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Evaluating postintervention survival of free-ranging odontocete cetaceans

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ABSTRACT

Until recently, few data were available for evaluating postintervention survival of free-ranging cetaceans receiving aid from humans through: rescue from stranding, with rehabilitation and release; rescue, rehabilitation and release of debilitated or entangled individuals that had not beached; rescue of entangled animals with immediate release; and rescue, transport, and release of out-of-habitat animals. Advances in medical diagnosis, husbandry and therapy have improved survival of rehabilitation cases, and advances in radio-telemetry have improved postrelease monitoring. In total, 69 cases (1986–2010) were evaluated, involving 10 species of odontocete cetaceans with release data. Findings suggested a success criterion of surviving at least six weeks postrelease is useful in evaluating intervention strategies. No species had better success than others. Stranded beached cetaceans were less successful than free-swimming rescued animals. Rehabilitated animals were less successful than those released without rehabilitation. Mass stranded dolphins fared better than single stranded animals. Old age, diminished hearing ability, and lack of maternal care were factors in several unsuccessful cases. Success is not clearly related to rehabilitation duration. Retaining healthy individuals from mass strandings until all animals are ready for release may reduce success for some. Transport durations for unsuccessful cases were greater than for successful cases.

Key words: stranding, mass stranding, rehabilitation, disentanglement, postrelease monitoring.

Important questions have been raised regarding the relative risks and benefits of rehabilitating and releasing stranded odontocete cetaceans, but until recently few data have been available to support an appropriate evaluation (Moore *et al.* 2007). In the early years of cetacean rehabilitation, success in getting the animals to the point of release was infrequent, but success rates have improved markedly in recent years

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thanks to increased experience and knowledge, and improved diagnostics and facilities (Wilkinson and Worthy 1999, Zagzebski *et al.* 2006). Concurrently, safe and practical techniques for monitoring rehabilitated cetaceans postrelease have become available, especially involving radio and or satellite-linked telemetry, providing the potential for assessing the success of the animals released back into the wild (Scott *et al.* 1990, Lander *et al.* 2001). Decreased tag size and increased experience with attachments lasting for periods of months have helped to allay concerns about safety risks from the tags themselves (Kastelein *et al.* 1997, Wells 2005, Wells *et al.* 2009, Balmer *et al.* 2011). Recognizing that rehabilitation can be a very expensive undertaking, requiring extended allocations of limited medical, facility, and staff resources, increasing effort has been made in recent years to monitor rehabilitated cetaceans postrelease in order to evaluate the success of the treatments.

A few cases of postrelease monitoring of odontocete cetaceans have been published, with varying levels of information resulting from different monitoring approaches. Direct radio-tracking of VHF transmitters has been performed off Florida for bottlenose dolphins (*Tursiops truncatus*) for 7–100 d (Mazzoil *et al.* 2008) and a pygmy sperm whale (*Kogia breviceps*) for 4 d (Scott *et al*. 2001), providing location and surfacing information and opportunities for direct observations. Remote satellite-linked tracking of cetaceans in offshore habitats, where VHF tracking likely would not have been feasible, has been accomplished for at least seven species of rehabilitated cetaceans, including: harbor porpoises (*Phocoena phocoena*) for 50 d in the western Atlantic (Westgate *et al.* 1998) and for 5 mo off California (Zagzebski *et al.* 2006), two bottlenose dolphins off Florida tracked for 4–47 d (Wells *et al.* 1999), a rough-toothed dolphin (*Steno bredanensis*) tracked for 49 d in the western Atlantic (Wells *et al.* 2008*a*), a long-finned pilot whale (*Globicephala melas*) tracked for 94 d off New England (Mate *et al*. 2005), and an Atlantic white-sided dolphin (*Lagenorhynchus acutus*) tracked for 6 d in the Gulf of Maine (Mate *et al.* 1994). In some cases, it has been possible to combine satellite-linked tracking with the collection of dive depth and duration data, as occurred in the tracking of: an Atlantic spotted dolphin (*Stenella frontalis*) for 24 d in the Gulf of Mexico (Davis *et al.* 1996), two long-finned pilot whales (*Globicephala melas*) off New England for 127–132 d (Nawojchik *et al.* 2003), a Risso's dolphin (*Grampus griseus*) for 24 d in the Gulf of Mexico and Atlantic Ocean (Wells *et al.* 2009), and seven rough-toothed dolphins in the western Atlantic for 12–38 d (Wells and Gannon 2005, Wells *et al.* 2008*a*). A number of other cases have yet to be fully evaluated and published.

Some, but not all, of the published reports provided case-by-case assessments of postrelease success. Measures of success varied, and depended on the techniques used for monitoring. Duration of contact with an animal postrelease (duration of tracking) was a common measure, but in only one case was a specific minimum time period offered as a threshold for defining success (Wells *et al.* 2008*a*). In a number of cases where tracking methods have provided appropriate data, such parameters as rates of travel, water depth, distance from shore, minimum daily distance traveled, travel direction relative to prevailing currents, typical and maximum dive depth, dive depth relative to prey's position in the water column, dive duration, time at depth, and proportion of time at the surface have been compared to nonstranded conspecifics. Lengthier tracks have provided opportunities to assess temporal trends in measures that relate to condition and abilities, such as travel rates and dive parameters. To date, a general framework or set of criteria for assessing release success systematically and consistently across cases has yet to be produced. No comprehensive effort to review postrelease success relative to initial cause of stranding or intervention, duration of rehabilitation, treatments, rehabilitation facility conditions, or life history parameters has been published. Such data are useful for guiding future approaches to rehabilitation to maximize the probability of a successful effort and long-term survival of the animal.

By combining published reports and unpublished but verified rehabilitation cases in which postrelease monitoring occurred, a critical mass of cases now exists to begin to evaluate the postrelease success of rehabilitated small cetaceans in a more general sense, to reach broader conclusions. Applying the efforts of a team of cetacean scientists and veterinarians with extensive experience in cetacean rehabilitation and/or postrelease monitoring, the process was initiated by addressing these basic questions: What is the meaning of the term "postrelease success?" What set of parameters should be used to properly measure success, and how can they best be applied to odontocete species of various habitat and ecological requirements? Can a minimum period of apparently "normal" behavior postrelease be used as a basic criterion for assigning success? How can other parameters such as travel rates, habitat use, or dive data be incorporated into evaluations of success? What factors from the stranding response or rehabilitation process tend to be associated with postrelease success? Can this information be used to refine the initial selection criteria for potential rehabilitation candidates? After review of these questions the panel determined the set of conditions or circumstances that are most likely to lead to postrelease success, or to lack of success, for small odontocetes postintervention.

