# Final

# Spatial Use by Cuvier's Beaked Whales, Short-finned Pilot Whales, Common Bottlenose Dolphins, and Short-beaked Common Dolphins Satellite Tagged off Cape Hatteras, North Carolina, in 2014

*Submitted to:*

Naval Facilities Engineering Command Atlantic under Contract No. N62470-10-D-3011, Task Orders 14 and 21, Issued to HDR, Inc.

*Prepared by*

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Cuvier's beaked whale (*Ziphius cavirostris*) off Cape Hatteras. Photographed by Danielle Waples, Duke University, taken under NOAA Scientific Permit No. 14809 (Douglas Nowacek) and NOAA General Authorization Letter of Confirmation 16185 held by Duke University.

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## Acronyms and Abbreviations

| | |
|---|---|
| hr | hour(s) |
| km | kilometer(s) |
| LIMPET | Low-Impact Minimally-Percutaneous External-electronics Transmitter |
| m | meter(s) |
| min | minute(s) |
| photo-ID | photo-identification |
| SD | standard deviation |
| SPOT | Smart Position and Temperature |

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# 1. Introduction

The purpose of this report is to summarize information obtained through the remote deployment of Low-Impact Minimally-Percutaneous External-electronics Transmitter (LIMPET) satellite tags on odontocete cetaceans off Cape Hatteras, North Carolina, in 2014. This study was undertaken to provide information on spatial use and diving behavior of a number of species of odontocetes, with particular emphasis on Cuvier's beaked whales (*Ziphius cavirostris*) and short-finned pilot whales (*Globicephala macrorhynchus*).

The present work was intended to complement ongoing research by Duke University off Cape Hatteras (herein referred to as the Duke program) by providing information on the movement and diving behavior of these species over the medium term (weeks to months). The Duke program is focusing on shorter-term dive behavior (i.e., hours to days) using Digital Acoustic Tags and longer-term movements (i.e., months to years) using photo-identification (photo-ID) techniques (Swaim et al. 2014). The photo-ID work has demonstrated a surprisingly high degree of re-sightings, in particular, of short-finned pilot whales, suggesting some degree of residency in the Cape Hatteras Study Area. Attempts were made in the field to obtain digital images of all tagged animals to ensure that linkages could be drawn between the photo-ID and satellite tagging work. Photographic matches of tagged animals and their associates are presented in the annual report of the Duke program (Foley et al. 2015).

# 2. Methods

Two types of Argos-linked satellite tags were used in this study, a location-only Smart Position and Temperature (SPOT)5 or a location-depth Mk10-A (both produced by Wildlife Computers, Redmond, Washington), both in the LIMPET configuration (Andrews et al. 2008). Tags were remotely deployed using a DAN-INJECT JM 25 pneumatic projector, and were attached with two surgical-grade titanium darts with backward-facing petals. Target area for all tags was the dorsal fin or the base of the fin. Two dart lengths were used depending on the species. Short darts (4.4-centimeter) were used on common bottlenose dolphins (hereafter bottlenose dolphins; *Tursiops truncatus*) or short-beaked common dolphins (*Delphinus delphis*), and long darts (6.8-centimeter) were used on short-finned pilot whales and Cuvier's beaked whales.

For each tag type (i.e., location-only or location-depth), there were different programming combinations depending on species, based on the average number of respirations per hour from previous tagging studies and taking into account the speed of surfacing and likelihood of the tag remaining attached for longer than approximately 30 days, which varies by species. The number of hours (hr) transmitting per day for location-only tags by species was: short-finned pilot whales – 10 hr, bottlenose dolphins and short-beaked common dolphins – 14 hr, and Cuvier's beaked whales – 18 hr. The number of hours transmitting per day for location-depth tags by species was: short-finned pilot whales and bottlenose dolphins – 17 hr and Cuvier's beaked whales – 20 hr. The total number of possible tag transmissions per day was varied to reflect the number of hours transmitting per day. Location-only tags programmed for deployment on small odontocetes transmitted daily through the lifespan of the tags, while those deployed on

short-finned pilot whales were duty-cycled to transmit daily for the first 60 days, then every third day for seven transmission days (i.e., covering a span of 21 days), then every fifth day for the remainder of the tag attachment. For deployments on Cuvier's beaked whales, duty-cycling was set with transmissions daily for 80 days, then every second day for five days of transmissions, and the remainder of transmissions every fifth day. Location-depth tags on small odontocetes were set to transmit every day for the life of the tag, while for Cuvier's beaked whales, tags were set to transmit every day for 28 days, then every other day for the remainder of the tag life. For short-finned pilot whales tags were programmed to transmit daily for the first 20 days, every third day for 10 transmission days, and every ninth day for the duration of tag attachment. With this duty-cycling schedule, the theoretical battery life for the short-finned pilot whale location-only tags was 161 calendar days. Location-depth tags had a theoretical battery life of 22 days (bottlenose dolphins), 25 transmission days (short-finned pilot whales), or 39 transmission days (Cuvier's beaked whales), given tag-programming parameters.

Location-depth tags were programmed to provide dive statistics (e.g., start and end time, maximum depth, and duration) for any dives which exceeded the species-specific depth threshold. Thresholds were: short-finned pilot whales – 20 meters (m); bottlenose dolphins – 30 m; and Cuvier's beaked whale – 50 m. For the purposes of comparison, dive statistics were only calculated for dives exceeding 50 m for all species. For bottlenose dolphins, depth readings of 3 m were used to determine the start and end of dives; thus dive durations for that species are slightly negatively biased. Given typical odontocete descent and ascent rates of 1 to 2 meters/second, bottlenose dolphin dive durations recorded are likely only 6 to 12 seconds shorter than actual dive durations. Prior to each field effort, satellite pass predictions were carried out using the Argos website to determine the best hours of the day for transmissions given satellite overpasses for the approximately 2-month period starting at the beginning of each deployment period.

Locations of tagged individuals were estimated by the Argos system using the least-squares method and were assessed for plausibility using the Douglas Argos-filter version 8.5 to remove unrealistic locations, following protocols previously used (Schorr et al. 2009; Baird et al. 2010, 2011). Resulting filtered location data were processed with ArcMap 10.2.2 to determine depth, distance from shore, and distance from the 200-m isobath. Depth values were generated from 30 arc-second data from the General Bathymetric Chart of the Oceans 2014[1], and the 200-m isobath dataset used was http://databasin.org/datasets/75e1256c18bb4ac48d4ca6d6fe65e06e. These GIS analyses should be considered preliminary in nature, and will be re-done as higher resolution bathymetry data are compiled. Given the inherent lack of precision associated with Argos-derived locations, combined with the steep continental slope and relatively low-precision bathymetry data used, we report median and maximum depths of tagged animal locations. Maximum depths are less likely to be influenced by Argos location quality or the steep slope given that the deepest locations of most tagged individuals were well seaward of the continental shelf (see **Results**).

[1] http://www.gebco.net/about_us/overview/

When more than one tag was deployed on the same species, we assessed whether individuals were acting in concert during the period of overlap by measuring the straight-line distance (i.e., not taking into account potentially intervening land masses) between pairs of individuals when locations were obtained during a single satellite overpass (approximately 10 minutes [min]). We used both the mean distances between pairs of individuals and the maximum distance between pairs to assess whether individuals were acting independently, following protocols described by Schorr et al. (2009) and Baird et al. (2010).

Pseudotracks were created to provide a visual display of the approximate location and depth of dives between known surface locations. Dive locations should be assumed to be inaccurate, with the least accurate positions in the middle of the segments between the two surface locations. Pseudotrack lines are generated using a custom R script (Version 3.1.2; R Core Team 2014) that produces a KML file for display in Google Earth Pro. For each segment between two surface locations, animal speed and bearing is calculated between the two points. The distance of the dives from the start of the segment is calculated by multiplying the elapsed time since the start of the segment by the speed. Positions are generated along the segment by passing the starting position of the segment, bearing and distance to the destPoint function of the R package geosphere (Version 1.3-11; Hijmans 2014).

# 3. Results

Field efforts were undertaken for tagging in May, June, and September 2014. Thirty tags were available for deployment: 10 location-depth and 20 location-only tags (Mk10-A and SPOT5, respectively). Twenty-nine tags were deployed (**Table 1**), and one location-only tag was lost during a deployment attempt. Of the 29 tags, 25 were deployed in the dorsal fin or at the base of the dorsal fin, two were deployed below the base of the fin (one each on a short-finned pilot whale and a Cuvier's beaked whale), and two were deployed in the flank (both on short-finned pilot whales).

Five tags were deployed on bottlenose dolphins in five different groups (on four different days). Three were location-only tags and two were location-depth tags, with attachment durations ranging from 6.3 to 17.5 days (**Table 1**). Assessment of distance between individuals that had temporally overlapping tag data (TtTag015 and TtTag016, TtTag017 and TtTag018) indicated that while TtTag017 and TtTag018 were acting independently during the period of tag overlap (median distance apart = 27.0 kilometers [km], maximum = 84.9 km), location data from TtTag015 and TtTag016 were likely not independent for the entire period of overlap (**Figure 1**), with median and maximum distances apart of 3.5 km and 32.8 km, respectively. Cumulative distances moved by these five individuals ranged from 1,196 to 1,481 km, yet the individuals remained a mean distance from tagging locations of from 11.9 to 32.0 km, with a maximum distance moved from the tagging location of 84.4 km (**Table 2**; **Figures 2 and 3**). Median depths determined at locations of tagged individuals ranged from 305 to 1,899 m, with maximum depths at tagged animal locations ranging from 2,037 to 2,794 m. All but one individual appeared to spend the majority of their time beyond the shelf break (**Table 3; Figure 3**). Dive data were obtained from both of the location-depth tags, with 8.5 days and 2.8 days of

dive data from TtTag016 and TtTag018, respectively. From the two individuals combined, 894 dives deeper than 30 m were documented, with maximum dive depths and durations recorded of 720 m and 10.2 min for TtTag016, and 944 m and 13.8 min for TtTag018 (**Table 4**).

A single location-only tag was deployed on a short-beaked common dolphin, and location data were obtained over a 40-day period (**Table 1**). The cumulative distance moved by this individual was 4,436 km, yet the individual remained a median distance of 145.6 km from the tagging location, and had moved a maximum of 720.7 km from the tagging location when the tag stopped transmitting (**Table 2**). Over the first 32 days of the 40-day period, the dolphin moved to the north away from the tagging location and back again to the general area of tagging (**Figure 4**) on four occasions, primarily remaining over the shelf break and continental slope. For the last eight days of tag data, the dolphin moved more directionally to the northeast, primarily remaining on the continental shelf (**Figure 5**). The median depth of tagged animal locations over the 40-day span was 297 m (**Table 3**).

Tag data were obtained from three Cuvier's beaked whales, with one location-only tag and two location-depth tags (**Table 1**). Tags were deployed on two individuals in the same encounter in September 2014, although assessment of distance between the two individuals during the period of tag overlap indicates the individuals did not act in concert (median distance apart = 148 km; maximum = 218 km; **Figure 6**). Movement patterns of the three individuals varied considerably, with one (ZcTag030) remaining a mean distance of 8.6 km (standard deviation [SD] = 5.7) from the tagging location, while ZcTag029 and ZcTag031 remained a mean of 43.7 (SD = 57.4) and 123.1 km (SD = 61.8) from the tagging locations, respectively (**Table 2**). Patterns of movement in relation to the tagging area varied among the three individuals (**Figure 7**), with ZcTag029 and ZcTag031 returning to the general area of tagging after varying periods. Individuals also showed varying patterns of movement north or south of the tagging area (**Figures 8 through 10**). From the location-depth tags deployed, 41.9 days of dive data were obtained, recording 1,944 dives deeper than 50 m (**Table 4**). An example of a pseudotrack of dive and location data over an approximately 22-hour period is shown in **Figure 11**, with deep dives during this example ranging from 1,519 to 1,903 m. Maximum dive depths and dive durations documented were 2,800 m and 98.0 min for ZcTag029 and 2,160 m and 86.6 min for ZcTag030 (**Table 4**). Median depths at locations of tagged individuals ranged from 1,725 to 2,274 m (maximum from 2,817 to 3,015 m; **Table 3**), suggesting that many of the dives were likely to, or close to, the sea floor.

