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Radio-Tracking and Survivorship of Two Rehabilitated Bottlenose Dolphins (*Tursiops truncatus*) in the Indian River Lagoon, Florida

Marilyn S. Mazzoil,[1] Stephen D. McCulloch,[1] Marsh J. Youngbluth,[1] David S. Kilpatrick,[1, 2] M. Elizabeth Murdoch,[1] Blair Mase-Guthrie,[3] Daniel K. Odell,[4] and Gregory D. Bossart[1]

[1]*Harbor Branch Oceanographic Institute at Florida Atlantic University – Marine Mammal Research and Conservation, 5600 U.S. 1 North, Ft. Pierce, FL 34946, USA; E-mail: Mmazzoil@hboi.fau.edu*
[2]*Southside Veterinary Hospital, 935 36th Court, SW, Vero Beach, FL 32968, USA*
[3]*National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, FL 33149, USA*
[4]*Hubbs-SeaWorld Research Institute, 6295 Sea Harbor Drive, Orlando, FL 32821, USA*

Abstract

Despite an increase in the number of stranded dolphins rehabilitated and returned to the wild, the survivorship of these cetaceans is poorly documented. Since rehabilitation and release programs remain limited in scope, the release of dolphins from different age and sex cohorts provides information that is pertinent to protocols for future release candidates. Novel opportunities to track the survivorship of two rehabilitated bottlenose dolphins with radio transmitters occurred in 2001 and 2003 in the Indian River Lagoon (IRL), Florida. Both dolphins were male and had been identified prior to rehabilitation during a photo-identification monitoring program. Dolphin C6 stranded with multiple life-threatening shark wounds in 2000, at age 24, and was released after a successful 6-mo period of rehabilitation. This dolphin re-established an existing male pair-bond with dolphin C7, traveled 67 km from the release site, and survived 100 d before he died from asphyxiation by an exotic fish that lodged in his pharynx. Carter, a calf orphaned in 2003 at 1 y of age, was released following a 3-mo period of care that provided adequate nutrition and weight gain needed for survival in the wild. This young dolphin remained within a 10-km radius of the release site, failed to form a stable relationship with other dolphins, and appeared to have survived only 7 d when radio transmissions from an acoustic tag ceased. These two cases represent the radio-tracking studies of the oldest and youngest known bottlenose dolphins rehabilitated and released in the IRL.

Key Words: rehabilitation, release, survivorship, telemetry, bottlenose dolphin, *Tursiops truncatus*

Introduction

Bottlenose dolphins (*Tursiops truncatus*) are the most frequently stranded cetaceans in the United States (Odell, 1991). Stranding incidents along the western North Atlantic seaboard appear to be on the rise from both anthropogenic and natural causes (Waring et al., 2000). However, rescue-rehabilitation-and-release of stranded cetaceans has been relatively infrequent. In the U.S., from 1972 to 1995, only 1% (65 of 6,768) of stranded cetaceans were successfully rehabilitated (Wilkinson & Worthy, 1999). In a 25-y period (1977 to 2002), only 7% (5 of 70) of live-stranded odontocetes in central and northern California were released back into the wild (Zagzebski et al., 2006). From 1992 to 1997, the U.S. Southeast Regional Stranding Network rehabilitated and released 20 cetaceans (Wells et al., 1999). As the care and treatment of cetaceans improves and more rehabilitation facilities are established (St. Aubin et al., 1996), the number of survivors eligible for release is likely to increase.

The return of rehabilitated odontocetes to the wild remains a cautious practice due in part to the lack of information about the fate of many of the released individuals (Geraci & Lounsbury, 2005) and to the expense and logistics involved with tracking efforts (Gulland et al., 2001). The effectiveness of rehabilitation programs will continue to be uncertain until more survival verification data are obtained (Wilkinson & Worthy, 1999). Fortunately, the U.S. National Marine Fisheries Service (NMFS), responsible for implementing the U.S. Marine Mammal Protection Act of 1972, endorses post-release monitoring in order to evaluate the success, costs, and benefits of cetacean rehabilitation efforts and to establish protocols such as age and physiological factors for future release candidates ("Draft Release of Stranded Marine Mammals to the Wild," 1997).

Tracking studies of stranded and rehabilitated deep-water cetaceans have provided information relevant to the survivorship of an Atlantic spotted dolphin (*Stenella frontalis*) (Davis et al., 1996), an Atlantic white-sided dolphin (*Lagenorhynchus acutus*) (Mate et al., 1994), bottlenose dolphins (Wells et al., 1999), common dolphins (*Delphinus delphis*) (Zagzebski et al., 2006), harbor porpoises (*Phocoena phocoena*) (Westgate et al., 1998; Zagzebski et al., 2006), long-finned pilot whales (*Globicephala melas*) (Nawojchik et al., 2003), rough-toothed dolphins (*Steno bredanensis*) (Manire & Wells, 2005), and short-finned pilot whales (*G. macrorhynchus*) (Mate et al., 2005).

This paper describes the tracking and follow-up evaluation of two rehabilitated and released dolphins, the oldest and youngest known to date, into the Indian River Lagoon (IRL), a coastal estuarine environment along the eastern boundary of Florida where dolphin social structure is relatively known (Kent et al., in press). Few (3.8% or 32 of 834 cases) dolphins have stranded alive in this estuary (Stolen et al., 2006). Only two individuals have been previously rehabilitated and returned to the IRL, and neither was monitored in order to assess post-release survivorship.

Materials and Methods

Study Area

Bottlenose dolphins inhabit the IRL year-round. The estuary is a 251-km long waterway and comprises 40% of the inland sea along the east coast of Florida (Figure 1). The average depth is 0.9 m and the width ranges from 0.8 to 8 km. A 3- to 4-m deep Intracoastal Waterway (ICW) bisects the estuary from north to south. Five inlets and one lock connect the IRL to the Atlantic Ocean. A variety of habitats in this regime—seagrass beds, sandy bottom expanses, spoil islands, and mangrove forests—support a high diversity of flora and fauna (*The Indian River Lagoon National Estuary Program*, 1996). Data for the long-term residency of dolphins exist from re-sightings of naturally marked dolphins and those originally freeze-branded by Odell & Asper (1990) (Mazzoil et al., 2005).

