A REVIEW OF STRANDED MARINE TURTLES TREATED BY USHAKA SEA WORLD (SAAMBR) IN DURBAN, SOUTH AFRICA

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INTRODUCTION

Of the world's seven sea turtle species, five are found in South African waters (Sink *et al.*, 2019). The southwest Indian Ocean subpopulations of loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles nest on the beaches of northern KwaZulu-Natal (KZN) while green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles feed and mature in several offshore ecosystems along the South African coast (Sink *et al.*, 2019). Globally, loggerhead and leatherback turtles have been assessed as Vulnerable on the IUCN Red List (Wallace *et al.,* 2013a; Casale & Tucker, 2017), but regional populations in the Southwest Indian Ocean have been assessed as Near Threatened and Critically Endangered respectively (Wallace *et al.*, 2013b; Nel & Casale, 2015,). Hawksbill turtles have been globally assessed as Critically Endangered (Mortimer & Donnelly, 2008) while green turtles as Endangered (Seminoff, 2004). Furthermore, olive ridley (*Lepidochelys olivacea*) turtles are rare along the coast and only enter South African waters as strays (Hughes, 1989).

Since 1963, the local conservation management agency, currently known as Ezemvelo KZN Wildlife (EKZNW), has spearheaded turtle conservation efforts in South Africa. The number of nesting leatherback turtles rose from an average of 21 per season in the first 10 years of study, fluctuating annually, to as many as 164 individual females in a single season (1994/95). Since then, the numbers have declined but stabilised at 80 and 100 individual females per season (Hughes, pers. comm., 2020). The loggerhead turtle population has risen more consistently, from ~250 to >1,700 nests laid annually in northern KZN (Nel *et al.*, 2013). Sea turtles have benefited from the protection of nesting beaches in the iSimangaliso Marine Protected Area since 1979 and the adjacent Ponta do Ouro Partial Marine Reserve in southern Mozambique since 2009. However, numbers of nesting turtles of both species during the last three nesting seasons have been "disappointing" (Hughes, pers. comm.).

Injured, diseased or otherwise incapacitated nesting females and turtles of other life stages are unable to function normally and may flounder at sea or wash up on shore, a phenomenon known as stranding. Strandings occur for a variety of reasons including vessel strikes, ingestion of plastic, incidental capture in fishing gear, disease, and predation by sharks amongst many others (Flint *et al.*, 2015). Once stranded, these animals have a reduced chance of survival if not brought into human care. Understanding trends in stranded species, numbers, size class and sites, and the factors that contribute to successful rehabilitation will assist future turtle rehabilitation efforts.

METHODS

This study analysed trends in live stranded turtles admitted to the uShaka Sea World Turtle Rehabilitation Centre (TRC) in Durban, South Africa, between 2007 and 2019. Stranded turtles found along the coast of KZN are brought to the TRC by members of the public or local authorities. Records are kept of each animal, including date of stranding, species, location of stranding, and the condition of the turtle on admission. An active file for each turtle is maintained throughout their rehabilitation that details present conditions, diagnosis, and treatment as well as husbandry information. The outcome of each case is also recorded. Data on released turtles includes location, date of release, and tag information if applicable. Over time, the quality of the data has varied. Initially, data were stored in a hardcopy format. Since 2015, the data have been transferred onto the Zoological Information Management System (ZIMS, https://www.species360.org/), an international data management system designed to manage information on animals in zoos and aquaria.

Descriptive analysis of the data was undertaken using MS Excel. Animals were pooled into three weight classes: <1kg, 1-50kg and >50kg. The sex of most animals could not be determined due to immaturity and similarities in tail length. The location of the stranded animal was recorded based on one of four predetermined regions on the KZN coast from north to south: iSimangaliso Wetland Park (~186km), North Coast (~152km), Central (~80km) and South Coast (~138km) (Figure 1).

