NOAA Technical Memorandum NMFS-SEFSC- 551

PROTECTED SPECIES AERIAL SURVEY DATA COLLECTION AND ANALYSIS IN WATERS UNDERLYING THE R-5306A AIRSPACE

FINAL REPORT SUBMITTED TO U.S. MARINE CORPS, MCAS CHERRY POINT

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NOTICE

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Protected Species Aerial Survey Data Collection and Analysis in Waters Underlying the R-5306A Airspace

Final Report Submitted to U.S. Marine Corps, MCAS Cherry Point

Executive Summary

To be in compliance with the Endangered Species Act and the Marine Mammal Protection Act, the United States Department of the Navy is required to assess the potential environmental impacts of conducting at-sea training operations on sea turtles and marine mammals. Limited recent and area-specific density data of sea turtles and dolphins exist for many of the Navy's operations areas (OPAREAs), including the Marine Corps Air Station (MCAS) Cherry Point OPAREA, which encompasses portions of Core and Pamlico Sounds, North Carolina.

Aerial surveys were conducted to document the seasonal distribution and estimated density of sea turtles and dolphins within Core Sound and portions of Pamlico Sound, and coastal waters extending one mile offshore. Sea Surface Temperature (SST) data for each survey were extracted from 1.4 km/pixel resolution Advanced Very High Resolution Radiometer remote images. A total of 92 turtles and 1,625 dolphins were sighted during 41 aerial surveys, conducted from July 2004 to April 2006.

In the spring (March – May; 7.9°C to 21.7°C mean SST), the majority of turtles sighted were along the coast, mainly from the northern Core Banks northward to Cape Hatteras. By the summer (June – Aug.; 25.2°C to 30.8°C mean SST), turtles were fairly evenly dispersed along the entire survey range of the coast and Pamlico Sound, with only a few sightings in Core Sound. In the autumn (Sept. – Nov.; 9.6°C to 29.6°C mean SST), the majority of turtles sighted were along the coast and in eastern Pamlico Sound; however, fewer turtles were observed along the coast than in the summer. No turtles were seen during the winter surveys (Dec. – Feb.; 7.6°C to 11.2°C mean SST). The estimated mean surface density of turtles was highest along the coast in the summer of 2005 (0.615 turtles/km^2, SE = 0.220). In Core and Pamlico Sounds the highest mean surface density occurred during the autumn of 2005 (0.016 turtles/km^2, SE = 0.009). The mean seasonal abundance estimates were always highest in the coastal region, except in the winter when turtles were not sighted in either region. For Pamlico Sound, surface densities were always greater in the eastern than western section. The range of mean temperatures at which turtles were sighted was 9.68°C to 30.82°C. The majority of turtles sighted were within water ≥ 11°C.

Dolphins were observed within estuarine waters and along the coast year-round; however, there were some general seasonal movements. In particular, during the summer sightings decreased along the coast and dolphins were distributed throughout Core and Pamlico Sounds, while in the winter the majority of dolphins were located along the coast and in southeastern Pamlico Sound. Although relative numbers changed seasonally between these

areas, the estimated mean surface density of dolphins was highest along the coast in the spring of 2006 (9.564 dolphins/km², SE = 5.571). In Core and Pamlico Sounds the highest mean surface density occurred during the autumn of 2004 (0.192 dolphins/km², SE = 0.066). The estimated mean surface density of dolphins was lowest along the coast in the summer of 2004 (0.461 dolphins/km², SE = 0.294). The estimated mean surface density of dolphins was lowest in Core and Pamlico Sounds in the summer of 2005 (0.024 dolphins/km², SE = 0.011). In Pamlico Sound, estimated surface densities were greater in the eastern section except in the autumn. Dolphins were sighted throughout the entire range of mean SST (7.60°C to 30.82°C), with a tendency towards fewer dolphins sighted as water temperatures increased.

Based on the findings of this study, sea turtles are most likely to be encountered within the OPAREAs when SST is ≥ 11°C. Since sea turtle distributions are generally limited by water temperature, knowing the SST of a given area is a useful predictor of sea turtle presence. Since dolphins were observed within estuarine waters year-round and throughout the entire range of mean SST's, they likely could be encountered in the OPAREAs any time of the year. Although our findings indicated the greatest number of dolphins to be present in the winter and the least in the summer, their movements also may be related to other factors such as the availability of prey.

Introduction

To be in compliance with the Endangered Species Act and the Marine Mammal Protection Act, the United States Department of the Navy is required to assess the potential environmental impacts of conducting at-sea training operations to sea turtles and marine mammals. Marine Corps Air Station (MCAS) Cherry Point's restricted airspace, R-5306A, encompasses portions of Core and Pamlico Sounds, and is used on a regular basis by the U.S. Marine Corps for training activities that involve the deployment of ordnance from aircraft at two operations areas (OPAREAs): the Piney Island Bombing Range (BT-11), and the Brant Island Shoal Bombing Target (BT-9) (Figure 1). Both sea turtles (Epperly *et al.*, 1995a,b) and marine mammals (Read *et al.*, 2003a,b; NMFS at NOAA Beaufort Lab, unpublished data) inhabit the estuarine waters of North Carolina and are likely to occur in the vicinity of these OPAREAs.

Since 1988, National Marine Fisheries Service (NMFS) research has demonstrated the importance of North Carolina's inshore waters as developmental habitat for neritic, juvenile loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles (Epperly *et al.*, 1995a,b; NMFS at NOAA Beaufort Lab, unpublished data). Aerial surveys (Epperly *et al.*, 1995b) and public sighting records (NMFS at NOAA Beaufort Lab, unpublished data) have documented the occurrence of sea turtles in R-5306A; some sightings were within the vicinity of bombing targets BT-9 and BT-11. Telemetry and biopsy surveys in Pamlico and Core Sounds (NMFS at NOAA Beaufort Lab, unpublished data), along with boat-based surveys of the Neuse River estuary (Gannon, 2003) and Pamlico Sound including BT-9 and BT-11 ranges (Read *et al.*, 2003b), have demonstrated these areas are frequently used by bottlenose dolphins (*Tursiops truncatus*) as well.

The use of Core and Pamlico Sounds by sea turtles and dolphins changes seasonally. As water temperatures warm in the spring, sea turtles enter the sounds and distribute themselves throughout these estuarine waters during the summer. Cooling water temperatures in the fall result in the migration of turtles from the sounds to warmer coastal waters (Epperly *et al.*, 1995a, b). Turtles are rarely encountered in water temperatures < 11ºC (Epperly *et al.*, 1995c; Coles and Musick, 2000; NMFS at NOAA Beaufort Lab, unpublished data). While bottlenose dolphins are known to reside in the estuarine waters of North Carolina year-round (Read *et al.*, 2003b), little is known of their seasonal distribution. Although data are limited, it appears bottlenose dolphins are found primarily in the northern areas of Pamlico Sound in summer. In the winter, bottlenose dolphins are commonly found in the southern Pamlico Sound, particularly in the southern part of the Neuse River, including coastal areas of Cherry Point MCAS. However, it is hypothesized that during the coldest months, when water temperatures do not support populations of prey, dolphins move from the estuary to nearshore coastal areas that border Pamlico Sound, particularly south of Cape Hatteras (NMFS at NOAA Beaufort Lab, unpublished data). Verification of the seasonal use of Pamlico Sound by these protected species may provide a window when impacts of training activities would be minimal or negligible. If water temperature is a primary factor influencing the movements of turtles and dolphins into and out of the Sounds, documentation of the sea surface temperature at which sightings occur may allow for predicting those windows when operations are more or less likely to impact these species.