Subjects and Case Histories

Freeze-Brand C6 (FBC6, HBOI-0010)—On 31 August 2000, a 24-y-old, freeze-branded male dolphin, C6, stranded live on a boat ramp in Vero Beach at McWilliams Park, Indian River County (27.65430N, -80.36922W) in the IRL. Local law enforcement agencies and staff from SeaWorld Florida rescued and transported this dolphin to Harbor Branch Oceanographic Institute (HBOI) for critical care and stabilization. Initial physical examination indicated the dolphin was in a generalized catabolic state (weight = 188 kg) with severe multifocal shark bite wounds. Symmetry and measurements of the gape and tooth cusp marks in the wounds indicated bull shark (*Carcharhinus leucas*) bites (G. Gilmore, Dynamac Corporation, pers. comm., examination on 3 September 2000). Cutaneous, subcutaneous, and skeletal muscle excavations occurred over approximately 30% of his body. By the end of a 6-mo rehabilitation process, all wounds had healed, the dolphin was alert, and he weighed 227 kg. Since few male dolphins in the IRL live past 25 (Stolen & Barlow, 2003), C6 was designated as a marginal release candidate by the NMFS and returned to the IRL on 5 March 2001. C6 was carried by stretcher and released 0.1 km from the rehabilitation facility into the IRL (27.53619N, -80.34872W) at the southernmost sector of his known home range.

Carter (CRTR, HBOI-0317)—On 9 August 2003, HBOI staff responded to a stranding call in Vero Beach, 0.4 km south of McWilliams Park, Indian River County, in the ICW (27.65069N, -80.37251W) of the IRL. The adult dolphin was dead but recognized as a resident female first identified in 1997 (WSCR, HBOI-0318). Her 1-y-old calf, born in August 2002, was beside her and attempted to suckle intermittently. This calf was displaced when two adult males engaged in mounting the dead cow. The cow was tied alongside a rescue boat and transported 13 km to HBOI for necropsy. The males departed, but the calf followed in echelon position, attempting to nurse three times from the dead cow. HBOI requested and received authorization from the NMFS to collect the calf for further evaluation. The calf was gently netted without incident, triaged at HBOI, and transported to Mote Marine Laboratory (MML) on 11 August 2003.

Animal care staff at MML rehabilitated this calf for potential future release. When collected, the 1.7-m long male calf was dehydrated and underweight at 45 kg. He was treated with antibiotics for a mild intestinal infection and given adequate nutrition. During the recovery process, the young dolphin exhibited stereotypic behaviors and an increased awareness of humans. After a 3-mo period in captivity, HBOI and MML veterinary and scientific staff recommended that this calf be released into the wild as soon as possible in order to mitigate any possible degradation of learned foraging, social, and survival skills, and to avoid a prolonged dependence on human intervention for provision of nutritional needs. The release had inherent risks related to the young age (< 2 y), unknown ability to forage successfully, unknown acceptance into a social group, and the

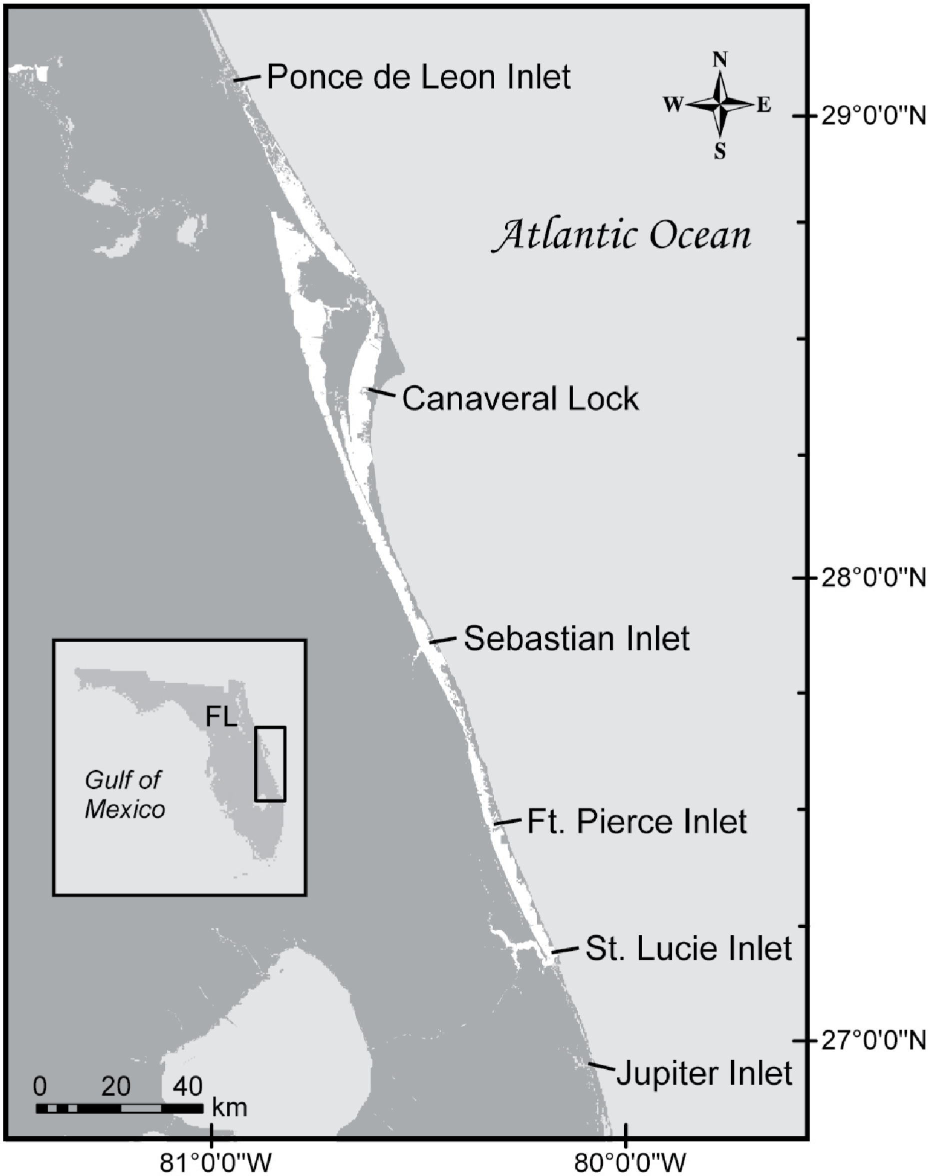

Figure 1. Map of the Indian River Lagoon, Florida study site, which extends from Ponce de Leon to Jupiter inlets

threat of predation from sharks. The NMFS designated Carter as a marginal release candidate and approved the release plan in October 2003. Carter was freeze-branded 956 on both the left and right dorsal and body. At the time of release (23 October 2003), Carter weighed 77 kg. He was placed in a 7 m × 12 m × 2 m temporary holding enclosure set up adjacent to a spoil island in the IRL (27.53517N, -80.33947W), St. Lucie County, located in the southern sector of his previously documented sightings with his mother.