Twenty satellite tags were deployed on short-finned pilot whales, although two tags were likely removed by conspecifics within a few minutes of tagging (**Table 1**). Both of these tags were deployed on individuals within the same group, and both deployments were in the flank. From previous LIMPET tag deployments by Cascadia Research Collective in Hawaiian waters, deployments in the flank appear most likely to be removed by conspecifics (CRC unpublished data). Of the remaining 18 tags, attachment durations ranged from 0.3 to 193.8 days (median = 49 days).

Excluding the single tag attachment of less than one day (0.3 days), the remaining 17 tags were deployed during 11 different encounters, with one to four tags deployed during an encounter.

Distances between all possible pairs of individuals with overlapping tag data obtained during the same satellite overpasses were calculated (*n* = 76 pairs). For pairs of whales tagged within the same encounter, the mean distance apart ranged from 2.5 to 117.5 km, with maximum distances between individuals within a pair of 9.9 to 243.1 km (**Table 5**). For pairs tagged in different encounters during the same day, mean distance apart ranged from 6.2 to 73.0 km, with maximum distances apart ranging from 10.2 to 315.7 km (**Table 5**). For those tagged on different days, mean distance apart ranged from 12.2 to 1,044.6 km, and maximum distance apart ranged from to 37.2 to 1,091.3 km (note: data not shown). Determining at what mean and maximum distances apart to consider whether the animals were acting in concert is problematic, in part given the inherent inaccuracies associated with Argos-derived locations. For false killer whales, another odontocete with strong social bonds, Baird et al. (2011) considered animals with mean distances apart of less than 5 km and maximum distances apart of less than 25 km to be members of the same social group. Using these criteria, only two pairs of individuals (both individuals of each pair tagged within the same encounter) would be considered members of the same social group (**Table 5**). There were, however, four additional pairs of individuals (one pair tagged during the same encounter and three pairs tagged during the same day) with mean distances apart of less than 10 km and maximum distances apart of 9.9 to 12.1 km (**Table 5**) that may also be part of the same social groups. It is interesting to note that during the one encounter when four individuals were satellite tagged on 11 September 2014 (encounter 4 – see **Table 1**), analyses of distances between tagged individuals indicate that three separate social groups were likely present in the encounter. One of the six possible pair-combinations had individuals remaining a mean distance apart of 3.2 km (GmTag098 and GmTag100, **Table 5**), but the other five possible pair combinations (involving GmTag097, GmTag099 and the above two individuals) had mean distances apart ranging from 27.5 to 117.5 km (with maximum distances apart ranging from 90.3 to 243.1 km; **Table 5**).

Mean and maximum distances moved varied considerably among individuals (**Table 2**), as did the typical depths used (**Table 3**), suggesting considerable variability in movement patterns and habitat use among pilot whale groups off the U.S. Atlantic coast. Two of the tagged whales were documented moving seaward of the U.S. Exclusive Economic Zone, GmTag087 (**Figure 12**) and GmTag088 (**Figure 13**). However, these were two of the three longest duration tag attachments for pilot whales, of 193.8 and 104.0 days, respectively, and there is a significant relationship between attachment duration and both the mean (regression, $p = 0.035$, $R^2 = 0.299$) and maximum (regression, $p = 0.002$, $R^2 = 0.535$) distance moved from the tagging locations, so it is possible that some of the other individuals tagged may have moved greater distances or outside of the Exclusive Economic Zone had tags remained attached for longer periods. Two individuals tagged within the same group (GmTag094 and GmTag095) showed very similar distributions along the shelf break, although analysis of distances between these individuals indicated they were acting independently, with mean and maximum distances between them of 74.0 and 292.4 km, respectively (**Figures 14 and 15**). The individual with the second-longest track, GmTag103 (109 days), remained closely associated with the Cape Hatteras Study Area, but also moved away from the continental slope into oceanic waters (**Figure 16**).

# 4. Discussion

This study provides information on the movements and habitat use of four different species of odontocetes along the east coast of the U.S. and represents the first dedicated satellite tagging effort on free-ranging small and medium-sized odontocetes off the U.S. Atlantic Coast. Tag deployments have provided the first long-distance movement information for Cuvier's beaked whales off the U.S. Atlantic Coast, as well as the first information on long-term and long-distance movements of short-finned pilot whales in the area, other than information obtained from previously stranded individuals released off Florida (Wells et al. 2013).

We obtained data from five tagged bottlenose dolphins, although two of the individuals may not have been acting independently over the duration of tag overlap (**Figure 1**). Whether such distances represent individuals being part of the same social group, or simply foraging in the same area is difficult to discern, although the prolonged (i.e., several days) separations by greater than 10 km suggest the latter is more likely. The tagged bottlenose dolphins displayed high site fidelity, remaining on the edge and slope of the continental shelf off Pamlico Sound in North Carolina (**Figures 2 and 3**). The results show a similar pattern between the animals tracked in May and June (TtTag014, TtTag015 and TtTag016) and the animals tracked in September (TtTag017 and TtTag018). Only one of the five tagged bottlenose dolphins spent much time on the continental shelf (TtTag014, **Table 3**), and the individuals remained a median distance offshore ranging from 53 to 76 km (**Table 3**), indicating they are all part of the Western North Atlantic offshore stock of bottlenose dolphins (Waring et al. 2014). Dive data obtained from two of the bottlenose dolphins (**Table 4**) included maximum dive depths of 720 and 944 m, the latter of which is likely the deepest dive depth recorded for this species (Baird et al. 2013).

The single short-beaked common dolphin spent its first month after tagging on the upper continental slope traveling back and forth off the coast of North Carolina, Virginia, Maryland and Delaware (**Figure 4**), after which it traveled up to the waters off New England, spending much of its time traveling in the shallower waters of the continental shelf (**Figure 5**). The northern and inshore movements in mid-summer are consistent with what is known of this species from large-scale sighting surveys off the U.S. East Coast (Waring et al. 2013).

Other than a few position fixes on the edge of the continental shelf, the Cuvier's beaked whales spent their time on the continental slope off the coasts of North Carolina, Virginia and Maryland (**Figures 8, 9 and 10**). The limited number of tagged animals makes it difficult to determine whether this area represents the home range of this specific population, though the behavior of all the animals returning to the tagging area (**Figure 7)** suggests that this could be a resident, instead of an oceanic population. Deploying additional satellite tags would allow for a much better understanding of the range and habitat use of this population. The extensive dive data records obtained from two individuals will allow for a comparison of diving patterns of this species with data obtained elsewhere (i.e., Hawai'i, California, Italy; Baird et al. 2006, 2008; Schorr et al. 2014; Tyack et al. 2006).

While the photo-ID work suggests that short-finned pilot whales display a high degree of site fidelity off Cape Hatteras, satellite tagging demonstrates that these animals cover a significant

range up and down the continental slope, from Powell Canyon (south of Georges Bank) in the north, to off Cape Lookout Shoals in the south, with movements at least occasionally into international waters (**Figures 12 and 13**). There were high concentrations of locations in the canyons along the shelf break, including Norfolk Canyon, Washington Canyon, Baltimore Canyon, Wilmington Canyon, and Hudson Canyon. Unlike most of the other pilot whales that stayed along the continental slope, GmTag088 travelled across deep water to the New England Seamount Chain (**Figure 13**). Overall, the distribution of locations of tagged short-finned pilot whales (**Figure 17**) closely matches what is known about the distribution of this species north of Cape Hatteras, with sightings of short-finned pilot whales extending only as far north as Georges Canyon, approximately 125 km northeast of the furthest tagged animal location (Waring et al. 2014). The considerable variability in movement patterns and habitat use likely reflects patterns that vary by social group, and understanding site fidelity and association patterns determined through photo-ID will help in interpreting such variability.

# 5. Acknowledgments

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# A

# Figures

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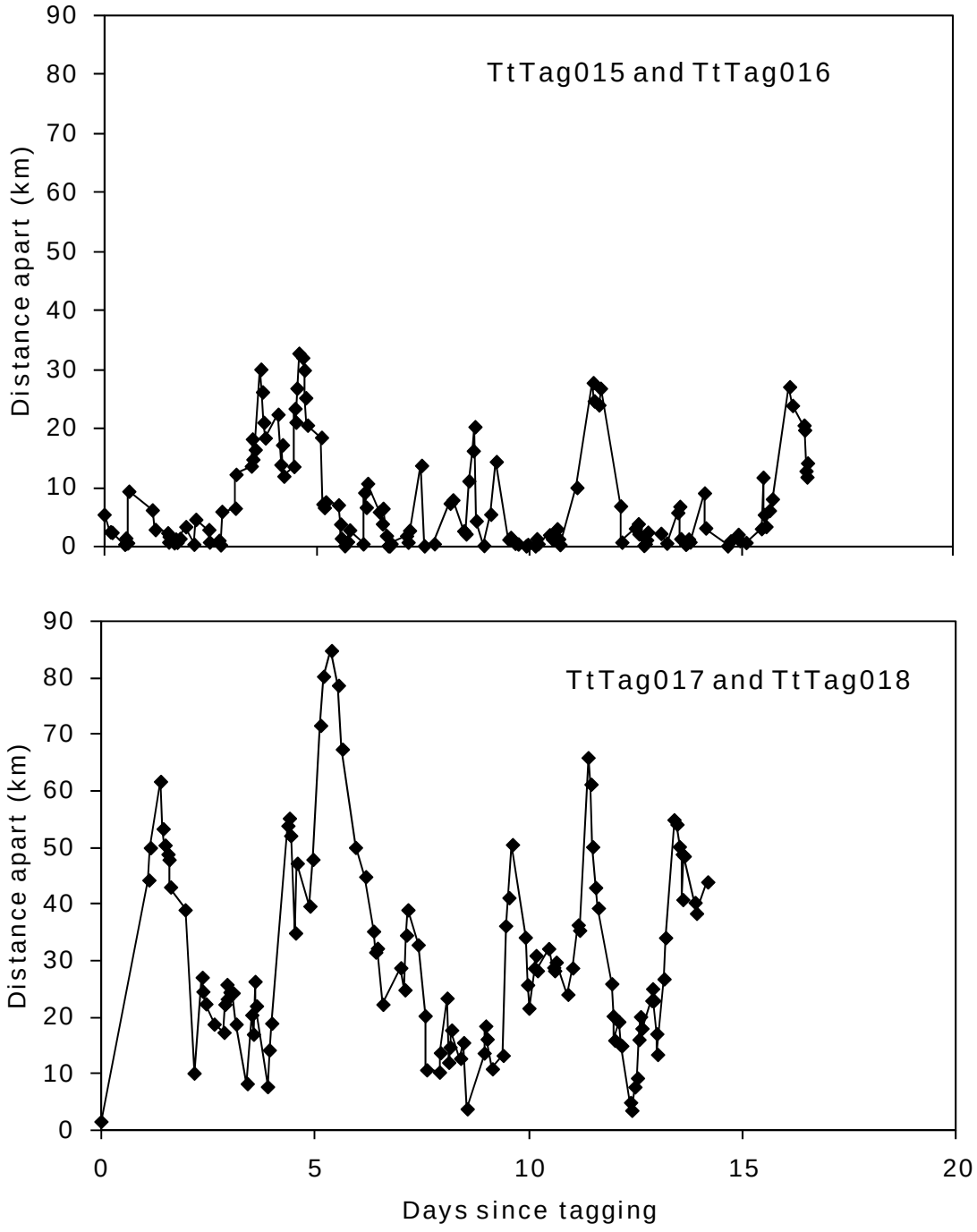


**Figure 1. Plots of distance between individual tagged bottlenose dolphins with temporally overlapping tag data. TtTag015 and TtTag016 remained a mean distance apart of 3.5 km (maximum of 32.8 km). The x- and y-axis scales are the same for comparison.**