The Cherry Point OPAREA lies within the developmental habitat for both sea turtles and dolphins, and training exercises at the two bombing ranges (BT-9 and BT-11) occur on a regular basis. However, previous aerial surveys such as those conducted by Epperly *et al*. (1995b) have been limited within the OPAREAs due to restricted access, so the use of R-5306A by these species is unknown. As a result of restricted access, estimates of impacts to these species from training operations would be based on insufficient data. Aerial surveys are the most feasible means to obtain this information since R-5306A is a large area that encompasses a complex intersection of water bodies and land masses.

We were contracted by MCAS Cherry Point for assistance in achieving the following three specific objectives:

1. Survey the waters of Core and Pamlico Sounds within R-5306A to document the seasonal distribution of sea turtles and marine mammals sighted;

2. Provide relative numbers of animals sighted as an index of abundance that can be compared among seasons within the scope of this survey; and

3. Provide observer training to MCAS Cherry Point personnel sufficient to allow these personnel to conduct pre-exercise range sweeps and post-exercise impact surveys for protected species.

Methods

Aerial Survey

From July 2004 to April 2006 aerial surveys were conducted in a high-wing, twin-engine aircraft over portions of Core and Pamlico Sounds that lie within R-5306A and extend approximately one mile offshore of those limits (Figure 2). We used survey methods similar to Epperly *et al*. (1995b). Surveys consisted of either 15 or 16 east-west oriented transects, with the starting transect randomly selected to reduce bias (Cochran, 1977; Eberhardt *et al*., 1979). Transects were equi-distant from the starting transect, and spaced 4.5 km apart. We surveyed approximately 3.8% of the coastal area and 6.9% of Core and Pamlico Sounds during each flight. Surveys were conducted at an altitude of 147 m and a ground speed of 166-175 km/hr, using a Garmin GPSMap 295 to maintain position along each transect during a survey. It took approximately five hours to complete all transects. We scheduled flights so that mid-survey would occur as close to noon as possible. Although we attempted weekly surveys, flights were undertaken only when winds were less than 18 km/hr and wave height was less than 0.6 m, with no or few whitecaps (Beaufort Sea State ≤ 3). If conditions deteriorated after a survey began, we aborted the survey. Two observers positioned on opposite sides of the plane reported sea turtle and dolphin sightings to a data recorder, who logged in positional data and associated time with a hand-held Garmin GPS 12XL. The data recorder also noted sea state, glare, flight speed, altitude, change in weather, fishing activity, visibility, and turbidity throughout the flight. Due to the difficulty of distinguishing species at high altitudes, we did not identify turtles to species except in the case of leatherback turtle (*Dermochelys coriacea*) sightings. All dolphins sighted were assumed to be bottlenose dolphins since they are the only dolphin species inhabiting the area surveyed. Group size and direction of movement was also recorded for dolphins. The data recorder was always positioned on the same side of the plane as the observer with the least amount of experience sighting animals and reported sightings only when actively engaged in training an observer, or when it became apparent that the observer did not see an animal. A minimum of two training sessions were required before MCAS Cherry Point personnel were considered trained.

Distribution and Density Data

All estimates of density are surface estimates, and therefore do not account for animals below the water's surface. We derived density estimates using strip-transect methods. A number of assumptions should be considered when using the strip-transect method to analyze data: 1) transect lines are located randomly; 2) sighting conditions such as sun position and glare, sea state, weather, size of animals, and sightability differences within the 0.15-0.30 km strip do not effect the observers ability to sight animals, and all animals are sighted; 3) animals are only counted once during each survey; and 4) sightings are independent events (Burnham and Anderson, 1984). We conservatively chose a strip width of 0.15 km based on previous aerial surveys of Core and Pamlico Sounds (Epperly *et al*., 1995b). Densities were derived by season: Spring (March-May), Summer (June-August), Autumn (September-November) and Winter (December-February) and by geographic area: Coastal, Pamlico and Core Sounds, Western Pamlico Sound, and Eastern Pamlico Sound (Figure 2).

We estimated the density of animals per km^2 for each season and geographic area using the following equation:

$$D = N / A$$

where:

D = Density of animals observed
N = Number of animals observed
A = Area surveyed (km^2)

Sea Surface Temperature Data

Sea surface temperature (SST) data was recorded during surveys using a Cyclops 300 independent infrared temperature sensor mounted onto the outside of the survey aircraft. We also extracted SST data after surveys from 1.4 km/pixel resolution Advanced Very High Resolution Radiometer (AVHRR) remote images collected by NOAA Polar Orbiting Environmental Satellites (NPOES) 15, 16, 17, and 18. Images were downloaded from the U.S. southeastern regional node of NOAA's Comprehensive Large Array-data Stewardship System (CLASS) website (NOAA Satellite and Information Service, 1989). Only images taken in the daytime were used. Data extracted from the images were pixel temperature values from the same day and were geo-located with turtle and dolphin sightings. We digitally reconstructed geo-coordinates (latitude and longitude) along transects from beginning and end waypoints using

Matlab Software (The Mathworks, Inc., 1994). Geo-coordinates were converted from reconstructed flight lines and those associated with turtle sightings to row and column pixel locations based on the Mercator projection of the images (1248 rows x 1160 columns) and the bounding box (Northwest corner, 36.8943 ˚N, 87.8404 ˚W, and Southeast corner, 72.7996 ˚W, 22.5862 ˚N) of the remote images. Row and column pixel locations were used to index and extract SST data and removed SST pixels identified by NOAA's Coastwatch as missing data, land, or clouds (NOAA Satellite and Information Service, 1989). Minimum, maximum, and mean values of the remaining pixels were used to describe the SST observed among satellites along each survey transect and during dolphin and turtle sightings. The null hypothesis that observing sea turtles and marine mammals was independent of the mean SST of surveys was tested by performing a χ^2 test.

Results

Due to inclement weather, the project timeframe, military training exercises, pilot availability, and a NOAA issued aviation safety stand-down, surveys were not evenly distributed seasonally among years. We surveyed 8 times in the spring, 13 times in the summer, 14 times in the autumn, and 6 times in the winter for a total of 41 surveys. A total of 92 turtles and 1,625 dolphins were sighted.

Seasonal Distribution and Sea Surface Temperature

In the spring the majority of turtles were sighted along the coast, mainly from the northern Core Banks northward to Cape Hatteras (Figure 3). A couple of turtles were sighted just within the eastern Pamlico Sound and one was within the vicinity of BT-11. By the summer turtles were fairly evenly dispersed along the entire survey range of the coast and Pamlico Sound, with only a few sightings in Core Sound and the Pamlico and Neuse Rivers. The only leatherback turtle sighted was just south of Cape Hatteras. In the autumn, the majority of turtles sighted were along the coast and in eastern Pamlico Sound; however, fewer turtles were observed along the coast than in the summer. One turtle was seen in the Neuse River. The greatest number of turtles sighted within Core Sound occurred in autumn, with four individuals being seen. No turtles were seen in the entire study area during the winter surveys.

Dolphins were distributed along the entire survey range of the coast and within eastern Pamlico Sound in the spring, with only a few animals sighted in Core Sound, the Pamlico and Neuse Rivers, and West Bay (Figure 4). By summer the number of observed dolphins along the coast had declined, but were relatively evenly distributed in Pamlico Sound and could still be found in the Pamlico and Neuse Rivers. A few groups were sighted just outside Bay River, within West Bay, and in Core Sound. By autumn dolphin sightings increased along the coast once again, and large groups of 10–50 individuals were seen in and around the Neuse and Bay Rivers. In the winter, the majority of dolphins were along the coast and just inside Pamlico Sound, with some small groups of 1-6 individuals found in the Neuse River and West Bay.

