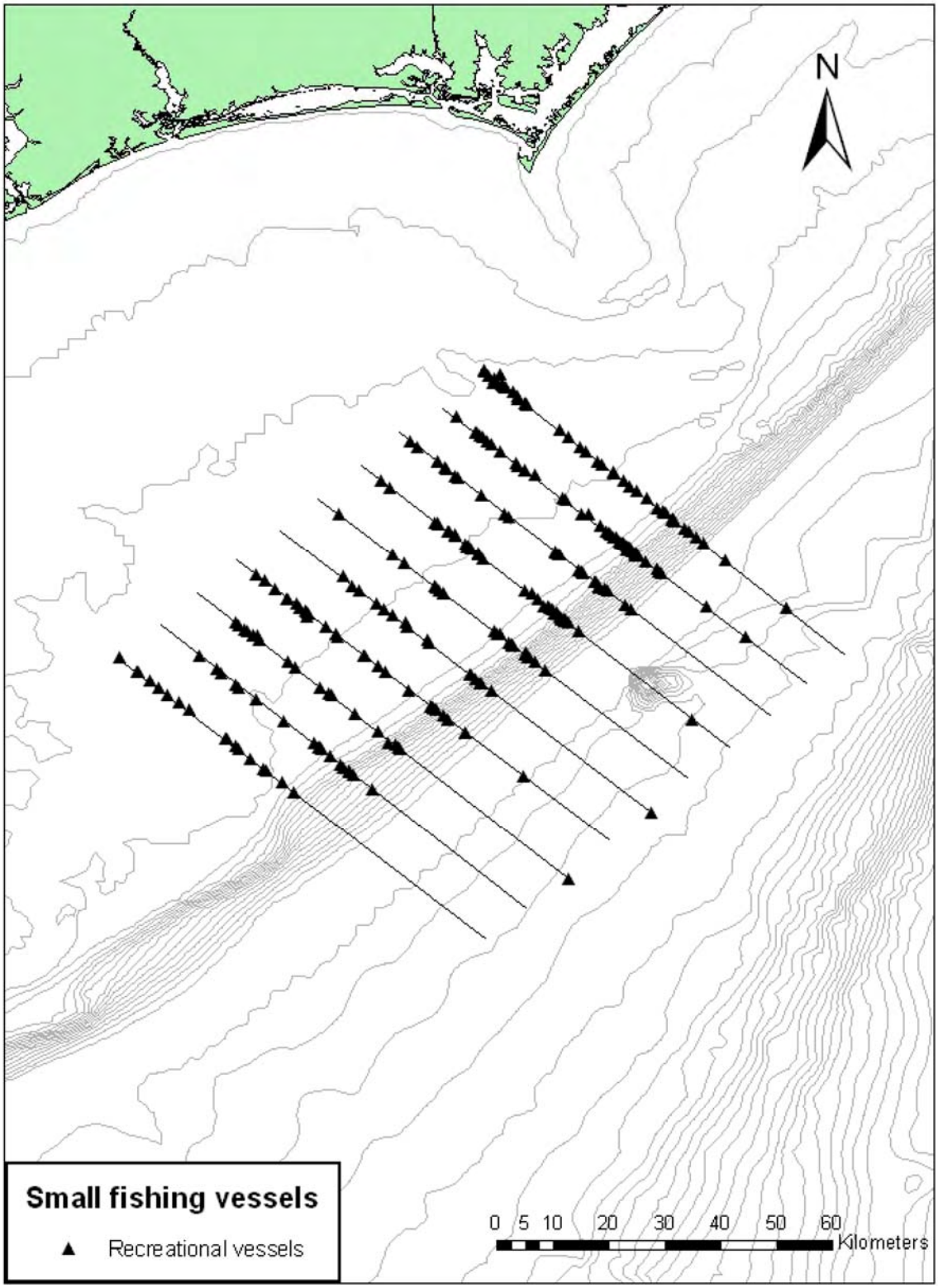


Figure 19. Location of recreational vessels observed in the Onslow Bay NC USWTR proposed location.

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Appendix A

Date:____________ Observer Side:__________ GPS#:___________ Page___ of _____
Pilot/Co-Pilot________________ Observers Left/Right:_____________ Hobbs:_________________________

Time	Waypoint #	Event	Heading	Track #	Visibility	BSS	Cloud	Glare L	Glare R	Vertical Angle	Horizontal degree	Sighting Cue	Species	Reliability	Min #	Max #	Best Est	Calves Y/N	Avoid Y/N	Pho/Vid (Y/N)	

Appendix B

Codes for Variables on USWTR Aerial Survey Data Sheet

Date: YYYYMMDD **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)
2.2 = Sighting of commercial fishing vessel
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

Sighted by: 1= pilot 2= co-pilot 3= observer left side 4= observer right side

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

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

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

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

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

Vertical Angle is given in rough increments of 20 degrees with 1 being directly on the trackline and 5 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.

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

Appendix B

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 physalis*	Bph
Brydes whale	*Balaenoptera edeni*	Bed
humpback whale	*Megaptera novaeangliae*	Mno
unidentified balaenopterid	Family *Balaenopteridae*	BALA
sperm whale	*Physeter catadon*	Pca
pygmy sperm whale	*Kogia breviceps*	Kbr
dwarf sperm whale	*Kogia simus*	Ksi
unidentified Kogia	*Kogia* spp.	KOGI
bottlenose whale	*Hyperodon 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 melaena*	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 clymene*	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		
basking shark	*Cetorhinus maximus*	Cma
manta ray	*Manta birostris*	Mbi
ocean sunfish	*Mola mola*	Mmo
spotted eagle-ray	*Aetobatus narinari*	Ana
Unidentified elasmobranch Unidentified marine vertebrate		CHON VERT

Appendix C

Sighting #_____ - UNCW USWTR Aerial Survey - Date:_____

Sighting Data Sheet

Initial Sighting on Track

Time:_____ WP:_____ Sighting Cue:_____

Confidence: 1 2 3 4 Vertical Angle: 1 2 3 4 Horizontal Bearing in Degrees:_____

Observer:_____ Observer Side: L R

Actual Time and Position of Sighting

Time: _____ WP #:_____

Species: _____ Numbers: (Low/ High/ Best):____/____/____

Photographer:_____ Frame Numbers: _____ to _____ Spacer:_____

Final Time and Position of Sighting

Time: _____ WP#: _____

Behavior and Additional Comments:

Appendix D - UNCW Aerial Survey Sighting Summary

26 June 2007 Sighting # 1

Initial Sighting on Track
Time: 10:52 WP#: 6 Lat: 34.15206 Long: -76.45457 Track Line: 10
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 65
Observer: PBN Observer Side: Right

Time and Position of Sighting (Estimated)
Time: 10:52 WP #: 7 Lat: 34.16203 Long: -76.48301 Beaufort Sea State: 2
Species: Unidentified cetacean Features used in species ID: N/A
Numbers (Low/ High/ Best): 3 / 4 / 3 Calves observed? No
Photographer: N/A Frame Numbers: N/A Spacer: N/A Representative Images: N/A
Calculated Distance from Track Line: 2.8 km

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
Three dolphin-sized animals were sighted on the right side. Broke track and flew to area of sighting cue. Animals believed to be large dolphins or other cetacean species. Plane circled three times on side of plane where animals were initially seen. We then circled at between 750 and 1000 ft on the opposite side of line as animals' movement would have crossed track line. Waypoint # 8 Animals spotted again approximately 1 mile off the right side of the plane. Unable to relocate animals for photo documentation and species identification.

26 June 2007 Sighting # 2

Initial Sighting on Track

Time: 11:21 WP: 12 Lat: 33.97076 Long: -76.22106 Track Line: 10
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 45
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 11:22 WP #:13 Lat: 33.92919 Long: -76.17125 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Robust gray dolphins with short stocky rostrum, white area on dorsal caudal peduncle, gradually tapering body
Numbers: (Low/ High/ Best): 60 / 90 / 80 Calves observed? No
Representative Image(s): 2776, 3685, 3887, 4089, 4190, 4594
Photographer: PBN Frame Numbers: 453 to 4796 Spacer: 4897
Calculated Distance from Track Line: 6.5 km

Final Time and Position of Sighting
Time: 11:35 WP#: 14 Lat: 33.93683 Long: -76.17852
Calculated Distance Traveled: 1.1 km

Behavior and Additional Comments:
Brownish dolphins active at the surface. Dolphins active below surface – spinning, overlapping each other and changing direction sharply. Pairs of dolphins were very active swimming parallel to each other and changing direction. Estimate multiple groups of 20+ animals. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

26 June 2007 Sighting # 3

Initial Sighting on Track
Time: 11:50 WP: 19 Lat: 33.85745 Long: -76.20297 Track Line: 9
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 45
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 11:51 WP #: 20 Lat: 33.86192 Long: -76.19399 Beaufort Sea State: 2
Species: *Globicephala macrorhynchus* Features used in species ID: Large black cetaceans with bulbous melons and rounded dorsal fins, short pectorals fins clearly visible.
Representative Images: 67116, 73112, 78127, 91140
Numbers: (Low/ High/ Best): 28 / 35 / 32 Calves observed? Yes
Photographer: PBN Frame Numbers: 4998 to 110159 (55 images) Spacer: None
Calculated Distance from Track Line: 1.0 km

Final Time and Position of Sighting
Time: 12:03 WP#: 21 Lat: 33.87344 Long: -76.18783
Calculated Distance Traveled: 1.4 km

Behavior and Additional Comments:
Initial sighting animals were in loose groups of 2 to 3 in a horizontal line.
Mix of adults and young animals. Towards end of sighting animals moved into two groups within 100m. Also sighted another group of 6-10 animals (included in low/high/best numbers) within a couple of hundred meters. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

18 July 2007 Sighting #1

Initial Sighting on Track
Time: 10:01 WP: 22 Lat: 33.88693 Long: -76.36988 Track Line: 8
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 10:06 WP #:23 Lat: 33.88348 Long: -76.37331 Beaufort Sea State: 3
Species: Unidentified delphinid Features used in species ID: Animals were most likely *Tursiops truncatus* judging from features observed from the plane, but since no images were obtained species identification cannot be made with 100% certainty, hence the designation ”unidentified delphinids” is used in this case.
Numbers: (Low/ High/ Best): 4 / 7 / 6 Calves observed? No
No images obtained
Calculated Distance from Track Line: 0.5 km

Final Time and Position of Sighting
Time: 10:08 WP#: 24 Lat: 33.88526 Long: -76.36339
Calculated Distance Traveled: 0.9 km

Behavior and Additional Comments:
Animals sighted directly under plane swimming parallel to each other heading away from the track line. When we circled the area of the sighting we were unable to relocate the animals to photograph or confirm the species.

Appendix D - UNCW Aerial Survey Sighting Summary

7 August 2007 Sighting # 1

Initial Sighting on Track
Time: 11:06 WP: 20 Lat: 33.70546 Long: -76.39396 Track Line: 6
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 30
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 11:07 WP # 21 Lat: 33.70572 Long: -76.39433 Beaufort Sea State: 2
Species: Unidentified delphinids Features used in species ID: N/A
Numbers: (Low/ High/ Best): 2 / 4 / 3 Calves observed? No
Photographer: PBN Frame Numbers: 1 to 2 Spacer: 3 Representative Images: N/A
Calculated Distance from Track Line: 0.04 km

Final Time and Position of Sighting
Time: 11:29 WP#: 22 Lat: 33.69614 Long: -76.38772
Calculated Distance Traveled: 1.2 km

Behavior and Additional Comments:
Animals initially sighted moving away from track-line. Actual position was taken as plane flew directly over animals after which there was no re-sight. Circled area the animals were last seen at between 750 and 1000 ft altitude. The animals were moving fast at the surface with racing shallow dives and low angled explosive leaps. The two photos taken are blurry but do show distinct dark/light aspect discussed below. The dolphins observed exhibited long sleek, torpedo shaped bodies with narrow peduncles, with a gray/brown dorsal side and white/light flanks and ventral side, with white extending up on top of peduncle. Dashed line indicates approximate area plane covered attempting to re-sight animals.

25 September 2007 Sighting # 1

Initial Sighting on Track
Time: 10:43 WP: Left 21 Lat: 34.15946 Long: -76.59785 Track line: 9
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Same as above
Species: Unidentified delphinids Features used in species ID: N/A
Numbers: (Low/ High/ Best): 5 / 7 / 6 Calves observed? No
Photographer: N/A Frame Numbers: N/A Spacer: N/A Representative Images: N/A
Calculated Distance from Track Line: N/A

Final Time and Position of Sighting
Time: Same as above – not re-sighted WP#: Same as above – not re-sighted
Calculated Distance traveled: N/A

Behavior and Additional Comments:
Small group of unidentified dolphins traveling towards track line. Animals appeared uniformly grey. Group not re-sighted after we broke track.

25 September 2007 Sighting # 2

Initial Sighting on Track
Time: 10:58 WP: Left 23 Lat: 34.09045 Long: -76.52966 Track line: 9
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 100
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 11:01 WP #: 24 Lat: 34.08935 Long: -76.54013 Beaufort Sea State: 3
Species: *Stenella frontalis* Features used in species ID: highly spotted appearance, lighter flanks and ventral side, overall slender appearance, and appendage shape (thin, sickle shaped fluke, and small, slender dorsal fin)
Numbers: (Low/ High/ Best): 4 / 4 / 4 Calves observed? No
Representative Images: 8, 13, 27, 59, 65
Photographer: RJM Frame Numbers: 1 to 65 Spacer: 66 Calculated Distance from Track Line: 1.0 km

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
Group of four *Stenella frontalis* traveling parallel to the track line, about 200 meters off. From the plane, animals appeared brown/grey with visibly lighter areas on the flanks and on the peduncle.
Photographs taken during circling allowed for identification to species. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

14 October 2007 Sighting #: 1

Initial Sighting on Track
Time: 09:30 WP: 7 Lat: 33.47865 Long: -76.75892 Track line: 1
On/Off Effort: On Sighting Cue: Splash
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: WAM Observer Side: Left

Time and Position of Sighting
Time: 09:33 WP #: 8 Lat: 33.48366 Long: -76.75950 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Species identification based on overall appearance (somewhat stocky, slate gray, with lighter areas on caudal peduncle and dorsal thorax) observed in the field as well as from good quality photographs obtained.
Numbers: (Low/ High/ Best): 35 / 42 / 40 Calves observed? No
Representative Images: 8, 11, 16, 27
Photographer: PBN Frame Numbers: 1 to 41 Spacer: 42
Calculated Distance from Track Line: 0.6 km

Final Time and Position of Sighting
Time: 09:38 WP#: 9 Lat: 33.48450 Long: -76.76177

Behavior and Additional Comments:
Dolphins initially heading Southwest, movements during encounter less uni-directional and included several dolphins taking coordinated turns. Animals split up into three distinct groups, which joined at the end of the encounter. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

Appendix D - UNCW Aerial Survey Sighting Summary

17 November 2007 Sighting # 1

Initial Sighting on Track
Time: 09:34 WP: 8 Lat: 34.09924 Long: -77.23202 Track line: N/A
On/Off Effort: Off Sighting Cue: White water
Vertical Angle: 2 Horizontal Bearing in Degrees: 30
Observer: LLL Observer Side: Left

Actual Time and Position of Sighting
Time: 09:35 WP #: 10 Lat: 34.11094 Long: -77.21801 Beaufort Sea State: 1
Species: *Eubalena glacialis* Features used in species ID; Large, rotund, black whales with characteristic callosities, large square pectoral fins, double blow
Numbers: (Low/ High/ Best): 2 / 2 / 2 Calves observed? No
Representative Images: 46, 52, 76
Photographer: RJM Frame Numbers: 1 to 110 Spacer: N/A (changed cards after Egl encounter)
Calculated Distance from Track Line: 1.8 km

Time and Position of Sighting
Time: 09:52 WP#: 11 Lat: 34.12420 Long: -77.20407
Calculated Distance traveled: 2.0 km

Behavior and Additional Comments:
Two adult right whales traveling together, apparently heading north. At one time, a sport fishing vessel passed the whales within ¼ mile at high speed. Circled animals at 1000 ft altitude. No avoidance reaction noted.

17 November 2007 Sighting # 2

Initial Sighting on Track
Time: 10:04 WP#: 13 Lat: 33.90739 Long: -76.92276 Track line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 10:13 WP #: 14 Lat: 33.91301 Long: -76.94720 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Gradually tapering body, uniformly gray, *Tursiops*-like dorsal and pectoral fins
Numbers: (Low/ High/ Best): 3 / 4 / 3 Calves observed? No
Representative Images: 4, 11, 15
Photographer: RJM Frame Numbers: 2 to 24 Spacer: 25, 26
Calculated Distance from Track Line: 2.3 km

Final Time and Position of Sighting
Time: 10:21 WP#: 15 Lat: 33.91400 Long: -76.94028
Calculated Distance traveled: 0.7 km

Behavior and Additional Comments:
Right off the track line, “skinny” in appearance, bright white ventral side. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

17 November 2007 Sighting # 3

Initial Sighting on Track
Time: 10:31 WP#: 10 (R) Lat: 33.70922 Long: -76.66014 Track line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 10:32 WP #: 20 (L) Lat: 33.71345 Long: -76.67102 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Short, stocky rostrums, gradually tapering bodies, overall gray coloration, white on dorsal caudal peduncle.
Numbers: (Low/ High/ Best): 16 / 20 / 18 Calves observed? No
Representative Images: 35, 36, 44
Photographer: RJM Frame Numbers: 27 to 53 Spacer: 54
Calculated Distance from Track Line: 1.1 km

Final Time and Position of Sighting
Not recorded
Calculated Distance traveled: N/A

Behavior and Additional Comments:
Dolphins behave and look like *Tursiops truncatus*, some with white on ventral side of caudal peduncle. Dolphins in two main groups, with about seven to 10 individuals in each group. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

17 November 2007 Sighting # 4

Initial Sighting on Track
Time: 10:38 WP#: 12 (R) Lat: 33.67650 Long: -76.61501 Track line: 4
On/Off Effort: On Sighting Cue: Dark shape under water
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 10:42 WP #: 22 Lat: 33.68648 Long: -76.60471 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Robust, gray, with white/lighter area on caudal peduncle
Numbers: (Low/ High/ Best): 9 / 9 / 9 Calves observed? No
Representative Images: 64, 65
Photographer: RJM Frame Numbers: 55 to 68 Spacer: 69-70
Calculated Distance from Track Line: 1.5 km

Final Time and Position of Sighting
Time: 10:44 WP#: 23 Lat: 33.69524 Long: -76.60556
Calculated Distance traveled: 1.0 km

Behavior and Additional Comments:
Looks like a group of *Tursiops truncatus*: robust, gray, with white/lighter area on caudal peduncle. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

17 November 2007 Sighting # 5

Initial Sighting on Track
Time: 11:06 WP#: 29 Lat: 33.67079 Long: -76.7392 Track line: 3
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 60
Observer: RJM Observer Side: R

Time and Position of Sighting
Time: 11:08 WP #: 30 Lat: 33.66896 Long: -76.73108 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Robust, stocky dolphins with gradually tapering bodies, short rostrums, lighter area on dorsal caudal peduncle.
Numbers: (Low/ High/ Best): 23 / 25 / 23 Calves observed? No
Representative Images: 78, 85
Photographer: RJM Frame Numbers: 71 to 90 Spacer: 91
Calculated Distance from Track Line: 0.8 km

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
Dolphins in four to five sub-groups. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

18 November 2007 Sighting # 1

Initial Sighting on Track
Time: 09:35 WP#: 14 Lat: 33.76496 Long: -76.08201 Track line: In transit from 10 to 9
On/Off Effort: Off Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 09:36 WP #: 15 Lat: 33.76686 Long: -76.07981 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Robust, stocky dolphins, short rostrums, gradually tapering body, white area on dorsal caudal peduncle
Numbers: (Low/ High/ Best): 2 / 3 / 3 Calves observed? No
Representative Images: 15, 18, 21
Photographer: PBN Frame Numbers: 1 to 21 Spacer: 22
Calculated Distance from Track Line: 0.3 km

Final Time and Position of Sighting
Time: 09:40 WP#: 16 Lat: 33.76381 Long: -76.07506
Calculated Distance traveled: 0.6 km

Behavior and Additional Comments:
Two animals swimming in close proximity to each other. Many “zig zags” and strong surfacings. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

18 November 2007 Sighting # 2

Initial Sighting on Track
Time: 10:08 WP#: 21 Lat: 34.19695 Long: -76.72245 Track line: In transit between 9 and 8
On/Off Effort: Off Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 110
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 10:13 WP #: 27 Lat: 34.20727 Long: -76.71849 Beaufort Sea State: 3
Species: Unidentified delphinid Features used in species ID: N/A
Numbers: (Low/ High/ Best): 2 / 2 / 2 Calves observed? No
Representative Images: N/A
Photographer: N/A – no images taken Frame Numbers: N/A
Calculated Distance from Track Line: 1.2 km

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
Two unidentified dolphins, which we were unable to relocate. Position reported for "Actual Time and Position of Sighting" is the estimated location of dolphins when initially sighted.

18 November 2007 Sighting # 3

Initial Sighting on Track
Time: 10:42 WP#: 27 Lat: 33.65711 Long: -76.19892 Track line: In transit between 8 and 7
On/Off Effort: Off Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 120
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 10:44 WP#: 28 Lat: 33.66277 Long: -76.19807 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Robust, stocky dolphins with gradually tapering bodies and short rostrums
Numbers: (Low/ High/ Best): 15 / 23 / 20 Calves observed? No
Representative Images: 45, 46, 53, 55, 56, 57
Photographer: PBN Card #: 1 Frame Numbers: 23 to 59 Spacer: 60
Calculated Distance from Track Line: 0.6 km

Final Time and Position of Sighting
Time: 10:45 WP#: 29 Lat: 33.66212 Long: -76.19703
Calculated Distance Traveled: 0.1 km

Behavior and Additional Comments:
Animals sighted on right. Long dispersed line of animals. Biggest group consisted of approximately five dolphins. Formed into groups of three to four during encounter – still traveling in a dispersed line. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

18 November 2007 Sighting # 4

Initial Sighting on Track
Time: 11:08 WP#: 31 Lat: 33.98997 Long: -76.63126 Track line: 7
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 4 Horizontal Bearing in Degrees: 100
Observer: PBN Observer Side: Right

Time and Position of Sighting (Estimated)
Time: 11:10 WP #: 32 Lat: 33.98763 Long: -76.59155 Beaufort Sea State: 3
Species: Unidentified marine vertebrate Features used in species ID: N/A
Photographer: N/A – no images obtained
Calculated Distance from Track Line: 3.7 km

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
A body was observed about one mile off the right side. We broke track to investigate but were unable to relocate.

19 November 2007 Sighting # 1

Initial Sighting on Track
Time: 09:33 WP#: 9 Lat: 33.76293 Long: -76.60171 Track line: 5
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 09:34 WP #: 10 Lat: 33.76166 Long: -76.60302 Beaufort Sea State: 2
Species: Unidentified delphinid Features used in species ID: Species ID could not be established
Numbers: (Low/ High/ Best): 14 / 23 / 20 Calves observed? Yes
Representative Images: N/A
Photographer: RJM Card #: 1 Frame Numbers: 1 to 22 Spacer: 23
Calculated Distance from Track Line: 0.2 km

Final Time and Position of Sighting
Time: 09:38 WP#: 11 Lat: 33.76312 Long: -76.60751
Calculated Distance Traveled: 0.5 km

Behavior and Additional Comments:
Spread out group. Individuals with white dorsal peduncle (*Tursiops truncatus*?). At least one mother/calf pair. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

19 November 2007 Sighting # 2

Initial Sighting on Track
Time: 09:46 WP#: 13 Lat: 33.68801 Long: -76.49910 Track line: 5
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 110
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 09:46 WP #: 14 Lat: 33.68980 Long: -76.49696 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Short rostrums, white area on caudal peduncle, body gradually tapering towards flukes
Numbers: (Low/ High/ Best): 4 / 4 / 4 Calves observed? No
Representative Images: 25, 31, 32, 33
Photographer: RJM Card #: 1 Frame Numbers: 24 to 35 Spacer: 36
Calculated Distance from Track Line: 0.3 km

Final Time and Position of Sighting
Time: 09:49 WP#: 15 Lat: 33.68984 Long: -76.49962
Calculated Distance Traveled: 0.3 km

Behavior and Additional Comments:
Slow surface travel, spread out, long down times. One dolphin appears *real* light. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

19 November 2007 Sighting # 3

Initial Sighting on Track
Time: 09:50 WP#: 17 Lat: 33.66096 Long: -76.46282 Track line: 5
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 100
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 09:52 WP #: 18 Lat: 33.66871 Long: -76.46501 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Gray color, with light caudal peduncle.
Numbers: (Low/ High/ Best): 8 / 10 / 8 Calves observed? Yes
Representative Images: N/A - all images distant and out of focus
Photographer: RJM Card #: 1 Frame Numbers: 37 to 57 Spacer: 58
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 09:57 WP#: 19 Lat: 33.66397 Long: -76.46321
Calculated Distance Traveled: 0.6 km

Behavior and Additional Comments:
Dolphins spread out. Gray color, with light caudal peduncle. One mother/calf pair. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

19 November 2007 Sighting # 4

Initial Sighting on Track
Time: 10:13 WP#: 24 Lat: 33.77940 Long: -76.49418 Track line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 10:14 WP #: 25 Lat: 33.78396 Long: -76.49154 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Gray bodies, white peduncle area – indicative of *Tursiops truncatus*.
Numbers: (Low/ High/ Best): 4 / 6 / 5 Calves observed? No
Representative Images: N/A – all Photographer: RJM Frame Numbers: 59 to 75 Spacer: 76 images distant and out of focus
Calculated Distance from Track Line: 0.6 km

Final Time and Position of Sighting
Time: 10:21 WP#: 26 Lat: 33.78147 Long: -76.49614
Calculated Distance Traveled: 0.5 km

Behavior and Additional Comments:
Long dive times – evasive maneuver in response to plane? Four to five individuals together, one singleton a distance away. Circled animals at between 750 and 1000 ft.

19 November 2007 Sighting # 5

Initial Sighting on Track
Time: 10:29 WP#: 29 Lat: 33.92059 Long: -76.67939 Track line: 6
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 80
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 10:30 WP #: 30 Lat: 33.91649 Long: -76.68142 Beaufort Sea State: 2
Species: Unidentified delphinid Features used in species ID: N/A
Numbers: (Low/ High/ Best): 11 / 12 / 11 Calves observed? No
Representative Images: N/A – all images distant and/or out of focus
Photographer: RJM Card #: 1 Frame Numbers: 77 to 83 Spacer: N/A – changed card
Calculated Distance from Track Line: 0.5 km

Final Time and Position of Sighting
Time: 10:37 WP#: 32 Lat: 33.91190 Long: -76.67596
Calculated Distance Traveled: 0.7 km

Behavior and Additional Comments:
Aerial behavior consisting of multiple high leaps was observed. The group was spread out over hundreds of meters. A dolphin approached and interacted with a piece of *Sargassum*. Dolphins split into two groups (4 and 7 individuals, respectively). Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

19 November 2007 Sighting # 6

Initial Sighting on Track
Time: 10:52 WP#: 40 Lat: 34.02480 Long: -76.66977 Track line: 7
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Not recorded
Beaufort Sea State: 2
Species: Unidentified marine vertebrate Features used in species ID: N/A
Numbers: (Low/ High/ Best): ? Calves observed? No
Photographer: N/A - no images obtained
Calculated Distance from Track Line: N/A

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
Sighting of unidentified "body" (could have been a cetacean or a shark) more or less on the track line. Unable to relocate or to establish species identity.

19 November 2007 Sighting # 7

Initial Sighting on Track
Time: 11:10 WP#: Not recorded Track line: 7
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 120
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 11:10 WP #: 44 Lat: 33.80440 Long: -76.38555 Beaufort Sea State: 2
Species: Unidentified delphinid Features used in species ID: N/A
Numbers: (Low/ High/ Best): 22 / 25 / 22 Calves observed? No
Representative Images: N/A – all images distant and out of focus
Photographer: RJM Card #: 2 Frame Numbers: 1 to 46 Spacer: 47
Calculated Distance from Track Line: N/A

Final Time and Position of Sighting
Time: 11:15 WP#: 45 Lat: 33.80348 Long: -76.38563
Calculated Distance Traveled: 0.1 km

Behavior and Additional Comments:
Two distinct groups, separated by 200 m. Slow travel a few meters below surface. Long down times. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

19 November 2007 Sighting # 8

Initial Sighting on Track
Time: 11:46 WP#: 65 Lat: 34.13667 Long: -76.69469 Track line: 8
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 11:47 WP #: 66 Lat: 34.13428 Long: -76.69248 Beaufort Sea State: 2
Species: Unidentified delphinid Features used in species ID: N/A
Numbers: (Low/ High/ Best): 3 / 3 / 3 Calves observed? No
Representative Images: N/A – images distant and/or out of focus
Photographer: RJM Frame Numbers: 48 to 55 Spacer: 56
Calculated Distance from Track Line: 0.33 km

Final Time and Position of Sighting
Time: 11:50 WP#: 67 Lat: 34.13198 Long: -76.68411
Calculated Distance Traveled: 0.8 km

Behavior and Additional Comments:
Three unidentified dolphins, spread out. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

19 November 2007 Sighting # 9

Initial Sighting on Track
Time: 12:21 WP#: 79 Lat: 33.83212 Long: -76.03973 Track line: 10
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 60
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 12:22 WP #: 80 Lat: 33.82424 Long: -76.04104 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Short rostrums, dark gray cape, lighter gray flanks
Numbers: (Low/ High/ Best): 37 / 45 / 40 Calves observed? No
Representative Images: 57, 58
Photographer: RJM Frame Numbers: 57 to 86 Spacer: 87
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 12:27 WP#: 81 Lat: 33.82587 Long: -76.03839
Calculated Distance Traveled: 0.3 km

Behavior and Additional Comments:
Animals divided in four groups with between six and fifteen individuals in each.
Animals separated by a few hundred meters, swimming in a line. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

Appendix D - UNCW Aerial Survey Sighting Summary

11 December 2007 Sighting # 1

Initial Sighting on Track
Time: 12:52 WP#: 30 Lat: 33.76967 Long: -76.87654 Track line: 3
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 12:57 WP #: 34 Lat: 33.76840 Long: -76.87553 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Sturdy grey animal, with short rostrum
Numbers: (Low/ High/ Best): 1 / 1 / 1 Calves observed? No
Representative Images: None obtained
Photographer: N/A – no images obtained
Calculated Distance from Track Line: 0.2 km

Final Time and Position of Sighting
Time: 12:58 WP#: 35 Lat: 33.76769 Long: -76.87483
Calculated Distance Traveled: 0.1 km

Behavior and Additional Comments:
A single animal was initially seen swimming parallel to the plane heading Northwest. The survey team broke track and circled the animal to determine species. Positive identification of the bottlenose dolphin was made and no photographs were taken. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 February 2008 Sighting # 1

Initial Sighting on Track
Time: 14:02 WP#: 47 Lat: 33.66223 Long: -76.99553 Track line: 1
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 110
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 14:06 WP #: 48 Lat: 33.67197 Long: -76.99567 Beaufort Sea State: 2
Species: Unidentified delphinid Features used in species ID: N/A
Numbers: (Low/ High/ Best): 6 / 9 / 7 Calves observed? No
Representative Images: 3, 7, 17
Photographer: PBN Frame Numbers: 1 to 23 Spacer: 24-25
Calculated Distance from Track Line: 1.1 km

Final Time and Position of Sighting
Time: 14:09 WP#: 49 Lat: 33.67652 Long: -76.99292
Calculated Distance Traveled: 0.6 km

Behavior and Additional Comments:
Traveling in loose echelon formation. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 February 2008 Sighting # 2

Initial Sighting on Track
Time: 14:45 WP#:60 Lat: 33.71961 Long: -76.94130 Track line: 2
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 14:47 WP #: 61 Lat: 33.72402 Long: -76.93654 Beaufort Sea State: 2
Species: Unidentified delphinid Features used in species ID: N/A
Numbers: (Low/ High/ Best): 11 / 15 / 13 Calves observed? No
Representative Images: N/A
Calculated Distance from Track Line: 0.7 km
Photographer: PBN Card #: 8 GB Frame Numbers: 26 to 53 Spacer: 54
Representative Images: N/A

Final Time and Position of Sighting
Time: 14:48 WP#:62 Lat: 33.72292 Long: -76.93753
Calculated Distance Traveled: 0.2 km

Behavior and Additional Comments:
Loose grouping, well spaced. At least one juvenile in the group. Some leaping/breaching observed. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

29 February 2008 Sighting # 1

Initial Sighting on Track
Time: 10:01 WP#: 4 Lat: 33.96936 Long: -76.87355 Track line: 5
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 110
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 10:02 WP #: 5 Lat: 33.96629 Long: -76.88037 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: Dorsal fin shape and placement, white rostrum tip, spotted appearance
Numbers: (Low/ High/ Best): 7 / 9 / 8 Calves observed? No
Representative Images: 20, 28
Photographer: RJM Frame Numbers: 1 to 30 Spacer: 31
Calculated Distance from Track Line: 0.7 km

Final Time and Position of Sighting
Time: 10:08 WP#: 6 Lat: 33.97091 Long: -76.88685
Calculated Distance Traveled: 0.8 km

Behavior and Additional Comments:
Dispersed group, traveling in singles, pairs and threes. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

29 February 2008 Sighting # 2

Initial Sighting on Track
Time: 10:17 WP#: 12 Lat: 33.80597 Long: -76.65815 Track line: 5
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 10:18 WP #:13 Lat: 33.81298 Long: -76.65336 Beaufort Sea State: 3
Species: *Stenella frontalis* Features used in species ID: Spotted appearance, white blaze on flank, white rostrum tip, overall body shape
Numbers: (Low/ High/ Best): 5 / 8 / 7 Calves observed? No
Representative Images: 36, 38, 55
Photographer: RJM Frame Numbers: 32 to 57 Spacer: 58
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time:10:25 WP#: 14 Lat: 33.8104 Long: -76.65896
Calculated Distance Traveled: 0.8 km

Behavior and Additional Comments:
Very spread out group, singles and pairs. Non-directional movement, no calves seen from the air. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

29 February 2008 Sighting # 3

Initial Sighting on Track
Time: 11:16 WP#: 34 Lat: 34.04125 Long: -76.69906 Track line: 7
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 11:17 WP #: 35 Lat: 34.03670 Long: -76.70746 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: White blaze on flanks, presence of spots dorsal fin shape and placement
Representative Images: 62, 67, 68, 71
Numbers: (Low/ High/ Best): 24 / 30 / 27 Calves observed? Yes
Photographer: RJM Frame Numbers: 59 to 85 Spacer: 86
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
Two tightly packed groups separated by a couple of hundred meters. At least one mother/calf pair observed. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

29 February 2008 Sighting # 4

Initial Sighting on Track
Time: 11:27 WP#: 38 Lat: 33.97303 Long: -76.60936 Track line: 7
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 130
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 11:28 WP #: 39 Lat: 33.94679 Long: -76.57219 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: White rostrum tip, lighter blaze on flanks, alternating "bands" or areas of light and dark coloration on dorsal side of body
Numbers: (Low/ High/ Best): 23 / 29 / 26 Calves observed: No
Representative Images: 91, 94, 99, 100, 102, 105, 118, 126
Photographer: RJM Frame Numbers: 87 to 133 Spacer: 134
Calculated Distance from Track Line: 4.5 km

Final Time and Position of Sighting
Time: 11:30 WP#: 40 Lat: 33.96366 Long: -76.56958
Calculated Distance Traveled: 1.9 km

Behavior and Additional Comments:
Very tight group, circling tight – on a bait ball? The group eventually broke up into three smaller groups, spread out over a couple of hundred meters. The group split up further, into singles and pairs. Possible avoidance reaction to the aircraft observed. Circled animals at between 750 and 1000 ft.

11 March 2008 Sighting # 1

Initial Sighting on Track
Time: 10:53 WP#: 33 Lat: 33.76278 Long: -76.33524 Track Line: 7
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 10:53 WP #: 34 Lat: 33.76047 Long: -76.35219 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Animals were robust and showed light coloration on the peduncle consistent with *Tursiops truncatus*.
Numbers (Low/ High/ Best): 15 / 16 / 15 Calves observed? No
Representative Images: 4, 7, 14
Photographer: PBN Frame Numbers: 1 to 20 Spacer: 21
Calculated Distance from Track Line: 1.6 km

Final Time and Position of Sighting
Time: 10:57 WP#: 35 Lat: 33.76543 Long: -76.35758
Calculated Distance Traveled: 0.6 km

Behavior and Additional Comments:
Animals were seen first about a ½ mile off track line heading towards the line (roughly south). They were traveling in a line as singles with some groups of two or three and were loosely spaced. Circled animals at between 750 and 1000 ft. No signs of disturbance or avoidance of the plane were noted.

11 March 2008 Sighting # 2

Initial Sighting on Track
Time: 14:06 WP#: 56 Lat: 34.07035 Long: -76.48395 Track line: 9
On/Off Effort: On Sighting Cue: Body
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 14:08 WP #: 57 Lat: 34.07214 Long: -76.47394 Beaufort Sea State: 2
Species: Unidentified delphinid Features used in species ID: N/A
Numbers: (Low/ High/ Best): 5 / 7 / 5 Calves observed? No
Representative Images: N/A
Photographer: PBN Frame Numbers: 21 to 81 Spacer: 82
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 14:22 WP#: 58 Lat: 34.06348 Long: -76.44946
Calculated Distance Traveled: 2.5 km

Behavior and Additional Comments:
Animals were moving very fast spending most of the time just below the surface and spent little time exposed when taking a breath. There was a lot of space between the individuals and we did not observe any occasions when the animals would form into groups of two or more. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

11 March 2008 Sighting # 3

Initial Sighting on Track
Time: 14:32 WP#: 62 Lat: 34.19558 Long: -76.65213 Track line: 9
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 14:23 WP #: 63 Lat: 34.18987 Long: -76.65739 Beaufort Sea State: 3
Species: *Stenella frontalis* Features used in species ID: White rostrum tips, light blaze on flanks, some individuals heavily spotted
Numbers: (Low/ High/ Best): 30 / 40 / 35 Calves observed? No
Representative Images: 94, 102, 107, 108, 112, 114, 121, 129, 135, 136, 156
Photographer: PBN Frame Numbers: 83 to 157 Spacer: 158 Calculated Distance from Track Line: 0.8 km

Final Time and Position of Sighting
Time: 14:38 WP#: 64 Lat: 34.19153 Long: -76.66280
Calculated Distance Traveled: 0.5 km

Behavior and Additional Comments:
Animals were interacting with one another at the surface in two dense groups. Saw many animals turning on their side or upside down as well as active surfacing events. Groups were traveling southeast, opposite of the survey plane. Animals began traveling more directed/noticeably as the encounter continued. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

Appendix D - UNCW Aerial Survey Sighting Summary

13 March 2008 Sighting # 1

Initial Sighting on Track
Time: 10:52 WP#: 10 Lat: 33.40348 Long: -76.53284 Track Line: In transit between 1and 2
On/Off Effort: Off Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 110
Observer: PBN Observer Side: Left

Time and Position of Sighting
Not recorded
Species: Unidentified Delphinid Features used in species ID: N/A
Numbers (Low/ High/ Best): 1 / 2 / 1 Calves observed? No
Photographer: N/A – no images obtained
Calculated Distance from Track Line: N/A

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments
Opportunistic sighting of one, potentially two, unidentified dolphin(s) during transit between offshore ends of track lines 1 and 2. The plane did not break track, hence, the exact position of the animals cannot be established.

