Sea Turtle Conservation: Tackling 'Floating Syndrome' A Caribbean Perspective

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ABSTRACT

In July 2013, a severely debilitated, critically endangered juvenile hawksbill sea turtle *(Eretmochelys imbricata)* washed ashore on Campbleton Beach, in northeast Tobago, West Indies. Four years later, in June 2017, a similarly debilitated, vulnerable sub-adult loggerhead sea turtle (*Caretta caretta*) stranded on Manzanilla Beach, on the east coast of Trinidad, West Indies. Floating Syndrome was diagnosed in both cases. Based on local resource availability, several modifications were effectively made to previously documented sea turtle management techniques, particularly pertaining to selection of gelatin diet ingredients for nutritional support and equipment used for handling and restraint. Despite the very limited resources and the absence of a well-equipped facility on the islands for long-term management of larger aquatic vertebrates, each animal was successfully rehabilitated after 10 weeks of therapy which included correction of serum biochemical abnormalities, fluid therapy, dietary modification, assist-feeding and freshwater therapy. Once fully recovered, the turtles were returned to their respective stranding sites and were successfully released. Rescue, rehabilitation and release of these animals were made possible through the collaborative efforts of a multitude of local and international wildlife conservation organisations and volunteers. These represent the first documented cases of successful rehabilitation and release of a hawksbill sea turtle and a loggerhead sea turtle with Floating Syndrome in Trinidad and Tobago. Furthermore, it is the first known and first documented loggerhead sea turtle stranding case for Trinidad and Tobago.

Key words: Sea Turtles, Hawksbill, *Eretmochelys imbricata*, Loggerhead, *Caretta caretta*, Threatened species, Rehabilitation, Caribbean.

INTRODUCTION

Of the seven species of sea turtles, six are present in the wider Caribbean, and five have been recorded for Trinidad and Tobago; the leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*), loggerhead (*Caretta caretta*) and olive ridley (*Lepidochelys olivacea*) (Dow *et al.* 2007; Eckert and Eckert 2019; Forestry Division (GORTT) *et al.* 2010;). All five are long-lived, migratory species that are considered Threatened by the IUCN, are listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and have been designated as Environmentally Sensitive Species under local law in 2014, following the closure of the seasonal sea turtle fishery in 2011.

Leatherbacks visit only to breed and they are the dominant species nesting in Trinidad and Tobago, which is recognised as one of the largest rookeries of this species in the world (Eckert *et al.* 2012). Significant but scattered nesting of hawksbills takes place on beaches throughout Trinidad and Tobago (Dow *et al.* 2007; Eckert and Eckert 2019; Forestry Division (GORTT) *et al.* 2010; Walker *et al.* 2015), while nesting by greens is more limited, and nesting by olive ridleys and loggerheads is described as infrequent (Dow *et al.* 2007; Eckert and Eckert 2019).

A handful of loggerhead nesting records for the north coast of Trinidad and Great Courland Bay in Tobago have been reported by Forestry Division (GORTT) *et al.* (2010), and more recently, two live hatchlings were encountered at Turtle Beach (Great Courland Bay), Tobago in 2010 (Cazabon-Mannette, personal comment). Eckert and Eckert (2019) have identified two beaches in Trinidad and three in Tobago where loggerhead nesting has been reported.

In addition to nesting activity, hawksbills and greens are commonly encountered foraging around both islands year round, and comprise the bulk of sea turtles harvested at sea by fisherfolk (Cazabon-Mannette 2016; Forestry Division (GORTT) *et al.* 2010). Extensive information on the offshore activities of these species is lacking, however, due to a paucity of offshore studies. Forestry Division (GORTT) *et al.* (2010) report that loggerheads are rare locally, but have been observed foraging offshore both islands, and a single record of at-sea harvest in Toco, Trinidad was documented in a survey conducted in 1982-83 (Chu Cheong 1995). More recent evidence of foraging loggerheads comes from a local conservationist's video of an individual harvested at sea at a fishing depot in Guayaguayare, Trinidad in 2010, and divers' underwater photos of an individual at Charlotteville, Tobago in 2012

(Cazabon-Mannette, personal comment). A live loggerhead entangled in rope and fishing line was also encountered in April 2020 in Chaguaramas, and a dead loggerhead was recorded at Icacos in September 2019 (Cazabon-Mannette, personal comment).