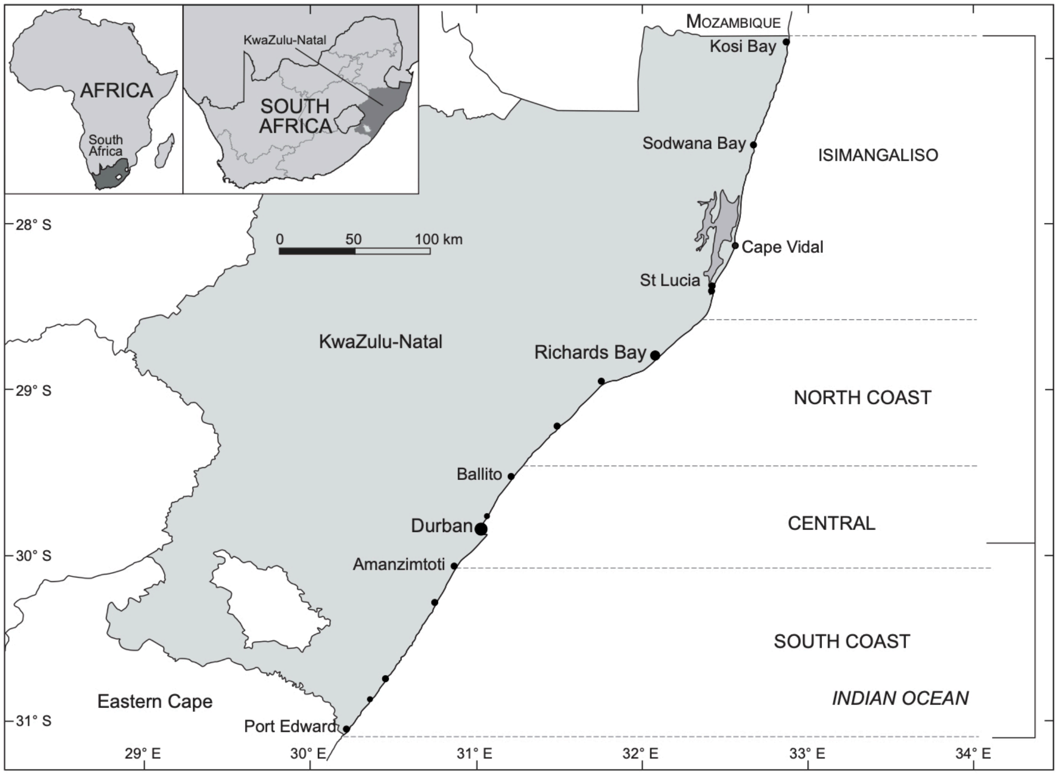

Figure 1. The KwaZulu-Natal Coast, including the iSimangaliso Wetland Park, North Coast, Central and South Coast regions.

The state of the animal on arrival was classified as: *Poor*: the animal is lethargic, little to no response to external stimulus, signs of extreme dehydration (e.g., eyes sunken)/emaciation, extensive trauma (bones visible/recent amputation/blood loss). *Stable*: the animal reacts to external stimuli, but reactions/movements are slow, some signs of dehydration, no signs of extensive trauma/ blood loss. Any amputated limbs are healing. *Good*: the animal is hydrated (e.g., eyes not sunken in), alert, readily reacts to external stimulus, able to move easily without any encouragement.

Unless it was obvious, the cause of stranding was often difficult to ascertain. General notes on the condition of the animal on arrival were recorded including buoyancy disorder (animal could not dive), dehydration, epibiota growth on body (barnacles, leeches, etc), entanglement in fishing gear or plastic (including ingestion of plastic and/ hooks), obvious infection, external injury (body damage caused by a possible boat strike, predator attack or other), internal injury, parasites, and unknown (no visible signs of injury or illness). The three most obvious conditions for each animal were selected for this analysis. The outcome of rehabilitation was categorised as release to the wild, permanent housing in the uShaka Sea World Turtle exhibit (if the animal was unable to live independently in the wild), or death. Necropsies were performed on over 80% of turtles that had died. No turtles were euthanised.

Equipment for rehabilitation in the TRC includes large pools and tanks with filtered seawater, and a medical centre fully equipped with a digital X-ray machine, endoscope, infusion pumps, etc. Diagnoses are made through cultures, blood samples, and other procedures in the well-equipped laboratory. The TRC also receives turtles that stranded elsewhere along the South African coast. These turtles usually undergo a period of rehabilitation in other centres (such as the Two Oceans Aquarium in Cape Town) before being sent to the TRC, and hence were excluded from this analysis.

RESULTS

Biometrics

Between 2007 and 2019, 51 turtles were admitted to the TRC: 22 green turtles, 20 loggerheads, and nine hawksbills. Eight leatherback hatchlings were recorded in two stranding events, seven of which were returned to the sea within two days and one which died; all were excluded from the analyses.

Table 1. Live stranded turtles received annually by the uShaka Sea World Turtle Rehabilitation Centre, 2007-2019.

