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# A Summary of Sea Turtles Released from Rescue and Rehabilitation Programs in the United States, with Observations on Re-Encounters

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**Abstract. – A survey of sea turtle rehabilitation facilities in the United States revealed that 34 facilities released 11,417 sea turtles through 2016. The number of turtles released per time period increased over time, with 80% of releases occurring between 2007 and 2016, 15% between 1997 and 2006, and 5% prior to 1997. Twenty facilities reported a total of 314 first re-encounters and 6 second re-encounters of turtles that had been previously released, including 12 turtles encountered while successfully nesting. Results revealed substantial efforts to rehabilitate sea turtles in the United States, with some rehabilitated turtles surviving for extended periods after release, but with the fate of most remaining unknown. Greater efforts to determine the long-term outcome for a larger proportion of rehabilitation cases are warranted.**

**Key Words. – sea turtle; rescue; rehabilitation; veterinary**

Wildlife rescue, rehabilitation, relocation, and release (RRRR) has become a well-established endeavor within the field of veterinary medicine (Sleeman and Clark 2003). Veterinary schools offer course work in this discipline and some maintain wildlife hospitals (Stoskopf et al. 2001; Kaufman et al. 2004). Many veterinarians spend their career within this field. In the United States, networks (including federally mandated and authorized networks) have been established to respond to ill or injured wildlife, and many states recognize wildlife rehabilitators as licensed professionals. The general public has come to expect that "something should be done" for ill or injured wildlife, likely influenced by social media and television programming depicting animal rescue activities.

Rehabilitation efforts may improve the welfare of an individual animal through the use of analgesia and treatment of injuries and illness, and RRRR efforts may end the suffering of a terminally ill or injured animal through euthanasia. RRRR activities can provide effective public outreach regarding wildlife biology and conservation issues (Feck and Hamann 2013), and RRRR increases knowledge of the basic biology and veterinary care of the involved species (Caillouet et al. 2016). Despite these potential positive outcomes, RRRR remains controversial, and its role in species conservation remains unclear. It has been thought that RRRR projects might divert resources from other conservation efforts, result in release of unfit individuals, spread disease, or cause "genetic pollution" (Moore et al. 2007; Quakenbush and Beckmen 2009; Baker et al. 2015).

Chelonians are among the most imperiled vertebrate taxa (Turtle Conservation Coalition 2018). Among the world's 7 sea turtle species, 2 are considered Critically Endangered, 1 Endangered, 3 Vulnerable, and 1 Data Deficient (International Union for Conservation of Nature [IUCN] 2017). Anthropogenic factors including fisheries interactions, vessel-strike, pollution, hunting and poaching, egg harvesting, beach development, and habitat degradation have led to global declines in sea turtle populations (IUCN 2017). These anthropogenic effects, as well as natural phenomena (e.g., cold stunning, infectious disease), may lead to sea turtle morbidity and mortality. When encountered by humans, compromised turtles may be delivered to rehabilitation centers for veterinary care. In the United States, federal recovery plans for loggerhead (*Caretta caretta*) and Kemp's ridley turtles (*Lepidochelys kempii*) acknowledge RRRR efforts as part of the larger Sea Turtle Stranding and Salvage Network (STSSN) efforts (National Marine Fisheries Service [NMFS] and the US Fish and Wildlife Service [USFWS] 2008; NMFS et al. 2011). Although RRRR is not explicitly listed as a recovery action in these plans, the Kemp's ridley recovery plan does state, "The STSSN in the U.S. and the stranding network in Mexico should be continued to help protect and manage Kemp's ridley populations in the marine environment. These networks can document hot spots of nearshore negative human/sea turtle interactions and provide data that can be used to focus monitoring, research, and management actions to recover Kemp's ridleys. The stranding networks collect information on the biology of the species, which is also important for protection and management in the marine environment. Additionally, live stranded turtles are transported to rehabilitation facilities and a large percent are later released, thus directly contributing to conservation" (NMFS et al. 2011, p. II-18).