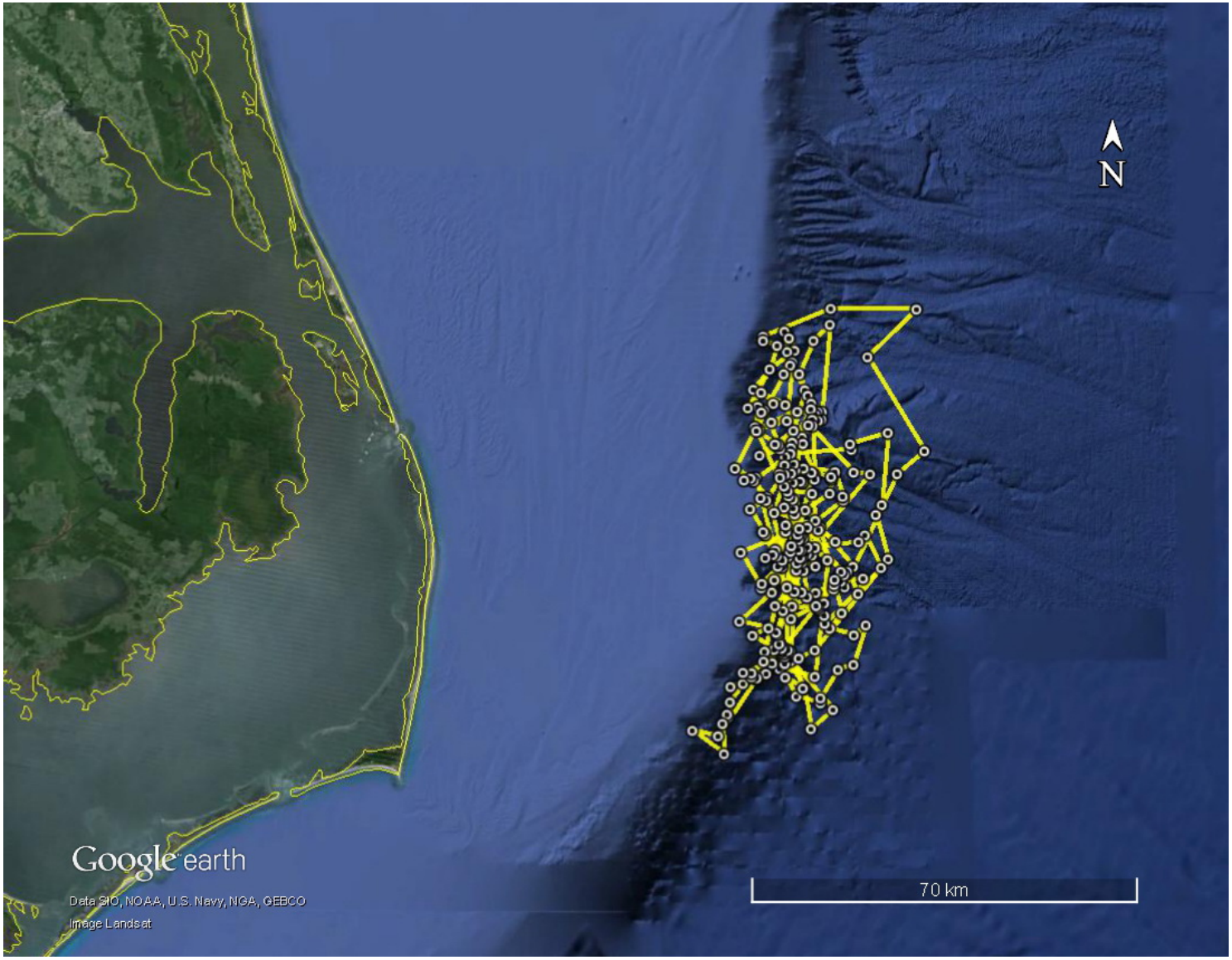


**Figure 2. All filtered locations of bottlenose dolphin TtTag015 over the 17.5-day tag-attachment duration, with consecutive locations joined by a line.**

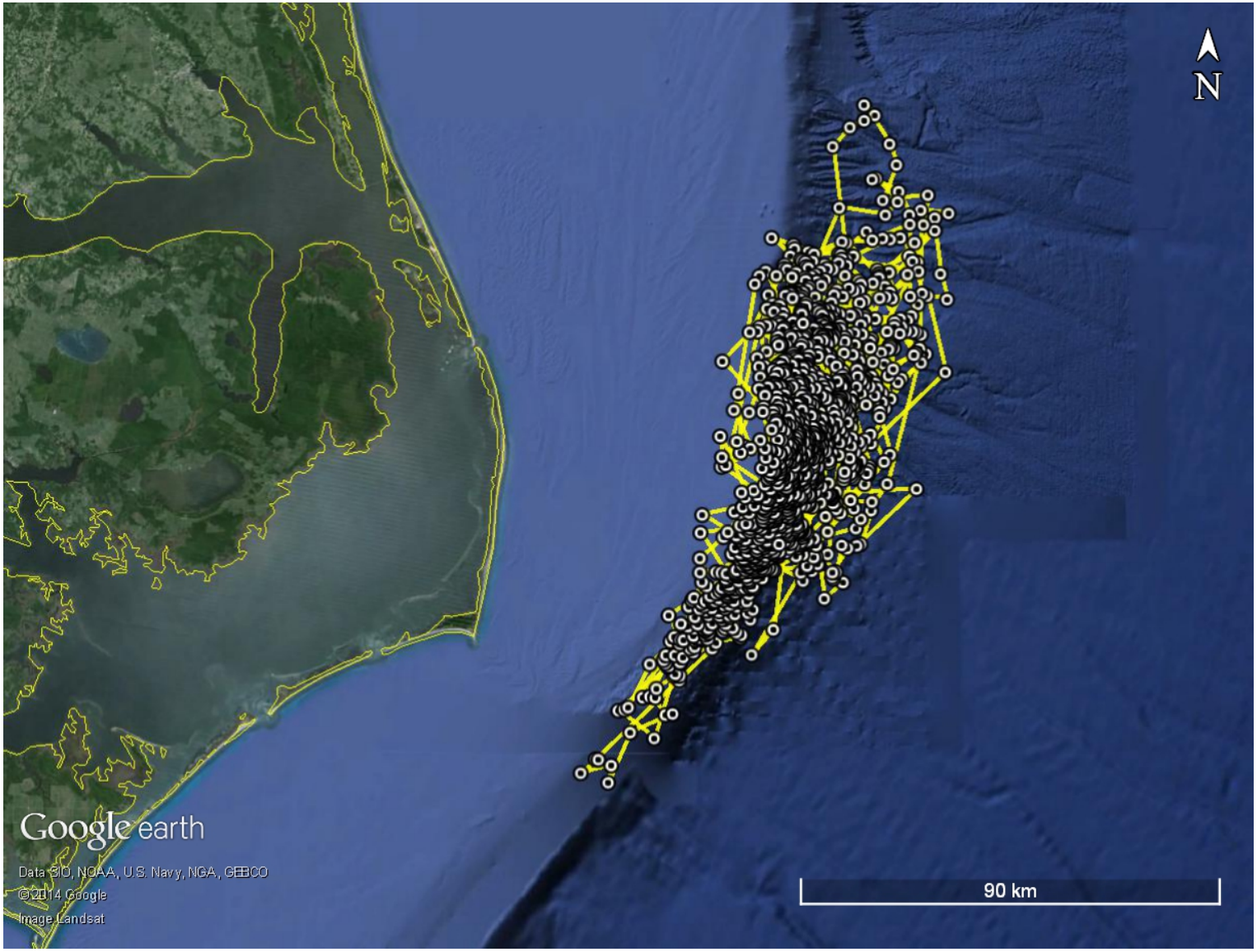


**Figure 3. All filtered locations of all five satellite-tagged bottlenose dolphins off North Carolina in 2014, with consecutive locations for each individual joined by a yellow line.**