The focus of this review is on the fates of small cetaceans released after rehabilitation or at-sea interventions, rather than on the success of cetacean rehabilitation in general. A subset of small cetaceans that have been through rehabilitation is included in this review—those cases that have responded positively to treatment and reached the point where authorities have decided that they likely can survive back in the wild. A purpose of this review was to assess the fates of animals for which release decisions were made, to help refine this difficult decision making process.

Materials and Methods

Case selection—The primary goal of the project was to evaluate the success of free-ranging small cetaceans that had received aid from humans. "Aid" in this context is defined as (1) rescue of live-stranded beached animals with subsequent rehabilitation and release; (2) rescue of free-swimming debilitated or entangled individuals with subsequent rehabilitation and release; (3) rescue of free-swimming entangled animals with immediate release; and (4) rescue, transport to appropriate habitat, and release without rehabilitation of free-swimming out-of-habitat animals. One increasingly important subset of human intervention, immediate release of individuals from mass strandings without rehabilitation, with follow-up monitoring, was not considered in detail because information available at the time of the case review was insufficient to warrant analysis (but see Sampson *et al*. 2012 for a recent review). Evaluation of success of the individual case required collection of data postrelease. Follow-up monitoring involved direct visual observations, sighting reports, information from repeat strandings, VHF radio-tracking, and/or satellite-linked remote tracking. Case information was compiled from all known published and unpublished sources through mid-2010 in the United States that included data from postrelease monitoring of small cetaceans. These cases were evaluated relative to a variety of factors potentially influencing release success, as such data were available (Table 1).

Table 1. Factors potentially influencing release success.

Biological	Medical condition	Rehabilitation process
Age	Stranding cause	Duration of rehabilitation
Sex	Severity of illness or injury	Medication type
Reproductive condition	Subsequent health challenges	Diet type, feeding method
Social patterns	Nutritional status	Facility design/size
Sensory abilities	Immune competence	Presence of conspecifics
Locomotory abilities		Preparation for release
		Duration of transport for release

Case evaluation—The ideal aim of releasing a cetacean from rehabilitation is to return the animal to the wild population of origin in full health, where it survives to reproduce. However, monitoring a small cetacean after release is technically and logistically difficult, and to date reliable methodology that allows tracking for multiple years is not available. Thus for the purpose of this review, a definition of rehabilitation success was developed based on the available data from previously released animals, and the experience of veterinarians familiar with medical conditions of small cetaceans as well as that of ecologists familiar with the movements and behavior of small odontocetes. There are limited data on the duration small odontocetes have been observed after release, and the problems they encountered. By examining the number of weeks after release an animal is known to have survived (see Fig. 1), it is apparent that most animals that survived at least six to nine weeks were detected for months beyond this period. In most cases, if release failed, the failure (for whatever reason) usually occurred within the first six weeks. During the first six weeks postrelease, 57% of cases died or disappeared, but only 14% of cases were lost over the next nine weeks.

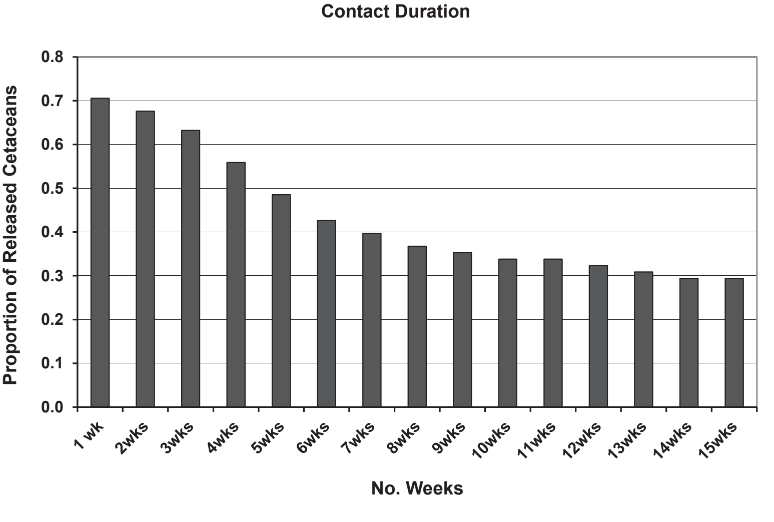

Figure 1. Proportions of released cetaceans known to be alive at the end of each week postrelease. Note the apparent inflection point after about week 6, suggesting that cetaceans surviving at least 6 wk are likely to survive for many more weeks.

Release success (S) was therefore defined as: following release, the cetacean exhibits ranging patterns, habitat use, locomotion, behavior, and social interactions typical for the species, stock or individual, and/or at least does not exhibit abnormal behavior, for a minimum of six weeks. Not all of these data will be available in all cases. To obtain these data, direct visual observations are best, but in the absence of observations, some of these data may need to be inferred from radio and or satellite-linked telemetry.

In contrast, failure (F) is defined as: direct evidence of atypical mortality, restranding, reliance on human provisioning, use of habitats atypical for the species, stock, or individual, atypical surfacing/respiration/dive patterns, or severely abnormal clinical signs.

Three further types of cases were identified, where data were insufficient to clearly define the release as successful or not, usually due to a tag failure. Cases where circumstantial evidence from the medical history and/or initial release data made it very likely that the release was successful were scored as unknown, positive (UP). Cases in which the clinical history or initial release behavior made it very likely that a negative outcome occurred were scored as unknown, negative (UN). If data were insufficient to make a determination, the case was defined as undetermined, data deficient (UDD).

Results and Discussion

Overview

In total, 69 cases from 1986 to 2010 were compiled and reviewed, involving 10 species of small odontocete cetaceans: 31 bottlenose dolphins (*Tursiops truncatus*) (Table S1), 17 rough-toothed dolphins (*Steno bredanensis*), five short-finned pilot whales (*Globicephala macrorhynchus*), three long-finned pilot whales (*G. melas*), four Risso's dolphins (*Grampus griseus*), four harbor porpoises (*Phocoena phocoena*), two common dolphins (*Delphinus delphis*), one Atlantic white-sided dolphin (*Lagenorhynchus acutus*), one Atlantic spotted dolphin (*Stenella frontalis*), and one pygmy sperm whale (*Kogia breviceps*) (Table S2; for the sake of simplicity, all will be referred to as dolphins from this point forward). Of these, 41 cases involved single strandings or rescues, while 28 of the cases involved mass strandings. Thirteen of the bottlenose dolphin cases and all 38 of the cases involving other species were strandings, with subsequent rehabilitation efforts. Eighteen bottlenose dolphin cases were rescue captures brought about by entanglement, out-of-habitat, or maternal death situations. Seven of these rescues led to rehabilitation, while the remaining 11 cases involved on-site examination, treatment if necessary, and release without rehabilitation.