13 March 2008 Sighting # 2

Initial Sighting on Track
Time: 11:11 WP#: 17 Lat: 33.78600 Long: -77.02495 Track line: 2
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 11:12 WP #: 18 Lat: 33.78600 Long: -77.02509 Beaufort Sea State: 2
Species: *T. truncatus/S. frontalis* Features used in species ID: N/A
Representative Images: 2, 3, 16 - 19
Numbers: (Low/ High/ Best): 3 / 3 / 3 Calves observed? No
Photographer: RJM Frame Numbers: 1 to 21 Spacer: 22
Calculated Distance from Track Line: 0.01 km

Final Time and Position of Sighting
Time: 11:25 WP#: 19 Lat: 33.79058 Long: -77.02509
Calculated Distance Traveled: 0.5 km

Behavior and Additional Comments:
Initially dove for several minutes, brief surface intervals, “long” dive times. Looks like *Tursiops truncatus*, slow swimming, sturdy, grey. The pair swam belly to belly for a distance before diving. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

13 March 2008 Sighting # 3

Initial Sighting on Track
Time: 11:37 WP#: 25 Lat: 33.85306 Long: -76.98408 Track Line: 3
On/Off effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 11:40 WP #: 26 Lat: 33.86134 Long: -76.98522 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Uniform grey and sturdy
Numbers: (Low/ High/ Best): 4 / 7 / 5 Calves observed? No
Representative Images: 23, 26, 36 - 38
Photographer: RJM Frame Numbers: 22 to 39 Spacer: 40
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 11:51 WP#: 27 Lat: 33.86319 Long: -76.99237
Calculated Distance Traveled: 0.7 km

Behavior and Additional Comments:
Spread out, subsurface, one dolphin observed with a fish in its mouth, one juvenile observed. Looked like *Tursiops*, uniform grey and sturdy. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

13 March 2008 Sighting # 4

Initial Sighting on Track
Not recorded
Track line: In transit between 10 and 9
On/Off Effort: Off Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 14:54 WP #: 49 Lat: 33.45850 Long: -76.08279 Beaufort Sea State: 2
Species: *Tursiops/S. frontalis* Features used in species ID: N/A
Numbers: (Low/ High/ Best): 6 / 7 / 7 Calves observed? Yes
Representative Images: 50, 51, 52
Photographer: PBN Frame Numbers: 46 to 55 Spacer: 56
Calculated Distance from Track Line: N/A

Final Time and Position of Sighting
Not recorded

Behavior and Additional Comments:
Opportunistic sighting which occurred during transit between offshore ends of track lines 10 and 9. Slow surface travel. Looks like *Tursiops truncatus*. At least one mother/calf pair present in group. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

13 March 2008 Sighting # 5

Initial Sighting on Track
Time: 15:49 WP#: 60 (R) Lat: 33.79359 Long:-76.24798 Track line: 8
On/Off Effort: On Sighting Cue: Body
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 15:50 WP #: 77 (L) Lat: 33.78488 Long: -76.25704 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Robust, sturdy looking animals. Short and blunt rostrums
Numbers: (Low/ High/ Best): 12 / 16 / 15 Calves observed? No
108 Representative Images: 62-65, 69, 71, 72, 75 – 84, 89
Photographer: RJM Frame Numbers: 57 to 107
Calculated Distance from Track Line: 1.3 km

Final Time and Position of Sighting
Time: 15:57 WP#: 78 (L) Lat: 33.79132 Long: -76.25838
Calculated Distance Traveled: 0.7 km

Behavior and Additional Comments:
When first encountered, animals were grouped up in one group. Slow travel, lots of tactile interaction. Broke up into three smaller groups. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 April 2008 Sighting # 1

Initial Sighting on Track
Time: 10:28 WP#: 22 Lat: 34.137876 Long: 76.697346 Track Line: 8
On/Off Effort: On Sighting Cue: Splash
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 10:31 WP #: 23 Lat: 34.142246 Long: 76.696676 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: short rostrum, overall stocky appearance, light gray coloration with darker gray cape dorsally
Numbers (Low/ High/ Best): 3 / 3 / 3 Calves observed? No
Representative Images: 46, 59, 60
Photographer: PBN Card #: 1 Frame Numbers: 36-61 Spacer: 62
Calculated Distance from Track Line: 0.5 km

Final Time and Position of Sighting
Time: 10:38 WP#: 24 Lat: 34.14173 Long: 76.68058
Calculated Distance traveled: 1.5 km

Behavior and Additional Comments
Animals traveling in a dispersed line, surfacing very quickly and moving fast. When first encountered, animals were traveling parallel to the track-line. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 April 2008 Sighting # 2

Initial Sighting on Track
Time: 10:55 WP#: 28 Lat: 33.80687 Long: 76.263807 Track Line: 8
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 10:56 WP #: 29 Lat: 33.806142 Long: 76.2667 Beaufort Sea State: 2
Species: *Steno bredanensis* Features used in species ID: Sloping forehead, long rostrum, white lower jaw, large pectorals, and a large triangular and erect dorsal fin.
Numbers (Low/ High/ Best): 24 / 28 / 26 Calves observed? No
Representative Images: 71-73, 77, 78, 80-86
Photographer: PBN Card #: 1 Frame Numbers: 63-86 Spacer: 87
Calculated Distance from Track Line: 0.3 km

Final Time and Position of Sighting
Time: 11:00 WP#: 30 Lat: 33.80272 Long: 76.268908
Calculated Distance traveled: 0.4 km

Behavior and Additional Comments
Animals traveling slowly just sub-surface. Animals in groups of 5 or 6 and few pairs – this grouping stayed the same for the entire encounter. The general impression of overall behavior was that it was distinctly *different* as compared to that of the two other dolphin species encountered so far in the USWTR (*Tursiops truncatus* and S*tenella frontalis*). Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 April 2008 Sighting # 3

Initial Sighting on Track
Time: 11:05 WP#: 33 Lat: 33.720092 Long: 76.151712 Track Line: 8
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 5 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting (Estimated)
Time: 11:06 WP #: 34 Lat: 33.727066 Long: 76.169633 Beaufort Sea State: 3
Species: Unidentified Marine Vertebrate Features used in species ID: N/A
Numbers (Low/ High/ Best): 1 / 1 / 1 Calves observed? No
Representative Images: N/A
Frame Numbers: None taken Spacer: None
Calculated Distance from Track Line: 1.8 km Photographer: N/A Card #: 1

Final Time and Position of Sighting
N/A animal not re-sighted after initial sighting

Behavior and Additional Comments
Unable to resight animal after initial sighting cue. Note that the latitude and longitude given for the sighting is the *estimated* location.

25 April 2008 Sighting # 4

Initial Sighting on Track
Time: 14:23 WP#: 60 Lat: 33.593157 Long: 76.507016 Track Line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 14:30 WP #: 62 Lat: 33.598467 Long: 76.508261 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Stocky body tapering gradually towards the flukes, overall grey with darker grey cape, short rostrum, light area on dorsal peduncle
Numbers (Low/ High/ Best): 10 / 13 / 12 Calves observed? No
Representative Images: 89-91, 114, 118, 119, 120, 123, 124
Photographer: PBN Card #: 1 Frame Numbers: 88-125 Spacer: 126
Calculated Distance from Track Line: 0.6 km

Final Time and Position of Sighting
Time: 14:35 WP#: 63 Lat: 33.598544 Long: 76.501084
Calculated Distance traveled: 0.7 km

Behavior and Additional Comments
Originally only two animals sighted swimming parallel to one another. Upon relocating animals found a group of 10 to 13 animals in a loosely associated group at the surface interacting with one another. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 April 2008 Sighting # 5

Initial Sighting on Track
Time: 15:55 WP#: 82 Lat: 33.754493 Long: 77.117432 Track Line: 1
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting (Estimated)
Time: 16:00 WP #: 83 Lat: 33.754524 Long: 77.109181 Beaufort Sea State: 2
Species: Unidentified Marine Vertebrate Features used in species ID: N/A
Numbers (Low/ High/ Best): 6 / 6 / 6 Calves observed? No
Representative Images: No images taken
Calculated Distance from Track Line: 0.8 km

Final Time and Position of Sighting:
N/A - Animals not re-sighted after initial observation

Behavior and Additional Comments
Unable to relocate after original sighting, no pictures taken.

Appendix D - UNCW Aerial Survey Sighting Summary

26 April 2008 Sighting # 1

Initial Sighting on Track
Time: 10:52 WP#: 16 Lat: 33.619196 Long: 76.542062 Track Line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 10:54 WP #: 17 Lat: 33.623796 Long: 76.544074 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Light area on dorsal surface of caudal peduncle, overall stocky impression with body gradually tapering towards flukes,
Numbers (Low/ High/ Best):10/20/15 Calves observed? No
Representative Images: 2, 19, 28, 29, 34
Photographer: RJM Card #: 1 Frame Numbers: 1-60 Spacer: 61
Calculated Distance from Track Line: 0.5 km

Final Time and Position of Sighting
Time: 11:06 WP#: 18 Lat: 33.620975 Long: 76.547019
Calculated Distance traveled: 0.4 km

Behavior and Additional Comments
Two groups, one with 7 to 9 individuals. Lots of time spent underwater swimming greater distances. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

26 April 2008 Sighting # 2

Initial Sighting on Track
Time: 11:23 WP#: 25 Lat: 33.942430 Long: 76.969566 Track Line:
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 110
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 11:25 WP #: 26 Lat: 33.943435 Long: 76.970047 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Looks like *Tursiops truncatus*
Numbers (Low/ High/ Best): 4 / 4 / 4 Calves observed? No
Representative Images: 54, 64, 69, 71
Photographer: RJM Card #: 1 Frame Numbers: 43-71 Spacer: 72
Calculated Distance from Track Line: 0.1 km

Final Time and Position of Sighting
Time: 11:30 WP#: 27 Lat: 33.940982 Long: 76.966646
Calculated Distance traveled: 0.4 km

Behavior and Additional Comments
Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

26 April 2008 Sighting # 3

Initial Sighting on Track
Time: 13:43 WP#: 40 Lat: 33.899138 Long: 76.258527 Track Line:
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 13:49 WP #: 41 Lat: 33.896252 Long: 76.249675 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Overall stocky appearance with body gradually tapering towards flukes, short rostrum, gray coloration, lighter area on dorsal surface of caudal peduncle, dorsal fin diagnostic of *Tursiops truncatus*.
Numbers (Low/ High/ Best): 8/10/9 Calves observed? No
Representative Images: 78, 83, 84, 85, 97, 98
Photographer: RJM Card #: 1 Frame Numbers: 72-101 Spacer: 102
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 13:54 WP#: 42 Lat: 33.905679 Long: 76.247605
Calculated Distance traveled: 1.0 km

Behavior and Additional Comments
Tight group, surface travel. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

26 May 08 Sighting # 1

Initial Sighting on Track
Time: 09:03 WP#: 11 Lat: 33.48363 Long: -76.63709 Track Line: 2
On/Off Effort: On Sighting Cue: Splash
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 09:03 WP #: 12 Lat: 33.474728 Long: -76.63210 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Gray, sturdy animals with short, blunt rostrums.
Numbers (Low/ High/ Best): 12/14/13 Calves observed? No
Representative Images: 20, 21, 23, 27
Photographer: RJM Card #: 1 Frame Numbers: 1 to 36 Spacer: 37
Calculated Distance from Track Line: 1.1 km

Final Time and Position of Sighting
Time: 09:14 WP#: 13 Lat: 33.47141 Long: -76.64319
Calculated Distance traveled: 1.1 km

Behavior and Additional Comments
Shallow swim, slowly just beneath the surface, some turning on their sides. Gray, sturdy, light dorsal caudal peduncle – looks like *Tursiops*. Encountered more and more dolphins, several pairs, one trio. Some fast traveling and quick surfacings. Circled animals at between 750 and 1000 ft. No avoidance reaction noted. The calculated distance from track line (1.093 km) and the calculated distance traveled (1.093 km) are the actual numbers, by coincidence they are the same.

26 May 2008 Sighting # 2

Initial Sighting on Track
Time: 10:55 WP#: 37 Lat: 33.64292 Long: -76.31364 Track Line: 6
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 11:00 WP #: 38 Lat: 33.63598 Long: -76.30902 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Sturdy, light gray animals with darker gray cape, short, blunt rostrum.
Numbers (Low/ High/ Best): 12/15/13 Calves observed? Yes
Representative Images: 38, 39
Photographer: RJM Card #: Frame Numbers: 38 to 43 Spacer: 44
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 11:12 WP#: 39 Lat: 33.64201 Long: -76.31417
Calculated Distance traveled: 0.8 km

Behavior and Additional Comments
Dolphins traveling in singles and pairs, coloration pattern suggestive of *Tursiops*. Animals were split into two sub-groups, one mother/calf pair observed. Group difficult to follow. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

26 May 2008 Sighting # 3

Initial Sighting on Track
Time: 11:22 WP#: 40 Lat: 33.85749 Long: -76.61129 Track Line: 6
On/Off Effort: On Sighting Cue: Body
Vertical Angle: 3 Horizontal Bearing in Degrees: 80
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 11:23 WP #: 41 Lat: 33.84225 Long: -76.60023 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Short rostrum, light gray flanks with darker gray cape
Numbers (Low/ High/ Best): 20/25/23 Calves observed? Yes
Representative Images: 51, 76, 94
Photographer: RJM Card #: 1 Frame Numbers: 45 to 96 Spacer: No
Calculated Distance from Track Line: 2.0 km

Final Time and Position of Sighting
Time: 11:36 WP#: 42 Lat: 33.84992 Long: -76.60478
Calculated Distance traveled: 1.0 km

Behavior and Additional Comments
Dispersed and slowly traveling group. Lots of white bellies showing, as well as some white rostrum tips. Sub-groups separated by 10's to 100's of meters. Traveling at a "leisurely" pace. One mother –calf pair observed. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

26 May 2008 Sighting # 4

Initial Sighting on Track
Time: 14:17 WP#: 52 Lat: 34.20038 Long: -76.51738 Track Line: 10
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 50
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 14:19 WP #: 53 Lat: 34.21452 Long: -76.51423 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: Spotted appearance, long rostrum with white tip, blaze on flank
Numbers (Low/ High/ Best): 11 / 12 / 9 Calves observed? No
Representative Images: 147, 148, 155, 156, 157, 158, 160
Photographer: RJM Card #: 1 Frame Numbers: 137 to 160 Spacer: 161
Calculated Distance from Track Line: 1.6 km

Final Time and Position of Sighting
Time: 14:25 WP#: 54 Lat: 34.21637 Long: -76.51139
Calculated Distance traveled: 0.3 km

Behavior and Additional Comments
Animals were split into two sub-groups. Several dolphins "on" each other, rolling, lots of tactile interaction observed. Milling. White bellies showing. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

26 May 2008 Sighting # 5

Initial Sighting on Track
Time: 15:30 WP#: 67 Lat: 33.81997 Long: -76.28082 Track Line: 8
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Left

Time and Position of Sighting
Time: 15:31 WP #: 68 Lat: 33.82133 Long: -76.27602 Beaufort Sea State: 3
Species: *Globicephala macrorhynchus* Features used in species ID: Large black animals, with bulbous melons and short angular pectoral fins clearly visible.
Numbers (Low/ High/ Best): 5/ 12 / 9 Calves observed? No
Representative Images: 177, 178, 179
Photographer: RJM Card #: 1 Frame Numbers: 162 to 180 Spacer: 181
Calculated Distance from Track Line: 0.5 km

Final Time and Position of Sighting
None taken

Behavior and Additional Comments
Very spread out group, traveling in ones and twos. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

Appendix D - UNCW Aerial Survey Sighting Summary

26 May 2008 Sighting # 6

Initial Sighting on Track

Time: 16:05 WP#: 65 Lat: 33.953939 Long: -76.582045 Track Line: 7
On/Off Effort: On Sighting Cue: Splash
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting

Time: 16:06 WP #: 73 Lat: 33.95292 Long: -76.57421 Beaufort Sea State: 3
Species: *Tursiops truncatus* Features used in species ID: Gray, sturdy animals with blunt rostrum
Numbers (Low/ High/ Best): 6 / 7 / 6 Calves observed? No
Representative Images: 217, 228, 242
Photographer: RJM Card #: 1 Frame Numbers: 182 to 243 Spacer: 244
Calculated Distance from Track Line: 0.7 km

Final Time and Position of Sighting

Time: 16:17 WP#: 74 Lat: 33.96578 Long: -76.56110
Calculated Distance traveled: 1.9 km

Behavior and Additional Comments

Dolphins feeding on large school of fish, charging through the school. Fish looks fairly large (50-70 cm) Two to three dolphins at a time at the back edge of school, two to three dolphins 100 m to the side or behind school. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

27 May 2008 Sighting # 1

Initial Sighting on Track

Time: 9:56 WP#: 9 Lat: 33.523432 Long: 76.685647 Track Line: 2
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 4 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting

Time: 9:57 WP #: 10 Lat: 33.515733 Long: 76.689246 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Images showing rostrum shape, dorsal coloration and dorsal fin shape
Numbers (Low/ High/ Best): 5 / 11 / 12 Calves observed? No
Representative Images: 3, 4, 7, 8, 9, 10, 13, 15, 16, 18, 20, 26
Photographer: PBN Card #: 1 Frame Numbers: 2 to 26 Spacer: 27
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting

Time: 10:02 WP#: 11 Lat: 33.513852 Long: 76.692635
Calculated Distance traveled: 0.4 km

Behavior and Additional Comments

Animals seen traveling in relatively close group heading away from the trackline. Found two groups of animals, one with about 4 animals and the other with about 7 animals but probably more animals swimming under one another. Animals were seen swimming upside down showing bellies to the surface. Upon circling animals the distance between the two groups decreased. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

27 May 2008 Sighting # 2

Initial Sighting on Track
Time: 10:40 WP#: 17 Lat: 33.597114 Long: 76.650571 Track Line: 3
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 10:41 WP #: 18 Lat: 33.592923 Long: 76.65565 Beaufort Sea State: 2
Species: *Globicephala macrorhynchus* Features used in species ID: Photos showing squared off head, black body coloration, dorsal and pectoral fin shape
Numbers (Low/ High/ Best): 10 / 12 / 12 Calves observed? Yes
Representative Images: 35, 43, 45, 52, 59
Photographer: PBN Card #: 1 Frame Numbers: 28 to 70 Spacer: 71
Calculated Distance from Track Line: 0.7 km

Final Time and Position of Sighting
Time: 10:45 WP#: 19 Lat: 33.595499 Long: 76.654216
Calculated Distance traveled: 0.3 km

Behavior and Additional Comments
Animals in a tight linear group and showed no changes with plane present. Two small calves observed and one juvenile. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

27 May 2008 Sighting # 3

Initial Sighting on Track
Time: 11:00 WP#: 24 Lat: 33.597154 Long: 76.507192 Track Line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 11:13 WP #: 25 Lat: 33.595927 Long: 76.508913 Beaufort Sea State: 3
Species: *Grampus griseus* Features used in species ID: Photos showing coloration/ scarring on animals side. Also round melon without rostrum, and long pectoral fins, tall falcate dorsal fin
Numbers (Low/ High/ Best): 4 / 5 / 5 Calves observed? No
Representative Images: 81, 98, 101, 103, 110, 113, 120
Photographer: PBN Card #: 1 Frame Numbers: 72 to 133 Spacer: 134
Calculated Distance from Track Line: 0.2 km

Final Time and Position of Sighting
Time: 11:21 WP#: 26 Lat: 33.592403 Long: 76.509597
Calculated Distance traveled: 0.4 km

Behavior and Additional Comments
Initially 3 animals seen swimming away from the trackline in a loose horizontal line
5 animals in total seen upon relocating group, all were traveling at a very slow rate of speed. Some of the animals were dark in color and a few with very light heads and sides. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

Appendix D - UNCW Aerial Survey Sighting Summary

24 June 2008 Sighting # 1

Initial Sighting on Track

Time: 13:54 WP#: 27 Lat: 33.934722 Long: 76.957584 Track Line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting

Time: 14:00 WP #: 28 Lat: 33.937103 Long: 76.964589 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: Spots visible, blaze on flank, white rostrum tip
Numbers (Low/ High/ Best): 4 / 6 / 5 Calves observed? No
Representative Images: 33, 35, 38, 43, 44, 45, 68, 72
Photographer: PBN Card #: 1 Frame Numbers: 26 to 76 Spacer: 77
Calculated Distance from Track Line: 0.7 km

Final Time and Position of Sighting

Time: 14:07 WP#: 28 Lat: 33.943832 Long: 76.963251
Calculated Distance Traveled: 0.8 km

Behavior and Additional Comments

Animals traveling in a close group heading towards the trackline when first sighted. Animals relocated on right side of plane. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

24 June 2008 Sighting # 2

Initial Sighting on Track

Time: 14:13 WP#: 31 Lat: 33.79267 Long: 76.771215 Track Line: 4
On/Off Effort: On Sighting Cue: 3
Vertical Angle: 3 Horizontal Bearing in Degrees: 120
Observer: PBN Observer Side: Right

Time and Position of Sighting

Time: 14:15 WP #: 32 Lat: 33.800619 Long: 76.781757 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Robust grey animals, short rostrum tip
Numbers (Low/ High/ Best): 4 / 7 / 7 Calves observed? No
Representative Images: 101, 102, 116, 118, 131-136, 138, 145, 146, 147, 148
Photographer: PBN Card #: 1 Frame Numbers: 79 to 150 Spacer: 151
Calculated Distance from Track Line: 1.3 km

Final Time and Position of Sighting

Time: 14:20 WP#: 33 Lat: 33.792216 Long: 76.769888
Calculated Distance traveled: 1.4 km

Behavior and Additional Comments

Initial observation had animals traveling quickly and breaking hard at the surface causing a disturbance. Some animals cut back on their path and hung out in an area before continuing on. Upon circling animal began to circle around in one area not traveling a particular direction. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

24 June 2008 Sighting # 3

Initial Sighting on Track
Time: 14:22 WP#: 34 Lat: 33.774027 Long: 76.745051 Track Line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Left

Time and Position of Sighting
Time: 14:22 WP #: 35 Lat: 33.772186 Long: 76.741641 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: Flank blaze present, white rostrum tip, spotted pattern clearly visible
Numbers (Low/ High/ Best): 34 / 37 / 35 Calves observed? Yes
Representative Images: 161, 171, 173, 177, 186, 189, 193, 194, 198, 199, 200
Photographer: PBN Card #: 1 Frame Numbers: 152 to 203 Spacer: 204
Calculated Distance from Track Line: 0.4 km

Final Time and Position of Sighting
Time: 14:25 WP#: 36 Lat: 33.771411 Long: 76.745038
Calculated Distance traveled: 0.3 km

Behavior and Additional Comments
Large group of animals traveling in smaller groups of 2 or 5, loose grouping originally but group tightened up some upon circling. Animals spent most of the time below the surface. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

24 June 2008 Sighting # 4

Initial Sighting on Track
Time: 14:48 WP#: 42 Lat: 33.507385 Long: 76.534704 Track Line: 3
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 14:48 WP #: 43 Lat: 33.507569 Long: 76.532724 Beaufort Sea State: 2
Species: *T. truncatus/S. frontalis* Features used in species ID: Sharp, pointed dark dorsal cape (cape edge close to blow hole), grey body
Numbers (Low/ High/ Best): 2 / 2 / 2 Calves observed? No
Representative Images: 207, 208, 216, 217, 218, 221
Photographer: PBN Card #: 1 Frame Numbers: 206 to 222 Spacer: 223
Calculated Distance from Track Line: 0.2 km

Final Time and Position of Sighting
Time: 14:49 WP#: 44 Lat: 33.509441 Long: 76.531364
Calculated Distance traveled: 0.2 km

Behavior and Additional Comments
Two animals traveling in close proximity to one another. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

24 June 2008 Sighting # 5

Initial Sighting on Track

Time: 14:51 WP#: 46 Lat: 33.550452 Long: 76.593091 Track Line: 3
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 60
Observer: PBN Observer Side: Right

Time and Position of Sighting

Time: 14:52 WP #: 47 Lat: 33.551987 Long: 76.594555 Beaufort Sea State: 2
Species: *Steno bredanensis* Features used in species ID: Long thin rostrum, with white lower jaw. Large dorsal fin set far forward on body, large triangular pectorals. Thin, concave, darker dorsal cape.
Numbers (Low/ High/ Best): 3 / 5 / 5 Calves observed? Yes
Representative Images: 228-230, 234, 235-238, 246
Photographer: PBN Card #: 1 Frame Numbers: 224 to 247 Spacer: 248
Calculated Distance from Track Line: 0.1 km

Final Time and Position of Sighting

Time: 14:54 WP#: 48 Lat: 33.551045 Long: 76.595054
Calculated Distance traveled: 0.1 km

Behavior and Additional Comments

Animals traveling together in a single group. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

24 June 2008 Sighting # 6

Initial Sighting on Track

Time: 15:34 WP#: 52 Lat: 33.508931 Long: 76.667731 Track Line: 2
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 120
Observer: RJM Observer Side: Left

Time and Position of Sighting

Time: 15:35 WP #: 53 Lat: 33.516511 Long: 76.66473 Beaufort Sea State: 2
Species: *Steno bredanensis* Features used in species ID: Large dorsal fin set far forward on body, large triangular pectorals.Long thin rostrum, with white lower jaw.
Numbers (Low/ High/ Best): 7 / 10 / 10 Calves observed? No
Representative Images: 262, 267, 268-270, 273, 274, 276, 277, 296, 297
Photographer: PBN Card #: 1 Frame Numbers: 250 to 303 Spacer: End card 1
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting

Time: 15:40 WP#: 54 Lat: 33.516134 Long: 76.651189
Calculated Distance traveled: 1.3 km

Behavior and Additional Comments

Animals in a well spaced group traveling fast and splashing while surfacing. Animals appeared to be chasing something because most of the animals were changing directions and diving while we were circling them. We observed a shark of roughly the same size as the dolphins in the same area. Pictures revealed that the shark may be interacting with dolphins. Judging from the long thin tail, broad head, and large spade shaped pectoral fins the observed shark may have been a thresher shark. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

24 June 2008 Sighting # 7

Initial Sighting on Track
Time: 15:50 WP#: 58 Lat: 33.395708 Long: 76.647814 Track Line: 1
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 15:52 WP #: 59 Lat: 33.398254 Long: 76.639548 Beaufort Sea State: 2
Species: *Tursiops truncates* Features used in species ID: Grey animals, short rostrum, gradually tapering peduncle.
Numbers (Low/ High/ Best): 25 / 25 / 25 Calves observed? No
Representative Images: 3, 6, 8, 9, 11, 34, 45
Photographer: PBN Card #: 2 Frame Numbers: 1 to 50 Spacer: 51
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 15:56 WP#: 60 Lat: 33.401374 Long: 76.644092
Calculated Distance traveled: 0.5 km

Behavior and Additional Comments
Animals traveling slowly and on their side sometimes very close to the surface. Many single animals in loose groups and a few groups of 2 or 3. Animals formed into pairs swimming belly to belly. Group not traveling in any definite direction. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

24 June 2008 Sighting # 8

Initial Sighting on Track
Time: 16:15 WP#: 62 Lat: 33.74109 Long: 76.099344 Track Line: 1
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: PBN Observer Side: Right

Time and Position of Sighting
Time: 16:15 WP #: 63 Lat: 33.744705 Long: 76.09179 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: Flank blaze and color pattern consistent with *S. frontalis*. White rostrum tip.
Numbers (Low/ High/ Best): 10 / 10 / 10 Calves observed? No
Representative Images: 54, 60, 61, 68, 69, 73, 74, 77
Photographer: PBN Card #: 2 Frame Numbers: 52 to 82 Spacer: 83
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting
Time: 16:21 WP#: 64 Lat: 33.744849 Long: 76.089426
Calculated Distance traveled: 0.2 km

Behavior and Additional Comments
Tight group of approximately 10 animals just below the surface not traveling very fast. Animal spread out and then reformed into 2 groups during sighting. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

Appendix D - UNCW Aerial Survey Sighting Summary

25 June 2008 Sighting # 1

Initial Sighting on Track
Time: 09:47 WP #: 7 R Lat: 33.584993 Long: -76.368037 Track Line: 5
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: RJM Observer Side: Right

Time and Position of Sighting
Time: 09:47 WP#: 7 L Lat:33.584993 Long: -76.352499 Beaufort Sea State: 1
Species: *Tursiops truncatus* Features used in species ID: Grey, robust animals, with short rostrums, and gradually tapering peduncles
Numbers (Low/ High/ Best): 6/10/9 Calves observed? Yes
Representative Images: 311, 316, 321, 323, 324, 327
Photographer: RJM Card #: 1 Frame Numbers: 308 to 331 Spacer 332
Calculated Distance from Track Line: 0.4 km

Final Time and Position of Sighting
None taken

Behavior and Additional Comments
Looks like Tursiops from the air; sturdy, gray, white peduncle. Slow travel, 1 mother/calf pair, group spread out. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 2

Initial Sighting on Track
Time: 10:22 WP #:14 Lat: 34.057055 Long:-76.860306 Track Line 6
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: PBN Observer side: Left

Time and Position of Sighting
Time: 10:24 WP#:15 Lat: 34.050011 Long: -76.858224 Beaufort Sea State: 2
Species: *Stenella frontalis* Features used in species ID: Distinctive spotted and coloration pattern, white rostrum tip, lighter flank blaze
Numbers (Low/ High/ Best): 8/8/8 Calves observed? Yes
Representative Images: 337, 338, 345, 346, 362, 363
Photographer: RJM Card #: 1 Frame Numbers: 332 to 368 Spacer 369
Calculated Distance from Track Line: 0.8 km

Final Time and Position of Sighting
None taken

Behavior and Additional Comments
Looks like spotted dolphins, 1 mother/calf pair – calf looks young (i.e. small). Slow surface travel. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 3

Initial Sighting on Track

Time: 11:12 WP #: 25 Lat: 33.949522 Long: -76.459364 Track Line: 8
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees:: 90
Observer: PBN Observer side: Left

Time and Position of Sighting

Time: 11:15 WP#: 26 Lat: 33.941355 Long:-76.457001 Beaufort Sea State: 1
Species: *Tursiops truncatus* Features used in species ID: Short, blunt rostrum, robust body
Numbers (Low/ High/ Best): 2/2/2 Calves observed? No
Representative Images: 369, 370, 380, 388
Photographer: RJM Card #: 1 Frame Numbers: 369 to 389 Spacer 390
Calculated Distance from Track Line: 0.9 km

Final Time and Position of Sighting

None taken

Behavior and Additional Comments

Looks like *Tursiops* (fairly large, sturdy, short rostrum). Leisurely travel, tactile interaction – swimming close to each other. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 4

Initial Sighting on Track

Time: 11:54 WP #:30 Lat: 34.022289 Long:-76.418861 Track Line: 9
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: RJM Observer side: right

Time and Position of Sighting

Time: N/A – not re-sighted after break track
Species: Unidentified delphinid Features used in species ID: N/A
Numbers (Low/ High/ Best): 1 Calves observed? No
Best images used for species ID: None taken
Calculated Distance from Track Line: N/A

Final Time and Position of Sighting

None taken

Behavior and Additional Comments

Lone un-identified delphinid, not re-sighted after breaking track

25 June 2008 Sighting # 5

Initial Sighting on Track

Time: 12:14 WP # 34 Lat: 33.819674 Long:-76.019607 Track Line 10
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: RJM Observer side: Right

Time and Position of Sighting

Time: 12:15 WP#: 45 Lat: 33.831817 Long: -76.037992 Beaufort Sea State: 1
Species: *Grampus griseus* Features used in species ID: Rounded head with cleft in middle of melon, multiple white scratches and rake marks, some individuals with completely white head, lighter "suspenders' on flanks.
Numbers (Low/ High/ Best): 8/12/10 Calves observed? Yes
Representative Images: 393, 425, 494, 497, 499, 501, 508, 509
Photographer: RJM Card #: 1 Frame Numbers: 390 to 517 Spacer: 518
Calculated Distance from Track Line: 2.2 km

Final Time and Position of Sighting

None taken

Behavior and Additional Comments

Group spread out over 1 to 2 km, traveling in pairs or singles. A very small calf observed very close to larger individual, and a slightly larger calf observed swimming 30-40 m off the side of the group never "mingling" with the other members. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 6

Initial Sighting on Track

Time: 12:47 WP # 38 right Lat: 34.084891 Long: -76.361621 Track Line 10
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 1 Horizontal Bearing in Degrees: 90
Observer: RJM Observer side: Right

Time and Position of Sighting

Time: 12:48 WP#: 48 left Lat: 34.083751 Long: -76.361075 Beaufort Sea State: 1
Species: *Tursiops truncatus* Features used in species ID: Robust, grey single animal with a short rostrum
Numbers (Low/ High/ Best): 1/1/1 Calves observed? No
Representative Images: 536, 538, 539, 541, 542
Photographer: RJM Card #: 1 Frame Numbers: 533 to 546 Spacer 547
Calculated Distance from Track Line: 0.1 km

Final Time and Position of Sighting

None taken

Behavior and Additional Comments

Single dolphin interacting with whitish object in the water, looks like a piece of trash (see images). Dolphin looks like *Tursiops* (uniformly gray, sturdy). Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 7

Initial Sighting on Track

Time: 14:54 WP #: 60 Lat: 33.634163 Long: -76.559943 Track Line:4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 4 Horizontal Bearing in Degrees: 90
Observer: PBN Observer side: Left

Time and Position of Sighting

Time: 14:55 WP#: 61 Lat: 33.646071 Long: -76.546472 Beaufort Sea State: 1
Species: *Tursiops truncatus* Features used in species ID: Large, grey, sturdy looking animals, with short rostrums, lighter coloration on caudal peduncle
Numbers (Low/ High/ Best): 13/15/14 Calves observed? No
Representative Images: 548, 549, 550, 551, 552, 554, 555, 558, 560
Photographer: RJM Card #: 1 Frame Numbers: 547 to 561 Spacer: 562
Calculated Distance from Track Line: 1.8 km

Final Time and Position of Sighting

Not recorded

Behavior and Additional Comments

Group of *Tursiops* spread out in three sub-groups over about 200 meters. Milling; non-directional travel, belly-to-belly swimming. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 8

Initial Sighting on Track

Time: 15:01 WP #: 50 Lat: 33.592171 Long: -76.501968 Track Line: 4
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 90
Observer: RJM Observer side: Right

Time and Position of Sighting

Time: 1503 WP#: 64 Lat: 33.593274 Long: -76.507083 Beaufort Sea State: 1
Species: *Grampus griseus* Features used in species ID: Large robust animals. Rounded head with cleft through middle of melon, multiple scratch marks, lighter area on flanks ('suspenders')
Numbers (Low/ High/ Best): 5/5/5 Calves observed? Yes
Representative Images: 562, 563, 565, 566, 568, 570, 571, 577, 580, 581, 582, 583
Photographer: RJM Card #: 1 Frame Numbers: 562 to 583
Calculated Distance from Track Line: 0.5 km

Final Time and Position of Sighting

Not recorded

Behavior and Additional Comments

Slow travel, one mother/calf pair, one individual with white head. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 9

Initial Sighting on Track

Time: 15:54 WP #: 71 Lat: 33.534094 Long: -76.699321 Track Line 2
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 3 Horizontal Bearing in Degrees: 90
Observer: PBN Observer side: Left

Time and Position of Sighting

Time: 15:55 WP#: 72 Lat: 33.541729 Long: -76.695676 Beaufort Sea State: 2
Species: *Tursiops truncatus* Features used in species ID: Grey, sturdy animals. Short rostrum, gradually tapering body
Numbers (Low/ High/ Best): 11/12/11 Calves observed? No
Representative Images: 588, 594, 599, 602
Photographer: RJM Card #: 1 Frame Numbers: 581 to 602 Spacer
Calculated Distance from Track Line: 0.9

Final Time and Position of Sighting

Not recorded

Behavior and Additional Comments

Fats surface travel, including leaping. Looks like *Tursiops*. Pretty tight group. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

25 June 2008 Sighting # 10

Initial Sighting on Track

Time: 16:09 WP #: 76 Lat: 33.372752 Long: -76.620278 Track Line 1
On/Off Effort: On Sighting Cue: Body part
Vertical Angle: 2 Horizontal Bearing in Degrees: 45
Observer: PBN Observer Side: Left

Time and Position of Sighting

Time: 16:09 WP#:77 Lat: 33.368079 Long: -76.620278 Beaufort Sea State: 1
Species: *Tursiops truncatus* Features used in species ID: Grey, robust, tapered body, short rostrum
Numbers (Low/ High/ Best): 5/5/5 Calves observed? No
Representative Images: 604, 605, 607, 610, 611, 612, 614, 616
Photographer: RJM Frame Numbers: 604 to 616 Spacer 603
Calculated Distance from Track Line: 0.5 km

Final Time and Position of Sighting

None taken

Behavior and Additional Comments

Three of the dolphins swimming next to each other, when diving they line up vertically in a staggered fashion. One of these three was a smaller, juvenile sized dolphin. Circled animals at between 750 and 1000 ft. No avoidance reaction noted.

Appendix E

Notes on the Sighting Summary Sheet

The Sighting Summary, adapted from the Sighting Data Sheet used in the field (Fig. 3), integrates data gathered in the field with results from lab analyses to provide a full summary of each marine mammal sighting. A Sighting Summary was completed for all sightings, including sightings made while off-effort during transits between survey legs, as well as sighting cues which where never relocated.

The Sighting Summary sheet is broken into four sections; "Initial Sighting on Track", "Time and Position of Sighting", "Final Time and Position of Sighting", and "Behavior and Additional Comments". Each section and sub headings will be detailed below.

Initial Sighting on Track

Time*:* The time the break track GPS way-point was taken

WP#: GPS way-point number of the break track

Lat/Long: The latitude and longitude associated with the break track way-point

Track Line: The track line surveyed when the sighting was made

On/Off Effort: Whether the sighting was made during an active survey track line (i.e. On effort) or during transit BETWEEN track lines (i.e. off effort). Sightings made during off effort transit to and from the range are NOT included in the sighting summaries.

Sighting Cue: Whether the initial sighting was a splash, a breach or body part.

Vertical Angle: Vertical "angle" between 1 and 4, the lower edge of view ("1") to the horizon ("4"). A subjective and relative measure of how far away from the track line the initial sighting occurred.

Horizontal Bearing in Degrees: The horizontal degrees from front to back (0 to 180) at which the sighting occurred.

Observer: Three lettered initial of the observer who made the sighting

Observer Side: On which side of the plane in the direction of travel the sighting occurred.

Time and Position of Sighting

Time*:* The time the GPS way-point was taken while relocating animals and circling above

WP#: GPS way-point number of the sighting

Lat/Long: The latitude and longitude associated with the way point obtained while circling over animals

Beaufort Sea State: The sea state observed during the sighting

Species: Scientific binomial name of the marine mammal species involved in the sighting. When species identity could not be established unequivocally, the next higher taxonomic level to which identity could be established was used. If a cetacean was identified as a dolphin but images obtained during the encounter were not sufficient to establish species ID, the designation "unidentified delphinid" or "*T. truncatus/S. frontalis*" was used. The next higher level used was unidentified cetacean. If a large body was observed but

it could not be established whether a cetacean, fish/shark or turtle was involved in the sighting, the designation “unidentified marine vertebrate” was used.

Criteria used to identify species: Which species specific diagnostic features were used in classifying a sighting to species.

Best images used for species ID: The images obtained during the sighting that best displayed the features used to establish species.

Numbers (Low/ High/ Best): Low, high, and best estimate of number of animals involved in the sighting.

Calves observed? Whether any calves were observed during the encounter. A conservative measure was used, in that only animals roughly half the size of the associated larger animal (the presumed mother) were designated as calves.

Calculated Distance from Track Line: The distance between the break track way-point and the initial sighting way-point. For more information on how distance was calculated and errors inherent in this method, refer to the “Methods” section.

Photographer: Three lettered initials of observer seated in the right camera seat.

Card #: Memory card on which the photos from the particular sighting was made.

Frame Numbers: Starting and ending frame number

Spacer: Image used to separate sighting to clarify when one sighting ends and the next begins. Image typically of interior of plane or a 45 degree angle shot of the horizon.

Final Time and Position of Sighting

Time: WP#: Lat: Long: Calculated Distance traveled: ➔ see section above

Behavior and Additional Comments

Any behavioral notes obtained during the sighting (*e.g.* group formation, relative travel speed, feeding events or presumed copulation attempts, presence of other cetaceans or sharks in or around the animal(s) in the sighting, interaction with inanimate objects such marine debris). This section also includes notes on altitude of the survey plane during the encounter as well as any indications (or lack thereof) of the animal(s) reacting evasively to the presence of the plane.

