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Rehabilitation and Homing Behavior of a Satellite-Tracked Harbor Porpoise (*Phocoena phocoena*)

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Abstract

A yearling male harbor porpoise (*Phocoena phocoena*) stranded alive on the shores of Avon, North Carolina, and was rehabilitated for nearly 10 mo at the National Aquarium in Baltimore and the University of New England. The porpoise was released over 1,204 km north of its original stranding location and was tracked for 63 d with a satellite tag. The porpoise remained in the Gulf of Maine for 3 wks before moving south along the edge of the continental shelf, returning near to its original stranding site on the coast of North Carolina. Data suggests that the animal was thriving at the time of tag failure, 63 d after release. In this paper, the rehabilitation, release, tagging, tracking, and homing behavior (returning to a previously occupied home range or activity area) are described for this Northwest Atlantic harbor porpoise.

Key Words: satellite tag, rehabilitation, homing, harbor porpoise, *Phocoena phocoena*

Introduction

A yearling male harbor porpoise (*Phocoena phocoena*) was discovered stranded alive in the early morning hours on 21 March 2003 in Avon, North Carolina. The Virginia Aquarium and Marine Science Center Stranding Program (VAQS) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries Office, Beaufort, North Carolina, responded. The VAQS team examined the porpoise and found it to be emaciated, with linear marks that suggested recent net entanglement. They transported the porpoise to a temporary holding tank at the Virginia Aquarium and Marine Science Center stranding facility by 1430 h the same day. The porpoise was held overnight and transported to the National Aquarium in Baltimore (NAIB) the next day for long-term rehabilitation. The porpoise was placed in a stretcher and supported inside a small cetacean carrier consisting of an aluminum frame, a vinyl water collection bag, and open cell foam for support during its transport within a closed, temperature-controlled truck.

Upon admission, the porpoise was determined to be underweight and medically compromised. He was 117 cm in total length (snout to fluke notch), weighed 21.8 kg, and had an axial girth of 66 cm. A porpoise of this length is considered to be weaned or "young of the year" and approximately 10 mo of age (Read & Hohn, 1995). There were signs of predation by pecking seagulls and ligature marks on the pectoral flippers and flukes, suggesting injury from net entanglement. The animal swam in idiosyncratic tight circles with a head shake. During the course of the animal's rescue and rehabilitation, it was accessioned by the various agencies and organizations involved and provided with the following reference numbers: NAIB0304PP by the NAIB, NMFS Field #KMS256, NMFS Regional #SER03-191 NMFS, and NMFS National #SE-2003-1002375.

Materials and Methods

Medical Profile and Rehabilitation

Medically, the porpoise presented as underweight and dehydrated with a hematological analysis that was indicative of muscle trauma from stranding and transport. There was evidence of corneal opacity, which eventually resolved. Predation by birds at the time of beaching was seen by "peck" marks in the animal's skin, and there were line imprint lesions near the head that were suspected to be related to gillnet interaction.

While in rehabilitation, the animal exhibited a stereotypic tight circle swimming and an idiosyncratic "head shake," both of which could have been indicative of new surroundings in a rehabilitation setting. Deep chuffing (forceful exhalation in cetaceans) was noted from 26 March 2003 until 1 January 2004. The animal's blowhole was cultured and found to have a severe fungal infection. It was treated, but occasional recurrence was observed (Table 1). Tests were negative for morbilli virus and herpes virus (Oklahoma Animal Disease Diagnostic Laboratory: Morbillivirus CDV, DMV, and PDV Serum neutralization differential; Seal Herpesvirus serum neutralization type I; Seal Herpesvirus serum neutralization type II) as well as negative for both *Brucella abortus* and *B. canis* via card agglutination analysis.

After 3 d, a small (0.5 cm diameter), slightly raised skin lesion was noted at the dorsal surface of the right pectoral fin. Within the week, ten more small, pinpoint lesions had developed on both the left and right sides of the animal's dorsum just below the dorsal fin. The original lesion had progressed into a fluid-filled vesicle with an irregular surface. A biopsy of this lesion showed hyperplastic squamous epithelium consistent with trauma, papillomavirus infection, and poxvirus infection. No viral inclusions were noted. Antibiotic therapy used early in the treatment of this animal (Table 1) did not seem to have a marked effect on the resolution of the skin lesions which took 9 mo to completely resolve.