We were able to use the temperature sensor during only nine surveys due to inclement weather and equipment malfunctions. Since a valid statistical analysis would not be possible using these, we present only the results of SST data collected from images obtained from NOAA

Polar Orbiting Environmental Satellites (NPOES). SST data collected from the temperature sensor will be provided to MCAS Cherry Point separately.

The minimum SST encountered along transects for all surveys was 5.53°C and the maximum was 32.83°C (Table 5). The minimum mean temperature for all transects was 7.60°C (SE= 0.10), and the maximum mean temperature was 30.82°C (SE= 0.21). SST values were not available for all days, due to heavy cloud cover. The range of mean temperatures at which turtles were sighted was 9.68°C to 30.82°C (Figure 5). The range of mean temperatures at which dolphins were sighted was 7.60°C to 30.82°C (Figure 6). We rejected our null hypothesis ($p < 0.05$) of independence of turtle sightings and SST; turtles were found more often in warmer water. We could not do so with dolphin sightings; sightings were distributed across all temperatures, albeit with a tendency towards fewer dolphins sighted as water temperatures increased.

Seasonal Density

The estimated mean surface density of turtles was highest along the coast in the summer of 2005 (0.615 turtles/km², SE = 0.220) (Table 1). In Core and Pamlico Sounds the highest mean surface density occurred during the autumn of 2005 (0.016 turtles/km², SE = 0.009). The mean seasonal abundance estimates were always highest in the coastal region, except in the winter when turtles were not sighted in either region. For Pamlico Sound, surface densities were always greater in the eastern than western section (Table 2).

The estimated mean surface density of dolphins was highest along the coast in the spring of 2006 (9.564 dolphins/km², SE = 5.571) (Table 3). In Core and Pamlico Sounds the highest mean surface density occurred during the autumn of 2004 (0.192 dolphins/km², SE = 0.066). The estimated mean surface density of dolphins was lowest along the coast in the summer of 2004 (0.461 dolphins/km², SE = 0.294). The estimated mean surface density of dolphins was lowest in Core and Pamlico Sounds in the summer of 2005 (0.024 dolphins/km², SE = 0.011). In Pamlico Sound, estimated surface densities were greater in the eastern section except in the autumn (Table 4).

Observer Training

The following MCAS Cherry Point personnel received training to conduct pre-exercise range sweeps and post-exercise impact surveys for protected species: Robin Ferguson (8 Aug. 2004, 9 July 2005), Bill Rogers (22 May 2005), Gary Haught (11 March 2006), Bobby Luna (27 Aug. 2004, 21 Nov. 2005), Will Gainey (10 July 2004), and Lissa Grimes (24 June 2005).

Discussion

Seasonal Distribution and Sea Surface Temperature

While we observed more sea turtles in coastal than in estuarine waters, they were present in Core and Pamlico Sounds at all times of the year except for winter, similar to observations reported by Epperly *et al.* (1995b). The absence of turtle sightings during winter surveys indicates their emigration from these waters as SST fell below their tolerance level. As poikilotherms, sea turtles distributions are generally limited by water temperature (Bell and Richardson, 1978). The majority of turtles we sighted were within water ≥ 11°C. This finding is similar to what Epperly *et al*. (1995c) observed during aerial surveys in North Carolina nearshore and offshore waters from Nov. 1991 – March 1992. Likewise, Coles and Musick (2000), who conducted aerial surveys off North Carolina from May 1991-September 1992, observed turtles only in water ≥ 13.3°C. Although we sighted one turtle when the mean SST was 9.68°C, it was observed in coastal waters where fine-scale water temperatures were likely greater than the mean SST.

Dolphins were observed within estuarine waters and along the coast year-round; however, there were some general seasonal movements. Most notable were during the summer when sightings decreased along the coast, and dolphins were distributed throughout Core and Pamlico Sounds, and in the winter when the majority of the dolphins were located along the coast and the southeastern Pamlico Sound. These observations coincide with the hypothesis (Hohn, unpublished data) that dolphins migrate from the estuary to the nearshore coastal areas that border Pamlico Sound, particularly south of Cape Hatteras during the coldest months, when water temperatures do not support prey populations of fish. Dolphins were sighted throughout the entire range of mean SST (7.60°C to 30.82°C), indicating that these temperatures are within their thermal limits.

Seasonal Density

Our density estimates for turtles in Core and Pamlico Sounds appear lower than those found in Epperly *et al*. (1995b). They estimated surface density of turtles per survey to range from 0-.305 turtles/km² in the Core Sound, and from 0-0.065 turtles/km² in the southern Pamlico Sound, with the greatest densities from late spring through the summer. Our surface density estimates per survey for the Core and Pamlico Sounds were calculated together and range from 0-0.054 turtles/km². For comparison, the greatest number of turtles sighted in the Core and Pamlico Sounds occurred on 6 November 2005, with six turtles sighted in the Pamlico Sound (0.044 turtles/km²) and two sighted in Core Sound (0.171 turtles/km²). A statistical comparison between our results and those from Epperly *et al*. (1995b) is inappropriate to make because survey timeframe and the number of surveys conducted in the Core and Pamlico Sounds varied between studies. Also, they used clinometers to measure the distance of animals from the trackline, and although observers recorded their own sightings during the survey, they were not engaged in training other observers during the survey.

Boat surveys conducted by Read et al. (2003a) during July 2000 estimated the density of dolphins in Pamlico Sound (excluding BT-9 and BT-11) to be 0.24 dolphins/km². They also estimated the density of BT-9 and BT-11 to be 0.11 dolphins/km², and 1.23 dolphins/km² respectively, based on boat surveys conducted from July 2002 through June 2003 (excluding April, May, Sept. and Jan.) (Read *et al*., 2003b). Gannon (2003) estimated the density of dolphins in Turnagain Bay to be 0.65 dolphins/km², and 0.30 dolphins/km² for South River based on boat surveys conducted from 1998-1999. (Both Turnagain Bay and South River are within the Neuse River estuary). These density estimates are much greater than what we found in western Pamlico Sound, the only area with which we can make a comparison. For example, our density estimates ranged from 0.027 dolphins/km² in the winter, to 0.215 dolphins/km² in the autumn. It is likely that these differences in density estimates are not an indication of a decrease in population density of dolphins, but might reflect a difference in survey methods. Both the Read *et al*. (2003a, b) and Gannon (2003) studies were boat-based surveys. Because aerial surveys are conducted at a greater speed than boat surveys, it is more likely an animal will be missed during the survey, resulting in an underestimating of density (Marsh and Sinclair, 1989). Therefore, the boat based density estimates of Read et al. (2003a, b) and Gannon (2003) may be more accurate than the uncorrected estimates derived from our aerial surveys. However, our surveys cover a broader area and allow for relative comparisons within that larger area. In addition, their surveys in small areas were not conducted during all months of the year. For these reasons, a direct comparison with their density estimates is not possible.

Our estimates of density may have been affected by a number of different factors. Since we did not measure the distance of turtles and dolphins from the transect line, it is possible that some animals outside the 0.15 km survey strip were included in our analysis. Epperly *et al*. (1995a) found that 13% of the turtles sighted were outside the 0.15 survey strip. Using this estimate, 14 of the 92 turtles sighted may have been outside our survey strip. Also, although the spacing of transects (4.5km apart) is sufficient when surveying for sea turtles, it is not ideal when surveying for bottlenose dolphins since they can reach a maximum known speed of 20.5 km/hr (Rohr *et al.,* 2002). However, given the size of our survey area, transects spaced farther apart would likely have compromised our ability to provide accurate estimates of density. Likewise, our use of the data recorder as an observer while training observers, and the high number of observers needing to be trained may have affected our ability to sight animals. There were no corrections for these factors in the density calculations.

