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Movements and Dive Patterns of Short-Finned Pilot Whales (*Globicephala macrorhynchus*) Released from a Mass Stranding in the Florida Keys

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Abstract

Short-finned pilot whales (*Globicephala macrorhynchus*) are among the most common cetaceans to engage in mass strandings in the southeastern United States. Because these are primarily pelagic, continental shelf-edge animals, much of what is known about this species has derived from mass stranding events. Post-release monitoring via satellite-linked telemetry was conducted with two adult males determined on-site to be healthy, and released directly from a mass stranding of 23 pilot whales in May 2011, near Cudjoe Key, Florida. Tracking provided an opportunity to evaluate the decision for immediate release vs rehabilitation, and to learn more about the lives of members of this difficult-to-study species in the wild. The two pilot whales remained together for at least 16 d before transmissions from one pilot whale (Y-404) ceased. Dive patterns and travel rates suggested that Y-404's condition deteriorated prior to signal loss. Pilot Whale Y-400 was tracked for another 51 d, moving from the Blake Plateau to the Greater Antilles, remaining in the Windward Passage east of Cuba for the last 17 d of tracking. Once he reached the Antilles, Y-400 remained in high-relief habitat appropriate for the species and made dives within or exceeding the reported range for depth and duration for this species, following expected diel patterns, presumably reflecting continued good health. Telemetry data indicate that he made at least one dive to 1,000 to 1,500 m, and several dives lasted more than 40 min. Although the fates of the two released pilot whales may have been different, the concept of evaluating health and releasing individuals determined to be healthy at the time of stranding appears to have merit as an alternative to bringing all members of mass-stranded pilot whale groups into rehabilitation.

Key Words: short-finned pilot whale, *Globicephala macrorhynchus*, satellite-linked telemetry, dolphin tags, marine mammal rescue and rehabilitation, health assessment, mass stranding

Introduction

Short-finned pilot whales (*Globicephala macrorhynchus*) are among the most common cetaceans to engage in mass strandings in the southeastern United States (Geraci & Lounsbury, 2005). The primarily pelagic, continental shelf-edge habitat of pilot whales has historically limited opportunities for systematic studies of free-ranging animals in their natural habitat. As a result, opportunistic research involving mass strandings (e.g., Fehring & Wells, 1976; Irvine et al., 1979) and drive fisheries (e.g., Kasuya & Marsh, 1984; Marsh & Kasuya, 1991) provided much of the early information about this species, when the animals essentially came to the researchers. In places such as the Canary Islands or the Hawaiian islands, however, it has been possible to study this species where its preferred habitat is closer to shore. This access has led to a few descriptions of social behavior (e.g., Heimlich-Boran, 1993) and diving patterns (Baird et al., 2003; Madsen et al., 2007; Aguilar de Soto et al., 2008; Andrews et al., 2011).

Studies involving tagging of short-finned pilot whales in the wild are increasing, and they have discovered much of interest about their lives such as the sprints they make immediately preceding prey capture (Aguilar de Soto et al., 2008). However, such studies are often expensive, logistically challenging, and to date have been limited to relatively few sites.

One way to increase sample sizes and geographic distribution for behavioral studies of pilot whales is to take advantage of releasable pilot whales from mass strandings and apply new satellite-linked tagging technology for post-release monitoring. Based on studies of rehabilitated and released pilot whales, Mate et al. (2005) suggested that improvements in tag design, such as the incorporation of pressure sensors to provide depth of dive information, could provide information about how pilot whales use their three-dimensional habitat, and Nawojchik et al. (2003) suggested that future efforts to study the behavior of rehabilitated odontocetes will provide useful, opportunistic information on the behavioral ecology of these species.

Post-release monitoring of pilot whales can accomplish two purposes. First, it is important to evaluate the success of the animal's treatment and release (Mate et al., 2005; Wells et al., in press). As suggested by Nawojchik et al. (2003), efforts to study the behavior of rehabilitated odontocetes will help to guide decisions on the most appropriate course of action when dealing with stranded individuals.

Second, once the apparent health of the stranded, then released cetacean has been established, it is possible to begin to interpret behavior relative to natural patterns for the species, with the caveat that potential impacts from stranding and rehabilitation on post-release behavior are difficult to evaluate (Wells et al., 2009). One of the strongest justifications presented for engaging in the difficult and expensive process of cetacean rescue and rehabilitation is to advance our understanding of wild populations (Moore et al., 2007). Wells et al. (in press) evaluated 69 cases of released cetaceans following human intervention and suggested that if a cetacean survived at least 6 wks post-release, it was likely to continue to live and could be deemed successful. If the animal is surviving, it is reasonable to assume that it is using its natural abilities and skills effectively and appropriately. Thus, cetaceans released after receiving aid from humans can provide an alternative window into the lives of difficult-to-study species; and with appropriate caution, documented patterns can be considered representative.

Recent findings by Sampson et al. (2012) suggest one possible way to reduce the potential impact of human interventions on released cetaceans. Specifically, medical diagnoses on the beach that lead to immediate release should, in some cases, benefit the animals medically by reducing the risks of stress, illness, and injury from rehabilitation, and reduce exposure to humans and unnatural situations. We report herein on a case involving the immediate release and subsequent monitoring of two short-finned pilot whales from the site of a mass stranding in the Florida Keys in 2011, following on-site evaluation of their health. The results of this experimental release provide information on the success of this new intervention approach as well as data on the movements and dive patterns of short-finned pilot whales.

Methods

Description of the Stranding

Beginning on 5 May 2011, 23 short-finned pilot whales were found stranded as individuals and in scattered groups, spread out over many kilometers of convoluted coastline, flats, and mangrove islands in the lower Florida Keys of the U.S. Of these, 15 pilot whales were discovered dead over a period of 3 to 4 d. Eight were recovered alive over a 36-h period. Overall, the group included 13 females, five males, and five of unknown sex. Most were adults (19), one was a subadult, two were calves, and one was undetermined. Over the next 2 d, Marine Mammal Conservancy personnel and other stranding network members were able to move all eight of the live whales to a more centralized location near Cudjoe Key and set up a temporary enclosure for initial treatment and evaluation.