Following early development in the oceanic epipelagic zone, juvenile hawksbills and loggerheads exhibit an ontogenetic shift, recruiting to benthic, neritic developmental habitat, where they largely remain resident until moving on to their adult foraging range, as they approach sexual maturity (Meylan *et al.* 2011; Musick and Limpus 1997). The benthic developmental stage appears to alternate with a pelagic foraging mode in some Atlantic loggerheads (Meylan *et al.* 2011). Developmental foraging aggregations represent "mixed stocks" of individuals drawn from a variety of genetically distinct rookeries distributed widely around the region (Bolker *et al.* 2007; Bowen *et al.* 2004; Bowen *et al.* 1996; Cazabon-Mannette *et al.* 2016; Reece *et al.* 2006). Adult hawksbills and loggerheads make extensive migrations between foraging areas and nesting beaches (Blumenthal *et al.* 2006; Horrocks *et al.* 2001) and females exhibit natal homing; returning to the rookery of their birth to breed (Bass *et al.* 1996; Bowen *et al.* 1994; Diaz-Fernandez *et al.* 1999; Troeng *et al.* 2005).

Periodically, sea turtles wash ashore due to illness. Of the reported cases documented at the University of the West Indies, School of Veterinary Medicine (UWI-SVM), Aquatic Animal Health (AAH) Unit, fibropapillomatosis in green sea turtles is the most commonly seen pathologic condition in stranded sea turtles on the islands. Two such cases were admitted to the UWI-SVM AAH Unit, but were severely emaciated and ultimately died during treatment (Cazabon-Mannette and Phillips 2017). At least six other cases of live or dead animals with characteristic lesions have been reported and/or documented on social media in Trinidad and Tobago, while many others have likely gone unreported. For the period September 2010 to May 2020, the UWI-SVM AAH Unit also documented other conditions affecting sea turtles on these islands, including boat strike, drowning following entanglement in fishing nets, lacerations, poaching and Floating Syndrome. Floating Syndrome is a collective term for positive buoyancy disorders in sea turtles. It is most often associated with the presence of excess gas in the body, but may alternatively be a behavioural response to other pathological conditions, or be the result of neurological deficits, or it may be multifactorial in aetiology (Wyneken *et al.* 2006).

While successful sea turtle rehabilitation is routine at specialised, well-equipped, well-funded facilities in developed countries, it is an uncommon occurrence for many Caribbean territories, including Trinidad and Tobago, as rehabilitation poses a significant challenge where equally outfitted facilities are lacking. Challenges are further exacerbated when extended case management is required. Herein we report on collaborative conservation efforts that resulted in the successful rehabilitation and release of two cases of Floating Syndrome, in a hawksbill and a loggerhead, despite the absence of sophisticated aquatic animal rehabilitation facilities and resources in the country. The paper demonstrates that locally available resources, even if limited, can be effectively utilised to manage and rehabilitate stranded sea turtles. This report also constitutes the first known and documented loggerhead sea turtle stranding case for Trinidad and Tobago.

BACKGROUND

The hawksbill stranded on the Leeward/Caribbean coast of northeast Tobago, while the loggerhead stranded on the Atlantic (eastern) coast of Trinidad (Figure 1). The 8.3kg juvenile hawksbill (46.3cm curved carapace length (CCL)) was discovered debilitated and minimally responsive on July 3, 2013 on Campbleton Beach, Tobago (Figure 2a). The animal was rescued by a team of visiting zoology students from the University of Glasgow, Scotland, and members of a local sea turtle conservation group, North East Sea Turtles (NEST). The animal was kept indoors in shallow (5cm depth) freshwater for 5 days after which it was transferred to shallow natural seawater.

A veterinarian on the island visited on the day after the animal was rescued and administered an unknown antibiotic and a multivitamin, and advised that the care takers syringe-feed the animal 590ml of a popular commercially available electrolyte drink daily. Two days later, the veterinarian administered another dose of the antibiotic and a steroid, the identities and doses of which are unknown. As the animal became more alert and responsive to stimuli, the veterinarian advised that the animal be hand fed canned sardines daily. Care takers force fed the animal half a can of sardines (62.5g) twice daily. The animal began passing faeces two days after being rescued and did so periodically for ten days.

