CHARACTERIZATION OF BOTTLENOSE DOLPHIN *(TURSIOPS TRUNCATUS)* USE OF RESTRICTED AREAS IN THE PAMLICO SOUND, NC

by

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ABSTRACT

In two areas of the Pamlico Sound, NC, the U.S. Marine Corps and other branches of the military conduct training activities that involve airborne deployment of ordnance. Entry into these areas is restricted, and as such, they have not been included in previous surveys for marine mammals or other protected species. Since July 2002, however, we have been contracted by the Marine Corps to conduct photo-identification surveys for bottlenose dolphins in two bombing ranges (BT-9 near Brandt Island Shoal and BT-11 in Rattan Bay) and waters surrounding the ranges. We observed 261 dolphins (in 10 sightings) during eight surveys conducted between July and December, 2002. Of the 261 animals photographed, 100 met our criteria for distinctiveness; these 100 identifications represent 96 individual dolphins, as four were seen on two occasions. We matched 39 dolphins to the Duke University Marine Laboratory/University of North Carolina at Wilmington dorsal fin photo-identification catalog, and we made 57 new identifications. Many dolphins (185) were sighted inside the bombing range boundaries, sometimes in close proximity to the bombing targets. The BT-9 range had a daily occupancy of 0.17 sightings/survey day and an hourly occupancy of 0.09 sightings/hour; BT-11's daily occupancy was 0.38 sightings/survey day and its hourly occupancy was 0.31 sightings/hour; waters adjacent to the bombing ranges had a daily occupancy of 0.88 sightings/survey day and an hourly occupancy of 0.45 sightings/hour. The combined (bombing ranges and adjacent waters) mean dolphin group size was 26.1 ± 27.4 SD. The mean density of BT-9 (75 km^2) was 0.11 dolphins/km^2 and the mean density of BT-11 (11 km^2) was 1.50 dolphins/km^2. This work represents the first systematic survey effort for bottlenose dolphins in restricted areas of the Pamlico Sound.

DEDICATION
&
ACKNOWLEDGEMENTS

This work is dedicated to the memory of my father – Michael Maher – himself a brilliant scientist, but more importantly, a caring human being who tried to make the world a better place. I know that he would be proud of my accomplishments during the past year, especially my perseverance through all the changes in project topics.

Several people supported both this project and me, and for that, I am extremely greatful. Dr. Andy Read has been a marvelous advisor. Although he takes on more than any human should, he somehow manages to make time for his students. Kim Urian dedicates much of her time, and endless amounts of effort, to mentoring the next generation of marine mammal scientists. I am lucky to have had her support, both personally and professionally, over the past six years. With her perennial smiles and laughter, Danielle Waples makes the Read lab a fun place to work. Danielle's willingness to help others (e.g., reading multiple drafts of my MP) is recognized and appreciated. Damon Gannon spent a large amount of time walking me through his data and suggesting appropriate statistical methodology. In addition, he gave me guidance on this project during a time when he had a lot of other stuff on his mind (e.g., his dissertation defense). Dave Johnston, Kerry Irish, and Phebe Drinker spent many weekends doing the Marine Corps dolphin surveys. Dr. Laela Sayigh was not involved with this project, but she provided me the opportunity, back in January of 1998, to participate in dolphin ecology research in Wilmington, NC. Working with Laela opened many doors, including the opportunity to work with Kim and Andy.

Bill Rogers and Robin Ferguson of the Marine Corps Air Station at Cherry Point Environmental Affairs Department have demonstrated a sincere interest in understanding dolphin use of the bombing ranges. Julian Gaskill and T.R. Brown of the Range Operation Command Center looked out for our well-being by monitoring the bombing ranges while we surveyed, and Odle Wood provided scheduling support.

My family has been integral to my pursuit of educational and life opportunities. My mom encourages me to take chances and to follow my dreams. My grandparents never cease to support me, and my brother reminds me of the importance of not living to please others. The Palos crew, truly my second family, has had unending faith in me. All my friends challenge me to lead a balanced life. And, of course, my canine child, Zuba, is a source of inspiration about 'just getting on with it' and facing each day with a positive outlook.

Thank you all very much.

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Introduction

Multiple branches of the United States military use bombing ranges in the Pamlico Sound, NC (Figure 1) to practice airborne deployment of ordnance – or bombs. Boat-based surveys for bottlenose dolphins have occurred in the vicinity of these bombing ranges in the past, but, as the military restricts entry into the ranges, no surveys for marine mammals had been conducted inside the range boundaries. Since July 2002, however, we have been contracted by the Marine Corps Air Station at Cherry Point, NC to conduct photo-identification surveys for bottlenose dolphins in two bombing ranges: the BT-9 bombing range near Brandt Island Shoal (Figure 2), in which live ordnance is deployed during training activities, and the BT-11 bombing range in Rattan Bay (Figure 2), where training operations involve inert ordnance only (Biological Assessment for Bombing Operations at BT-9 and BT-11 [BA] 2001).

Military training activities in the Pamlico Sound, NC have the potential to adversely affect bottlenose dolphins – the only cetacean species known to frequent the area – and thus fall under the provisions of the Marine Mammal Protection Act (MMPA). Passed in 1972, the MMPA regulates interactions between marine mammals and humans. This legislation established a moratorium, with few exceptions (e.g. scientific research and commercial fishing), on the 'taking' of marine mammals in waters of the United States. The MMPA defines 'take' as meaning "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal" (16 USC § 1362 part 3.13). The MMPA defines harassment as "any act of pursuit, torment, or annoyance which (a) 'has the potential to injure a marine mammal or marine mammal stock in the wild' (Level A Harassment) or (b) 'has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering'"

(Level B Harassment) (16 USC § 1362 parts 3.18A-C). Injuries associated with the pressure effects of live ordnance would constitute Level A harassment. Examples of such injuries include loss of hearing, concussions, rupture of tissue, and/or death. Displacement of dolphins from an area because of exposure to high levels of anthropogenic sound represents an example of Level B harassment. Airborne deployment of ordnance in the Pamlico Sound bombing ranges has the potential to cause both Level A and Level B harassment to bottlenose dolphins, and thus, it is imperative to understand the use of these areas by dolphins.

After meeting with representatives from the Marine Corps' Environmental Affairs Department to discuss the project, we defined our objectives as follows:

1) determine if bottlenose dolphins use the BT-9 and BT-11 bombing ranges and the waters adjacent to these two areas, and
2) if dolphins are using these areas, characterize their use by describing the environmental conditions of the sightings, identifying individual animals, and calculating mean occupancy, mean group size, and mean density for each range and the adjacent waters.