Finally, our density estimates represent the number of turtles and dolphins on the surface of the water and do not account for animals that are below the surface, and thus, undetectable. An adult, female bottlenose dolphin that was radio tagged and monitored by satellite-based receivers spent an average of 87.1% (SE= 0.6) of the time submerged, with a mean dive duration of 25.8 (SE=0.5) seconds (Mate *et al.*, 1995). Therefore, given our flight speed of 166-175 km/hr, it is reasonable to assume that surveys did not account for all dolphins because some would have been submerged, and, thus, undetectable.

Using data collected by means of radio and acoustic telemetry from loggerhead turtles within the Chesapeake Bay, Byles (1988) estimated that turtles spend 5.3% of their time on the surface during the summer and fall months. Therefore, for every one turtle on the surface there are 18.9 turtles estimated to be below the surface. Recent work in Virginia by Mansfield (2006) suggests that the surfacing behavior of turtles varies with season. She found that the mean time turtles spent on the surface in the spring ranged from 9.9%-30.0%. Turtles with higher surfacing times were also tracked in deeper, cooler waters of the Bay mouth or Atlantic coastline. Nelson (1996) also observed seasonal variations in surfacing behavior among juvenile loggerheads tracked in Georgia, with turtles spending a greater percentage of their time (19.0%) at the surface in the spring compared to later in the season. Because the variability in sightability (surfacing behavior) of turtles depends upon season and geographic location, we did not incorporate their correction factor into our density estimates. Determining the surfacing behavior of turtles and dolphins inhabiting North Carolina estuarine and coastal waters would provide more accurate density estimates.

Conclusion

Based on the findings of this study, sea turtles are most likely to be encountered within the OPAREAs when SST is $\geq$ 11°C. Since sea turtles distributions are generally limited by water temperature, knowing the SST of a given area is a useful predictor of sea turtle presence. Since dolphins were observed within estuarine waters year-round and throughout the entire range of mean SST's, they likely could be encountered in the OPAREAs any time of the year. Although our findings indicated the greatest number of dolphins to be present in the autumn and the least in the winter, their movements also may be related to other factors such as the availability of prey.

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Table 1. Survey effort and strip-transect estimates of seasonal density by year for turtles on the surface of the Core and Pamlico Sounds, and the coastal region of North Carolina, 2004-06.

			Sounds (2,221.38 km²)								Coastal Region (138.5 km²)							
Year	Season	Day	Animals	Transects surveyed (km²)	Density (km²)	Mean Seasonal Density Estimate	SE	Estimated turtles	Mean Seasonal Abundance Estimate	SE	Animals	Transects surveyed (km²)	Density (km²)	Mean Seasonal Density Estimate	SE	Estimated turtles	Mean Seasonal Abundance Estimate	SE
2004	Summer	10 Jul	1	167.6	0.0060	0.0103	0.0048	13	23	10.6	0	5.76	0.0000	0.0726	0.0445	0	10	6.2
		25 Jul	5	179.6	0.0278			62			0	5.76	0.0000			0		
		8 Aug	0	174.4	0.0000			0			1	5.76	0.1736			24		
		19 Aug	2	167.4	0.0119			27			1	5.28	0.1894			26		
		27 Aug	1	180.4	0.0055			12			0	5.76	0.0000			0		
	Autumn	4 Sep	0	147.5	0.0000	0.0033	0.0025	0	7	5.6	0	5.28	0.0000	0.0947	0.0716	0	13	9.9
		3 Oct	0	150.8	0.0000			0			3	5.28	0.5682			79		
		10 Oct	0	149.6	0.0000			0			0	5.28	0.0000			0		
		24 Oct	0	153.1	0.0000			0			0	5.28	0.0000			0		
		29 Oct	0	145.3	0.0000			0			1	5.28	0.1894			26		
		6 Nov	0	145.4	0.0000			0			0	5.28	0.0000			0		
		11 Nov	1	146.7	0.0068			15			0	5.28	0.0000			0		
		20 Nov	3	150.3	0.0200			44			0	5.28	0.0000			0		
2005	Winter	13 Feb	0	152.2	0.0000			0			0	5.28	0.0000			0		
	Spring	6 Mar	0	168.2	0.0000	0.0033	0.0033	0	7	7.3	0	5.76	0.0000	0.3788	0.2678	0	52	37.1
		14 May	0	158.3	0.0000			0			6	5.28	1.1364			157		
		22 May	0	152.3	0.0000			0			0	5.28	0.0000			0		
		30 May	2	152.3	0.0131			29			2	5.28	0.3788			52		
	Summer	4 Jun	0	151.8	0.0000	0.0115	0.0032	0	25	10.1	0	5.28	0.0000	0.6155	0.2199	0	85	30.5
		11 Jun	3	157.8	0.0190			42			10	5.28	1.8939			262		
		18 Jun	2	156.7	0.0128			28			4	5.28	0.7576			105		
		24 Jun	0	154.0	0.0000			0			4	5.28	0.7576			105		
		3 Jul	1	147.9	0.0068			15			1	5.28	0.1894			26		
		9 Jul	2	147.5	0.0136			30			1	5.28	0.1894			26		
		6 Aug	4	151.7	0.0264			59			5	5.28	0.9470			131		
		21 Aug	2	149.9	0.0133			30			1	5.28	0.1894			26		
	Autumn	2 Sep	4	149.7	0.0267	0.0157	0.0087	59	35	19.3	1	5.28	0.1894	0.1894	0.0489	26	26	6.8
		9 Oct	1	146.9	0.0068			15			2	5.28	0.3788			52		
		30 Oct	1	149.5	0.0067			15			0	5.28	0.0000			0		
		6 Nov	8	147.4	0.0543			121			1	5.28	0.1894			26		
		20 Nov	0	147.3	0.0000			0			1	5.28	0.1894			26		
		27 Nov	0	147.0	0.0000			0			1	5.28	0.1894			26		
	Winter	10 Dec	0	150.2	0.0000	0.0000		0	0		0	5.28	0.0000	0.0000		0	0	
		23 Dec	0	153.1	0.0000			0			0	5.28	0.0000			0		
2006		21 Jan	0	147.0	0.0000			0			0	5.28	0.0000			0		
		28 Jan	0	146.4	0.0000			0			0	5.28	0.0000			0		
		25 Feb	0	154.7	0.0000			0			0	5.28	0.0000			0		
	Spring	11 Mar	0	147.4	0.0000	0.0017	0.0017	0	4	3.8	0	5.28	0.0000	0.0947	0.0947	0	13	13.1
		31 Mar	0	146.4	0.0000			0			0	5.28	0.0000			0		
		16 Apr	1	147.3	0.0068			15			0	5.28	0.0000			0		
		23 Apr	0	148.9	0.0000			0			2	5.28	0.3788			52		

Table 2. Strip-transect estimates of density by season for turtles on the surface of the Western and Eastern Pamlico Sounds, North Carolina, 2004-2006.

Season	Western Pamlico Sound (1,108 km^2)				Eastern Pamlico Sound (893 km^2)			
	Animals	Transects surveyed (km^2)	Density (km^2)	Estimated turtles	Animals	Transects surveyed (km^2)	Density (km^2)	Estimated turtles
Spring 2005-06	1	538.9	0.0018	2	2	449.2	0.0045	4
Summer 2004-05	9	808.4	0.0111	12	12	673.8	0.0178	16
Autumn 2004-05	1	875.7	0.0011	1	14	730	0.0192	17
Winter 2005-06	0	404.2	0	0	0	336.9	0	0

Table 3. Survey effort and strip-transect estimates of seasonal density by year for dolphins on the surface of the Core and Pamlico Sounds, and the coastal region of North Carolina, 2004-06.