Appendix F

Date:_____

USWTR Daily Plane Log Sheet

Pilot in Command:_____ Second in Command:_____

Observers:_____

Plane:_____

Time take off: _____ HOBBS Start:_____

Land for lunch:_____

Track Lines and Direction (e.g. N to S) Flown:_____

Take off after lunch:_____ HOBBS Stop:_____

Land:_____ HOBBS Total:_____

Track Lines and Direction (e.g. N to S) Flown:_____

Overall weather:_____

General Observations

_____

_____

_____

_____

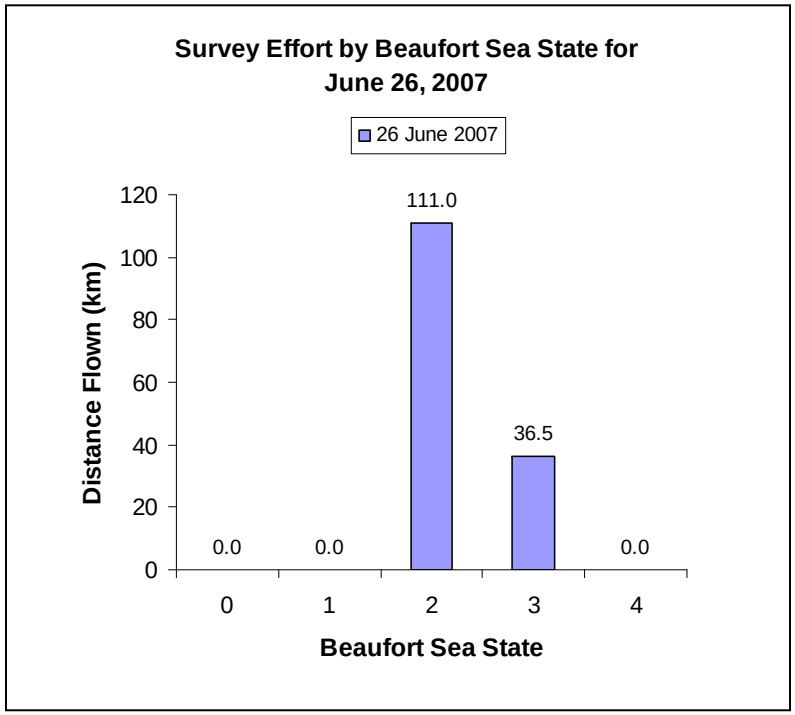
_____

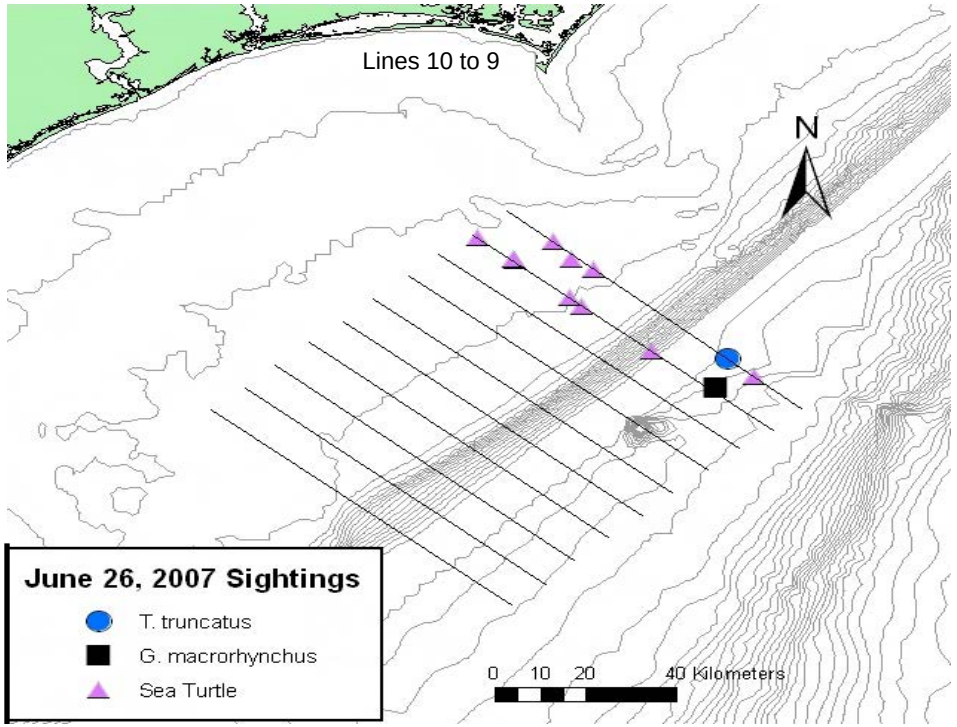
_____

_____

26 June 2007

Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	80	2	10
Globicephala macrorhynchus	1	32	2	9
Sea Turtle	8	1	2	
Sea Turtle	2	1	3	





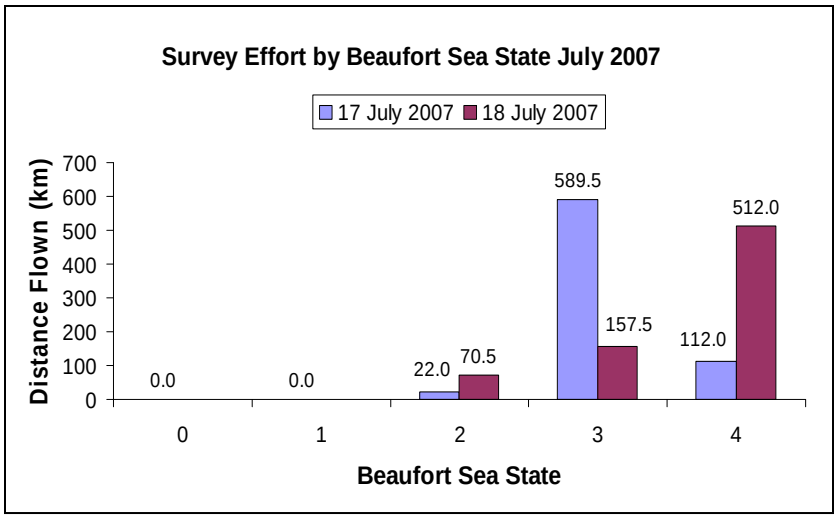
Appendix G

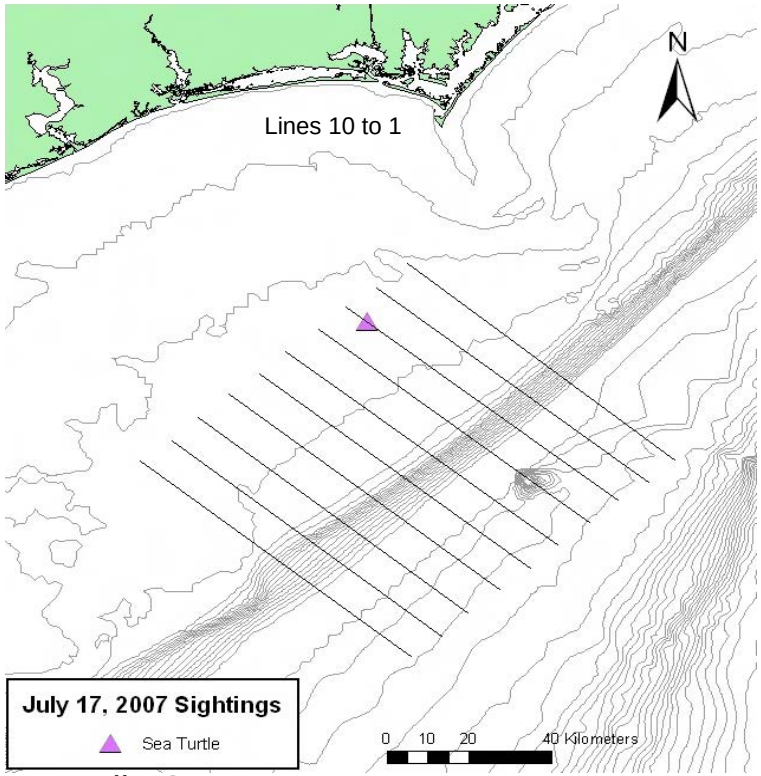
17 July 2007

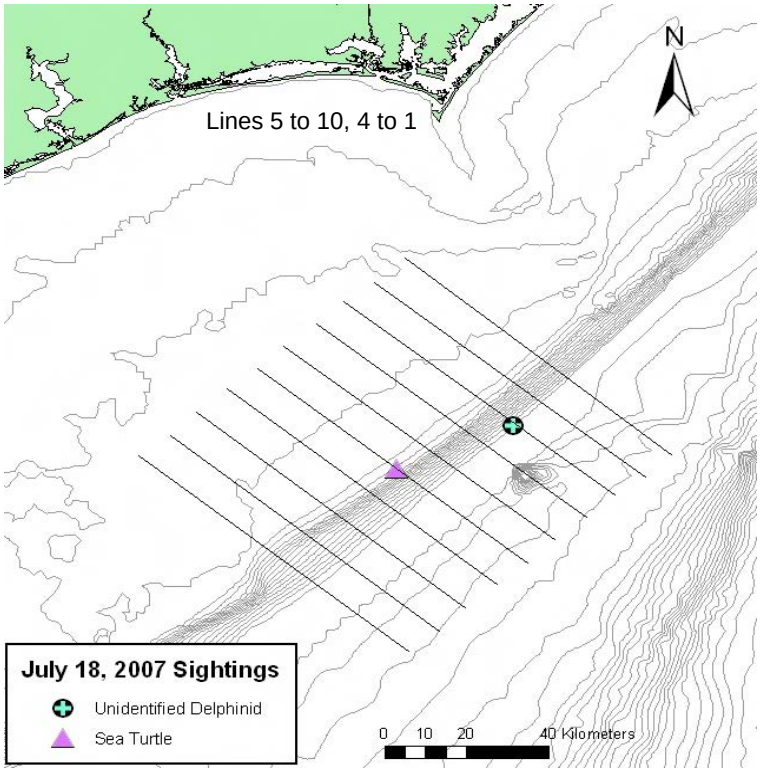
Species	# of sightings	# of individuals	BSS
Sea Turtle	1	1	3

18 July 2007

Species	# of sightings	# of individuals	BSS	Line
Unidentified Delphinid	1	6	3	8
Sea Turtle	1	1	4	





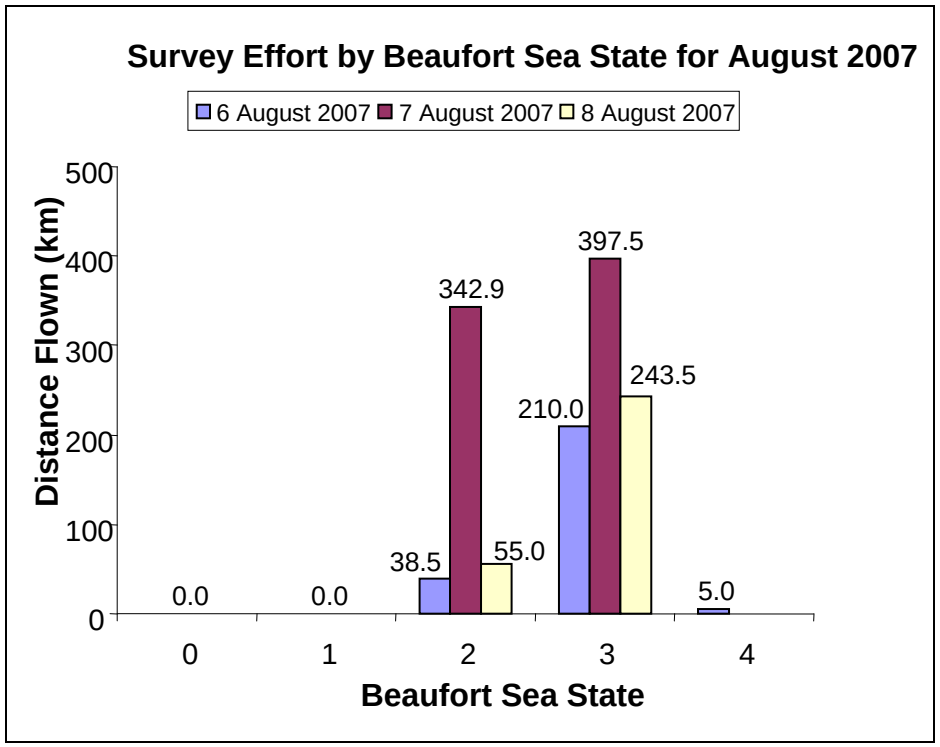


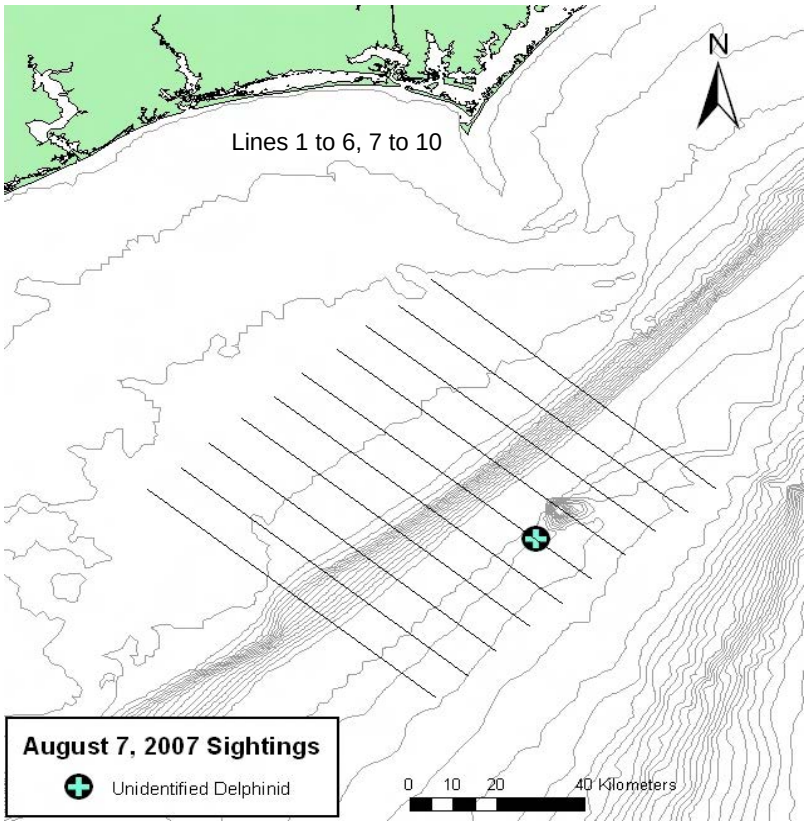
Appendix G

7 August 2007

Species	# of sightings	# of individuals	BSS	Line
Unidentified Delphinid	1	3	2	6

August 6 and 8 had no cetacean or sea turtle sightings





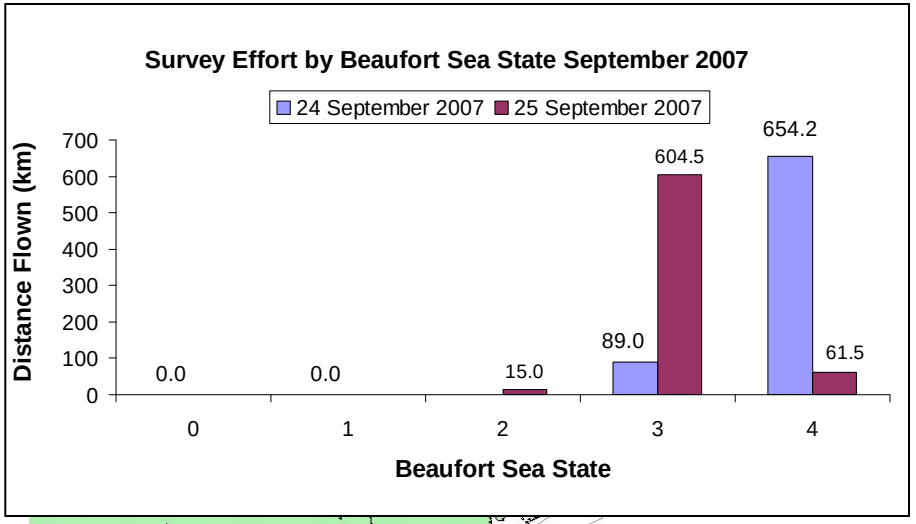
Appendix G

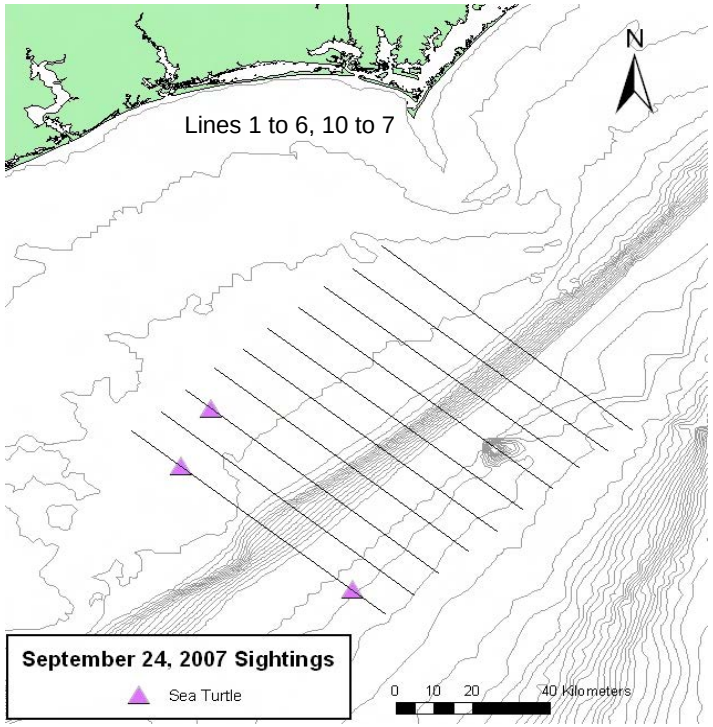
24 September 2007

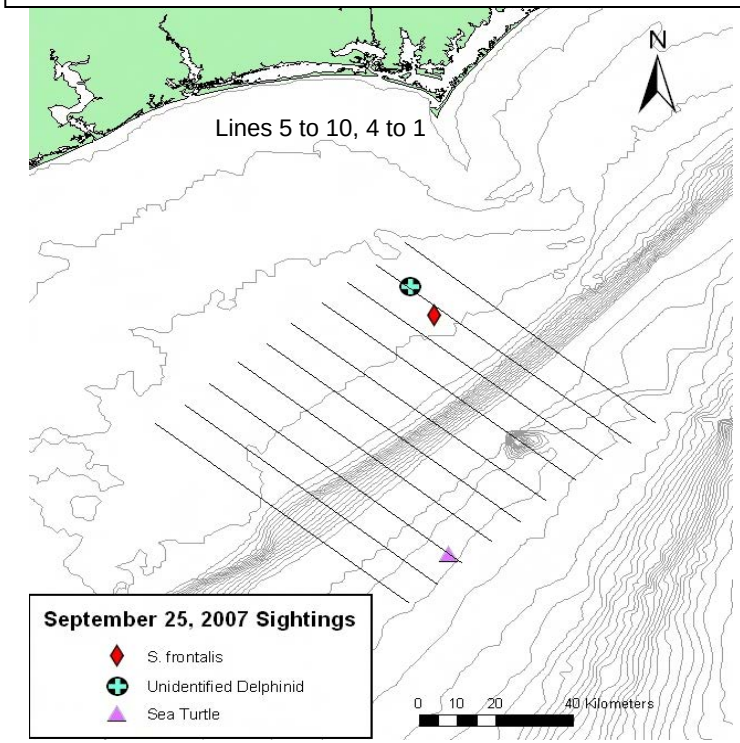
Species	# of sightings	# of individuals	BSS
Sea Turtle	3	1-2	4

25 September 2007

Species	# of sightings	# of individuals	BSS	Line
Stenella frontalis	1	4	3	9
Unidentified Delphinid	1	6	3	9
Sea Turtle	1	1	3	





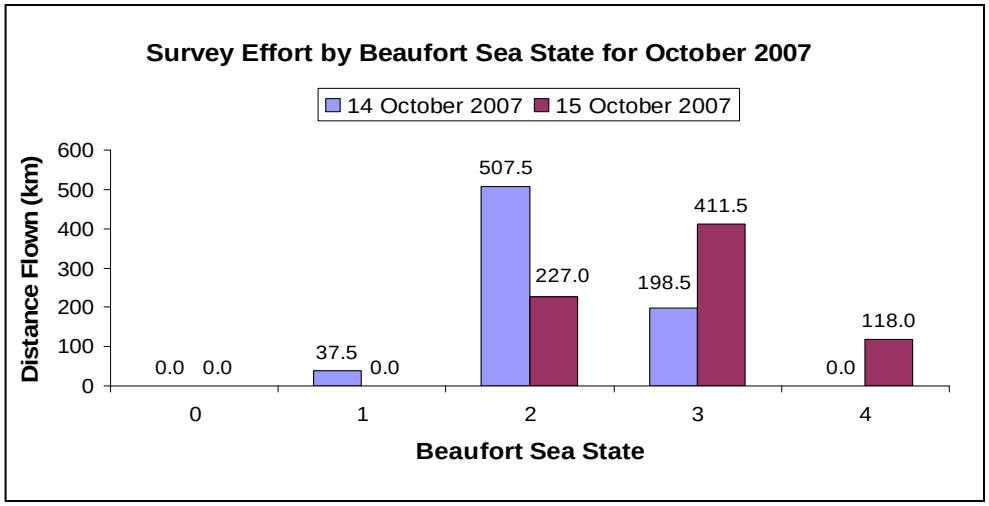


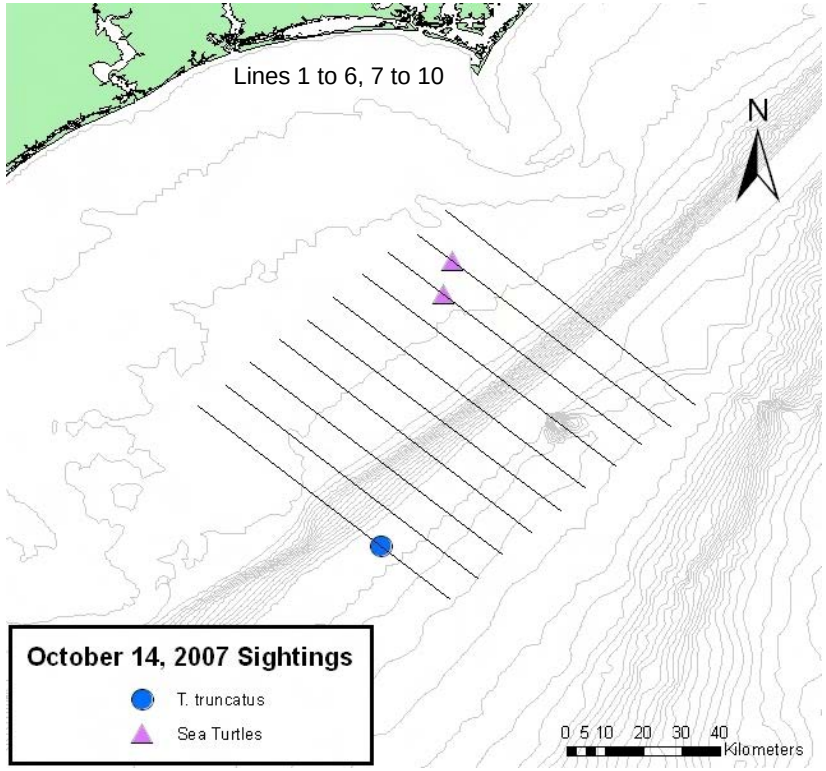
Appendix G

14 October 2007

Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	40	2	1
Sea turtle	2	2	2	

15 October 2007 - no cetacean or sea turtle sightings





17 November 2007

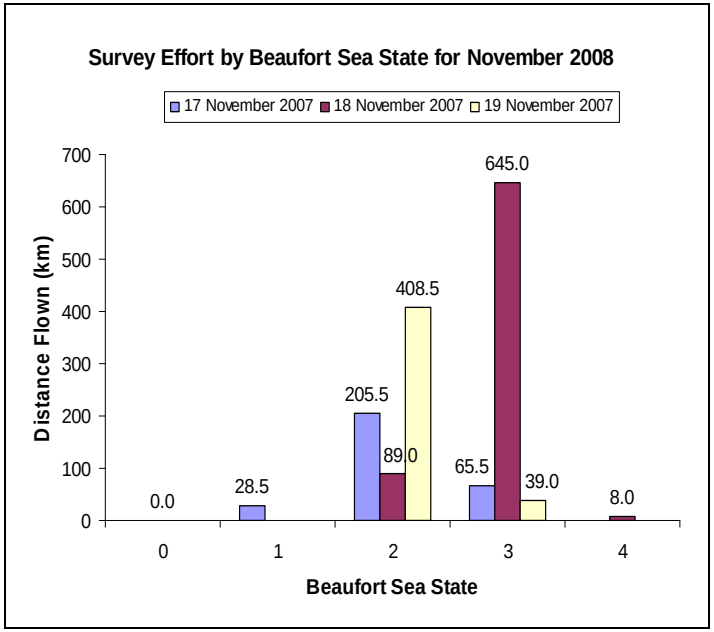
Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	3	2	4
Tursiops truncatus	1	9	2	4
Tursiops truncatus	1	18	2	4
Tursiops truncatus	1	23	2	3
Sea Turtles	1	1	1	
Sea Turtles	10	1	2	
Sea Turtles	1	1	3	

18 November 2007

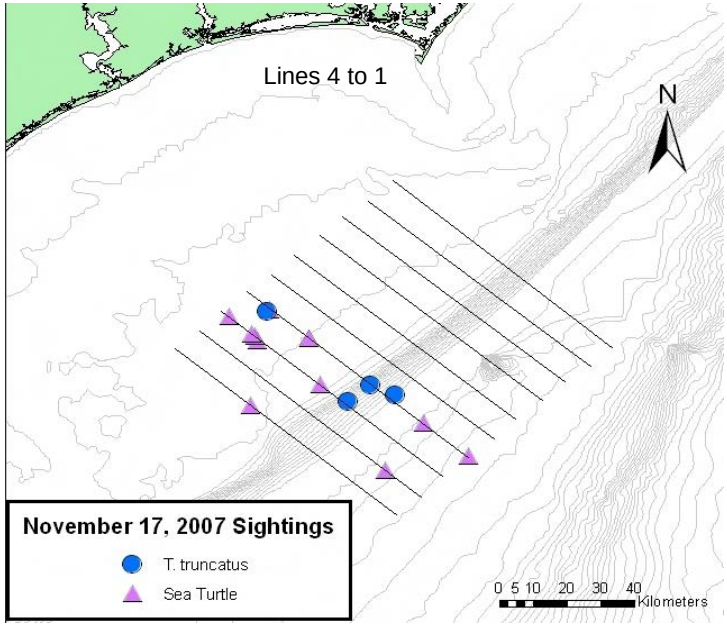
Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	3	2	9
Sea Turtles	1	1	2	
Sea Turtles	6	1-2	3	
Sea Turtles	1	2	4	

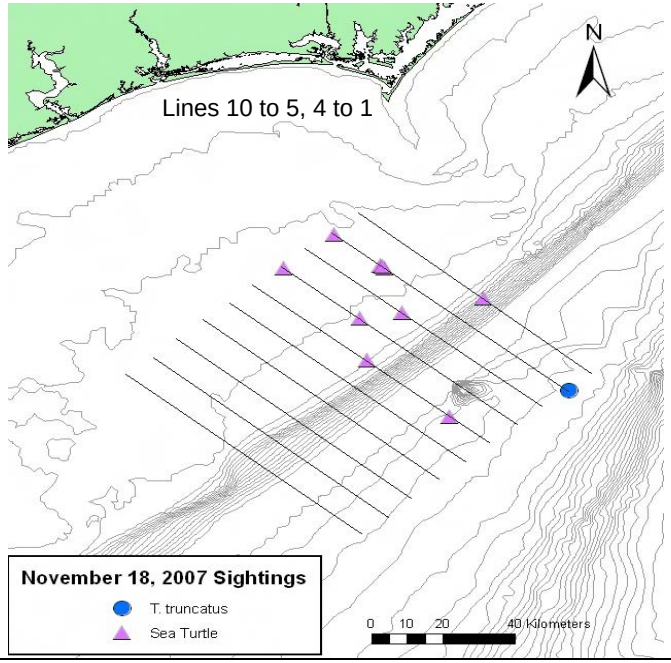
19 November 2007

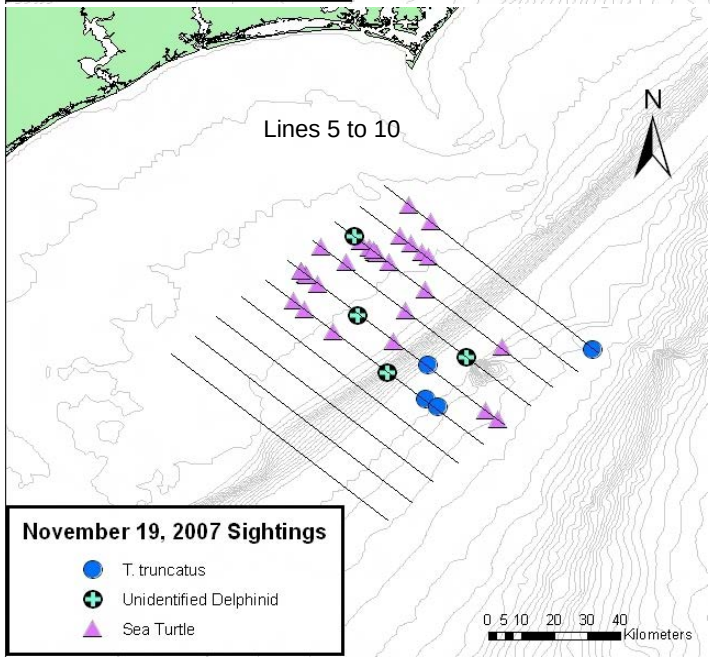
Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	4	2	5
Tursiops truncatus	1	5	2	6
Tursiops truncatus	1	8	2	5
Tursiops truncatus	1	40	2	10
Unidentified Delphinid	1	3	2	8
Unidentified Delphinid	1	11	2	6
Unidentified Delphinid	1	20	2	5
Unidentified Delphinid	4	22	2	7
Sea Turtles	25	1-2	2	
Sea Turtles	2	1	3	

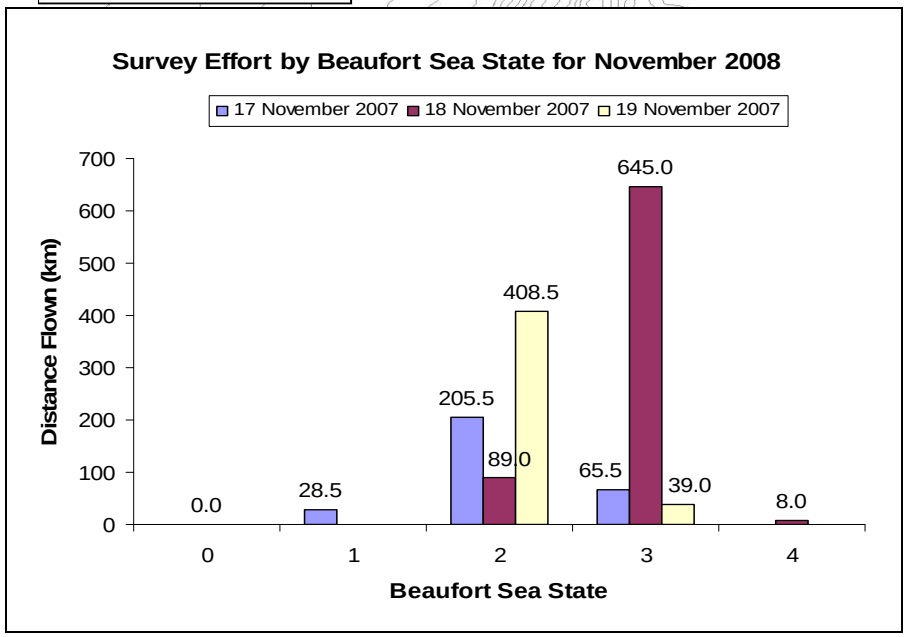


Appendix G


Lines 4 to 1
N
November 17, 2007 Sightings
T. truncatus
Sea Turtle
0 5 10 20 30 40
Kilometers


Lines 10 to 5, 4 to 1
N
November 18, 2007 Sightings
T. truncatus
Sea Turtle
0 10 20 40 Kilometers


Lines 5 to 10
N
November 19, 2007 Sightings
T. truncatus
Unidentified Delphinid
Sea Turtle
0 5 10 20 30 40
Kilometers

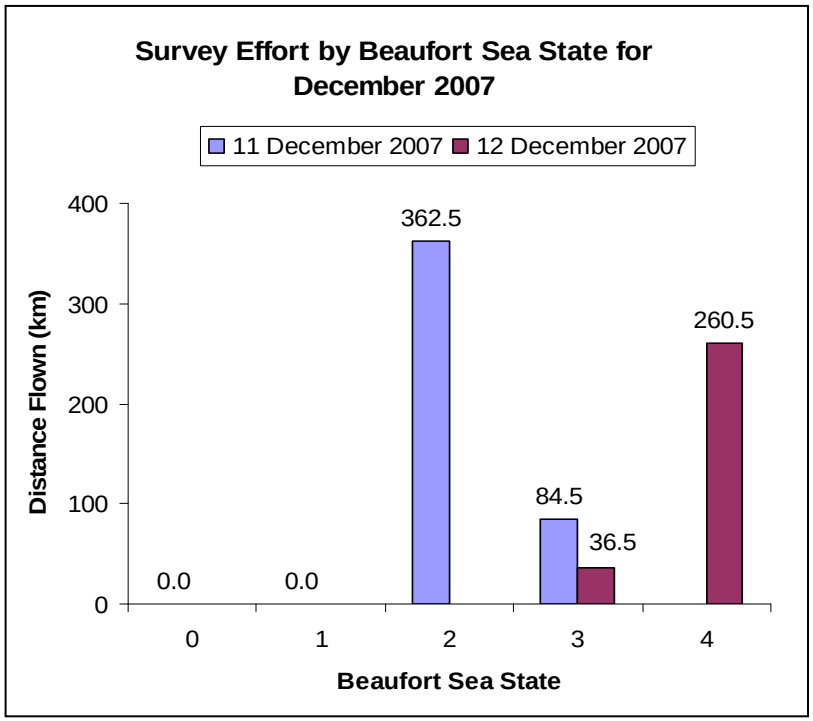

Survey Effort by Beaufort Sea State for November 2008
17 November 2007
18 November 2007
19 November 2007
Distance Flown (km)
700
600
500
400
300
200
100
0
0.0
28.5
205.5
89.0
408.5
65.5
645.0
39.0
8.0
0
1
2
3
4
Beaufort Sea State

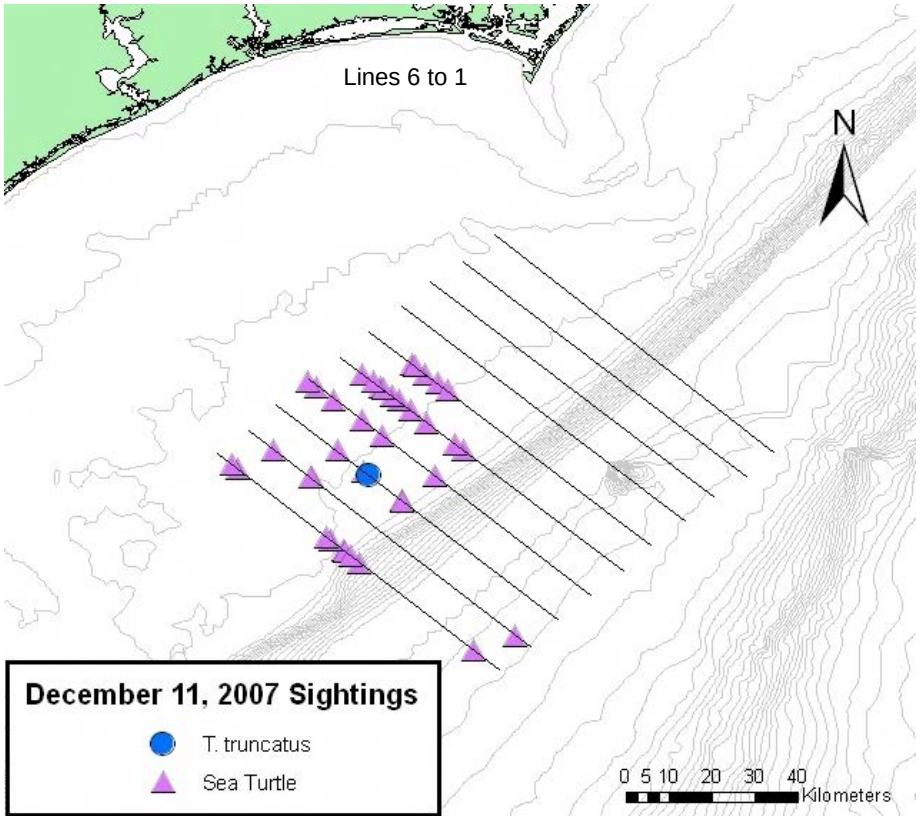
Appendix G

11 December 2007

Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	1	2	3
Sea Turtle	53	1-2	2	
Sea Turtle	1	1	3	

12 December 2007 no cetacean or sea turtle sightings





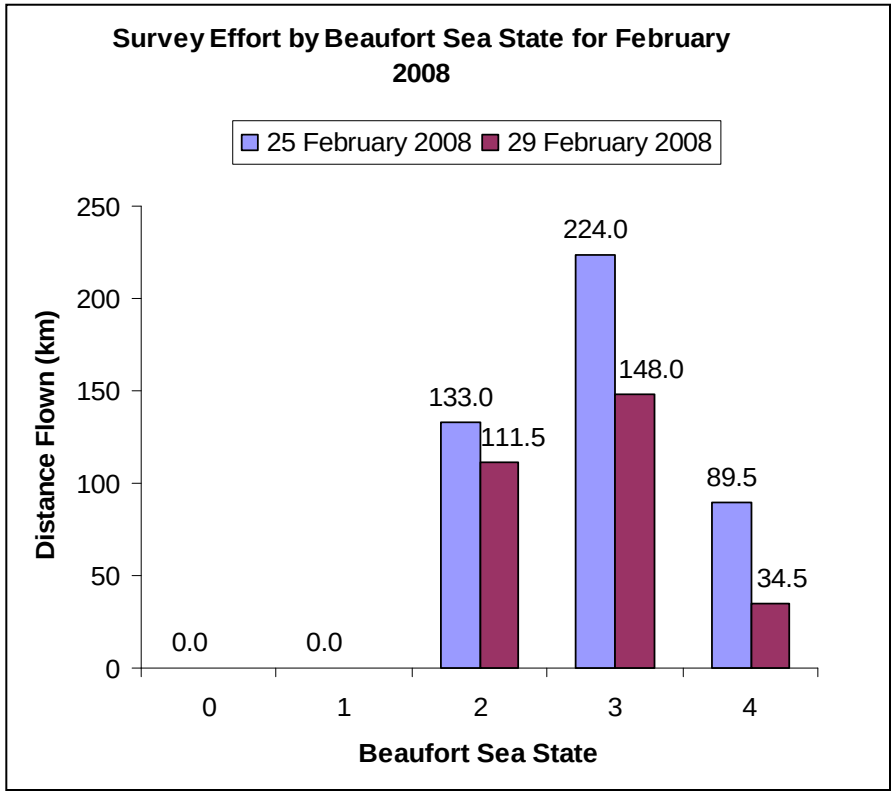
Appendix G

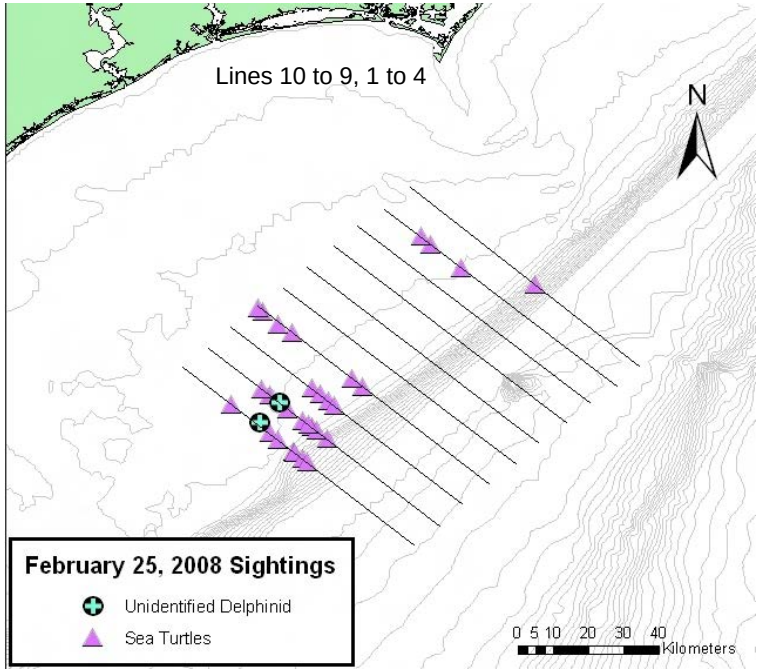
25 February 2008

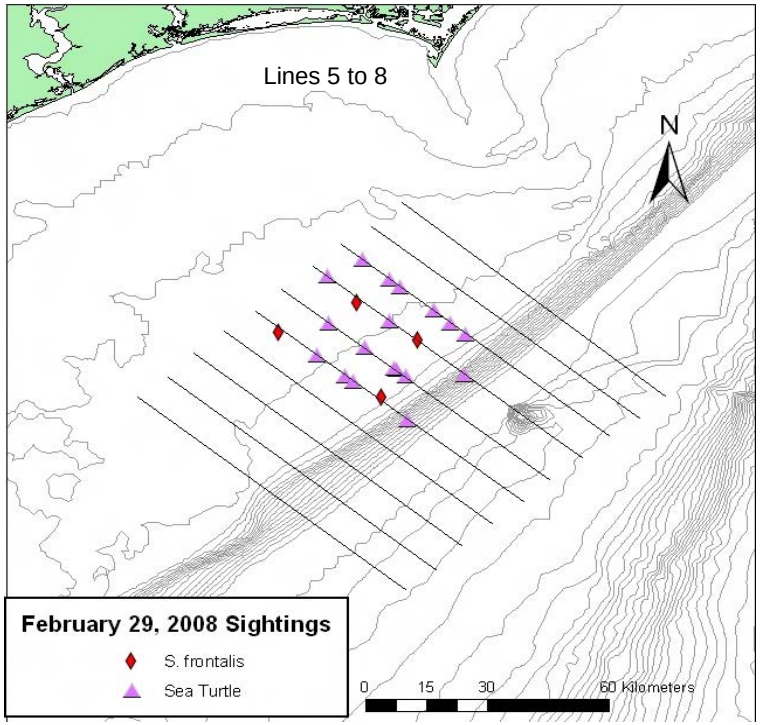
Species	# of encounters	# of individuals	BSS	Line
Delphinid	1	13	2	2
Delphinid	1	7	2	1
Sea Turtle	12	1	2	
Sea Turtle	16	1-2	3	
Sea Turtle	1	1	4	

29 February 2008

Species	# of encounters	# of individuals	BSS	Line
Stenella frontalis	1	8	2	5
Stenella frontalis	1	27	2	7
Stenella frontalis	1	26	2	7
Stenella frontalis	1	7	3	5
Sea Turtle	6	1	2	
Sea Turtle	12	1	3	