Year	Green	Hawksbill	Loggerhead	Total
2007	1	0	3	4
2008	1	1	0	2
2009	4	1	1	6
2010	2	1	1	4
2011	1	1	1	3
2012	0	0	0	0
2013	2	2	1	5
2014	1	0	2	3
2015	1	0	4	5
2016	2	1	0	3
2017	1	1	2	4
2018	4	1	5	10
2019	2	0	0	2
Total	**22**	**9**	**20**	**51**

The number of turtles received by TRC each year varied between none and 10 individuals (Table 1). There was no obvious trend in the annual number of stranded turtles over the period under review, although more turtles were received in 2018 than in any other year. One adult turtle was identified as a male, while the others were too small to be positively sexed.

Nearly half (49%) of the stranded turtles weighed less than 1kg, 41% weighed 1-50kg and only three weighed more than 50kg. The weight was not recorded for two cases. The weight of stranded turtles differed among species (Table 2) where nearly all the loggerhead turtles weighed <1kg with an average weight of 46.5g. The average weight of the green turtles was 16.5kg while the average weight of hawksbill turtles was 13.1kg.

Location of stranding

Overall, the number of strandings per region was not proportionate to its coastline, since most stranded turtles were received from the central region, with the fewest from the iSimangaliso area. Most of the loggerhead turtles were found in the central region, while the stranded green turtles were distributed throughout the region, with the fewest from the Central region (Table 3). No hawksbill turtles were recorded from the North Coast.

Seasonality of stranding

There was a seasonal trend in strandings, with more turtles stranding and subsequently entering the TRC, during the summer months. This pattern is driven by small loggerhead turtles that strand between January and April. Other species strand throughout the year, with a slight peak in September for green turtles (Figure 2).

Condition at stranding

The turtles admitted into the TRC exhibited various conditions (Figure 3). No easily discernible cause of stranding for most of the turtles was identified. Recording of health conditions was inconsistent. For example, a turtle with an infection that resulted in a buoyancy disorder may be recorded as 'infection' or 'buoyancy disorder', while an animal admitted floating with an external injury may be recorded as 'external injury' since it could not be determined whether it was injured because it was floating or was floating because it was injured. Green turtles exhibited buoyancy disorders, external injuries, encounters with fishing gear and infections. The small loggerhead turtles seldom exhibited obvious conditions, although a few did have visible injuries. Hawksbill turtles were often injured on arrival. Dehydration was often noted but was usually secondary to other conditions. The growth of epibiota on the flippers or carapace and parasites was less commonly noted and an internal injury could only be diagnosed if obvious (e.g., blood in the faeces). Plastic fragments were found in the gut during the necropsies of only one green and one loggerhead turtle, each weighing <1kg.

Table 2. Weight of sea turtles rehabilitated at the uShaka Sea World Turtle Rehabilitation Centre after stranding on the KwaZulu-Natal Coast, 2007-2019.

	% in Weight Class			
Sea Turtle	<1kg	1-50kg	>50kg	Unknown
Green (n=22)	13.6	72.7	9.1	4.5
Hawksbill (n=9)	33.3	55.6	11.1	0.0
Loggerhead (n=20)	95.0	0.0	0.0	5.0

Table 3. Location of rehabilitated at the uShaka Sea World Turtle Rehabilitation Centre after stranding on the KwaZulu-Natal Coast, 2007-2019.

	% at Each Location			
Sea Turtle	iSimangaliso (~186km)	North Coast (~152km)	Central Coast (~80km)	South Coast (~138km)
Green (n=22)	22.7	31.8	9.1	36.4
Hawksbill (n=9)	33.3	0.0	44.4	22.2
Loggerhead (n=20)	0.0	20.0	65.0	15.0