Two weeks after being rescued, attempts were made to release the animal in a shallow area of the bay, however, it became immediately apparent that the animal had a buoyancy disturbance and was unable to submerge when it attempted to dive. Persistent caudal positive buoyancy was evident. After multiple dive attempts, the animal quickly became exhausted and the release attempt was aborted. On the following day, another release attempt was made. The animal could submerge and swim with only slight caudal positive buoyancy for a few minutes, but on surfacing to breathe, it could not re-submerge. No further release attempts were made. Daily hand feeding of 125-

Fig.1. Stranding sites of two sea turtles diagnosed with Floating Syndrome in Trinidad and Tobago, West Indies. A severely debilitated, critically endangered juvenile hawksbill sea turtle *Eretmochelys imbricata* washed ashore on Campbleton Beach in northeast Tobago in July 2013 **(S1)**. A similarly debilitated, vulnerable sub-adult loggerhead sea turtle *Caretta caretta* stranded on Manzanilla Beach on the east coast of Trinidad in June 2017 **(S2)**.

200g of sardines or fresh bait fish was continued, however, the animal experienced multiple episodes of diarrhoea followed by the absence of faeces. After six weeks of care in Tobago by its rescuers, the animal was transferred to the UWI-SVM, AAH Unit at the University of the West Indies, School of Veterinary Medicine, St. Augustine Campus, in Trinidad, for physical examination, diagnostics and rehabilitation following ongoing gastrointestinal upsets and continued problems with buoyancy regulation.

The loggerhead was discovered in a very similar condition on June 30, 2017 on Manzanilla Beach, Trinidad. The 63.0kg, 82.75cm CCL sub-adult was also severely debilitated on stranding (Figure 2b). It too was minimally responsive. It was rescued and immediately transported from its stranding site to the El Socorro Centre for Wildlife Conservation, a non-profit, non-governmental wildlife conservation centre in Trinidad, the only site on the island at which an adequately sized (approximately 3785L) marine holding tank was readily available for immediate use at the time of the stranding. The animal was managed as a patient of the UWI-SVM, AAH Unit.

MATERIALS AND METHODS

Physical Examination and Diagnostics

The physical condition of each animal was quickly assessed upon discovery of the animals at the stranding sites. Detailed physical examinations were carried out upon arrival at the rehabilitation facilities. Prognostic indicators were determined based on animal behaviour and physiological parameters. The animals were assessed for an estimation of sexual maturity, weight, determination of morphometric measurements, presence of lesions, general body condition, presence of reflexes, function of cranial nerves, and the level of activity and coordination of