By the evening of 6 May 2011, two adult males were tentatively determined by the attending veterinarians and National Oceanic and Atmospheric Administration (NOAA) Fisheries Service to be the only members of the group to be of adequate health and condition for release. Their determination was based on the pilot whales' robust body condition, normal respiratory quality and effort, apparent awareness of their surroundings, and their ability to maintain a normal body position within the water column when not supported by people or flotation devices. Evaluation of blood samples from the morning of 7 May 2011 confirmed this assessment, and the two males were tagged, transported by boat approximately 16 km offshore (24.47° N, 81.37° W), and released in waters of 160 m depth, about 20 km from the steep dropoff of the Pourtales Escarpment.

Of the remaining live whales, one was humanely euthanized, and five were subsequently transported to a rehabilitation center. Three were euthanized during rehabilitation, and two were subsequently deemed nonreleasable by NOAA Fisheries due to young age (dependent calf lacking survival skills) or ongoing medical issues (severe scoliosis). These remaining two pilot whales were transferred to Sea World in Orlando, Florida, for continuing treatment.

Tagging and Release

The two presumed healthy pilot whales were tagged on 7 May 2011with single-point attachment SPLASH-10 satellite-linked transmitters (Wildlife Computers, Redmond, WA, USA), following protocols approved by Mote Marine Laboratory's Institutional Animal Care and Use Committee. These tags provided data on location, dive depths, and dive durations. Tagging was performed by experienced personnel standing in the water. The tag was fitted along the lower third of the dorsal fin, approximately 35 mm cranial to the trailing edge. The tagging location was identified, marked with a permanent ink pen, and prepared with a surgical cleaning technique alternating solutions of 2% chlorhexidine (Dermachlor, Butler Schein™ Animal Health, Dublin, OH, USA) and methanol. Lidocaine hydrochloride 2% and epinephrine (1:100,000) was injected into the attachment site with a N-Tralig intraligamentary syringe (Integra Miltex, Plainsboro, NJ, USA). A hole was bored with a sterile coring tool, and the tag was attached with a 45-mm-long, 5/16" diameter, delrin pin, threaded on each end to accept a zinc-plated lock nut and stainless steel washer for securing the tag. Pilot Whale Y-404 (MMC-Gm-1311), a 378-cm male, received PTT 50766 (Figure 1). Pilot Whale Y-400 (MMC-Gm-0911), a 406-cm male, received PTT 100412 (Figure 2). Tagging required about 5 min for each whale and was completed by 1244 h EDT (1644 h UTC).

The tagged pilot whales were transported offshore on an open end salvage boat, under the guidance of staff from the Marine Mammal Conservancy and Sea World. The two pilot whales were loaded with an onboard crane in slings and placed far forward on the open ended bow for the trip to blue water. The pilot whales were placed side by side. For safety reasons, because there was little room between the two animals, the original plan of releasing them at the same time was modified to a staggered release. The pilot whales were slid one at a time out of their stretchers into the water. The first pilot whale stayed near the boat as the second pilot whale was slid into the water. They swam away together at about 1745 h EDT (2145 h UTC). No personnel were in the water during the release.

Figure 1. Pilot Whale Y-404 (MMC-Gm-1311), tagged with PTT 50766 (Photo by Randall S. Wells, Sarasota Dolphin Research Program)

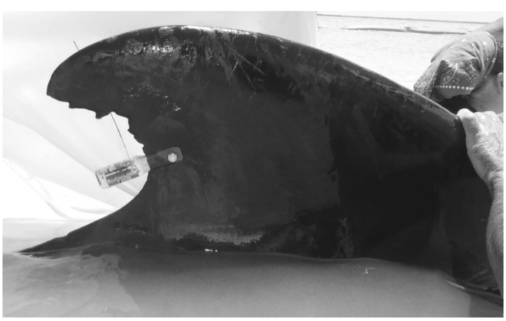

Figure 2. Pilot Whale Y-400 (MMC-Gm-0911), tagged with PTT 100412 (Photo by Randall S. Wells, Sarasota Dolphin Research Program)

Tracking

The SPLASH-10 tags were programmed for 400 transmissions per day to optimize opportunities for getting complete dive data records. They were both set to the same 8-h "on" window, from 0700 h through 1459 h UTC to allow monitoring of the proximity of the two pilot whales. For dive data analyses, the following 6-h (UTC) histogram blocks were used: Dawn = 0800-1359 h; Day = 1400-1959 h; Dusk = 2000-0159 h; and Night = 0200-0759 h. The selected histogram data sampling interval was 10 s, and the following data bins were used:

- *Dive Depth (m)* – 2; 50; 100; 200; 300; 400; 500; 600; 700; 800; 900; 1,000; 1,500; > 1,500
- *Dive Duration (min)* – 0.5; 1.0; 1.5; 2.0; 2.5; 3.0; 4.0; 5.0; 10.0; 15.0; 20.0; 30.0; 40.0; > 40.0
- *Time-at-Temperature (°C)* – 6; 8; 10; 12; 14; 16; 18; 20; 22; 24; 26; 28; 30; > 30
- *Time-at-Depth (m)* – 2; 50; 100; 200; 300; 400; 500; 600; 700; 800; 900; 1,000; 1,500; > 1,500

Tag transmissions were received and processed by Service Argos (CLS, 2008), and preliminary data were accessed daily via the Internet. Final processed data were provided monthly by Argos on a CD-ROM. Plausible locations were identified by filtering (Douglas et al., 2012). Values of 20 km/h as the sustained rate of travel and 10 km for maximum redundant distance were used as threshold filtering criteria. All positions with Argos location quality conditions of LC 1, 2, or 3 were automatically included. More than 90% of locations successfully passed the Distance-Angle-Rate filter and were used for subsequent analyses.

Rates of travel (km/h) were calculated along straight paths that connected single "best" locations per PTT duty cycle, based on the Argos LC and number of messages. These rates are "sustained rates of travel" over approximately day-long periods and should be considered minimum estimates.

Sea surface temperatures (SST) were obtained from a global, daily, online Optimum Interpolation (OI) SST dataset derived from Advanced Very High Resolution Radiometer (AVHRR) imagery with 0.25 degree spatial resolution (Reynolds et al., 2007).

Water depth for each filtered location was obtained from NOAA (Amante & Eakins, 2009). A daily water depth was calculated by averaging the depths for all filtered locations for a given day.