Year	Season	Day	Sounds (2,221.38 km²)								Coastal Region (138.5 km²)							
			Animals	Transects surveyed (km²)	Density (km²)	Mean Seasonal Density Estimate	SE	Estimated dolphins	Mean Seasonal Abundance Estimate	SE	Animals	Transects surveyed (km²)	Density (km²)	Mean Seasonal Density Estimate	SE	Estimated dolphins	Mean Seasonal Abundance Estimate	SE
2004	Summer	10 Jul	6	167.6	0.0358	0.0625	0.0151	80	139	33.6	9	5.76	1.5625	0.4609	0.2943	216	64	40.8
		25 Jul	12	179.6	0.0668			148			1	5.76	0.1736			24		
		8 Aug	12	174.4	0.0688			153			0	5.76	0.0000			0		
		19 Aug	19	167.4	0.1135			252			3	5.28	0.5682			79		
		27 Aug	5	180.4	0.0277			62			0	5.76	0.0000			0		
	Autumn	4 Sep	0	147.5	0.0000	0.1917	0.0663	0	426	147.3	1	5.28	0.1894	4.4981	1.9988	26	623	276.8
		3 Oct	22	150.8	0.1459			324			2	5.28	0.3788			52		
		10 Oct	14	149.6	0.0936			208			2	5.28	0.3788			52		
		24 Oct	63	153.1	0.4115			914			11	5.28	2.0833			289		
		29 Oct	10	145.3	0.0688			153			25	5.28	4.7348			656		
		6 Nov	29	145.4	0.1994			443			51	5.28	9.6591			1338		
		11 Nov	11	146.7	0.0750			167			13	5.28	2.4621			341		
		20 Nov	81	150.3	0.5389			1197			85	5.28	16.0985			2230		
2005	Winter	13 Feb	18	152.2	0.1183			263			105	5.28	19.8864			2754		
	Spring	6 Mar	7	168.2	0.0416	0.0317	0.0125	92	71	27.8	37	5.76	6.4236	3.6892	0.9510	890	511	131.7
		14 May	0	158.3	0.0000			0			15	5.28	2.8409			393		
		22 May	4	152.3	0.0263			58			18	5.28	3.4091			472		
		30 May	9	152.3	0.0591			131			11	5.28	2.0833			289		
	Summer	4 Jun	4	151.8	0.0263	0.0242	0.0111	59	54	24.8	2	5.28	0.3788	3.2197	1.6031	52	446	222.0
		11 Jun	15	157.8	0.0951			211			25	5.28	4.7348			656		
		18 Jun	0	156.7	0.0000			0			2	5.28	0.3788			52		
		24 Jun	6	154.0	0.0390			87			11	5.28	2.0833			289		
		3 Jul	0	147.9	0.0000			0			0	5.28	0.0000			0		
		9 Jul	2	147.5	0.0136			30			5	5.28	0.9470			131		
		6 Aug	1	151.7	0.0066			15			72	5.28	13.6364			1889		
		21 Aug	2	149.9	0.0133			30			19	5.28	3.5985			498		
	Autumn	2 Sep	3	149.7	0.0200	0.0451	0.0147	45	100	32.6	23	5.28	4.3561	3.5038	0.8194	603	485	113.5
		9 Oct	0	146.9	0.0000			0			0	5.28	0.0000			0		
		30 Oct	8	149.5	0.0535			119			23	5.28	4.3561			603		
		6 Nov	11	147.4	0.0746			166			31	5.28	5.8712			813		
		20 Nov	4	147.3	0.0272			60			20	5.28	3.7879			525		
		27 Nov	14	147.0	0.0953			212			14	5.28	2.6515			367		
	Winter	10 Dec	34	150.2	0.2264	0.0951	0.0503	503	211	111.8	43	5.28	8.1439	8.9773	3.7901	1128	1243	524.9
		23 Dec	32	153.1	0.2090			464			124	5.28	23.4848			3253		
2006		21 Jan	4	147.0	0.0272			60			8	5.28	1.5152			210		
		28 Jan	0	146.4	0.0000			0			27	5.28	5.1136			708		
		25 Feb	2	154.7	0.0129			29			35	5.28	6.6288			918		
	Spring	11 Mar	12	147.4	0.0814	0.1454	0.0512	181	323	113.6	46	5.28	8.7121	9.5644	5.5716	1207	1325	771.7
		31 Mar	24	146.4	0.1639			364			135	5.28	25.5682			3541		
		16 Apr	8	147.3	0.0543			121			14	5.28	2.6515			367		
		23 Apr	42	148.9	0.2820			626			7	5.28	1.3258			184		

Table 4. Strip-transect estimates of density by season for dolphins on the surface of the Western and Eastern Pamlico Sounds, North Carolina, 2004-2006.

Season	Western Pamlico Sound (1,108 km²)				Eastern Pamlico Sound (893 km²)			
	Animals	Transects surveyed (km²)	Density (km²)	Estimated dolphins	Animals	Transects surveyed (km²)	Density (km²)	Estimated dolphins
Spring 2005-06	51	538.94	0.0946	105	51	449.25	0.1135	101
Summer 2004-05	30	808.41	0.0371	41	31	673.89	0.0460	41
Autumn 2004-05	189	875.78	0.2158	239	37	730.05	0.0506	45
Winter 2005-06	11	404.2	0.0272	30	60	336.93	0.1780	159

Table 5. Minimum, maximum, and mean sea surface temperature (SST) along aerial survey transects, and sea turtles and dolphins sighted in the Core and Pamlico Sounds, and the coastal region of N.C., 2004-06.

Date	Minimum SST (°C)	Maximum SST (°C)	Mean SST (°C)	Standard Error of Mean SST	Turtle Sightings in Sounds	Dolphin Sightings in Sounds	Turtle Sightings in coastal region	Dolphin Sightings in coastal region
2004								
10 Jul	28.64	32.2	29.83	0.14	1	6	0	9
25 Jul	27.08	31.05	29.16	0.32	5	12	0	1
8 Aug	22.83	29.38	25.88	0.22	0	12	1	0
19 Aug	25.98	29.55	27.43	0.16	2	19	1	3
27 Aug	26.02	28.63	27.15	0.08	1	5	0	0
4 Sep	26.02	28.23	27.2	0.11	0	0	0	1
3 Oct	23.91	25.64	24.67	0.03	0	22	3	2
10 Oct	21.77	24.43	22.95	0.09	0	14	0	2
24 Oct	NA	NA	NA	NA	0	63	0	11
29 Oct	15.92	18.15	16.94	0.06	0	10	1	25
6 Nov	17.32	19.74	18.31	0.06	0	29	0	51
11 Nov	11.53	15.39	14.08	0.12	1	11	0	13
20 Nov	12.36	13.38	12.69	0.09	3	81	0	85
2005								
13 Feb	6.36	8.99	7.86	0.13	0	18	0	105
6 Mar	6.87	9.46	7.97	0.14	0	7	0	37
14 May	19.38	21.08	20.14	0.08	0	0	6	15
22 May	17.66	18.18	17.88	0.03	0	4	0	18
30 May	NA	NA	NA	NA	2	9	2	11
4 Jun	NA	NA	NA	NA	0	4	0	2
11 Jun	24.42	25.75	25.18	0.11	3	15	10	25
18 Jun	26.38	27.12	26.72	0.06	2	0	4	2
24 Jun	23.74	27.09	25.33	0.13	0	6	4	11
3 Jul	25.09	27.83	27.09	0.05	1	0	1	0
9 Jul	NA	NA	NA	NA	2	2	1	5
6 Aug	29.07	32.83	30.82	0.21	4	1	5	72
21 Aug	27.86	32.49	30.42	0.26	2	2	1	19
2 Sep	27.17	32.25	29.6	0.21	4	3	1	23
9 Oct	14.6	16.29	15.53	0.06	1	0	2	0
30 Oct	24.35	24.85	24.57	0.07	1	8	0	23
6 Nov	16.98	19.31	17.87	0.06	8	11	1	31
20 Nov	NA	NA	NA	NA	0	4	1	20
27 Nov	8.71	10.4	9.68	0.10	0	14	1	14
10 Dec	10.59	10.88	10.78	0.14	0	34	0	43
23 Dec	5.53	8.49	7.6	0.10	0	32	0	124
2006								
21 Jan	8.96	9.66	9.37	0.04	0	4	0	8
28 Jan	10.3	11.83	11.17	0.10	0	0	0	27
25 Feb	NA	NA	NA	NA	0	2	0	35
11 Mar	12.68	17.55	14.95	0.13	0	12	0	46
31 Mar	14.03	19.34	15.07	0.12	0	24	0	135
16 Apr	17.67	20.62	19.61	0.09	1	8	0	14
23 Apr	19.72	22.66	21.72	0.09	0	42	2	7