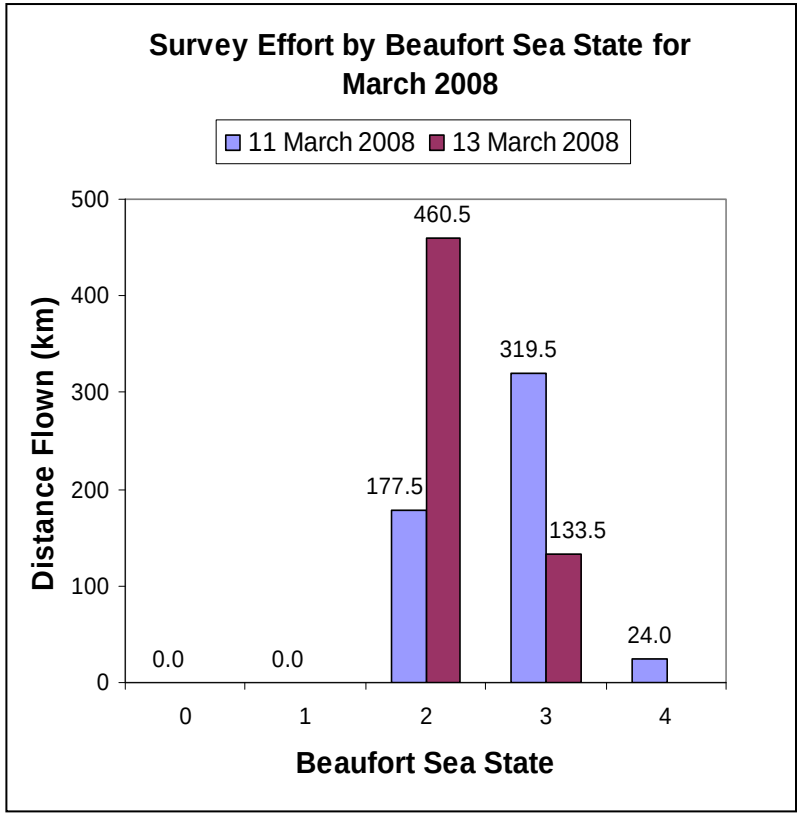
Appendix G

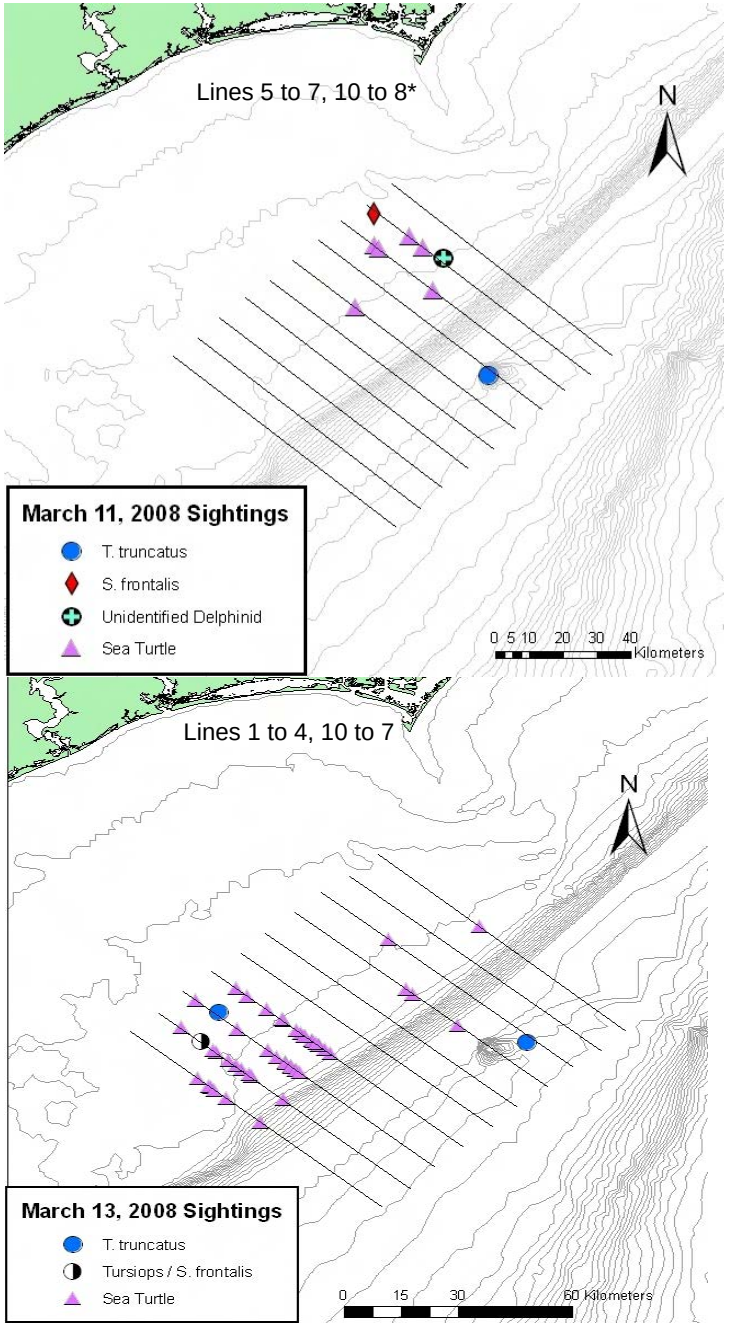
11 March 2008

Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	15	3	7
Stenella frontalis	1	36	2	9
Unidentified Delphinid	1	5	2	9
Sea Turtle	5	1	2	
Sea Turtle	1	1	3	

13 March 2008

Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	5	2	3
Tursiops truncatus	1	13	2	8
Tursiops/ Stenella frontalis	1	3	2	2
Sea Turtle	44	1-3	2	
Sea Turtle	3	1-2	3	





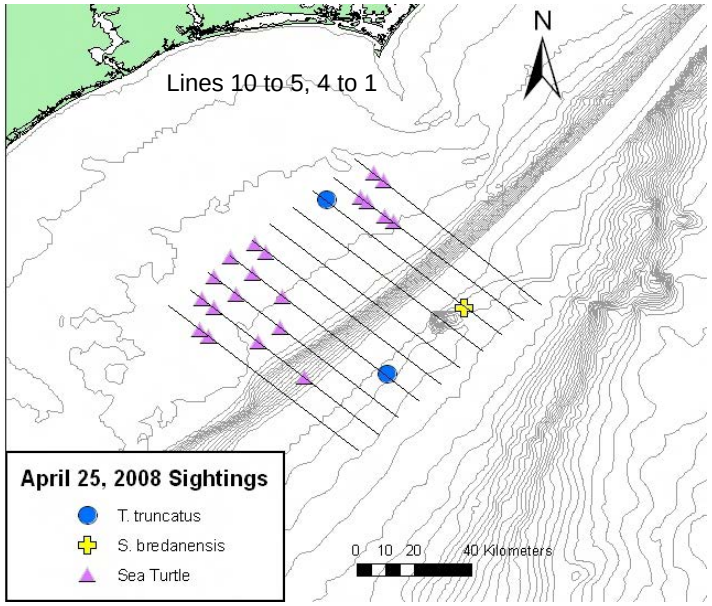
Appendix G

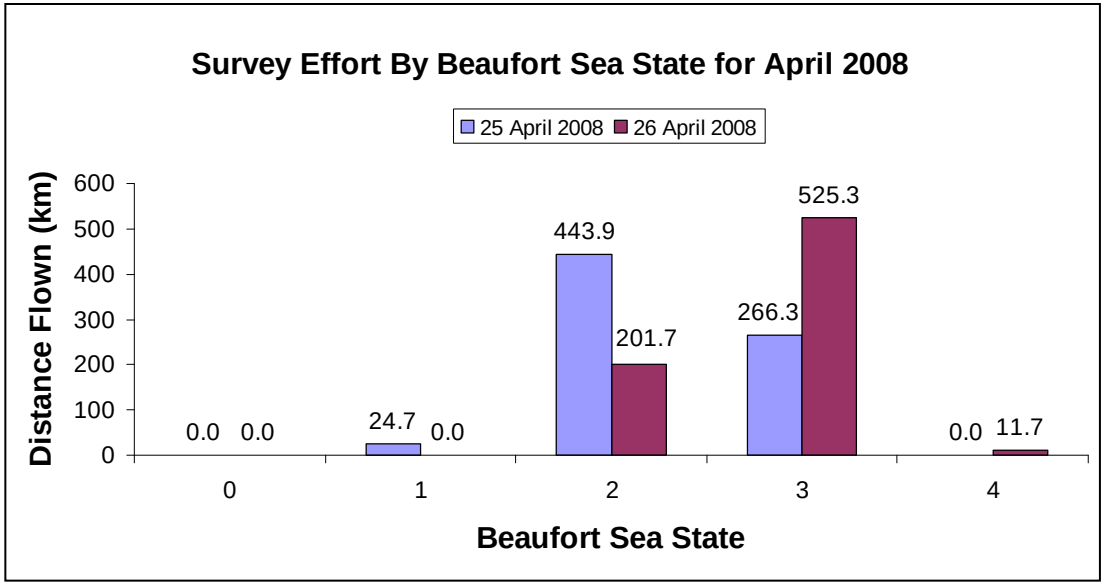
25 April 2008

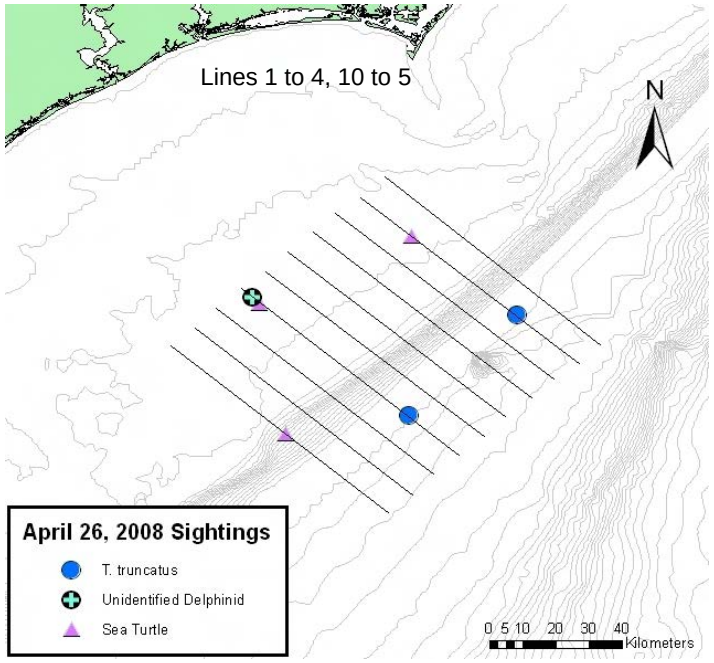
Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	3	2	8
Tursiops truncatus	1	12	3	4
Steno bredanensis	1	26	2	8
Sea Turtle	11	1	2	
Sea Turtle	1	3	2	
Sea Turtle	1	4	2	
Sea Turtle	4	1	3	

26 April 2008

Species	# of sightings	# of individuals	BSS	Line
Tursiops truncatus	1	15	2	4
Tursiops truncatus	1	9	2	9
Tursiops truncatus	1	4	2	4
Sea Turtle	3	1	3	







Appendix G

25 May 2008

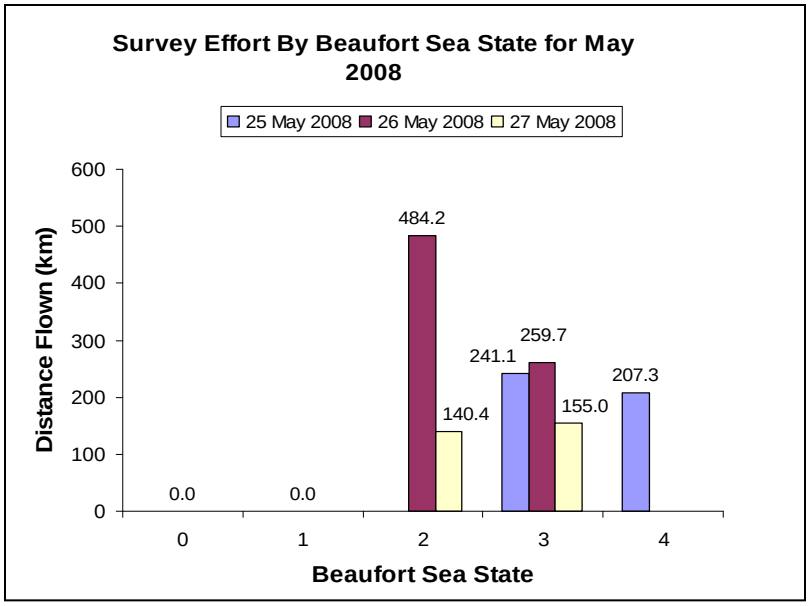
Species	# of sightings	# of individuals	BSS
Sea turtle	1	1	3

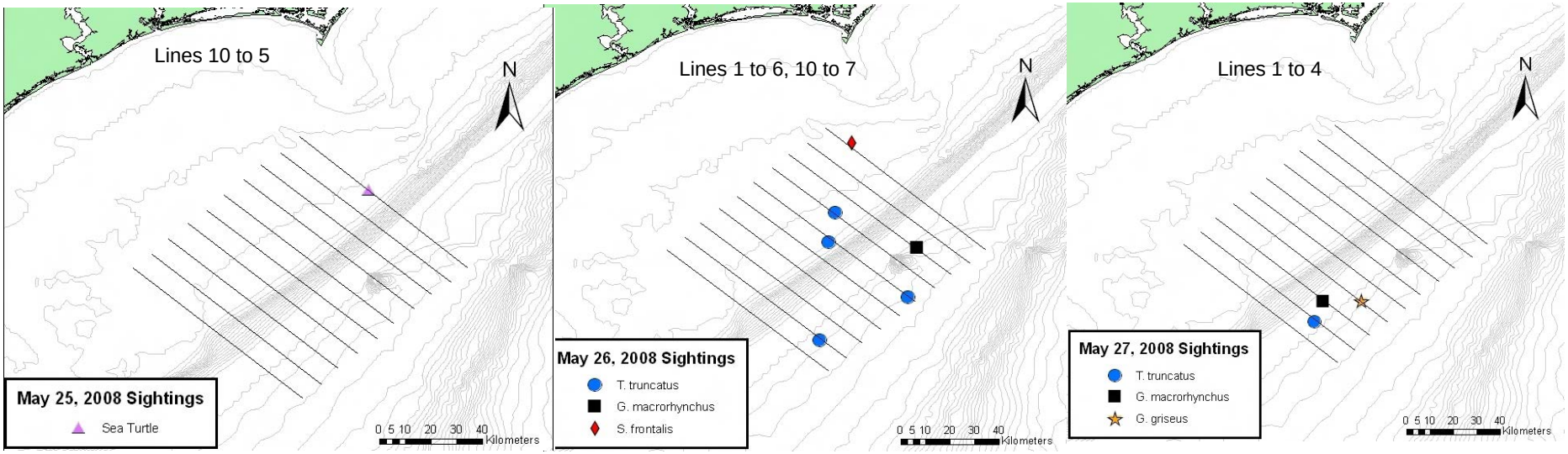
26 May 2008

Species	# of sightings	# of individuals	BSS	Line
Globicephala macrorhynchus	1	9	3	8
Stenella frontalis	1	11	2	10
Tursiops truncatus	1	13	2	6
Tursiops truncatus	1	13	2	2
Tursiops truncatus	1	23	2	6
Tursiops truncatus	1	6	3	7

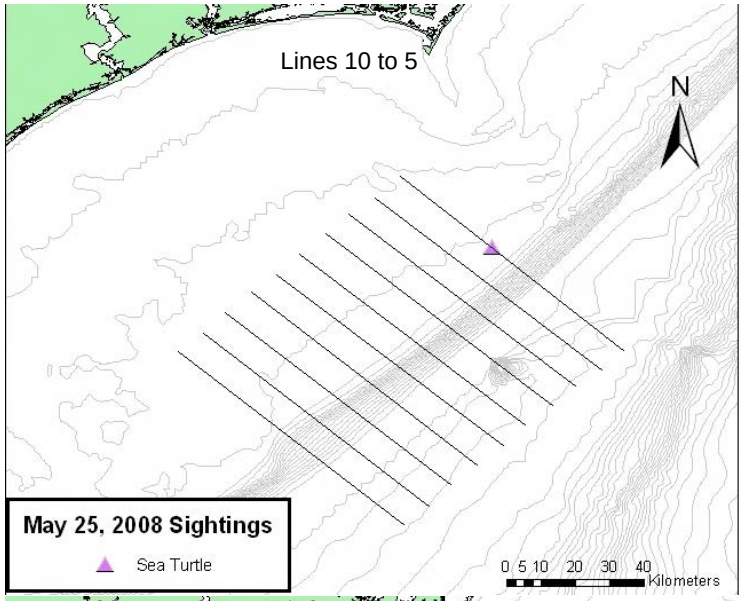
27 May 2008

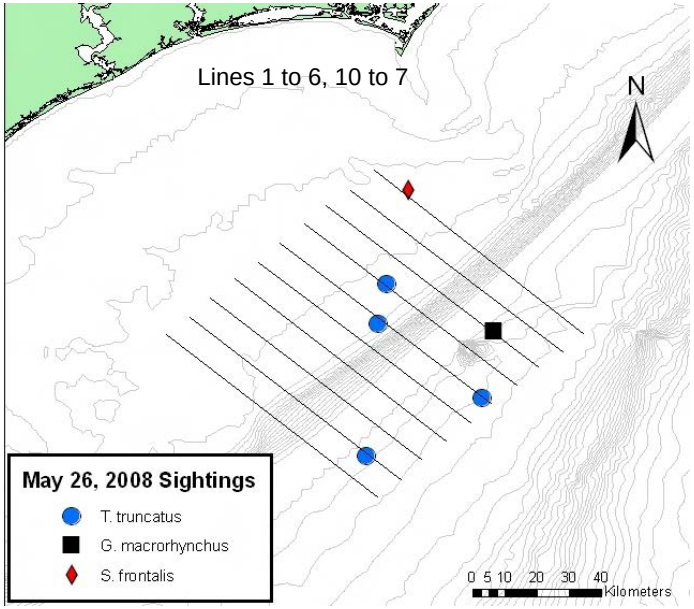
Species	# of sightings	# of individuals	BSS	Line
Grampus griseus	1	5	3	4
Globicephala macrorhynchus	1	12	2	3
Tursiops truncatus	1	12	2	2

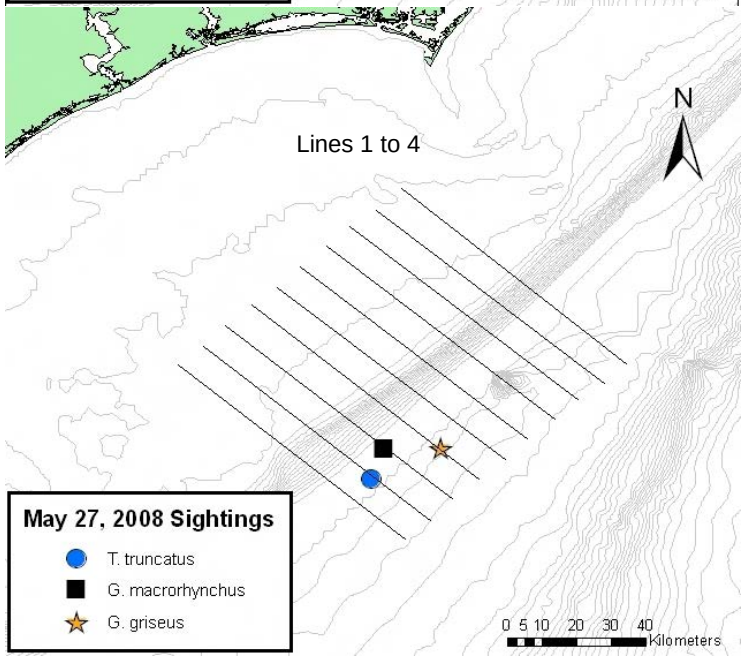


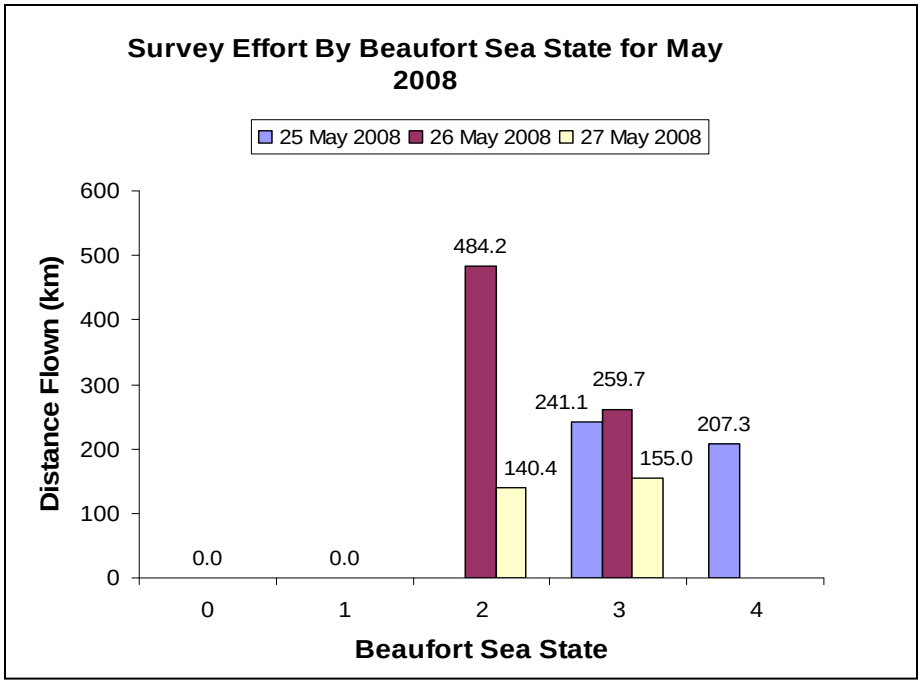


Appendix G


Lines 10 to 5
N
May 25, 2008 Sightings
Sea Turtle
0 5 10 20 30 40
Kilometers


Lines 1 to 6, 10 to 7
N
May 26, 2008 Sightings
T. truncatus
G. macrorhynchus
S. frontalis
0 5 10 20 30 40
Kilometers

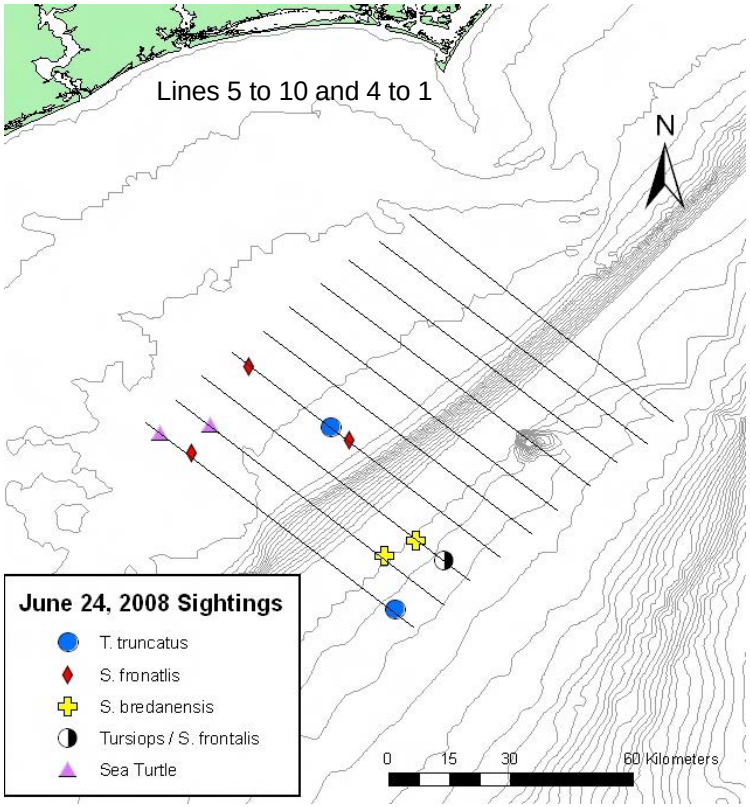

Lines 1 to 4
N
May 27, 2008 Sightings
T. truncatus
G. macrorhynchus
G. griseus
0 5 10 20 30 40
Kilometers

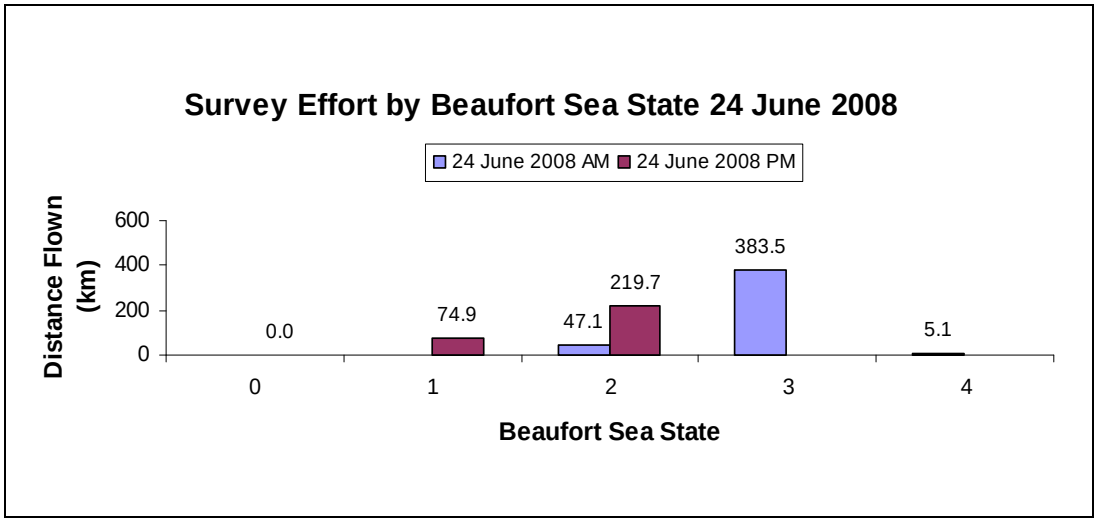

Survey Effort By Beaufort Sea State for May 2008
25 May 2008
26 May 2008
27 May 2008
Distance Flown (km)
600
500
400
300
200
100
0
0.0
0.0
484.2
140.4
241.1
259.7
155.0
207.3
0
1
2
3
4
Beaufort Sea State

Appendix G

24 June 2008

Species	# of sightings	# of individuals	BSS	Line
Steno bredanensis	1	9	2	2
Steno bredanensis	1	5	3	3
Stenella frontalis	1	5	2	4
Stenella frontalis	1	35	2	4
Stenella frontalis	1	10	2	1
Tursiops truncatus	1	7	2	4
Tursiops / Stenella frontalis	1	2	2	3
Tursiops truncatus	1	25	2	1
Sea Turtle	2	1	2	

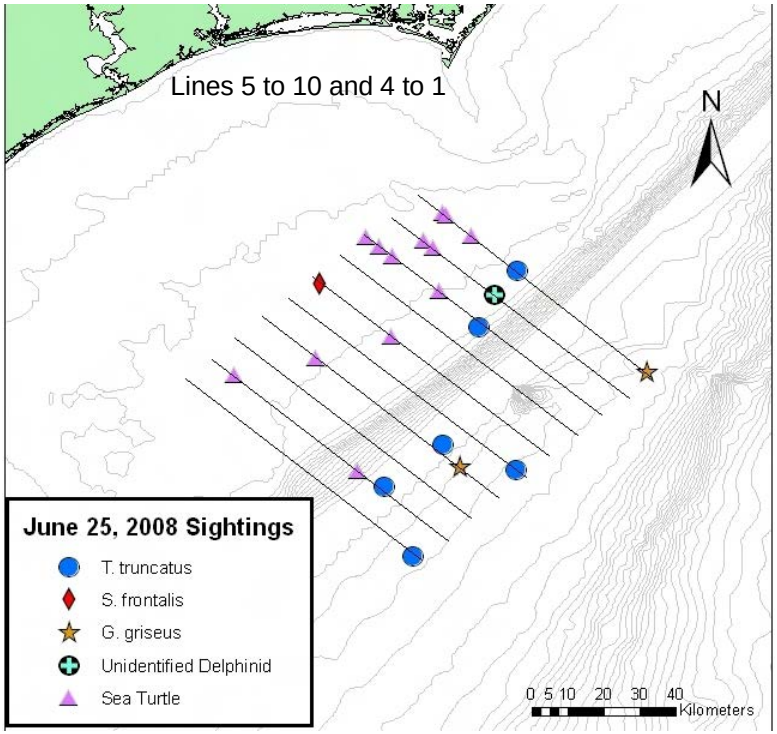


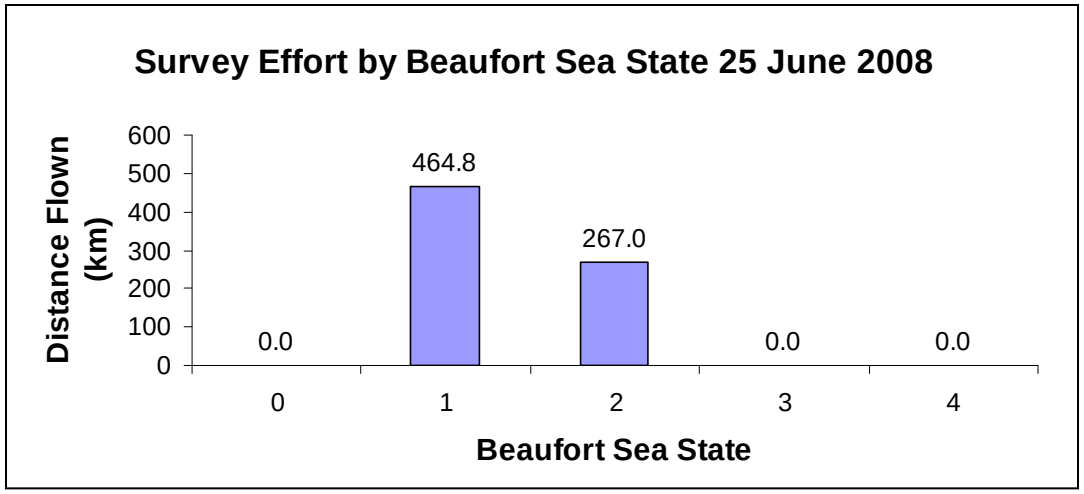


Appendix G

25 June 2008

Species	# of sightings	# of individuals	BSS	Line
Grampus griseus	1	10	1	10
Grampus griseus	1	5	1	4
Tursiops truncatus	1	2	1	8
Tursiops truncatus	1	14	1	4
Tursiops truncatus	1	11	2	2
Tursiops truncatus	1	15	1	1
Tursiops truncatus	1	9	1	5
Tursiops truncatus	1	1	1	10
Stenella frontalis	1	8	2	6
Unidentified Delphinid	1	1	2	9
Sea Turtle	10	1	1	
Sea Turtle	3	1	2	





Appendix G

VESSEL-BASED SURVEYS AND PASSIVE ACOUSTIC MONITORING OF THE PROPOSED UNDER SEA WARFARE TRAINING RANGE (USWTR) IN ONSLOW BAY, NORTH CAROLINA, JUNE 2007 TO JUNE 2008

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Dave Johnston
Kim Urian
Lynne Williams
Lesley Thorne
Lucie Hazen
Danielle Waples

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Submitted to:
The Department of the Navy
Norfolk, VA

Vessel-based Surveys and Passive Acoustic Monitoring

Introduction

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. Vessel-based platforms allow for biopsy sampling to ensure that all species encountered are correctly identified, as described below.

To ensure maximum detection rates, we employed a traditional visual survey approach, supplemented by passive acoustic monitoring using a towed hydrophone array. The towed array facilitated compilation of an acoustic library of species-specific recordings, which will be useful for the passive acoustic monitoring component of this research program (see below).

The use of a shipboard platform has also allowed us to monitor the use of the USWTR and adjacent areas by individual animals using photo-identification techniques. Species for which this approach is feasible include sperm whales, beaked whales, humpback whales, bottlenose dolphins, spotted dolphins, pilot whales and Risso's dolphins. This method can provide information on patterns of seasonal and inter-annual residency. Such information will be critical to interpreting any future changes in density documented in the USWTR area.

We have also collected information on the occurrence and density of seabirds using a traditional strip transect approach.

At present, our vessel-based surveys have been used primarily to estimate density. Observations made during these surveys have allowed preliminary estimation of the density and abundance of marine mammals and sea turtles in the proposed USWTR area (see below). Survey tracks and the locations of sightings from the vessel-based surveys from June-December 2007 have been posted on OBIS-SEAMAP (http://seamap.env.duke.edu/).

Methods

Study Area

The survey study area consists of a box approximately 37% larger than the proposed USWTR; the USWTR area itself is 25 nm (46 km) long and 20 nm (37 km) wide (approximately from NW to SE – see Figure 1). We established ten 40-nm (74 km) long transect lines that cross the survey area, oriented parallel to the short axis of the USWTR boundaries and perpendicular to the primary bathymetric and prevailing oceanographic features influencing the study area. The transect lines are spaced approximately 5 nm (9.3 km) apart. This design yields a total of 400 nm (741 km) of track line available for surveys and all ten transect lines were surveyed by both aerial and shipboard platforms.

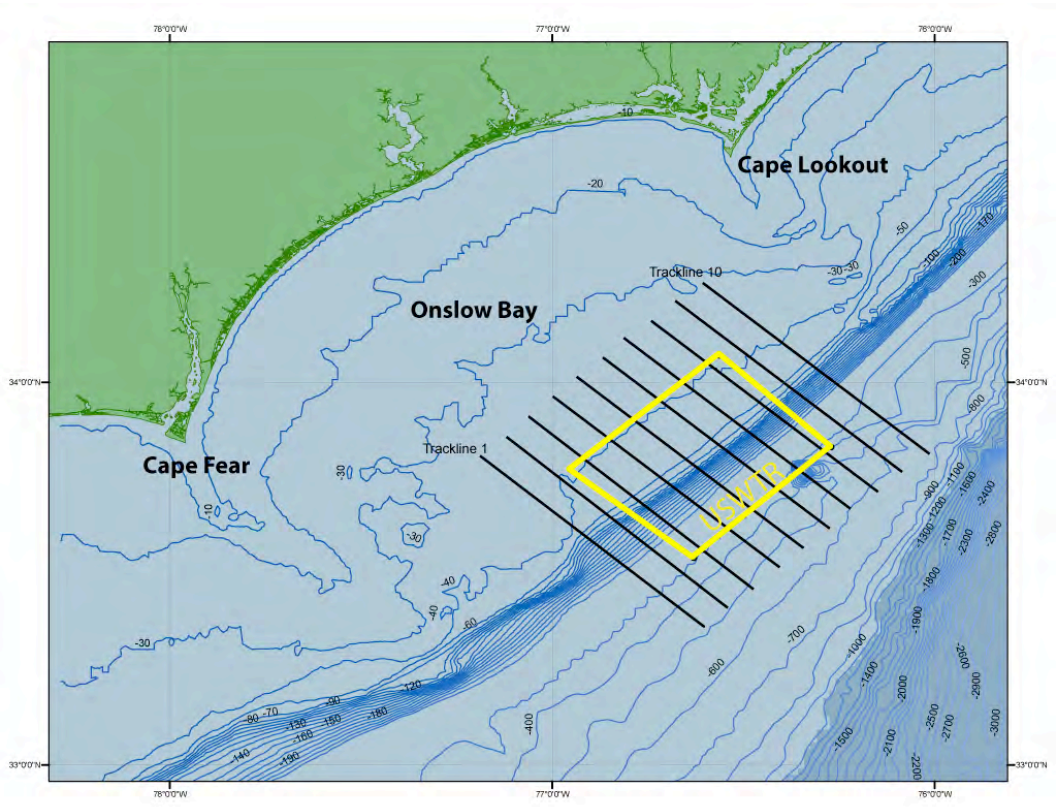

Figure 1. Map of the study area, the proposed Undersea Warfare Training Range (USWTR) and the basic bathymetry of Onslow Bay.

Vessel Survey Data collection

Visual surveys

Visual surveys for cetaceans and other marine megafauna were conducted from two survey platforms: the M/V *Sensation* (Figure 2a), a 16m offshore fishing vessel and the R/V *Cetus* (Figure 2b), a modified 12m offshore fishing vessel.

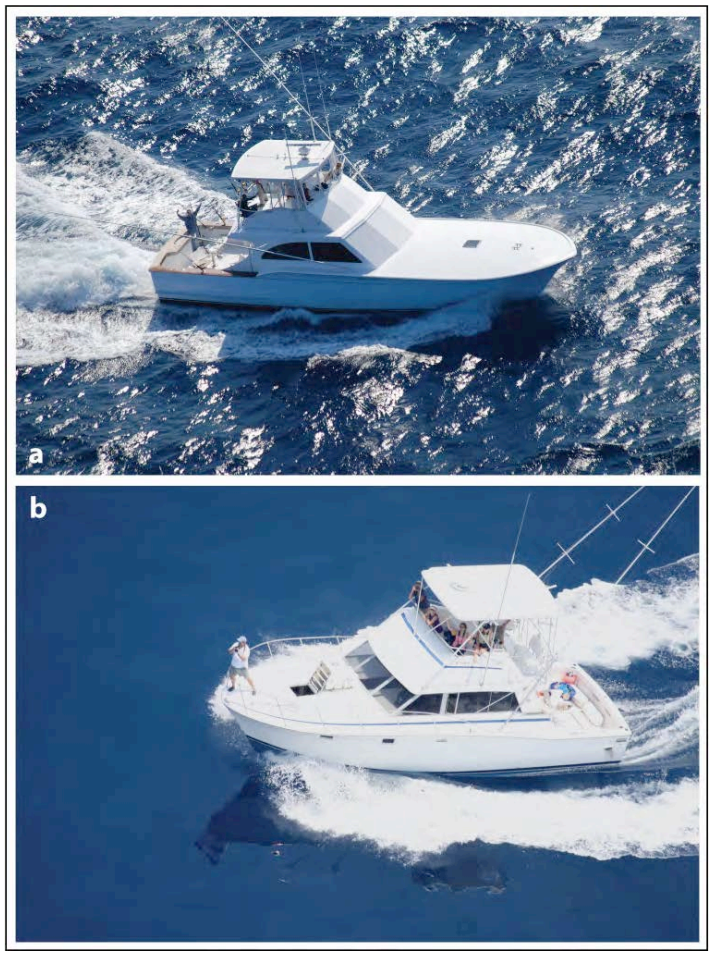

Figure 2. Aerial photogrpahs of the M/V Sensation (a) and the R/V Cetus (b).

Visual surveys were conducted from the flying bridge (5.0m and 4.2m above waterline for the *Sensation* and *Cetus* respectively) by naked eye and 7x50 binoculars. To prepare for these surveys, a classroom training exercise was held for all marine mammal observers at the Duke University Marine Laboratory in Beaufort, NC on April 24th, 2007. The workshop was led by Ms. Erin LaBrecque, who has extensive experience as a shipboard observer for NOAA and who received training from the CREEM group at the University of St. Andrews, Scotland. Observers were instructed in line transect theory, field methods, data collection protocols, and species identification.

Two observers (port and starboard) scanned constantly from straight ahead to 90˚ abeam either side of the trackline. A center observer monitored the trackline, coordinated with the vessel skipper and acted as data recorder for sightings and environmental conditions. Observations were conducted following standard distance sampling/line transect methods for cetaceans, similar to those employed in Barlow (2006). During ship surveys, the location, species present and behavior of each cetacean encounter were recorded. Each primary

observer estimated group size independently; these values were averaged at the end of the survey to generate an overall estimate of group size. Environmental conditions (weather and sea state, depth and sea surface temperature) were collected every 30 minutes, or when sighting conditions changed. Both sighting and environmental data were input into an at-sea data collection system (Vis-Survey, developed by Dr. Lance Garrison, NOAA/SEFSC) linked with the onboard GPS. Whenever possible, photographs of encountered cetaceans were obtained for species identification confirmation and individual photo-identification. Photographs were obtained with Canon or Nikon digital SLRs equipped with 100-300mm zoom lenses. Photographs were shot in 24-bit color at a resolution of 3072 X 2048 pixels and saved in jpg format.

Seabird counts were conducted concurrent with marine mammal observations. An experienced observer recorded seabirds in a 90 degree bow-beam arc within 300 meters of the ship on the starboard side of the ship (Tasker *et al*. 1984). As with mammal sightings, the observer recorded the time and location of the sighting. Species identification, abundance, general behavior (sitting, flying, or foraging), and associations with other marine species were recorded for each bird sighting, and the presence of ship-following birds was noted separately to avoid biases in quantitative analyses.

Passive Acoustic Monitoring

Passive acoustic data were collected in the proposed range using two methods: towed hydrophone array and bottom-mounted recorder.

Towed Array

Whenever possible, a four-element array was towed behind the survey vessel to allow acoustic detection of cetaceans in the vicinity of the survey vessel. The towed array (Seiche Instruments, UK) consisted of 4 hydrophone elements with approximate linear sensitivity to frequencies between 1kHz and 100 kHz. The array was towed approximately 150m behind the ship and acoustic signals were routed to an analog to digital converter/mixer (MOTU Traveler, MOTU, Cambridge, MA) sampling at 192 kHz. These signals were then passed to two personal laptop computers outfitted with software for real-time visualization/recording

(*Ishmael* 1.0) and spatial localization (*WhalTrak* 2.0) of cetacean sounds. A trained acoustician monitored the array and made recordings of all potential cetacean sounds detected, as well as other novel sounds. When possible, the acoustician attempted to localize cetacean vocalizations with time difference of arrival (TDOA) techniques using two or more hydrophone elements using *Ishmael* and *Whaltrak* software.

Bottom-mounted Recorder

To develop a time-series of acoustic monitoring data in the USWTR study area, we employed a High Frequency Acoustic Recording Package or HARP (Wiggins and Hildebrand 2007). This instrument combines high and low frequency hydrophone elements for detecting the vocalizations of both odontocete and mysticete whales and can sample at rates high enough to capture the echolocation clicks of many odontocetes. The instrument was deployed, recovered and redeployed near the center of the USWTR box, close to the 200m shelf break. The first deployment was at N 33.791 and W -76.524 at a depth of 162m; the second deployment (currently underway) was at N 33.811 and W -76.428 at a depth of 232m (see Figure 3). In both deployments the instrument was programmed to record for 5-minute periods separated by an inactive interval of five minutes and to record sound at a sample rate of 200 kHz.