To estimate separation distances between the two pilot whales, analyses were performed using only location pairs that were temporally coincident (< 10 min apart) and both of standard Argos location quality (LC 1, 2, or 3) (Wells et al., 2013). Average separation was calculated using all pair-wise locations during daily intervals. In general, we considered estimated separations of < 1.5 km within a 10-min window to be indicative of "close proximity." This is within the radius of accuracy of the Argos location data selected for our analyses and could place the animals side-by-side or up to 3 km apart.

Results

Movements

As shown in Table 1, both tags provided data on movements and dive patterns after release. Pilot Whale Y-404 was tracked for 16 d, from 7 May 2011 through 22 May 2011. Pilot Whale Y-400 was tracked for 67 d, from 7 May 2011 through 12 July 2011. In total, 118 filtered positions were obtained for Y-404, and 390 positions were obtained for Y-400 (Table 1).

Over the first 16 d of tracking, the two pilot whales moved north together through the Atlantic Ocean with the prevailing current until they reached a point north of the Blake Spur on Day 10, off the edge of the Blake Plateau (Figure 3). They circled together off the edge of this shelf through Day 16, and then signals ceased from Y-404. After cessation of signals from Y-404, the remaining tag indicated that Y-400, at least, first moved south over the Blake Plateau, and then continued well offshore to the north and east of the Bahamas. He then proceeded southward, passing along the eastern edge of Silver Bank on Day 38, and then moved westward along the northern shore of the Dominican Republic, often moving with prevailing currents. The pilot whale maneuvered to the north around Great Inagua Island on Day 44. He continued to the northeast tip of Cuba on Day 48, and then moved to the Windward Passage, separating Cuba from Haiti, on Day 50, and remained there for the remaining 17 d for which signals were received.

Water Depth

Average daily water depths increased steadily from the time of release through the first 8 d. Thereafter, the pilot whales were only in waters less than 1,000 m on 3 d. Once they reached deep water on 15 May, the pilot whales were in waters averaging more than 2,500 m. Water depths and whale status were stratified into three discrete periods: Period 1 – "shallow" (≤ 1,000 m), before the whales first moved off the Blake Plateau (7 to 14 May); Period 2 – "deep" (> 1,000 m), after they moved off the plateau, while both whales were still transmitting (15 to 22 May); and Period 3 – Y-400 alone, in mostly deep water (> 1,000 m), after Y-404 ceased transmitting (23 May to 12 July). After the pilot whales moved into deeper water on 15 May, no significant difference in average daily water depth for Y-400 was found (t-test, $p = 0.72$) when comparing the time when Y-404 was transmitting (Period 2) to the time after cessation of signals from Y-404 (Period 3) (Table 2).

Rate of Travel

Overall, the pilot whales traveled at their highest mean daily rate (up to > 7 km/h) while in waters ≤ 1,000 m deep (Figure 4). Rates declined to less than about 2 km/h by 17 May, after they moved into water > 1,000 m deep, and remained low for the next several days until signals from Y-404 ceased. Travel rates for Y-400 subsequently increased to approximately 2 to 5 km/h for the next several weeks until Y-400 settled into a pattern of localized movements in and near the Windward Passage.

Water Temperature

Based on satellite sensing, the whales were in areas of SST > 25° C throughout the track (Figure 5). As Y-400 swam through the open Atlantic, he encountered increasing SSTs. During the final month of tracking, nearly all of his locations were in areas of 28° to 29° C SST. As measured directly from the temperature sensors on the tags themselves, and including the water column sampled during dives, the pilot whales were in waters of 22° to 30° C at least 86% of the time.

Dive Patterns

In total, 13,329 dive depth records were obtained from the two pilot whales (Table 1). Overall, 88% of the dives were to depths of 50 m or less and 5% were to 50 to 100 m. Deep dives (> 500 m; Aguilar de Soto et al., 2008) accounted for 1.6% of all dives. Four dives exceeded 900 m. The deepest dive recorded,

Table 1. Summary information for two male pilot whales tagged on 7 May 2011

Pilot whale ID	Roto tag	Satellite-linked tag ID	Body length (cm)	Date of last signal	Tracking duration (days)	No. of filtered locations	No. of dives
MMC-Gm-1311	Y-404	50766	378	22 May 2011	16	118	2,175
MMC-Gm-0911	Y-400	100412	406	12 July 2011	67	390	11,154