Contingency Plan

A contingency plan was established in the event that the released dolphins would be unable to thrive in the wild. An experienced recovery team and relevant capture equipment were made available for the first 30 d post-release, which is considered the most critical survival period for a released dolphin (Wells et al., 1999). Recovery criteria included physical and behavioral stress indicators modified from Brill & Friedl (1993). Physical distress indicators encompassed life-threatening injury, discharge of fluids from the blowhole, respiratory compromise, blackened skin or blisters due to prolonged surface exposure, visual signs of disease, or elevated respiration rates. Additionally, areas of diminishing muscle tone and weight loss observed in emaciated dolphins were identified as key indicators to develop a body score index based on visual or photographic evaluation. These body regions were epaxial muscle, ear os, chin skin folds, cervical region, nuchal crest, dorsal ridge of scapula, ribs, facial bones, and transverse processes (Table 1). Behavioral stress indicators included continuous or prolonged stranding on spoil islands or shore, lethargy, prolonged surface exposure, isolation, inability to navigate, failure to demonstrate necessary foraging skills to provide for base nutritional needs, nuisance behaviors (e.g., soliciting food, biting, and aggression towards humans), and fisheries or boat interactions that could endanger the dolphin or the general public.

Telemetry Equipment and Plan
Prior to release, a VHF radio transmitter (Advanced Telemetry Systems Model 10-28) similar to those deployed by Wells et al. (1999) was attached to C6. The 15.7-g 13 mm × 45 mm transmitter was sealed inside an epoxy capsule and had a battery life expectancy of 60 d. A smaller VHF radio transmitter (10-g 13 mm × 41 mm, Advanced Telemetry Systems Backmount Transmitter Model MM120), with a battery life of 65 d, was attached to Carter. Both transmitters had a 33-cm long whip antenna with an effective range of approximately 5 km at sea level. The repetition rates were set to 100 pulses/min, and a duty cycle was programmed for 12 h/d in order to extend battery life. The tags were designed to transmit in the 164.000 to 167.999 MHz range, which avoided radio interference from Patrick Air Force Base and the Kennedy Space Center located nearby.

The dorsal fin was cleansed with alcohol, and lidocaine hydrochloride was injected into the tagging site to provide local anesthesia. A 5-mm hole, 2 cm from the posterior margin in the upper third of the dorsal fin, was made with a modified cork borer. A stainless steel nut and bolt was used to secure the epoxy capsule to a livestock ear tag (Jumbo Roto-tags, Dalton Supplies, Nettlebed, England), which was then attached through the hole in the dorsal fin.

Two ATS receivers (R4000 and FM100) in conjunction with a fixed, four-element Yagi antenna array were used for post-release monitoring. The antenna was mounted to the 1.8-m tower of a 6.4-m Grady White research vessel for water-based monitoring, or carried with the receiver as a portable unit for land-based tracking on nine causeways and one inlet bridge (Sebastian) that spans the central and southern regions of the IRL. Tracking surveys were conducted daily for the first 2 wks, then twice weekly for the remainder of the tag attachment.

Results

Freeze-Brand C6 (HBOI-0010)
Week 1 (5 March to 11 March 2001)—Upon release at 1015 h, C6 breached three times and swam to the ICW. He remained in this area for 1.5 h, engaged in social behavior with two adult dolphins, and then headed north. By sunset at 1830 h, he was feeding next to a spoil island, was alone, and had traveled 16 km. The body condition index score was 3 (ideal) at the time of release. High winds prevented vessel-based tracking on post-release Day 2, but a radio signal was detected from land from 1100 to 1630 h. His position was triangulated from CR510 causeway, Sebastian Inlet Bridge, and the west shore, 25 to 35 km north of the release site. On Day 3, C6 was tracked by boat and located 27 km north of the release site, milling in a group of eight adult dolphins. On Day 4, C6 was tracked by boat and located 2 km south from Day 3, socializing with

Table 1. Body condition index score based on weight loss observable from photographs or observations of wild dolphins

Body condition index score	1	2	3	4	5
Description	Emaciated	Underweight	Ideal	Overweight	Obese
Epaxial muscle definition	Concave	Slightly concave	Flat	Convex	Convex
Ear os	Exposed	No dimpling	Slight dimpling	Dimpled	Significantly dimpled
Chin skin folds	Not present	Not present	Not present	Present	Present
Cervical region (lateral)	Concave	Mild concavity	Flat	Broad	Broad
Nuchal crest	Depressed	Slightly depressed	Flat	Slight mid-dorsal indentation	Mid-dorsal indentation
Dorsal ridge of scapula	Exposed	Slightly exposed	Not observed	Not observed	Not observed
Ribs	Exposed	Slightly exposed	Not observed	Not observed	Not observed
Prominent facial bones	Exposed	Slightly exposed	Not observed	Not observed	Not observed
Transverse processes	Exposed	Slightly exposed	Not observed	Not observed	Not observed

a group of three adults and three calves. Despite extensive vessel and land-based tracking attempts, no signals were detected throughout Days 5 and 6.

Week 2 (12 March to 18 March 2001)—On Day 7, a radio signal was triangulated from a boat and causeway position 25 to 32 km north of the release site, but no visual contact was made. On Day 8, C6 was tracked by boat and located 30 km north of the release site, engaged in feeding behavior with one adult dolphin along the eastern shoreline. The body condition index score remained a 3 (ideal) based on visual observations. On Day 10, radio signals were received during a boat survey; the signals were at least 35 km north of the release site, but nightfall prevented further visual confirmation. No signals were detected during land-based tracking throughout Days 11 to 14.

Week 3 (19 March to 25 March 2001)—On Day 16, C6 was tracked by boat and located 61 km north of the release site. He was with a freeze-branded dolphin, C7 (Odell & Asper, 1990), and a third presumed adult, SUBM. Three days later (Day 19), C6 was located from radio signals during a boat survey 66 km north of the release site, with C7, SUBM, and freeze-brand dolphin 39 (Odell & Asper, 1990) with her calf. The body condition index score was 3 (ideal) based upon photographic evaluations.

Week 4 (26 March to 1 April 2001)—No signals were detected during one boat and one land-based survey.

Week 5 (2 April to 8 April 2001)—On Day 29, radio signals were received on a causeway 74 km north of the release site. A boat was deployed, but no visual contact occurred; the search was suspended at dusk. The next day (Day 30), C6 was tracked during a boat survey 65 km from the release site with C7, SUBM, and 20 to 22 other dolphins. The body condition index score remained a 3 (ideal) based upon photographic evaluations.