After being returned to an acceptable state of health and physical condition (Manire et al. 2017), rehabilitated sea turtles are released to the wild. Prior to release, turtles that are considered large enough are generally identified with flipper tags and a passive integrated transponder (PIT) tag. However, the long-term outcome for rehabilitated turtles remains undocumented unless they are later encountered and their tags identified, a situation that is inherently unlikely given the marine environment in which sea turtles spend the great majority of their lives and the many disparate databases where tagging data are held. Caillouet et al. (2016) called for an investigation of the long-term outcome for RRRR Kemp's ridley turtles so that the contribution of such programs to the Kemp's ridley population might be evaluated. Satellite tagging studies have produced variable conclusions about the short-term outcome (months to several years) for RRRR sea turtles, with some reporting postrelease behavior that is consistent with that of healthy conspecifics and others reporting abnormal postrelease behavior (Cardona et al. 2012; Mestre et al. 2014; Robinson et al. 2017). At least 1 loggerhead turtle has later been documented successfully nesting after an RRRR event (Nutter et al. 2000).

This study was conducted to quantify the number of sea turtles released from RRRR programs in the United States and to quantify and characterize the circumstances in which such turtles were later re-encountered.

## METHODS

A survey was sent electronically to all 42 US facilities that are permitted to conduct sea turtle rehabilitation. Each facility was asked to report the following information: the number of green turtles (*Chelonia mydas*), Kemp's ridley turtles, and loggerhead turtles that had been released from their rehabilitation program prior to 1997, 1997–2006, and 2007–2016; the total number of turtles released with PIT tags within these time periods; and the number of tagged turtles that had been re-encountered at a later date. These time periods were selected to cover 2, 10-yr periods prior to the survey, as well as to capture earlier efforts, with interest in documenting whether release numbers had changed over time. Data requested for re-encountered turtles included species, initial release date and location (state), re-encounter date and location (state or, if outside of the United States, country), re-encounter status (alive vs. dead), re-encounter circumstance (e.g., nesting, cold-stunned, entangled), and the method by which the turtle was identified. Facilities were given 7 mo to complete the survey, and reminders were sent to each facility up to 3 times. Completed surveys were collated, and descriptive summaries were generated. As a proxy for turtle postrelease movements, a "states between" value was assigned for turtles that were re-encountered beyond an adjacent state from their release site. For example, a turtle released in North Carolina and re-encountered in Florida was assigned a states between value of 2 (South Carolina and Georgia). For international re-encounters, states between values were not calculated. In cases where dates were unclear (e.g., only a month and year were reported), the most conservative possible date was assigned for calculation of time intervals. For example, a turtle released in "April 2014" and re-encountered in "January 2016" was assigned a release date of 4/30/14 and a re-encounter date of 1/1/16, respectively. Data for re-encountered individuals were reviewed to ensure that no turtle was included twice (i.e., if 2 facilities reported the same re-encounter).

A Student's $t$-test was used to investigate the difference in the number of days until re-encountering released turtles, dependent on whether the turtle was encountered alive or dead. Binary logistic regression was conducted to examine whether the duration until re-encountering a turtle explained the probability of the individual being found alive or dead (dependent variable; coded as 0 or 1). Statistical analyses were conducted using SPSS version 20 (SPSS Inc.).

## RESULTS

Thirty-four facilities and 1 state agency (NC) completed the survey, including facilities in Florida (12), North Carolina (5), Texas (3), Massachusetts (3), California (1), Connecticut (1), Georgia (1), Louisiana (1), New Jersey (1), New York (1), Maryland (1), Pennsylvania (1), South Carolina (1), Virginia (1), and Washington (1). Facilities that did not respond included 1 each in Hawaii, Texas, California, Mississippi, South Carolina, and 3 in Florida.

In total, 11,417 sea turtles were released through 2016, of which 8836 (77%) were PIT tagged. Facilities in Florida released the most turtles (6297) followed by North Carolina (1680) and Texas (1568). Smaller numbers of turtles were released by facilities located in Georgia (405), Massachusetts (336), Virginia (314), Louisiana (259), South Carolina (205), New York (177), Maryland (116), Pennsylvania (51), Washington (7), California (1), Connecticut (1), and New Jersey (0). Table 1 provides release data organized by time period and species. The number of turtles released per time period increased over time, with

**Table 1.** Number of Kemp's ridley (Lk), green (Cm), and loggerhead (Cc) turtles released from US rehabilitation programs.

| No. of turtles released | Lk | Cm | Cc | Species not reported | Total released (total released with PIT Tag) |
|---|---|---|---|---|---|
| Prior to 1997 | 61 | 297 | 103 | 56 | 517 (1) |
| 1997–2006 | 385 | 780 | 572 | | 1737 (1306) |
| 2007–2016 | 2153 | 5380 | 1158 | 472 | 9163 (7529) |
| Total | 2599 | 6457 | 1833 | 528 | 11,417 (8836) |

80% of releases occurring between 2007 and 2016; 15% between 1997 and 2006; and only 5% prior to 1997.