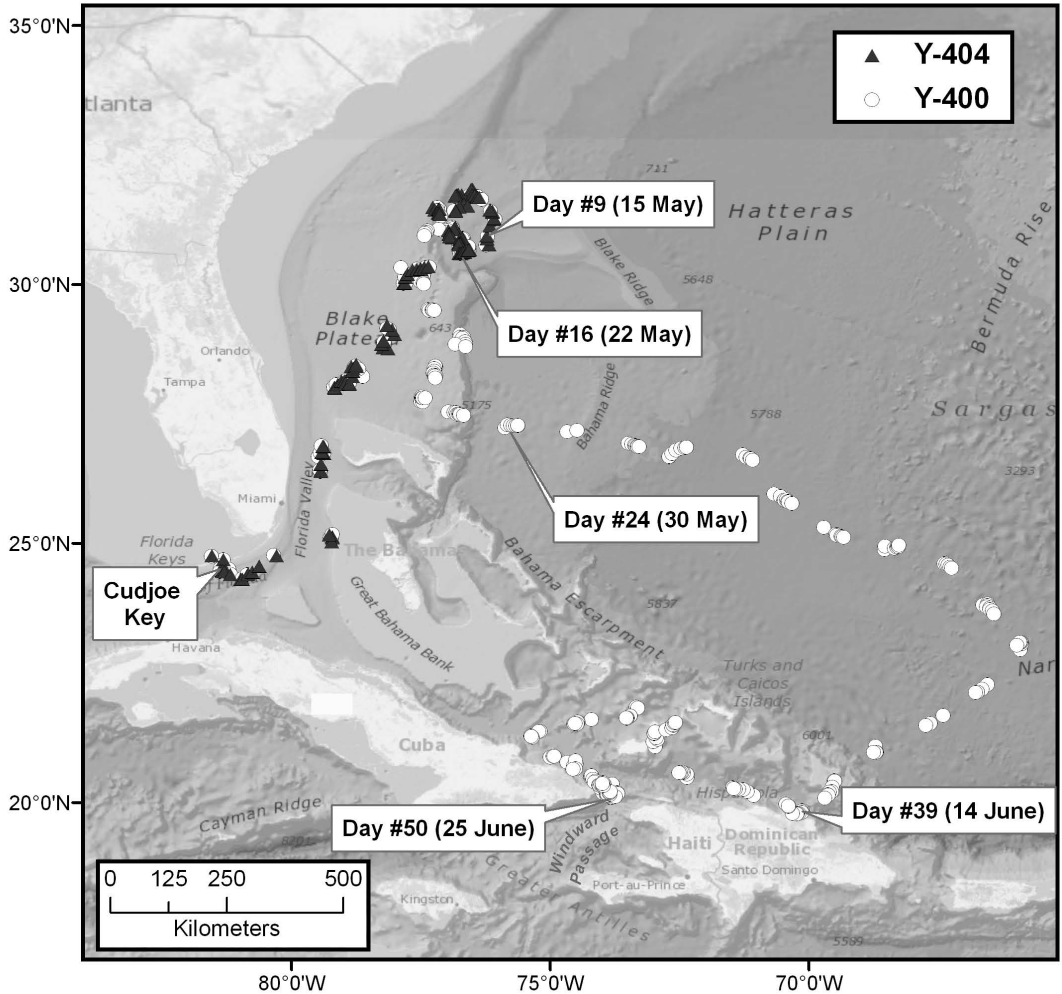

Figure 3. Movements of two tagged pilot whales, Y-400 and Y-404, from satellite-linked tracking; the pilot whales stranded near Cudjoe Key, Florida, and were released on 7 May 2011. Pilot Whale Y-400 was tracked to the Windward Passage, at the eastern tip of Cuba.

Table 2. Comparisons of daily water depths for the two pilot whales, stratified into three discrete periods: Period 1 – "shallow" (≤ 1,000 m), before the whales first moved off the Blake Plateau (7 to 14 May); Period 2 – "deep" (> 1,000 m), after they moved off the plateau, while both whales were still transmitting (15 to 22 May); and Period 3 – Y-400 alone, in mostly deep water (> 1,000 m), after Y-404 ceased transmitting (23 May to 12 July)

Period	Mean daily water depth (m)	SD	*n*	Min daily water depth (m)	Max daily water depth (m)
1	639	289	8	133	921
2	2,681	531	8	1,563	3,276
3	2,795	1,767	51	581	5,821

between 1,000 m and 1,500 m, was made by Y-400 north of the Dominican Republic on Day 39.

Dive depths were considered relative to the three water depth and whale status periods described under "Water Depth" above. All three periods were comparable in terms of the vast majority of dives being to 100 m or less (Figure 6). The two pilot whales exhibited similar dive profiles while

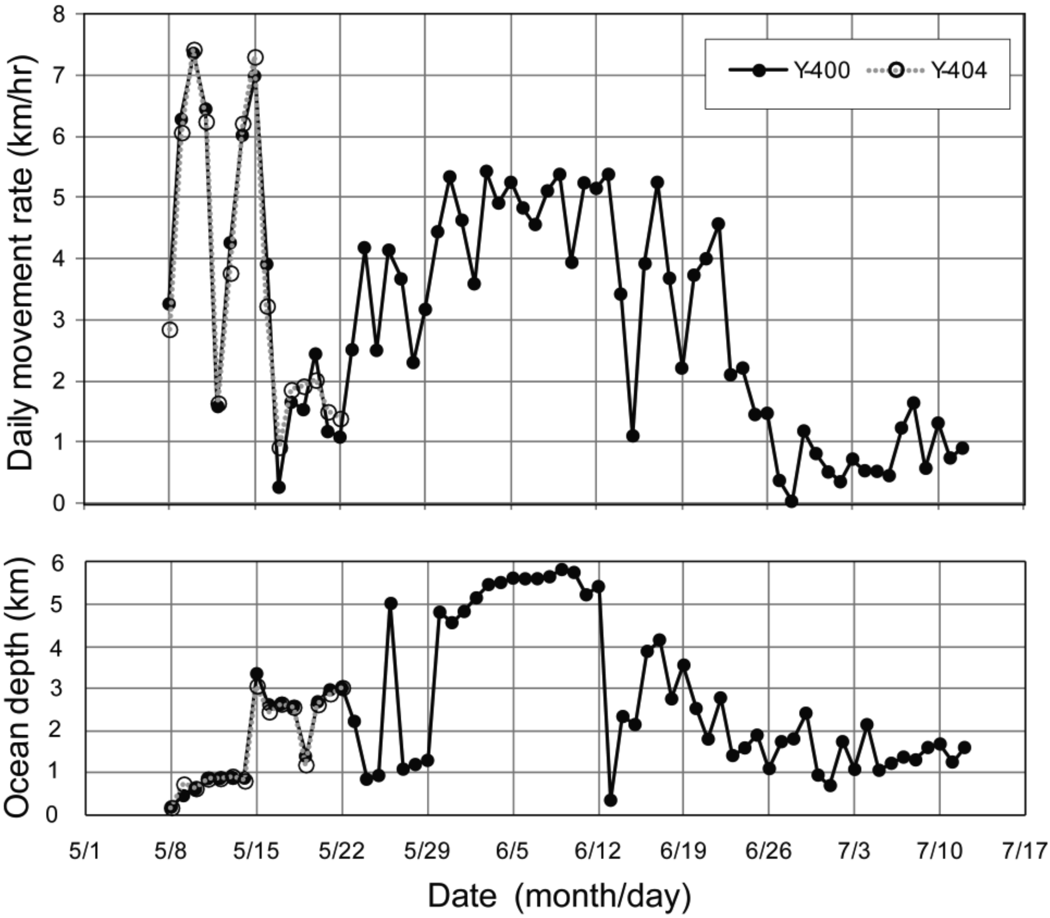

Figure 4. Mean daily travel rates for two male pilot whales released from a mass stranding near Cudjoe Key, Florida, on 7 May 2011 and tracked via satellite-linked transmitters, relative to water depths at the locations of the pilot whales

both were transmitting. However, Y-400 engaged in more dives in excess of 200 m during Period 3 when Y-404 was no longer transmitting. Within Period 3, once Y-400 reached the Windward Passage, his proportion of deep dives (> 500 m) more than tripled (0.049) from the proportion he made in deep water before arriving at Windward Passage (0.016).