Week 6 (9 April to 15 April 2001)—On Day 37, C6 was tracked by a boat survey 67 km north of the release site. He was with a group of six dolphins, but no other identities could be confirmed because of the low-light photographic conditions at dusk.

Post-release sighting locations of C6 were similar to those observed prior to the stranding and rehabilitation (Figure 2). No further sightings of

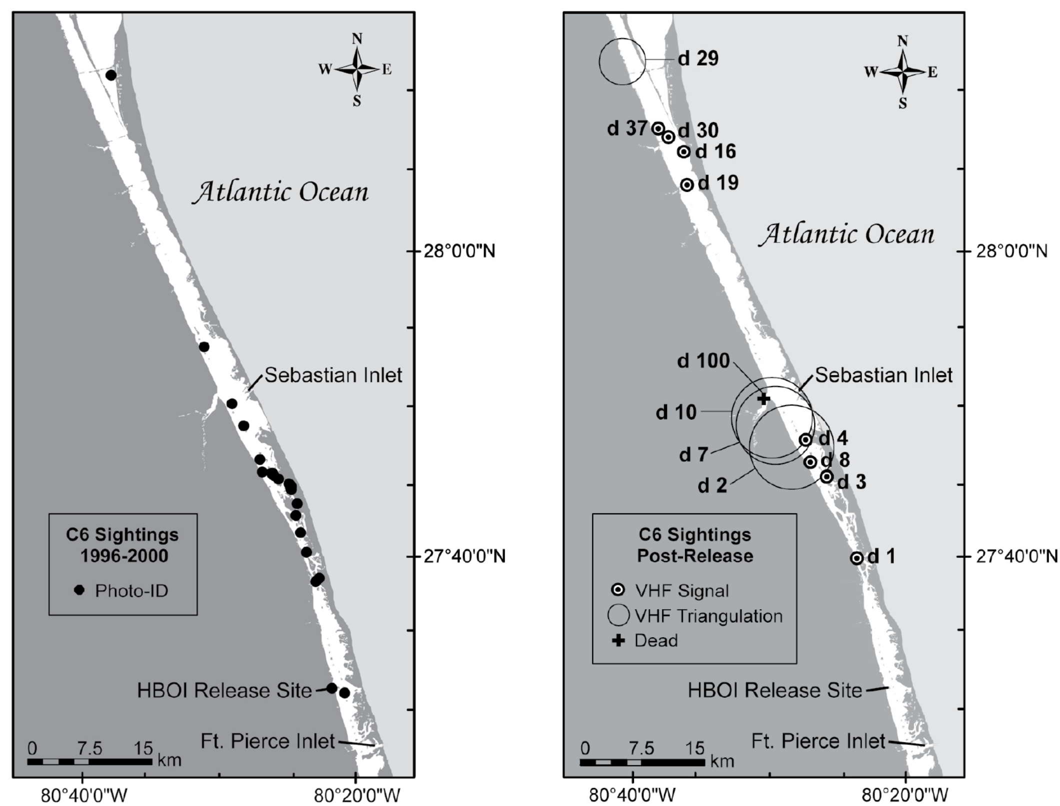

Figure 2. Dolphin C6 sighting history: pre and post stranding event

C6 occurred during monthly systemwide photo-identification surveys in April or May (Weeks 7 through 14). On 12 June 2001, 100 d post-release, C6 was recovered dead 35 km north of the release site during an unusual mortality event (Wilkinson, 1996) in the IRL (*Marine Mammal Commission*, 2001). Necropsy results indicated that he died of asphyxiation by a non-indigenous black chin tilapia (*Sarotherodon melanotheron*) fish (G. Gilmore, pers. comm., 20 June 2001), which was ventro-laterally lodged in his larynx (Bossart et al., 2003).

Carter (HBOI-0317, MML-0329)
Day 1 (23 October 2003)—Carter was transported to the temporary holding pen in the IRL, which was situated next to a spoil island. The gate was opened after 1 h at 1020 h. The calf left the enclosure 10 min later and moved towards a group of three dolphins sighted in the area: a cow/calf pair and a presumed adult traveling south. All four dolphins milled and displayed probable feeding behavior near the spoil island for 5 min, whereupon the group of three continued south. No physical interaction was noted between Carter and these dolphins. Subsequently, Carter chased finger-size mullet (*Mugil cephalus*) along the island sandbar, and over the next 2 h moved 0.8 km south to another spoil island. He swam back and forth alongside this spoil island shoreline for the remainder of the day.

Day 2 (24 October 2003)—Carter was located 0.8 km north of the release site along the southern shoreline of a spoil island. Over the next 5 h he swam south in shallow water (< 1.2 m). The calf remained east of the ICW, close to a spoil island shoreline that was 2.6 km south of the release site. Despite plentiful baitfish in the area, no probable feeding or feeding activities were observed during daylight.

Day 3 (25 October 2003)—Carter remained along the spoil island from the previous day, swimming in small circles and ignoring nearby baitfish. At 1130 h, he swam rapidly away from five approaching dolphins and repositioned in 0.6-m deep water next to the eastern shoreline. At 1615 h, the calf was chased by two adult dolphins for 5 min and then returned to the site. Thereafter, the calf made multiple fast rushes, chasing baitfish in the shallows, but prey ingestion could not be confirmed. He remained along the eastern shoreline at sunset.

Day 4 (26 October 2003)—Carter reversed his travel path, was located 7.6 km north (5 km north of the release site), and had joined a 10-y-old male (HERA FB942) and another presumed adult dolphin. The group of three swam together for 2.5 h, bow riding the research vessel or pushing baitfish up into the shallow waters where Carter was observed catching fish. After this interaction, Carter milled in the area alone for the rest of the day. The body condition index score was 3 (ideal) based upon photographic evaluations.

Day 5 (27 October 2003)—Carter was tracked to the same area as the previous day, moving in and out of the deeper waters of the ICW. He made multiple fast bursts toward baitfish during the day but did not visibly interact with any dolphins milling and feeding in the vicinity. The body condition score remained a 3 (ideal) based upon photographic evaluations.

Day 6 (28 October 2003)—Carter was tracked 9.7 km southeast of the release site in a series of man-made canals and mangrove islands where he actively foraged for 3 h.

Day 7 (29 October 2003)—Carter was tracked and found swimming along the east shoreline, parallel to the release site, with another calf. By the end of the day, he was alone, 6.2 km north of the release site, in shallow water along the west shore.