The porpoise spent 6 mo at NAIB in Baltimore, where he improved medically and behaviorally. Arrangements were made to transport the animal north to Maine, with the assumption that a release from that region would give the animal the best chance to encounter conspecifics in an area known for abundant harbor porpoises. On 5 September 2003, he was transported to the University of New England (UNE), Biddeford, Maine, using the same transport method described earlier and aboard a U.S. Coast Guard Falcon Jet. The porpoise spent an additional 4 mo being prepared for release at the UNE facility. At the time of release, the porpoise was 129-cm long and weighed 41.36 kg, growing 12 cm and nearly doubling in weight. Its body condition and its length of 129 cm appeared to be comparable to wild conspecifics (Read & Tolley, 1997). The 10-mo rehabilitation included numerous medical treatments, husbandry procedures, environmental enrichment techniques, and counterconditioning (Geraci & Lounsbury, 2005; Schofield et al., 2005). During the latter part of rehabilitation, the porpoise was gradually acclimated to local sea water and ambient temperatures using a natural water flow-through system at UNE.

Table 1. Overview of medications used throughout the rehabilitation of the porpoise by the veterinary staff from the National Aquarium in Baltimore (NAIB), Virginia Aquarium and Marine Science Center Stranding Program (VAQS), and the University of New England, Marine Animal Rescue Center (MARC)

Medication dosage	Treatment application
Calcium gluconate IM 1 ml/10 #, Selenium IM 0.6 mg/kg, Prednisolone IM 37.5 mg, 0.26 cc valium (0.06 mg/kg)	Stabilizing for transport at rescue (VAQS)
Diazepam (variable throughout rehabilitation)	Adjustment period to new areas of rehabilitation, when exhibiting abnormal behavior such as tight circle swimming, medical procedures, and transports (NAIB, VAQS, MARC)
Ceftazadime 20 mg/kg IM SID 3 d; followed by Cephalexin 15 mg/kg PO BID 14 d	Suspected possible skin and/or respiratory fungal infection treatment provided until diagnostics could be conducted and results obtained; discontinued when no evidence of bacterial infection present (NAIB)
Itraconazole 5 mg/kg PO BID 5 d then 2.5 mg/kg PO BID 4 d	Suspected possible skin and/or respiratory fungal infection treatment provided until diagnostics could be conducted and results obtained; discontinued when no evidence of fungal infection present (NAIB)
Nystatin 500000 IU TID 15 d	Possible gastrointestinal fungal elements seen concurrent with abdominal discomfort; treatment appeared ineffective and cultures were negative so treatment was discontinued (NAIB)
Ivermectin 7 cc once	Nematode treatment (MARC)

Release Determination and Plan

The staff of NAIB and UNE presented a release determination and release plan for this porpoise (NAIB0304PP, aka "Gus") to NOAA Fisheries. The plan reported the basis of the determination and included information on the absence of diagnosable disease, independence from medication, demonstration of a wariness of humans, and the porpoise's ability to track and ingest live fish.

NOAA Fisheries requires a review of behavior, life history, and natural history prior to the release of any rehabilitated marine mammal. The presence of conspecifics is presumed to be important criteria for determining an appropriate release site—a critical component of a release plan. Though this species is thought of as minimally social, its age class warranted release into a known area of conspecific activity. The decision to release this animal 15 to 20 km from Portland, Maine, was based on numerous harbor porpoise sightings: (1) 28 October 2003, east of Cape Elizabeth, Maine; (2) aerial survey on 7 November 2003 that produced three sightings of harbor porpoises in the areas north of Platts Bank (43º 25' N, 69º 28.4' W); and (3) along Three Dory Ridge (43º 25' N, 69º 19' W), approximately 88.51 km southeast of Cape Elizabeth, Maine (Wenzel, pers. comm., and from general stock range information found in Waring et al., 2004).