In total, 10,553 dive duration records were obtained from the two pilot whales (Figure 7). Overall, 57% of dives were less than 5 min long, 79% were less than 10 min, 90% were less than 20 min, and 99% were less than 30 min. However, 1% of dives exceeded 30 min in duration, and 20 (21%) of these dives exceeded 40 min. Most of the longest dives (83%) occurred during dusk, night, and dawn. Dive durations were considered over the same three water depth and whale status periods as for dive depths. No dramatic differences were observed across periods or between the pilot whales (Figure 7).

Time-at-depth analyses integrate across dive depth and dive duration data. In total, 219 records were obtained for average time spent in selected depth ranges. On average, 31% of the pilot whales' time below the surface was spent within the top 2 m, 84% was within 50 m, and 88% was within 100 m of the surface. Average time at depth was considered over the three water depth and whale status periods (Figure 8). Both whales spent more time at greater depths (50 to 500 m) when they were in deeper regions. Pilot Whale Y-400 spent more time at deeper depths (50 to 1,000 m) while in deep water after Y-404 ceased transmitting (Figure 8).

Diurnal dive patterns were evident from examination of time-at-depth data for Y-400 (Figure 9). Most of the time spent below 50 m deep occurred during dusk, night, and dawn, with the highest percentage of time spent at deep depths occurring at night. Little time was spent below 50 m during the day.

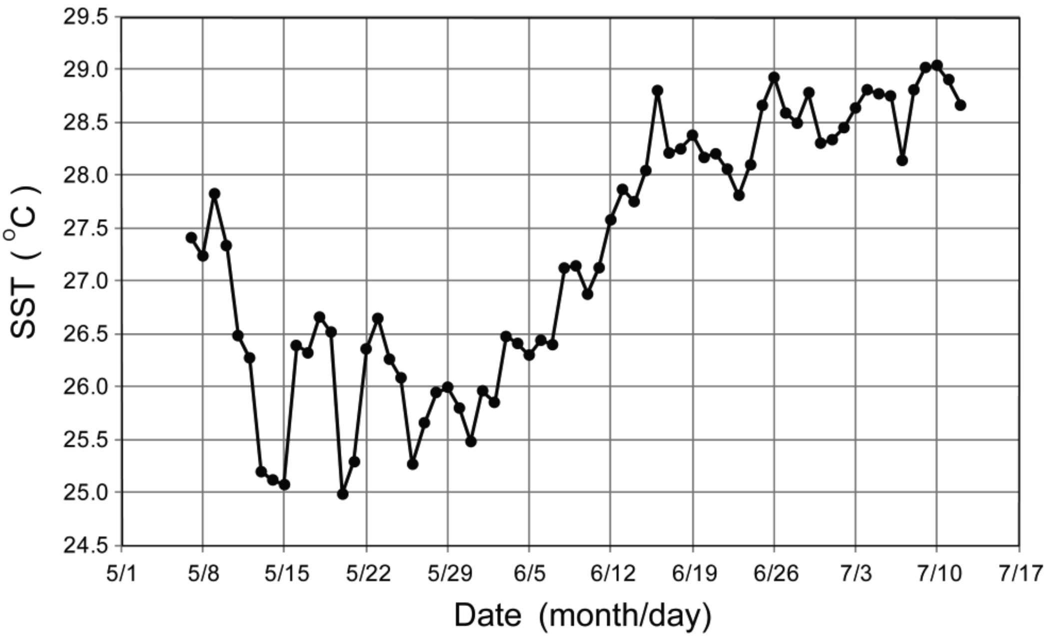

Figure 5. Sea surface temperatures (SST) experienced by two tagged pilot whales, Y-400 and Y-404, following release from a mass stranding near Cudjoe Key, Florida, on 7 May 2011; SST was recorded by remote satellite imagery from the areas through which the two pilot whales passed. The close proximity of the two pilot whales during the tracking allowed a single daily SST point to represent surface temperatures for both pilot whales over the period both tags were transmitting.

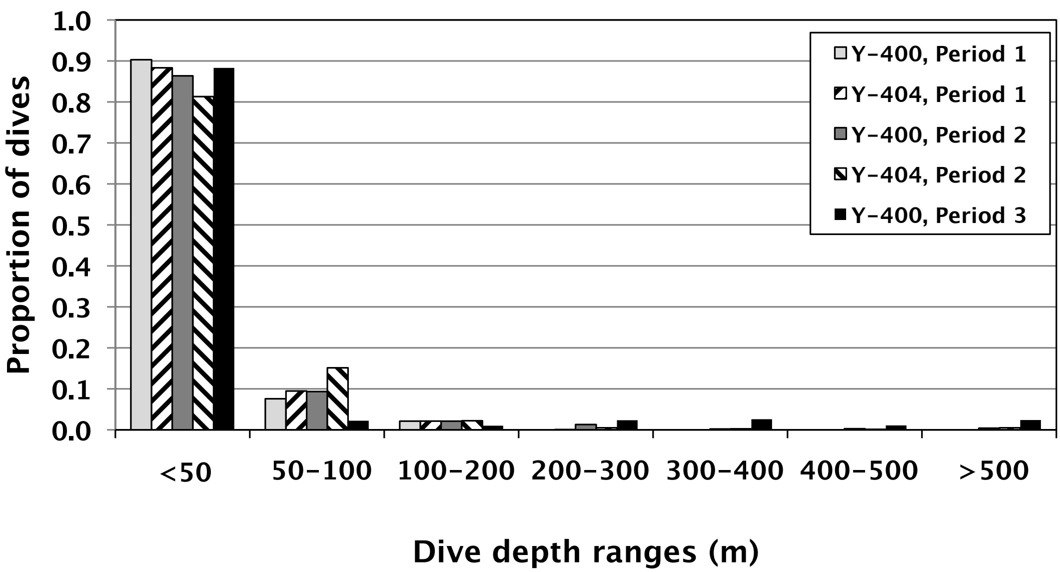

Figure 6. Proportions of dives made by two tagged pilot whales, Y-400 and Y-404, to selected depth ranges. Data are stratified into three discrete periods: Period 1 – "shallow" (≤ 1,000 m), before the whales first moved off the Blake Plateau (7 to 14 May); Period 2 – "deep" (> 1,000 m), after they moved off the plateau, while both whales were still transmitting (15 to 22 May); and Period 3 – Y-400 alone, in mostly deep water (> 1,000 m), after Y-404 ceased transmitting (23 May to 12 July).