Post-release sightings of Carter occurred within a 10-km radius of the release site and were dissimilar in range size to those observed prior to the death of his mother (Figure 3). Despite efforts to track the calf for the next 10 d, which included multiple vessel and aerial surveys with VHF equipment, no other signals from the tracking device or visual observations of Carter were recorded and he was presumed dead.

Discussion

Survivorship of Other Young and Orphaned Marine Mammals
The duration of the rehabilitation stay or the age of orphanage for cetaceans < 2 y of age has yet to be significantly correlated with post-release survival. Cases exist for the survival of these young from both lengthy rehabilitative stays (> 6 mo) and orphaned incidents, and a number of cases of presumed mortality have also been documented. Three survivors of a mass stranding of long-finned pilot whales, ages 1, 1.5, and 2 y, were released after a 7-mo period of rehabilitation (Mate et al., 2005). The oldest calf was satellite tagged and joined a group of conspecifics 20 d after release. Overall movement patterns were consistent with reported pilot whale distribution (Payne & Heinemann, 1993) over the 94-d monitoring period, indicative of a successful reacclimation of at least the eldest whale to the wild. An immature harbor porpoise, < 2 y old, was released after 13 mo of rehabilitation. Satellite telemetry provided 50 d of data (Westgate et al., 1998), and tracking data were similar to satellite-linked transmitter deployments on free-ranging individuals of this

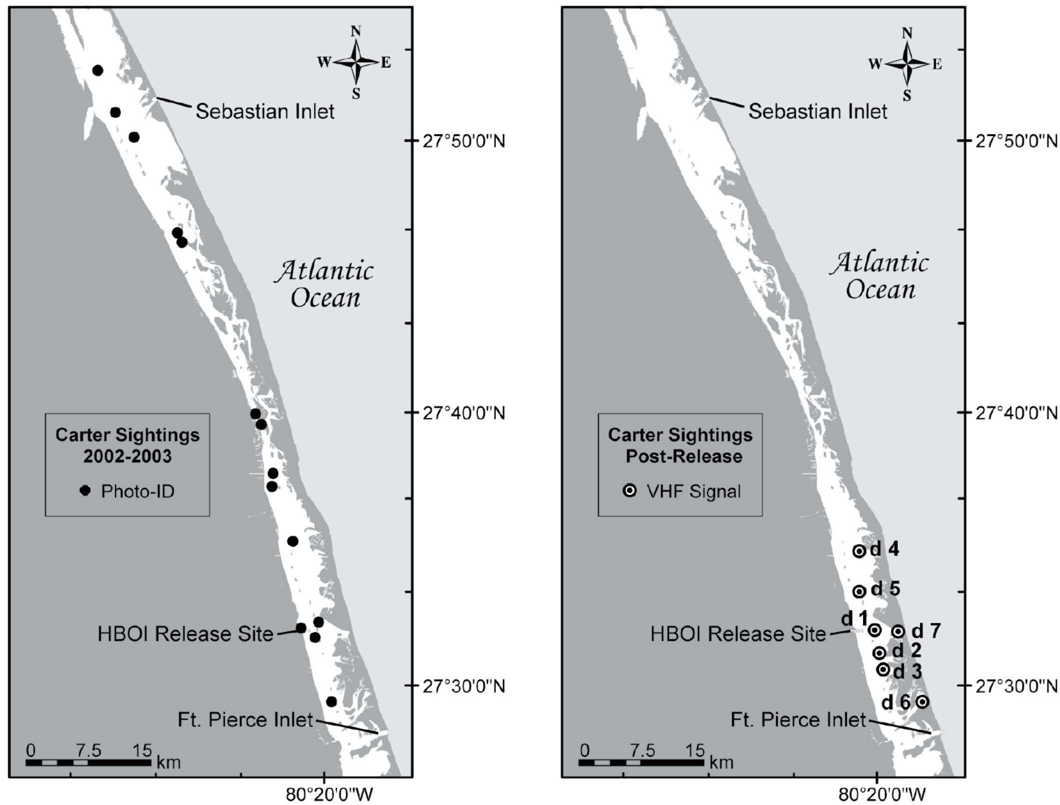

Figure 3. Dolphin Carter sighting history: pre and post stranding event

species (Read & Westgate, 1997), suggesting that a lengthy rehabilitation for younger animals may contribute to a successful reacclimation in the wild.

At least two young bottlenose dolphin calves, orphaned at 14 and 15 mo in Sarasota Bay, Florida, are known to have survived as evidenced by photo-identification records (Allen et al., 2005). In spite of the existence of a grandmother and aunts in the home range, these calves were not adopted but have survived for at least 6 mo and 12 y, respectively. Another 15-mo-old orphaned calf was presumed dead in < 5 mo (Allen et al., 2005). A second case of an orphaned calf < 2 y old occurred in the IRL in 2006 when the known mother (PHAN) of a 15-mo-old calf (c2PHAN) died from complications related to a boat injury (HBOI-0611; D. Kilpatrick, pers. comm., 6 December 2006). The female calf survived 24 d before it was recovered dead (HBOI-0612) within 0.6 km from the recovery site of her mother. Multiple, fresh tooth-rake marks on the carcass indicated attacks by conspecifics. The orphaned calf's tooth-rake coverage values were > 0.5 (using methods in Scott et al., 2005), significantly higher than the zero value for calves in Shark Bay, Australia, suggestive of agonistic encounters with elevated aggression in the absence of maternal protection. The cause of death was likely multifactorial: related to pneumonia, chronic stress, and starvation.

Survivorship of a Released IRL Dolphin in 1991

A 2.0-m long male bottlenose dolphin (SWF-Tt-9014-B) that stranded in Vero Beach, Indian River County, in the IRL (27.57091N, -80.36079W) on 23 July 1990 was rehabilitated and released by SeaWorld Florida on 2 May 1991. SWF-Tt-9014-B (freeze-branded upside down "A") was documented in photo-identification surveys in 2000; and in 2004, he was captured and released as part of the IRL Health and Environmental Risk Assessment (HERA) project (Bossart et al., 2006). Age was estimated by examination of dentine layers of an extracted tooth, and it was established that he was 4 y old at the time of stranding in 1990 (W. McFee, pers. comm., NOAA/NOS/NCCOS, 2004). In Australia, 67% of dolphin calves were weaned by their fourth birthday (Mann et al., 2000). At 4 y, SWF-Tt-9014-B was relatively mature, and this condition probably facilitated his survival post-release.