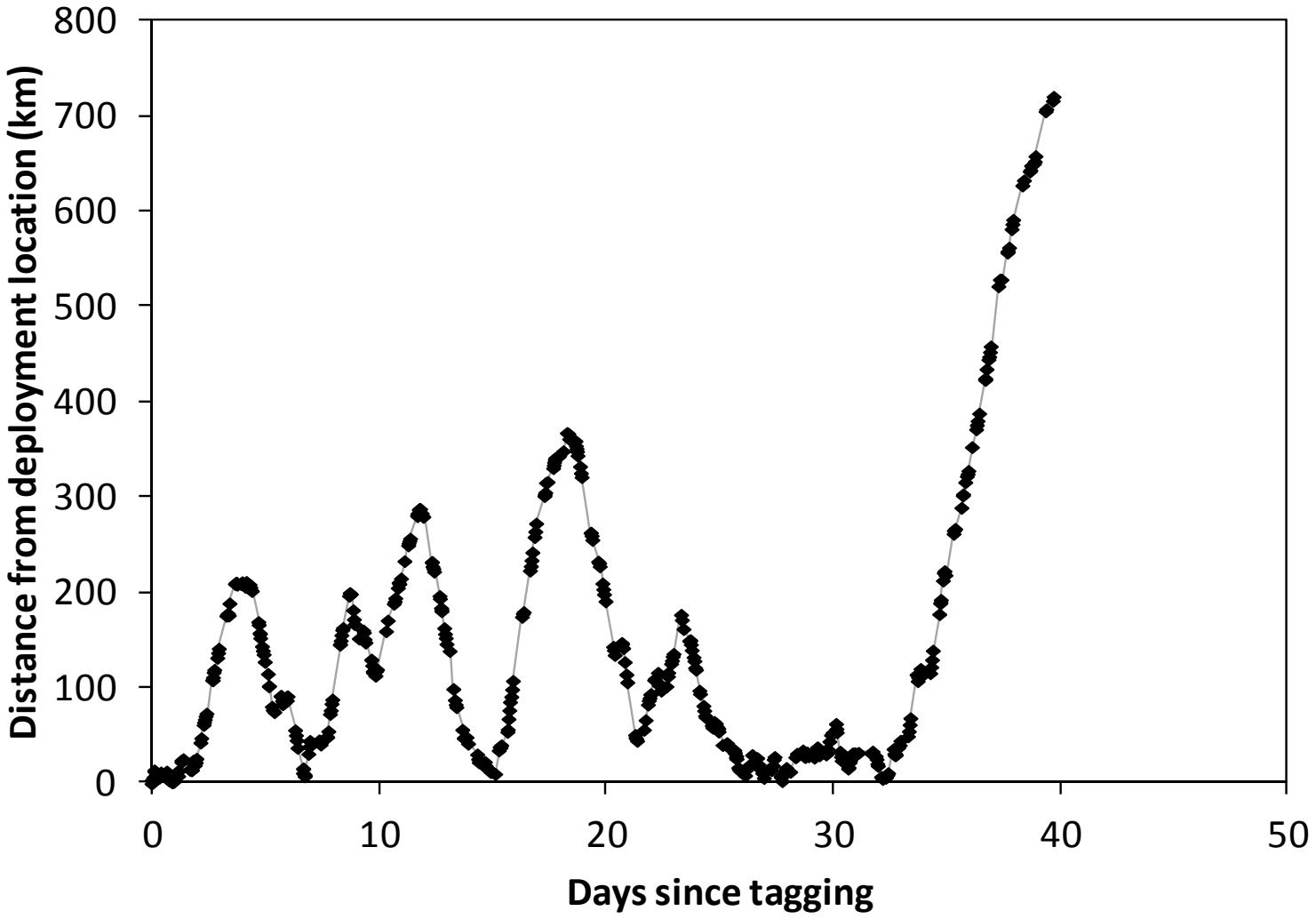


**Figure 4. Distance from deployment location for the short-beaked common dolphin satellite tagged off North Carolina.**

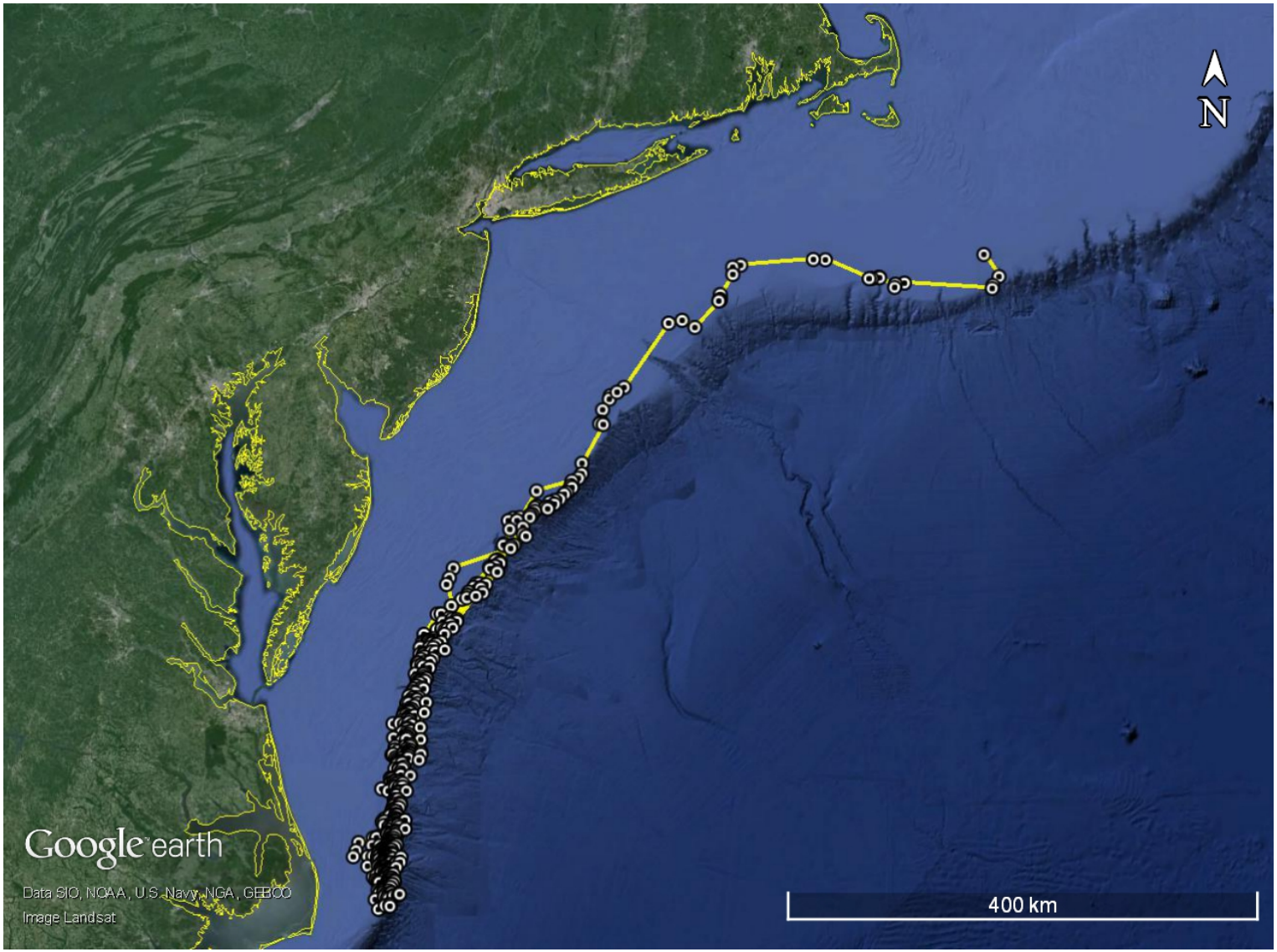


**Figure 5. All filtered locations of short-beaked common dolphin tagged off North Carolina over a 40-day period, with consecutive locations joined by a line.**

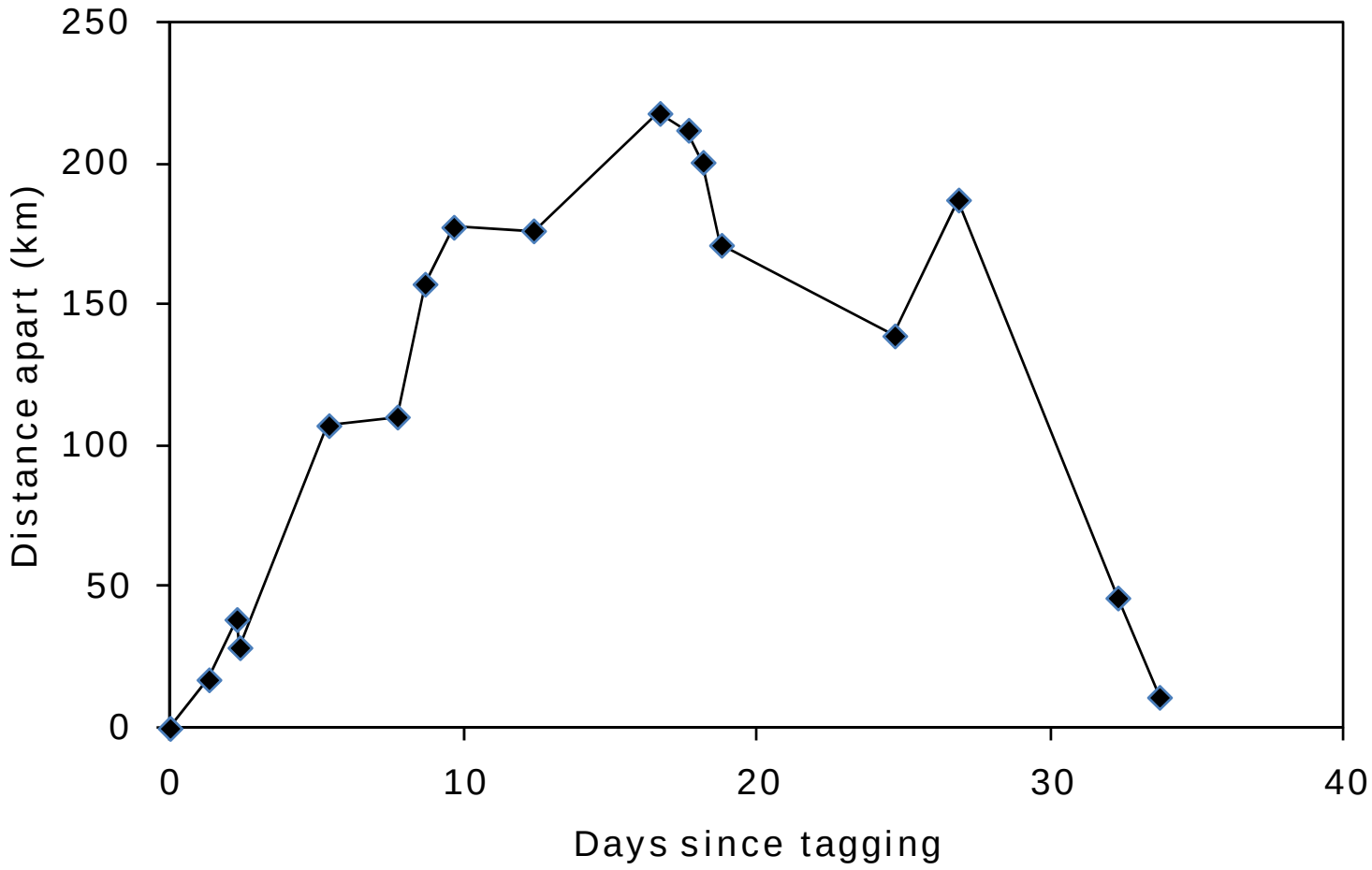


**Figure 6. Distance between Cuvier's beaked whales ZcTag030 and ZcTag031 over the period of tag overlap. While tagged within the same group on 16 September 2014, the two individuals acted independently.**

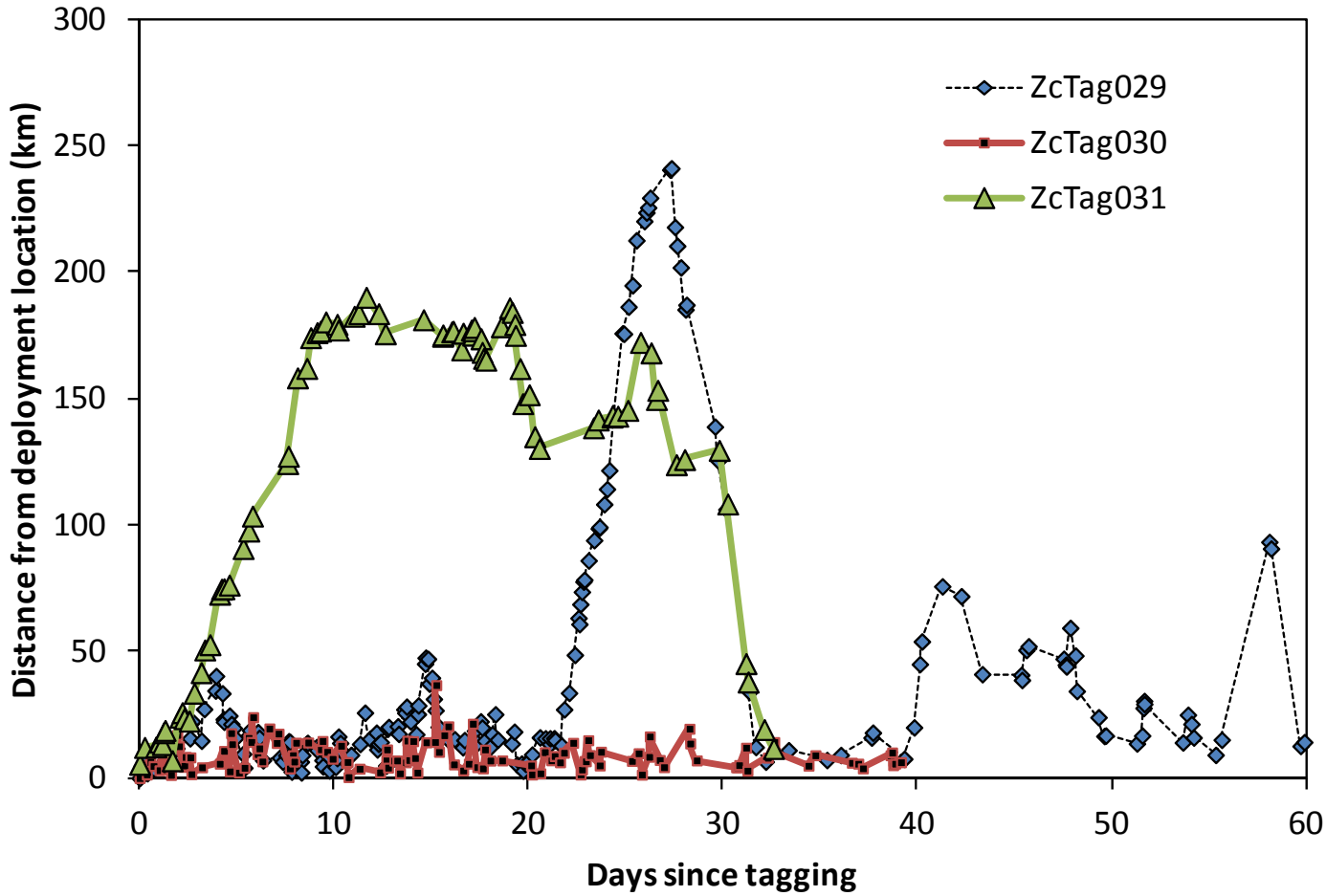


**Figure 7. Distance from tagging location for three satellite-tagged Cuvier's beaked whales tagged off North Carolina.**


**Figure 8. All filtered locations of Cuvier's beaked whale ZcTag029 tagged off North Carolina over a 60-day period, with consecutive locations joined by a line.**