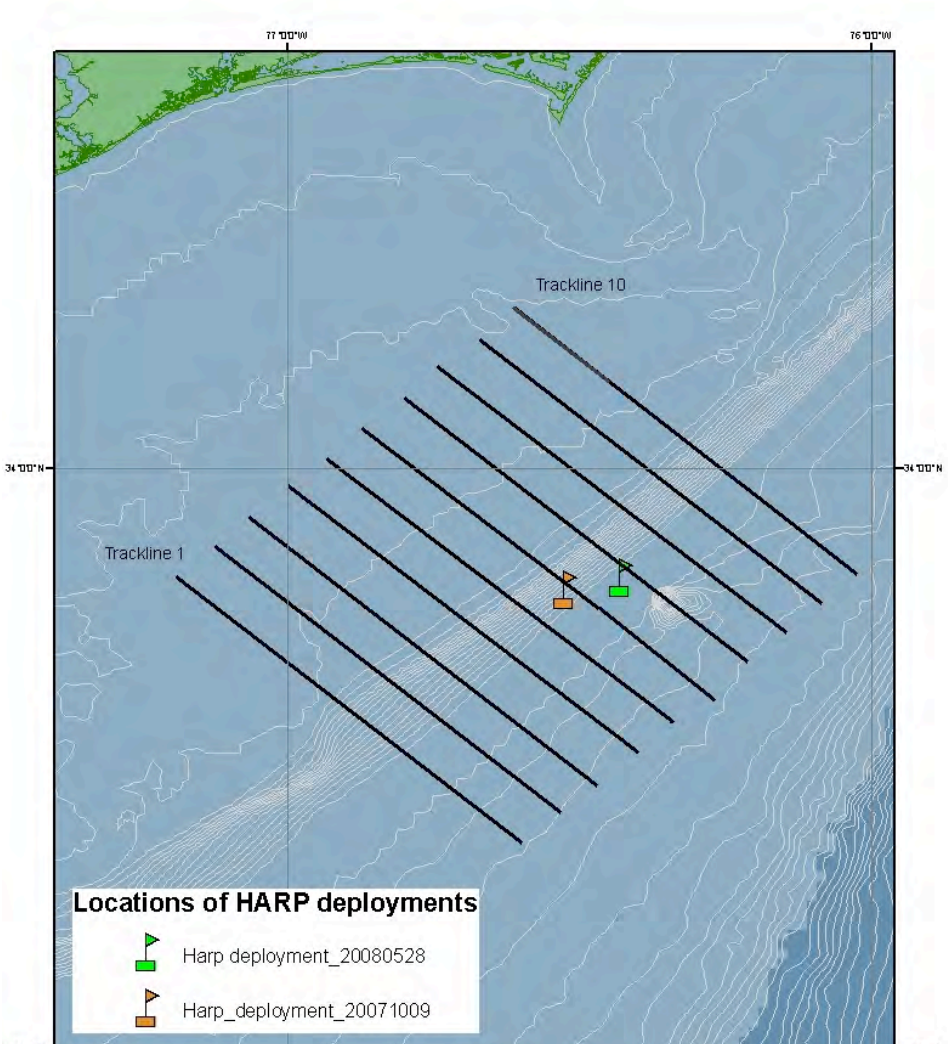

Figure 3. Location of HARP deployments in Onslow Bay, NC.

Data analysis

Vessel survey trackline and effort data and sightings were compiled and mapped using ArcGIS 9.2 to illustrate the location of effort and sightings within the study area. In addition, the statistical distributions of survey effort, sea state and marine mammal sightings by synoptic depth and sea surface temperature were examined using JMP 7.0. The sighting data (including radial distance and bearing estimates for each cue) were forwarded to the Centre for Research into Ecological and Environmental Modeling at the University of St Andrews, UK for further details on density estimation (see below).

Acoustic Analysis

We are analyzing the towed hydrophone array recordings with the sound analysis software program *Raven 1.3* (Bioacoustics Research Program of the Cornell Lab of Ornithology). We are using *Raven* to locate and save selections of whistles and clicks so that we can further analyze species-specific patterns.

From each single-species group recorded with the towed array, we are randomly selecting up to 35 whistles (to avoid oversampling individuals and groups, following Oswald *et al.* 2007) of the best quality (loud and clear with an acceptable signal-to-noise ratio) for further spectral analysis. We will measure a variety of different parameters (including, but not limited to, start, end, minimum, and maximum frequency; duration; number of inflection points, and number of steps) for each selected whistle. Once these parameters have been measured, we will use a combination of multivariate discriminate function analyses (DFAs) and non-parametric classification and regression trees (CARTs) to look for species-specificity in whistles, similar to the approach used by Oswald *et al.* (2003).

We will also look for species-specific patterns in clicks using techniques similar to those employed by Soldevilla *et al.* (2008). It will be impossible to know which animal produces each click train in a recording session, so the number of click trains selected will be limited to a maximum of two times the estimated group size (as in Soldevilla *et al.* 2008). We are randomly selecting a single click from each click train found during a recording session for further analysis. Once we finish selecting clicks, the clicks for each species will be compiled and divided into two groups—a training group and a testing group. We will examine the clicks in the training group for peaks and notches that are found consistently at the same frequencies for a particular species. Once we have chosen the peak and notch frequencies for each species using the training group, the testing group will be examined for peaks and notches that occur within those same frequency ranges (determined with the training data) for each species. For those clicks having peaks and notches at the predetermined frequencies, we will perform analyses of variance (ANOVAs) using these testing group data to examine frequency differences in peaks and notches of different species' clicks and to determine if there are significant differences between species.

In addition to the above analyses, we also plan to explore techniques that combine both whistles and clicks into a single classifying analysis (perhaps combining certain parameters of each call type into a single DFA) in the hopes that the inclusion of both call types will increase the classification rates.

We plan to locate marine mammal sounds in the HARP data record using two methods: (1) long-term spectral averages (LTSAs; Wiggens and Hildebrand 2007) and (2) whistle and click detectors. LTSAs provide a way to look at an hour to weeks of data on the same spectrogram, which allows rapid review of large data sets. We have used LTSAs made using a MATLAB-based acoustic program called *Triton* (Hildebrand Lab at Scripps Institution of Oceanography) to look for cetacean whistle and click events in the HARP data from the first deployment (October 10, 2007 – January 16, 2008; Figure 4). We manually inspected these LTSAs in *Triton* for high-energy locations denoting whistle and click events. In the next few months, we will use whistle and click detectors that are built into the *Triton* software to help in finding additional vocal events.

Once we have detected all the whistles using both methods, we will choose loud and clear whistles with acceptable signal-to-noise ratios for further analysis. Oswald *et al.* (2007) found that using multiple whistles versus individual whistles increased correct classification rates; therefore, we will use multiple whistles for these analyses. We will measure the same parameters measured in determining species-specific differences on these newly selected whistles. These values will then be processed using a combination of DFAs and CARTs to determine to which species the whistles most likely belong.

Once we have detected all click events, we will select one click from each click train for further analysis. We will examine the selected clicks for peaks and notches that occur within frequency ranges determined with the training data described previously for each species. This examination will help determine which species produced the clicks. Finally, we will compile the predicted species identification for each click during each active vocal period to determine which species has been identified most often.

At this point, for those instances when both whistles and clicks are detected in a single vocal event, we will compare the predicted species identification for both the whistles and clicks from that same event to determine if the same species was selected. In addition to determining the likely vocalizing species in this way, we also will test the exploratory techniques that combine both whistles and clicks into a single classifying analysis as mentioned previously.

Once we have found all calls present in the HARP data and have determined the species to which those calls most likely belong, we plan to sort the vocal events by species and bin them by season to look for patterns. We then will run a logistic regression model for each species that takes into account the season to (1) determine which seasons are significantly different from each other in terms of presence of vocalizations and (2) make predictions of when different species can be expected to be present in the area based on vocalizations.

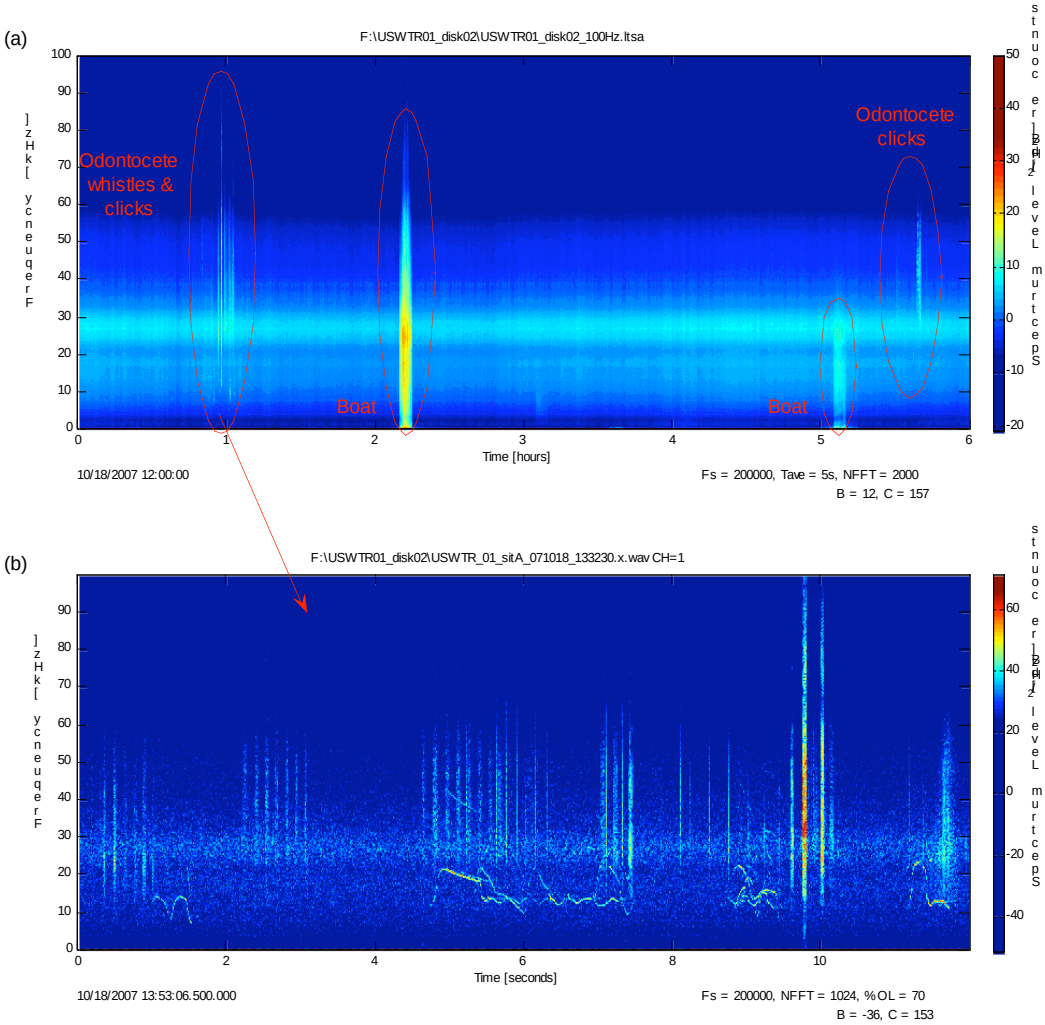

Figure 4. (a) An example of a LTSA showing high-energy events found in HARP data from October 18, 2007, and (b) spectrogram showing odontocete whistles and clicks.

Data storage

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

Results

Vessel Survey Effort

Table 1 provides the details on vessel survey effort. All tracklines in the study area were surveyed at least twice during the study period, except track line 1. During the study period approximately 124 hours of marine mammal observations and 80 hours of seabird observations were completed.

Sighting effort was conducted in Beaufort sea states ranging from 0 to 4. Most effort (30 of 31 lines) was conducted using the M/V Sensation survey platform. The distribution of survey effort by sea state (as a percentage of total effort) is presented in Figure 5. The majority of survey effort (67.5%) was conducted in Beaufort 2 and 3 conditions, and 16.4 percent of survey effort was conducted in optimal (Beaufort 0 and 1) sighting conditions.

Table 1. Vessel survey effort on tracklines in the study area from June 2007 through June 2008.

Survey Line	Surveys Conducted
1	1
2	2
3	3
4	4
5	4
6	3.5
7	3.5
8	3.5
9	3
10	3.5
Total	31

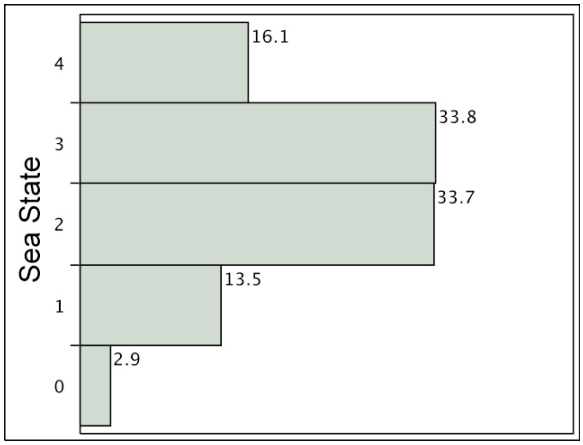

Figure 5. Distribution of sea state conditions (% of total effort) for USWTR vessel surveys during June 2007 through June 2008.

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Marine Mammal and Sea Turtle Line Transect Sightings

A total of 35 marine mammal sightings were made during vessel surveys (31 while on effort, 4 while off effort). The details of these sightings are compiled in Table 2, and in Figures 6 through 13. Four species of cetaceans were detected visually in the study area during vessel-based surveys: bottlenose dolphins (*Tursiops truncatus,* n = 24*)*, Atlantic spotted dolphins (*Stenella frontalis,* n = 5), pilot whales (*Globicephala macrorhynchus,* n = 1), Risso's dolphin (*Grampus griseus,* n = 2). In addition, three sightings were made of unidentified delphinids. No mixed-species groups were observed.

Table 2. Vessel-based cetacean sightings made in the USWTR study area during June 2007 through June 2008.

Date	Vessel	Line	Depth	Temperature	Species	Group Size
6/25/07	Sensation	6	265	27.7	*Tursiops truncatus*	3
6/25/07	Sensation	6	300	27.7	*Tursiops truncatus*	1
6/26/07	Sensation	7	176.7	27.7	*Tursiops truncatus*	4
6/26/07	Sensation	7	223.1	27.9	*Tursiops truncatus*	7
6/26/07	Sensation	7	296.3	28.8	*Tursiops truncatus*	11
6/26/07	Sensation	7	248.7	28.6	*Tursiops truncatus*	7
6/26/07	Sensation	7	219.5	28.5	*Tursiops truncatus*	4
6/27/07	Sensation	9	34.9	26.9	*Unidentified delphinid*	1
7/24/07	Sensation	1	365.7	29.6	*Tursiops truncatus*	14
7/24/07	Sensation	1	311	29.3	*Tursiops truncatus*	2
7/25/07	Sensation	2	272.5	29.3	*Tursiops truncatus*	6
8/3/07	Sensation	10	31.1	27.7	*Stenella frontalis*	4
8/3/07	Sensation	10	33.5	27.7	*Stenella frontalis*	9
8/6/07	Sensation	9	607.1	29.9	*Tursiops truncatus*	5
8/7/07	Sensation	9	40.2	29.2	*Tursiops truncatus*	4
8/7/07	Sensation	7	435.3	29.6	*Globicephala spp.*	40
8/31/07	Sensation	4	342	29.8	*Tursiops truncatus*	15
8/31/07	Sensation	4	468	29.9	*Unidentified dolphin*	1
8/31/07	Sensation	6	35.5	28.7	*Stenella frontalis*	9
9/25/07	Sensation	3	36.7	28.4	*Stenella frontalis*	5
9/25/07	Sensation	3	340.2	28.8	*Tursiops truncatus*	7
10/9/07	Sensation	1	190.2	29.1	*Tursiops truncatus*	2
10/17/07	Sensation	1	438.9	27.4	*Tursiops truncatus*	5
11/12/07	Sensation	1	371.2	26.4	*Tursiops truncatus*	14
11/12/07	Sensation	2	120.5	24.8	*Tursiops truncatus*	6
11/20/07	Sensation	1	235.9	25.7	*Tursiops truncatus*	23
11/20/07	Sensation	2	71.1	24.9	*Unidentified delphinid*	1
3/10/08	Sensation	7	541.3	22.4	*Tursiops truncatus*	10
3/13/08	Sensation	5	42.2	20.9	*Tursiops truncatus*	6
5/1/08	Sensation	6	41	24.8	*Stenella frontalis*	4
6/3/08	Sensation	4	491.9	26.9	*Tursiops truncatus*	3
6/25/08	Cetus	10	nan	nan	*Grampus griseus*	44
6/25/08	Cetus	10	nan	nan	*Grampus griseus*	20
6/25/08	Cetus	10	nan	nan	*Tursiops truncatus*	12
6/25/08	Cetus	10	nan	nan	*Tursiops truncatus*	4

Descriptive statistics for the two species sighted most frequently, *T. truncatus* and *S. frontalis*, are presented in Figures 6 and 7 respectively. In general, bottlenose dolphins were detected in waters deeper than spotted dolphins (mean of 292m vs 35m respectively). Mean group size for bottlenose dolphins was slightly greater than for spotted dolphins (7.3 vs 6.2 individuals per group).

A total of 18 loggerhead turtles were detected during vessel-based surveys. The locations of turtle sightings are presented in Figure 14.

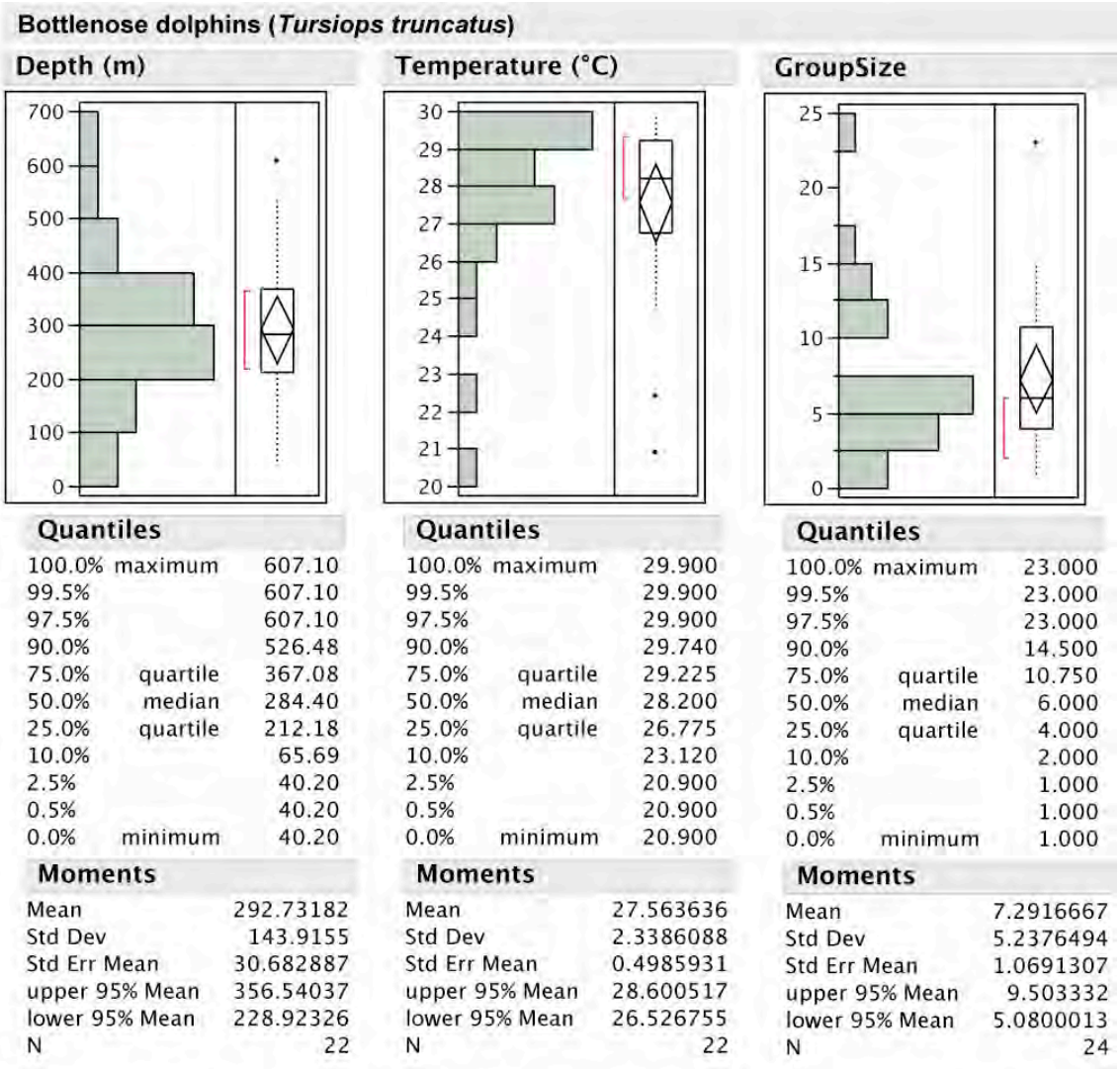

Figure 6. Descriptive statistics for group size estimates and synoptic sea surface temperature and depth values for bottlenose dolphin (*Tursiops truncatus*) sightings during visual/acoustic line transects surveys in the USWTR study area (June 2007 - June 2008).

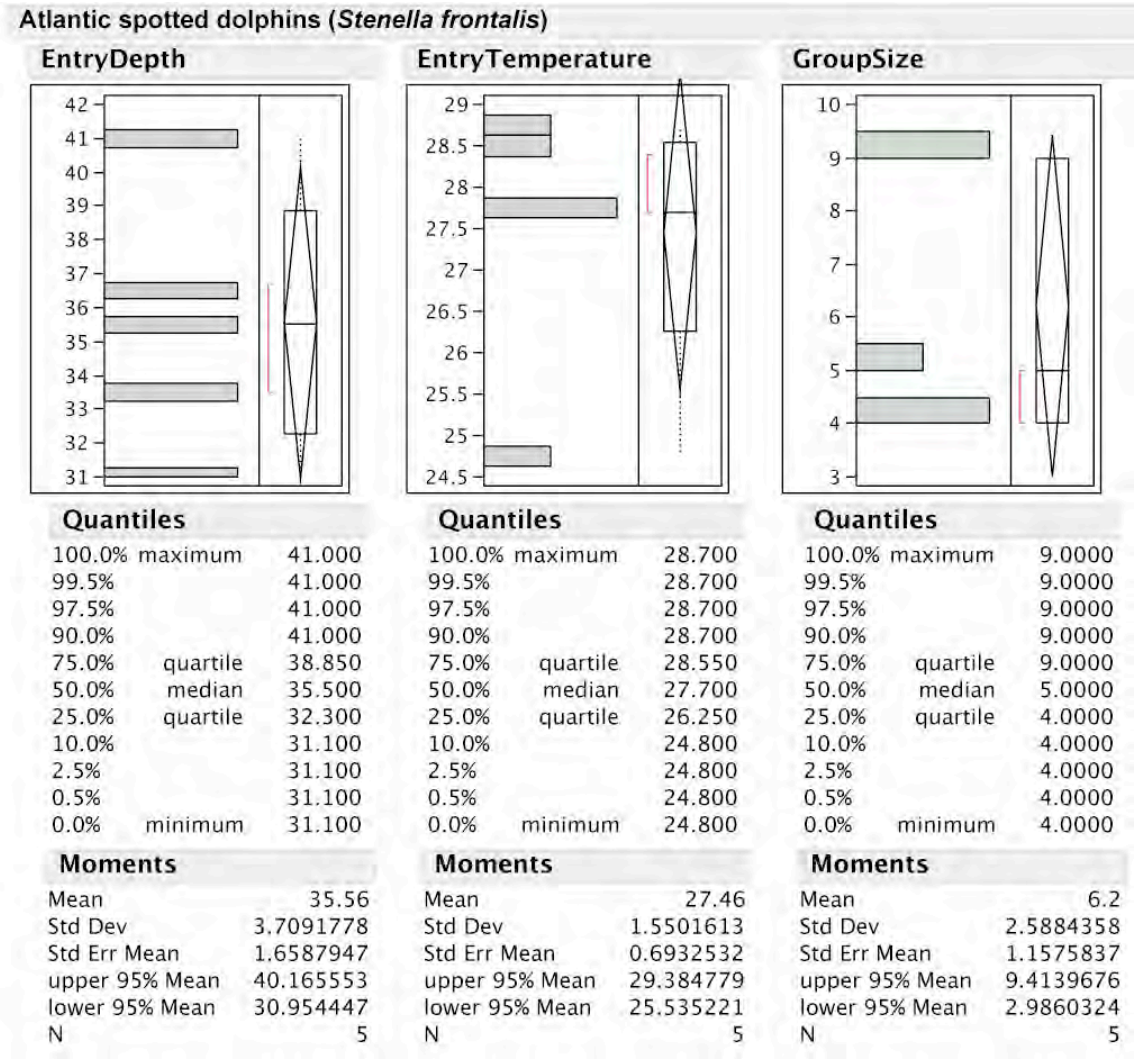

Figure 7. Descriptive statistics for group size estimates and synoptic sea surface temperature and depth values for Atlantic spotted dolphins (*Stenella frontalis*) sightings made during visual/acoustic line transect surveys in the USWTR study area (June 2007 - June 2008).

Distributions and habitat associations of cetaceans

The distributions of marine mammal sightings (by species) are presented in Figures 8 through 13. In general, *S. frontalis* sightings were restricted to shallow shelf waters, whereas *T. truncatus* distributions ranged over a large area with most animals detected in deeper waters. These habitat relationships are also illustrated in the matched pair plot in Figure 13. Here, differences and means of the match pairs of environmental data for each sighting (synoptic depth and sea surface temperature) are plotted on opposite axis to depict how both environmental variables relate to the distribution of sightings. The plot reveals that the small number of *S. frontalis* cluster together, indicating perhaps more narrow habitat associations, whereas the *T. truncatus* sightings exhibit a wider range of habitat associations in terms of depth and sea surface temperature (SST). The plot also reveals the habitat associations of the unidentified dolphins sightings, two of which cluster tightly with *S. frontalis*, suggesting that they may have been spotted dolphins.

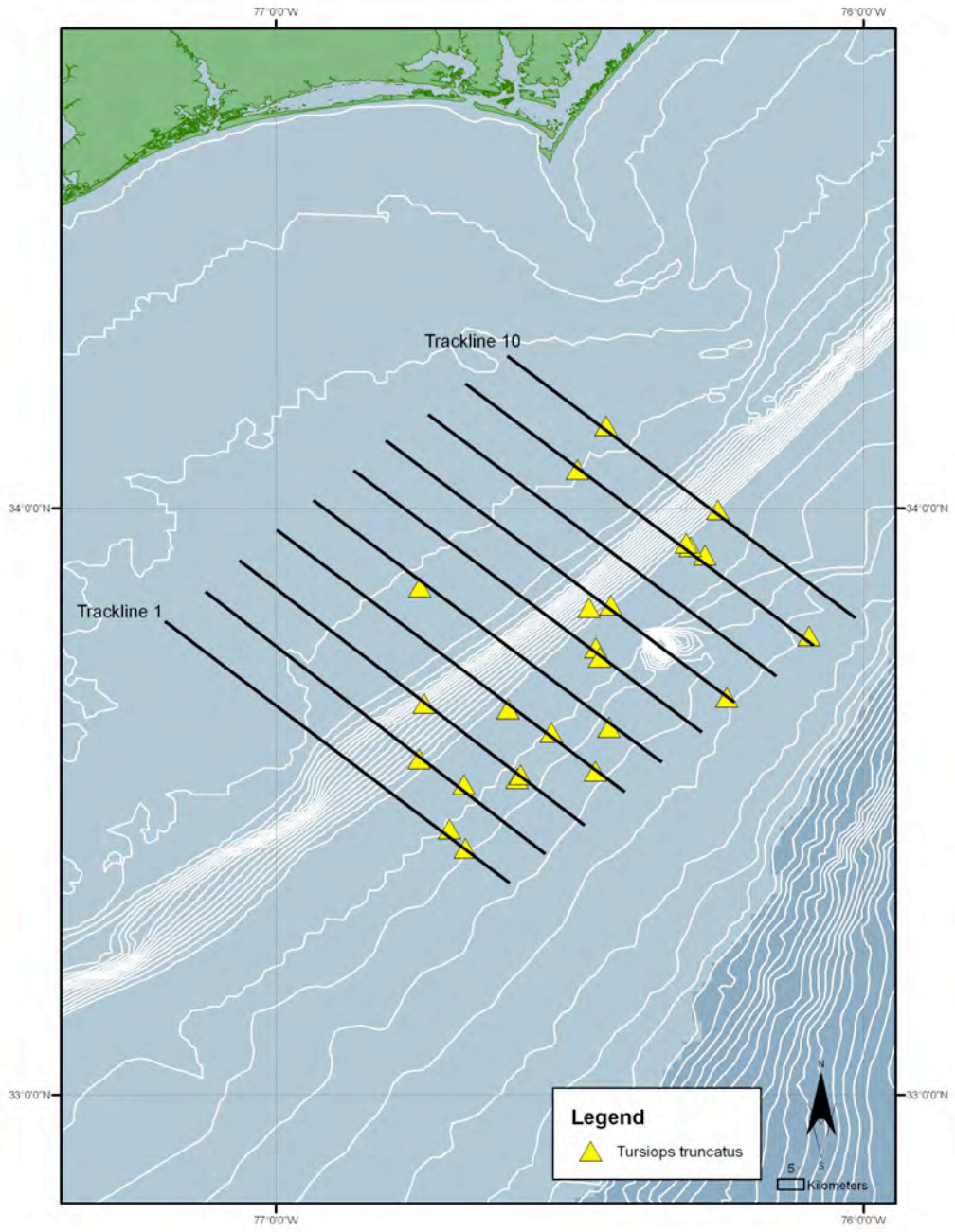

Figure 8. Distribution of bottlenose dolphin (*Tursiops truncatus*) sightings made during vessel-based surveys in Onslow Bay, NC, June 2007 through June 2008.

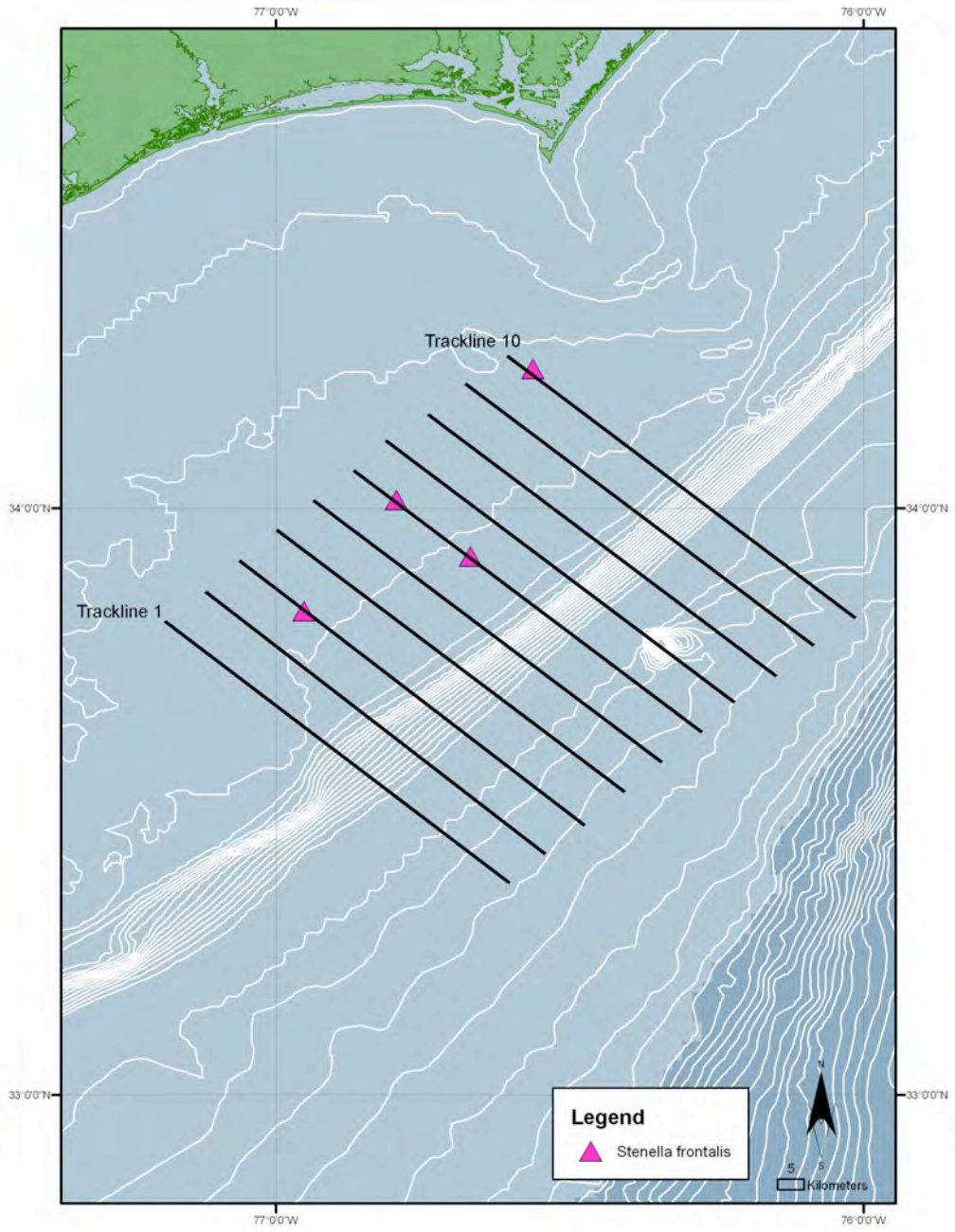

Figure 9. Distribution of Atlantic spotted dolphin (*Stenella frontalis*) sightings made during vessel-based surveys in Onslow Bay, NC, June 2007 through June 2008.

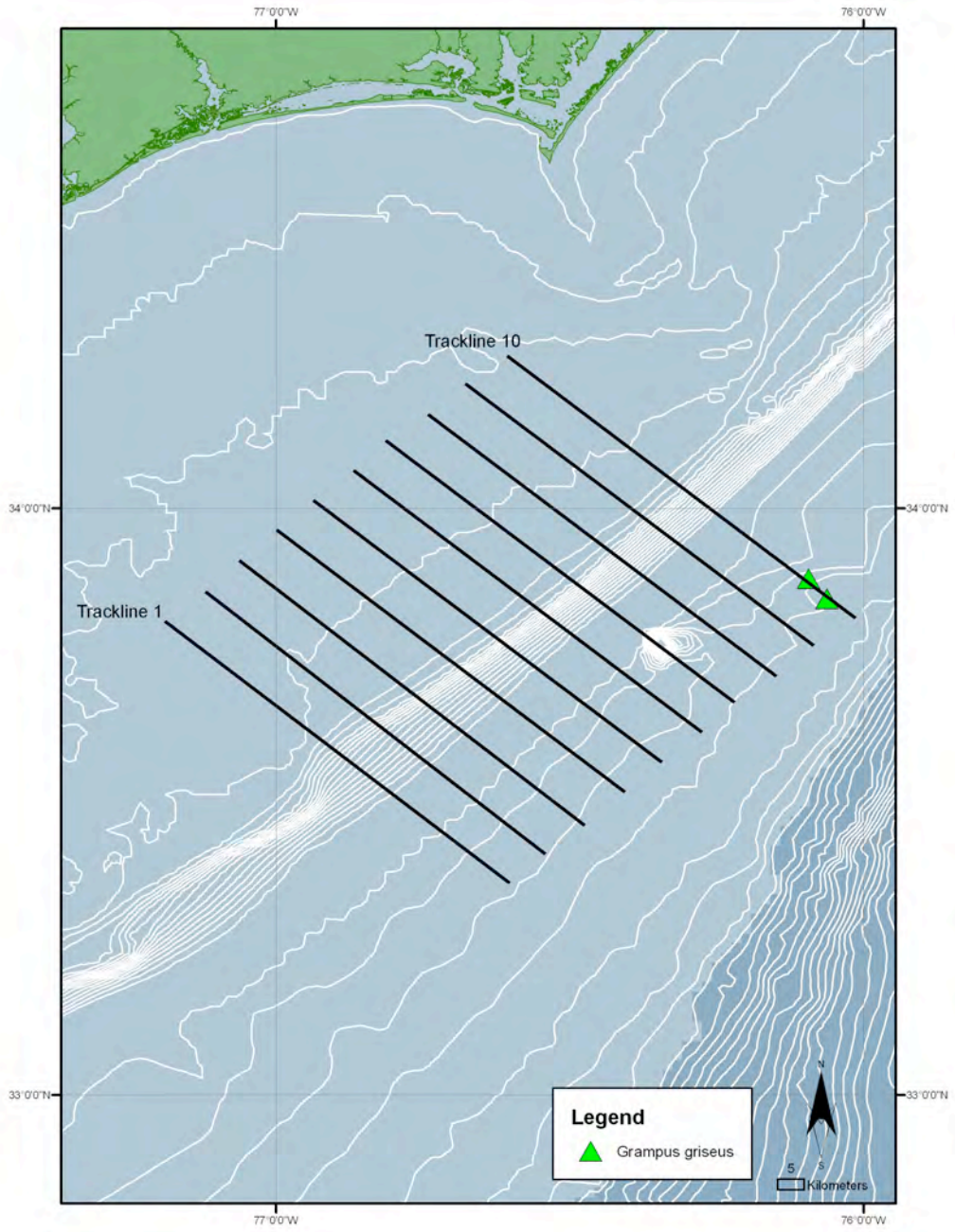

Figure 10. Distribution of Risso's dolphin (*Grampus griseus*) sightings made during vessel based surveys in Onslow Bay, NC, June 2007 through June 2008.

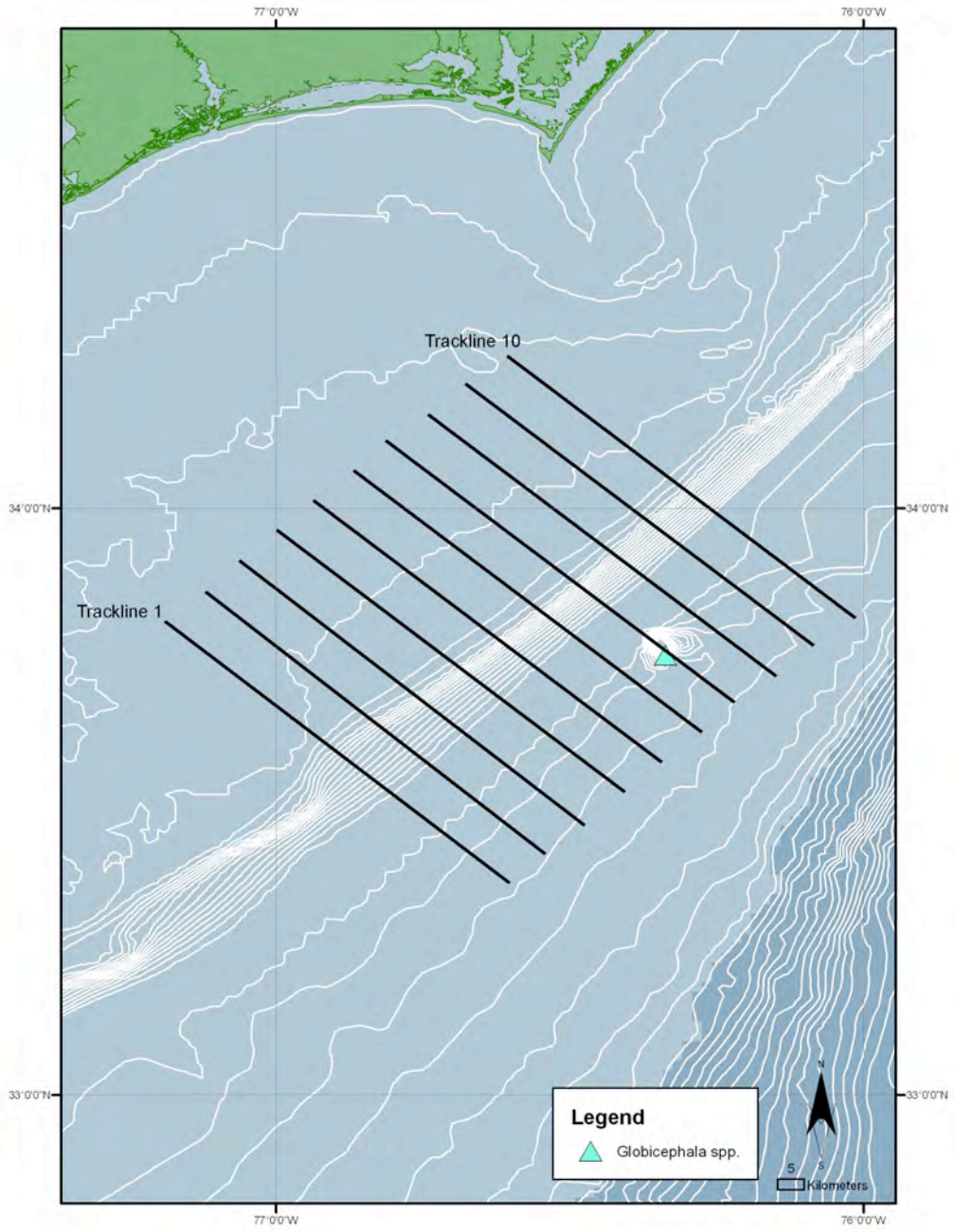

Figure 11. Location of the single pilot whale (*Globicephala* sp) sighting made during vessel-based surveys in Onslow Bay, NC, June 2007 through June 2008.