Social Structure

In the IRL, group size is larger when calves are present, signifying that mothers may rely on the assistance of conspecifics in calf-rearing (Kent et al., in press). Females are known to affiliate to some degree based upon reproductive status (Wells et al., 1987; Herzing & Brunnick, 1997; Rogers et al., 2004; Kent et al., in press). Presumably such socialization facilitates shared calf rearing, defense against male harassment, and predation (Connor, 2000; Mann et al., 2000). Maximum coefficient of association (COA) values often vary less across populations for females than males, and females tend to have larger numbers of casual associates (Quintana-Rizzo & Wells, 2001; Kent et al., in press) as well as larger social networks (Smolker et al., 1992). In the IRL, females with calves have more affiliations than females without calves (Kent et al., in press). This fluid social structure may have provided Carter with more opportunities to affiliate with familiar mother-calf groups, but the brevity of encounters precluded any long-term opportunities to assimilate into dolphin society. Social isolation may prevent long-term rehabilitation of solitary-stranded odontocetes because young individuals are likely to lack the skills and experience needed to survive after reintroduction (Nawojchik et al., 2003).

In contrast to variable female associations, pair-bonds among dolphin males of similar age may develop early in life (Wells et al., 1987), solidify at sexual maturity between the ages of 10 to 15 y (Owen et al., 2002), and can be maintained for a decade or more—for example, 12 y for *T. aduncus* (Connor et al., 1999) and > 20 y among *T. truncatus* (Wells, 1991). In photo-identification data from 1996 to 2000, prior to the stranding event, C6 and C7 were a stable male pair with the highest COA value (Kent et al., in press). The first observation of this pair occurred in 1980 when they were captured together, freeze branded, and released (Odell & Asper, 1990). After the rehabilitation and release of C6, the dyad reunited. The reestablishment of a previous relationship demonstrated the ability to reintegrate into a natural, functional social unit (e.g., a pair of bonded males), one criterion for a successful release (Wells et al., 1998). Similarly, pair-bonding contributed to the successful release of two male juvenile bottlenose dolphins (Wells et al., 1998) and two juvenile long-finned pilot whales (Nawojchik et al., 2003).

Predation

Lethal and nonlethal predator-prey interactions between sharks and dolphins have been documented worldwide (see review in Heithaus, 2001a). Predation pressure has been suggested as an important determinant of group size in dolphins (Wells et al., 1980; Heithaus, 2001b). Eight species of sharks inhabit the IRL, including the year-round resident bull shark (Gilmore, 1977; Snelson & Williams, 1981), a known marine mammal predator (Heithaus, 2001a). The presence of sharks may partially explain the larger calf group sizes found in the IRL (Kent et al., in press). Evidence of shark attacks exists from physical examinations during the HERA project in which 31% (28 of 90) of dolphins had one or more shark bite scars (Sayre et al., in litt., 1 May 2006). Overall, calves and juveniles show a relatively lower prevalence of shark bite wounds, suggesting that attacks on young dolphins are probably fatal (Mann & Barnett, 1999; Maldini, 2003) or that young *T. aduncus* and *T. truncatus* are protected by adults (Wells et al., 1987; Cockcroft et al., 1989).

Predation may have been the cause of disappearance for four of nine captive dolphins rehabilitated and released off of Western Australia, where a high frequency of shark bites on dolphins (74% or 95 of 128) has been reported (Heithaus, 2001b). A 3-y-old dolphin disappeared 2 d post-release, and two dolphins, ages 3 and ~14 to 16 y, disappeared after 8 d (Gales & Waples, 1993). The loss of the fourth dolphin, age 3 mo, after 30 d may have been related to poor health because of the inability of its mother to forage successfully. Emaciated calves are noted to have an increased risk of shark attacks (Mann & Barnett, 1999).

The post-release behavior of Carter included affinity for shallow water along spoil islands and the shoreline. We speculate this behavior was due to his avoidance of aggressive conspecifics as well as his awareness of predators in the deeper channel waters. Dolphins in Sarasota, Florida, increase usage of shallow water expanses during the spring and summer seasons when bull sharks are most abundant (Wells et al., 1987). Inhabiting a more confined space may increase the chance of predator detection (Wells et al., 1980). In Australia, the reproductive success of female dolphins was predicted by water depth, where shallow waters were associated with allowing mother-calf pairs to detect and avoid predatory sharks (Mann et al., 2000). A young unprotected dolphin is no match for a skilled predator. Even small sharks (1.7 to 2.0 m) are capable of killing calves (Mann & Barnett, 1999). We attribute the disappearance of Carter after 7 d to a fatal shark attack, but we cannot dismiss a possible conspecific incident or boat strike that resulted in incapacitating or mortally wounding the calf, whereupon he was scavenged by sharks. Despite intensive vessel and aerial survey coverage, no carcass was discovered, and Carter was not observed during subsequent photo-identification surveys in the IRL or Atlantic Ocean that took place August 2003 to December 2006.

Rationale for Rehabilitation, Release, and Recapture
Rehabilitating dolphins is expensive, nominally $40,000 to 50,000 per individual. Up to $100,000 has been spent on cetaceans in need of lengthy rehabilitation prior to release (St. Aubin et al., 1996). Consequently, the number of animals tagged and released after rehabilitation is likely to remain limited, and the contribution to conservation may be more indirect through public exposure, education, and scientific research (Gulland et al., 2001) rather than as numerical additions to non-endangered populations. In a few cases, rehabilitated, released, and tagged individuals have provided the only data available to investigate the diving behavior and movement of a species (Davis et al., 1996) or stock (Wells et al., 1999), and in one case, provided the longest record (132 d) of movement of a species (Nawojchik et al., 2003).

The decision to recapture a released animal is a difficult one, requiring a balance between variable and under-reported acclimation periods with the ability to survive. Three former captive dolphins, ages 3, ~14 to 16, and ~14 to 16 y, respectively, which were rehabilitated and released into the wild, were recaptured after 12, 13, and 44 d, respectively, because of weight loss (Gales & Waples, 1993). Photographic indices of body condition (Pettis et al., 2004; Politi et al., 2004) are non-invasive assessments of general health and should serve to document the progression of weight loss and severity and provide a basis for recapture. However, these indices should be used with caution as lacking knowledge of body mass trends in populations (e.g., high in winter and low in summer) and the ability of individuals to survive over years in poor body condition as seen in the IRL (Mazzoil, unpub. data) make it difficult to apply these as stand-alone criteria. The development of survival evaluation protocols, such as those recommended by the Interagency/Oceanaria Manatee Working Group for released orphan and captive-bred endangered manatees, would also serve to facilitate field evaluations of released dolphins.