Past Examples of Post-Release Monitoring

Past examples of post-release monitoring were reviewed while considering this animal's release. Two previous cases of successful rehabilitation and release of harbor porpoises were in the northeast and mid-Atlantic regions. Case No. NAIB9508PP (freeze brand 508) was 121-cm long, weighed 23.6 kg at rescue, and after 13 mo of rehabilitation, it was 142 cm in length and weighed 47.7 kg. This tagged porpoise was released 55 km east of Ocean City Inlet, Maryland, and was monitored for 50 d before the transmitter tag failed near Buzzards Bay, Massachusetts. The release was deemed a success based on interpretation of the animal's tracking data (Westgate et al., 1998).

The second successful release was of Case No. NAIB9901PP (freeze brand 901, aka "Aqua"), a male harbor porpoise that stranded on 20 January 1999 near Wellfleet Harbor, Massachusetts. The porpoise was held at the New England Aquarium for 5 d and then transferred to NAIB. He was estimated to be 8 mo old at the time of stranding. At admission, the animal was emaciated, 105 cm in length, and weighed 15.9 kg. At release, after 6 mo of rehabilitation, he had grown to 114 cm in length and weighed 32.7 kg. The porpoise was transferred to Mystic Aquarium in Mystic, Connecticut, and released on 18 June 1999, just off Gloucester, Massachusetts. The porpoise was tracked for 61 d using a satellite transmitter with an estimated battery life of 8 wks. The animal spent the entire time off the coast of Massachusetts in the western Gulf of Maine. Spatial and dive data suggested the porpoise was foraging and thriving.

Previous data from eight wild-caught porpoises fitted with transmitters and tracked from August to October during 1994 and 1995 demonstrated that porpoises were in the western and southern Gulf of Maine during these autumn months. The satellite tag of one harbor porpoise transmitted for 212 d, from August 1995 to March 1996, indicating that the porpoise traveled throughout the central Gulf of Maine. None of these eight tagged porpoises left the Gulf of Maine, and most traveled along the 92-m isobath. Tagged harbor porpoises displayed considerable variability in their movement patterns (Read & Westgate, 1997). Based on previous information, it was reasonable to expect that the Gulf of Maine was an appropriate habitat and that after release, the porpoise would remain there.

Post-Release Monitoring: Freeze Branding and Satellite Tagging and Transmitter

The harbor porpoise in this study was released offshore on 20 January 2004 at 43º 33.8' N latitude and 70º 8.1' W longitude, which is approximately 3 nmi east of Cape Elizabeth, Maine (Figure 1). The animal was freeze branded for future visual observation, and a satellite transmitter was attached to the dorsal fin prior to release using techniques for applying tags to cetaceans as described by Read & Westgate (1997) and Westgate et al. (1998).

The freeze branding occurred on the day prior to the release. Bronze cetacean branding irons in the configuration "304" were placed in liquid nitrogen and then placed on the porpoise's dermis for up to 10 s. The animal showed minimal disturbance, and when placed in the water, proceeded to eat fish and behave normally.

The tag was a satellite-linked time-depth recorder (STDR – T16 manufactured by Wildlife Computers*),* measuring 4.6-cm tall by 1.9-cm wide, 6.35-cm sloping to the top by 9.5-cm long on the bottom. Closed cell surgical polyurethane foam was used as backing behind the tag. Three pins were used to mount the tag to the dorsal fin—0.635 cm of Delrin, a plastic used in human bone repairs. Nylon washers backed with foam were used to secure the tag on the opposite side of the fin. Pins were only threaded on the part that extended beyond the width of the fin. The pins were cut with a wire cutter, so they did not stick out beyond the washer, thereby preventing the nut from backing off and further securing it with a drop of epoxy. The tag was attached with dissolvable hardware designed to detach from the animal within 6 mo.