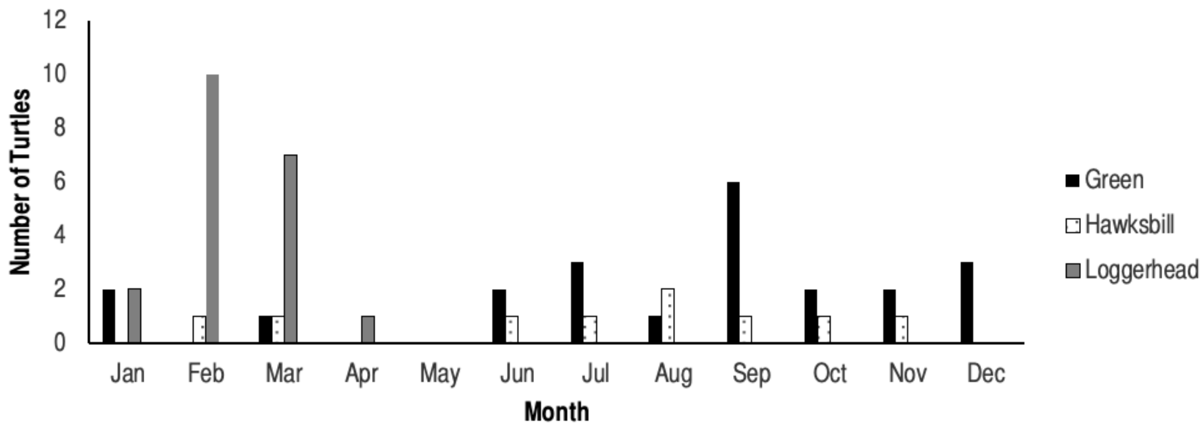

Figure 2. Monthly variation in number of turtles, per species, stranding on the KwaZulu-Natal Coast, 2007-2019.

Outcome of rehabilitation efforts

Of the turtles that entered the TRC, over half were released, while 14.0% could not be released due to the severity of their injuries. These turtles were placed on exhibit in the uShaka Sea World aquarium. Death was a more frequent outcome for turtles that arrived in poor condition, while 91.0% and 83.3% of those that arrived in a stable or good state respectively were released. A total of 18 turtles died (35%) during rehabilitation. There was little difference in the response rate of rehabilitation among species (Table 4).

The outcome of the rehabilitation process did not appear to be related to the weight of the turtle on arrival (Figure 4).

For all the species, the average time spent in rehabilitation was 208 days (range: 1-1,485 days). Ten

Table 4. State of arrival and rehabilitation outcome for sea turtles rehabilitated at the uShaka Sea World Turtle Rehabilitation Centre after stranding on the KwaZulu-Natal Coast, 2007-2019.

	Rehabilitation Outcome (%)		
State on Arrival	**Died**	**Exhibit**	**Released**
Poor	50.0	14.7	35.3
Stable	0.0	9.1	90.9
Good	0.0	16.7	83.3
Species			
Green	40.9	9.1	50.0
Hawksbill	22.2	11.1	66.7
Loggerhead	35.0	20.0	45.0

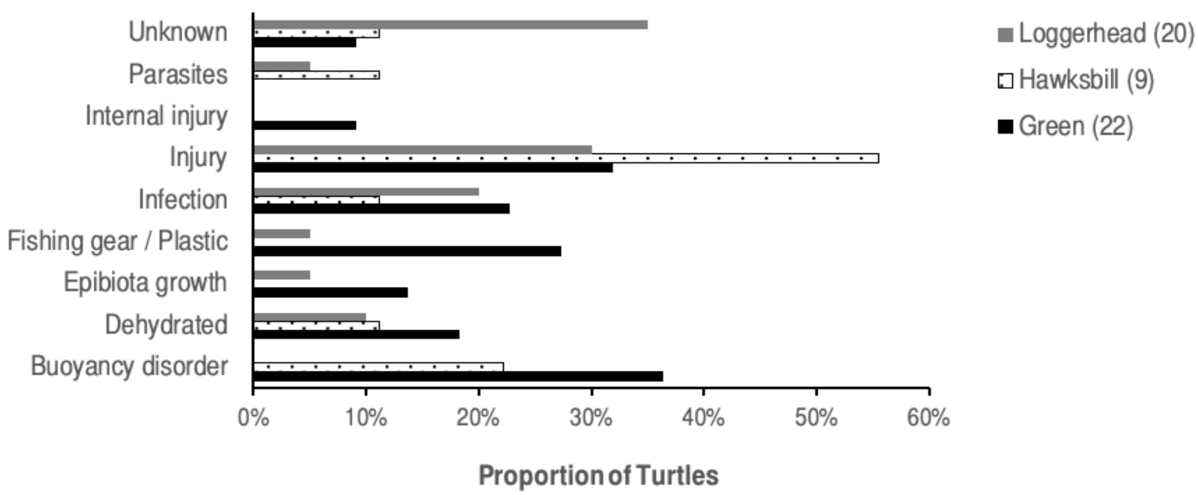

Figure 3. Conditions of sea turtles admitted to the uShaka Sea World TRC after stranding on the KwaZulu-Natal Coast, 2007-2019. Most turtles exhibited more than one condition; the proportion presented reflects the condition was one of three recorded on arrival.