The successful reintroduction of C6 and the failure of Carter to thrive appear to be age dependent and related to the ability to assimilate into an existing social structure (C6) or navigate in a new order (the absence of maternal protection in Carter's case). Survival may also be inherent to individual factors that cannot be readily evaluated (e.g., generational knowledge, individual mental fitness, behavior, and hierarchal structure). In areas where predation risk is high, a lengthy rehabilitation for immature animals to gain mass should be considered, but few facilities exist for such recovery. Future investigations of the behavior of rehabilitated and released odontocetes will be necessary to guide management decisions that can optimize their ability to survive in the wild.

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Literature Cited

Allen, J. B., Hofmann, S., Gannon, J. G., & Wells, R. S. (2005). Behavior of orphaned bottlenose dolphin calves within a long-term resident community in Sarasota Bay, Florida. *Proceedings of the Sixteenth Biennial Conference on the Biology of Marine Mammals*. San Diego, CA. 330 pp.

Bossart, G. D., Goldstein, J. D., Murdoch, E. M., Fair, P. A., & McCulloch, S. D. (2006). Health assessment of bottlenose dolphins in the Indian River Lagoon, Florida and Charleston, South Carolina. *Harbor Branch Oceanographic Technical Report 93*. 36 pp.

Bossart, G. D., Meisner, R., Varela, R., Mazzoil, M., McCulloch, S., Kilpatrick, D., et al. (2003). Pathologic findings in stranded Atlantic bottlenose dolphins (*Tursiops truncatus*) from the Indian River Lagoon, Florida. *Florida Scientist*, *66*(3), 226-238.

Brill, R. L., & Friedl, W. A. (1993). Reintroduction to the wild as an option for managing navy marine mammals. *Naval Command, Control and Ocean Surveillance Center, RDT&E Division, Technical Report 154*. 84 pp.

Cockcroft, V. G., Cliff, G., & Ross, G. J. B. (1989). Shark predation on Indian Ocean bottlenose dolphins *Tursiops truncatus* off Natal, South Africa. *South African Journal of Zoology*, *24*(4), 305-309.

Connor, R. C. (2000). Group living in whales and dolphins. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), *Cetacean societies* (pp. 199-218). Chicago: University of Chicago Press. 433 pp.

Connor, R. C., Heithaus, M. R., & Barre, L. M. (1999). Superalliance of bottlenose dolphins. *Nature*, *397*, 571-572.

Davis, R. W., Worthy, G. A. J., Würsig, B., Lynn, S. K., & Townsend, F. I. (1996). Diving behavior and at-sea movements of an Atlantic spotted dolphin in the Gulf of Mexico. *Marine Mammal Science*, *12*(4), 569-581.

Draft release of stranded marine mammals to the wild: Background, preparation, and release criteria. (1997). *U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-OPR.* 76 pp. Retrieved 2 March 2008 from www.nmfs.noaa,gov/pr/pdfs/health/release.pdf.

Gales, N., & Waples, K. (1993). The rehabilitation and release of bottlenose dolphins from Atlantis Marine Park, Western Australia. *Aquatic Mammals*, *19*(2), 49-59.

Geraci, J. R., & Lounsbury, V. J. (2005). *Marine mammals ashore: A field guide for strandings* (2nd ed.). Baltimore: National Aquarium in Baltimore. 371 pp.

Gilmore, R. G., Jr. (1977). Fishes of the Indian River Lagoon and adjacent waters, Florida. Bulletin of the Florida State Museum. *Biological Sciences*, *22*(3), 101-148.

Gulland, F. M. D., Dierauf, L. A., & Rowles, T. K. (2001). Marine mammal stranding networks. In L. A. Dierauf & F. M. D. Gulland (Eds.), *Marine mammal medicine* (2nd ed.) (pp. 45-67). Boca Raton, FL: CRC Press. 1,063 pp.

Heithaus, M. (2001a). Predator-prey and competitive interactions between sharks (order Selachii) and dolphins (suborder Odontoceti): A review. *Journal of Zoology*, *253*, 53-68.

Heithaus, M. (2001b). Shark attacks on bottlenose dolphins (*Tursiops aduncus*) in Shark Bay, Western Australia: Attack rate, bite scar frequencies, and attack seasonality. *Marine Mammal Science*, *17*(3), 526-539.

Herzing, D. L., & Brunnick, B. J. (1997). Coefficients of association of reproductively active female Atlantic spotted dolphins, *Stenella frontalis*. *Aquatic Mammals*, *23*(3), 155-162.

The Indian River Lagoon National Estuary Program: Comprehensive Conservation and Management Plan. (1996). 337 pp.

Kent, E., Mazzoil, M., McCulloch, S., & Defran, R. H. (In press). Group characteristics and social affiliation patterns of bottlenose dolphins (*Tursiops truncatus*) in the Indian River Lagoon, Florida. *Florida Scientist*.

Maldini, D. (2003). Evidence of predation by a tiger shark (*Galeocerdo cuvier*) on a spotted dolphin (*Stenella attenuata*) off O'ahu, Hawai'i. *Aquatic Mammals*, *29*(1), 84-87.

Manire, C. A., & Wells, R. S. (2005, November). *Rough-toothed dolphin rehabilitation and post-release monitoring* (Mote Marine Laboratory Technical Report #1047).

Mann, J., & Barnett, H. (1999). Lethal tiger shark (*Galeocerdo cuvier*) attack on bottlenose dolphin (*Tursiops* sp.) calf: Defense and reactions by the mother. *Marine Mammal Science*, *15*(2), 568-575.

Mann, J., Connor, R. C., Barre, L. M., & Heithaus, M. R. (2000). Female reproductive success in bottlenose dolphins (*Tursiops* sp.): Life history, habitat, provisioning, and group-size effects. *Behavioral Ecology*, *11*(2), 210-219.

Marine Mammal Commission: Annual report to Congress, 2000. (2001). 253 pp.

Mate, B. R., Stafford, K. M., Nawojchik, R., & Dunn, J. L. (1994). Movements and dive behavior of a satellite-monitored Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in the Gulf of Maine. *Marine Mammal Science*, *10*(1), 116-121.

Mate, B. R., Lagerquist, B. A., Winsor, M., Geraci, J., & Prescott, J. H. (2005). Movements and dive habits of a satellite-monitored longfinned pilot whale (*Globicephala melas*) in the northwest Atlantic. *Marine Mammal Science*, *21*(1), 136-144.

Mazzoil, M., McCulloch, S. D., & Defran, R. H. (2005). Observations of the site fidelity of bottlenose dolphins (*Tursiops truncatus*) in the Indian River Lagoon, Florida. *Florida Scientist*, *68*(4), 217-226.