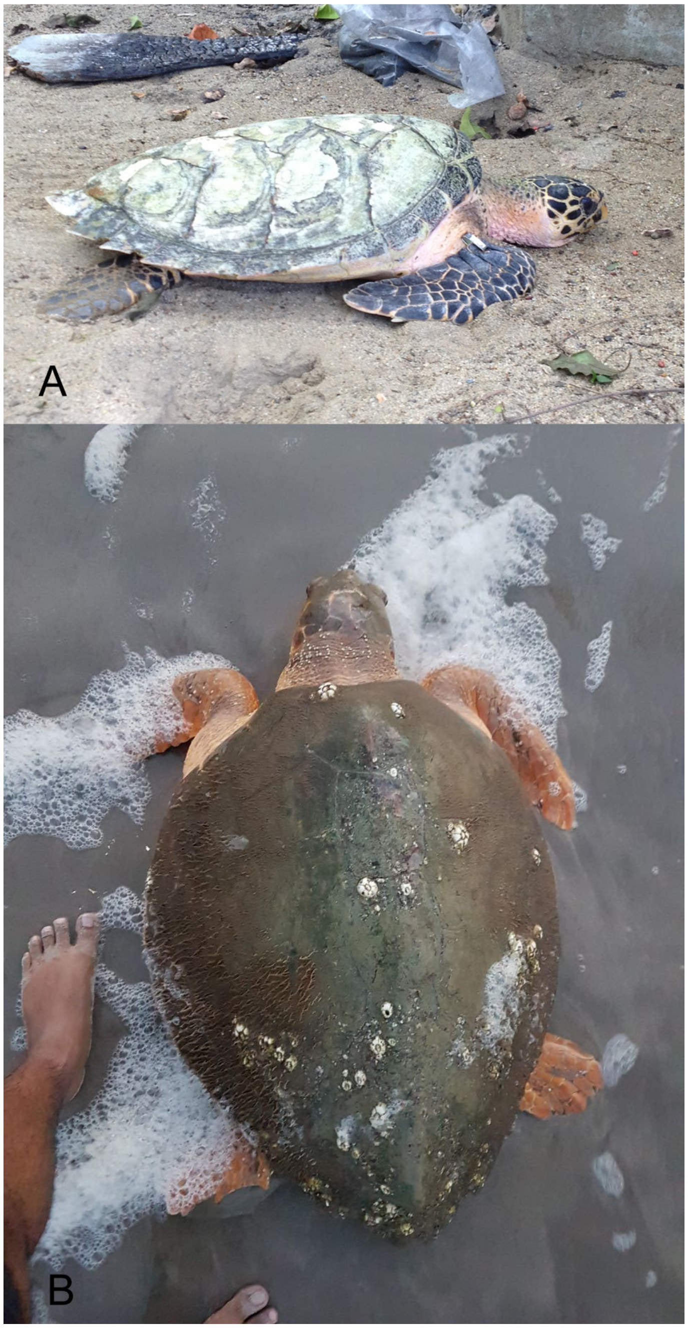

Fig. 2. Two stranded sea turtles diagnosed with Floating Syndrome in Trinidad and Tobago, West Indies. **(A)** A severely debilitated, critically endangered juvenile hawksbill sea turtle (*Eretmochelys imbricata*) washed ashore on Campbleton Beach in northeast Tobago on July 3, 2013. **(B)** A similarly debilitated, vulnerable sub-adult loggerhead sea turtle (*Caretta caretta*) stranded on Manzanilla Beach on the east coast of Trinidad on June 30, 2017.

movement in and out of water. Blood samples and whole body radiographs were taken. Small quantities of faecal material and rectal mucus, collected per rectum, were submitted for bacterial culture and sensitivity and were also examined for gastrointestinal parasites.

Medical Management

Immediate measures included addressing dehydration and hypoglycaemia via intracoelomic (IC) administration of 5% dextrose/0.9% sodium chloride sterile solution at a rate of 10-18ml/kg/day. An additional 20ml single bolus of 50% dextrose solution was administered orally via feeding tube. Nutritional and haematological deficits were initially targeted via the intramuscular administration of a multivitamin containing Vitamins B, E and A twice weekly, along with a single dose of Vitamin K1 at 0.25mg/kg to address clotting insufficiency sometimes seen in debilitated sea turtles. Iron dextran was administered intramuscularly at 6mg/kg once weekly. Once blood parameters improved, Becoplex oral Vitamin B and Vitamin C supplement (Carlisle Laboratories Ltd., St. Thomas, Barbados) was administered daily at 15-20ml in the feed. Broad spectrum antibiotic coverage was instituted for the duration of the rehabilitation process, since severely debilitated sea turtles often succumb to bacterial infections secondary to being severely immunocompromised. On admission, long acting oxytetracycline was administered at 40mg/kg every 72 hours, pending the results of faecal culture and sensitivity. Based on the results of faecal culture and sensitivity, the antibiotic regimen for the hawksbill was modified to enrofloxacin at 5mg/kg administered orally every 48 hours for 6 treatments, while the regimen for the loggerhead was modified to four-quadrant antibiotic coverage using a combination of metronidazole at 20mg/kg once daily for 5 days and procaine benzylpenicillin at 20,000IU/kg every other day until the animal had fully recovered. Deworming was achieved using fenbendazole at 25mg/kg orally and praziquantel at 8mg/kg orally. Both drugs were repeated two weeks later. Additional therapeutic agents included oral simethicone as needed to stimulate the elimination of gas from the digestive tract, mineral oil gavages, KY Jelly enemas and oral Lactulose Sandoz Solution (Sandoz Inc. New Jersey, USA) administration for catharsis.

Dietary Management

On presentation, neither animal ate on its own. Gel diets were therefore prepared as shown in Table 1. The animals were tube fed daily at a rate of 0.5 – 3.0% body weight, split over three feedings daily in the case of the hawksbill, and as one feeding in the case of the loggerhead. Animals were maintained in an upright position at a 60° to 90° angle for 30 minutes post-feeding to minimise regurgitation. Body weight was re-assessed every two weeks. In the case of the loggerhead, after approximately seven weeks the animal had gained strength and began eating small quantities on its own. Tube feeding was therefore reduced to once every other day.