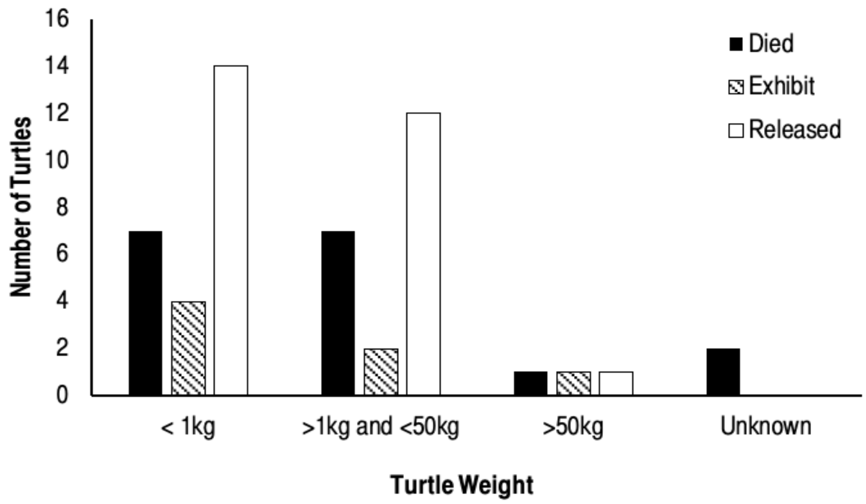

Figure 4. Weight on arrival and rehabilitation outcome for sea turtles rehabilitated at the uShaka Sea World Turtle Rehabilitation Centre after stranding on the KwaZulu-Natal Coast, 2007-2019.

turtles spent <10 days in the TRC. Green turtles spent an average of 199 days in the TRC. Excluding one turtle that spent 4 years undergoing rehabilitation, loggerhead turtles spent an average of 190 days in the TRC, while hawksbill turtles spent 125 days in the TRC.

DISCUSSION

The three species of turtles (loggerhead, green and hawksbill) that were brought into the TRC during the study period varied in stranding location, weight, condition, duration of rehabilitation and eventual outcome. The small sample size and high variability made it difficult to interpret the success of treatments administered. However, pertinent observations are discussed as they may contribute to an improvement in our understanding of turtle stranding and rehabilitation.

There was no clear trend in the number of turtles in total or per species admitted per year. Although Flint *et al.* (2015) noted an increase in the number of turtles being sent to rehabilitation centres in Australia over time, this was not apparent at TRC despite improved public awareness of what to do when encountering a stranded turtle. uShaka Sea World has publicised the plight of turtles on-site in aquarium signage and through social and print media. The formation of a 'Stranding Network', co-ordinated by the local conservation authority (Ezemvelo KZN Wildlife) and made up of individuals who have been trained in how to handle stranded animals has also contributed to better handling of stranded animals. Numerous organisations (including Ezemvelo KZN Wildlife, lifeguards, the National Sea Rescue Institute, the South African Police Services, conservancies, etc.) have staff working on or near popular beaches. Staff have attended workshops facilitated by uShaka Sea World and are now trained as first responders and follow national protocols for stranded animals. It was thought that this increase in awareness and capability of response would have resulted in an increase in reported strandings of live turtles. However, the numbers of live stranded turtles of each species may be more closely linked to the population size of turtles at sea rather than human interventions. As an indication of the prevalence of different turtle species along the KZN coast, the bycatch of the bather protection nets (shark nets) were analysed. Interestingly, loggerhead turtles were the most frequently caught (67%) in the shark nets along the KZN coast between 1981 and 2008, where green (19.6%), leatherback (8.8%) and hawksbill (3.1%) turtles made up the rest of the bycatch. Most of the animals caught were classified as immature, however they were all large enough to be caught in the large meshed gill nets (25 cm bar) (Brazier *et al.*, 2012). Given their prevalence in the area it is surprising that larger loggerhead turtles were not brought into the TRC.

The location of live stranded turtles is more likely to be a function of human presence along the coast rather than the absolute number of animals stranding. Most turtles were received from the Central region, an area with a high level of coastal development and a high associated human population density. Although both loggerhead and leatherback turtles nest on the beaches of the iSimangaliso Wetland Park, neither of these species were reported stranding from those beaches. Except for public access points such as Sodwana Bay, Cape Vidal and St Lucia, the iSimangaliso Wetland Park beaches are remote with few people, so turtle strandings are often likely to go unreported. In this study, small loggerhead turtles were primarily found stranded in the central part of the coast. It is likely that these small turtles were post-hatchlings that had drifted southwards in the Agulhas Current after hatching on the beaches of the iSimangaliso Wetland Park and Ponto do Ouro Partial Marine Reserve. This would also account for the seasonal nature of their stranding between January and April. This pattern of stranding has been noted since the early 1970's (Hughes, 1974). Not surprisingly, the turtles from the central KZN coast were slightly smaller than those found stranded further south (Ryan *et al*., 2016), as it would have taken slightly longer for them to reach the more southern beaches. The green and hawksbill turtles that were rescued along the whole KZN coast ranged in size. Both species stranded throughout the year.