Identifying individual animals and calculating the mean occupancies, group sizes, and densities help us to understand dolphin use of the Pamlico Sound. Identification of individuals helps us to determine whether certain dolphins exhibit site fidelity to the area. Site fidelity, in turn, allows us to establish whether distinct classes of dolphins use particular areas more than others, e.g. dolphins with calves consistently using an area. Calculations of dolphin occupancy (measured in sightings per day and sightings per hour) give an indication of how often dolphins are likely to be in an area. If dolphins are in a particular area, density and group size calculations provide insight into the patterns of use, in terms of how many dolphins are in a region at a time.

By understanding how many dolphins are in a given space over a given time, we can draw inferences about the importance of the area for the animals.

Background

The BT-9 and BT-11 bombing ranges are located near the mouth of the Neuse River, in the Pamlico Sound (Figure 2). The US military has been using these two bombing ranges for ordnance delivery training since the 1940s (BA 2001).

Habitat diversity in the Neuse River estuary is relatively low, but varies with depth, sediment type, slope, salinity, and concentration of dissolved oxygen (Gannon 2003). The BT-9 target area ranges in depth from 1.2 meters (m) to 6.1 m, with the shallow areas concentrated along the Brandt Island Shoal (which runs down the middle of the restricted area in a northwest to southeast orientation) (BA 2001). The BT-11 target area ranges in depth from 0.3 m along the shoreline to 3.1 m in the center of Rattan Bay (BA 2001).

Previous Survey Effort

The BT-11 bombing range is directly adjacent to Turnagain Bay, and is downstream from the South River (Figure 2). Dolphins were frequently sighted in both Turnagain Bay and the South River during previous surveys in the Neuse River. Based on data from surveys conducted in the Neuse River during 1998, 1999, and 2000, D. Gannon found that dolphins selected habitats of less than 3.5 m significantly more than deeper habitats (2003). Specifically, 96% of all sightings from the three-year Neuse River study, which surveyed over all seasons, occurred in areas less than 3.5 m deep (Gannon 2003). As all of the BT-11 range is less than 3.5 m deep, and portions of the BT-9 range are less than 3.5 m deep, we predicted that we would find dolphins in both ranges during our surveys, but more frequently in BT-11.

Using data from surveys conducted by D. Gannon between July and December, 1998-2000, we calculated the mean occupancy, mean group size, and mean density[1] for Turnagain Bay (1998-2000) and the South River (1998-1999) (Table 1). Results from months other than July-December 1998-2000 were excluded to avoid incorporating seasonal variation that would not be represented in our work[2]. These calculations provide values against which calculations from the current survey work in the bombing ranges and adjacent waters can be compared.

Based on 56 survey days that included 12 sightings of dolphin groups, Turnagain Bay's daily occupancy was 0.21 sightings/day, its mean group size was 19.8 ± 8.2 SD, and its mean density was 0.61 dolphins/km^2 (Table 1) (D. Gannon, personal communication 2003). During 1998 and 1999 D. Gannon surveyed the South River 43 times and had 11 sightings of dolphin groups; from these surveys and sightings, we calculated the South River's daily occupancy to be 0.26 sightings/day, its mean group size to be 17.3 ± 12.2 SD, and its mean density to be 0.37 dolphins/km^2 (D. Gannon, personal communication 2003).

In addition to the past Neuse River work, Andy Read and Kim Urian led a team of researchers that conducted surveys in July 2000 to determine the abundance of dolphins in North Carolina bays, sounds, and estuaries (Read *et al.* 2003). Although not surveyed due to restrictions on entry, both the BT-9 and BT-11 bombing ranges were within the northern portion (the Pamlico Sound) surveyed. The mean dolphin group size from these surveys was 20.0 ± 18.1 SD. The team estimated the average density of the Pamlico Sound as 0.24 dolphins/km^2 by dividing the abundance estimate of 919 bottlenose dolphins for the northern area by the northern region's surface area (3,822 km^2; based on ArcGIS version 3.2).

[1] The area surveyed in Turnagain Bay during 1998-2000 was about 7 km^2 and the area surveyed in the South River during 1998-1999 was about 12 km^2.

Methods

We began monthly boat-based dolphin surveys in the Pamlico Sound bombing ranges and adjacent waters in July, 2002. Surveys could be scheduled only for weekends, and required coordination among multiple parties associated with the Marine Corps. We had hoped to survey twice per month, but military training and poor weather conditions precluded this from happening every month. All surveys were conducted aboard the R/V Proteus, a 7 m, outboard-powered, center-console vessel, at a speed of 16-18 knots in a Beaufort Sea State 2 or less. At least three observers participated in each survey: a boat captain, a primary photographer, and a secondary photographer/data recorder.

Both the bombing ranges and their adjacent waters – including West, Long, and Turnagain Bays and parts of the Neuse River – were surveyed (Figure 2). We incorporated the presence of dolphins in waters adjacent to the bombing ranges in portions of the analysis because animals may move into or out of the bombing ranges prior to, during, or after a survey, and because we wanted to compare the occupancies, group sizes, and densities of the bombing ranges to those of the adjacent waters. Although always commencing at the Range Operation Command Center (Figure 2), the surveys were designed to optimize sighting conditions, and thus the routes varied from survey to survey. All survey track lines and sighting locations were logged with a handheld GPS.

Once dolphins were encountered, we recorded many environmental variables. For example, location, depth, and salinity were noted at the beginning of each sighting, while estimations of group size and composition were noted at the end of each sighting.

[2] Because we used the same time period (July-December), the densities and group sizes for Turnagain Bay and the South River are likely to be negatively biased because the largest groups of dolphins seen during the Neuse River work were documented during the spring months (Gannon 2003).

We used standard photo-identification techniques to document unique patterns on the dorsal fins of dolphins (Urian and Wells 1996). These methods are well-established and have been applied to a variety of wild cetaceans. We took color photographs with SLR cameras having 300 mm lenses. Once developed, slides were labeled with the date and sighting number. All slides were evaluated for quality, considering aspects such as focus, contrast, angle of the fin to the photographer, and visibility of the fin in the frame of the picture. We assessed only those slides rated as average to excellent, using a weighted scale of all measurements of quality, for distinctiveness (Read *et al.* 2003). Slides meeting distinctiveness requirements were compared to the Duke University Marine Laboratory (DUML)/University of North Carolina at Wilmington (UNCW) dorsal fin catalog. This catalog includes photographs taken during dolphin surveys in the waters around Beaufort, NC since 1995 and in the waters near Wilmington, NC since 1996. Currently, the catalog has active records for 497 individual dolphins. If, after comparison with the catalog, we did not make a fin match, we assigned the animal a new identification number.