Hydrotherapy

Animals were housed in marine tanks of either natural or artificial seawater. The hawksbill tank contained

Table 1. Hawksbill *Eretmochelys imbricata* and Loggerhead *Caretta caretta* Sea Turtle Gelatin Diet Recipes used in the rehabilitation of two stranded sea turtles in Trinidad and Tobago.

Ingredients	Amount	*E. imbricata* gelatin diet	*C. caretta* gelatin diet
Tilapia Grower Pellets (National Flour Mills Limited, Feed Mill, Port-of-Spain, Trinidad and Tobago)	212.5g	√	√
Dasheen/Taro Leaves (*Colocasia esculenta*)	142.0g	√	
Malabar spinach (*Basella alba* and/or *Basella rubra* L.)	142.0g		√
Canned sardines	282.5g	√	√
Shrimp (peeled)	141.0g	√	
Squid (viscera removed)	141.0g	√	
Frozen Seafood mix (thawed):			
(Squid, Shrimp, Octopus, Mussels (shells removed), Clams (shells removed), Conch (shell removed).	282.0g		√
Ginger (*Zingiber officinale*) root or powder	5.0g	√	√
Oyster shell calcium (Nature's Blend, National Vitamin Company, Casa Grande, AZ, USA) or Coral calcium (GNC Holdings Inc, Pittsburgh, PA, USA)	1.3g	√	√
Gelatin	225g	√	√
Water	1600ml	√	√

approximately 568L (150 US gallons) of artificial seawater (Instant Ocean® Sea Salt, Aquarium Systems USA and France) prepared according to manufacturer's instructions to a concentration of approximately 32ppt. The average daily water temperature was 27°C. The water was continuously mechanically filtered and was changed every 1-2 weeks. The loggerhead tank contained approximately 3785L (1000 US gallons) of natural seawater at a salinity of approximately 27ppt (brackish water) and an average daily temperature of 28°C. The seawater was collected from Trinidad's west coast, trucked to the conservation centre and was UV sterilised.

Freshwater therapy was performed in the latter weeks of the rehabilitation period when animals had clearly regained strength and were showing improvement in gastrointestinal function. To facilitate ease of return to diving, each turtle was placed in a freshwater tank for 6-8 hours daily. Freshwater (dechlorinated) tanks were appropriately sized to allow the turtles to dive to at least approximately 1.5m (5ft). Animals were monitored to prevent accidental drowning through exhaustion. After 6-8 hours, animals were returned to their marine tanks.

Handling and Restraint

Manual restraint was readily accomplished with the hawksbill due to its relatively small size. Restraint during feeding was accomplished by placing the animal in an upright position in a small tub (Figure 3a). Towel rolls were placed beneath the animal to provide adequate padding for the caudal carapacial margin as the animal stood on end, and a foam block was placed behind the animal to secure the animal in position. Only light manual restraint was applied thereafter to minimise animal movement. The animal was readily manually lifted into and out of its treatment tanks.

Daily handling and restraint of the loggerhead presented a significant challenge, especially when moving the animal between the marine and freshwater hydrotherapy tanks. In the absence of appropriate equipment, the animal's size and weight posed a threat to the safety of both the animal and handlers. As such, volunteers constructed equipment components that were used in conjunction with other basic hardware items to achieve the desired handling and restraint goals. A marine mammal stretcher acquired from the Trinidad and Tobago Marine Mammal Stranding Network (TTMMSN) was used to carry the animal and to help restrain the flippers during feeding and medical management. A wooden bench was modified with hinges to allow the benchtop to be elevated to a 60° angle for feeding. The angle was maintained using a stack of concrete bricks. Bungee cords and ropes were used to secure the animal to the elevated benchtop throughout feeding (Figure 3b). This apparatus was used successfully for approximately 4 weeks, after which a local veterinary clinic donated an adjustable, mobile stainless steel examination table (Figure 3c). The animal was kept calm during feeding by covering its eyes with self-adhering bandages. This bandage also