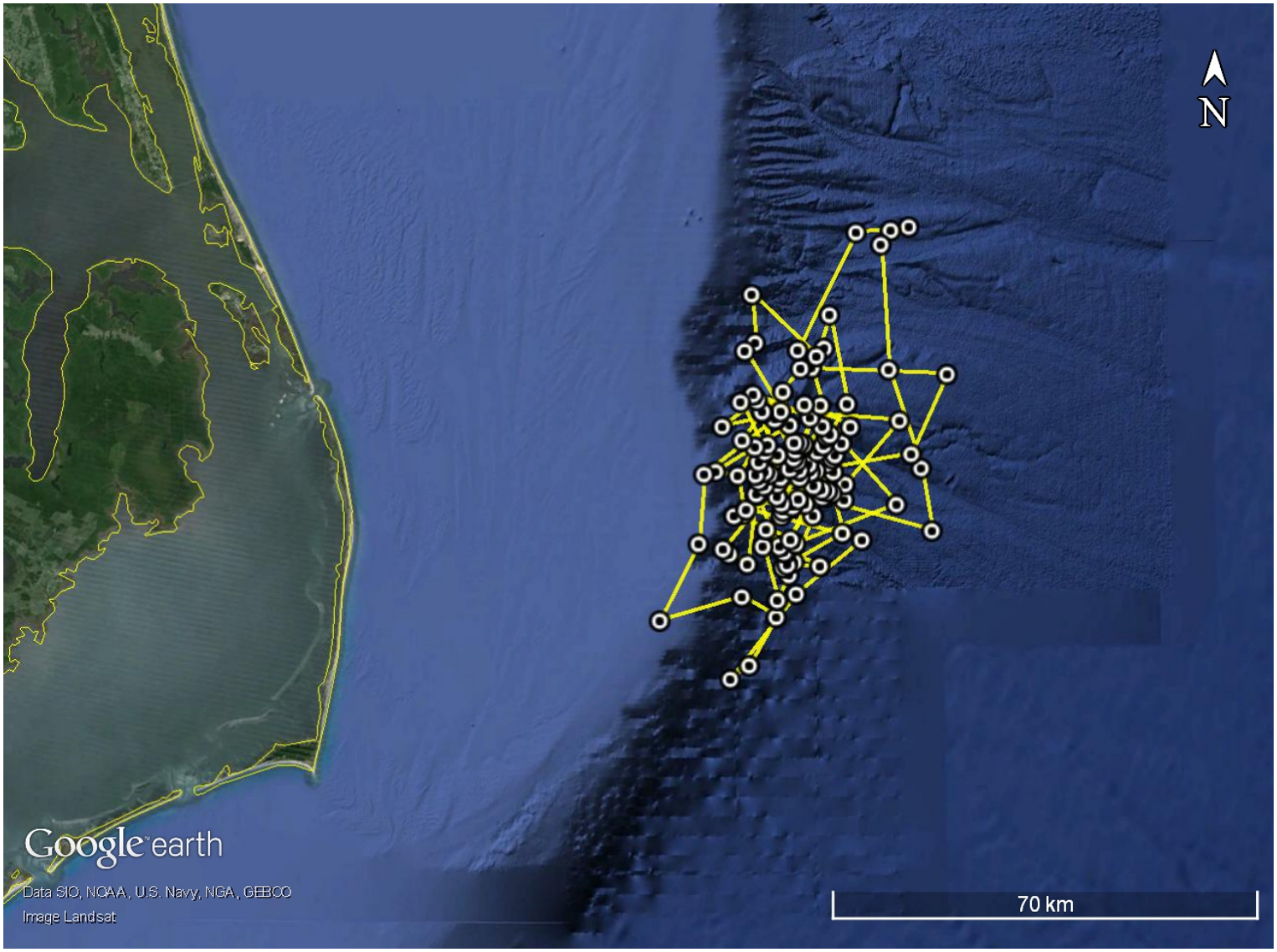


**Figure 9. All filtered locations of Cuvier's beaked whale ZcTag030 tagged off North Carolina over a 40-day period, with consecutive locations joined by a line.**

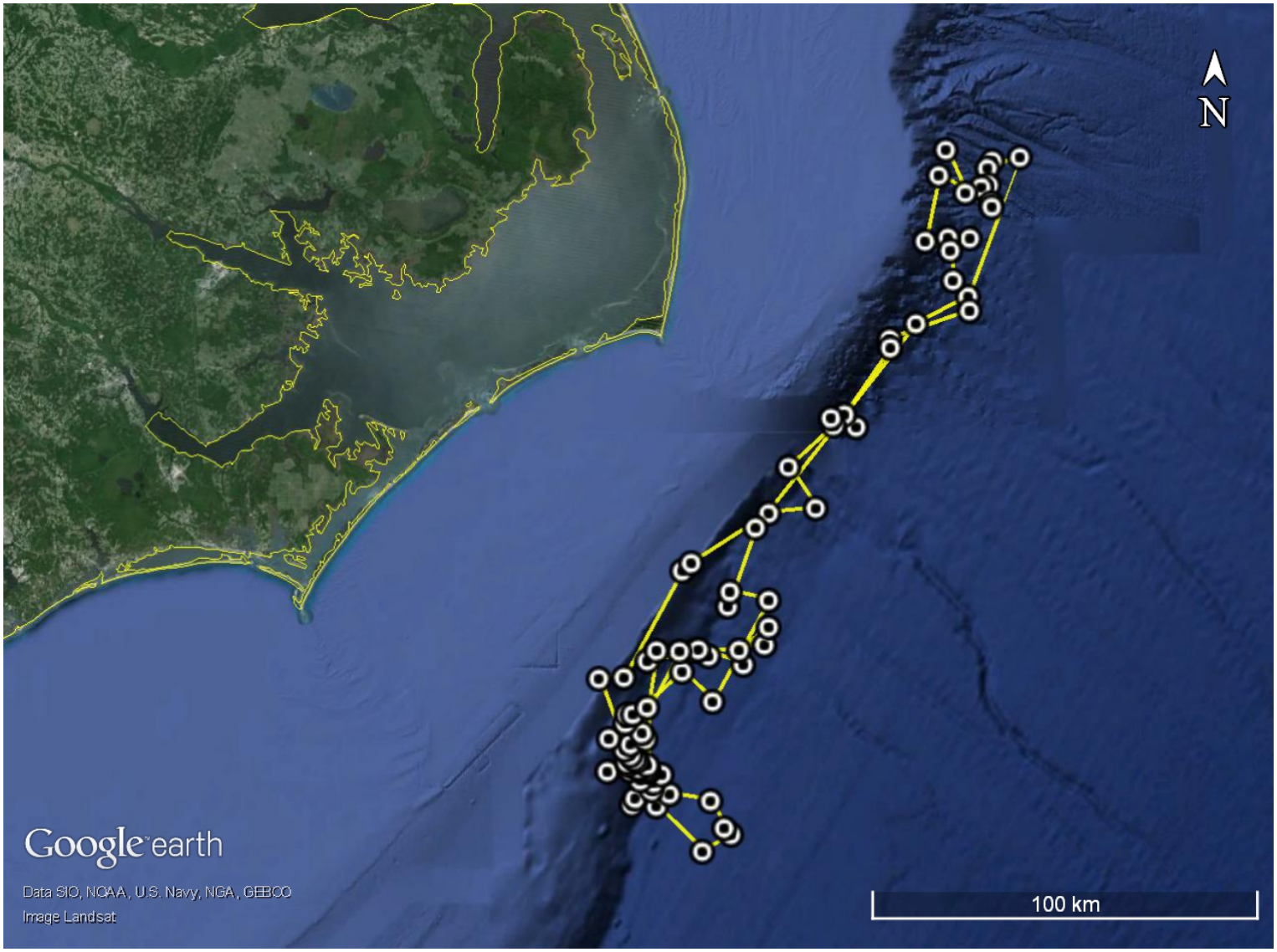


**Figure 10. All filtered locations of Cuvier's beaked whale ZcTag031 tagged off North Carolina over a 36-day period, with consecutive locations joined by a line.**

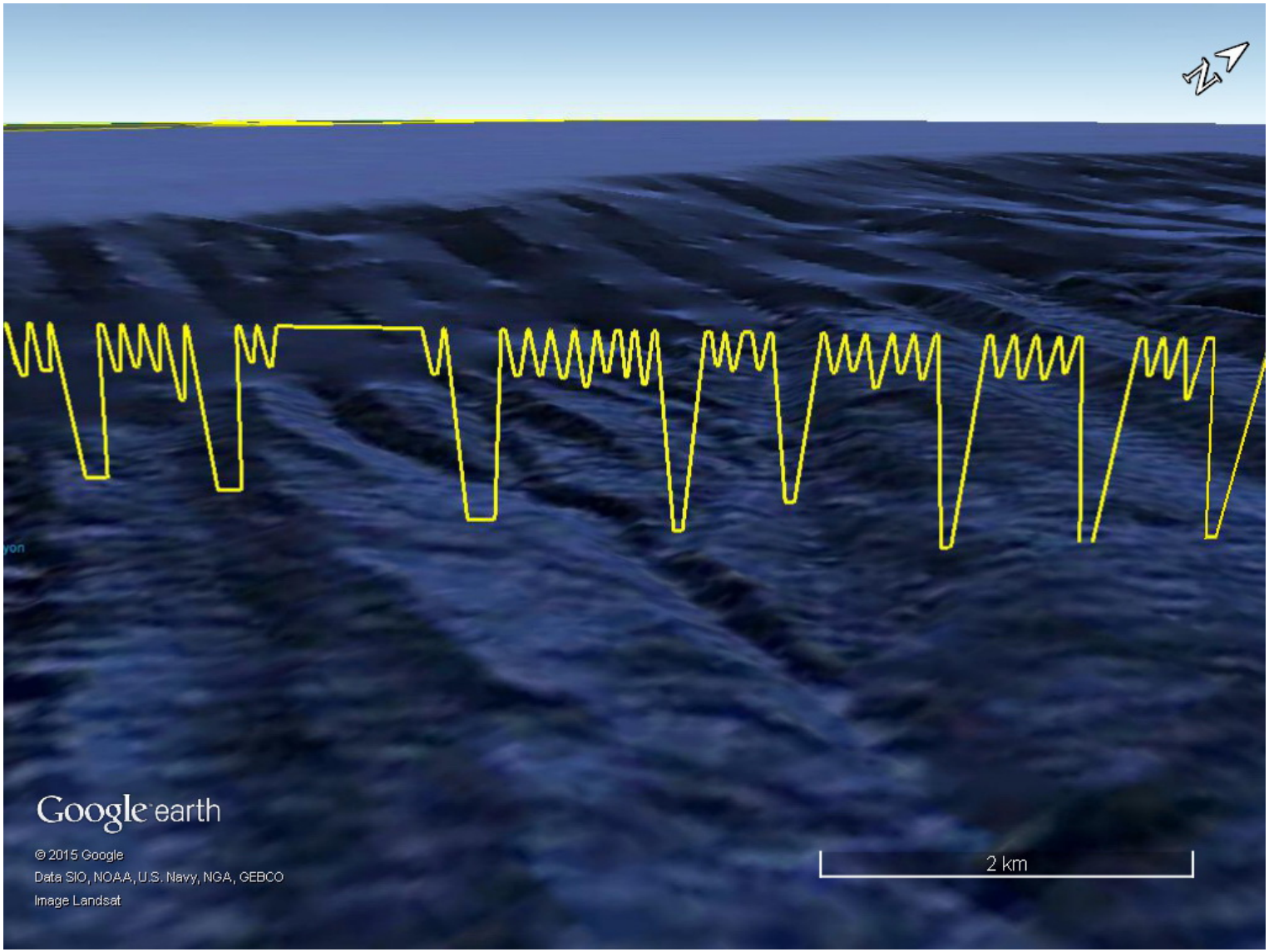


**Figure 11. An example of dive and location data from Cuvier's beaked whale ZcTag030 over a 21-hour 37-minute period starting on 19 September 2014 at 1239 (GMT) as the animal transits from the north (right side of figure) to south. The deep dives shown here range from 1,519 to 1,903 m in depth.**

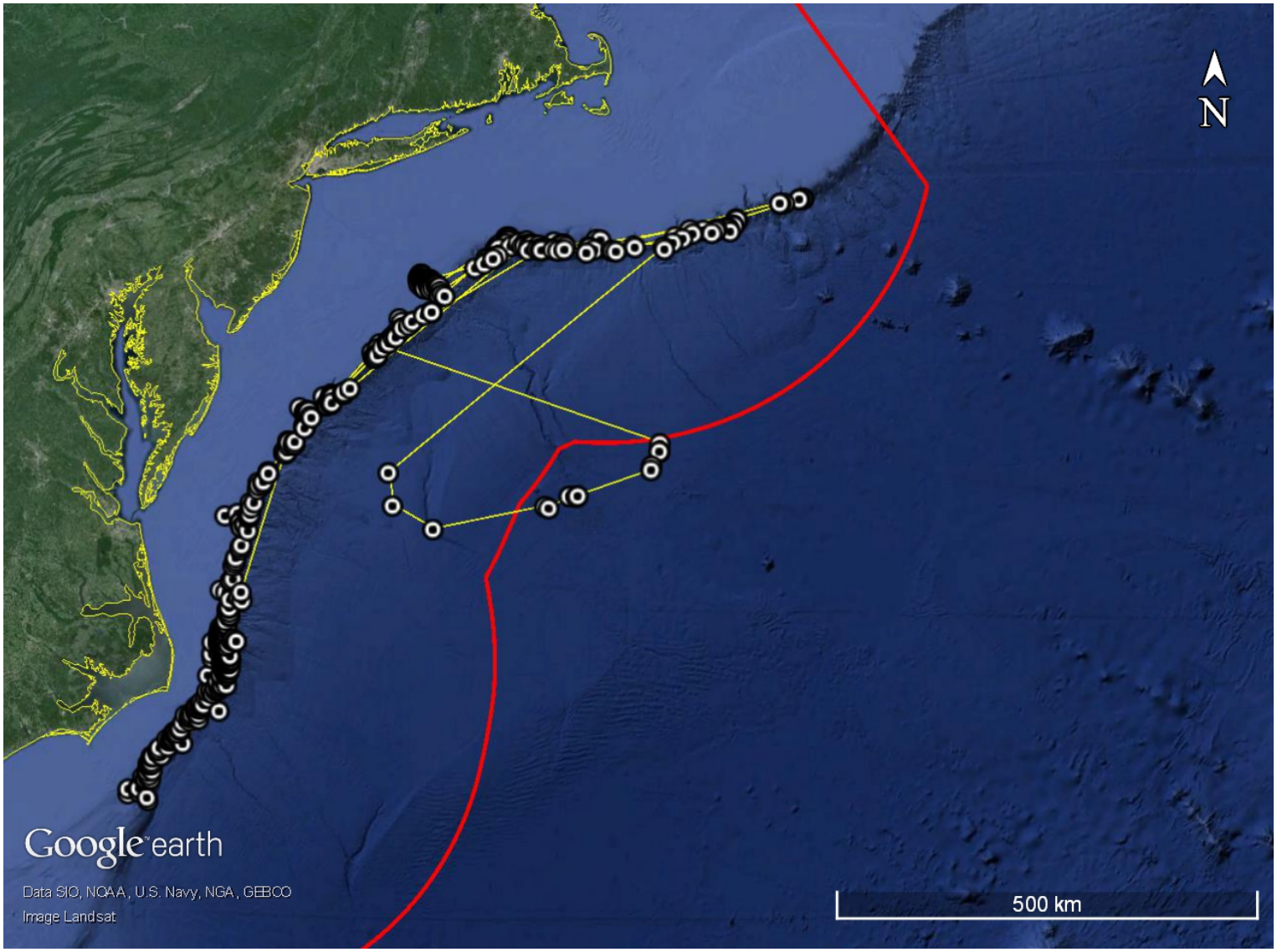


**Figure 12. Map showing all filtered locations of short-finned pilot whale GmTag087 tagged off North Carolina over a 194-day period, with consecutive locations joined by a yellow line. The U.S. Exclusive Economic Zone boundary is shown in a solid red line.**