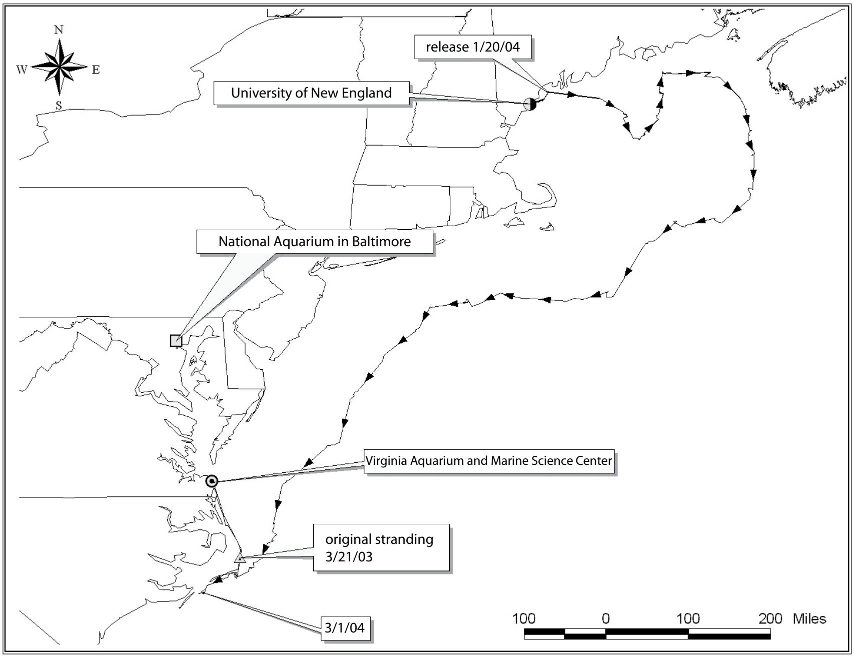

Figure 1. During 63 d, satellite telemetry tracking yielded over 300 valid location points on a tagged rehabilitated harbor porpoise. Data were collected on over 80,000 dives, a point-to-point travel distance of over 1,800 mi from release, and returning roughly to the place where he stranded. The porpoise traveled at roughly 56.3 km/d, staying in and among the 100 and 300 fathom lines and exceeded 80.4 km/d when homing in on the waters of North Carolina.

The nuts were galvanized steel, cut partly through to speed corrosion and backed with a stainless lock washer to also encourage corrosion. Images of the tag placement are provided in Figure 2.

The tag was programmed to transmit up to 500 times/d and was powered by two "M1" batteries. This configuration is rated to deliver roughly 10,000 transmissions (Wildlife Computers, pers. comm.). The daily rate was set high based on the assumption that the period immediately after release would be the riskiest. If there was trouble and the porpoise was at the surface, the chances for intervention would improve with better location data. The team-estimated track of up to 60 d was based on a conservative estimate of the likely number of transmissions from the tag as well as the behavior of the porpoise, assuming that he did well and was sending less than 500 signals/d.

The tag was programmed to signal daily for 8 h (0600 h to 1400 h EST), coinciding with the highest density of satellite coverage over the estimated tracking area. The goal was to produce at least two reliable locations (ARGOS LC accuracy Class 1 or greater) per day for a tracking period of 2 mo. Sixty days of tracking was considered a minimum time for demonstrating that the porpoise had survived reintroduction and had begun successful foraging. The tag had a 500-m depth range and a resolution of 2 m, and it was programmed to send dive depth, dive duration, and time at depth data compiled into binned histograms.

Location results were compiled daily and plotted using *ArcView*. The resulting maps, digital images, and summaries of dive data (weekly) were posted to a website (http://whale.wheelock.edu/whalenet-stuff/StopUNE04Hp) for easy access by participating organizations and the public. More detailed data, images, and near real time data analysis was posted to an online blog (http://gregearly.typepad.com/getrax/harbor_porpoise12004/index.html).

Results

The tag transmitted for 63 d following release. Over 300 location fixes were collected along with data on over 80,000 dives. Filtered rate of travel between successive points was calculated. Points that produced unreasonable rates of travel (e.g., > 2 m/s, 107 mi/d) were eliminated. Exceptions were made for points producing rates between 2 m/s and 3 m/s traveling over a distance of less than 8 km (10% of the total locations). By connecting "filtered" location fixes, a rough point-to-point track could be created covering 2,880 km from release in Maine to several kilometers of the porpoise's original stranding location in North Carolina. Tag data show that