We calculated occupancy of dolphins in the bombing ranges and adjacent waters. We defined daily occupancy of each area as the number of group sightings in the area per the number of survey days in the area, and hourly occupancy of each area as the number of sightings in the area per hours spent surveying the area. We calculated hourly occupancies to account for the disparity of effort among the areas (due to weather conditions). We based group size calculations on a combination of field estimates and analysis of sighting pictures.

In addition to describing the environmental conditions of each sighting, and calculating the mean occupancies and mean group sizes, we calculated the mean density of dolphins per km^2 for each bombing range. We assumed that while in a range, we would be able to see dolphins if they were present – e.g. we could assess each range in its entirety. Thus, we were able to

conduct a complete census (not a sample) of all dolphins in each range. From the census, we measured dolphin density in each range for every survey day. We defined the mean density of dolphins per km^2 as the sum of the number of animals from each sighting in a range divided by the number of survey days for the range; this value was then divided by the surface area of the range[3]. Although we assumed that we would detect dolphin groups if they were inside the ranges while we were surveying, this assumption may be more true for BT-11 than BT-9 (because BT-11 is smaller than BT-9).

Results

Monthly surveys

Between July and December, 2002, we conducted eight surveys in the bombing ranges and adjacent waters (Figure 3). We were able to survey two days in July, August and October; poor weather conditions precluded us from conducting more than one survey in November and December. No surveys were completed in September due to poor weather conditions and military training activities. On two occasions, August 10th and December 12th, weather conditions allowed us to survey in BT-11 only. In total, we spent approximately 46 hours on the water, of which roughly 37 hours were spent surveying for dolphins, and we covered a distance of 930 km. Table 2 summarizes our field effort for all survey days.

During the eight surveys in the bombing ranges and adjacent waters, we had six sightings in adjacent waters, one sighting in BT-9, two sightings in BT-11, and one sighting involving both adjacent waters and BT-11 (Figure 4). We encountered, using field estimates of group size, 261 dolphins. Four of ten sightings involved animals inside the bombing range boundaries, and 185 of the 261 dolphins encountered (71%) were inside the bombing ranges at some point during the

[3] The BT-9 bombing range is approximately 75 km^2 and the BT-11 range is approximately 11 km^2 (areas determined

sighting (meaning we initially sighted the group inside a range or sighted it in adjacent waters and followed it into a range).

Dolphin sightings occurred in depths between 0.9 and 3.1 m, in temperatures that ranged between 7 and 30 ^{0}C, and in salinities between 10 and 24 parts per thousand (ppt). Table 3 summarizes all environmental variables collected during each dolphin sighting.

Our ability to identify animals varied with fin characteristics, sighting conditions, and quality of photographs. We identified 100 of 261 dolphins encountered. These 100 identifications represent 96 individual dolphins, as 4 were seen on two occasions. We matched 39 dolphins to the DUML/UNCW dorsal fin catalog, and we made 57 new identifications. Fifty-nine percent of all dolphins identified were animals not in the DUML/UNCW catalog. Table 4 lists the dolphins identified during all sightings and the year they were first sighted by Duke or Wilmington researchers.

We saw four dolphins on more than one occasion. On August 10, 2002, two dolphins (identification codes FB720 and 71380) were seen in separate sightings. Only two animals were re-sighted on different days. These two animals, numbers 10460 and 60650, were each seen two times; both were photographed on October 19, 2002 and subsequently on December 12, 2002. None of the animals identified during the October and December sightings were identified during the July or August sightings.

Dolphin occupancy, group size, and density

We calculated mean occupancy (in days and hours), mean group size, and mean density, for each bombing range and the adjacent waters (Table 1). On December 12, 2002, we sighted a large group of dolphins (70 animals) in West Bay and subsequently followed them into the BT-

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using ArcGIS version 3.2).

11 range (Figure 5). When calculating the mean occupancies, mean group sizes, and mean densities, we treated this sighting as occurring in both adjacent waters and BT-11.

The mean daily occupancies were 0.88 sightings/day in adjacent waters, 0.17 sightings/day in BT-9, and 0.38 sightings/day in BT-11 (Table 1). We did not find a significant difference between the daily occupancies of the five areas (adjacent waters, BT-9, and BT-11 calculations based on current effort; Turnagain Bay and South River calculations based on previous effort) (Kruskal-Wallis One Way ANOVA, P=0.061). By hour, the mean occupancies were 0.45 sightings/hour in adjacent waters, 0.09 sightings/hour in BT-9, and 0.31 sightings/hour in BT-11 (Table 1). Although the hourly means are rather different, the daily differences were not significant (Kruskal-Wallis One Way ANOVA, P=0.161).

The groups we encountered in the bombing ranges and adjacent waters varied greatly in size, ranging from two to 70 animals. The combined (adjacent waters, BT-9, and BT-11) mean group size of dolphins observed was 26.1 ± 27.4 SD. By area, the mean group size was 20.9 ± 26.0 SD in adjacent waters, 50 in BT-9 (based on one sighting), and 45 ± 37.4 SD in BT-11. We did not find a significant difference in the size of dolphin groups in adjacent waters, BT-9, BT-11, Turnagain Bay (1998-2000), and the South River (1998-1999) when using a Kruskal-Wallis One Way ANOVA (P = 0.601).

Incorporating all survey effort and sightings, the mean density of BT-9 was 0.11 dolphin/km^2 while the mean density of BT-11 was 1.50 dolphins/km^2. We did not calculate the mean density for adjacent waters, as the area of adjacent waters surveyed changed each survey day. Using a Kruskal-Wallis One Way ANOVA to test for differences between the daily densities of BT-9, BT-11, Turnagain Bay (1998-2000), and the South River (1998-1999), we did not find a significant difference between the areas (P = 0.692).

Discussion

In addition to using waters adjacent to the ranges, bottlenose dolphins use the BT-9 and BT-11 bombing ranges. More specifically, their patterns of use follow the patterns documented in other portions of the Pamlico Sound: they prefer shallow areas along shorelines (e.g. BT-11) to deeper areas[4] (e.g. BT-9).