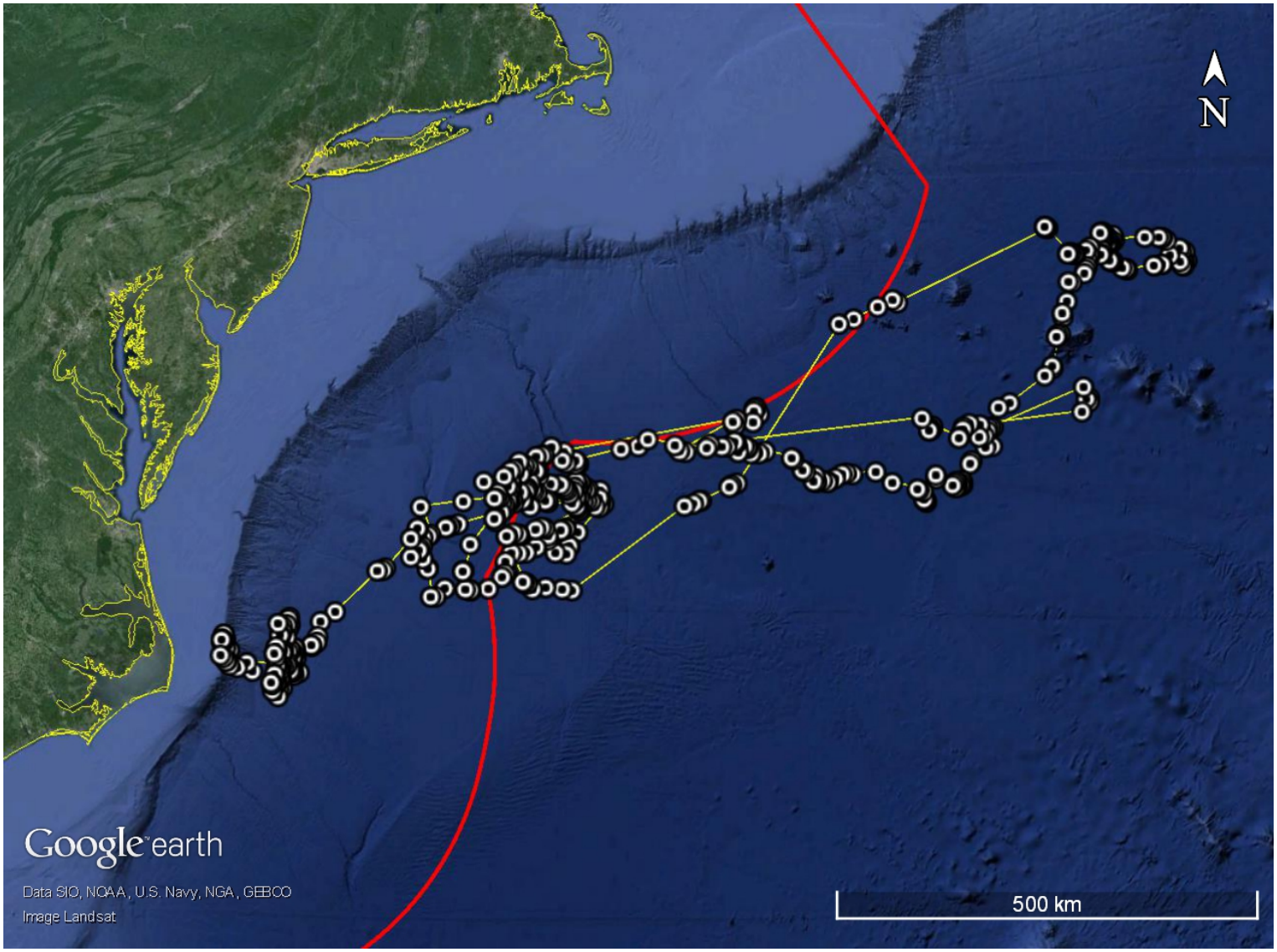


**Figure 13. Map showing all filtered locations of short-finned pilot whale GmTag088 tagged off North Carolina over a 104-day period, with consecutive locations joined by a yellow line. The U.S. Exclusive Economic Zone boundary is shown in a solid red line.**

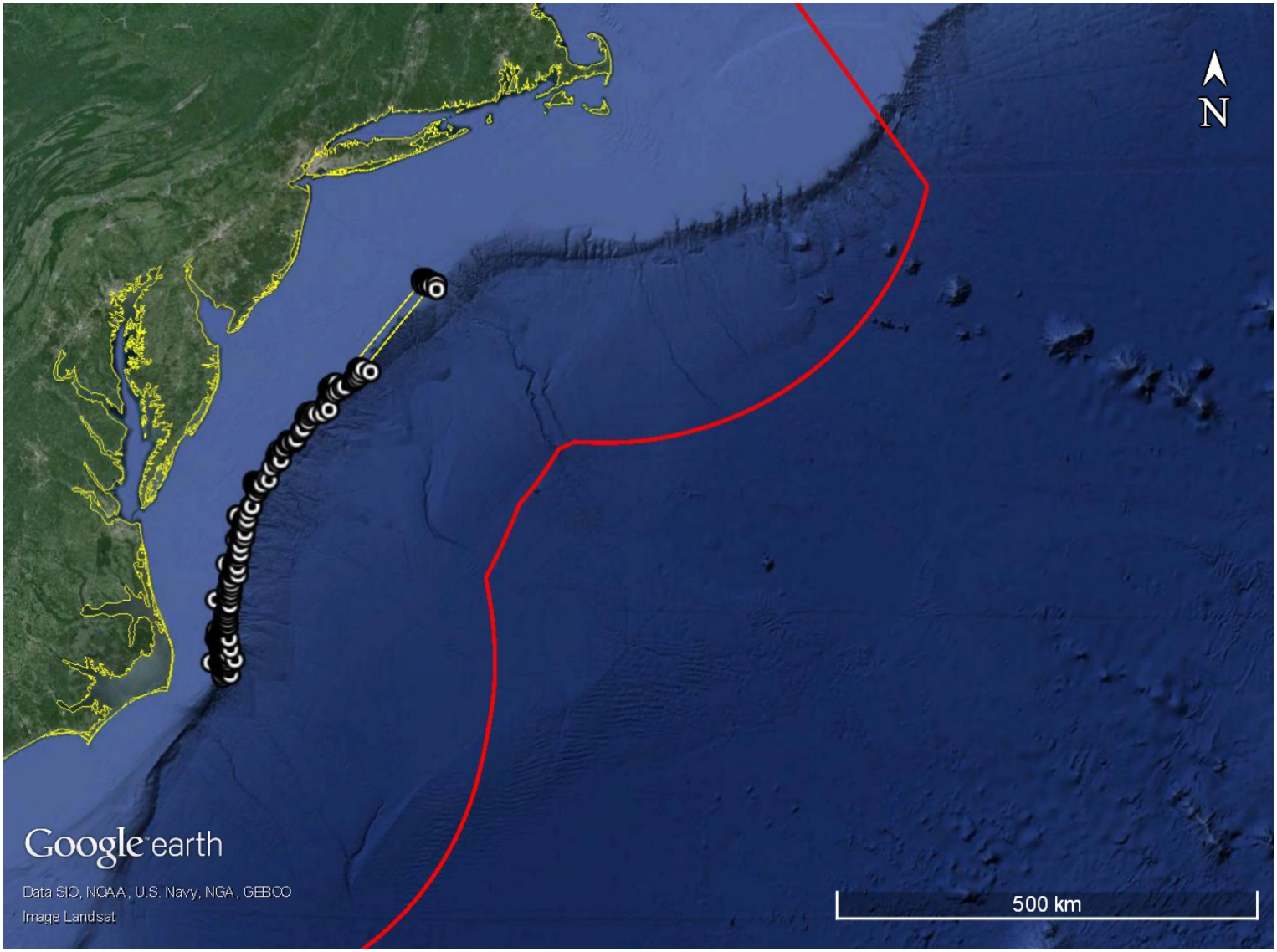


**Figure 14. Map showing all filtered locations of short-finned pilot whale GmTag094 tagged off North Carolina over an 85-day period, with consecutive locations joined by a yellow line. The U.S. Exclusive Economic Zone boundary is shown in a solid red line.**

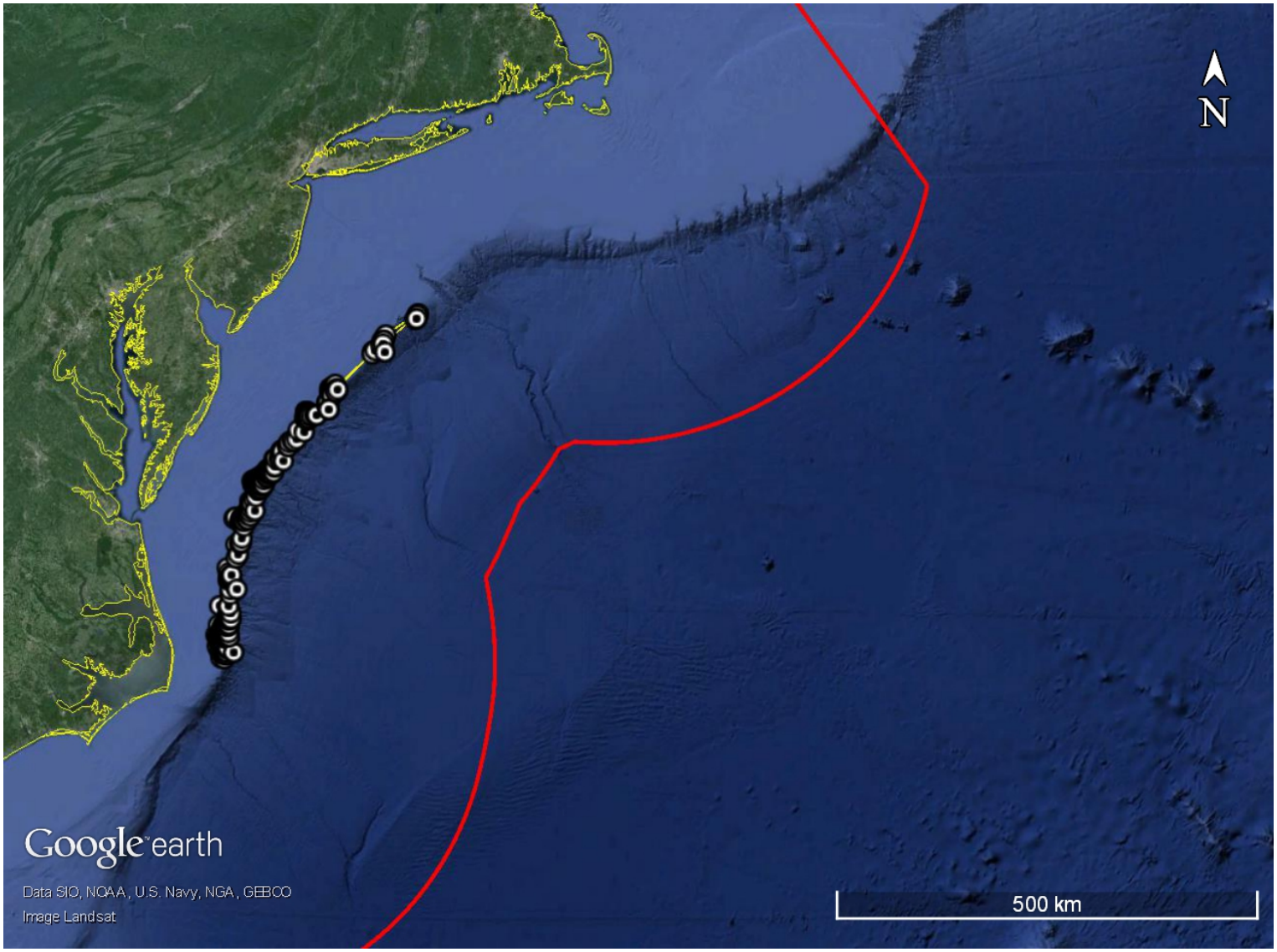


**Figure 15. Map showing all filtered locations of short-finned pilot whale GmTag095 tagged off North Carolina over an 84-day period, with consecutive locations joined by a yellow line. The U.S. Exclusive Economic Zone boundary is shown in a solid red line.**