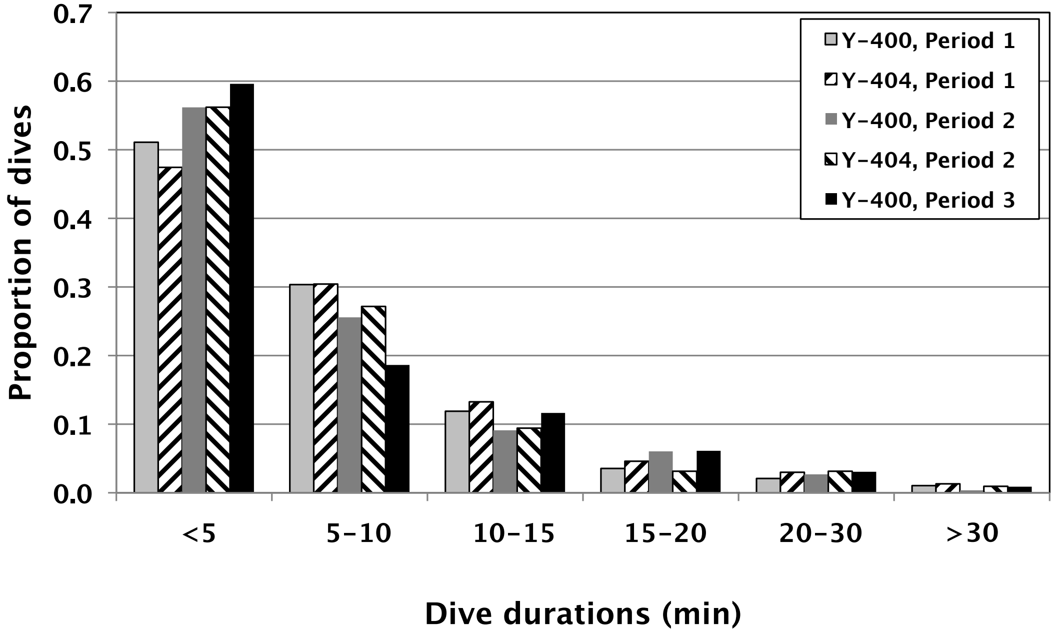

Figure 7. Proportions of dives of selected duration ranges made by Pilot Whales Y-400 and Y-404. Data are stratified into three discrete periods: Period 1 – "shallow" ($\leq$ 1,000 m), before the whales first moved off the Blake Plateau (7 to 14 May); Period 2 – "deep" (> 1,000 m), after they moved off the plateau, while both whales were still transmitting (15 to 22 May); and Period 3 – Y-400 alone, in mostly deep water (> 1,000 m), after Y-404 ceased transmitting (23 May to 12 July).

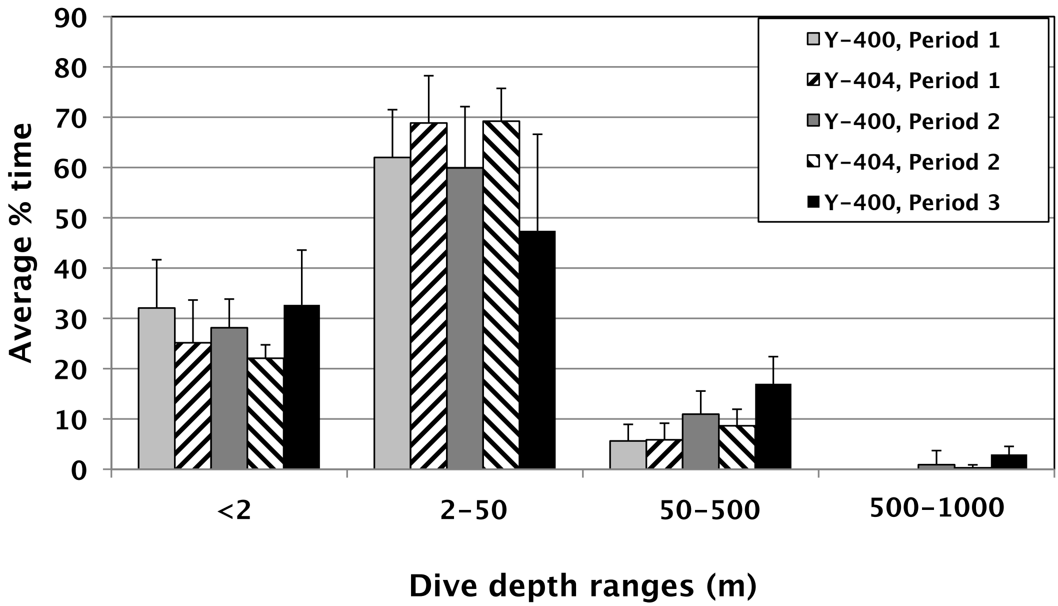

Figure 8. Average percentage of time tagged two pilot whales, Y-400 and Y-404, spent in selected depth ranges; standard deviations are shown. Data are stratified into three discrete periods: Period 1 – "shallow" ($\leq$ 1,000 m), before the whales first moved off the Blake Plateau (7 to 14 May); Period 2 – "deep" (> 1,000 m), after they moved off the plateau, while both whales were still transmitting (15 to 22 May); and Period 3 – Y-400 alone, in mostly deep water (> 1,000 m), after Y-404 ceased transmitting (23 May to 12 July).