None of the variables considered in our analysis of dolphin use of the two ranges and adjacent waters (and when possible, Turnagain Bay and the South River) were significantly different among the areas. This may reflect the patterns of dolphin use of these areas of the Pamlico Sound, but it is possible that the lack of significance results from a small sample size. With only a sixth-month period of time, and only eight surveys, we are just beginning to understand the patterns of dolphin use of the bombing ranges.

Our observations suggest that dolphins are present almost everyday in waters adjacent to the restricted areas, are often present in BT-11, and are present less often in the BT-9 range. Data on the hourly occupancies follow the same pattern, with dolphins sighted approximately once every two hours in adjacent waters, roughly once every three hours in BT-11, and once every 10 hours in BT-9. These occupancy calculations act as crude predictors of the frequency of future sightings in the bombing ranges, although it is important to note that they are based on a small sample of observations.

The mean daily occupancies of adjacent waters, BT-9, BT-11, Turnagain Bay (1998-2000), and the South River (1998-1999), and the hourly occupancies of adjacent waters, BT-9, and BT-11, were not significantly different from each other. Based on the lack of significance,

we conclude that that there is no difference in occupancy patterns among the ranges and adjacent waters (including Turnagain Bay and the South River). However, again, this conclusion is based on a small sample.

Although the mean density of dolphins in BT-11 was more than twice as large as the density of any of the other areas, the daily densities were not significantly different. This suggests that dolphins use the BT-11 range much like they do Turnagain Bay, the South River, and other nearby waters. This suggestion is supported by the lack of significant difference among the group size of dolphins in each area; dolphin groups of similar size are using the various regions (the group size comparisons did not include the results from the surveys in the Pamlico Sound during July, 2000). The calculated mean densities of BT-11, Turnagain Bay (1998-2000), and the South River (1998-1999) were all greater than the estimated density of the entire Pamlico Sound (0.24 dolphins/km^2), although the Pamlico Sound density estimate includes large areas of open water known to be used less frequently by dolphins than areas nearer to shore. We could not determine if the daily densities of the areas were significantly different from the Pamlico Sound density because the Pamlico Sound value was estimated rather than measured. Of 261 animals encountered in the bombing ranges and adjacent waters, only two were re-sighted on different days. Additionally, approximately 60% of all the animals identified were new identifications. Based on the low number of re-sightings and the large proportion of new identifications, we believe the bombing ranges are being used by many dolphins that have home ranges extending beyond our study area.

The Marine Corps is working to address the potential for airborne deployment of ordnance to adversely affect dolphins in the ranges by incorporating our survey results into the development and testing of ordnance impact models. As no predictive techniques are currently

[4] The sighting in BT-9 occurred at a depth of 2.0 m near the Brandt Island shoal.

available to evaluate the potential for injury to marine mammals from exposure to high pressure impacts in shallow waters (BA 2001), our results allow for a more-informed estimation of the number of animals potentially affected.

Dolphins could be adversely affected by military training activities if they are in the bombing ranges while such activities occur. For example, if pre-flight surveys do not detect dolphins in the ranges, and training activities are conducted while dolphins are present, the animals may be exposed to acoustic harassment (Level B) and/or physical injury (Level A harassment). The likelihood of training activities being labeled as harassment would increase if the animals were inside BT-9 and near the point of impact between the live ordnance and the water (if the target is missed). If inert ordnance causes loud sounds upon impact with the water, adverse acoustic effects (Level B and possibly Level A harassment) may be a problem in BT-11 even though the pressure effects may not be a source of injury.

The possibility that some dolphins may be adversely affected seems reasonable based on our work, but we also recognize that there are possible positive aspects to animals frequenting the bombing ranges. First, dolphins in restricted areas would not be exposed to boat traffic (and consequently humans, and potentially noise harassment) as they would in unrestricted portions of the Pamlico Sound. Second, prey availability may be greater inside the ranges, as their restricted nature precludes human fishing effort. Increased prey availability inside the ranges could lead to changes in the activity budgets of animals using the ranges, as those animals could potentially spend less energy and/or time foraging.

Conclusion

The Marine Mammal Protection Act affords dolphins protection from most forms of human harassment; as such, minimizing the potential for military training activities to harm dolphins is an important goal. Understanding dolphin use of the BT-9 and BT-11 bombing ranges is an important first step in meeting the previously mentioned goal, as it allows dolphins to be included in discussions of how military training activities affect the natural, non-human environment. In addition to increasing our knowledge of dolphin use of the Pamlico Sound, this project demonstrates the potential for collaborative efforts – between scientists and the military, for example – to address conservation and environmental concerns.

Our work represents the first systematic survey effort for Atlantic bottlenose dolphins in the two bombing ranges. We found that the ranges are used by dolphins – both previously identified as well as newly identified animals. Although our conclusions should be seen as preliminary because of the small amount of effort over a short period of time, we hope that they prove helpful to the military.

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Table 1. Mean daily and hourly occupancy, group size, and density for the areas considered during Marine Corps bottlenose dolphin surveys and during past survey effort[5] in nearby waters.

Area	**No. of survey days**	**No. of dolphin sightings**	**Survey hours**	**Area (km^2)**	**Mean daily occupancy (sightings/day)**	**Mean hourly occupancy (sightings/hour)**	**Mean group size (± SD)**	**Mean density ($dolphins/km^2$)**
Adjacent waters	8	7	15.6	Changes each survey	0.88	0.45	20.9 ± 26.0	--
BT-9	6	1	11.2	75	0.17	0.09	50	0.11
BT-11	8	3	9.7	11	0.38	0.31	45 ± 37.4	1.50
Turnagain Bay (1998-2000)	56	12	--	7	0.21	--	19.8 ± 8.2	0.61
South River (1998-1999)	43	11	--	12	0.26	--	17.3 ± 12.2	0.37

[5] Gannon, personal communication 2003.

Table 2. Summary of field effort for Marine Corps bottlenose dolphin photo-identification surveys.

Cumulative survey day	Date	Time on water (h:mm)	Distance surveyed (km)	No. of dolphin sightings	No. of dolphins	Bombing range surveyed
1	20-Jul-02	6:05	155	1	2	BT-9 & BT-11
2	21-Jul-02	6:53	167	2	6	BT-9 & BT-11
3	10-Aug-02	5:33	60	2	42*	BT-11
4	11-Aug-02	5:56	146	0	0	BT-9 & BT-11
5	19-Oct-02	6:24	118	2	113	BT-9 & BT-11
6	20-Oct-02	4:56	109	2	28	BT-9 & BT-11
7	24-Nov-02	5:15	118	0	0	BT-9 & BT-11
8	12-Dec-02	4:53	57	1	70	BT-11
TOTAL		**45:55**	**930**	**10**	**261**	

* 2 of these dolphins were encountered in multiple sightings

Table 3. Summary of dolphin sightings in the bombing ranges and adjacent waters.