Twenty facilities reported a total of 314 (2.8%) first re-encounters and 6 (0.05%) second re-encounters. The number of re-encountered turtles reported by facilities in each state was roughly proportional to the number of turtles that were released by facilities located in that state. Facilities located in Florida, Texas, and North Carolina documented the largest number of re-encounters. Re-encounters typically occurred within approximately 1 yr of release, although much longer intervals (up to 13 yrs) and much shorter intervals (0 d) were also recorded. The number of days until re-encountering turtles was similar for both alive and dead specimens ($t = 0.32$, df = 302, $p = 0.75$). Furthermore, the duration since release did not affect the probability of re-encountering turtles as either alive or dead (Wald statistic = 0.10, df = 1, $p = 0.75$).

While at least 78% of turtles were alive at the time of re-encounter, the majority of live re-encounters were associated with second stranding events, illness, or injury. Circumstances of re-encounters are described in Table 2, and descriptive data regarding the timing of re-encounters are provided in Table 3. First re-encounters were assigned to a single descriptive circumstance, except for 3 cases that were each assigned to 2 categories (fibropapilloma and cold-stun; fibropapilloma and buoyancy anomaly; fish hook ingestion and cold stun, respectively). The method of identification for re-encountered turtles is reported in Figure 1. Most re-encounters occurred in the same state as release (86%) or an adjacent state (4%). Twenty-nine turtles were re-encountered more than 1 state away from their release site, including states between values of 11 ($n = 1$), 8 ($n = 1$), 7 ($n = 2$), 6 ($n = 4$), 4 ($n = 2$), 3 ($n = 2$), 2 ($n = 11$), and 1 ($n = 6$). The highest states between values include release and re-encounter pairings, respectively, of Florida and Massachusetts, North Carolina and Massachusetts, Florida and New Jersey, and Virginia and Texas. One Kemp's ridley turtle released in Maryland in 2011 was harvested in Honduras 1 yr later (identified by its satellite tag, reported back to the release facility). One green turtle released in Texas was recovered dead the following day in Mexico.

**Table 2.** Circumstances of re-encounters for 314 sea turtles that were released from US rehabilitation programs. Data shown for individual states indicate the state in which a re-encountered turtle had been initially released. States not shown include California, Connecticut, Louisiana, New Jersey, Pennsylvania, and Washington, from which no re-encountered turtles were released.[a]

| | First re-encounter[b] | Second re-encounter | FL | NC | TX | GA | MA | VA | SC | NY | MD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 314 | 6 | 187 | 30 | 55 | 5 | 4 | 12 | 9 | 9 | 2 |
| Alive | 245 | 4 | 166 | 18 | 44 | 4 | 2 | 3 | 5 | 1 | 1 |
| Dead | 64 | 2 | 19 | 12 | 8 | 1 | 2 | 9 | 4 | 8 | 1 |
| Data deficient | 5 | 0 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Circumstance | | | | | | | | | | | |
| Boat strike | 13 | 0 | 4 | 3 | 0 | 1 | 0 | 3 | 2 | 0 | 0 |
| Cold stun | 145 | 3 | 128 | 9 | 0 | 0 | 1 | 0 | 1 | 6 | 0 |
| Fish hook ingestion | 53 | 0 | 14 | 2 | 33 | 2 | 0 | 2 | 0 | 0 | 0 |
| Net entanglement/capture | 10 | 0 | 1 | 1 | 2 | 0 | 3 | 1 | 0 | 0 | 1 |
| Fibropapilloma | 4 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Power plant entrainment | 6 | 1 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| In-water research study | 9 | 0 | 4 | 1 | 0 | 1 | 0 | 0 | 3 | 1 | 0 |
| Debilitated turtle syndrome | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Nesting | 12 | 1 | 1[c] | 0[d] | 9 | 0 | 0 | 1 | 1 | 0 | 0 |
| Buoyancy anomaly | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Line entanglement | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PIT tag infection | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 60 | 1 | 26 | 10 | 11 | 1 | 1 | 6 | 2 | 2 | 1 |