The duration of rehabilitation in the TRC was high in comparison to a study in Australia where 35% of turtles were released within 28 days of arrival and average days in care decreased from 392 in 1999 to 84 in 2013 (Flint *et al.*, 2017). However, it was similar to the findings from Florida, USA, where time in rehabilitation varied between one year and more than three years (Baker *et al.*, 2015). In our study, rehabilitation success did not increase with body size as was found by Baker *et al.* (2015).

As has been noted in other regions (Flint *et al.*, 2017), the primary cause of stranding is usually difficult to ascertain. Many turtles exhibited multiple conditions, e.g. buoyancy disorders, infection, and external wounds. Buoyancy disorders, often caused by gas trapped within the intra-coelomic cavity, render the turtles unable to dive and feed. Such animals eventually strand in a weakened state (Mettee, 2014). Damaged lungs, infections, intestinal blockages, and stress can also cause turtles to become buoyant. Our study found that buoyancy disorders were prevalent in green turtles. Dehydration was common, although this was often overshadowed by more serious traumas. The range of conditions on arrival recorded at the TRC was similar to that noted by other studies (e.g., Flint *et al.*, 2017) where disease, buoyancy disorder and fracture were most commonly noted.

It was generally easier to attribute the cause of stranding for turtles that showed obvious signs of an encounter with fishing gear or had external wounds. Turtles can become entangled in fishing gear, caught as bycatch, swallow fishhooks or line, or become damaged after impact injuries caused by vessels. The inshore habitats of the loggerhead and green turtles make them particularly vulnerable to fishing gear impacts, as most fishing effort is expended closer to the coast (Everett, 2014). The incidence of direct interaction with fishing gear was far lower in our study than that noted by previous studies (Poli *et al*., 2014; Nelms *et al.*, 2016). This difference is likely due to the relative lack of large commercial fishing operations off the KZN coast compared to other areas (Everett, 2014).

Previous studies have noted ingestion of plastic pollution to be a threat to turtle survival *(*Hoarau *et al*., 2014; Nelms *et al.*, 2016). However, unlike a study conducted in the southern Cape, South Africa, where 60% of loggerhead post-hatchlings that died within two months of stranding had ingested plastic fragments (Ryan *et al*., 2016), plastic pollution was only noted in two turtles in this study.

Half of the stranded turtles in this study were released. Those that could not be released, as they would not be able to survive independently in the wild, due to injury or poor condition, were placed into the uShaka Sea World Turtle Exhibit. These success rates compare favourably to those in Queensland, Australia where 35% of the study animals were released (Flint *et al.*, 2017) and in Florida, USA where 36.8% were released (Baker *et al*., 2015).

Treatments varied with the condition of each animal upon arrival and the individual animal's response to treatment was different. Each action, response, and outcome were monitored and recorded to ensure that findings could be used in future cases. The state of the animal on arrival was one of the primary predictors of the success of the rehabilitation. Since over half of the animals that arrived in a poor state died, the efforts expended on these individuals should be weighed against their chance of survival. Where resources (both time and financial) are limited, it may be wise to critically assess the chance of survival for each individual prior to commencing a lengthy process of rehabilitation. However, the large variability in most factors related to the outcome makes it a difficult decision. In our study, some of the most compromised animals survived, while some of those that appeared to be in a relatively good condition died. Perhaps the efforts expended on each animal are justified, should the resources (time and financial) be available.

Each animal undergoes a thorough health assessment prior to release from the TRC. However, turtles that require extended periods in rehabilitation may not be the best candidates for release. During the rehabilitation period they may have been exposed to pathogens which they may transmit to the wild population on release (Baker *et al.*, 2015). More research is warranted to determine the survival of turtles that are released.