Cumulative sighting no.	Date	Sighting no.	Latitude	Longitude	Location	Depth (m)	Water temp. (^{0}C)	Salinity (ppt)	No. of dolphins	No. of dolphins identified
1	20-Jul-02	1	34.97062	-76.48898	Adjacent waters	0.9	30	23	2	1
2	21-Jul-02	1	34.97052	-76.41082	Adjacent waters	3.1	29	21	2	0
3	21-Jul-02	2	34.97045	-76.40451	Adjacent waters	2.0	29	21	4	0
4	10-Aug-02	1	34.97782	-76.48473	Adjacent waters	2.5	25	24	40	13
5	10-Aug-02	2	35.01622	-76.48015	BT-11	1.1	25	20	2	2
6	19-Oct-02	1	35.20199	-76.42783	BT-9	2.0	19	21	50	25
7	19-Oct-02	2	35.04067	-76.48648	BT-11	2.0	19	18	63	29
8	20-Oct-02	1	34.96851	-76.40415	Adjacent waters	2.1	19	10	24	2
9	20-Oct-02	2	34.96727	-76.49245	Adjacent waters	2.5	19	10	4	1
10	12-Dec-02	1	35.02132	-76.43091	Adjacent waters & into BT-11	2.0	7	16	70	27
TOTAL									**261**	**100**

Table 4. Summary, by date, of all animals identified during Marine Corps bottlenose dolphin photo-identification surveys.

Identification no.	Date(s)	Sighting no.(s)	Year of first identification
80720	20-Jul-02	1	New
*FB720	10-Aug-02	1	1995
	10-Aug-02	2	
*71380	10-Aug-02	1	2000
	10-Aug-02	2	
FB403	10-Aug-02	1	1999
20040	10-Aug-02	1	1995
60010	10-Aug-02	1	1995
70010	10-Aug-02	1	1995
70220	10-Aug-02	1	1995
80090	10-Aug-02	1	1995
10580	10-Aug-02	1	New
40130	10-Aug-02	1	New
71370	10-Aug-02	1	New
90370	10-Aug-02	1	New
90380	10-Aug-02	1	New
71470	19-Oct-02	1	New
71480	19-Oct-02	1	New
60590	19-Oct-02	1	1998
71230	19-Oct-02	1	1998
20410	19-Oct-02	1	New
80760	19-Oct-02	1	New
20420	19-Oct-02	1	New
71210	19-Oct-02	1	1998
60680	19-Oct-02	1	New
71490	19-Oct-02	1	New
90410	19-Oct-02	1	New
30060	19-Oct-02	1	New
20430	19-Oct-02	1	New
80770	19-Oct-02	1	New
**60650	19-Oct-02	1	New
	12-Dec-02	1	
60690	19-Oct-02	1	New
20440	19-Oct-02	1	New
71500	19-Oct-02	1	New
71510	19-Oct-02	1	New
60700	19-Oct-02	1	New
80780	19-Oct-02	1	New
10620	19-Oct-02	1	New
60710	19-Oct-02	1	New
60720	19-Oct-02	1	New

Identification no.	Date(s)	Sighting no.(s)	Year of first identification
90420	19-Oct-02	1	New
71520	19-Oct-02	2	New
60730	19-Oct-02	2	New
**10460	19-Oct-02 12-Dec-02	2 1	1998
71130	19-Oct-02	2	1998
40120	19-Oct-02	2	1998
20450	19-Oct-02	2	New
60740	19-Oct-02	2	New
80790	19-Oct-02	2	New
71260	19-Oct-02	2	1998
80800	19-Oct-02	2	New
60750	19-Oct-02	2	New
60760	19-Oct-02	2	New
71530	19-Oct-02	2	New
80810	19-Oct-02	2	New
90430	19-Oct-02	2	New
71540	19-Oct-02	2	New
71550	19-Oct-02	2	New
71560	19-Oct-02	2	New
80820	19-Oct-02	2	New
71570	19-Oct-02	2	New
90440	19-Oct-02	2	New
71580	19-Oct-02	2	New
50120	19-Oct-02	2	1998
90450	19-Oct-02	2	New
90460	19-Oct-02	2	New
90470	19-Oct-02	2	New
71590	19-Oct-02	2	New
60770	19-Oct-02	2	New
60780	19-Oct-02	2	New
20460	20-Oct-02	1	New
71600	20-Oct-02	1	New
71610	20-Oct-02	2	New
80400	12-Dec-02	1	1998
71200	12-Dec-02	1	1998
50160	12-Dec-02	1	New
10590	12-Dec-02	1	New
71390	12-Dec-02	1	New
71400	12-Dec-02	1	New
10600	12-Dec-02	1	New
71150	12-Dec-02	1	1998
20320	12-Dec-02	1	1998
40060	12-Dec-02	1	1998

Identification no.	Date(s)	Sighting no.(s)	Year of first identification
71410	12-Dec-02	1	New
10610	12-Dec-02	1	New
80740	12-Dec-02	1	New
80750	12-Dec-02	1	New
71420	12-Dec-02	1	New
20390	12-Dec-02	1	New
20400	12-Dec-02	1	New
60660	12-Dec-02	1	New
71430	12-Dec-02	1	New
90390	12-Dec-02	1	New
60670	12-Dec-02	1	New
71440	12-Dec-02	1	New
71450	12-Dec-02	1	New
90400	12-Dec-02	1	New
71460	12-Dec-02	1	New

* Denotes a dolphin seen in two sightings on the same day
** Denotes a dolphin seen twice during surveys from July-December, 2002