[a] FL = Florida; NC = North Carolina; TX = Texas; GA = Georgia; MA = Massachusetts; VA = Virginia; SC = South Carolina; NY = New York; MD = Maryland.
[b] Release state was not reported for one re-encountered turtle.
[c] While only 1 nesting encounter was reported by Florida in the survey, 2 additional successful post-RRRR nesting turtles are known to have been released by a Florida facility that did not respond to the survey (C.A.M., unpubl. data, 2018).
[d] While no nesting encounters were reported by North Carolina in the survey, 1 successful post-RRRR nesting turtle has been previously described from North Carolina (Nutter et al., 2000).

**Table 3.** Days between release and re-encounter events for 314 sea turtles. SD = standard deviation.

| | Range | Mean | Median | SD |
|---|---|---|---|---|
| Days between first release and first re-encounter (*n* = 314) | 0–4907 | 456 | 263 | 704 |
| Days between second release and second re-encounter (*n* = 6) | 1–2440 | 940 | 378 | 1312 |
| Days between first release and second re-encounter (*n* = 6) | 274–3049 | 1201 | 729 | 1124 |

Twelve turtles were re-encountered during successful nesting events (Table 4). In addition, 1 Florida facility reported knowledge of 2 additional turtles re-encountered during successful nesting, but the turtles had been released from a Florida facility that abstained from the survey (C.A.M., unpubl. data, 2018).

## DISCUSSION

Results of this study demonstrate that a minimum of 11,417 sea turtles have been released from US RRRR programs through 2016. Inclusion of release data from 8 facilities that abstained from the survey would drive this number higher. Rehabilitation allowed for later successful nesting for at least 12 turtles, increasing the known total of successful postrehabilitation nesters to 15 (Nutter et al. 2000; C.A.M., unpubl. data, 2018). We found that the number of released turtles per time period increased over time. While this may partly be a reflection of less-robust record keeping in the past, or loss of older data, the temporal increase in the number of released turtles mirrors an increase in the number of large stranding events (e.g., Foley et al. 2007; Stacy 2012; Innis and Staggs 2017; Shaver et al. 2017). The temporal increase in released turtles also likely reflects the creation and expansion of RRRR facilities, and associated public awareness. For example, some high-capacity RRRR facilities have only recently opened (e.g., Georgia Sea Turtle Center in 2007; Texas Sealife Center in 2013) while others have recently expanded capacity (e.g., Loggerhead Marinelife Center in 2007; New England Aquarium in 2010; Karen Beasley Sea Turtle Rescue and Rehabilitation Center in 2014).

The use of PIT tags increased over time, with only 1 PIT tag deployed prior to 1997, but over 8000 have been deployed since that time. This mirrors the general availability of PIT tag technology, documentation of its use in sea turtles (Dutton and McDonald 1994; Wyneken et al. 2010), and requirement of its use by sea turtle RRRR facilities (US Fish and Wildlife Service [USFWS] 2013).

It is important to recognize that this study did not seek to determine the initial stranding location nor release location for all 11,000 turtles. Release location was only requested for turtles that were later re-encountered to allow for comparison to their re-encounter location. As a result, this study does not allow for evaluation of the relative outcome by stranding location nor release location. For some states (e.g., Florida), it is likely that turtles cared for at facilities in that state were also released in that state. However, for other states where sea turtles are seasonal