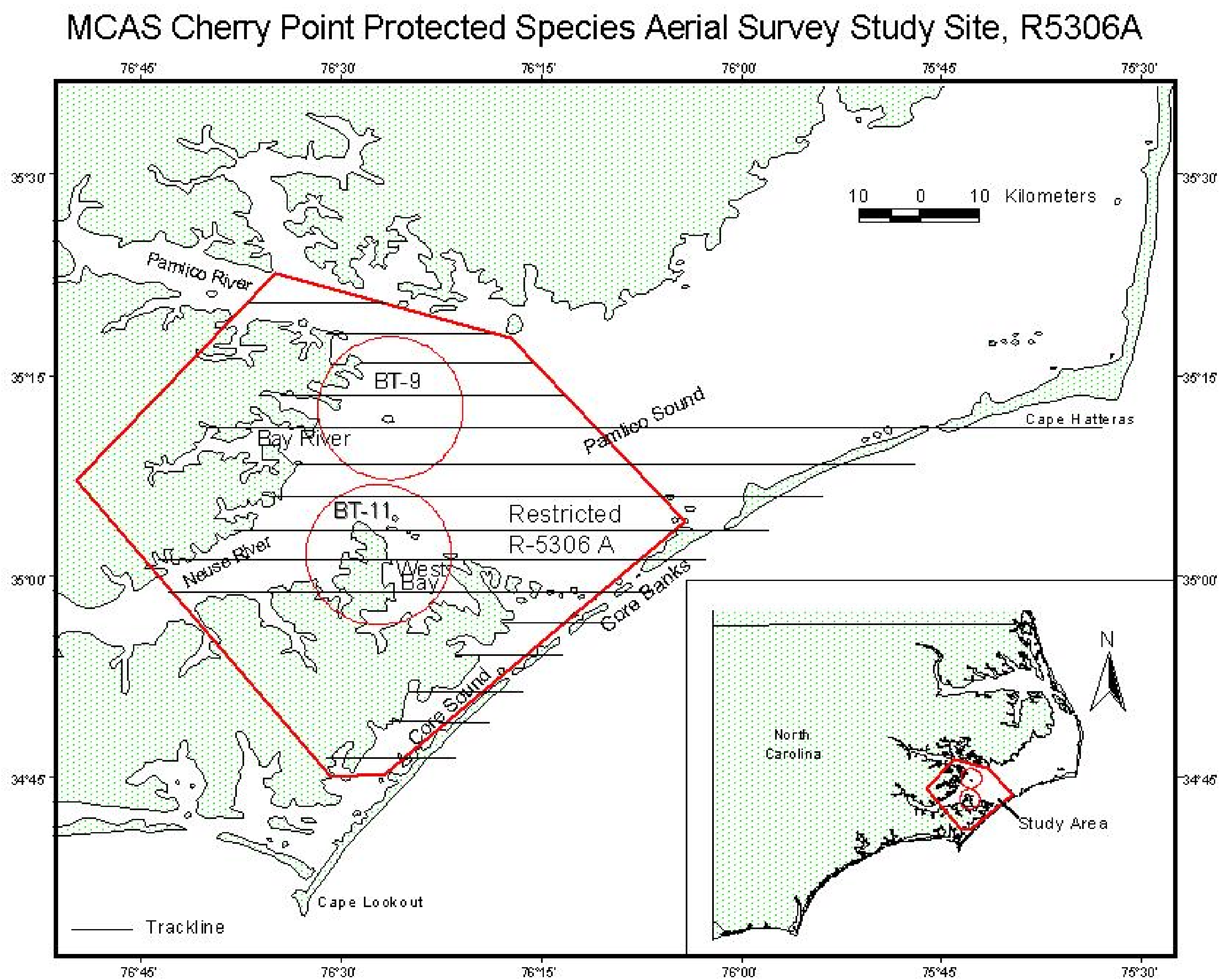

Figure 1. Restricted Airspace R5306A, Study Site for MCAS Cherry Point Protected Species Aerial Surveys 2004 – 2006.