Nawojchik, R. D., St. Aubin, D. J., & Johnson, A. (2003). Movements and dive behavior of two stranded, rehabilitated long-finned pilot whales (*Globicephala melas*) in the northwest Atlantic. *Marine Mammal Science*, *19*(1), 232-239.

Odell, D. K. (1991). A review of the southeastern United States marine mammal stranding network: 1978-1987. In J. E. Reynolds III & D. K. Odell (Eds.), *Marine mammal strandings in the United States* (NOAA Technical Report NMFS 98) (pp. 19-23). Proceedings of the Second Marine Mammal Stranding Workshop, Miami, Florida.

Odell, D. K., & Asper, E. D. (1990). Distribution and movements of freeze-branded bottlenose dolphins in the Indian and Banana Rivers, Florida. In S. Leatherwood & R. R. Reeves (Eds.), *The bottlenose dolphin* (pp. 515-540). San Diego: Academic Press. 653 pp.

Owen, E. C., Wells, R. S., & Hoffman, S. (2002). Ranging and association patterns of paired and unpaired adult male Atlantic bottlenose dolphins, *Tursiops truncatus*, in Sarasota, Florida, provide no evidence for alternative male strategies. *Canadian Journal of Zoology*, *80*, 2072-2089.

Payne, P. M., & Heinemann, D. W. (1993). The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf edge and slope waters of the north-eastern United

States, 1978-1988. *Report of the International Whaling Commission*, *14*(Special issue), 51-68.

Pettis, H. M., Rolland, R. M., Hamilton, P. K., Brault, S., Knowlton, A. R., & Kraus, S. D. (2004). Visual health assessment of North Atlantic right whales (*Eubalaena glacialis*) using photographs. *Canadian Journal of Zoology*, *82*, 8-19.

Politi, E., Bearzi, G., & Airoldi, S. (2004). Evidence for malnutrition in bottlenose dolphins photoidentified in the eastern Ionian Sea. *Eastern Research on Cetaceans*, *14*, 234-236.

Quintana-Rizzo, E., & Wells, R. S. (2001). Resighting and association patterns of bottlenose dolphins (*Tursiops truncatus*) in the Cedar Keys, Florida: Insight into social organization. *Canadian Journal of Zoology*, *79*, 447-456.

Read, A. J., & Westgate, A. J. (1997). Monitoring the movements of harbour porpoises (*Phocoena phocoena*) with satellite telemetry. *Marine Biology*, *130*, 315-322.

Rogers, C. A., Brunnick, B. J., Herzing, D. L., & Baldwin, J. D. (2004). The social structure of bottlenose dolphins, *Tursiops truncatus*, in the Bahamas. *Marine Mammal Science*, *20*(4), 688-708.

Scott, E. M., Mann, J., Watson-Capps, J. J., Sargeant, B. L., & Connor, R. C. (2005). Aggression in bottlenose dolphins: Evidence for sexual coercion, male-male competition, and female tolerance through analysis of toothrake marks and behaviour. *Behaviour*, *142*, 21-44.

Smolker, R. A., Richards, A. F., Connor, R. C., & Pepper, J. W. (1992). Sex differences in patterns of association among Indian Ocean bottlenose dolphins. *Behaviour*, *123*, 38-68.

Snelson, F. F., Jr., & Williams, S. E. (1981). Notes on the occurrence, distribution, and biology of elasmobranch fishes in the Indian River Lagoon System, Florida. *Estuaries*, *4*(2), 110-120.

St. Aubin, D. J., Geraci, J. R., & Lounsbury, V. J. (1996). Rescue, rehabilitation, and release of marine mammals: An analysis of current views and practices. *U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-OPR-8.* 65 pp.

Stolen, M. K., & Barlow, J. (2003). A model life table for bottlenose dolphins (*Tursiops truncatus*) from the Indian River Lagoon system, Florida, U.S.A. *Marine Mammal Science*, *19*(4), 630-649.

Stolen, M. K., Noke Durden, W., & Odell, D. K. (2006). Historical synthesis of bottlenose dolphins (*Tursiops truncatus*) stranding data in the Indian River Lagoon system, Florida, from 1977-2005. *Florida Scientist*, *70*(1), 45-54.

Waring, G. T., Quintal, J. M., & Swartz, S. L. (2000). U.S. Atlantic and Gulf of Mexico marine mammal stock assessments. *U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NE-162*. 309 pp.

Wells, R. S. (1991). The role of long-term study in understanding the social structure of a bottlenose dolphin community. In K. Pryor & K. S. Norris (Eds.), *Dolphin societies: Discoveries and puzzles* (pp. 199-225). Berkeley: University of California Press. 397 pp.

Wells, R. S., Bassos-Hull, K., & Norris, K. S. (1998). Experimental return to the wild of two bottlenose dolphins. *Marine Mammal Science*, *14*(1), 51-71.

Wells, R. S., Irvine, A. B., & Scott, M. D. (1980). The social ecology of inshore odontocetes. In L. M. Herman (Ed.), *Cetacean behavior: Mechanisms and functions* (pp. 263-317). New York: Wiley. 480 pp.

Wells, R. S., Scott, M. D., & Irvine, A. B. (1987). The social structure of free-ranging bottlenose dolphins. In H. H. Genoways (Ed.), *Current mammalogy* (pp. 247-305). New York: Plenum Press. 519 pp.

Wells, R. S., Rhinehart, H. L., Cunningham, P., Whaley, J., Baran, M., Koberna, C., et al. (1999). Long distance offshore movements of bottlenose dolphins. *Marine Mammal Science*, *15*(4), 1098-1114.

Westgate, A. J., Read, A. J., Cox, T. M., Schofield, T. D., Whitaker, B. R., & Anderson, K. E. (1998). Monitoring a rehabilitated harbor porpoise using satellite telemetry. *Marine Mammal Science*, *14*(3), 599-604.

Wilkinson, D. M. (1996). National contingency plan for response to unusual marine mammal mortality events. *U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-OPR-9.* 118 pp.

Wilkinson, D. M., & Worthy, G. A. J. (1999). Marine mammal stranding networks. In J. R. Twiss Jr. & R. R. Reeves, (Eds.), *Conservation and management of marine mammals* (pp. 396-411). Washington, DC: Smithsonian Institution Press. 471 pp.

Zagzebski, K. A., Gulland, F. M. D., Haulena, M., Lander, M. E., Greig, D. J., Gage, L., et al. (2006). Twenty-five years of rehabilitation of odontocetes stranded in central and northern California, 1977 to 2002. *Aquatic Mammals*, *32*(3), 334-345.