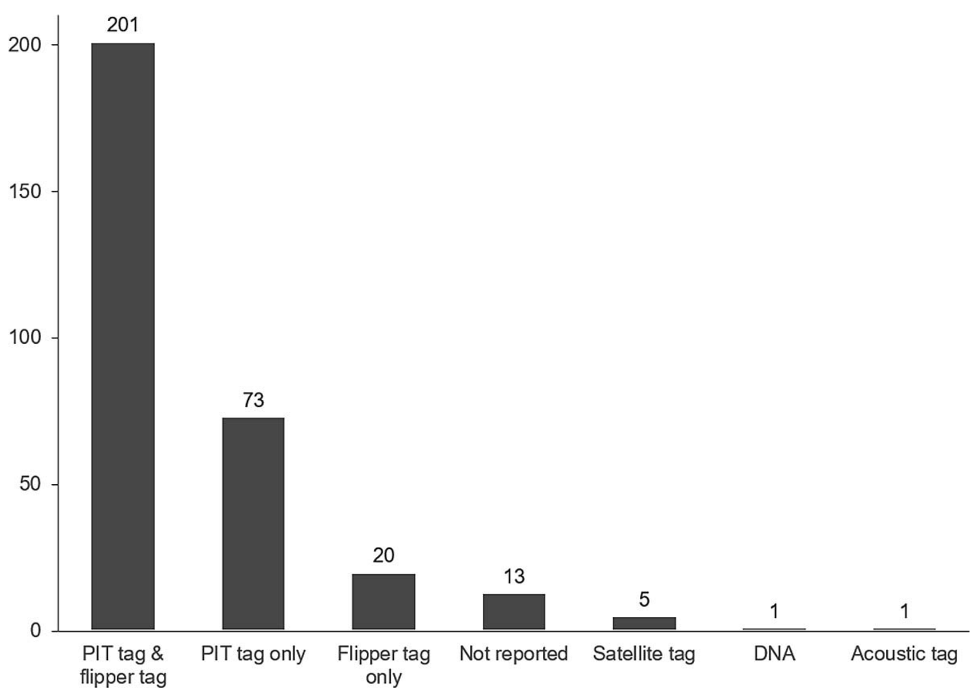


**Figure 1.** Method by which 314 sea turtles were identified when re-encountered after release from US rehabilitation facilities. Numbers indicate number of turtles in each category.

**Table 4.** Sea turtles encountered nesting successfully after release from a rehabilitation facility. Lk = Kemp's ridley; Cm = green turtle; Cc = loggerhead turtle; TX = Texas; VA = Virginia; FL = Florida; SC = South Carolina; NR = not reported.

| | Species | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lk | Lk | Lk | Lk | Lk | Lk | Lk | Lk | Lk | Lk | Cm | Cc |
| Release location | TX | TX | TX | TX | TX | TX | TX | TX | TX | VA | FL | SC |
| Nesting location | TX | TX | TX | TX | TX | TX | TX | TX | Mexico | TX | FL | SC |
| Days between release and nesting | 721 | 2200 | 1100 | 15 | 1811 | 37 | 679 | 675 | 1803 | 2252 | 504 | NR |

residents, and large numbers of strandings occur (e.g., Massachusetts), it is common for turtles to be medically managed and then transported to other states for eventual release (Hunt et al. 2016).

Similarly, one cannot conclude from this study that states that released few turtles (e.g., Connecticut, New Jersey) have less success, as very few turtles strand in those states in general. It is interesting to note that 10 of 12 turtles re-encountered during nesting were Kemp's ridley turtles, 9 of which had been released in Texas. These data are insufficient to guide management decisions at this time, but prospective studies should be designed to determine if releasing turtles at certain locations results in greater likelihood of future nesting.

Of considerable interest and importance is the fate of over 11,000 turtles that were not re-encountered. A pessimistic view might suggest that they are all dead. An optimistic view might suggest that they are all alive, having never again intersected with a human observer. The truth falls between these extremes. A number of factors may limit the future detection of a released turtle. For males, which typically never return to land under normal circumstances, their presence might only be detected during a stranding event or during in-water research studies. For females, their presence might be similarly detected, and females may also be detected during nesting beach surveillance. However, many turtles released from US RRRR programs are juveniles (e.g., Innis et al. 2014), such that it could be decades before sexually mature females might be detected nesting. Even under ideal circumstances, where intense nesting beach surveys might detect the PIT tag of an RRRR turtle, it is often logistically impossible to access every turtle due to widespread nesting, mass nesting (arribadas), rapid nesting, nocturnal nesting, limited personnel, and limited numbers of PIT tag detectors (Shaver et al. 2016). For example, in Texas where Kemp's ridley nesting is approximately 100 times less than at major Mexican nesting beaches (Wibbels and Bevan 2016), personnel were only able to examine half of nesting turtles for the presence of tags (Shaver et al. 2016), stating, ". . . a program that aims to observe nesting turtles at nearly 100% of the nests would require an extremely large labor force and be cost-prohibitive" (p. 171).