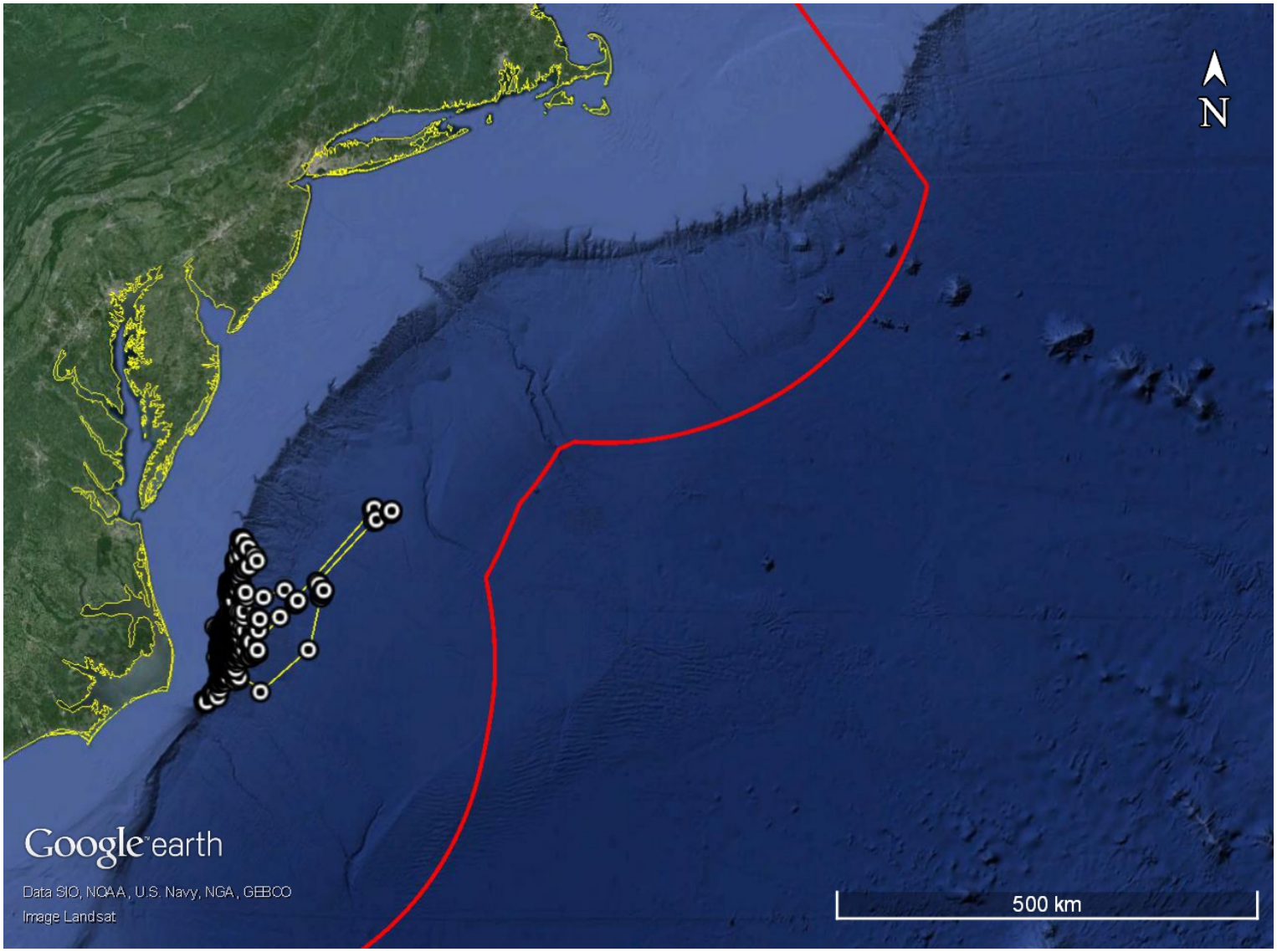


**Figure 16. Map showing all filtered locations of short-finned pilot whale GmTag103 tagged off North Carolina over a 109-day period, with consecutive locations joined by a yellow line. The U.S. Exclusive Economic Zone boundary is shown in a solid red line.**

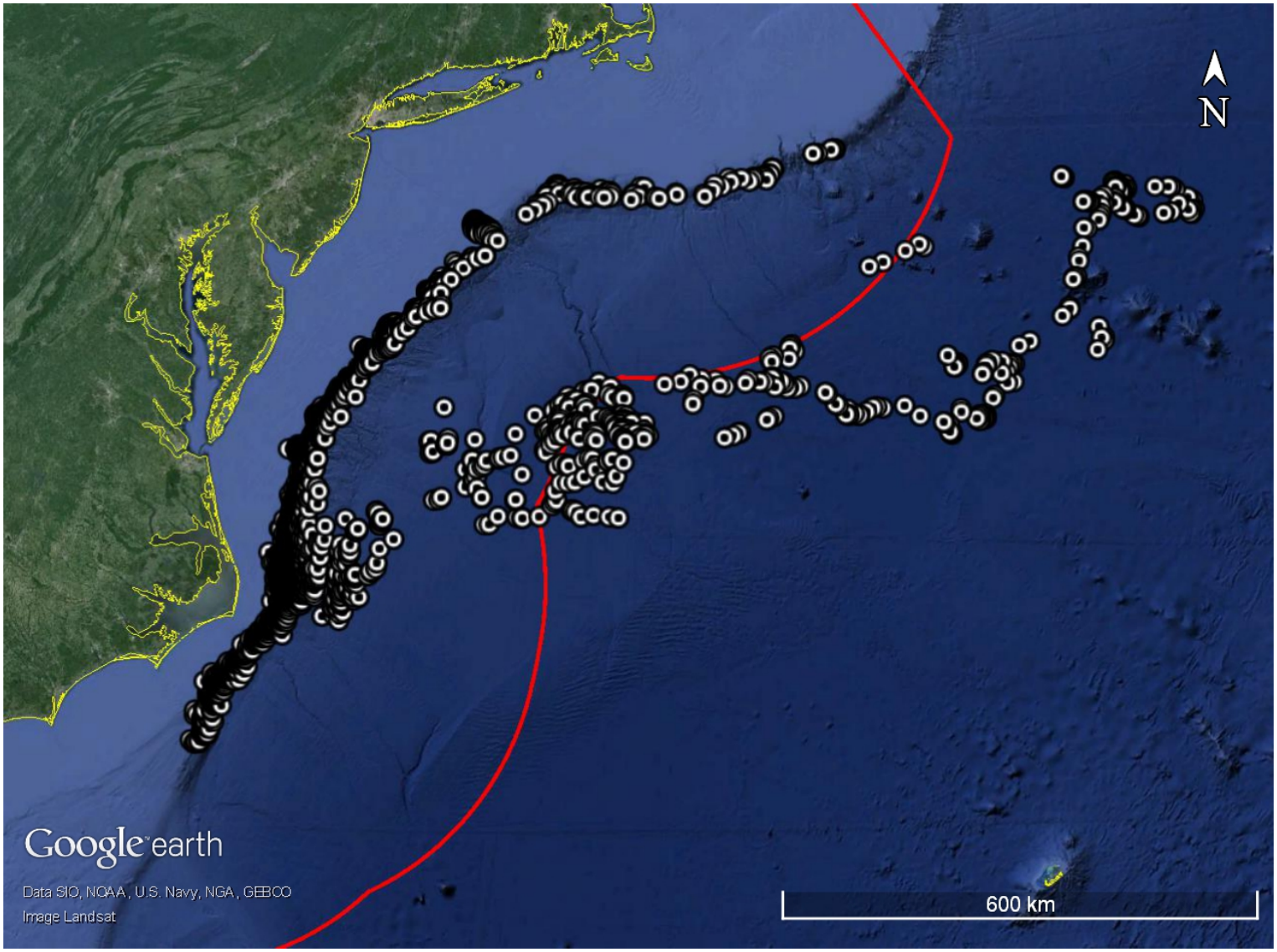


Figure 17. Map showing all filtered locations of all short-finned pilot whales tagged off North Carolina (see **Table 1**). The U.S. Exclusive Economic Zone boundary is shown in a solid red line.

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# B

# Tables

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**Table 1. Summary details on satellite tag deployments off Hatteras, North Carolina, during May, June, and September 2014**

| Species[1] | Tag ID | Tag Type | Deployment Date | Sighting # | Tag duration (days) | Deployment Latitude | Deployment Longitude |
|---|---|---|---|---|---|---|---|
| Tt | TtTag014 | SPOT5 | 5/18/2014 | 1 | 16.3 | 35.62 | -74.81 |
| Tt | TtTag015 | SPOT5 | 6/11/2014 | 5 | 17.5 | 35.70 | -74.72 |
| Tt | TtTag016 | Mk10-A | 6/11/2014 | 6 | 16.8 | 35.71 | -74.71 |
| Tt | TtTag017 | SPOT5 | 9/13/2014 | 6 | 16.3 | 35.69 | -74.70 |
| Tt | TtTag018 | Mk10-A | 9/16/2014 | 1 | 6.3 | 35.56 | -74.80 |
| Zc | ZcTag029 | Mk10-A | 5/13/2014 | 1 | 59.9 | 35.55 | -74.78 |
| Zc | ZcTag030 | Mk10-A | 9/16/2014 | 4 | 40.4 | 35.66 | -74.72 |
| Zc | ZcTag031 | SPOT5 | 9/16/2014 | 4 | 35.6 | 35.65 | -74.72 |
| Dd | DdTag001 | SPOT5 | 6/12/2014 | 1 | 39.7 | 35.59 | -74.85 |
| Gm | GmTag084 | SPOT5 | 5/14/2014 | 4 | 0.3 | 35.64 | -74.74 |
| Gm | GmTag085 | Mk10-A | 5/14/2014 | 4 | 37.5 | 35.64 | -74.75 |
| Gm | GmTag086 | SPOT5 | 5/14/2014 | 4 | 78.6 | 35.64 | -74.76 |
| Gm | GmTag087 | SPOT5 | 5/18/2014 | 3 | 193.8 | 35.65 | -74.77 |
| Gm | GmTag088 | SPOT5 | 6/7/2014 | 1 | 104.0 | 35.77 | -74.82 |
| Gm | GmTag089 | Mk10-A | 6/8/2014 | 4 | 0.0 | 35.58 | -74.76 |
| Gm | GmTag090 | SPOT5 | 6/8/2014 | 4 | 54.4 | 35.58 | -74.76 |
| Gm | GmTag091 | Mk10-A | 6/8/2014 | 4 | 0.0 | 35.59 | -74.76 |
| Gm | GmTag092 | SPOT5 | 6/11/2014 | 2 | 49.0 | 35.76 | -74.76 |
| Gm | GmTag093 | Mk10-A | 6/11/2014 | 2 | 18.0 | 35.77 | -74.77 |
| Gm | GmTag094 | SPOT5 | 6/11/2014 | 5 | 84.7 | 35.75 | -74.82 |
| Gm | GmTag095 | SPOT5 | 6/11/2014 | 5 | 83.8 | 35.78 | -74.84 |
| Gm | GmTag096 | SPOT5 | 9/11/2014 | 2 | 1.3 | 35.57 | -74.77 |
| Gm | GmTag097 | SPOT5 | 9/11/2014 | 3 | 31.7 | 35.59 | -74.72 |
| Gm | GmTag098 | Mk10-A | 9/11/2014 | 3 | 27.9 | 35.60 | -74.73 |
| Gm | GmTag099 | SPOT5 | 9/11/2014 | 3 | 63.5 | 35.59 | -74.72 |
| Gm | GmTag100 | Mk10-A | 9/11/2014 | 3 | 25.0 | 35.60 | -74.72 |
| Gm | GmTag101 | SPOT5 | 9/13/2014 | 4 | 32.3 | 35.60 | -74.78 |
| Gm | GmTag102 | SPOT5 | 9/13/2014 | 4 | 9.4 | 35.60 | -74.78 |
| Gm | GmTag103 | SPOT5 | 9/13/2014 | 5 | 109.2 | 35.67 | -74.77 |