Follow-up monitoring was performed as possible for all 69 cases. Tracking lasted, or resightings occurred, over periods ranging from less than one day to more than 1,500 d (Table 2, 3). Forty-two cases were tracked *via* satellite-linked transmitters (28 of these also had VHF transmitters, Table S3). Twenty were tracked *via* VHF tags only. Seven were not tagged, but were individually identifiable. The best release data available to us from any and all sources indicated that 29 (42%) were Successes (S) and 26 (38%) were Unknown-Positives (UP). Seven (10%) were Failures (F), including three recovered carcasses, three re-strandings, and one unexpected disappearance. Five (7%) were Unknown-Negatives (UN), involving behavioral concerns prior to loss of contact. The remaining two (3%) cases were Undetermined, Data Deficient (UDD), involving loss of contact with seemingly healthy animals within one day of release (Table 2, 3).

Table 2. Comparison of success across categories of aid provided to cetaceans. S = Successful; UP = Unknown, Positive; UN = Unknown, Negative; F = Failed

Aid category (species)	%S	%UP	%UN	%F	Average contact days: S	Range (days)	*n*
Stranded, rehabilitated, released (non-*Tursiops*)	36	55	6	3	104	49–157	36
Stranded, rehabilitated, released (*Tursiops*)	31	31	7	31	237	47–616	13
Rescued, rehabilitated, released (*Tursiops*)	43	29	14	14	1,070	854–1,490	7
Rescued and released immediately (*Tursiops*)	82	0	9	9	862	365–1,451	11

Table 3. Percentage of bottlenose dolphin cases that were successful (S) or unknown, positive (UP), by age class.

	Adult	Subadult	Calf
Stranded, single	67% (6/9)	50% (2/4)	na (0/0)
Captured, single, out-of-habitat	67% (4/6)	100% (3/3)	na (0/0)
Captured, single, entangled	100% (2/2)	100% (2/2)	50% (1/2)
Overall	71% (12/17)	78% (7/9)	50% (1/2)

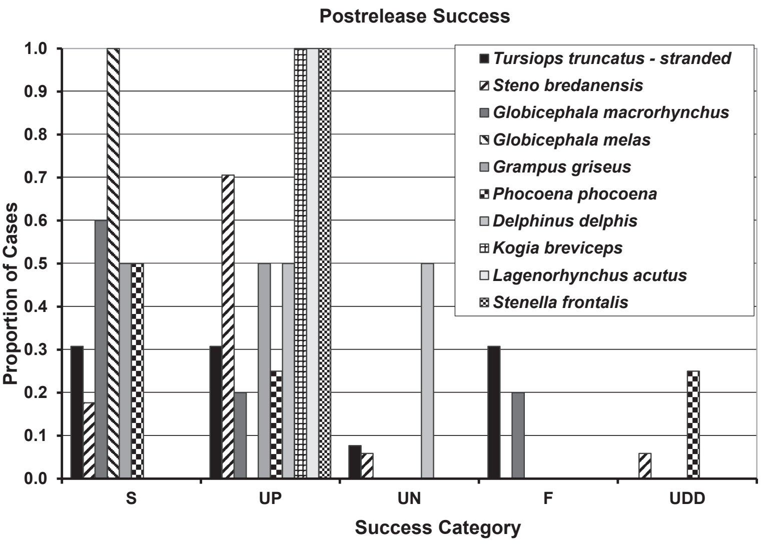

Figure 2. Proportions of stranding cases classified by success category, by species. S = Successful; UP = Unknown, Positive; UN = Unknown, Negative; F = Failed; UDD = Unknown, Data Deficient. Rescued, nonstranded bottlenose dolphins are not included.

The different species did not exhibit any dramatic differences in success for stranding cases as categorized by our criteria (Fig. 2). The across-species variability evident in Figure 2 is at least in part an artifact of small sample sizes for some species, such as *K. breviceps*, *D. delphis*, *S. frontalis*, *G. melas*, and *L. acutus*, where three or fewer cases were considered. Overall, the tendency is for most of the species considered here to demonstrate a greater likelihood of postrelease success than failure. Maximum duration of postrelease contact was up to an order of magnitude longer for bottlenose dolphins (up to more than 1,500 d) than for any of the other species (up to about 150 d for rough-toothed dolphins and a harbor porpoise), but this is perhaps not too surprising given the coastal or inshore habitat that facilitated observations or tracking of most of the released bottlenose dolphins, and the offshore nature of the other species, requiring remote tracking.

Circumstances Leading to Aid

Three categories of circumstances leading to human aid of cetaceans were considered: (1) stranding, rehabilitation, and release; (2) rescue capture, rehabilitation, and release; and (3) rescue capture and immediate release. The circumstances involved in aiding the cetaceans appeared to influence postrelease success. The first category involved all ten species, while the other two categories involved only bottlenose dolphins. In general, a smaller percentage of cases involving stranded cetaceans were successful than those involving rescue captures (Table 2). This is not too surprising, given that rescues requiring captures typically involved less-moribund animals than stranded animals, and the process of stranding is stressful and often the culmination of ongoing illness, injury, or age related concerns. Similarly, a smaller percentage of cases involving rehabilitation were successful as compared to cases involving immediate release and no rehabilitation (Table 2). Again, this is not too surprising given that the decision for immediate release was based on a veterinary assessment that the animal did not require further treatment or that rehabilitation posed an increase in the potential for a negative outcome when weighed against the present concerns. There was no significant difference in the average number of postrelease contact days for successful rescued, rehabilitated, and released bottlenose dolphins *vs.* successful rescued and immediately released bottlenose dolphins (Table 2). However, the average number of postrelease contact days was significantly greater for successful rescued dolphins than for successful stranded dolphins (*t*-test, $P < 0.001$) (Table 2).

Within the category of stranded and rehabilitated cetaceans, about a third of cases were clear successes, for bottlenose dolphins (31%) and the other nine species (36%) (Table 2). However, the non-*Tursiops* species had a higher percentage of UP cases than did the bottlenose dolphins (55% *vs.* 31%), and a much lower percentage of Failures (3% *vs.* 31%). There was no significant difference in the average number of postrelease contact days for successful stranded bottlenose dolphins *vs.* successful stranded non-*Tursiops* (Table S3). The coastal or inshore nature of most of the bottlenose dolphins may increase the likelihood that failure cases could be documented, whereas the more pelagic species may not survive another trip inshore to strand, questioning the ultimate fates of UP non-*Tursiops* cases.

Age Relationships

Statistical examination of age-related factors was limited to bottlenose dolphins due to insufficient numbers of individuals of different age classes for other species. Age did not appear to play a clear role in the success of bottlenose dolphin cases, regardless of whether they were (1) stranded individuals; (2) single, out-of-habitat individuals that were captured; or (3) single entangled individuals that were captured (Table 3). In each category, at least half of the cases were successful or positive, regardless of age.