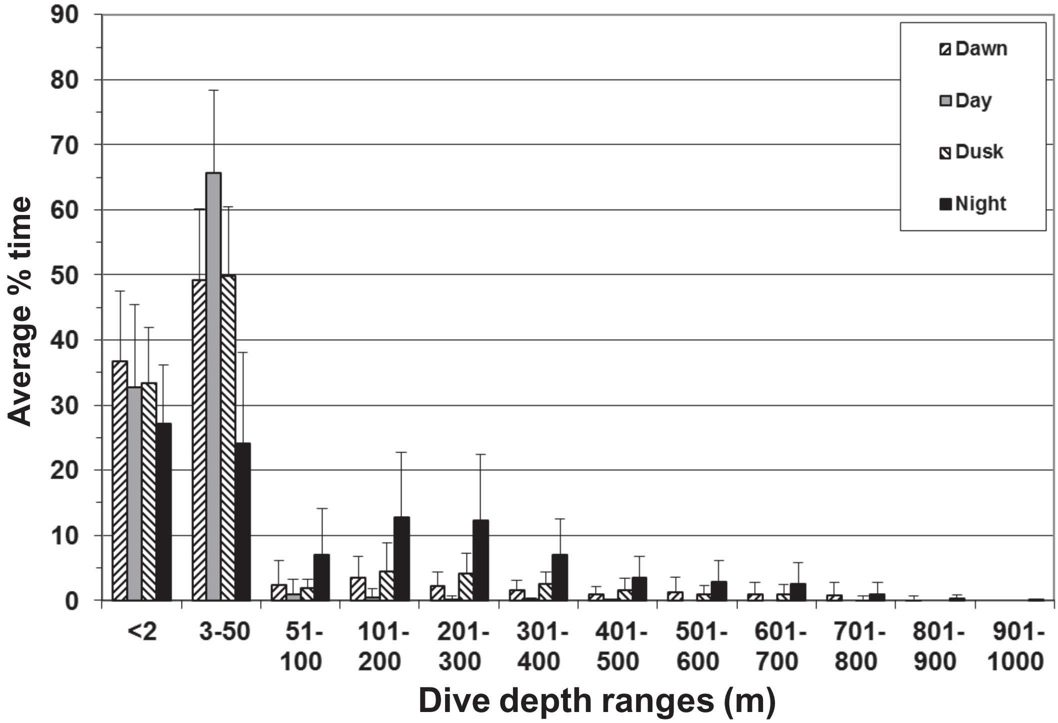

Figure 9. Diurnal dive patterns for Pilot Whale Y-400 during Period 3, alone, primarily in deep water, following cessation of signals from Y-404. Average percentage of time spent in selected depth ranges, by time of day; standard deviations are shown. Time blocks (local time): Dawn = 0400-0959 h; Day = 1000-1559 h; Dusk = 1600-2159 h; and Night = 2200-0359 h.

Proximity

The whales remained close together for almost the entire 16 d and 900 km when both tags were transmitting. Separation analyses showed the whales to be 0.53 km apart, on average (SD = 0.380, n = 15). For perspective, two transmitters deployed on any one animal would likely show a mean separation similar to what was found for these two, purely due to the (in)accuracy of the technique.

Discussion

Releases of stranded cetaceans with follow-up monitoring provide opportunities to evaluate treatment decisions. If monitoring is of sufficient duration, and the animal appears healthy, it also provides a window for learning about the life of the animal. Tracking duration is one indicator of success post-release (Wells et al., in press), and it is typically a function of the condition of the tag, the attachment, and the animal. The 67-d track for one of the pilot whales, Y-400, was within the expected range given the estimated battery life of the tag. At the time of its last status report, 4 d before its last signal, battery voltage was still above the transmission threshold, but the tag had exceeded the 25,000 expected transmissions. Thus, battery exhaustion is the hypothesized cause for transmissions ending. Pilot Whale Y-404 stopped transmitting after 16 d. The last status report, 6 d before the final transmission, indicated good battery condition, and it had made only about 6,000 of the expected 25,000 transmissions. Thus, battery exhaustion is unlikely to have caused cessation of transmissions from Y-404's tag.

In combination, tracking data for several behavioral parameters suggest that the condition of Pilot Whale Y-404 may have declined prior to the final transmission on 22 May. Y-404 did not make any dives below 100 m after 18 May, whereas Y-400 made 31 dives to greater than 100 m during the same period, with some to depths of 700 to 800 m. Similarly, Y-404 made only five dives longer than 20 min after 18 May, while Y-400 made 12. Travel rates declined markedly during the final week of tracking for Y-404, and increased immediately for Y-400 following loss of signals from Y-404. Travel rates again declined markedly for Y-400 once he reached Windward Passage, but his increase in proportion of deep dives at Windward Passage suggests the travel rate decline was not related to a decline in condition.

It is not possible to determine conclusively if the abrupt, premature end of transmissions by Y-404 was due to animal death, tag failure, or attachment failure. It does not appear that there were any severe oceanographic or atmospheric phenomena that might have impacted the whales or tags. Wells et al. (in press) suggested that releases of small cetaceans should not be defined as successful if the animal is not monitored post-release for at least 6 wks. Based on this criterion and the available behavioral data, the status of the release of Y-404 should be considered to be unknown (but potentially negative), while the release of Y-400 should be considered successful. Attending veterinarians did not believe there were substantial differences in the physical, behavioral, or clinical laboratory assessments that would have predicted disparate outcomes for the two pilot whales.

This short-finned pilot whale case study provided an opportunity to assess the post-release fate of individuals from a mass stranding for which health assessment in the field guided the decision to release immediately rather than to hold them with the remainder of the group. Guidance from previous cases in which mass-stranded short-finned pilot whales had been marked and released from the beach without detailed medical assessments is limited. In two such cases, marked individuals subsequently restranded at other locations, up to several weeks post-release (Fehring & Wells, 1976; Irvine et al., 1979). Sampson et al. (2012) evaluated the health of stranded Atlantic white-sided dolphins (*Lagenorhynchus acutus*) and short-beaked common dolphins (*Delphinus delphis*) from mass strandings on Cape Cod, Massachusetts, and then performed satellite-linked follow-up tracking. They determined that it is reasonable to expect that at least some mass-stranded dolphins in stable physical and physiologic condition can be relocated and released on the same day as stranding, and that they will resume behavior and habitat use that is typical of the species. The apparent success of Y-400 supports the idea of releasing individuals determined by the attending veterinarians to be healthy, when logistically possible, rather than retaining them under rehabilitation conditions until the entire group can be released together. This becomes complicated when it is necessary to match dependent calves with their mothers, for example. In the case of this short-finned pilot stranding, it was determined weeks later that none of the individuals held for rehabilitation was releasable. It cannot be determined if Y-404 would have benefited from rehabilitation.