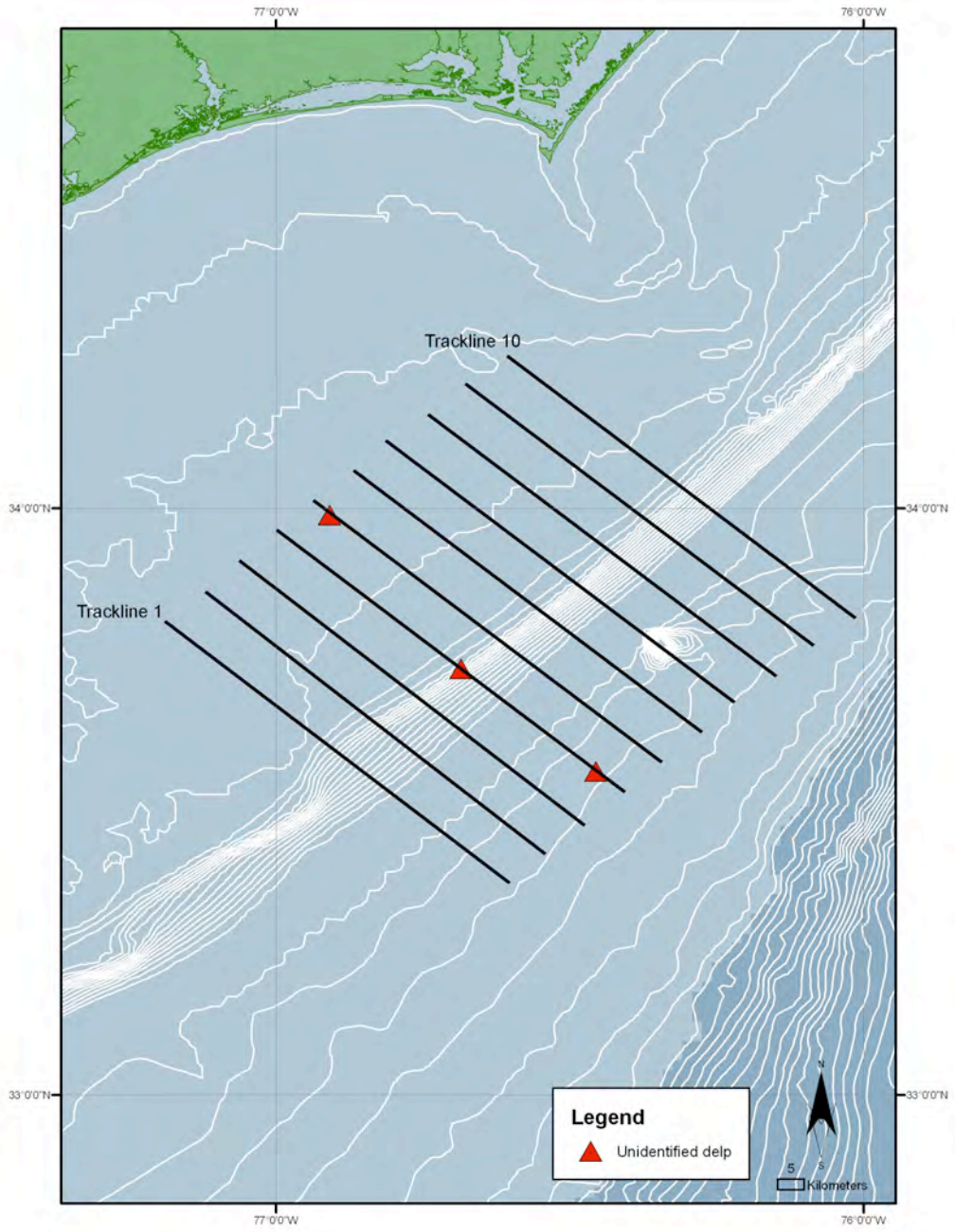

Figure 12. Locations of sightings of unidentified delphinids made during vessel-based surveys in Onslow Bay, NC, June 2007 through June 2008.

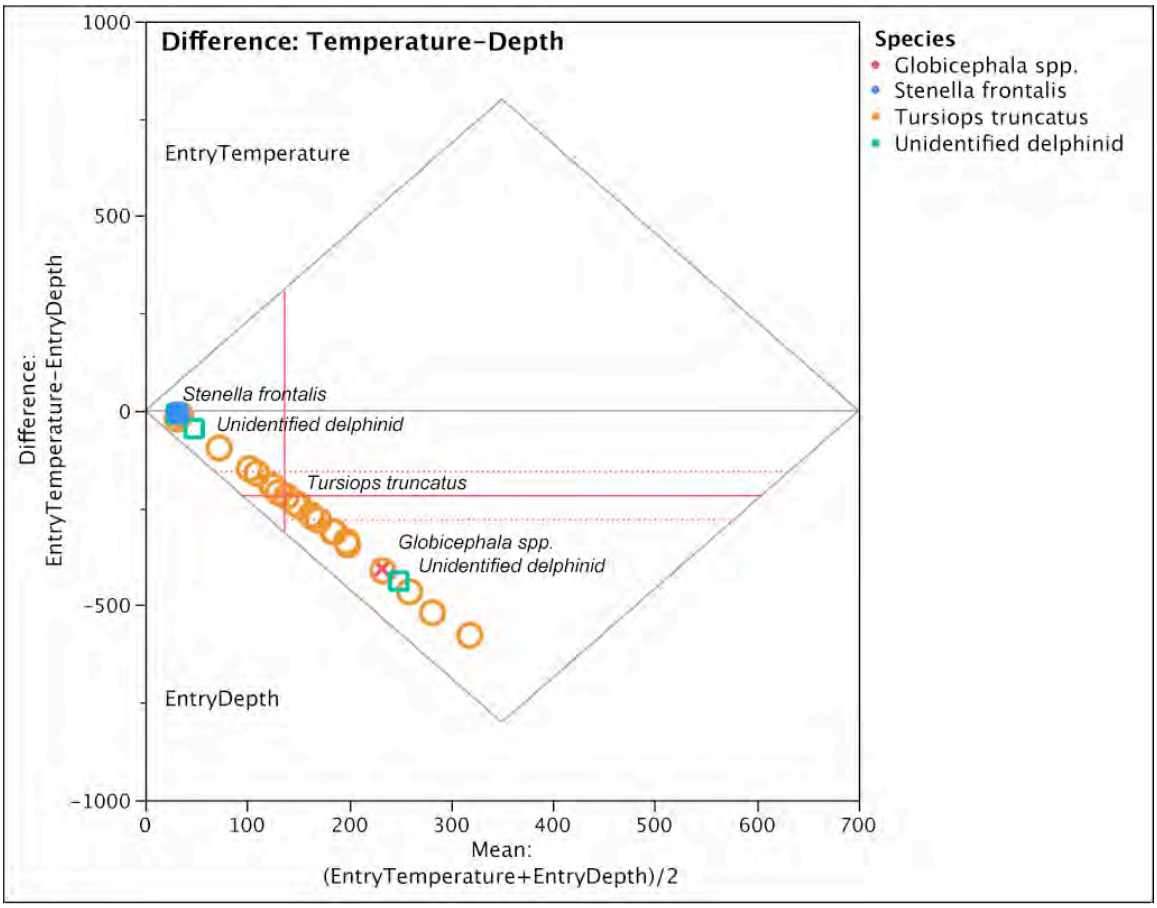

Figure 13. Matched-Pair Plot of sea surface temperature and depth measurements for sightings of cetaceans made during line transect surveys, June 2007 through June 2008.

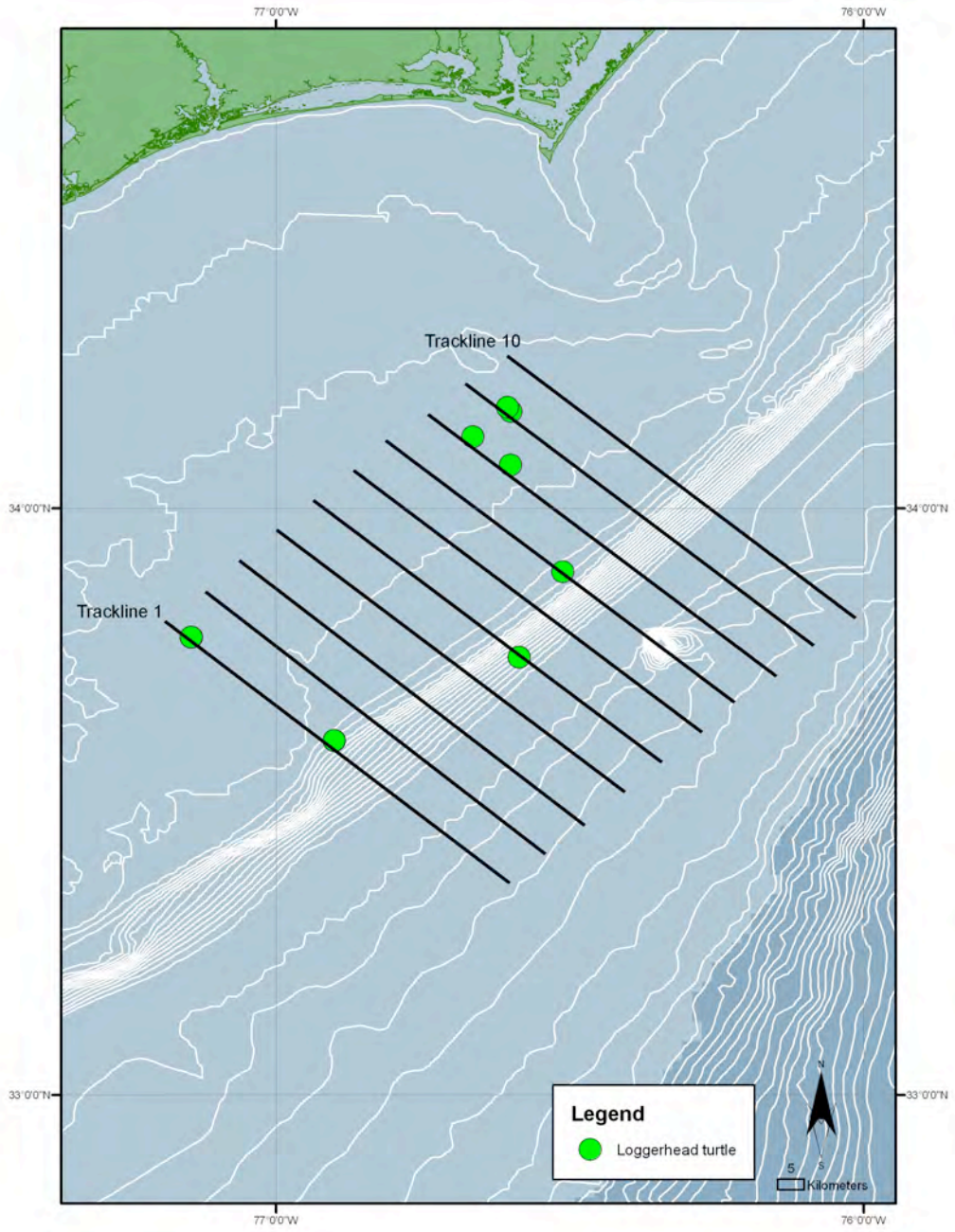

Figure 14. Location of loggerhead turtle sightings made during surveys in Onslow Bay, NC, June 2007 through 2008.

Photographic Effort

Digital photographs were obtained when possible and approximately 1000 digital images were taken for species identification and individual recognition purposes. Every attempt was made to photograph all animals encountered, primarily to validate species identification, but also to develop photo-identification catalogs for cetacean species in Onslow Bay. Images taken on the vessel-based surveys have been used to identify diagnostic features for comparison with images taken on the aerial surveys to improve species identification. The aerial survey observers and shipboard observers have meet twice, specifically to go through images taken from both platforms to confirm species identification.

We have developed initial photo-identification catalogs for bottlenose dolphins, spotted dolphins, pilot whales and Risso's dolphins from images taken during our surveys in Onslow Bay (Table 3). However, it is often difficult to maneuver the vessel to take good quality photo-identification images, especially while towing the passive acoustic array. To date, we have not re-sighted any individuals photographed, but we will continue to take images for photo-identification and add to our existing catalogs.

Table 3. Number of individual identifications from images taken during vessel-based surveys in Onslow Bay, June 2007-June 2008.

Species	Sightings	Images	Unique IDs
Tursiops truncatus	24	472	52
Stenella frontalis	5	76	3
Globicephala spp.	1	105	8
Grampus griseus	2	182	5

Dedicated photo-identification and biopsy surveys in Onslow Bay

We also deployed a visual and acoustic survey team aboard the R/V *Stellwagen*, a 21m research vessel, on two days in September 2007 to conduct photo-identification and biopsy sampling of marine mammals within the USWTR survey area (Table 4; Figure 15). The *Stellwagen* has a small boat that can be launched for photo-identification and biopsy sampling. The *Stellwagen* left the Duke University Marine Lab dock on September 23rd and conducted visual and acoustic surveys from 10:00 (when we entered the USWTR survey area) to 18:30. We had excellent survey conditions throughout the day on September 23rd (Beaufort sea state 0-2), but we did not observe any marine mammals or detect any vocalizing marine mammals with the towed hydrophone array. We remained offshore during the night and resumed visual and acoustic surveys on September 24th at 07:30. We detected one group of bottlenose dolphins acoustically and then visually, and obtained photo-ID images and biopsy samples from these animals. We limited our biopsy sampling to two animals per group on the advice of Dr. Patricia Rosel (NOAA-NMFS-SEFSC). We also detected two groups of spotted dolphins visually (neither were detected with the towed hydrophone array) and obtained photo-ID images and a single biopsy sample from these groups (Table 4, Figure 16). Many of these animals were very well marked. During the two days of surveys, we deployed the hydrophone array whiles searching for marine mammals

Table 4. Summary of sightings made during the R/V *Stellwagen* cruise, September 23-24, 2007.

Date	Time	Latitude	Longitude	Depth (m)	Temp (C°)	Species	Group size	#Photos	#Biopsy samples
22-Sep-07	17:03:19	33.69796	-76.61463	N/A	29.5	*Dermochelys coriacea*	1		
22-Sep-07	17:29:59	33.66744	-76.64909	N/A	29.5	*Caretta caretta*	1		
23-Sep-07	9:13:51	33.78826	-76.42420	N/A	29.5	*Tursiops truncatus*	38	329	2
23-Sep-07	16:06:25	34.14863	-76.49371	33.9	29.5	*Stenella frontalis*	5	0	0
23-Sep-07	16:23:23	34.16388	-76.50863	36.6	29.5	*Dermochelys coriacea*	1		
23-Sep-07	16:52:21	34.19453	-76.52993	32.7	29.0	*Caretta caretta*	1		
23-Sep-07	17:02:57	34.21345	-76.53794	32.7	29.0	*Caretta caretta*	1		
23-Sep-07	17:12:07	34.23673	-76.54601	32.4	29.0	*Stenella frontalis*	3	28	1

for 18.5 hours of combined visual and acoustic surveys. We also observed several loggerhead and leatherback turtles (Table 4, Figure 15). We returned on September 24th due to deteriorating weather conditions.

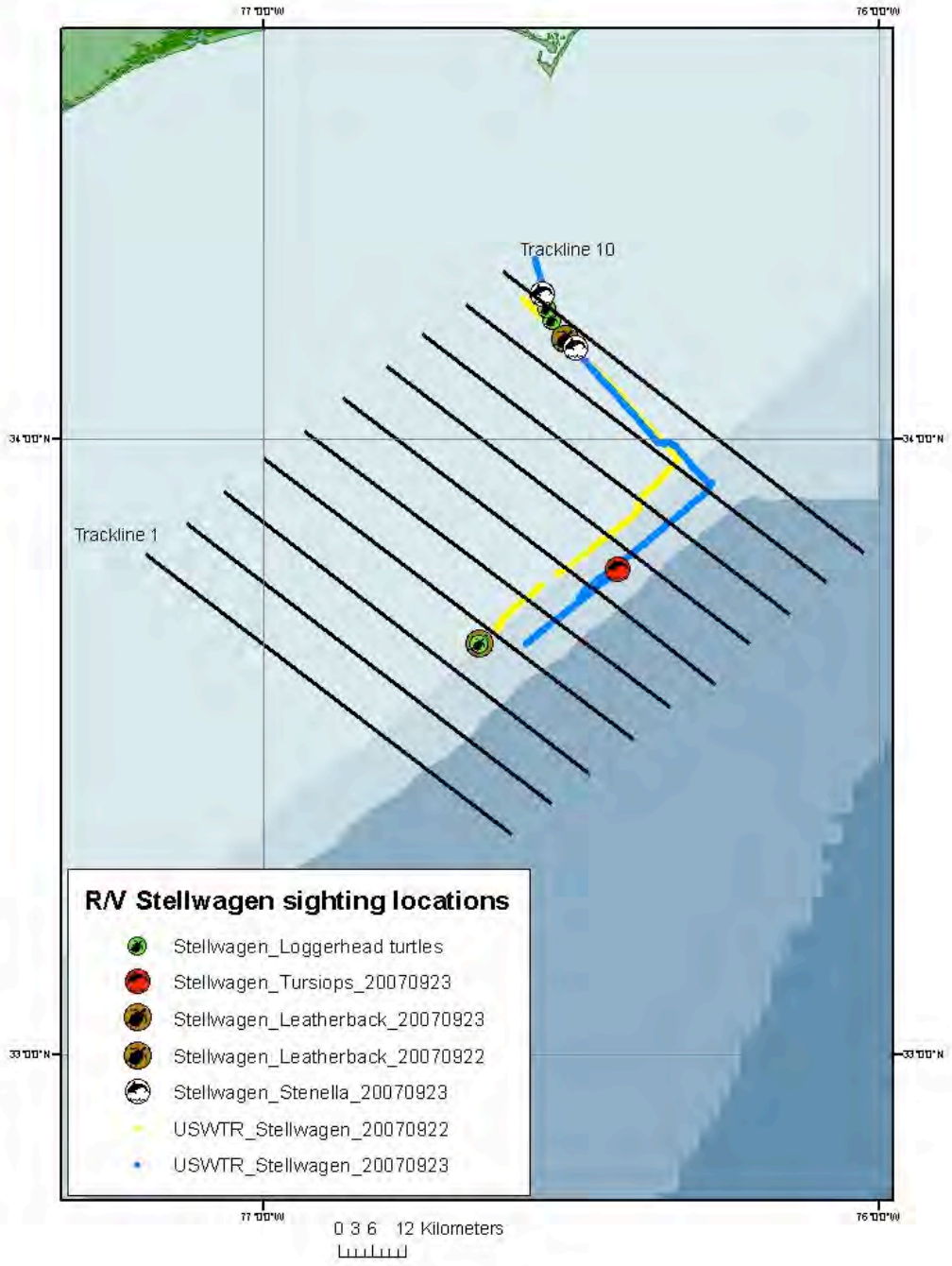

Figure 15. Locations of sightings from aboard the R/V Stellwagen, Sept, 23-24, 2007.

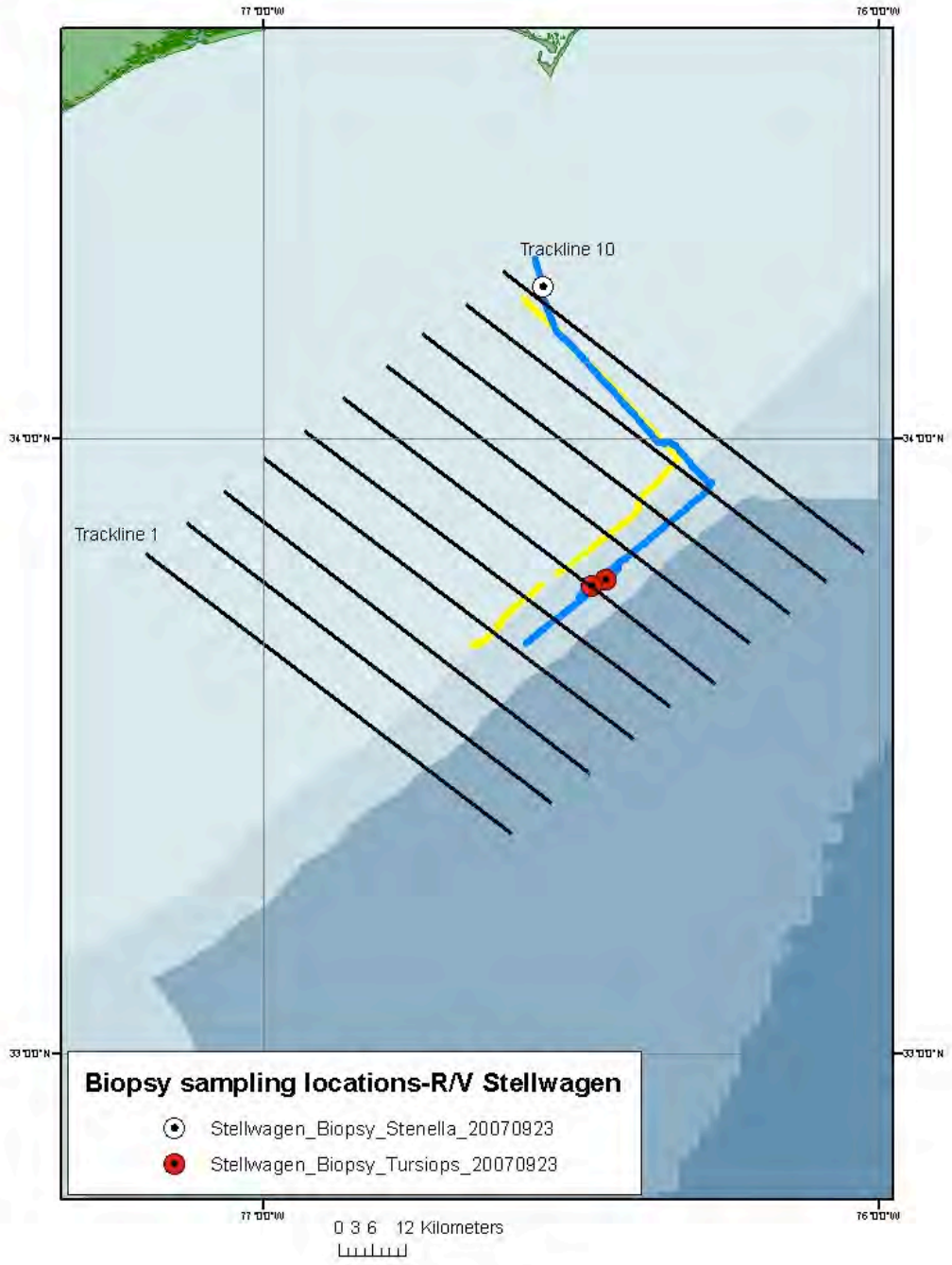

Figure 16. Locations of biopsy samples taken during R/V Stellwagen cruise, Sept. 24th, 2007

Passive Acoustic Monitoring

To date, we have performed 13 USWTR surveys (11 line-transect, two for photo-ID purposes) with the towed hydrophone array. During these surveys, we recorded 12 groups of animals that were positively identified by the visual observers. Of these 12 groups, seven were visually identified as offshore bottlenose dolphins and five groups were identified as Atlantic spotted dolphins. We used *Raven* to locate and save selections of whistles and clicks within these recordings. We plan to conduct further spectral analysis (measuring different parameters mentioned above) during the next few months.

In addition to the USWTR surveys, we used the towed array on two research cruises off Cape Hatteras, NC, and made recordings of one group of spotted dolphins, two groups of pilot whales, one group of bottlenose dolphins, and one group of short-beaked common dolphins. We also made recordings of several mixed-species groups, but we will not analyze these recordings for species-specific calls. As with the towed array recordings in the USWTR, we used *Raven* to locate and save selections of whistles and clicks in these recordings, and we plan to conduct further spectral analysis during the next few months to look for species-specific patterns.

To date, we have analyzed the HARP data from the first deployment using LTSAs to look for high-energy events (such as whistles and clicks). By using the LTSAs to examine these first 3.5 months of data, we found 520 marine mammal vocal events, one mid-frequency sonar event, four probable fish events, and 302 boat events (not including very low frequency shipping noise, which was abundant). Most of the marine mammal vocal events have not yet been identified to species (more *in situ* data collection with the towed array is needed), but we were able to classify six events as sperm whales (see Figure 17 for an example of sperm whale clicks). The duration of the 520 marine mammal vocal events ranged from one minute to just over 10 hours, with an average duration of 55 minutes. These results are summarized in Figures 18 and 19.

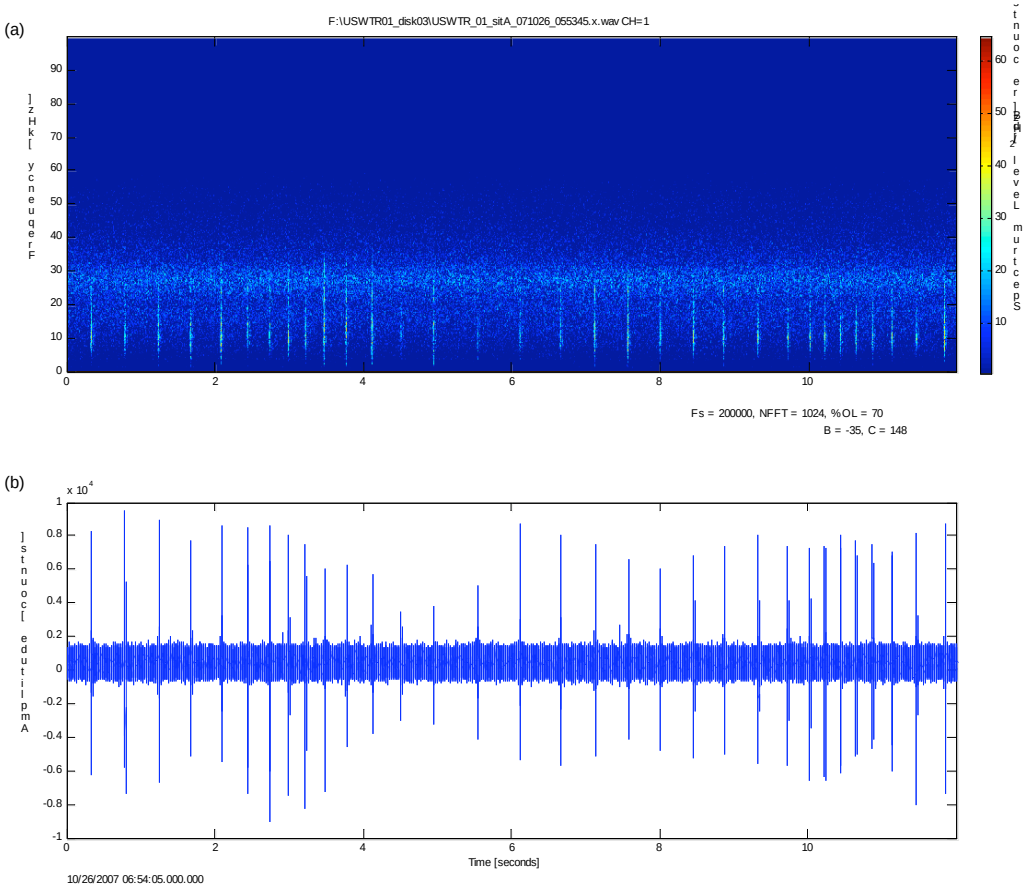

Figure 17. (a) Spectrogram and (b) waveform of sperm whale clicks found in HARP data from October 26, 2007.

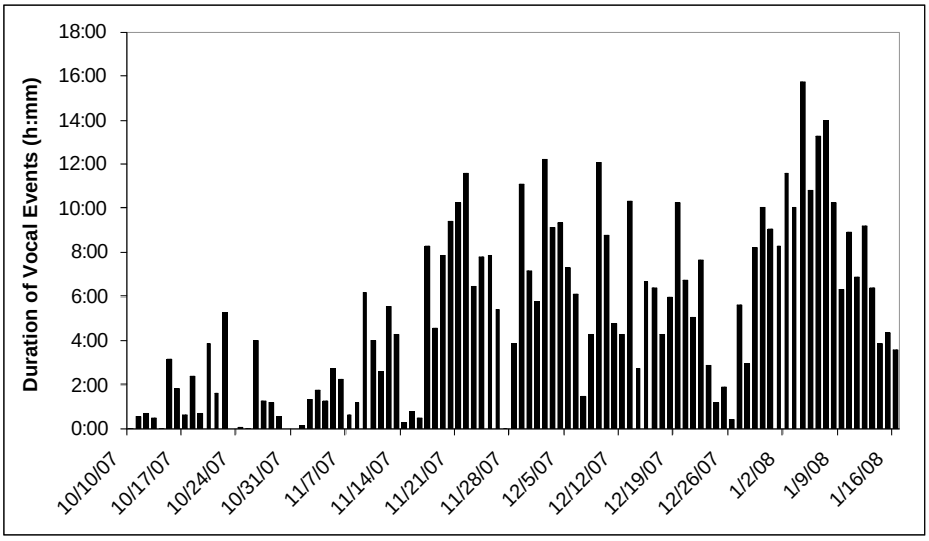

Figure 18. Total duration of vocal events (whistles and clicks) for each day during the first HARP deployment. Vocal events were found using LTSAs

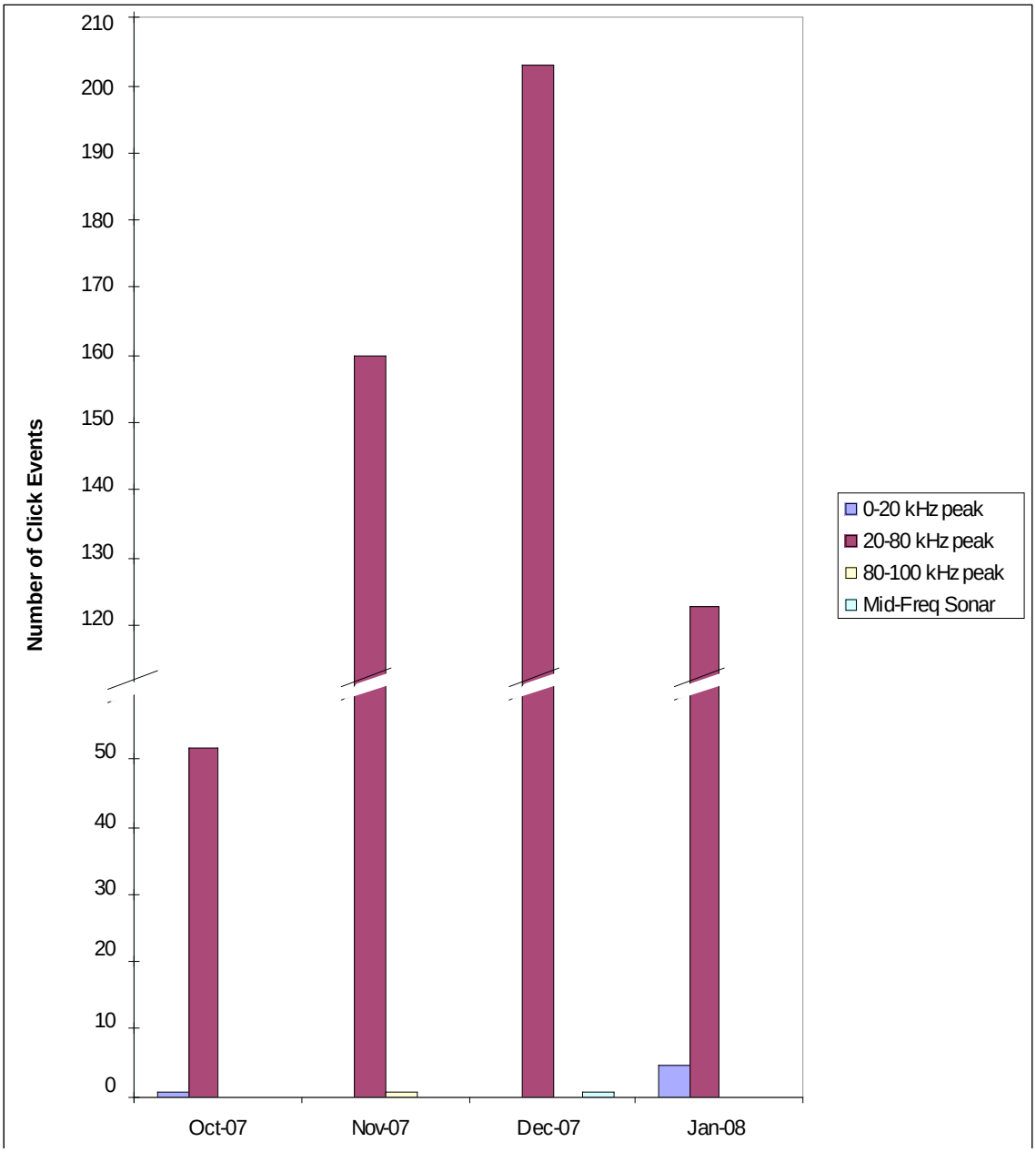

Figure 19. Total number of click events grouped into different frequency bins by peak amplitude for each month of the HARP's first deployment. Sperm whale clicks represent the 0-20 kHz peak bin; delphinids most likely represent the 20-80 kHz peak bin; and an unknown odontocete species represents the 80-100 kHz peak bin. Also included is the one mid-frequency sonar event.

Seabird Observations

During the first year of observations, we recorded 600 birds over approximately 80 hours of seabird observations (Table 5). The sighting per unit effort (SPUE), or the number of

seabirds recorded per hour of effort, ranged between 2.87 and 18.26, and was highest in September 2007. A total of 20 species of seabird were observed, with the largest number of species observed during the month of October. Table 6 shows the species of seabird observed in each survey month. Cory's Shearwaters (*Calonectris diomedea*) and Greater Shearwaters (*Puffinus gravis*) were by far the most frequently sighted birds, while unidentified Shearwaters (*Puffinus* sp.), Audubon's Shearwaters (*Puffinus lherminieri*), Black-capped Petrels (*Pterodroma hasitata),* Unidentified Storm Petrels, Wilson's Storm Petrels (*Oceanites oceanicus),* and unidentified Phalaropes (*Phalaropus* sp.) were also observed frequently. The highest diversity of seabird species was observed during the month of October, while June, July, August and November also showed high diversity indices (Table 7). In most months, seabirds were distributed evenly across species, as indicated by the high evenness indices for most months. September had a low diversity and a low evenness value, due to the high proportion of Cory's Shearwaters observed during that month.

The mean depths and sea surface temperatures of commonly sighted species are shown in Table 8. Black-capped Petrels, Sooty Terns (*Onychoprion fuscatus*), and White-tailed Tropicbirds (*Phaethon lepturus)* were observed in deeper waters than other seabird species, while Bridled Terns (*Onychoprion anaethetus),* Greater Shearwaters and Red-necked Phalaropes (*P. lobatus*) were observed in shallower waters. Arctic Tern (*Sterna paradisaea*), Black-capped Petrels, White-tailed Tropicbirds, and Manx Shearwaters (*Puffinus puffinus*) were found in somewhat cooler waters, while Greater Shearwaters, Bridled Terns, Sooty Terns, and Red-necked Phalaropes were observed in relatively warm waters. The distribution of seabirds observed during surveys in Onslow Bay is shown in Figures 20 through 25.

Table 5. Seabird sighting statistics by month during surveys in Onslow Bay, NC between June, 2007 and May, 2008. The sighting per unit effort (SPUE) was calculated by dividing the total number of birds observed by the total number of hours surveyed.

Month	Number of Species Observed	Total Number of Birds Observed	Total Hours Surveyed	SPUE by Month
June	8	68	16.97	4.01
July	8	43	14.97	2.87
August	10	183	14.53	12.59
September	5	70	3.83	18.26
October	12	142	17.30	8.21
November	6	22	4.23	5.20
March	5	49	3.88	12.62
May	6	23	4.65	4.95
TOTAL	**20**	**600**	**80.37**	**7.47**

Table 6. Seabird sightings by month from June, 2007 to May, 2008 during surveys in Onslow Bay, NC.

	Month								
SPECIES	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Mar.**	**May**	**TOTAL**
Audubon's Shearwater (*Puffinus lherminieri*)	11		7	1	2			9	30
Cory's Shearwater (*Calonectris diomedea*)	4	4	21	58	61	1			149
Greater Shearwater (*Puffinus gravis*)	13	9	119	1	8				150
Manx Shearwater (*Puffinus puffinus*)					12	4	1		17
Unidentified Shearwater (*Puffinus* sp.)	15	6	12	3	27	7	5	5	80
Black-capped Petrel (*Pterodroma hasitata)*	5				19		3	6	33
Leach's Petrel (*Oceanodroma leucorhoa*)		1							1
Wilson's Storm Petrel (*Oceanites oceanicus)*	6	6	7			3		1	23
Unidentified Storm Petrel	10	14	1		1	4			30
Bridled Tern (*Onychoprion anaethetus)*		1	7						8
Sooty Tern (*Onychoprion fuscatus*)			5	4					9
Arctic Tern (*Sterna paradisaea*)						1			1
Unidentified Tern			3		1				4
Red-necked Phalarope (*Phalaropus lobatus*)					3				3

Unidentified Phalarope (*Phalaropus* sp.)							34	1	35
White-tailed Tropicbird (*Phaethon lepturus)*	4	1	1					1	7
Falcon (*Falco* sp.)					3				3
Great Blue Heron (*Ardea herodias*)					1				1
Unidentified Loon (*Gavia* sp.)							3		3
Mourning Dove (*Zenaida macroura*)					1				1
Unidentifed Bird		1		3	3	2	3		12
TOTAL	**68**	**43**	**183**	**70**	**142**	**22**	**49**	**23**	**600**

Table 7. The Shannon diversity index (*H*) and the Shannon's equitability index (*E*) by month for seabird surveys in Onslow Bay, NC.

Month	Total Number Birds Observed	Diversity (*H*)	Evenness (E)
June	68	1.74	0.84
July	43	1.81	0.87
August	183	1.81	0.79
September	70	0.71	0.44
October	142	1.88	0.76
November	22	1.75	0.98
March	49	1.08	0.67
May	23	1.46	0.81

Table 8. Mean depth, sea surface temperature (SST in °F) for commonly sighted seabird species from surveys in Onslow Bay, NC

Species	Mean Depth	Mean SST
Audubon's Shearwaters (*Puffinus lherminieri*)	-275	80.86
Cory's Shearwaters (*Calonectris diomedea*)	-265	83.08
Greater Shearwaters (*Puffinus gravis*)	-207	84.33
Manx Shearwaters (*Puffinus puffinus*)	-257	79.14
Black-capped Petrels (*Pterodroma hasitata)*	-407	77.95
Leach's Petrel (*Oceanodroma leucorhoa*)	-226	
Wilson's Storm Petrels (*Oceanites oceanicus)*	-240	81.73
Arctic Tern (*Sterna paradisaea*)	-36	69.61
Bridled Terns (*Onychoprion anaethetus)*	-119	85.18
Sooty Terns (*Onychoprion fuscatus*)	-383	84.88
Red-necked Phalarope (*Phalaropus lobatus*)	-212	84.13
White-tailed Tropicbirds (*Phaethon lepturus)*	-345	78.64

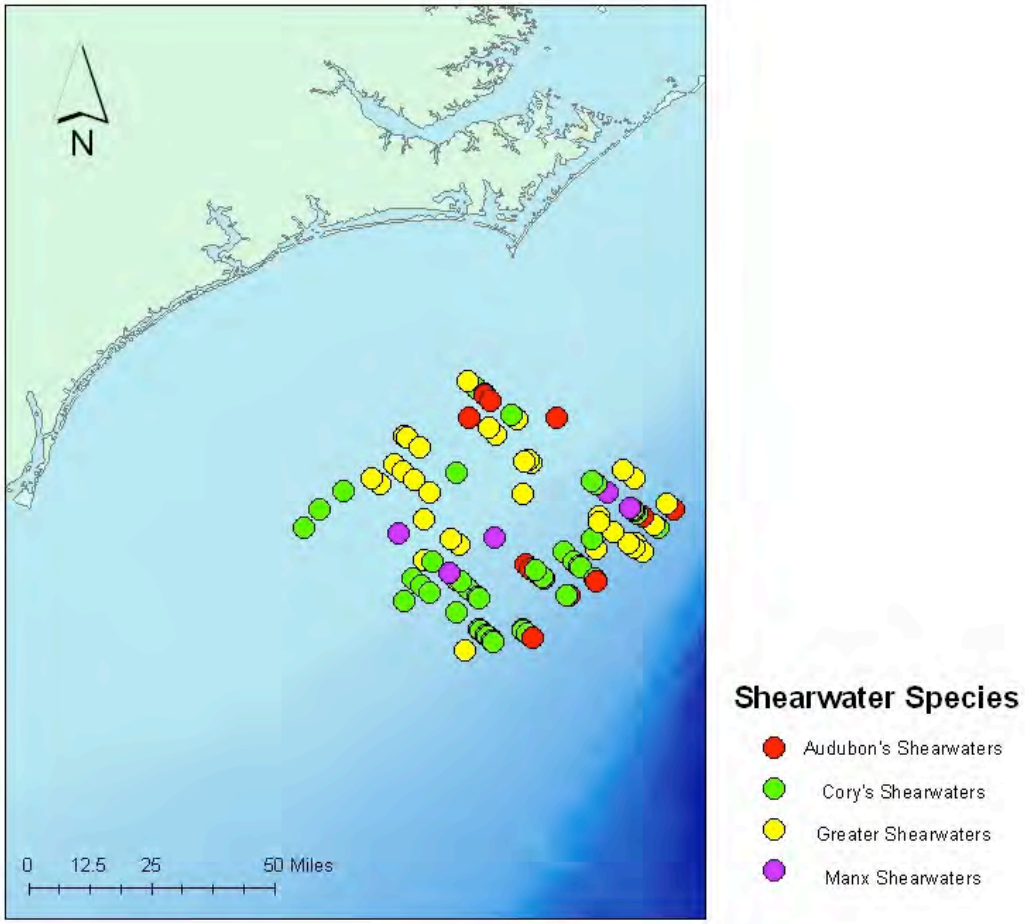

Figure 20. Distribution of Shearwater species observed during surveys in Onslow Bay, NC.