The lack of success of three calves may have been related at least in part to their ages relative to maternal dependency. Bottlenose dolphin MML-0701 (Filly) was observed independent of her mother (who remained in the area) at about 1.5 yr of age, 1.5–4.5 yr earlier than expected (Wells 2003). She was rescued and treated in rehabilitation for wounds related to fishing line embedded in her peduncle (Wells *et al.* 2008*b*). Upon release, she never associated with her mother, she acquired additional fishing line, and disappeared. Bottlenose dolphin HBOI-0317 (Carter) was the length of a 1–2 yr old at the time it was captured, after the loss of its mother. It disappeared and was believed to have died within a week of release following rehabilitation. Pilot whale calf FKMMRT-0307 was part of a mass stranding. It was released with four other whales from the stranding after 117 d in rehabilitation, but it separated from the others and died near shore from shark attack 9 d later.

In contrast, several cases suggested the apparent benefits of maternal involvement. Bottlenose dolphin calf MML-0335 (Placida) was treated and released in the field for entanglement injuries, and was observed with its mother over the next few months, and on its own, 3.8 yr treatment (Wells *et al.* 2008*b*). Risso's dolphin calf MML-0706AA (Big Al) was likely only a few weeks old when it stranded with its mother and others. Upon release offshore with its mother 146 d later, it remained near the boat, refusing to join its mother, who circled several hundred meters away. After about an hour, as the boat backed away, mother approached and the calf joined her (Wells *et al.* 2007).

At the other end of the age continuum, two bottlenose dolphin releases may have failed at least in part due to complications from old age. All of the teeth on adult male MML-0406 (Caesar II) were worn to the gum line, suggesting extreme old age. This animal also demonstrated severe hearing loss. Following release, Caesar II restranded within several days, was pushed offshore by beachgoers, meandered across an unprecedented variety of habitats around the eastern Gulf of Mexico, and from satellite-linked TDR data, showed declining behavioral indicators suggesting it died 35 d release. Tomi, another adult male with extremely worn teeth, was rescued from the Tomoka River near Ormond Beach, Florida, and transported to the Indian River Lagoon. Two days after release it restranded and died.

Stranding Circumstances: Individual vs. *Mass Strandings*

The bottlenose dolphins, harbor porpoises, pygmy sperm whale, Atlantic white-sided dolphin, Atlantic spotted dolphin, and common dolphins considered here stranded as individuals, as did one of the Risso's dolphins. All five short-finned pilot whales, all three long-finned pilot whales, three of four Risso's dolphins, and all 17 rough-toothed dolphins came ashore in mass strandings. Without regard to species differences, mass stranded dolphins seemed to fare better postrelease than single stranded animals, with 90% (25/28) *vs.* 70% (16/23) successful or positive cases. However, a variety of species-specific factors may contribute to this statistic, including the tendency for mass-stranded dolphins to live in habitats farther from shore, where monitoring is more challenging, and where postrelease carcasses may not reach shore.

The five short-finned pilot whales, from the same mass stranding, were released together, with mixed results. As mentioned above, the calf separated from the others and died from predation 9 d postrelease. Contact was lost with another within a day of release. The remaining animals were tracked for 57–117 d and separated into a pair that ranged into the Atlantic Ocean and a single that moved into the Gulf of Mexico. Most social associations at the time of stranding were not retained postrelease.

Two long-finned pilot whales from the same mass stranding, released together with satellite-linked tags, appeared to remain together for at least 127 d (Nawojchik *et al.* 2003). In another case, three juvenile long-finned pilot whales from the same mass stranding were released together, but only one was tagged. The tagged whale was seen with conspecifics 20 d postrelease (Mate *et al.* 2005).

The Risso's dolphins originated from a single stranding and two mass strandings. They were released as two separate individuals, each carrying satellite-linked tags, and a mother-calf pair (only the mother carried a satellite-linked tag). All three release cases were considered successful or positive, at least for the individuals with the satellite-linked tags (Wells *et al.* 2007, 2009).

The rough-toothed dolphins came from three mass strandings, in 1997, 2004, and 2005. The four 1997 dolphins were rehabilitated at two different facilities, released at different times as two pairs, and converged on the same region of the NE Gulf of Mexico. The three 2004 dolphins were released together and appeared to stay together postrelease. The remaining 10 dolphins, rehabilitated at two different facilities, were released in three separate pulses due to different amounts of effort required to prepare them for release. The first release involved an individual that moved north and then back south along the east coast of the United States, the second involved seven dolphins that moved eastward along the West Indies, and the third pair moved southward to the coast of Cuba (Wells *et al.* 2008*a*). Most of these releases appeared to be successful or positive. The animals released together seemed to remain together, but the different directions taken by each of the three release groups suggested that they did not reconstitute to the extent possible the larger group found together at the initial stranding.

The data suggest that it may not necessarily be advantageous to retain healthy members of a mass-stranded group in rehabilitation until all other individuals are ready for release. The apparent success of animals released as smaller subsets of the original group seems to indicate that such pulsed releases might be better than taking the risk that healthy animals may become ill during prolonged rehabilitation as they await others to be ready for release. Recent work by Sampson *et al.* (2012) provides additional support for immediately releasing some individuals from mass strandings rather than bringing them into rehabilitation with other schoolmates.

Causes of Strandings

Stranded cetaceans are often challenging for marine mammal veterinarians as the stranding event itself can cause medical complications to preexisting conditions (Zagzebski *et al.* 2006). Whenever a definitive diagnosis can be made through the initial medical work up, the probability of treatment success and release is increased. Some common causes of stranding are pneumonia, gastritis, severe parasitism, entanglement and foreign bodies, shark bite trauma, freshwater exposure, extreme weather events and bone fractures. Complications from stranding commonly include pneumonia, cardiomyopathy (associated with contracture bands), sunburn, and rostral fractures. For such specific diagnoses, early direct treatment can be employed and rehabilitation initiated.

Of the 69 cases considered in this report, 51 were strandings, and the other 18 cases were rescue captures, mostly of entangled or out-of-habitat dolphins. Definitive diagnoses were identified for only 20% (10) of the stranding cases, all involving single stranded animals. For the other 13 single stranded cases and the 28 mass stranded cases, the definitive causes of the strandings were not identified.

Only a single stranding case was considered anthropogenic. A plastic bag was removed from the gut of a pygmy sperm whale (Inky). After 201 d in rehabilitation the whale was released and tracked for 4 d, and was scored as UP (Scott *et al.* 2001). The absence of cases of stranded, entangled dolphins from the list considered for this report seems somewhat surprising given the proportion of cases of rescue captures for disentanglement (10%) and the frequency of occurrence of entanglement cases in free-ranging animals (Wells *et al.* 2008*b*). This finding suggests that entangled dolphins are more likely to die than to strand alive and be rehabilitated, and therefore underscores the value of early intervention through field disentanglements.