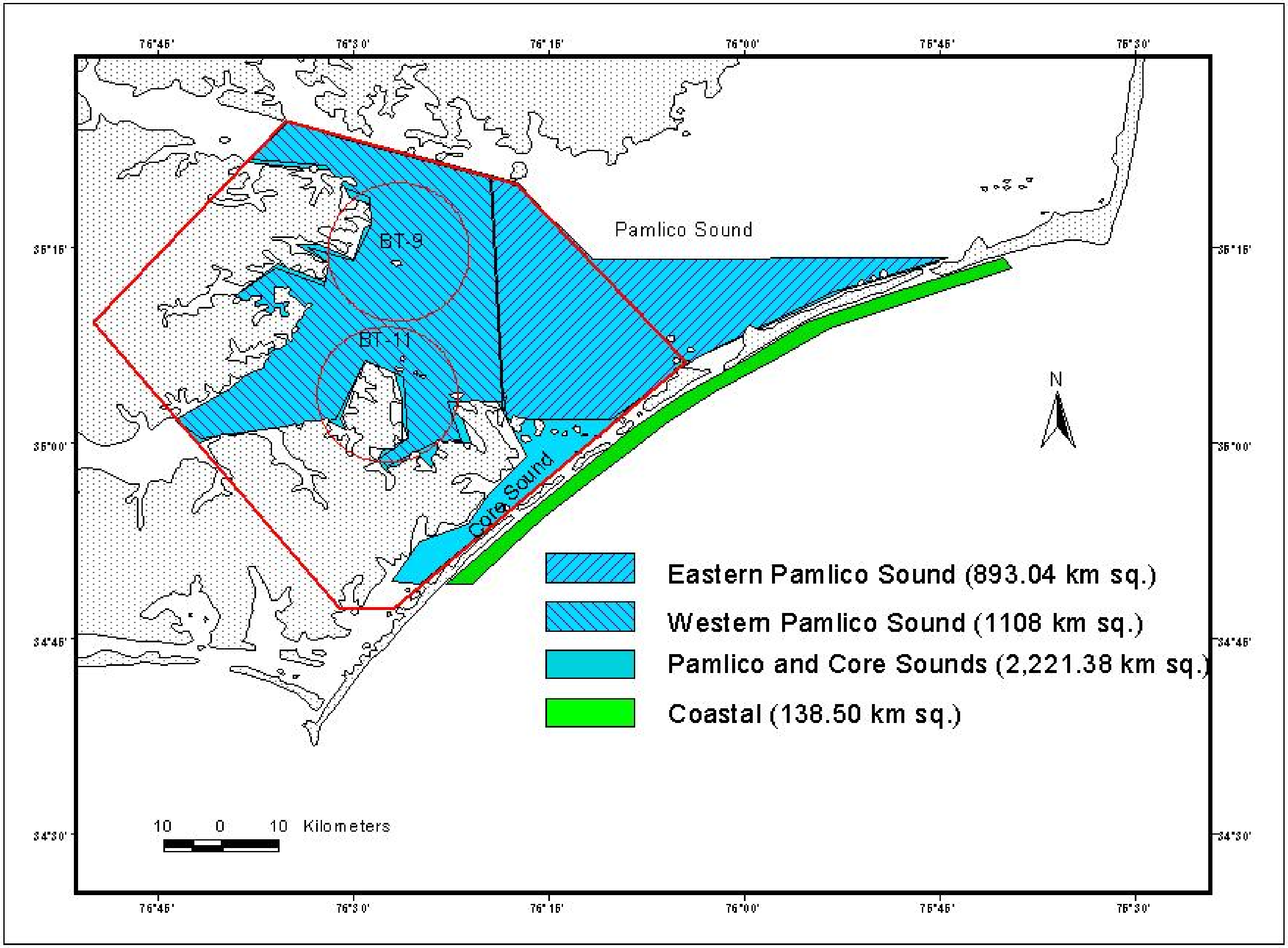

Figure 2. Subareas of Pamlico and Core Sounds, and the coast flown in MCAS Cherry Point protected species aerial surveys, North Carolina, 2004-06.

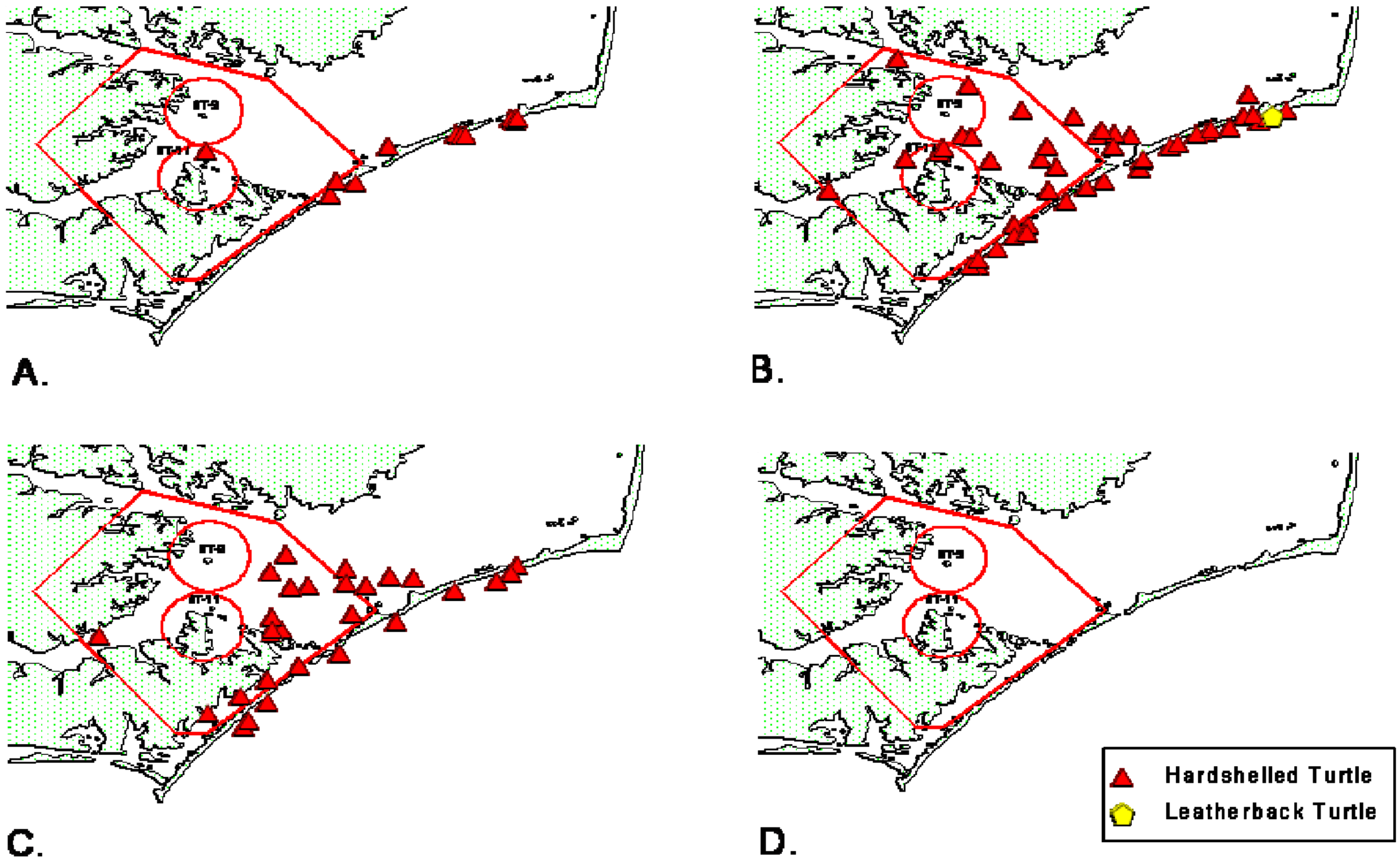

Figure 3. Seasonal distribution of turtle sightings from aerial surveys of Core and Pamlico Sounds, and extending one mile offshore, 2004-06. (A). Spring (Mar-May); (B). Summer (June-Aug); (C). Autumn (Sept-Nov); (D). Winter (Dec-Feb). Note: Each symbol represents one animal. Survey effort was not equal amongst seasons, and therefore the number of sightings shown may reflect differences in effort, not actual abundance.