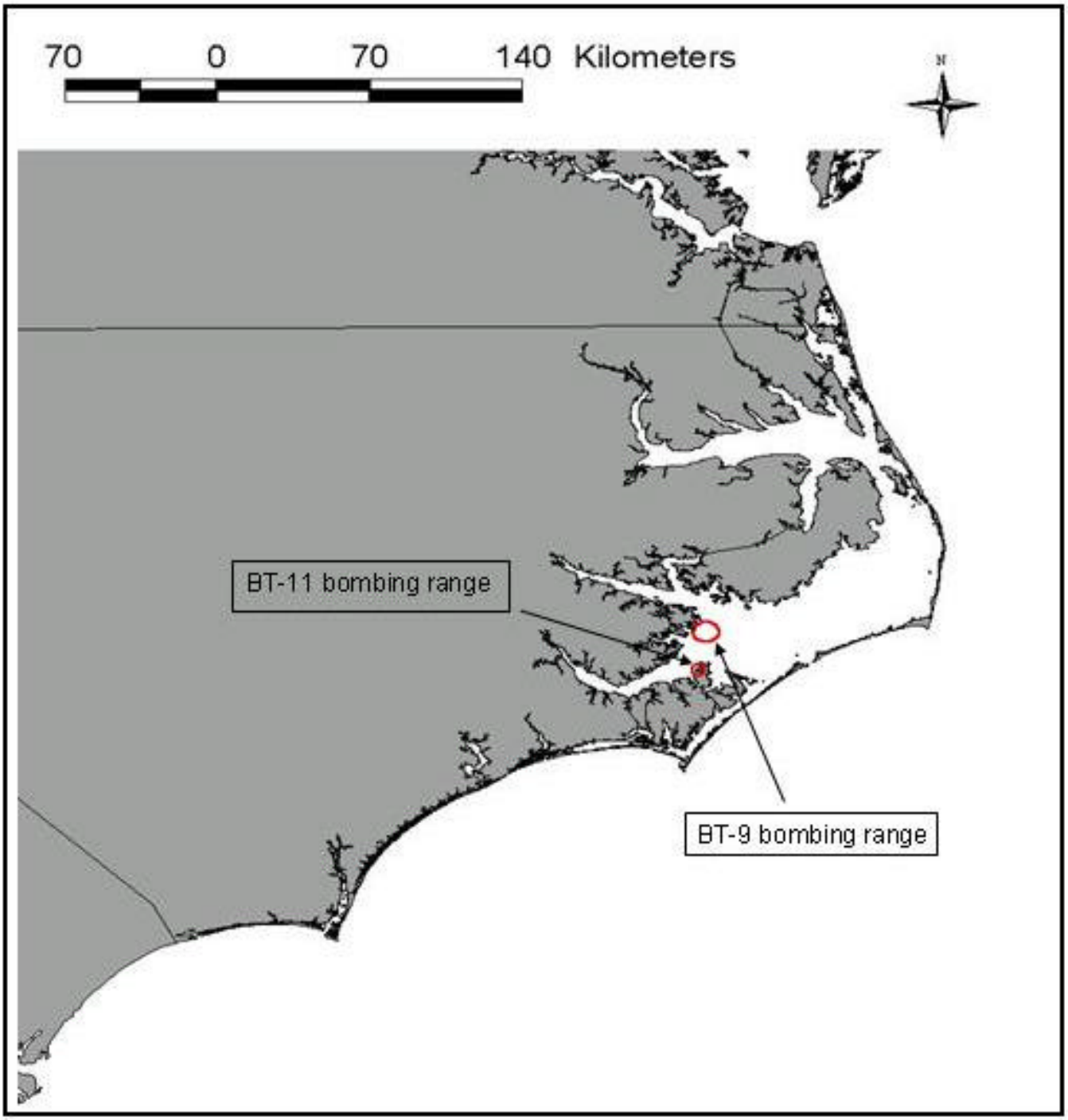

Figure 1. North Carolina coastline with Marine Corps bombing ranges shown in red.

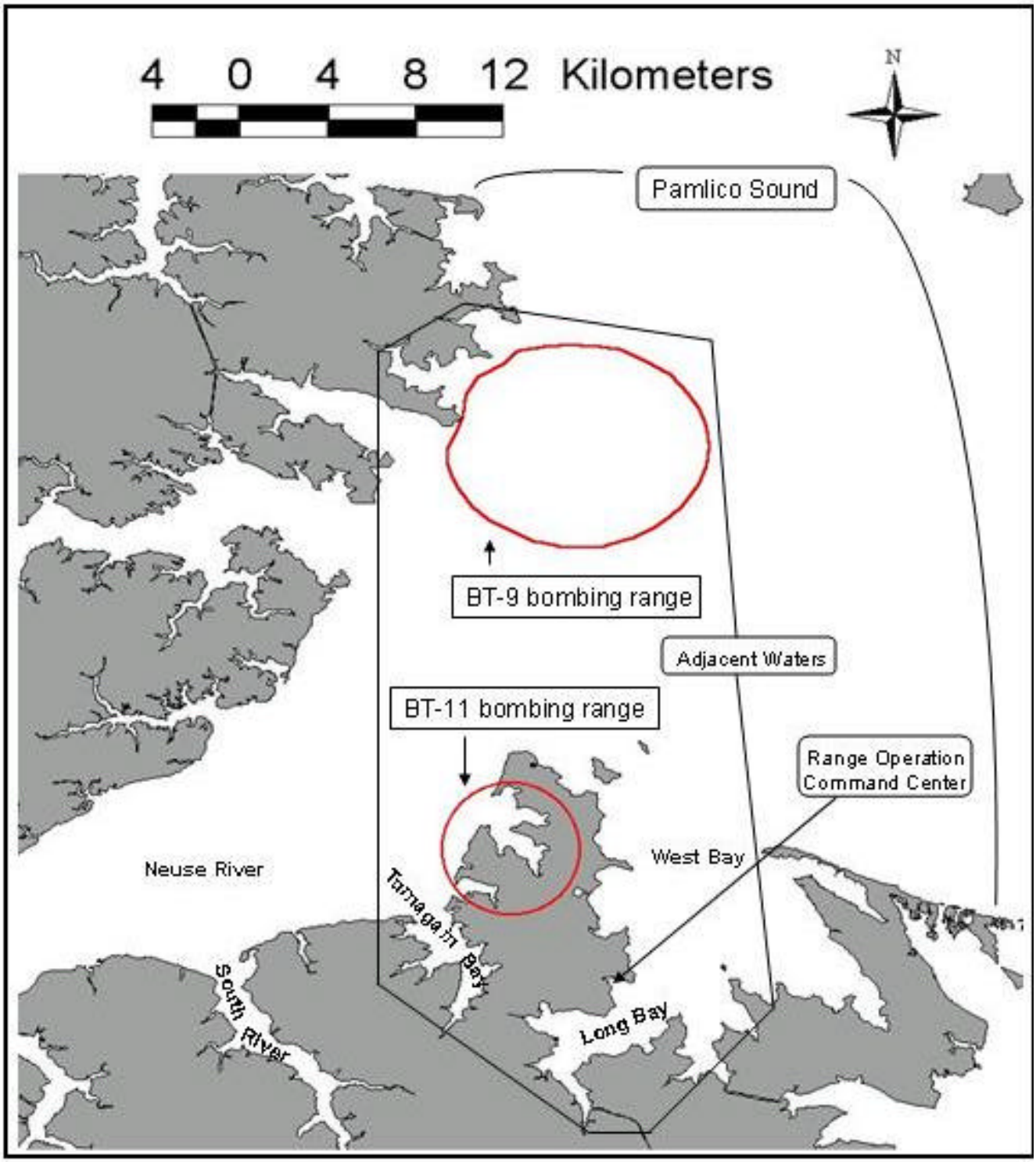

Figure 2. Map of study area for Marine Corps bottlenose dolphin surveys conducted between July and December, 2002.