Three other stranding cases involving bottlenose dolphins were identified as being caused at least in part by malnutrition and/or gastrointestinal (GI) tract issues. Two of these (Val, Buster) were scored as UP and the other (Peanut) died soon after release and was considered a failure. Four cases involving bottlenose dolphins were identified as being caused at least in part by pneumonia. These cases involved rehabilitation lasting 85–225 d, leading to mixed results. One case (Gulliver) was considered successful (Wells *et al.* 1999), and one (Jack) was UP. Another (Rudy) was UN due to less than favorable indications from tracking data (Wells *et al.* 1999). The final case (Dunham) failed due to shark predation upon release, leading to euthanasia. Potential confounding factors for interpreting the Dunham failure included release at an inappropriate site, an amputated fluke blade, and a long transport. Two other bottlenose dolphins (Freeway, C6) were treated over 107–186 d primarily for shark bite wounds, and were scored as S and UP following release.

Hearing loss was not identified as a cause of stranding for any of the reported cases. However in retrospect, several animals had diminished hearing discovered during rehabilitation that could have contributed to the initial stranding if it was already present. Mann *et al.* (2010) reported that 57% of bottlenose dolphins and 36% of rough-toothed dolphins that live-stranded or were rescued had significant hearing deficits. Hearing tests were performed on four Risso's dolphins and four bottlenose dolphins. All four Risso's dolphins were found to have normal hearing. Three of the four bottlenose dolphins (Caesar II, Castaway, and Filly) demonstrated hearing loss. Behaviors documented through remote tracking suggested Caesar II died, and led to a score of F. Castaway was an unsuccessful case (F) that was recovered at the release site and placed in captivity. Filly (UN) was an entangled calf that was captured, treated in rehabilitation, and released. Filly accumulated more fishing line before disappearing after several weeks in the wild. The lack of release success by dolphins with hearing impairments reinforces the recommendation of Mann *et al.* (2010) that the hearing of all cetaceans in rehabilitation should be tested, and strongly suggests that dolphins with hearing impairments should not be released.

Only one release case involved a dolphin with a missing appendage, and the contribution of this disability to the failure of the case remains unclear. Bottlenose dolphin Dunham was missing the right blade of the fluke, and had a mild case of scoliosis upon admit. Upon release, this dolphin was attacked by sharks and had to be euthanized. It is not known whether the lack of a fluke blade made a difference in this animal's inability to avoid predators, or if the release site was a contributing factor.

Several cases in the present report had definitive diagnoses, early direct care and favorable response. However most stranding diagnoses are empirical "working diagnoses" based on physical examinations, clinical chemistries, complete blood counts, serology, and other clinical procedures leading to a clinical impression of the underlying disease process. Treatments are adjusted based upon response to treatment changes in laboratory data and the clinical response of the patient. The final diagnosis may or may not emerge as a clear definitive entity, especially when treatment is successful and necropsy is lacking. Recent advances have increased accessibility to improved diagnostic equipment, techniques, and laboratories allowing for better treatment strategies. Portable digital radiography, ultrasonography, upper gastrointestinal endoscopy, and bronchial alveolar endoscopy and lavage, have been very helpful. The availability of computed axial tomography scans (CAT scans) and even magnetic resonance imaging (MRI) in some select cases has improved diagnostic capability. But even with improved technologies, the definitive diagnosis as to the cause of the stranding, even in the cases that undergo extensive necropsy examination, often remains elusive.

Influences of Rehabilitation and Release Logistics on Postrelease Success

The duration of human care was in part a function of factors leading to human involvement. For example, 61% of rescue captures of coastal bottlenose dolphins involved immediate release following examination and transport and/or treatment. In cases where rescued coastal bottlenose dolphins were admitted to rehabilitation rather than released immediately, the subsequent duration of rehabilitation was not significantly different from that for stranded coastal bottlenose dolphins (range = 37–225 d, Table S4). In addition, within the categories of rescue captures, mass strandings, and stranded coastal bottlenose dolphins, there were no significant differences in rehabilitation duration for S/UP cases *vs.* F/UN cases (Table S4). Data on single stranded animals other than coastal bottlenose dolphins were insufficient for analysis. Thus, success following release from rehabilitation does not appear to be clearly related to the duration of rehabilitation.

No significant difference was found in rehabilitation durations for mass stranded *vs.* single stranded animals (Table S4), but this finding may be somewhat misleading. The average time to completion of treatment of an individual that was part of a mass stranding is probably less than that for single stranded animals. In most mass stranding cases, specific causes of strandings were not identified, but animals were brought into rehabilitation for treatment of conditions that in many cases were secondary to the stranding itself. In some cases, individuals were retained in rehabilitation facilities for weeks to months after they had returned to releasable health, so they could be released with schoolmates that were still undergoing treatment.

As an alternative to waiting to release the entire surviving school together, in some cases small subunits of mass-stranded schools were released at intervals as they reached reasonable health. This was done with rough-toothed dolphins that stranded in the Florida panhandle in 1997 and in the Florida Keys in 2005. In the first case, the first released pair was successful (after 101 d in rehab), while the fate of the second pair was unknown (after 178 d in rehab). The 2005 case involved release of one tagged rough-toothed dolphin with another untagged schoolmate after 40 d in rehabilitation (S), seven dolphins released after 59 d (UP), and two dolphins released after 191 d (UP) (Wells *et al.* 2008*a*). While these pulsed releases of small subgroups of highly social species appear to be mostly successful in the short-term, the full range of consequences from separating individuals or subgroups from their schoolmates, relative to long-term survival and reproductive success, remains largely undetermined. Conversely, the potential risks of retaining individuals beyond the time they have regained releasable health should be considered relative to the possibility of health decline or mortality from prolonged time in rehabilitation, or physical limitations of facilities. In the two Risso's dolphin mass stranding cases, healthy individuals were retained to await schoolmates, but the schoolmates eventually died in rehabilitation (Wells *et al.* 2007, 2009). In both of these cases as well as the case of the single-stranded Risso's dolphin, Rocky, the released animals were tracked to areas of reasonable Risso's dolphin habitat.