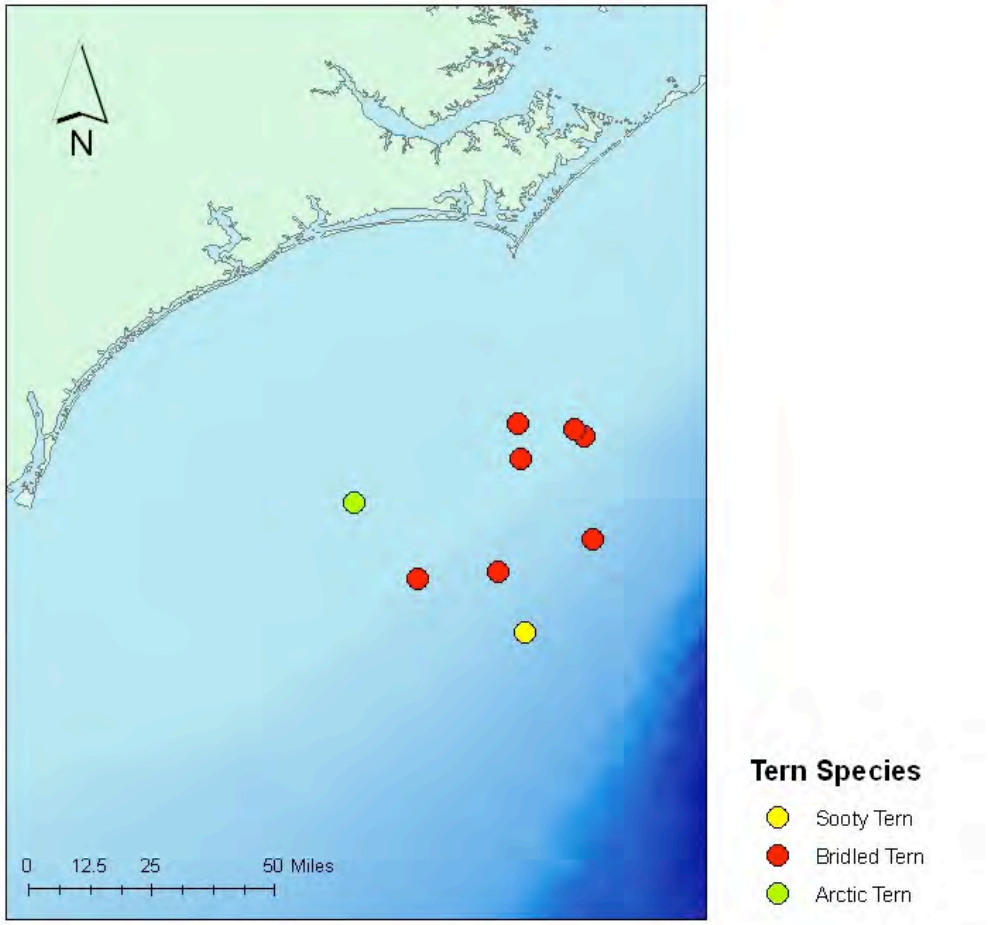

Figure 21. Distribution of Tern species observed during surveys in Onslow Bay, NC.

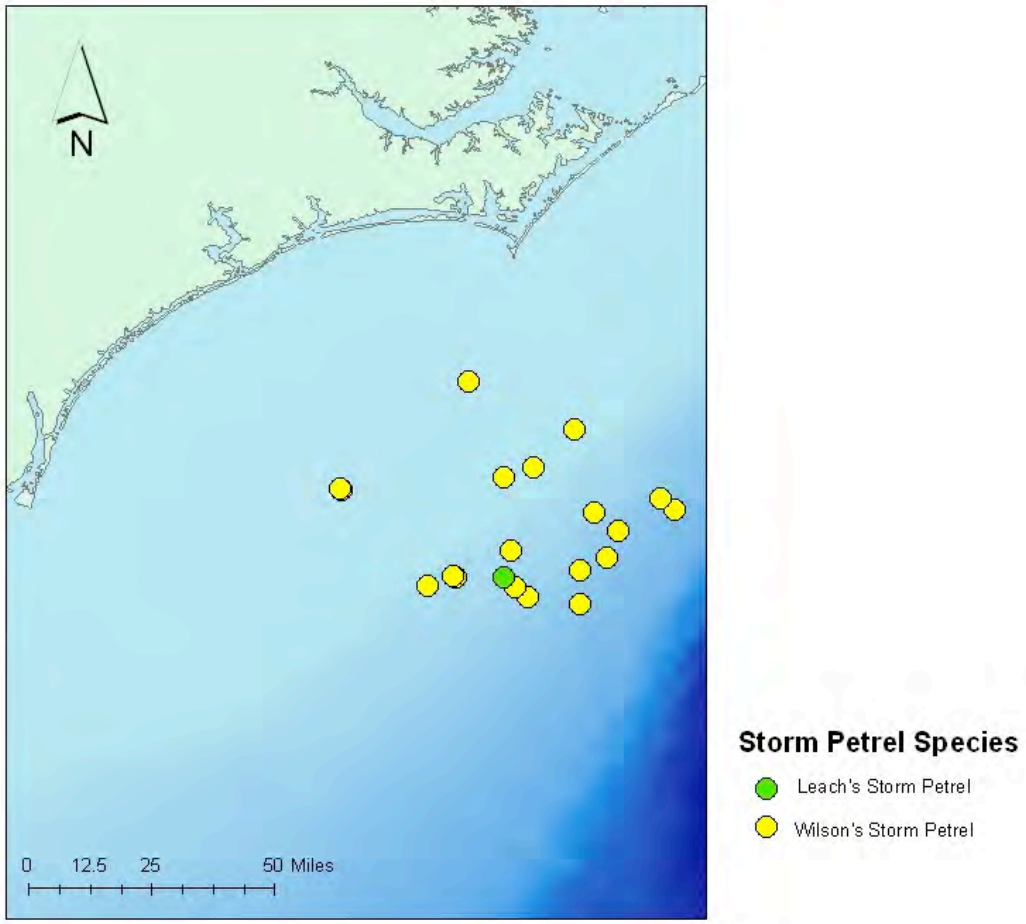

Figure 22. Distribution of Storm Petrel species observed during surveys in Onslow Bay, NC.

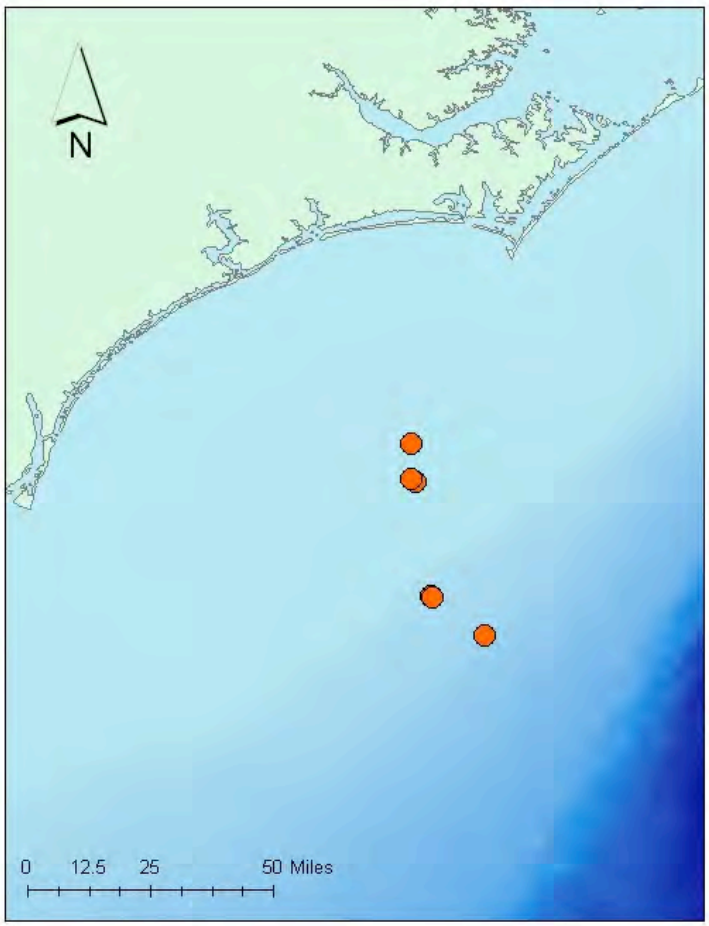

Figure 23. Distribution of Phalaropes observed during surveys in Onslow Bay, NC.

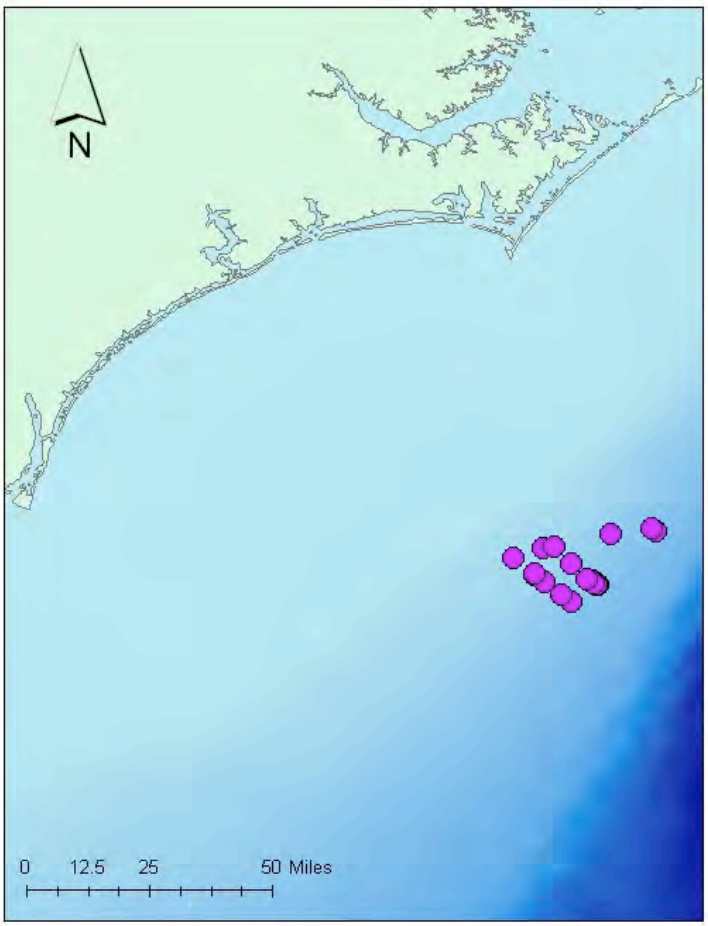

Figure 24. Distribution of *Pterdodrama* petrels observed during surveys in Onslow Bay, NC.

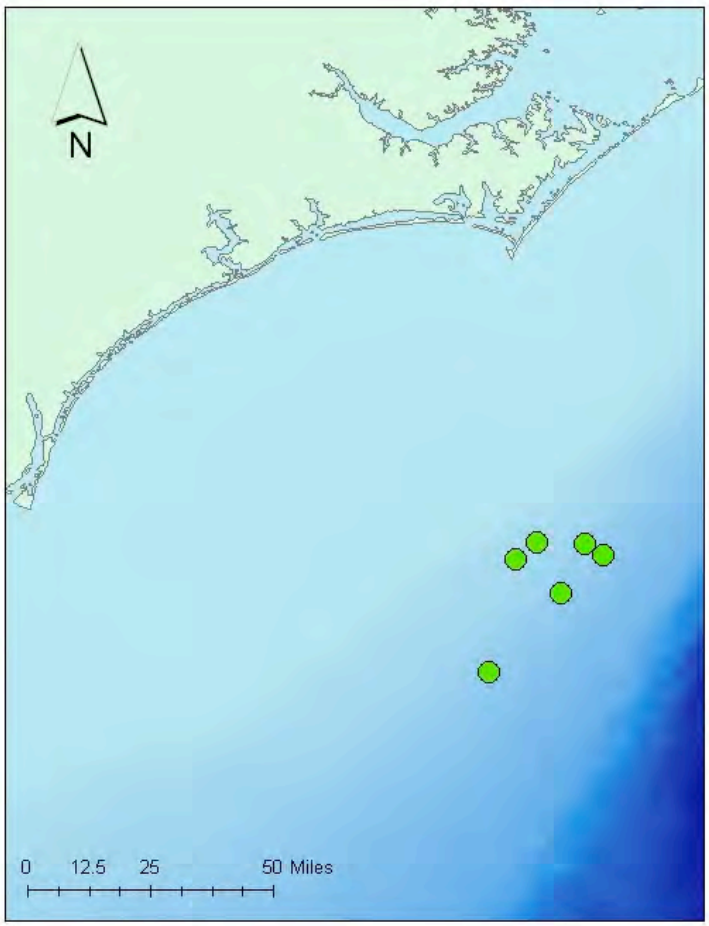

Figure 25. Distribution of White-tailed Tropicbirds observed during surveys in Onslow Bay, NC.

Vessel Sightings

A total of 239 vessels were encountered in the study area during vessel surveys, ranging from small recreational boats to large ocean-going cargo vessels. The number of each category of vessels sighted within the study area is presented in Figure 26.

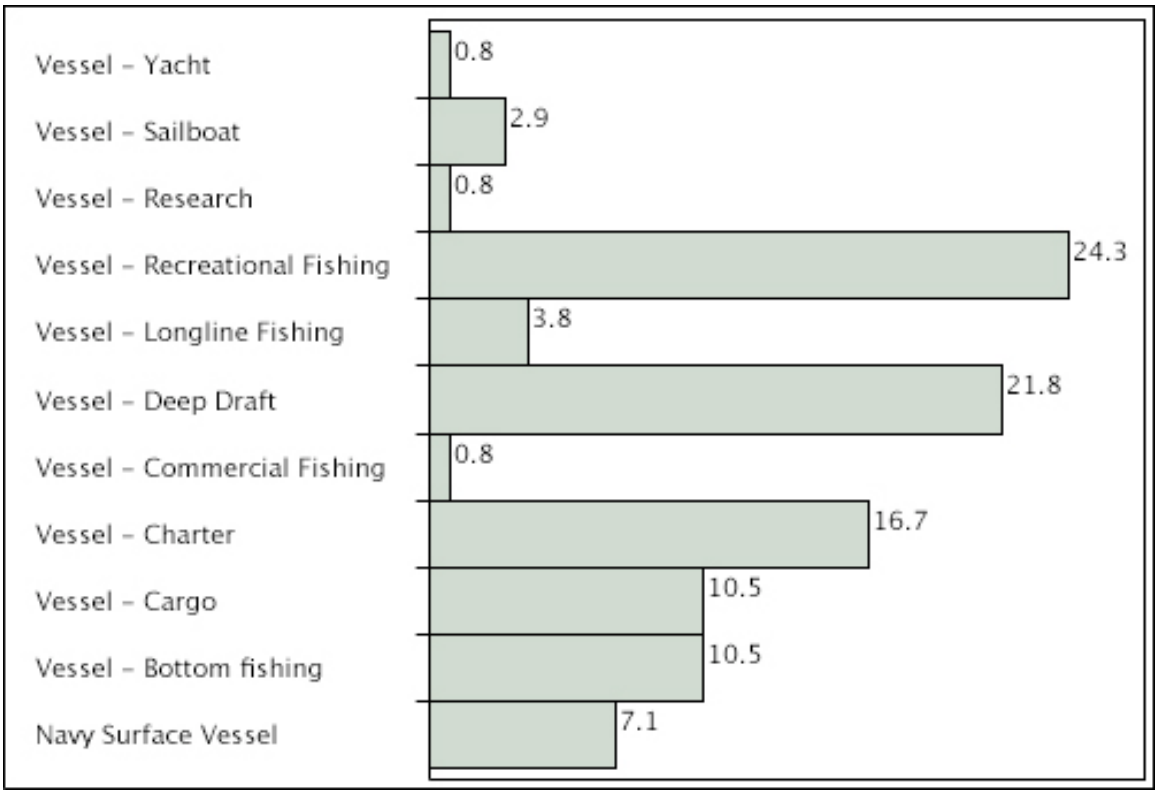

Figure 26. Distribution of vessels detected during surveys in Onslow Bay, NC, June 2007 through June 2008.

Acknowledgements

We thank Joel Bell (Naval Facilities Engineering Command Atlantic) for support and guidance and Dan Wilkinson (GeoMarine, Inc.) for contract administration. Debi Palka and Bob Gisiner provided critical insights into development of the monitoring plan. Keith Mullin and Kathy Foley allowed us to work under their biopsy permit (779-1633). Lance Garrison modified VisSurvey for our use. For assistance with the HARP we thank John Hildebrand, Chris Garsha, Alex Loer and Tim Boynton. For the shipboard surveys, we thank Matt Besch, Pete Zook, Erin LaBrecque, Elliott Hazen, Stacie Koslovsky, Beth Pike, Vicky Thayer, Ryan McAlarney, Peter Nilsson, Ramunis Zydelis, and numerous observers. A special thanks goes to Captain Dale Britt for his expertise and good nature. Surveys were conducted under NOAA Scientific Permit No. 948-1692-00, held by the UNCW.

Analysis of the UNCW and Duke University Aerial and Shipboard Surveys of the USWTR on the Atlantic Coast of the USA for the period June 2007 to June 2008 (also including analysis of the UNCW aerial survey data 1998 – 1999)

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CREEM, University of St Andrews

Abstract

Analysis of the data from the combined aerial and shipboard surveys of the USWTR carried out by Duke University and the University of North Carolina at Wilmington for the period June 2007 through June 2008, combined with that of the earlier aerial surveys of the UNCW for Onslow Bay 1998/1999, allowed estimation of approximate surface population sizes of bottlenose dolphins *Tursiops truncatus*, spotted dolphins, *Stenella frontalis*, pilot and beaked whales combined, and loggerhead turtles *(Caretta caretta)* as well as providing some evidence of the environmental correlates of the animals distributions.

Abundance for the USWTR region and an outer margin of 20 nm about it, was estimated by first fitting a detection function to the multi-platform survey data and then modelling the resultant estimated densities using a logistic general additive model. The estimated probability of presence was then multiplied by the estimated non-zero density to obtain an estimated overall abundance. Detection functions were not fitted to all of the sightings data owing to a paucity of data (shipboard whale sightings) or oddly distributed sightings (turtle data).

Estimates were made for the USWTR core region and the outer region for June 1998 (extrapolated), June 1999, June 2007 and June 2008 and for each month from July 2007 to June 2008. Estimated bottlenose dolphin numbers varied between c. 0 (95% CI: 0 – 0, August 2007) to c. 320 (0 – 2160, Jan 2008) for the inner region and 0 (0 – 0, August 2007) to c. 1140 (930 – 4800, Jan 2008) for the outer region. Estimated spotted dolphin numbers varied from 0 (0 – 0) in 1998 to c. 10 (0 – 610) in 2007/2008 in the inner region and 0 (0 – 410, 1998) to 55 (10 – 1400, 2008) in the outer region. Pilot and beaked whale numbers were very low (< 10) throughout the survey period. Estimated loggerhead turtle numbers varied from c. 10 (10 – 40, August/September 2007) to 140 (100 – 270, March 2008) in the inner region and 20 (10 – 60, August 2007) to 330 (210 – 500, March 2008) for the outer region. All the above estimates assumed perfect detection on the trackline. There was no evidence of a systematic decline in any species in the last ten years.

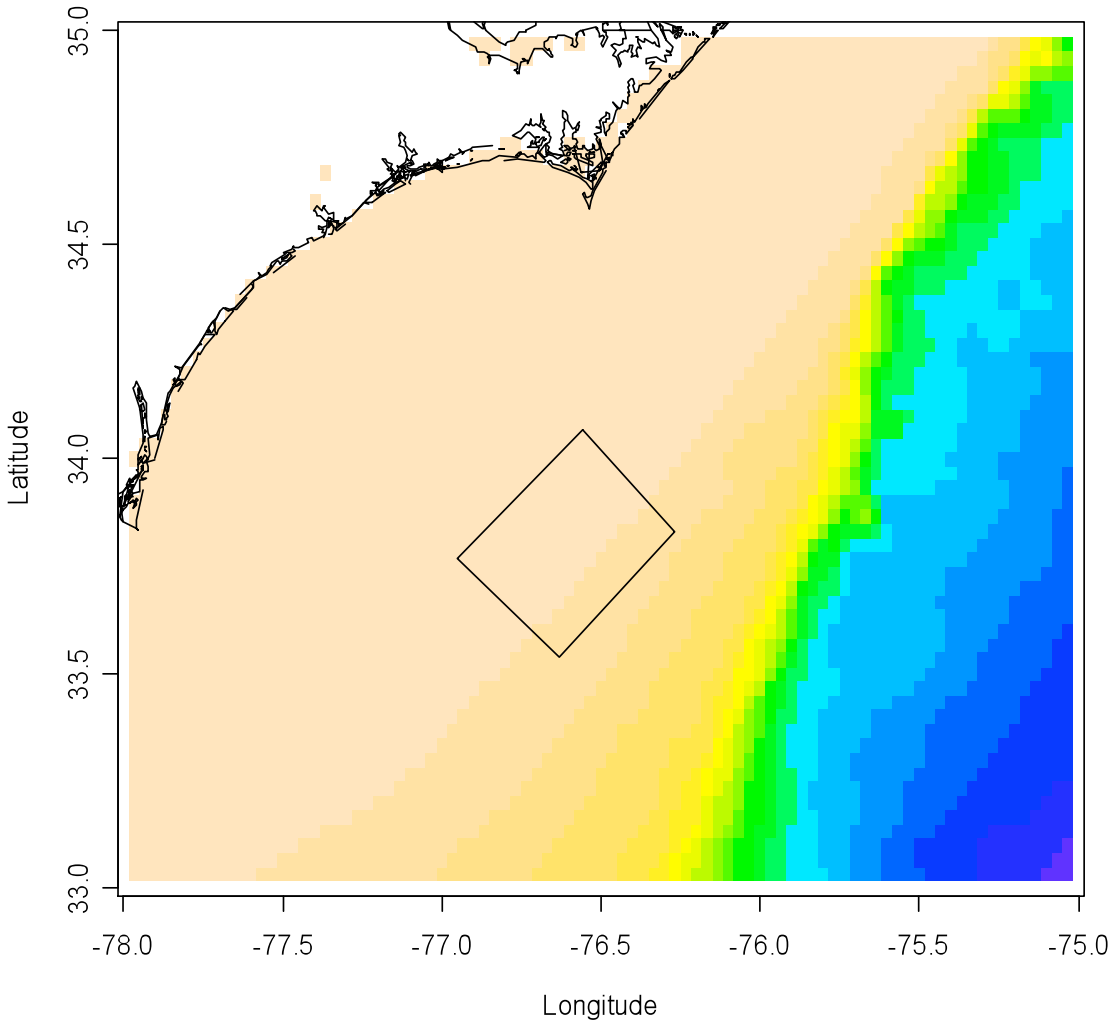
There was evidence that the abundance of bottlenose dolphins fluctuated with season (perhaps in response to temperature), as did the presence of loggerhead turtles. Spotted dolphins only appeared in the shallower parts of the region of interest from 2007.

Introduction

The document explains the analysis of the USWTR aerial and shipboard survey data for the first year (with the addition of additional shipboard data from June 2008) carried out by the University of North Carolina at Wilmington (UNCW) and Duke University respectively. The aim of these surveys was to establish base line data on the density of marine mammals in the USWTR region and if possible to develop a preliminary density surface of animals in the area of interest. Of further interest was the possibility that there could be environmental predictors of the marine animal density. Given the paucity of actual sightings within the region of interest such an analysis can supply only a preliminary investigation of animal numbers and all conclusions from this analysis should be regarded as tentative. Fortunately further survey data from the area was available from the aerial surveys done by UNCW off Onslow Bay from September 1998 to July 1999. Additionally sightings data undertaken from the same aerial platform was available from the ongoing right whale surveys carried out by UNCW closer to the coastline and the surveys undertaken near Wallop Island in 1998 and 1999.

Thus the analysis undertaken here, aimed to integrate the sightings and effort data from the 1998-1999 Onslow Bay survey (hereafter “Onslow survey”), the current ongoing aerial survey by UNCW (hereafter “USWTR aerial” survey) and the ongoing shipboard survey by Duke University (hereafter “USWTR ship” survey) augmented with sightings alone data from the 1998 – 1999 Wallop Island surveys (hereafter “Wallop” survey) and the ongoing right whale surveys (hereafter “right whale” survey) to increase to precision associated with the estimate of the detection functions and ultimately abundance.

Figure 1. The core USWTR area and depths (m) at 2 minute intervals. Each colour represents 200 m intervals from 4200 m depth (violet in lower right hand corner)



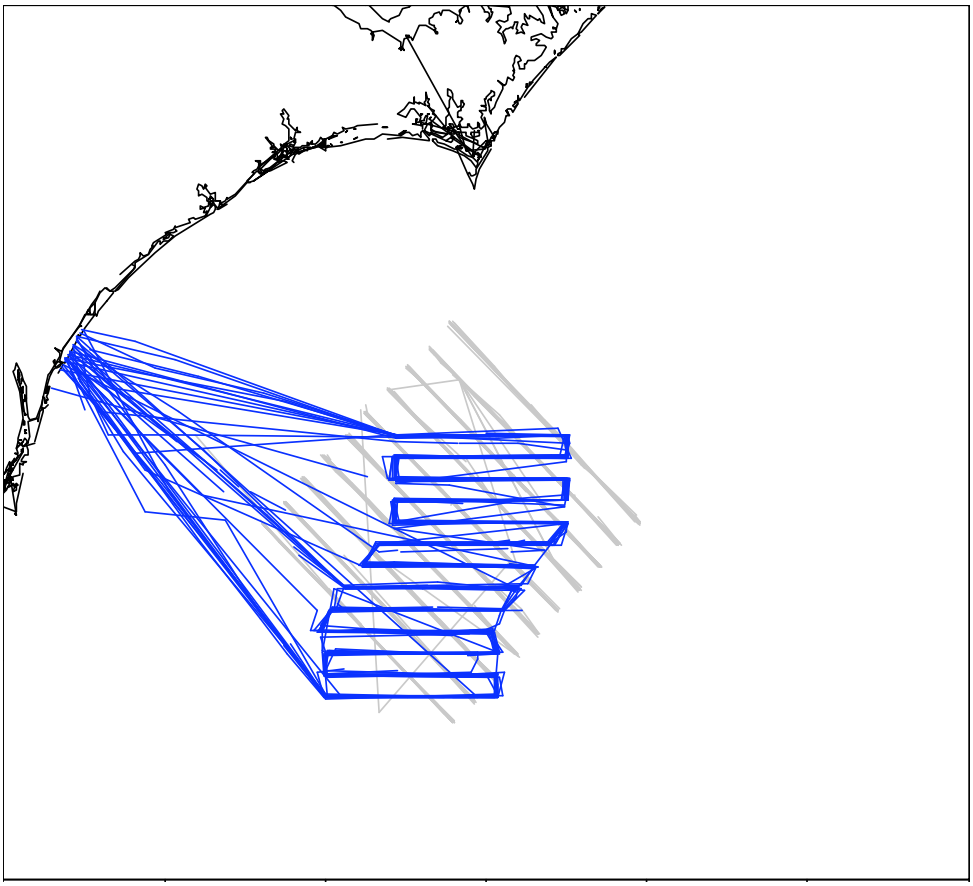
Methods

Area of interest and survey area

The USWTR area is given in figure 1 with approximate boundaries given by the black line. The boundaries are approximately 25 miles long (SW to NE) and 20 miles wide (NW to SE). The survey area extended to outside of this USWTR core by 20 nm (see grey transect lines in figures 2 and 3) so the total survey area is 1800 square nautical miles, with 500 of this (28%) within the USWTR itself. The survey area could be divided

into a core region (inside the USWTR) and an outer non-core region. Abundance estimates were obtained for both regions.

Figure 2. Realized aerial effort segments for USWTR 2007/2008 (grey) and Onslow 1998/1999 (blue)

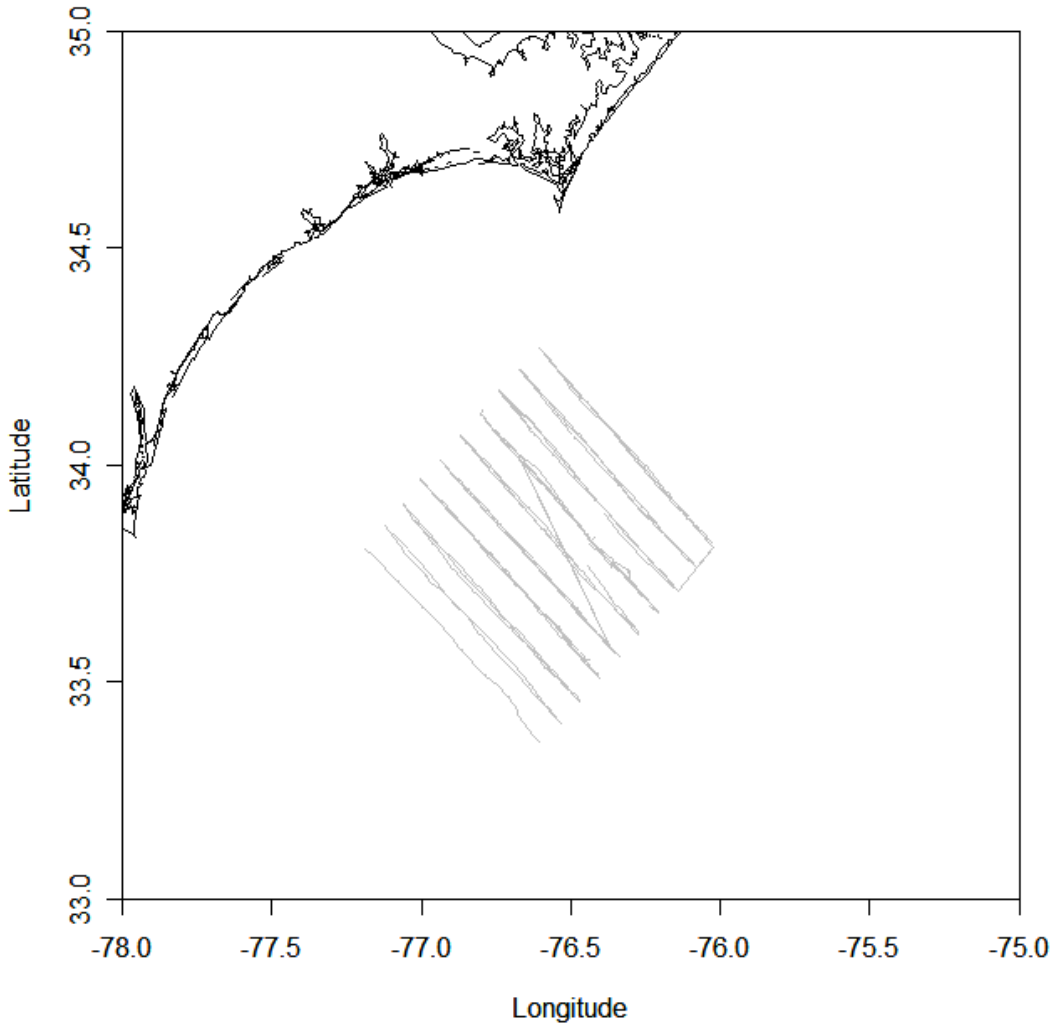


The realized aerial survey effort consisted of the 12820 km in 1998/1999 and 14481 km from June through and including May 2008 and can be seen in figure 2.

The area covered by the shipboard survey was almost identical to that of the USWTR aerial survey (Figure 3) except no realized effort was expanded outward from the shore. The total realized effort analysed here was 2231 km. Two vessels were used:

the *Sensation* and the *Cetus*. There was no evidence that detection varied between the two (see results).

Figure 3. Realized ship effort for USWTR 2007/2008 (grey)



Statistical analysis

Overview

In order to generate a density estimate of each species/taxa of interest and where possible to identify environmental variables driving animal abundance, the data were analysed by first estimating the probability of detection associated with each sighting and then estimating abundance per segment of trackline within the truncation distance. This

assumed that detection on the trackline occurred with probability one (see below for discussion). The estimated densities comprised the inputs for a General Additive Model (GAM) to obtain a model of animal density. From this an estimate of the total number of animals in the area of interest was obtained. All animal species were initially considered but only 4 taxa were modeled in detail: bottlenose dolphins *Tursiops truncatus,* spotted dolphins *Stenella frontalis,* medium sizes whales (i.e. pilot whales *Globicephala* sp. and ziphids) and loggerhead turtles *Caretta caretta.* It may be that with increased sample sizes, data from other species will become adequate for analysis.

Estimation of Detection Probabilities

In conventional line transect sampling the probability of detection depends only on the perpendicular distance of the sighting to the transect, and at zero perpendicular distance this is assumed to be one (denoted by $g(0) = 1$). In this analysis the effects of covariates, other than perpendicular distance were incorporated into the detection function model. This was achieved by setting the scale parameter in the model to be an exponential function of the covariates (Marques 2001). Thus the probability of detection becomes a multivariate function, $g(y,\boldsymbol{v})$, representing the probability of detection at perpendicular distance y and covariates $\boldsymbol{v}$ ($\boldsymbol{v} = v_1,..,v_Q$ where Q is the number of covariates). Using either a hazard-rate or half-normal detection function, the covariates were incorporated via the scale term, σ, where for sighting k, has the form:

$$\sigma_k = \exp\left(\beta_0 + \sum_{q=1}^{Q}(\beta_q v_{kq})\right)$$

here β_0 and β_q (q=1,…,Q) are parameters to be estimated. With this formulation, it is assumed that the covariates may affect the rate at which detection probability decreases as a function of distance, but not the shape of the detection function.

A stepwise forward selection procedure was used (starting with a model containing perpendicular distance only) to decide which covariates to include in the model, with a minimum Akaike's Information Criterion (AIC) inclusion criterion. All model selection was performed in the program *Distance* (v5.0; Thomas *et al*. 2002), and then the final selected models were re-fitted using a set of customized functions in the

statistical programming package *R* (*R* Developmental Core Team, 2002). This facilitated estimation of variance within *R* – (see below).

This procedure was followed for dolphins and turtles. In the case of ship sightings of medium whales (see below), the paucity of data required a slightly different approach. Given that the number of sightings (even with beaked whales and pilot whales combined) was too low (n = 1) to estimate a reliable shipboard detection function a Bayesian approach was implemented. In contrast to the frequentist approach, Bayesian analysis (e.g. Gelman et al. 1995) involves quantifying uncertainty about parameters prior to gathering data. Parameter estimates are updated using data combining prior information Updates take the form of a joint distribution for the parameters of interest from which one can obtain a range or credible interval which reflects one's actual uncertainty about the parameters after observing the data. The more new data is incorporated into the model, the less the effect of the prior distribution. In our case,specifying the prior distribution for the detection function parameters allows estimation from sample sizes that would be inadequate on their own. The aim was to get parameter estimates that could be used to obtain a detection probability which could be integrated into the next stage of the analysis.

The Bayesian analysis was performed using *R* to call the program *Winbugs* (Lunn *et al*. 2000) invoked from *R* using the *R* library *R2WinBUGS* (Gelman et al. 2008). The priors for the shipboard medium whale detection function were taken from an analysis of shipboard pilot whale sightings (Paxton et al., unpublished) from the north Atlantic in 2001. In this study Paxton *et al.* fitted a hazard rate detection function which was truncated at 1.5 km.

Estimation of density surfaces

In most cases the number of transect segments containing sightings was extremely low. This made fitting of models difficult so a variety of modelling approaches were undertaken. The initial aim was to implement a modified version of the 'count model' of Hedley et al. (1999) was used to model the trend in spatial distribution of the different species. The response variable for the model was calculated from the estimated number of individuals for a segment $\hat{N}_i$, for each i^{th} segment. This was calculated using an

estimator similar to the Horvitz-Thompson estimator (Horvitz and Thompson 1952), as follows:

$$\hat{N}_i = \sum_{j=1}^{n_i} \frac{s_j}{\int \hat{g}_{ij}(y,\mathbf{v})\ p(y)\ dy} \qquad i = 1,\ldots,T,$$

where, for segment *i*, $\int \hat{g}_{ij}(y,\mathbf{v})\ p(y)\ dy$ is the estimated probability of detection of the *j*th detected pod, n_i is the number of detected pods in the segment and s_j is the size of the *j*th pod. The total number of transect segments is denoted by *T*. By assumption, $p(y)$, the probability density function of actual (not necessarily observed) perpendicular distances is uniform up to the truncation distance. This is satisfied by randomly located transects.

Having obtained the estimated number of individuals in each segment, the density in segment *i*, $\hat{D}_i$, was estimated by $\hat{N}_i / a_i$ where a_i is the area of segment *i*. Segment area was calculated as the length of the segment multiplied by twice the truncation distance used to model the detection function. The survey tracklines were initially divided up into distinct segments based on when crafts had gone off effort and/or a change in environmental characteristics. A variety of segment lengths was tried in the range of 5 – 13 km. Eventually 10km km was selected as an appropriate compromise between maximising the ratio of non-zero to zero segments, maintaining environmental resolution and giving some measure of spatial independence (see results). In the case of the main USWTR data set this gave 1528 segments. In the case of the Onslow data this meant 1370 segments for the aerial survey with 738 segments for the shipboard survey (29 for *Cetus* and 689 for *Sensation*).

Attempts to model density directly were unsuccessful because of the high frequency of zeros. Therefore the presence or absence of animals in a particular segment was modeled using a logistic GAM. The predicted probability of presence of animals in a segment was then multiplied by the predicted non-zero density in a segment. Again because of the paucity of the data attempts to model varying non-zero density proved unsuccessful so in all cases the mean of the non-zero density was used. This may introduce a potential bias in that zeros are over represented i.e. some zeros are not true zeros but simply segments of low density where the animals though present were not observed.

The covariates considered in the analysis were longitude (*Lon*) and latitude (*Lat*), sea surface temperature (*Temp*) and depth (*Depth*), day of the year (*Dayofyear*) and year of survey (*Year)*. Depths and temperatures were taken during the shipboard survey but additional data was needed for the aerial survey and the prediction grid. Sea surface temperatures were obtained from the National Oceanic and Atmospheric Administration (NOAA, http://dss.ucar.edu/datasets/ds277.0/data/oiv2/) at one degree and weekly resolution and were an updated set (based on the analysis of Reynolds *et al.* (2002)). Depths were obtained from the ETOPO2 2 minute resolution relief data available from National Oceanographic and Atmospheric Administration (http://www.ngdc.noaa.gov/mgg/image/2minrelief.html). Temperatures and depths were associated with effort segments by finding the closest point in the temperature and bathymetry data to the midpoint of the effort segments using great circle distances (and additionally, time for temperature). Finally *Survey* was a factor variable which indicated the platform used (plane, *Cetus* or *Sensation*).

Scatterplots of the explanatory variables are shown in figure 4. Unsurprisingly *Temp* and *Dayofyear* were strongly correlated with each other as were *Lon, Lat* and *Depth* thus the inclusion of only one of these correlated variables in the final models should not be interpreted as necessarily precluding the influence of others.

Unbiased risk estimation implemented in the *mgcv* package (v. 1.1-7, Wood 2001) in *R* (v. 2.5.1) was used for covariate selection, augmented with diagnostic plots, using the principles described in Wood (2001). All covariates were considered for inclusion in the model as 1D smooths of untransformed covariate values. In addition, 2D smooths of *Lat* and *Lon* (as kilometer deviations from the equator and longitude 77˚W). were considered for inclusion into the GAM. A maximum of 4 degrees of freedom (5 knots) were allowed in the selection of 1D smooths for *Depth, Temp* and *Dayofyear*. In the case of *Lat* and *Lon,* 6 degrees of freedom (7 knots) and up to 13 degrees of freedom (14 knots) were allowed in the case of 2D smooths, thus allowing moderate flexibility but reducing the possibility of overfitting. The presence of unexplained spatial variation was checked by inspection of semivariograms of the residuals of the models. Data was fitted to all data across all years.

Due to gaps, changes in direction, stops in search effort along transects and changes in environmental conditions, effort could not always be split into segments of the desired length (see later). Therefore, the size of each segment varied and so the model was weighted by segment area.

The aim of all the initial models above was to estimate a density surface (see below). To investigate the underlying biological basis of the distributions of the animals, model selection for *Tursiops, Stenella* and *Caretta* was repeated without *Lon* and *Lat*. Sometimes the final biological model selected corresponded to the density surface only models.

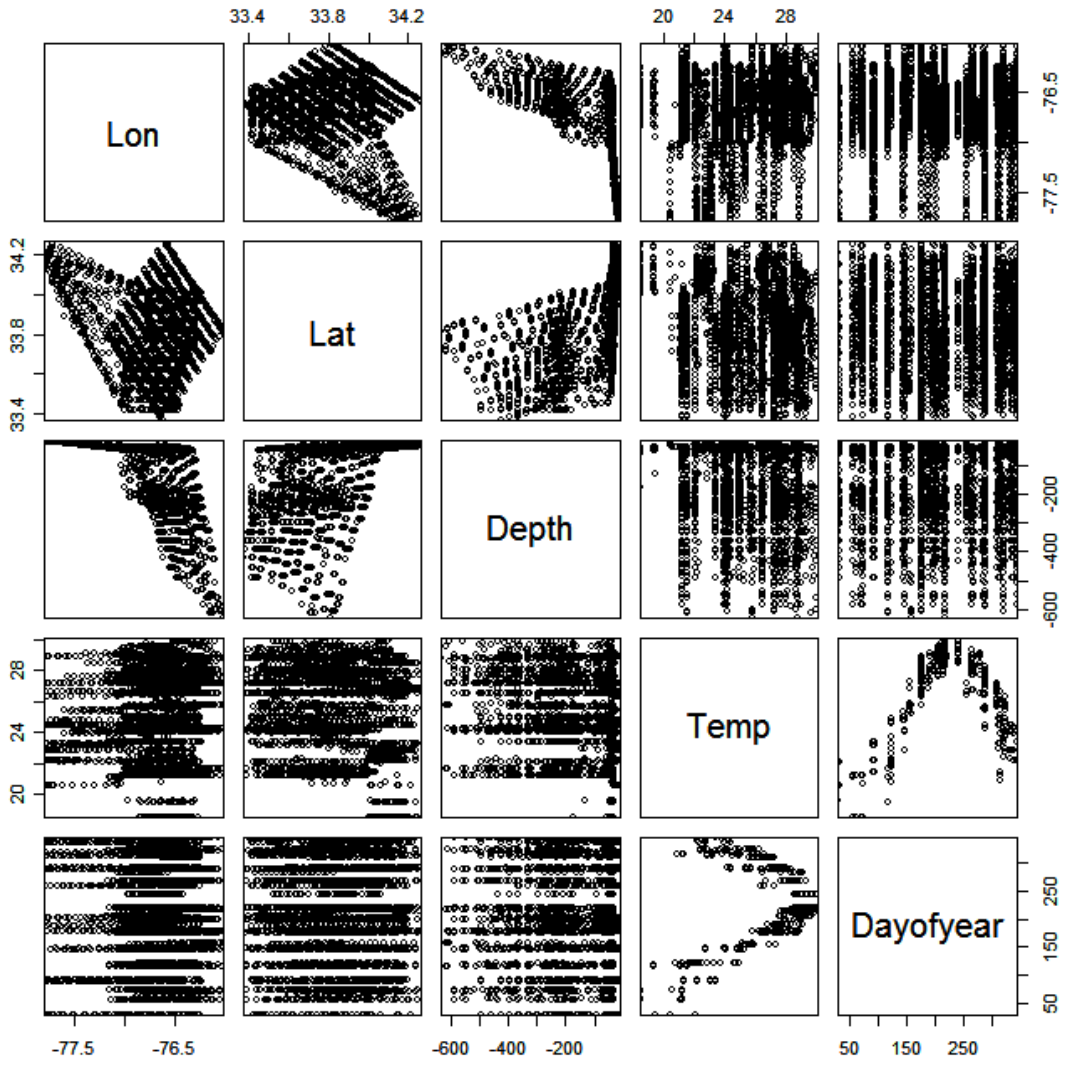
Prediction

The final model was used to predict density of marine animals throughout the survey region over a 2 minute resolution grid that was spanning the inner core USWTR area and the surveyed area around it. Animal abundance was estimated by numerically integrating under this predicted density surface. If survey mode was included in the model, abundance was predicted assuming the survey mode with the largest coefficient in the model as this would reflect the best detection on the trackline. Predictions were made for June of each of the survey years (although June was not surveyed in 1998) to allow comparison between years. Obviously models that did not contain *Dayofyear, Temp* or *Year* produced identical predictions for each of the four years and months.