[1] Dd = *Delphinus delphis*, Gm = *Globicephala macrorhynchus*; Tt = *Tursiops truncatus*, Zc = *Ziphius cavirostris*, Key: Spot = Smart Position and Temperature

**Table 2. Characteristics of movements in relation to tagging distance for satellite-tagged odontocetes with data for more than one day, tagged off North Carolina in 2014**

| Tag ID | # locations after filtering | Mean (SD) distance from tagging location (km) | Maximum distance from tagging location (km) | Total distance traveled (km) |
|---|---|---|---|---|
| TtTag014 | 293 | 32.0 (15.8) | 84.4 | 1,447.0 |
| TtTag015 | 231 | 18.6 (11.1) | 50.9 | 1,361.0 |
| TtTag016 | 214 | 21.1 (11.1) | 69.4 | 1,249.0 |
| TtTag017 | 231 | 18.5 (12.7) | 61.6 | 1,481.0 |
| TtTag018 | 178 | 11.9 (9.5) | 47.1 | 1,196.0 |
| ZcTag029 | 189 | 43.7 (57.4) | 241.0 | 2,058.0 |
| ZcTag030 | 120 | 8.6 (5.7) | 36.7 | 1,082.0 |
| ZcTag031 | 80 | 123.1 (61.8) | 190.0 | 852.0 |
| DdTag001 | 496 | 145.6 (148.7) | 720.7 | 4,436.0 |
| GmTag085 | 212 | 25.2 (31.4) | 198.3 | 1,265.8 |
| GmTag086 | 519 | 69.4 (69.2) | 325.4 | 3,775.0 |
| GmTag087 | 543 | 254.9 (235.5) | 834.4 | 7,563.5 |
| GmTag088 | 455 | 552.4 (367.1) | 1192.1 | 6,021.7 |
| GmTag090 | 354 | 124.1 (114.0) | 391.4 | 2,841.7 |
| GmTag092 | 316 | 137.0 (122.0) | 321.9 | 2,321.6 |
| GmTag093 | 202 | 36.2 (43.4) | 165.5 | 1,132.0 |
| GmTag094 | 423 | 143.4 (155.9) | 476.4 | 3,065.1 |
| GmTag095 | 350 | 145.3 (113.1) | 434.6 | 2,636.7 |
| GmTag096 | 17 | 4.0 (2.0) | 7.4 | 55.5 |
| GmTag097 | 210 | 10.8 (8.9) | 49.7 | 1,268.8 |
| GmTag098 | 219 | 104.6 (66.1) | 227.6 | 1,419.4 |
| GmTag099 | 465 | 40.0 (40.0) | 208.4 | 2,799.5 |
| GmTag100 | 251 | 105.7 (66.3) | 226.8 | 1,359.2 |
| GmTag101 | 256 | 64.1 (71.4) | 195.8 | 1,542.1 |
| GmTag102 | 96 | 29.9 (43.6) | 274.8 | 652.2 |
| GmTag103 | 608 | 35.7 (41.9) | 252.2 | 4,243.9 |

Key: Dd = *Delphinus delphis* (short-beaked common dolphin); Tt = *Tursiops truncatus* (bottlenose dolphin); Gm = *Globicephala macrorhynchus* (short-finned pilot whale); km = kilometer(s); Zc = *Ziphius cavirostris* (Cuvier's beaked whale)

**Table 3. Depth and distance from shore and the 200-m isobath from GIS analysis of filtered satellite-tag locations. Note: analyses are preliminary using 30 arc-second bathymetry data.**

| Tag ID | Depth (m) | | Distance from shore (km) | | | Distance from 200-m isobath (km) | |
|---|---|---|---|---|---|---|---|
| | Median | Max | Min | Median | Max | Median | Max |
| TtTag014 | 305.5 | 2,037 | 34.6 | 53.7 | 75.4 | 3.2 | 17.9 |
| TtTag015 | 1,301 | 2,292 | 50.5 | 66.5 | 94.5 | 4.0 | 30.4 |
| TtTag016 | 1,899 | 2,794 | 53.6 | 65.6 | 90.1 | 4.2 | 25.2 |
| TtTag017 | 1,643 | 2,162 | 56.1 | 76.5 | 103.3 | 12.1 | 38.3 |
| TtTag018 | 1,663 | 2,621 | 43.7 | 60.0 | 72.3 | 3.6 | 16.6 |
| ZcTag029 | 1,748 | 2,817 | 46.0 | 73.3 | 147.1 | 10.9 | 71.9 |
| ZcTag030 | 1,725 | 2,397 | 52.0 | 72.9 | 100.0 | 8.9 | 35.5 |
| ZcTag031 | 2,274 | 3,015 | 46.8 | 82.3 | 124.0 | 17.3 | 51.5 |
| DdTag001 | 297 | 1,626 | 34.5 | 90.9 | 155.5 | 3.8 | 35.4 |
| GmTag085 | 212 | 1,995 | 46.6 | 61.6 | 114.9 | 3.7 | 19.0 |
| GmTag086 | 790 | 2,829 | 44.0 | 69.0 | 132.6 | 3.1 | 17.3 |
| GmTag087 | 1,583 | 4,258 | 34.3 | 99.7 | 417.1 | 3.1 | 276 |
| GmTag088 | 4,279 | 5,147 | 56.9 | 398.9 | 615.1 | 258.6 | 395.2 |
| GmTag090 | 1,163 | 2,780 | 51.5 | 85.1 | 156.1 | 3.4 | 27.2 |
| GmTag092 | 1,260 | 2,855 | 49.1 | 92.8 | 140.5 | 2.6 | 23.5 |
| GmTag093 | 581 | 2,367 | 48.3 | 64.5 | 119.3 | 4.4 | 15.5 |
| GmTag094 | 957 | 2,502 | 46.1 | 89.2 | 153.8 | 2.7 | 17.4 |
| GmTag095 | 1,170 | 2,314 | 54.5 | 95.5 | 157.8 | 2.5 | 13.3 |
| GmTag096 | 1,766 | 2,133 | 56.0 | 62.2 | 66.6 | 1.9 | 7.9 |
| GmTag097 | 1,807 | 2,686 | 46.2 | 62.6 | 74.5 | 2.7 | 18.1 |
| GmTag098 | 2,151 | 2,912 | 34.5 | 65.7 | 101.7 | 3.4 | 30.6 |
| GmTag099 | 1,199 | 2,679 | 49.4 | 67.3 | 123.0 | 4.0 | 45.4 |
| GmTag100 | 2,102 | 2,865 | 37.7 | 65.3 | 98.9 | 2.6 | 29.2 |
| GmTag101 | 1,029 | 2,319 | 45.2 | 62.1 | 111.0 | 2.9 | 18.7 |
| GmTag102 | 1,365 | 2,431 | 53.5 | 60.7 | 112.1 | 3.0 | 11.0 |
| GmTag103 | 1,512 | 3,326 | 45.7 | 67.9 | 241.8 | 4.2 | 139 |

Key: Dd = *Delphinus delphis* (short-beaked common dolphin); Tt = *Tursiops truncatus* (bottlenose dolphin); Gm = *Globicephala macrorhynchus* (short-finned pilot whale); km = kilometer(s); m = meter(s); Zc = *Ziphius cavirostris* (Cuvier's beaked whale)

**Table 4. Summary of diving behavior data from location-depth tags.**

| Tag ID | # days behavior data | % of total record | % day time | % night time | # dives > 50 m | Max dive depth (m) | Max dive duration[1] (min) |
|---|---|---|---|---|---|---|---|
| TtTag016 | 8.5 | 51% | 54% | 46% | 459 | 720 | 10.2 |
| TtTag018 | 2.8 | 22% | 49% | 51% | 237 | 944 | 13.8 |
| ZcTag029 | 16.2 | 34% | 60% | 40% | 741 | 2,800 | 98.0 |
| ZcTag030 | 25.7 | 67% | 47% | 53% | 1,203 | 2,160 | 86.6 |
| GmTag085 | 15.4 | 42% | 58% | 42% | 588 | 1,072 | 20.0 |
| GmTag093 | 5.7 | 33% | 61% | 39% | 452 | 816 | 18.6 |
| GmTag098 | 19.6 | 72% | 48% | 52% | 942 | 1,104 | 26.0 |
| GmTag100 | 19.6 | 79% | 50% | 50% | 775 | 1,072 | 24.2 |

[1]For bottlenose dolphins, depth readings of 3 m are used to determine start and end of dive durations, thus dive durations are slightly negatively biased.

Key: % = percent; Tt = *Tursiops truncatus* (bottlenose dolphin); Gm = *Globicephala macrorhynchus* (short-finned pilot whale); m = meter(s); min = minute(s); Zc = *Ziphius cavirostris* (Cuvier's beaked whale)

**Table 5. Distances between selected pairs of short-finned pilot whales with temporally overlapping tag data. Distances are calculated when locations are received during the same satellite overpass. All pairs tagged within the same group and on the same day are shown, and selected pairs tagged on different days are included.**

| Pair | Mean distance apart (km) | Max distance apart (km) | Timing of tagging |
|---|---|---|---|
| GmTag084-085 | 7.2 | 9.9 | Same group |
| GmTag092-093 | 12.0 | 80.4 | Same group |
| GmTag094-095 | 74.0 | 292.4 | Same group |
| GmTag097-098 | 103.6 | 209.7 | Same group |
| GmTag097-099 | 27.5 | 90.3 | Same group |
| GmTag098-100 | 3.2 | 19.6 | Same group |
| GmTag098-099 | 117.4 | 235.4 | Same group |
| GmTag099-100 | 117.5 | 243.1 | Same group |
| GmTag101-102 | 2.5 | 10.6 | Same group |
| GmTag097-100 | 109.7 | 223.4 | Same group |
| GmTag092-094 | 73.0 | 315.7 | Same day |
| GmTag092-095 | 35.8 | 182.1 | Same day |
| GmTag096-100 | 6.7 | 11.2 | Same day |
| GmTag096-097 | 6.2 | 12.1 | Same day |
| GmTag096-098 | 11.4 | 19.9 | Same day |
| GmTag096-099 | 6.3 | 10.2 | Same day |
| GmTag101-103 | 57.1 | 169.5 | Same day |
| GmTag102-103 | 21.6 | 75.7 | Same day |
| GmTag085-086 | 27.6 | 100.9 | Different day |
| GmTag085-087 | 28.1 | 181.4 | Different day |
| GmTag085-088 | 162.0 | 344.2 | Different day |
| GmTag085-090 | 102.6 | 175.1 | Different day |
| GmTag085-092 | 74.2 | 160.5 | Different day |
| GmTag085-093 | 63.5 | 184.4 | Different day |
| GmTag085-094 | 55.5 | 175.5 | Different day |
| GmTag085-095 | 58.3 | 179.1 | Different day |
| GmTag086-087 | 160.1 | 713.9 | Different day |
| GmTag086-088 | 385.3 | 1021.5 | Different day |
| GmTag086-090 | 69.7 | 256.5 | Different day |
| GmTag086-092 | 70.2 | 308.5 | Different day |
| GmTag086-093 | 51.5 | 137.4 | Different day |
| GmTag086-094 | 37.3 | 148.7 | Different day |
| GmTag086-095 | 55.6 | 220.9 | Different day |

KeyGm = *Globicephala macrorhynchus* (short-finned pilot whale); km = kilometer(s)

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