General use of PIT tags has included variations in tag and tag-reader technology over time, such that some tags and readers have not been universally compatible (Epperly et al. 2015). This variation has likely resulted in failure to detect the presence of at least some tags. For instance, a tagged animal could be encountered, but the tag might not be detected due to tag reader incompatibility, or the tag reader could detect the tag but display the identification in a different format (e.g., hexadecimal vs. decimal), which makes tracing tag history difficult. A centralized, searchable tagging database with conversions for hexadecimal and decimal tags would greatly increase the ability to identify re-encounters. While flipper tags provide a more readily detected, inexpensive, and rapid identification method, their retention time may be limited, thus failing to provide a permanent identity (reviewed by Reisser et al. 2008), and flipper tags are often not applied to turtles deemed too small for the procedure. Finally, even if identified, the occurrence of a re-encounter must be reported in order for it to be documented. It is possible that various communication barriers result in failed reporting in some cases (e.g., investigator motivation, database errors, language, time, etc.), and that the perception of negative bias may inhibit reporting of some types of encounters (e.g., fisheries interactions; Hamelin et al. 2017). Data-sharing between various groups that intersect with tagged sea turtles (e.g., RRRR facilities, in-water research groups, nesting beach monitoring groups, STSSN) may not be complete. In summary, many aspects of sea turtle biology, current identification methods, and database coordination limit our understanding of the impact of sea turtle RRRR programs for species conservation.

Emerging technologies could improve the frequency of detection and the detectability duration for RRRR sea turtles. Postrelease monitoring with satellite tags is limited by a relatively short battery life (approximately 1–2 yrs), but acoustic tags may allow for battery life approaching a decade. Acoustic tags are passively detected as tagged animals swim in proximity to an array of submerged receivers. Arrays of receivers have been deployed along much of the United States coast, and such technology is in common use for fish ecology studies (e.g., Kneebone et al. 2014). Acoustic tags have been attached externally to sea turtles, but retention time may be less than the expected battery life, especially for fast-growing juvenile turtles (MacDonald et al. 2013; K. Hart, *pers. comm.*, November 2017). It is possible that surgical implantation of acoustic tags in RRRR sea turtles (as done for fish) might result in repeated detection of individuals for years after release. Such studies will require funding, further discussion, legal permitting, safety assessment, and efficacy trials. One re-encountered turtle in this study was identified in absentia by genetic detection of her eggs. This methodology, should it become widely utilized, may be a powerful method to detect the presence of individual females for years after an initial encounter (Shamblin et al. 2011). Additional technological advances will likely improve our ability to detect long-term sea turtle movements and habitat use.

There may be positive effects of RRRR programs for sea turtles, even if released animals do not ultimately contribute to the breeding population. It is clear that many of the advances in the veterinary management of sea turtles have come from experiences with RRRR patients (Caillouet et al. 2016; Manire et al. 2017). Also, as discussed by Caillouet et al. (2016), such programs might provide opportunities for substantial public outreach regarding the conservation of sea turtles. Although this idea makes sense intuitively, outcome assessments of sea turtle outreach programs are uncommon (Feck and Hamann 2013), so additional studies are encouraged.

In light of contemporary views on animal welfare, it can be expected that sea turtle RRRR efforts will continue irrespective of their contribution to the breeding population. While it can be argued that RRRR efforts might interfere with natural selection and consume resources, it is also clear that leaving thousands of injured or ill sea turtles to die without some level of response would be poorly received by the public. This is especially true in cases of adverse anthropogenic events (e.g., oil spills), but also likely applies for strandings linked to natural events (e.g., cold stunning). Current legal and conservation standards will not accept mass euthanasia of these patients. For some mass stranding events, if finite resources constrain the response, at least a minimal standard must be met such that the turtles' chances of survival are improved by intervention. If sanctioned RRRR efforts were to end, intervention by unqualified individuals could negatively impact animal welfare. Regarding the concern that financial resources allocated to RRRR programs could be better spent on other aspects of conservation, much of the financial support for sea turtle RRRR comes from private entities, and many funders that are specifically interested in supporting such care for individual animals may not necessarily divert that funding to other activities.

In summary, the number of sea turtles released from RRRR programs is increasing over time, yet the outcome of these efforts remains unclear for the great majority of cases. Facilities and personnel involved with sea turtle RRRR programs should critically evaluate their results, coordinate their data, and continue to pursue methodology to assess the long-term outcome for their patients.

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