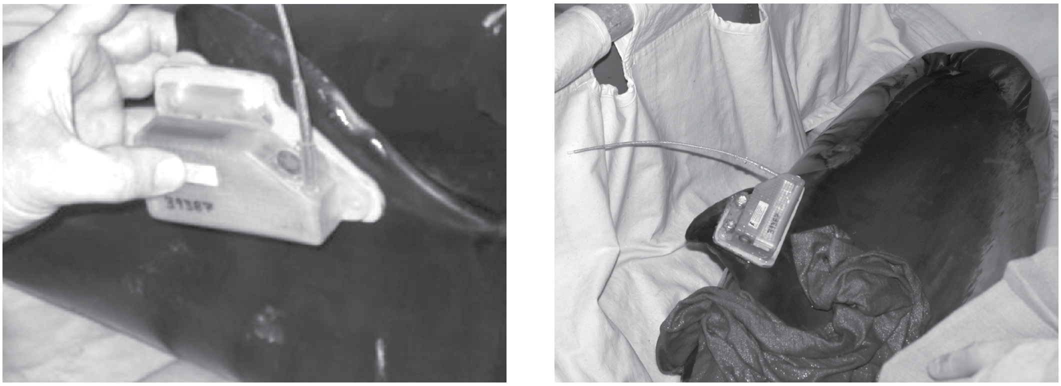

Figure 2. *Left:* Image of surgical polyurethane closed cell foam backing, the tag, and the three attachment points; *Right:* The tag in place on the dorsal fin while the porpoise rests in its stretcher prior to transport.

the tag lost power rapidly in the last 2 d of tracking, strong evidence of battery failure. Starting voltage was 5.3 V, increasing to 6.21 V during the first month of tracking. Average voltage over the 61 d was 5.87 V, and the final battery reading was 3.71 V. There was a steady decline in voltage during the final 12 d of tracking with a loss of over 42% of the average voltage (2.5 V) during this time. Prior to this, voltage was either steady or increasing.

During the first 3 d after release, the porpoise moved from the release site to Saco Bay and back to the release location about 6.4 km east of Cape Elizabeth, Maine. The porpoise appeared to be swimming very close to shore, moving somewhat erratically, and possibly circling, covering a distance of 12.8 km/d over shallow water with a depth of 20 to 40 m. All dives were less than 60-m deep and were distributed as follows: < 4 m (19%), 4 to 10 m (13%), 10 to 20 m (33%), 20 to 40 m (32%), and 40 to 60 m (3%). Most dives (65%) were between 10 and 40 m, roughly coinciding with the local bathymetry, suggesting that the porpoise was diving to the bottom.

Prior to release, the porpoise was largely inactive, often resting at the surface for long periods ("logging") and periodically sinking in a spiraling freefall to rest on the bottom of the pool. This was followed by more logging behavior. We attributed his behavior immediately following release to a period of initial orientation that required him to adjust to water depth, water temperature, sea state, exposure to the environment, and foraging. These and other variables were previously controlled during rehabilitation. Over the first 3 d after release, the porpoise moved slowly northward along the Maine coastline, picked up speed, and headed offshore. After traveling less than 16 km/d for the first 3 d following release, his track began to spread out and straighten as he moved offshore over some of the deepest water he would encounter in the Gulf of Maine (200 m).

Between tracking Days 6 and 17 (25 January to 5 February), before reaching George's Bank, 3.13% of his dives were reported as 100 m or greater in depth. Prior to this, no dives were recorded over 100 m. The only other period when dives of greater than 100 m was reported was during Days 21 to 31 (9 to 19 February) as the porpoise moved along the edge of the continental shelf south of George's Bank. During this time, 12.41% of the dives were to 100 m or greater. The highest number of deep (> 140-m deep) dives (2.17% of the dives during this day) were recorded on Day 21 (9 February) as the porpoise crossed the Great South Channel, south of George's Bank.

The track of the porpoise became straighter and linear by Day 14 (2 February) as he reached his farthest point north, just west of Nova Scotia. The track turned south and southeast, and by Day 21 (9 February), the porpoise reached the edge of the continental shelf on the eastern edge of southern George's Bank. Between Days 21 and 34 (9 February and 22 February), the porpoise traveled an average distance of 48 nmi/77 km/d, and passed within 8 km of his original stranding point (Table 2). Two days later (Day 36 or 24 February), the porpoise headed toward shore and was about 3 to 4 km off of the southeast edge of Cape Hatteras, North Carolina, when his daily rate of travel slowed dramatically. During the next month, the porpoise traveled an average of 36 nmi/d and moved back and forth along the North Carolina coast. This was an area about 16 × 32 km and roughly 5 to 8 km south of Cape Hatteras, with an activity center that was roughly 20 km from his original stranding location (Figure 3). On Day 63, the last day of transmissions from the tag, the animal was just south and east and within 15 km of his original stranding location. Telemetry data from the tag showed a steep, continuous power drop 2 d before the last transmission, which was interpreted as an

Table 2. Based on satellite tracking, the average distance traveled by a rehabilitated and tagged harbor porpoise for the 63-d duration of the tag; no satellite tag data were received on Day 6 nor Day 21.