Recent work on Cape Cod, Massachusetts, published after our analyses were completed, indicates that it may not be necessary in all cases for schoolmates from a mass stranding to be released together. Sampson *et al.* (2012) report that individual dolphins released separately have been tracked on converging courses and have been observed with conspecifics postrelease. Additional support for the idea that mass stranded cetaceans do not need to be released together comes from the case of the five pilot whales from the April 2003 mass stranding. These whales moved in three widely divergent directions upon release; school cohesion was not retained upon release. These findings suggest that it may be reasonable to release individuals from mass strandings by themselves under some circumstances. For example, if other schoolmates are not likely to be ready for release for weeks or months, it may be better to release the healthy individuals as early as possible. Release timing might be further expedited through reevaluation of health status. If most health parameters appear normal and no obvious health concerns remain, it may be better to release an individual before all parameters (*e.g.,* weight) are within "normal" ranges. Prolonged efforts to prepare a "perfect" dolphin may lead to decline in health and releasability. The failure of part of the pilot whale group may have been related to the relative ages of the individuals and assumptions on social adhesion that were based on a desired outcome rather that probable behavior postrelease. It emphasizes that successful outcomes are as dependent on behavioral evaluation as on achieving optimal health. Expedited return of gross and histopathology data from animals that died or were euthanized could also help in the treatment strategies and possibly reduce the time to release in those individuals that were in the rehabilitation process.

Efforts to release mass stranded animals immediately from the stranding site have met with mixed success over the years, but recent advances may make this an increasingly acceptable option. Fehring and Wells (1976) reported that repeated efforts to push a school of short-finned pilot whales off beaches as they proceeded south along the southwest coast of Florida were ultimately unsuccessful, with the animals eventually re-stranding farther south. Similarly, short-finned pilot whales tagged and pushed off the beach near Jacksonville, Florida, eventually restranded in South Carolina (Irvine *et al.* 1979).

Recent technological advances facilitating field assessment of health status have created the capacity to make informed judgments about which individuals may be good candidates for release from the stranding site. Subsequent to the completion of analyses for this review, Sampson *et al.* (2012) reported on 11 dolphins released from mass strandings on Cape Cod, Massachusetts, following health assessment, without rehabilitation, and often without other school members. At least 10 of these were believed to have survived. In another case that occurred following completion of quantitative analyses for this review, two male short-finned pilot whales of a mass stranding of 23 individuals in the Florida Keys in May 2011 were deemed sufficiently healthy for release based on blood values and lack of obvious medical problems. They were tagged and released within 2 d of stranding, and were tracked for 16 d (UN) and 66 d (apparent end of battery life, S), remaining together for nearly as long as both tags were operating (RSW, E. M. Fougeres, A. G. Cooper, R. O. Stevens, M. Brodsky, R. Lingenfelser and D. C. Douglas, unpublished data). It was eventually determined that none of the remaining members of the school were able to be released.

The distance between the stranding site and the release site does not appear to have a significant impact on release success (Table S4). These distances are often greater for offshore species and non-coastal bottlenose dolphins (22–649 km) than for stranded coastal bottlenose dolphins (5–78 km). In most cases it appears that efforts have been made to return rehabilitated stranded animals at least to appropriate habitat, or to their known home range when this information is available. The time required to transport the animals to the release site may be of greater consequence than the distance, but available data on transport times are sparse. It was not possible to test the relationship between transport time and release success for noncoastal *Tursiops* and other species because of insufficient data.

For coastal bottlenose dolphins, transport durations for unsuccessful cases (7.0 ± SD 2.83 h) were significantly greater (t-test, $P = 0.006$) than for apparently successful cases (1.1 ± SD 1.45 h), but sample sizes of transport durations were small. In one of the two unsuccessful cases for which transport times were provided, Dunham, a combination of factors may have led to the animal's demise from shark attack within 3 h of release. The 9 h transport was immediately followed by release into habitat that may have been unfamiliar to Dunham. It originally stranded on a Gulf of Mexico beach near the northern end of a barrier island chain. It was released in the Intracoastal Waterway, inside the barrier island chain, 19 km away from its stranding site. Along the central west coast of Florida, such different habitats would typically be occupied by different communities of dolphins (Wells *et al.* 1987), suggesting that Dunham might have been released out-of-habitat, potentially leading to disorientation and reduced survival capacity.

Monitoring Postrelease Success

The importance of postrelease monitoring for evaluating rehabilitation and rescue cases is evidenced by the data limitations identified in this report. Over the 69 cases considered for this report, the quantity and kinds of data available were uneven, making it difficult to reach strong conclusions about which kinds of intervention efforts might be most worthwhile. Over the 25 yr period represented in this report, advances in medical diagnosis, husbandry, and therapy have improved survival of rehabilitated cases to the point of release, and advances in radio-telemetry have improved our ability to monitor animals postrelease. The "gold standard" for postrelease monitoring remains direct long-term observation, but this is largely limited to coastal/inshore situations near established research sites, where ongoing field efforts provide opportunities for resightings.

Ideally, observations would be complemented by follow-up health assessments, but to the best of our knowledge this has only been possible twice, involving bottlenose dolphins in Sarasota Bay, Florida. Ginger, a stranded and rehabilitated 3 yr old female (Marine 2012), was captured and evaluated in 2010, two years postrelease. In a recent case that occurred after the cut-off for inclusion for detailed analyses for this report, a 9 mo old female (Nellie) was captured and disentangled from constricting line, released on site, and evaluated two years later. Both bottlenose dolphins were in good body condition and health upon reexamination.

Unfortunately, direct observations will remain impractical under many circumstances, especially for offshore cetaceans or noncoastal bottlenose dolphins. As an alternative, radio-telemetry can provide much information for evaluating the status of released cetaceans. VHF transmitters, used for direct, real-time radio-tracking, can facilitate locating dolphins for direct observations, and in the absence of direct observations they can provide data on movement patterns, habitat use, and surfacing patterns that can be used to assess the condition of the animal. Small VHF transmitters attached by a single pin to the trailing edge of the dorsal fin typically weigh less than 20 g, and will transmit for 2–3 mo. Tracking range depends on the height of the receiving antenna above the water, as transmissions are line-of-sight.

For cetaceans in habitats farther offshore, postrelease monitoring may be limited to remote tracking *via* satellite-linked tags. Currently available tags (*e.g.*, from Wildlife Computers, Redmond, WA) weigh about 55–78 g, and can be attached by a single delrin pin to the trailing edge of a dorsal fin. They provide 25,000 (time-depth-recording (TDR) tags) to 60,000 (location-only tags) potential transmissions that can be distributed over time to last for several months, depending on duty cycle programming. TDR tags provide options for collecting and transmitting data on such parameters as location, dive depths, dive durations, time spent at specific depth ranges, and time spent in specific temperature ranges. Data on movement rates, habitat use, and surface and dive patterns can be used to assess behavior. Multiple animals with tags programmed with identical duty cycles will provide information on proximity and social patterns.