Although release to the wild is the goal for every rehabilitation effort, the turtles that cannot be released can play a vital role in education and conservation (Feck & Hamann, 2013; Baker *et al.*, 2015; Martin *et al*., 2015). Research undertaken at the uShaka Sea World showed that the emotional connection generated between an animal in human care and visitors can be a contributing factor to future pro-environmental behaviour (Mann *et al.*, 2018). After a turtle encounter, visitors expressed an intention to undertake pro-environmental behaviours such as reducing, re-using and recycling (Mann & Ngcobo, 2017). When guests were asked what they would remember most from their interaction, they reported that the experience of being close to the animal was the most memorable. It has also been suggested that the high levels of excitement brought about by interacting with animals allows for higher levels of learning and retention (Mann *et al.*, 2020). In addition, social media posts about rehabilitation of stranded turtles generated greater engagement by the public than other animal rehabilitation posts (Mann & Zwane, 2019). This highlights the important role rehabilitation plays in sensitising the public to the plight of turtles and encouraging appropriate environmental behaviour.

Limitations

Analysis of a data series collected over time can be challenging if the data has not been recorded consistently and systematically. In this study there were a few inconsistencies with respect to data collection as the data was collected by different people over a period of time. The inconsistencies were compounded by missing data. A new system is now in place with standardized data collection fields that should help facilitate future analyses.

CONCLUSION

There is considerable debate on whether resources and skills would be better directed towards implementing strategies to mitigate the causes of turtle stranding, rather than treating injured animals, often with low success rates (Baker *et al.*, 2015; Flint *et al.*, 2017). Indeed, much work is required to reduce the negative impact of humans on turtles. However, we believe that rehabilitation of injured sea turtles can have positive outcomes, including improved understanding of rehabilitation practices and greater success, increased public support for marine conservation and pro-environmental behaviour, and increased numbers in wild populations after releases. We recommend further research on all these aspects.

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Literature cited:

Baker, L., W. Edwards & D.A. Pike. 2015. Sea turtle rehabilitation success increases with body size and differs among species. *Endangered Species Research* 29: 13-21.

Brazier, W., R. Nel, G. Cliff & S. Dudley. 2012. Impact of protective shark nets on sea turtles in KwaZulu-Natal, South Africa, 1981-2008. *African Journal of Marine Science* 34: 249-257.

Casale, P. & A.D. Tucker. 2017. *Caretta caretta* (amended version of 2015 assessment). *The IUCN Red List of Threatened Species* 2017: e.T3897A119333622. https://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T3897A119333622.en. Accessed on April 2, 2020.

Everett, B. 2014. Marine and estuarine fisheries along the KwaZulu-Natal coast: An inventory and brief description. *Oceanographic Research Institute* 312: 1-106.

Feck, A.D. & M. Hamann. 2013. Effect of sea turtle rehabilitation centres in Queensland, Australia, on people's perceptions of conservation. *Endangered Species Research* 20: 153-165.

Flint, J., M. Flint, C.J. Limpus & P.C. Mills. 2017. Status of marine turtle rehabilitation in Queensland. *Peer J* 5: e3132. DOI: 10.7717/peerj.3132.

Flint, J., M. Flint, C.J. Limpus & P.C. Mills. 2015. Trends in marine turtle strandings along the east Queensland, Australia coast, between 1996 and 2013. *Journal of Marine Biology* 2015: 1-7. DOI: 10.1155/2015/848923.

Hoarau, L., L. Ainley, C. Jean & S. Ciccione. 2014. Ingestion and defecation of marine debris by loggerhead sea turtles, *Caretta caretta*, from by-catches in the South-West Indian Ocean. *Marine Pollution Bulletin* 84: 90-96.

Hughes, G.R. 1974 The sea turtles of south-east Africa. II. The biology of the Tongaland loggerhead turtle *Caretta caretta* with comments on the leatherback turtle *Dermochelys coriacea* and the green turtle *Chelonia mydas* in the study region. *Oceanographic Research Institute* 36: 1-96.

Hughes, G.R. 1989. Sea turtles. In: *Oceans of Life off Southern Africa* (eds. Payne, A. & R.J.M. Crawford). Pp. 230-243. Vlaeberg Publishers: Cape Town, South Africa.

Mann, J., R. Ballantyne & J. Packer. 2018. Penguin promises: Encouraging aquarium visitors to take conservation action. *Environmental Education Research* 24: 859-874.

Mann, J., R. Ballantyne & J. Packer. 2020. The role of aquariums and zoos in encouraging visitor conservation action. In: *Encyclopedia of the World's Biomes* (eds. Goldstein, M. & D. DellaSala) Pp. 380-389. Elsevier: Amsterdam, Netherlands.

Mann-Lang, J.B. & K. Ngcobo. 2017. Once in a lifetime memories: Environmental learning associated with marine animal interactions. *International Zoo Educators* 53: 27-30.

Mann, J.B. & L. Zwane. 2019. Analysis of social media engagement 2019. *South African Association for Marine Biological Research,* Durban, Internal Report. Pp. 6.