Day	Average rate (km/d)	Day	Average rate (km/d)	Day	Average rate (km/d)	Day	Average rate (km/d)
1	26	**22**	76	**41**	61	**60**	64
2	11	**23**	92	**42**	53	**61**	87
3	2*	**24**	80	**43**	92	**62**	32
4	40	**25**	77	**44**	51	**63**	66
5	27	**26**	48	**45**	32		
7	39	**27**	77	**46**	51		
8	72	**28**	103	**47**	84		
9	90	**29**	130	**48**	51		
10	63	**30**	122	**49**	72		
11	39	**31**	93	**50**	98		
12	82	**32**	117	**51**	92		
13	127	**33**	72	**52**	84		
14	92	**34**	55	**53**	47		
15	74	**35**	29	**54**	53		
16	60	**36**	50	**55**	84		
17	106	**37**	66	**56**	61		
18	87	**38**	66	**57**	39		
19	79	**39**	39	**58**	60		
20	88	**40**	35	**59**	64		

*single location

indication of battery depletion. Our assumption, based on robust, regular localized movements in an area of previous activity, was that the harbor porpoise was alive and well at the time of tag failure and that the release had been successful.

Discussion

For more than 20 y, numerous groups, organizations, and aquaria have treated stranded, sick, or injured marine mammals with the goal of returning the animals to the wild. In the U.S., NOAA Fisheries authorizes and oversees the release of rehabilitated marine mammals. Authorized organizations are required by NOAA Fisheries to return rehabilitated marine mammals and turtles to the wild whenever feasible, providing that the animal is likely to survive and not be a risk to wild populations.

Determining the "best" place to return a cetacean to the wild is a complex process based on a large number of variables, many of which are poorly understood or lack data. Ideally, the rehabilitated cetacean should be released into its home range, genetic stock, and social unit, with the presumption that this increases the likelihood of survival. It is assumed that an animal will recognize and make the best use of available resources, environmental features, and social relationships, thereby recognizing and avoiding potential predators. However, the animal's prior home range is rarely known, nor is the animal's social unit nor ranging or migratory patterns. It is generally assumed that a stranded animal is likely to be exhibiting abnormal behavior prior to stranding and that stranding locations are not necessarily indicative of areas of normal, let alone optimal, habitat. When these factors are known, it is generally considered appropriate to release the animal at its stranding site, especially if there are conspecifics of the same genetic stock nearby. While the presence of conspecifics is an indication that a habitat is of potential use to a released animal, the results from this release indicate that it is not necessary for all individuals. Information about the variability in movements of individuals, although largely still unknown, is critical to a better understanding of the difference between *potential* range and *actual* range. Based on the results of this study, this appears to be an important distinction when considering the reintroduction of rehabilitated or relocated animals.

The nearshore waters of the Gulf of Maine are known to be a substantial part of the natural range for the Gulf of Maine population of harbor porpoises (Smith et al., 1993; Read & Hohn,