Changes in transmission features can also be informative, especially for distinguishing among failing animals, transmitters, or attachments. Failing animals will show abnormal behavioral readings in the parameters described above while tag status reports continue to indicate normal tag parameters such as battery voltage. A failing tag will be indicated by a decrease in the number of transmissions per day, and by decline of battery voltage below the threshold needed for transmission (*e.g*, 2.7 v for Wildlife Computers tags). A failing attachment that results in the tag being above the water's surface for less time might be indicated sequentially by: (1) decrease in the amount of dive or temperature data received (longer data messages will be cut short), (2) increase in the numbers of corrupt messages received, (3) decrease in the number of reasonable locations and increased number of undetermined locations, (4) increase in the number of status messages lacking usable data, and (5) decrease in the overall number of transmissions per day because the top wet/dry sensor is not exiting the water (Balmer *et al.* 2010).

Satellite-linked tracking of rehabilitated and released cetaceans provides information on movement patterns that would not otherwise be possible. In many cases such tracking has documented the use of habitat known to be appropriate for the species. In other cases, aberrant movement patterns have, in combination with other behavioral indicators, suggested failed releases. In still other cases, released cetaceans have demonstrated movements that have been unexpected and sometimes difficult to interpret. For example, bottlenose dolphin Rudy (Wells *et al.* 1999) and Risso's dolphin Clyde (Wells *et al.* 2009) moved from the Gulf of Mexico into the Atlantic Ocean. A pilot whale from the April 2003 mass stranding moved from the Atlantic Ocean to the Gulf of Mexico. Risso's dolphin Betty moved through much of the Gulf of Mexico before settling in appropriate habitat closer to the original stranding site (Wells *et al.* 2007). Few comparable data are available for these species to facilitate interpretation, so each documented case adds incrementally to available knowledge, and helps with future interpretations.

Double-tagging with both satellite-linked and VHF radio tags can be useful in situations where regular direct tracking is not possible. If an animal is exhibiting behaviors of concern that might warrant intervention, then the satellite-linked tag will provide the initial location data to direct observation and rescue teams to the general area. There the animal can be located through direct VHF tracking thereby facilitating locating individuals for interventions if necessary. Double-tagging also provides a means of interpreting loss of signals from one tag in situations where access to signals from both is possible. Also, small, single-pin attachment combined satellite-linked and VHF tags are available (*e.g.*, Sirtrack).

Recommendations

NOAA Fisheries (NMFS) provides guidance for release of stranded cetaceans in Whaley and Borkowski (2009): *Best Practices for Marine Mammal Response, Rehabilitation, and Release*. This document describes assessments to be used for evaluating release candidates relative to their release criteria, preparations for release, and follow-up monitoring. Our work provides information of relevance to supporting or refining a number of these assessments and protocols, leading to the following specific recommendations:

1. Given the record of failure documented in this report, cetaceans that restrand following release should not be considered for further release.
2 The poor record of success for release of dependent calves in the absence of their mothers suggests that they should not be considered as release candidates.
3. It may be worthwhile to release healthy individuals singly or in small groups from mass strandings, rather than holding them while waiting for the remaining animals to recover from health issues.
4. Although the sample size is small, releases of geriatric dolphins have not been successful. Such old animals should be considered nonreleasable.
5. The information reviewed on failed releases of animals with hearing impairments strongly supports performing diagnostic testing for auditory function both early in the rehabilitation process and prior to release, and animals with hearing impairments should be considered nonreleasable.
6. The authors recommend the following diagnostic considerations: Upon admittance to the rehabilitation facility the minimum database should include: (1) a thorough physical examination by a qualified marine mammal veterinarian; (2) routine blood samples for complete blood counts, standard serum chemistries including iron, fibrinogen and/or erythrocyte sedimentation rate and serum archiving; (3) upper gastrointestinal endoscopy with cytological samples of gastric contents, blowhole cytology, and examination of feces for parasites and ova. Depending on the cytological results, additional bacteriological cultures and antibiotic sensitivities may be requested; (4) lung auscultation and thoracic radiographs or ultrasound if warranted; (5) serum should also be sent for measurement of morbillivirus antibody titers. This test should be repeated in three weeks. Quarantine protocols should be in effect until after a second negative test result. The minimum database should be expanded based on certain specific criteria. Animals receiving severe shark bite wounds or evidence of puncture wounds should be radiographed for foreign material such as teeth or ray spines. If the animal is a female of reproductive age, serum or plasma progesterone levels should be measured, and if possible, an ultrasound examination for pregnancy should be performed upon admission. In the absence of an initial ultrasound exam, if the serum results indicate a possible pregnancy, ultrasound examination to verify pregnancy and findings including measurements of the fetus should be performed as soon as possible (for estimation of birthing date). If the ultrasound examination cannot be performed, a second serum progesterone analysis should be made two weeks after

the initial to help confirm the pregnancy. Early determination of pregnancy is of great importance as it will provide guidance for treatments including handling and medication selection. In recent years, hearing response testing has demonstrated that hearing loss is a common finding in stranded marine mammals. Hearing tests should be performed early in the rehabilitation process. Documentation of hearing status prior to treatment helps distinguish hearing loss that was present at stranding from hearing loss as a result of therapy, particularly use of aminoglycoside antibiotics often used in the rehabilitation treatment regimens. In addition, hearing tests must be repeated after treatment to assure the animal has a functional auditory system before being released back into the wild. Lastly, based on clinical signs and the marine mammal veterinarian's recommendation, other tests might be considered, including: Arbovirus titers, toxoplasmosis titers, adenovirus titers, and others. Bacterial cultures and sensitivity should be performed from gastric, fecal, and the respiratory system on presentation and prior to release to determine if the animals are exposing other animals to resistant bacteria or contracting resistant bacteria in the facility that may be taken back to the wild.

7. Mitigating problems arising from the rehabilitation process itself. It has been well-established in veterinary medicine that even with excellent care, animals that suffer stranding, examination, diagnostic data collection, transport and environmental change of the rehabilitation facility may still fail to thrive due to stress. Rather than the disease itself, stress must be seen as an intermediary of illness that exacerbates signs of other illnesses and can impede response to therapy. At every stage of care, stressors must be identified and minimized, but some negative effects are unavoidable. Often medical conditions requiring treatment, *i.e.*, gastrointestinal disturbances, respiratory infections, secondary fungal infections, or skin problems can be attributed to the rehabilitation and treatment processes. These secondary problems usually improve with appropriate treatment. Relapses are common and often prolong the time in rehabilitation. One problem that is not uncommon is scoliosis of the spine. This most often occurs during the rehabilitation process secondary to lack of swimming in a compromised animal. With early recognition and prompt, aggressive treatment, many cases can be reversed. Others cannot be corrected and permanent curvature of the spine results, and these patients should not be considered for release. Additionally, necropsy of stranded cetaceans has identified cardiomyopathy characterized by contraction band necrosis as a common lesion likely associated with physiologic damage during stranding (Turnbull and Cowan 1998). To date there has been limited diagnostic work on live stranded cetacean cardiac function to evaluate the importance of this lesion in the prognosis of live stranded animals, but further work in this area is warranted.
8. Releasability determination. Due to the paucity of data on factors influencing the likelihood of a successful release, the suitability of a cetacean for release after rehabilitation should be assessed on a case by case basis until more data are available. Before the release of a small cetacean from rehabilitation, the case should be reviewed by an independent group of experts, including a veterinarian experienced in cetacean medicine, an epidemiologist, a pathologist with experience in marine mammal pathology, a biologist familiar with the ecology of the species in question, and a manager familiar with stock structure and management issues for the stock from which the stranded animal came. Such a group could be assembled on a case by case basis. Prior to a conference call, the panel should be provided with detailed background information:

(a) case summary, including date, time, circumstances of stranding (including environmental conditions at time of stranding), transport, condition and diagnosis, treatment prescribed and implemented, responses to treatment,
(b) medical record spreadsheets, including blood parameters, medications (including doses, dates of administration), length, weights and girths, feeding records,
(c) list of diagnostic tests performed and findings, and tests pending,
(d) date and findings of hearing tests,
(e) sex and reproductive status,
(f) estimated age (including basis for this estimate),
(g) clear digital photographs of entire body (dorsal, ventral, both sides), with close-ups of injuries or lesions of concern,
(h) map showing location of stranding site and proposed release site, and
(i) descriptions of any aberrant behaviors or concerns.

9. It is strongly recommended that animals be released into waters or habitats familiar to them. In at least one case reviewed here (bottlenose dolphin Dunham), release into presumably unfamiliar habitat was thought to have contributed to the failure of the release. Several authors have described disorientation of dolphins released into unfamiliar habitats or to locations from which they have been absent for periods of years (Irvine 1971, Wells *et al*. 1998). Minimizing confusion and necessary adaptations would seem to be to an animal's advantage when returned to the wild.
10. Effect of transport duration/mode (to release site, including staging). It is not uncommon for a stranded cetacean to be transported long distances from the site from which it comes ashore to the rehabilitation facility. These transportations often involve more than one transport means (watercraft, truck or van, and even aircraft) and can be prolonged. Marine mammal facilities that can and are willing to receive these cases are few and far between. The stress of a prolonged transport back to the stranding site can be a negative stressor. Transport acclimatization should be part of the rehabilitation program for animals that are considered likely to be released. Transport acclimatization should be viewed as a training program accomplished by placing the cetacean in a transport container for gradually increasing lengths of time. For transports lasting less than 12 h releasing the dolphin immediately upon reaching the release site is recommended. If the transport is longer than 12 h, it is recommended that the cetacean be placed in a pool near to the release site for observation and stress recovery prior to release. The 12 h time is not absolute and would depend somewhat on the animal's temperament and previous clinical history, *i.e*., has the dolphin shown signs of excessive stress during routine procedures. These decisions are difficult and the opinion of the support staff on site providing care should be weighed heavily in the consensus, if one can be reached.
11. Marking of individuals for identification prior to release is strongly recommended. It is essential to provide them with the equivalent of a "medical ID bracelet" in the form of a freeze-brand and associated identification photos for immediate and unambiguous identification, should they be observed by others or should they restrand. Other kinds of markings such as cattle ear tags can also be helpful (Wells 2009).
12. Continuing evaluation of the effectiveness of cetacean rehabilitation efforts is only accomplished through outcome assessment. The use of electronic tags to monitor released dolphins whenever regular unaided visual contact is not possible is strongly recommended. Such monitoring should be designed to continue for at least six weeks. In the early years of electronic tagging and rehabilitation,

risks to the animal from the additional burden of relatively large tags and/or potential injuries from multiple attachment pins had to be weighed against the information to be gained (Irvine *et al.* 1982, Scott *et al.* 1990, Wells 2005, Balmer *et al.* 2010). However, recent developments in small tag designs and minimal single-pin attachments greatly reduced serious risks to the animals from the tagging (Balmer *et al.* 2011). Selection of electronic tags with additional sensors (for example, time-depth, temperature recording tags) over location-only tags whenever possible is further recommended. The additional information greatly improves interpretation of the condition of the animal, and generally is worth additional tag cost and the slight increase in tag size. Reports from the rehabilitation facilities should be standardized to include information on as many measures of release success as possible. Suggestions for parameters are provided in Table 4.

13. One of the more important findings of this review involved the apparent benefits of intervention in cases of entanglement or out-of-habitat situations. Entangled dolphins rarely strand alive, and therefore do not enter rehabilitation. The success of dolphins rescued and released was greater than for rehabilitated dolphins, suggesting the importance of intervening when possible. The occurrence of entanglements is on the rise, especially in the southeastern United States, leading to serious injuries and death of small cetaceans (Wells *et al.* 2008*b*). Stranding networks should develop clear criteria and plans for early intervention for entanglement or out-of-habitat cases. Plans for intervention should include establishing and maintaining contracts with experienced dolphin catchers and capture leads, and purchasing and prepositioning essential capture equipment in strategic locations. Development of volunteer rescue teams of cetacean handlers should be encouraged, through support of training activities during planned dolphin health assessments or other activities involving handling of wild dolphins.

Table 4. Potential measures of release success.

Parameter	Measure	Description
Survival	Duration of contact	Time to final signal or observation
	Habitat use	Remains in habitat appropriate for species:
		Water depth
		Distance from shore
		Physiography
		Water temperature
	Behavior	Engages in behavior appropriate for species:
		Travel rate (swimming speed)
		Travel direction relative to currents
		Minimum daily distance traveled
		Proportion of time at the surface
		Dive duration
		Dive depth, typical and maximum
		Dive depth relative to food availability
		Time at depth
		Association with conspecifics as appropriate
		Activity cycles
Health/well-being	Body condition	Requires close observation or handling
	Blood parameters	Requires handling
Reproduction	Observation	Requires observations with offspring

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Supporting Information

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Table S1. Release cases involving bottlenose dolphins. Cases are arranged by intervention circumstance, whether the dolphin was rescued after stranding, or through capture. Within these categories, cases are sorted by success designation.

Table S2. Release cases involving species other than bottlenose dolphins. Cases are arranged by species, and within species, by success designation.

Table S3. Tags deployed on released cetaceans. Cases arranged by species, and by success designation within species.

Table S4. Success relative to duration of rehabilitation, transport distance, transport time. Cases are arranged by intervention circumstance: rescue capture, mass stranding, individual stranding, and by species within each category.