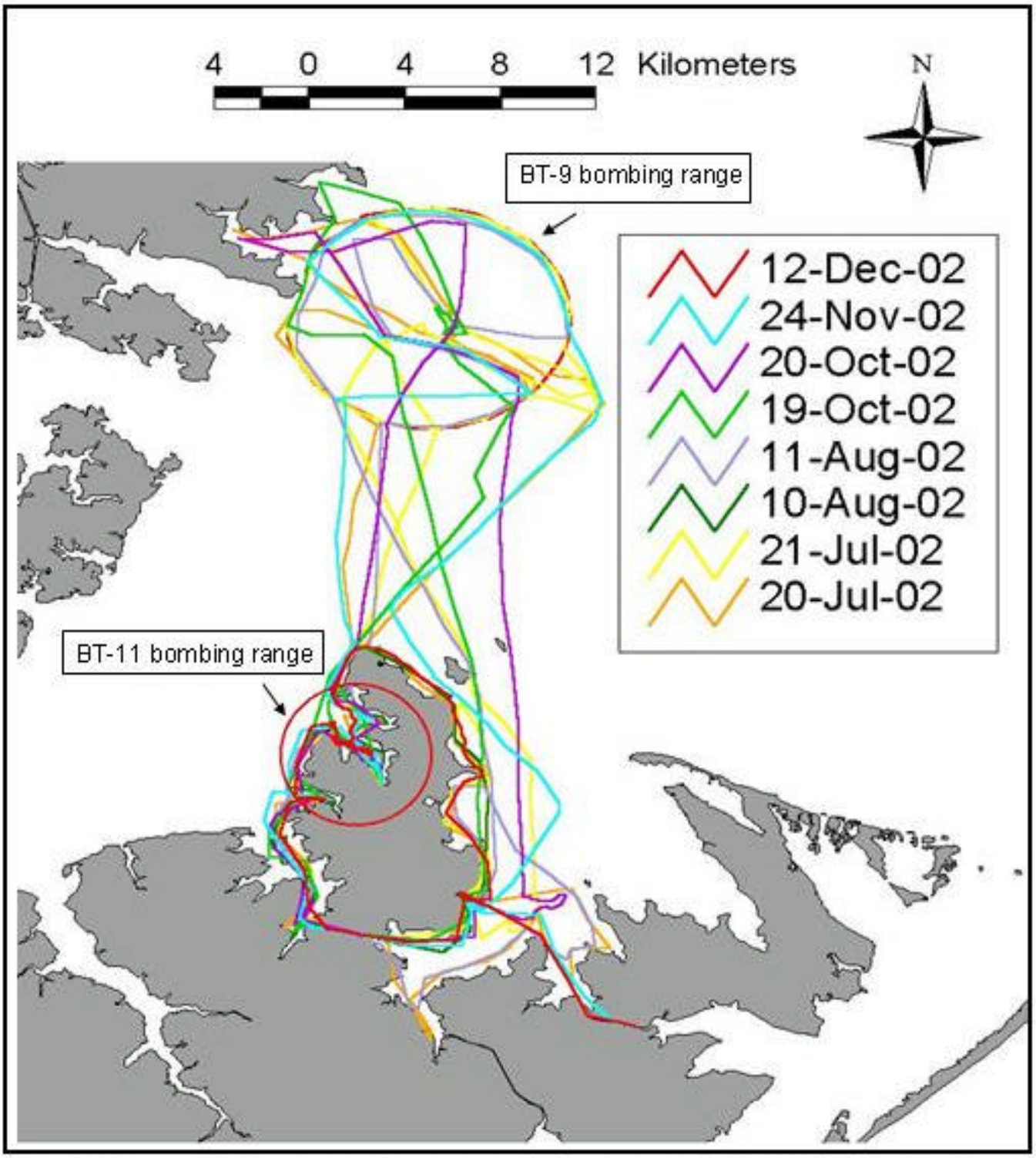

Figure 3. Tracks for all Marine Corps bottlenose dolphin surveys conducted between July and December, 2002.