Pilot Whale Y-400 appeared to remain within the species range and exhibit patterns of behavior typical of short-finned pilot whales in the North Atlantic during most of his track. Short-finned pilot whales tend to be found in tropical, subtropical, and warm temperate waters, especially on or near continental shelf breaks, slopes, and areas of high physiographic relief (Bernard & Reilly, 1999; Olson, 2009). Except for a period in the middle of the track when he was in the open Atlantic moving between the continental shelf east of South Carolina and the Windward Islands, Y-400 occupied high-relief habitats. For the last 17 d of tracking, Y-400 settled into the high-relief habitat associated with the Windward Passage, separating Cuba and Haiti. His movements during the last weeks of tracking into waters of 28° to 29° C were consistent with general distributional patterns for the species.

The diurnal pattern of dives for Y-400 is consistent with some previous reports of the animals being more active at night (Kritzler, 1952); making generally shallower, probably nonfeeding dives during the day when the deep scattering layer is deep; and making deeper dives at night, presumably to meet the rising layer (Olson, 2009). Baird et al. (2003) and Andrews et al. (2011) reported that short-finned pilot whales off Hawaii made some of their deepest dives during the day, but made nearly four times as many deep dives at night, presumably in response to the depth of vertically migrating prey. Aguilar de Soto et al. (2008) reported similar patterns for short-finned pilot whales off the Canary Islands, with the deepest dives being made during the day, and deep dives also being performed during night. Aguilar de Soto et al. used acoustic recordings to determine that these deep dives often appeared to be associated with foraging.

Dive depths for Y-400 fell within previously reported ranges. All but four of his dives were less than 900 m deep, with his deepest dive going to between 1,000 m and 1,500 m. Aguilar de Soto et al. (2008) reported foraging dives with a maximum depth of 1,018 m for short-finned pilot whales off the Canary Islands. Baird et al. (2003) reported 600 to 800 m as the deepest dives for Hawaiian short-finned pilot whales. Subsequent research in Hawaii recorded dives of up to 1,296 m (Andrews et al., 2011). Bowers & Henderson (1972) reported that a trained short-finned pilot whale dove to 504 m and possibly made a voluntary dive to 609 m.

Maximum dive durations for Y-400 apparently exceeded previously recorded dive durations for this species. Overall, 90% of his dives were less than 20 min, and 99% were less than 30 min. However, 1% of dives were 30 to 40 min in duration, and 20 (21%) of these dives exceeded 40 min. Bowers & Henderson (1972) reported dives by a trained short-finned pilot whale of up to 14.5 min. Aguilar de Soto et al. (2008) reported maximum dive durations of 21 min for Canary Island short-finned pilot whales. In Hawaii, short-finned pilot whales were reported to make dives of maximum durations of 27 min (Baird et al., 2003) and 22.4 min (Andrews et al., 2011). Because available data and consultations with scientists who had tagged short-finned pilot whales led us to believe that dives in excess of 30 min should not be expected, dive duration "bins" at the upper end of the range for Y-400 were not programmed to precisely measure longer dives; future studies should consider measuring longer dives more precisely.

Based on findings from this and previous studies, short-finned pilot whale dives appear to be comparable to those of long-finned pilot whales (*Globicephala melas*). Baird et al. (2002) recorded dives by long-finned pilot whales to up to 648 m and 12.7 min duration in the Ligurian Sea during tracking periods averaging about 5 h. Heide-Jørgensen et al. (2002) recorded long-finned pilot whale dives up to 828 m deep, lasting up to 18 min over 32 d of tracking around the Faroe Islands. Nawojchik et al. (2003) recorded dives of up to 320 m (approaching the sea floor) and more than 26 min for rehabilitated long-finned pilot whales tracked for 66 to 77 d in Georges Basin, with longer and deeper dives occurring at night. Mate et al. (2005) reported maximum dive duration of 28 min for a rehabilitated long-finned pilot whale tracked for 94.5 d.

Pilot whales are highly social animals, and associations with conspecifics appear to be very important (Olson, 2009). Mate et al. (2005) found that a single long-finned pilot whale released in the North Atlantic after rehabilitation was part of a larger group of pilot whales 20 d after release. Tracking data suggested that Y-400 and Y-404 remained in close proximity for the 16-d period both transmitters were functioning. Prolonged social associations are a distinctive feature of short-finned pilot whale societies as evidenced by behavior associated with mass strandings when the same individuals restrand together at new sites over periods of days or weeks (e.g., Irvine et al., 1979), and from field and genetic studies (Amos et al., 1993; Heimlich-Boran, 1993). Nawojchik et al. (2003) tracked two juvenile rehabilitated long-finned pilot whales for more than 4 mo off New England, and satellite tracking data indicated that they probably remained in close proximity during much of this time.

Not all releases of subsets of mass-stranded pilot whale schools result in continued close associations. In 2003, five short-finned pilot whales from the same mass stranding were released together with mixed results (summarized in Wells et al., in press). A calf separated from the others and died from predation near shore 9 d post-release. Contact was lost with another pilot whale within a day of release. The remaining animals were tracked for 57 to 117 d and separated into a pair that ranged into the Atlantic Ocean and a single that moved into the Gulf of Mexico.

Thanks in large part to technological improvements for diagnostics on the beach and for follow-up monitoring, it is now possible to begin to address questions about whether it is appropriate to release subsets of mass-stranded groups of highly social species. Sampson et al. (2012) have demonstrated the utility of assessing health on the beach to decide if individual dolphins are releasable, and they have tested their judgments through post-release monitoring involving satellite-linked tracking. Our findings from at least one of the two pilot whales released from the stranding site after on-site health assessment suggest that the animal survived and returned to patterns typical of pilot whales. Data to evaluate approaches to releases of stranded cetaceans are necessarily opportunistic and difficult to obtain. More data are needed from experimental attempts to release apparently healthy individuals from stranding sites, and it is essential that future cases involve post-release monitoring to determine the fates of the animals.

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