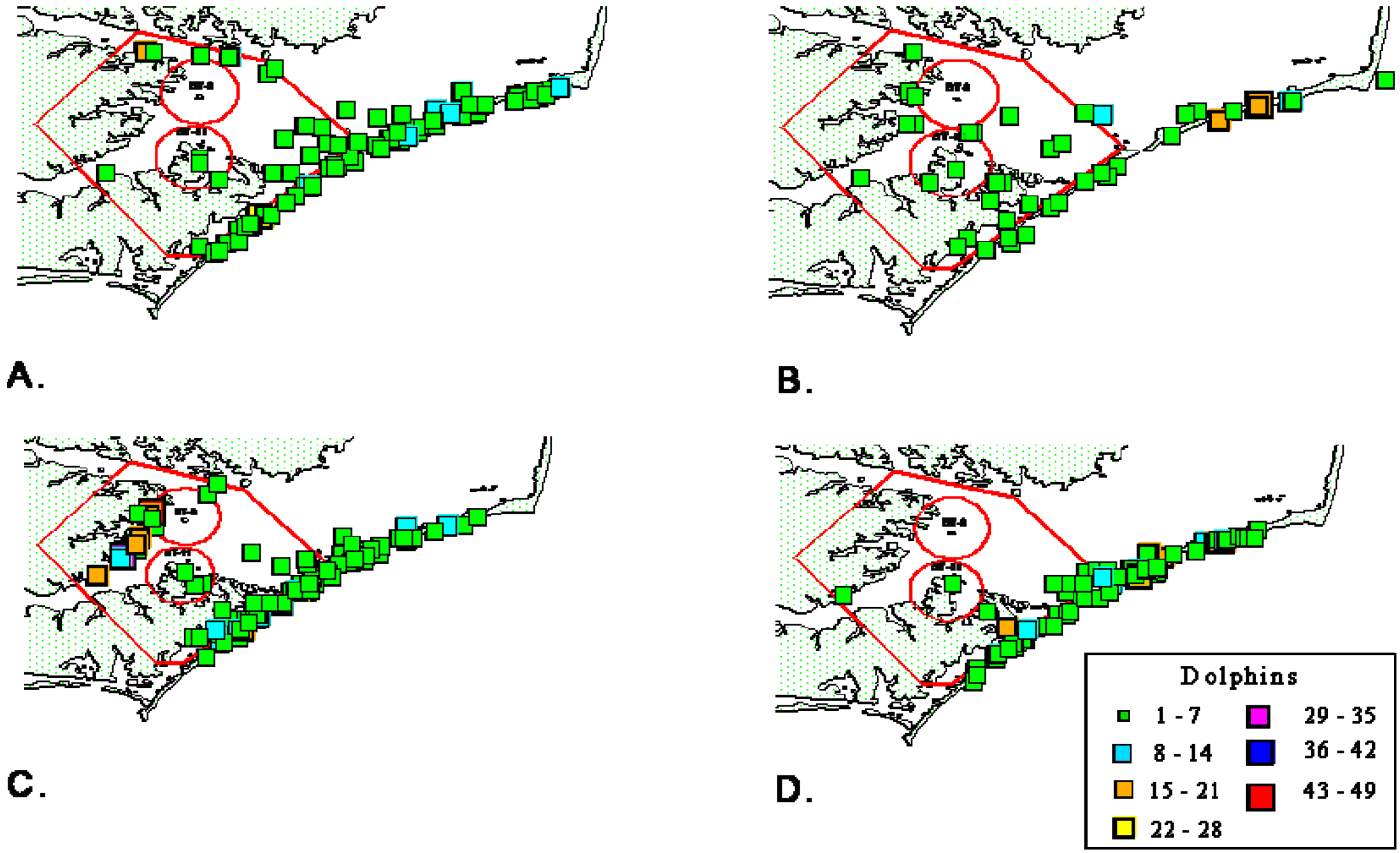

Figure 4. Seasonal distribution of dolphin sightings in aerial surveys of Core and Pamlico Sounds, and extending one mile offshore, 2004-06. (A). Spring (Mar-May); (B). Summer (June-Aug); (C). Autumn (Sept-Nov); (D). Winter (Dec-Feb). Note: Each symbol represents one animal. Survey effort was not equal amongst seasons, and therefore the number of sightings shown may reflect differences in effort, not actual abundance.

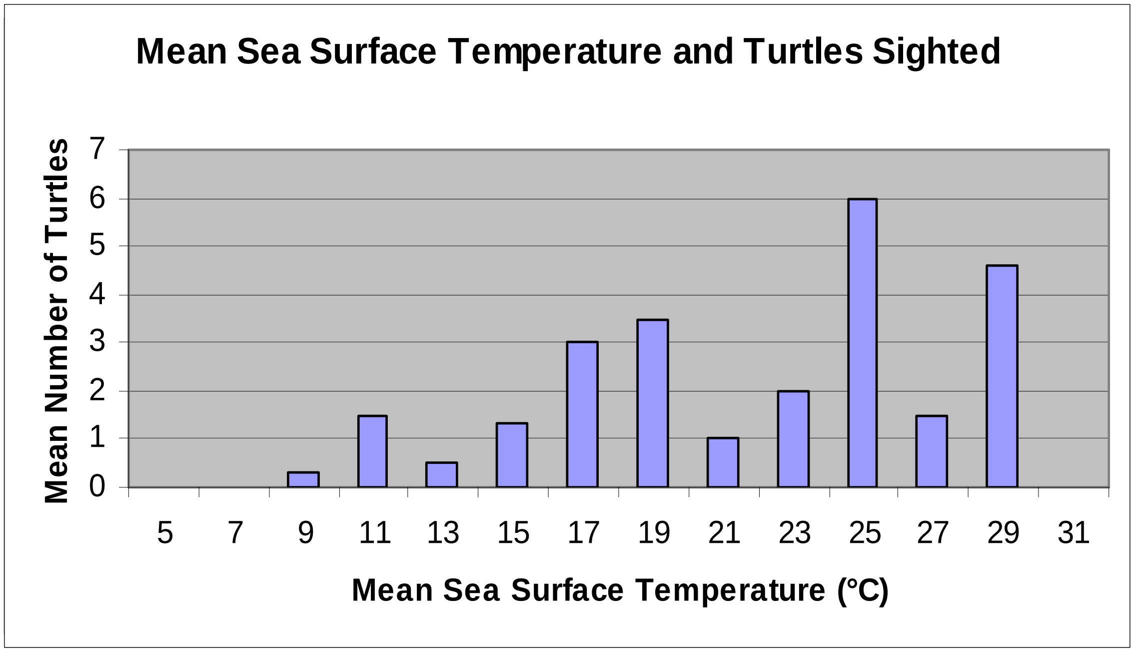

Figure 5. Mean number of turtles sighted at each mean sea surface temperature (SST) during aerial surveys of the Core and Pamlico Sounds, NC, 2004-06. Mean SST is the mean SST during a survey.

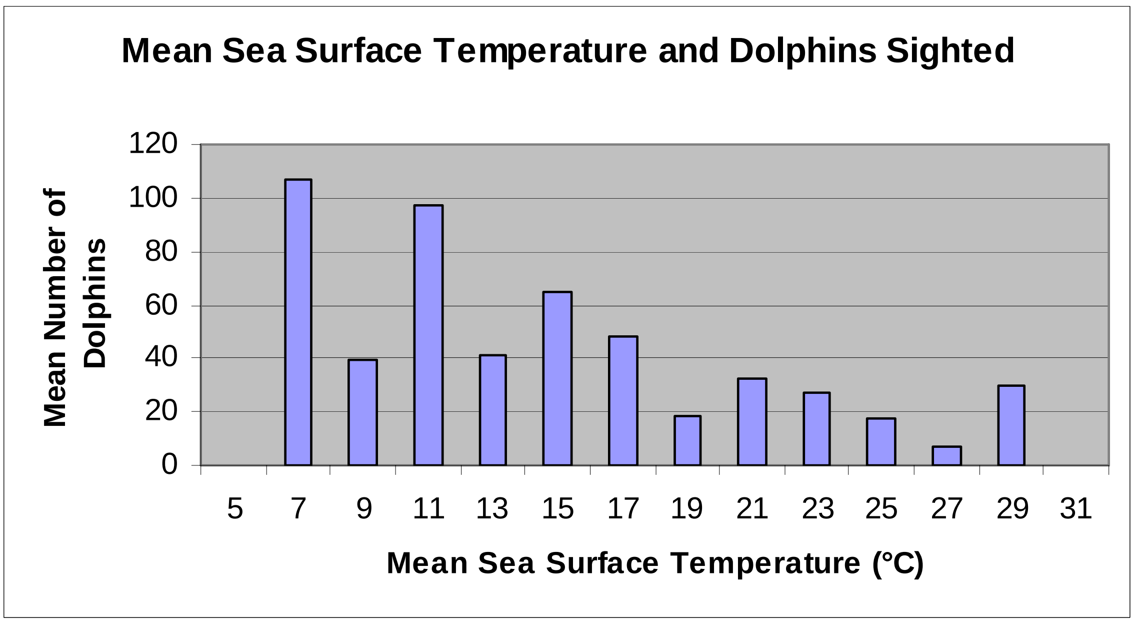

Figure 6. Mean number of dolphins sighted at each mean sea surface temperature (SST) during aerial surveys of the Core and Pamlico Sounds, NC, 2004-06. Mean SST is the mean SST during a survey.