Martin, J.M., K. Higgins, K. Lee, K. Stearns & L. Hunt. 2015. Integrating science education and marine conservation through collaborative partnerships. *Marine Pollution Bulletin* 95: 520-522.

Mettee, N. 2014. Marine Turtle Trauma Response Procedures: A Veterinary Guide. *Wider Caribbean Sea Turtle Conservation Network*. Technical Report 17. http://seaturtleguardian.org/. Accessed on October 15, 2018.

Mortimer, J.A. & M. Donnelly. 2008. *Eretmochelys imbricata*. *The IUCN Red List of Threatened Species* 2008: e.T8005A12881238. https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8005A12881238.en. May 02, 2020.

Nel, R. & P. Casale. 2015. *Caretta caretta* (South West Indian Ocean subpopulation). The IUCN Red List of Threatened Species 2015: e.T84199475A84199755. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T84199475A84199755.en. Accessed on May 08, 2020.

Nel, R., A. Punt & G.R. Hughes. 2013. Are coastal protected areas always effective in achieving population recovery for nesting sea turtles? *PLoS ONE* 8: e63525. DOI: 10.1371/journal.pone.0063525.

Nelms, S.E., E.M. Duncan, A.C. Broderick, T.S. Galloway, M.H. Godfrey, M. Hamann, P.K. Lindeque & B.J. Godley. 2016. Plastic and marine turtles: A review and call for research. *ICES Journal of Marine Science* 73: 165-181.

Poli, C., L.C.S. Lopez, D.O. Mesquita, C. Saska & R. Mascarenhas. 2014. Patterns and inferred processes associated with sea turtle strandings in Paraíba State, northeast Brazil. *Brazilian Journal of Biology* 74: 283-289.

Ryan, P.G., G. Cole, K. Spiby, R. Nel, A. Osborne & V. Perold. 2016. Impacts of plastic ingestion on post-hatchling loggerhead turtles off South Africa. *Marine Pollution Bulletin* 107: 155-169.

Seminoff, J.A. 2004. *Chelonia mydas*. *The IUCN Red List of Threatened Species* 2004: e.T4615A11037468. https://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en. Accessed on May 02, 2020.

Sink, K., M. van der Bank, P. Majiedt, L. Harris, L. Atkinson, S. Kirkman & N. Karenyi. 2019. *South African National Biodiversity Assessment 2018: Technical Report. Volume 4: Marine Realm*. South African National Biodiversity Institute: Pretoria, South Africa. http://bgis.sanbi.org/Projects/Detail/221. Accessed on March 10, 2020.

Wallace, B.P., M. Tiwari & M. Girondot. 2013a. *Dermochelys coriacea*. *The IUCN Red List of Threatened Species* 2013: e.T6494A43526147. https://dx.doi.org/10.2305/IUCN.UK.2013-2.RLTS.T6494A43526147.en. Accessed on May 02, 2020.

Wallace, B.P., M. Tiwari & M. Girondot. 2013b. *Dermochelys coriacea. (Southwest Indian Ocean subpopulation)*. *The IUCN Red List of Threatened Species* 2013: e.T46967863A46967866. https://dx.doi.org/10.2305/IUCN.UK.2013-2.RLTS.T46967863A46967866.en. Accessed on May 02, 2020.

CAMERA TRAPS IN SEA TURTLE RESEARCH AND CONSERVATION

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INTRODUCTION

Initially developed as an instrument for wildlife photography, camera traps were subsequently used in hunting and have now transformed into a conservation tool (Kucera & Barrett, 2010). Camera traps allow us to observe activities taking place in the wild with minimal intrusion and have many current and potential applications in sea turtle research and conservation.

Any camera that is not triggered by a human (instantly or at a pre-set time) is a camera trap, although some studies that use the term include pre-programmed cameras. In the past, camera trap studies have primarily focused on terrestrial mammals, exploring behavioural patterns as well as their presence in certain habitats. Such methods allowed researchers to collect relatively unbiased data for long periods of time. With technological advances, increased availability, and reduced prices, the popularity of camera traps as a research tool grew and they were adopted to study a variety of species.

For camera trap studies to be viable, it is necessary for researchers to know the exact area in which the target animal is expected, to ensure that it will trigger the camera trap. As terrestrial phases of the sea turtle life cycle are confined to predictable regions of nesting beaches and areas immediately adjacent to known nest locations, camera trapping is a viable method to study turtle biology and threats during nesting, egg incubation and hatchling