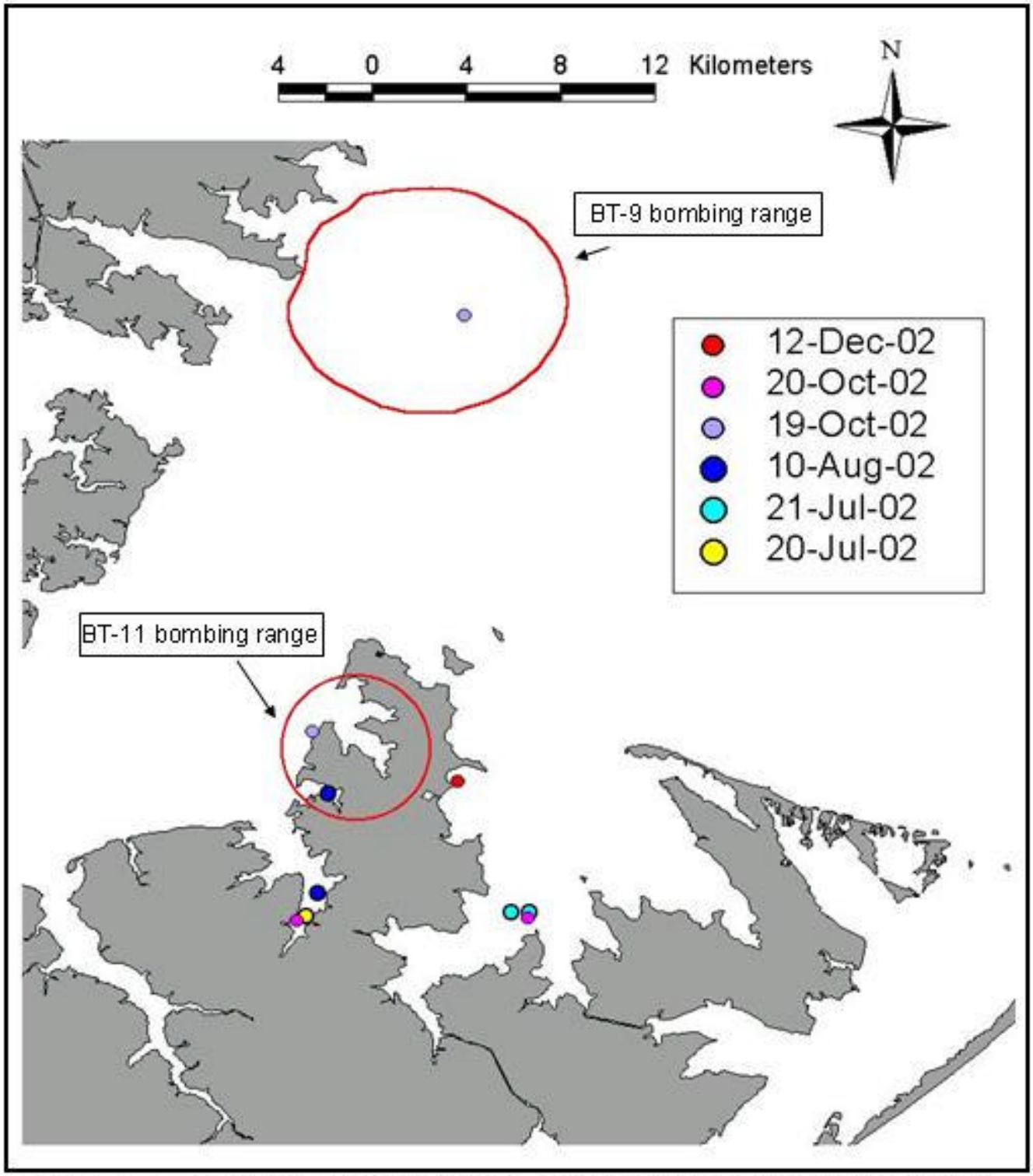

Figure 4. Location of bottlenose dolphin sightings from Marine Corps surveys conducted between July and December, 2002.

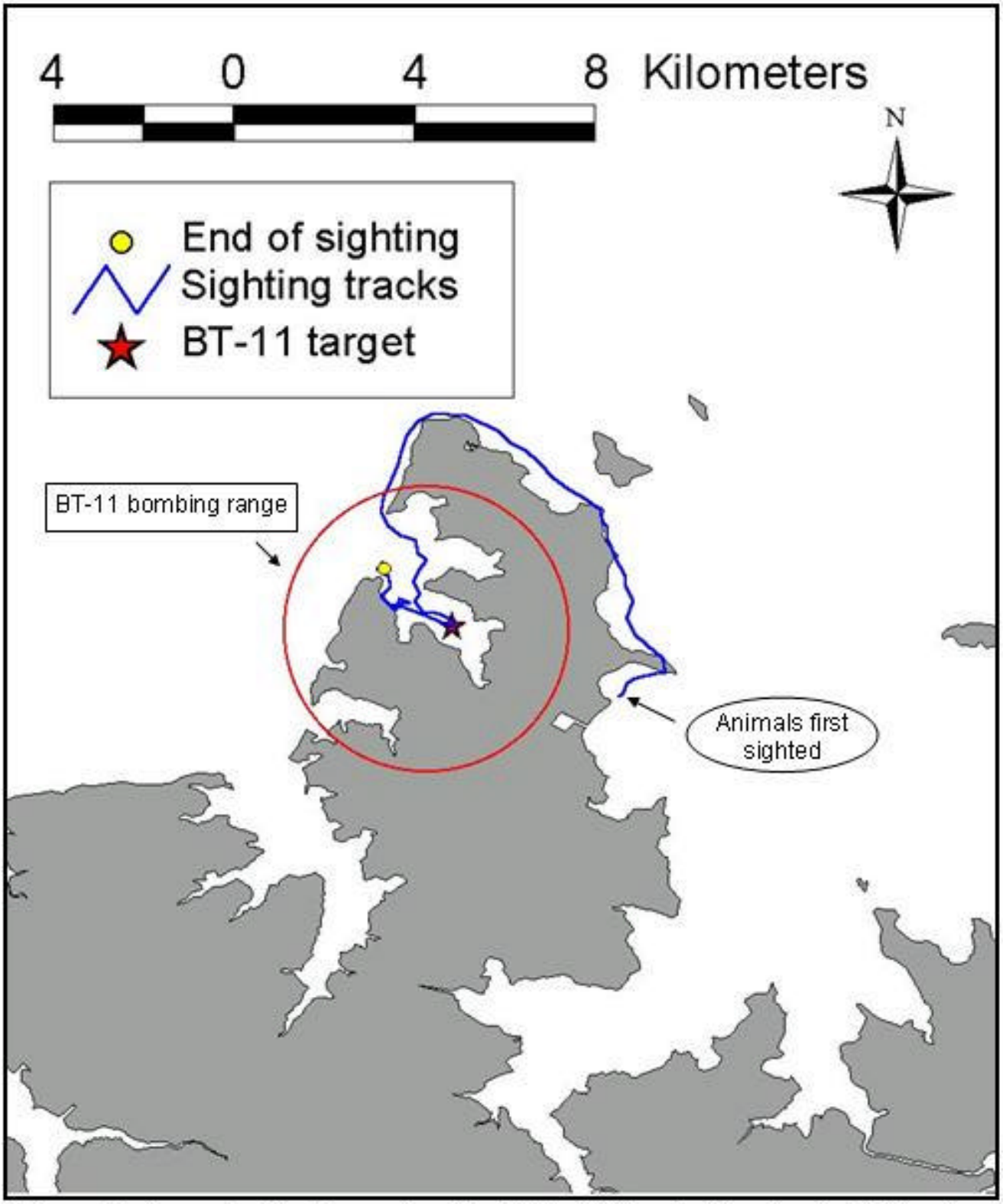

Figure 5. Layout of the December 12, 2002 sighting that involved dolphins in adjacent waters and the BT-11 range.