Variance estimation

Variance estimation was undertaken by bootstrapping the entire process above based on a selection of effort legs. The Bayesian component was integrated in by taking a random (coupled) pair of parameters from the posterior distribution of the hazard rate parameters produced by *Winbugs*.

Figure 4. Relationship of potential explanatory variables used in this analysis



Results

Aerial Surveys

In the case of the USWTR and right whale aerial surveys the surveys were carried out from the observation plane flying at a height of 305 m (1000 ft). The aerial surveys from 1998/1999 were carried out with almost precisely the same protocol as the ongoing USWTR surveys except that the plane flew at 230 m (750 ft). Thus the sightings data from these two surveys could be readily combined. Estimates of perpendicular distance were obtained either by reference to direct estimates of distance by observers, trigonometry from the declination angle of the plane to the observed animals or by trigonometry from the position of the plane at first observation of the animals and subsequent location directly above the animals. A total of 2410 sightings were available from all surveys (Onslow: 159, Wallop: 211, USWTR: 335 and right whale surveys: 1677). These numbers are for animals that could be assigned to reasonably specific taxonomic categories (see below). However for some sightings (primarily turtles) distance estimates were not available. It was assumed that such sightings occurred at random so detection probabilities (and hence estimated numbers, see below) were allocated to these sightings after estimation of the detection function with a proportion assumed lost due to being beyond the truncation distance (as in the sample of known distance sightings).

Sightings were grouped together based on the a priori similarity of form of the species seen. Table 1 gives the number of sightings before and after truncation, for taxa where there were sufficient numbers to allow further investigation. There were three morphologically similar groups dolphins (all species commonly referred to as dolphins), turtles (all turtles species) and whales (baleanopterids, pilot whales and beaked whales). Future work may allow splitting of these groups.

Table 1. Aerial sightings by species group

Sightings group	**Species within group (where identified)**	**Number of sightings before truncation**	**Truncation distance**	**Number of sightings after truncation**
Dolphins	Bottlenose, common, Risso's, spotted, rough toothed and unidentified dolphins	152	1500 m	141
Whales	Beaked whales, pilot whales, other whales	37	1500 m	32
Turtles	*Loggerhead, Leatherback, Kemp's Ridley* and unidentified turtles	239	100 m	164

Shipboard Surveys

In the case of the shipboard sightings there was a distinct paucity of sightings (n=55). Again the sightings were grouped by visual type to determine a detection function (table 2).

Table 2. Shipboard sightings by species group.

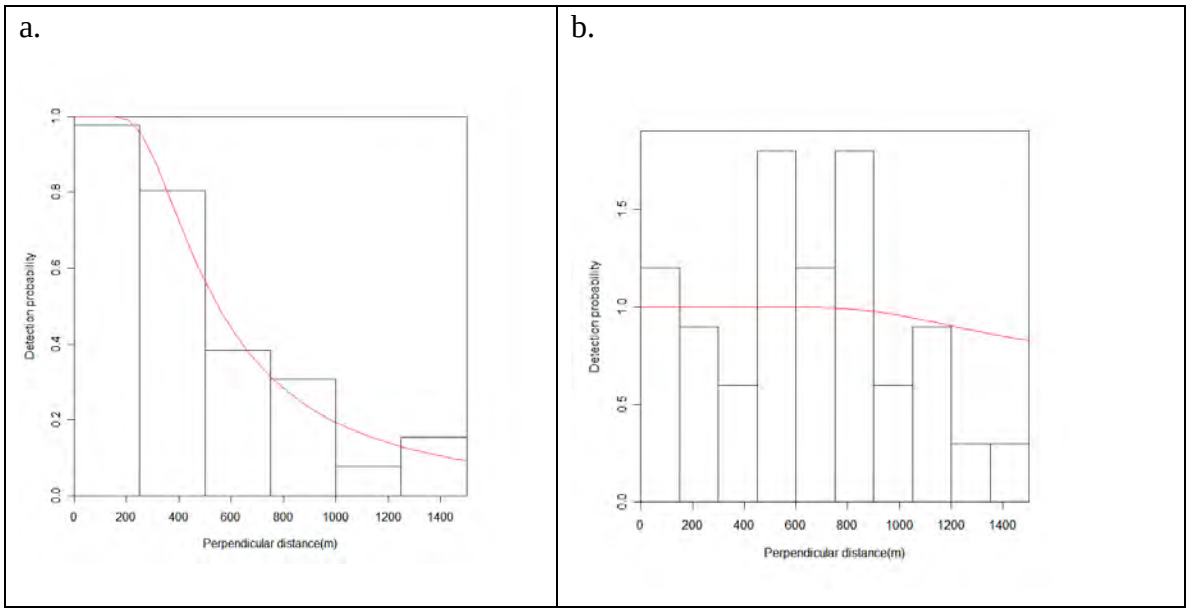
Sightings group	**Species within group (where identified)**	**Number of sightings before truncation**	**Truncation distance**	**Number of sightings after truncation**
Dolphins	Bottlenose, common, Risso's, spotted, rough toothed and unidentified dolphins	30	300 m	20
Medium whales	Beaked whales and pilot whales	1	1.0 km (taken from Paxton *et al.* (unpublished)	1
Turtles	*Loggerhead, Leatherback, Kemp's Ridley* and unidentified turtles	17	80 m	14

Aerial survey detection functions

In the case of dolphins and turtles, sightings data were fitted in *Distance* initially and then integrated into the whole analysis. Dolphin sightings were binned into 100 m widths and right truncated at 1.5 km. The best fit detection function for dolphins and medium whales were hazard rate functions (see Figure 5). No further covariates were chosen for selection into final model for dolphins although Beaufort sea state was included for large and medium whales.

The perpendicular distance distribution of turtle detections did not conform to the usual assumption of monotonically declining detection probability with increasing distance and a flat detection function of 1 out to 100m (corresponding to a strip transect survey with a strip of 200m width) was used in this case. The reasons for the unusual distribution are not known but it may have been caused in part by rounding of distances.

Figure 5. Aerial survey detection functions for a. dolphins, b. all medium and large whaleslooks a bit strange but binning does not help I assume this is due to few sightings



Ship survey detection functions

Dolphin sightings were binned into 100 m widths and right truncated at 300 m. The best fit for dolphins was a half-normal detection function (see Figure 6). Again no further covariates were chosen for selection into final model. Turtles were assumed to be a strip transect out to 80 m.

Figure 6. Ship survey detection functions for dolphins

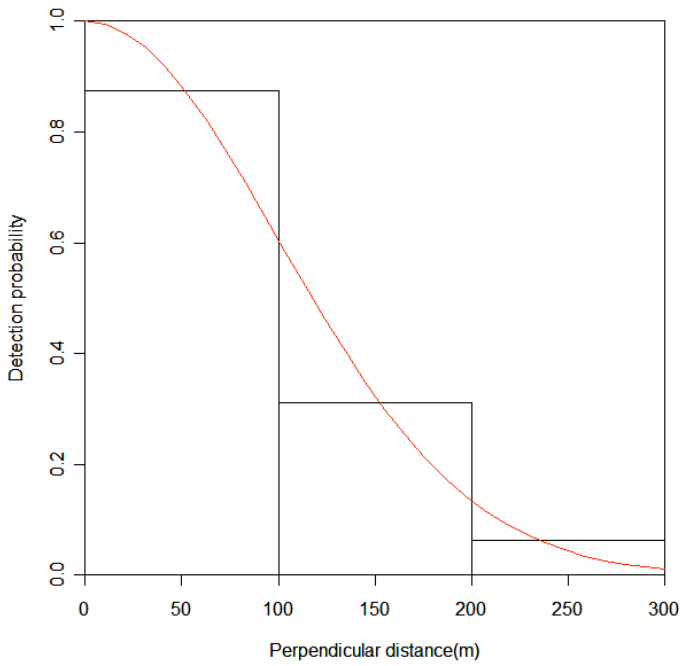


Table 3. Predictive and explanatory biological models for each species. s() indicates a smoothed function of the variable of interest. The final column gives the number of the relevant figure.

Species	**Model**	**Terms in model**	**Figure number**
Tursiops truncatus	Predictive, logistic component.	*Survey type + s(Lon, Lat)* + s(Depth) + s(Dayofyear) + s(Temp)*	7
	Explanatory logistic component.	*Survey type + s(Depth) + s(Dayofyear) + s(Temp)*	8
Stenella frontalis	Predictive, logistic component.	*Year + s(Depth)*	9
	Explanatory logistic component	*Year + s(Depth)*	10
Collective medium sized whales	Predictive, logistic component.	None	
	Explanatory logistic component	None	
Caretta caretta	Predictive, logistic component.	*s(Depth) + s(Temp)*	11
	Explanatory logistic component	*s(Depth) + s(Temp)*	12

*Smooth of nautical miles from the Greenwich meridian (east west) and nautical miles from the equator (north) rather than longitude an latitude.

Estimation of density surfaces

Bottlenose dolphins *Tursiops truncatus*

There were 3628 segments totalling 29534 km of effort across both surveys. In the case of bottlenose dolphins only 47 segments had a density greater than zero. The final fitted models for predicting abundance and for biological explanation are given in table 3. Figure 7 shows comparative surfaces for June 1998, June 1999, June 2007 and June 2008. Table 4 gives comparative abundances for years and table 5 gives abundances for July 2007 through June 2008. There is no evidence for any significant differences between years at this stage, for this species. There is however evidence of a difference over the course of the year with numbers peaking in winter (Table 5) presumably as a response to temperature changes. There was no evidence that there was residual spatial correlation in the data.

The explanatory model also revealed an effect of *Dayofyear* (Figure 8) as well as *Depth* in addition to the strong response to *Temp.* There was some evidence that survey platform influenced the abundance estimates implying differing probabilities of detection the trackline for the different platforms.

Figure 7. Estimated densities for *Tursiops truncatus* from the multiyear model (see above) clockwise from top left: June (1998), June (1999), June (2008) and June (2007). June (1998) is an extrapolation for comparison with other years (as June was not sampled that year) and should be viewed with caution. Points indicate centres of effort segments. Circle areas are proportional density estimates per segment visited. Colours indicate densities from 0 (violet) to 1 (yellow) in increments of 0.2 animals/km^2. Note that trackline orientations differed between the 1998/99 and 2007/08 aerial survey efforts.

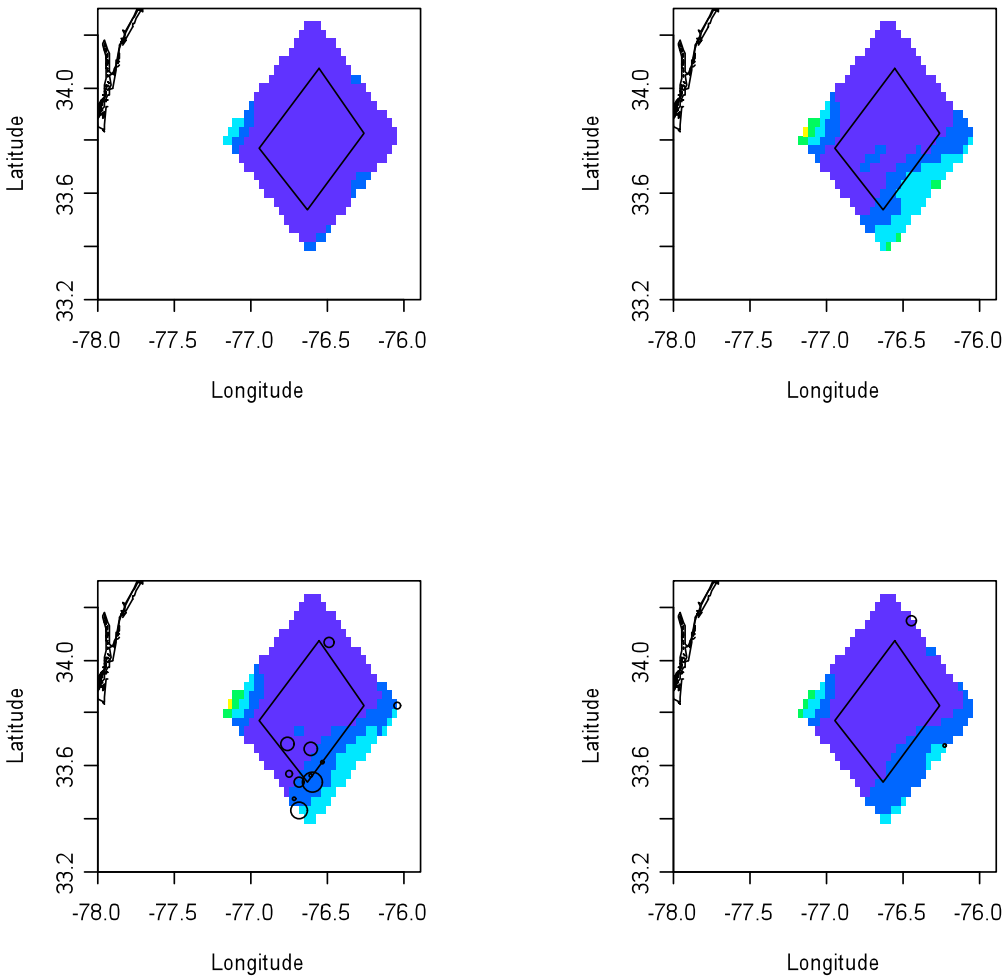


Table 4. Estimates for June for 1998 1999, 2007, 2008 for the USWTR region. Assuming g(0) = 1 for all survey crafts. June (1998) is an extrapolation for comparison with other years (as June was not sampled that year) and should be viewed with caution. Confidence intervals are shown in brackets.

Species	***Year***	***Inner USWTR core***	***Outer region***
Tursiops truncatus	*1998*	*70 (10 – 240)*	*360 (300 – 940)*
	1999	*230 (230 – 960)*	*800 (740 – 2200)*
	2007	*210 (10 – 210)*	*750 (80 – 2300)*
	2008	*160 (140 – 430)*	*620 (550 – 1520)*
Stenella frontalis	*1998*	*0 (0 – 10)*	*0 (0 – 410)*
	1999	*0 (0 – 527)*	*0 (0- 1214)*
	2007	*2 (0 – 385)*	*11 (0 – 1129)*
	2008	*10 (9 – 607)*	*55 (14 – 1434)*
Beaked and pilot whales	*All years**	*2 (0 – 4)*	*5 (0 – 8)*
Loggerhead turtles	*1998*	*20 (10 – 40)*	*40 (20 – 70)*
	1999	*30 (20 – 40)*	*50 (30 – 70)*
	2007	*30 (20 – 40)*	*60 (30 – 70)*
	2008	*20 (10 – 40)*	*40 (20 – 70)*

*Model contained no annually varying component

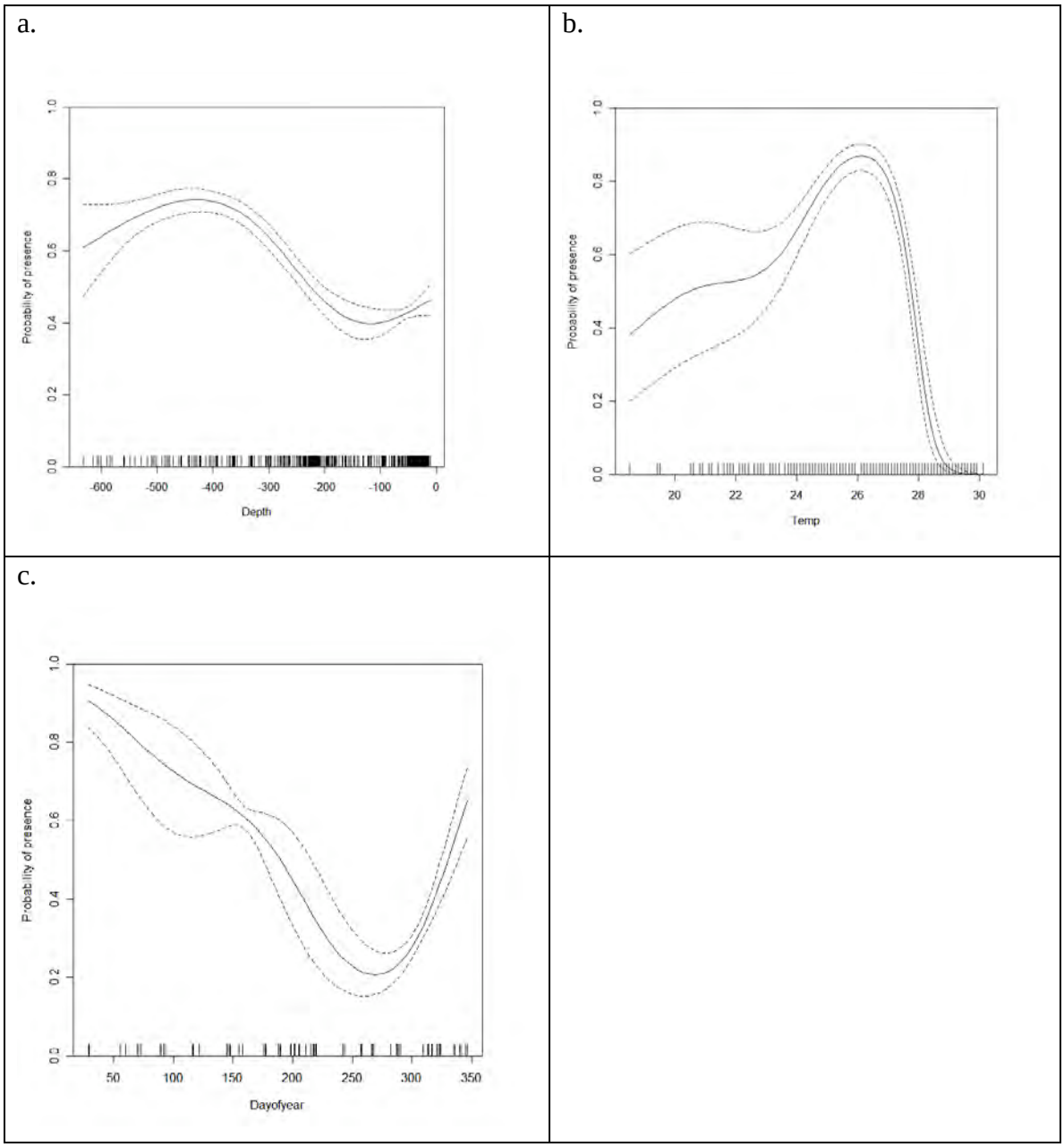
Table 5. Estimated monthly abundance July 2007 to June 2008.

Species	***Month***	***Inner USWTR core***	***Outer region***
Tursiops truncatus	*July 2007*	*60 (0 – 400)*	*230 (10 – 1110)*
	August 2007	*0 (0 – 0)*	*0 (0 – 16)*
	September 2007	*0 (0 – 10)*	*10 (0 – 60)*
	October 2007	*40 (0 – 130)*	*170 (130 – 460)*
	November 2007	*30 (0 – 170)*	*120 (0 – 500)*
	December 2007	*70 (0 – 340)*	*280 (250 – 1080)*
	January 2008	*320 (0 – 2160)*	*1140 (930 – 4800)*
	February 2008	*140 (120 – 640)*	*550 (460 – 1750)*
	March 2008	*80 (70 – 300)*	*320 (290 – 1050)*
	April 2008	*50 (6 – 190)*	*220 (190 – 700)*
	May 2008	*50 (0 – 200)*	*200 (180 – 634)*
	June 2008	*160 (140 – 430)*	*620 (550 – 1520)*
Stenella frontalis	*All months 2007**	*2 (0 – 385)*	*11 (0 – 1129)*
	*All months 2008**	*10 (0 – 607)*	*55 (14 – 1434)*
Beaked and pilot whales	*All months***	*2 (0 – 4)*	*5 (0 – 8)*
Loggerhead turtles	*July 2007*	*20 (10 – 40)*	*30 (20 – 70)*
	August 2007	*10 (0 – 20)*	*20 (10 – 40)*
	September 2007	*10 (10 – 30)*	*20 (10 – 60)*
	October 2007	*20 (10 – 40)*	*40 (30 – 70)*
	November 2007	*50 (20 – 70)*	*110 (60 – 140)*
	December 2007	*70 (60 – 80)*	*150 (100 – 220)*
	January 2008	*80 (60 – 120)*	*200 (140 – 300)*
	February 2008	*100 (70 – 170)*	*240 (160 – 360)*
	March 2008	*140 (100 – 270)*	*330 (210 – 500)*
	April 2008	*120 (81 – 215)*	*270 (180 – 430)*
	May 2008	*70 (40 – 90)*	*140 (100 – 210)*
	June 2008	*20 (10 – 40)*	*40 (20 – 70)*

*Model contained no temporal component within years

**Model contained no temporal component

Figure 8. Probability of presence of Tursiops in response to a. Depth, b. Temp and c. Dayofyear.



Spotted dolphin Stenella frontalis

In the case of *S. frontalis* there were 11 non-zero segments. A model was fitted consisting of smooths of *Depth* with *Year* as a factor. Unsurprisingly the estimates were associated with a wide confidence interval. Figure 8 gives the predicted surfaces for June of each year of interest. Tables 4 and 5 give the June annual estimates and the monthly estimates from 2007 to 2008 although because there was no temporally varying within year

variable the latter only change year on year. *Stenella* was not seen in the area during the UNCW 1997 – 1998 surveys and only appeared in 2007. There was no evidence of spatial correlation in the data except over very small distances (<0.5 km) presumably caused by successive densities of zero across years.

Because of the paucity of presence, only segments only a maximum of two variables were considered for both the abundance and explanatory models. The model was identical in each case with *Year* and *Depth. Stenella frontalis* was associated with shallower water (Figure 10)

Ziphids and pilot whales

In the case of the ziphids and pilot whales only 4 segments has non-zero estimates thus no attempt was made to model density. As the estimates were not based on temporal variables the values did not vary (see Tables 3 and 4). Little interpretation can be made of these results at this stage.

Figure 9. Estimated densities for Stenella frontalis clockwise from top left: June (1998), June (1999), June (2008) and June (2007). June (1998) is an extrapolation for comparison with other years (as June was not sampled that year) and should be viewed with caution. Grey points indicate centres of effort segments. Black circle areas are proportional to density estimates per segment visited. Colours indicate densities from 0 (violet) to 0.1 (yellow) in increments of 0.02 animals/km^2. Note that trackline orientations differed between the 1998/99 and 2007/08 aerial survey efforts.

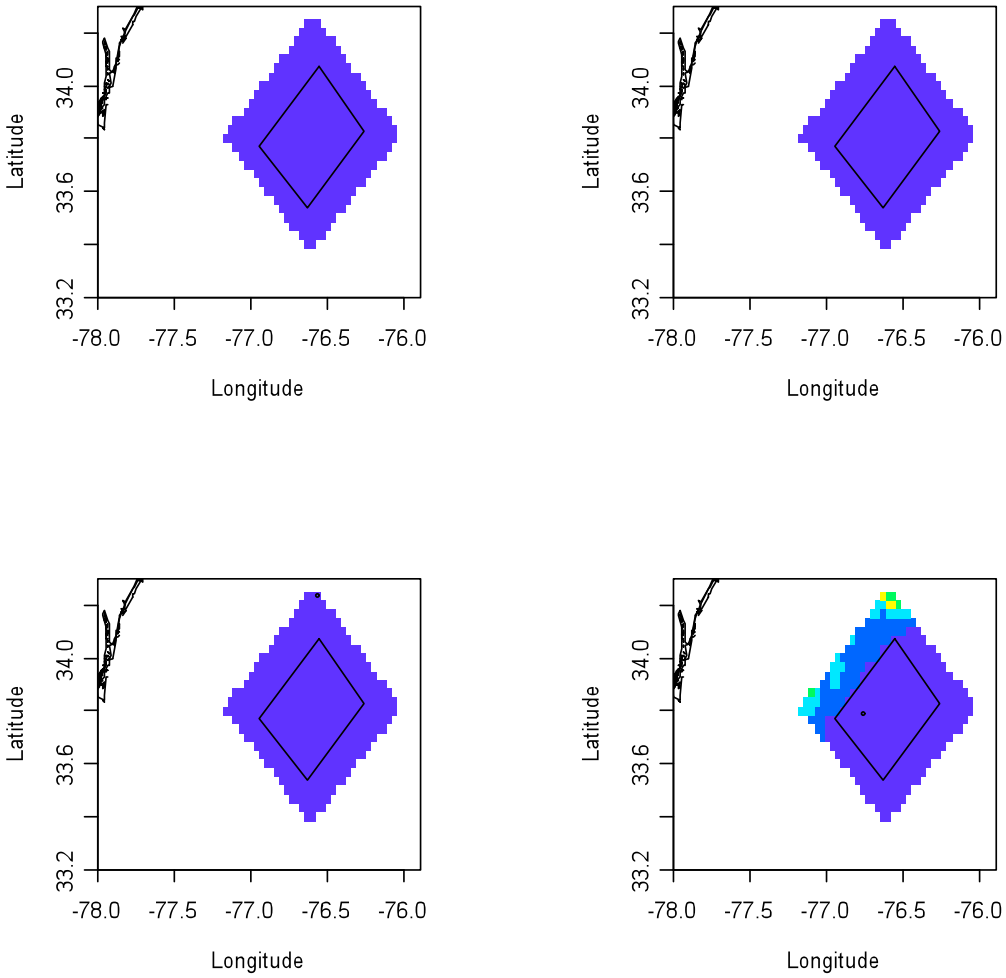
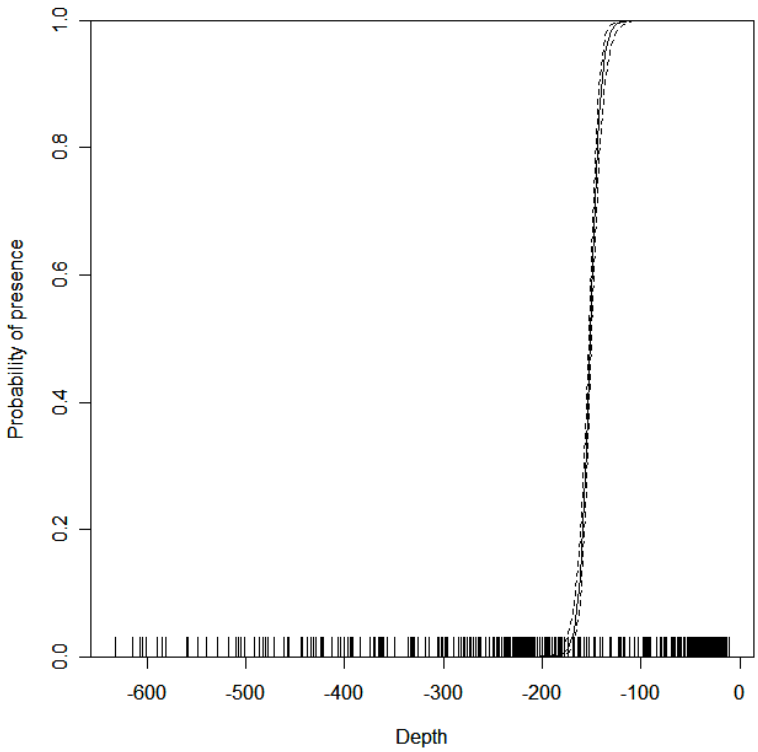


Figure 10. Probability of presence of *Stenella frontalis* in response to depth.



Caretta caretta

In the case of loggerhead turtles there were 47 non-zero segments. Presence was modelled with smooths of *Temp* and *Depth.* Turtles were more likely to be present in shallower and surprisingly colder waters (figure 12). There was no evidence of spatial correlation in the data except over very small distances (<0.5 km) presumably caused by successive densities of zero across years.

Figure 11. Estimated densities for Caretta caretta clockwise from top left: June (1998), June (1999), June (2008) and June (2007). June (1998) is an extrapolation for comparison with other years (as June was not sampled that year) and should be viewed with caution. Grey points indicate centres of effort segments. Black circle areas are proportional to density estimates per segment. Colours indicate densities from 0 (violet) to 0.03 (cyan) in increments of 0.01 animals/km^2. Note that trackline orientations differed between the 1998/99 and 2007/08 aerial survey efforts.

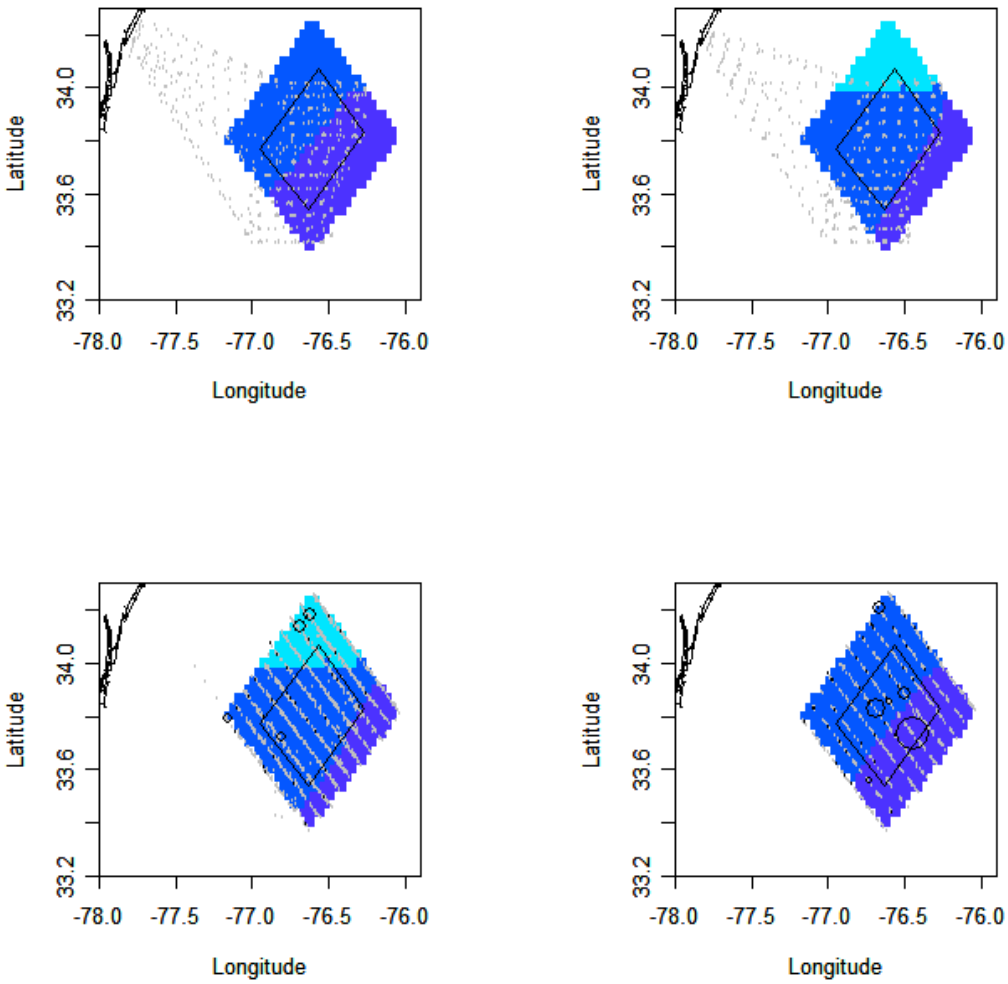
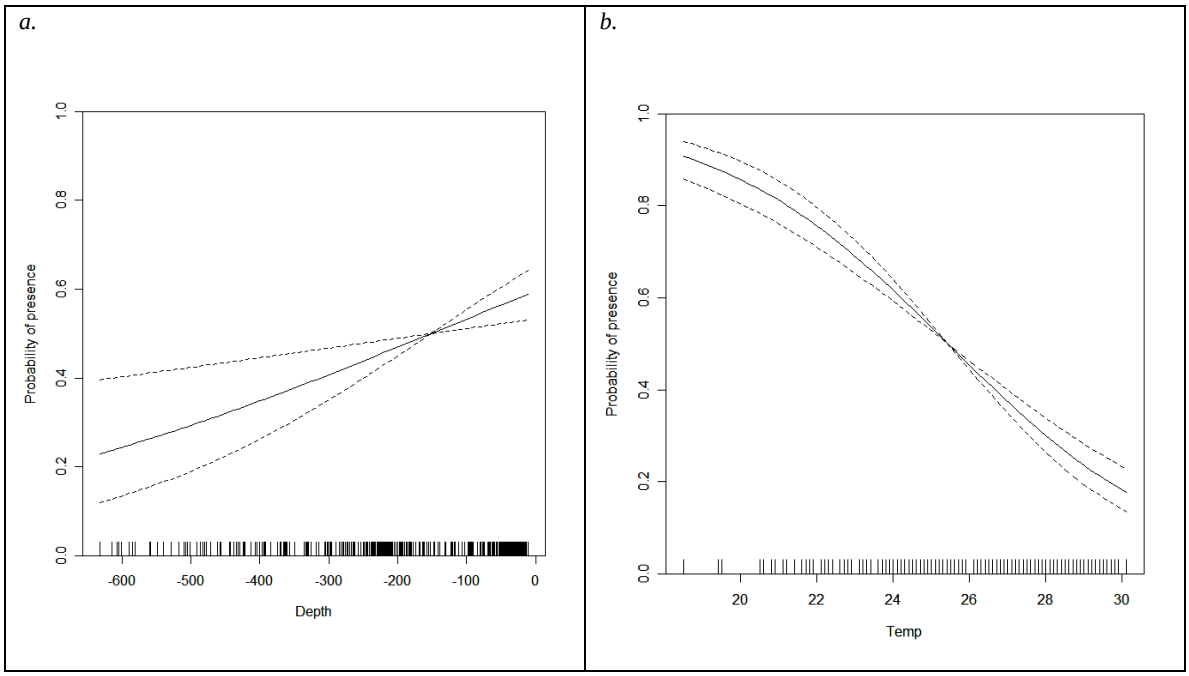


Figure 12. Probability of presence (on the linear predictor scale) of *Caretta caretta* in response to a. depth and b. sea surface temperature.



Discussion

Given the lack of sightings any conclusions about the reasons for the estimated distributions in the region should be regarded as extremely tentative. The lack of sightings for species other than those analysed above precluded estimates for other species. Nonetheless it seems reasonable to conclude that the region as a whole has few large marine fauna (save perhaps turtles, see below), data are inadequate to estimate trend and there is no evidence that any species has reduced in numbers over the time period considered. However the above results are all based on single observers with g(0) (detection probability) assumed to be one on the trackline for the species of interest. This unlikely be true especially for smaller cetaceans, therefore these estimates are likely underestimates of the total numbers in the region.

There are two reasons that g(0) may be less than 1. Firstly there is an availability bias associated with the presence of species at the surface. Cetaceans and turtles can spend only a small proportion of their time at the surface (see below). This bias was ameliorated here by only predicting using the factor associated with ships in models that

had factors for ship or aircraft (this effectively makes the g(0) estimate for aircraft no more negatively biased than that for ships). The second reason is perception bias: animals are missed on the trackline even if they are at the surface. Both availability bias and perception bias tend to be greater for fast-moving observers and are therefore greater for aircraft than for ships (see comparisons of *g*(0) in Palka 2005a and 2005b)

It might be expected that *Survey* should always appear in the models as *g*(0) should generally be higher for a ship than a plane. This was not always the case here - due in part to the low power to detect this effect because of the low number of sightings. *Survey* was a significant variable only in the case of bottlenose dolphins.

Correcting for availability bias due to diving can be done if the expected times of availability and unavailability are known as well as the transit speed of the observation vessel (e.g. Laake et al. 1979, Hedley and Bannister 2004, Paxton et al. submitted). These correction methods break down somewhat as the speed of the survey platform gets closer to that of the animals. They may therefore not work well for shipboard surveys but are likely to be quite adequate for aerial surveys. They do, however, depend on having reliable estimates of mean times of availability and unavailability. Because mean times were not available for all species, because they may differ within the species groups used in our analysis (groups determined in part by small sample size), and because mean times may be location-dependent, we have not used them here. Instead we correct g(0) bias for aircraft to be no greater than that from ships and accept that density and abundance estimates are likely negatively biased by some unknown amount.

Where it has been investigated *Mesoplodon densirostris* has been found to spend c. 26% of the time underwater (Baird *et al.* 2004) and Barlow (1999) estimated g(0)s of 0.45 and 0.23 for *Mesoplodon* and *Ziphius* respectively.

Forney et al. (1995) estimated *g*(0) to be 0.67 for smaller dolphin groups and Palka (2005a and b) estimated *g*(0) for small cetaceans to be in the range 0.58 – 0.95 depending on the craft used.

Where investigated loggerhead turtles have been found to spend c. 90% of their time diving (Houghton et al. 2002). This means that g(0) for this species could be very low indeed and the abundance estimates given here could be severely biased. Further no

attempt was made (at this stage) to include sightings of animals recorded only as unspecified turtles.

It is too early at this stage to consider if there is any evidence for unexpectedly low proportion of animals in the USWTR box in the relation to the outer area although such an analysis may be possible in the future.

The limited tentative biological conclusions that can be drawn reflect existing knowledge in the literature. The bottlenose dolphins avoid warm water, spotted dolphins are found in shallower water. As far as we are aware the association of loggerhead turtles with cooler waters is a novel finding but this may reflect a migratory route rather than a temperature preference per se.

Recommendations for the future

The USWTR survey work is ongoing, issues of potential interest in USWTR survey work in the future might include:

1. Improving detection function and density estimates by supplementing existing detections with those from future surveys.
2. Investigation of reliable methods for estimating g(0) without double-observer survey. Options include cue-based methods and use of appropriate availability correction methods based on data on availability patterns for each species.
3. Further elucidation of the environmental drivers of cetacean density in the area of interest perhaps by the use of additional variables.
4. Once military exercises begin, investigation of their effect on animal distributions within and outside the USWTR box.

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Future Considerations for Protected Species Monitoring at Potential USWTR Sites

1. Estimation of g(0)

As noted above, our preliminary estimates of the density of marine mammals in Onslow Bay are likely to be negatively biased because the results assume that g(0) (detection probability) is one on the trackline. This assumption is unlikely be true, especially for smaller cetaceans and deep-diving species. In the next year, we will investigate methods for estimating g(0) directly. The available options include double observer approaches, cue-based methods and use of appropriate correction methods based on data on availability patterns for each species.

2. Diving Behavior of Marine Mammals

In addition to understanding the surface distribution of marine mammals at proposed USWTR sites, it would be valuable to document the diving behavior of these animals within the range area. Detailed insight into diving behavior can be gained from the application of digital acoustic tags (DTAGs) that are applied to individual marine mammals for up to 24 hours. This approach would provide data that could be used to derive correction factors for availability (see above). Such baseline information could also be used in future modeling exercises examining the potential effects of exposure to anthropogenic sound.

3. Availability of Sea Turtles to Aerial and Shipboard Observers

It would also be desirable to obtain information on the diving behavior of sea turtles within potential USWTR sites. Such information can be readily obtained through the use of long-term satellite-linked dive recorders (SLDRs) that can be affixed to the carapace of hard-shelled turtles, such as loggerheads. Such tags can transmit positional and dive data for many months. A large number of loggerhead turtles nest along the beaches of North Carolina and eastern Florida, providing a readily accessible source of animals for such studies.

4. Autonomous Survey Vehicles

Visual surveys for protected species are necessary to estimate the density and distribution of marine mammals, but they are labor-intensive and costly. These drawbacks have led researchers to develop alternative monitoring methods, including autonomous vehicles that can detect the presence of marine mammals using visual or acoustic techniques. We would like to explore the use of unmanned underwater vehicles (UUVs) and unmanned aerial vehicles (UAVs) to supplement our ongoing monitoring programs. Several commercially available UUVs could be modified to detect marine mammals acoustically, including powered vehicles (*e.g.* the REMUS AUV), those that move passively through the use of ocean currents, or use buoyancy regulation and lift (*e.g.* drifters and ocean gliders). Such vehicles have been used successfully in experimental applications for marine mammal detection, identification and tracking.

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