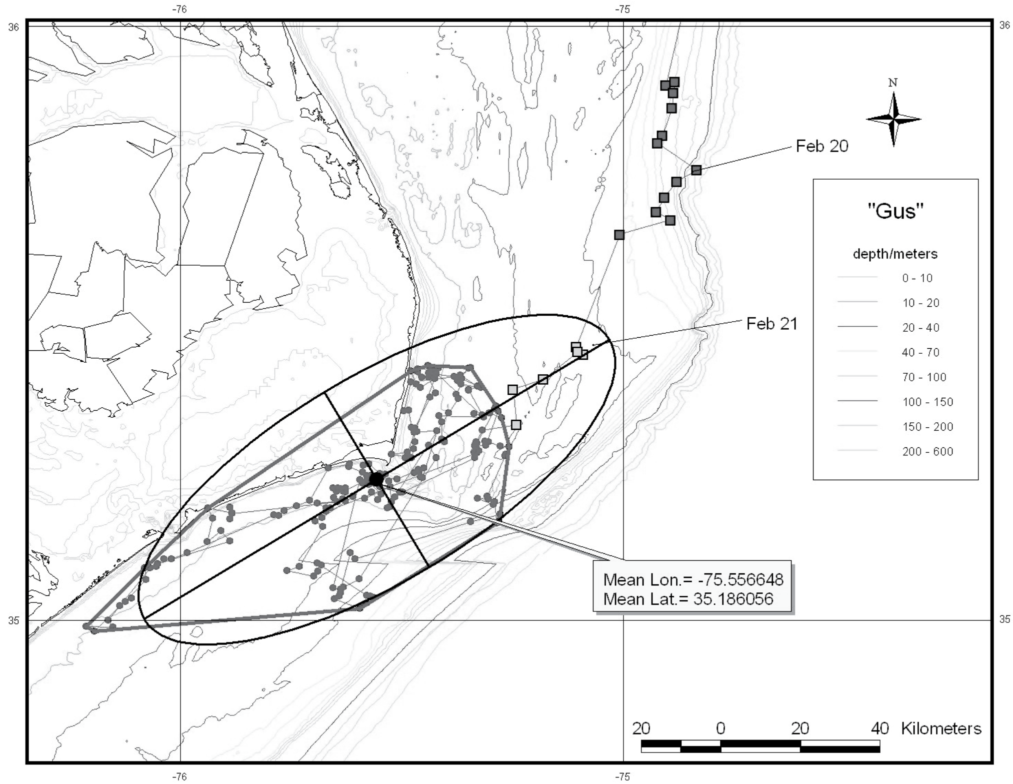

Figure 3. One of the rehabilitated and released harbor porpoise's activity center plots 21 February to 23 March 2004; the porpoise appeared to be moving back and from a center point. The oval is a Jennrich-Turner Home Range, including the 95% ellipse with major and minor axes. The gray outline within the ellipse is the minimum convex polygon (MCP) for the locations.

1995). The distribution of harbor porpoises has been modeled using sightings, surveys, strandings, and fishery takes reported by NOAA's Northeast Fisheries Observer Program. The most recent stock model states that during the summer months, harbor porpoises are concentrated in the northern Gulf of Maine and southern Bay of Fundy region, which is typically in depths less than 150 m. In winter months (January to March), porpoises are distributed in intermediate densities from North Carolina to New Brunswick, Canada (Waring et al., 2004). Generally, little is known about the offshore behavior, movements, southern distribution, and habitat use of individual harbor porpoises.

Researchers believed that this porpoise would remain in the Gulf of Maine based on the presence of conspecifics in the area and the fact that he had spent several months acclimating to local water conditions. Post-release monitoring, however, demonstrated that rather than remaining in this area, this individual returned to a presumed (based on the location of stranding) area of activity by traveling from the northernmost to southernmost extreme of the stock's reported range. This suggests that homing to a specific site occurred.

Homing behavior is defined as migratory movement that returns an animal to a previously occupied home range. Many species of cetaceans, marine carnivores, and ungulates perform seasonal migrations for the purpose of feeding and breeding (McCullough, 1985; Würsig, 1989; Quinn & Brodeur, 1991). Homing and site fidelity have also been documented in cetaceans (Würsig, 1989; Finley, 1990; Heide-Jorgensen et al., 2003) and in pinnipeds (Ridgway & Robison, 1985; Oliver et al., 1988; Ridoux et al., 1998; Born et al., 2005).

Young harbor porpoises of this age class are known to routinely strand in the mid-Atlantic. during the winter months. However, this post-release monitoring provided a unique insight into a seasonal migratory homing pattern that harbor porpoises may take from their northern home range. Homing and site fidelity for harbor porpoises are important for understanding fisheries management and strategies. Genetic analysis has been useful to discern the origin of the animals that move to the mid-Atlantic region in the winter months from the separately recognized stocks in the western North Atlantic (Rosel et al., 1999). Further research will be required to examine the relationship of genetics, stock structure, survival, reproduction, and homing behavior for North Atlantic harbor porpoises.

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