Fig.3. Restraint and handling techniques used during the rehabilitation of two stranded sea turtles diagnosed with Floating Syndrome in Trinidad and Tobago, West Indies. **(A)** Manual restraint was adequate for the juvenile hawksbill sea turtle (*Eretmochelys imbricata*). During feeding, the animal was placed in an upright positon in a small tub, with towels and foam blocks used for padding. **(B)** The sub-adult loggerhead sea turtle (*Caretta caretta*) was lifted using a marine mammal stretcher and placed on a wooden bench that was modified with hinges to allow the benchtop to be elevated to a 60° angle for feeding. The angle was maintained using a stack of concrete bricks. Bungee cords and ropes were used to secure the animal to the elevated benchtop throughout feeding. **(C)** The modified wooden bench in (B) was eventually replaced by an adjustable, mobile, stainless steel examination table that was donated by a local veterinary clinic. **(D)** The loggerhead was kept calm during feeding by covering its eyes with self-adhering bandages. This bandage also served to keep a mouth speculum, derived from a circular 7.5cm diameter PVC fitting, in position during feeding. **(E and F)** Volunteers purchased materials and constructed a wooden crane which allowed the loggerhead to be safely and more readily hoisted from the freshwater hydrotherapy tank.

served to keep a mouth speculum, derived from a circular 7.5cm diameter PVC fitting, in position during feeding (Figure 3d). Safely hoisting the animal out of its freshwater tank was particularly difficult. Volunteers again purchased materials and constructed a wooden crane which allowed the animal to be more readily retrieved from the tank using less effort and reduced the risk of handler injury (Figures 3e and 3f).

RESULTS

Physical Examination

Select morphometric data and clinical findings are presented in Table 2. Although size at sexual maturity reported in the literature is highly variable among and within populations, and size is therefore not considered as a reliable indicator of maturity (Meylan *et al.* 2011), minimum size at sexual maturity can be used to confirm immaturity. Minimum size at sexual maturity for hawksbills in the west Atlantic is straight carapace length (SCL) 67cm i.e. notch to notch (Meylan *et al*. 2011) which is the equivalent of approximately 70cm CCL (van Dam and Diez 1998). For loggerheads in the northwest Atlantic, the minimum size at sexual maturity is CCL 87.9 cm (Ehrhart and Witherington 1987). Therefore the morphometric data suggests that the hawksbill was a juvenile animal, while the loggerhead was a sub-adult (Table 2). Sexual dimorphism is only apparent in sea turtles after sexual maturity, at which point males develop a large and muscular prehensile tail which extends beyond the caudal margin of the carapace (Wibbels 1999). In the absence of additional ultrasound or endoscopic evaluation, sex could not be assumed for either animal.

Both animals were deemed to be in fair body condition at the time of clinical evaluation. Increased prominence of the biventer cervical and transverse cervical muscles and moderate to severely sunken eyes especially when angled head up/tail down, were consistent with sub-optimal body condition in both animals. The hawksbill was reportedly minimally responsive at the time of stranding, however, at the time of transfer to the UWI-SVM AAH Unit, the animal was alert and responsive. The loggerhead was minimally responsive at the time of clinical examination.

Table 2. Stranding location, select morphometric data and clinical findings for a hawksbill sea turtle *Eretmochelys imbricata* and a loggerhead sea turtle *Caretta caretta* that stranded in Trinidad and Tobago, West Indies.

	E. imbricata	***C. caretta***
Stranding location	Latitude: 11°19'01.5 N Longitude: 060°33'38 W	Latitude: 10°29'44.0 N Longitude: 61°02'37.5 W
Straight carapace length notch-tip (SCL) (cm)	Data unavailable	80.0
Curved carapace length notch-tip (CCL) (cm)	46.3	82.75
Straight width (cm)	Data unavailable	68.0
Curved width (cm)	40.0	78.0
Weight on presentation (kg)	8.3	63.0
Thin neck?	Mild	Mild
Tendons of neck stretched and obvious?	Mild	Mild
Shoulder area sunken behind leading edge of carapace?	Mild	No
Radius and humerus thin?	No	No
Plastron and inguinal area sunken?	Mild	Mild
Eyes sunken (especially if stood on rear end)?	Severe	Severe
Overall estimation of body condition	Fair	Fair
Compulsive circling in water?	None	None
Head posture	Level	Level
Head movement	Normal	Normal
Body posture	Caudal positive buoyancy	Tilted right
Limb movement, strength and coordination (in and out of water)	Normal	Normal
Animal picks up its head to breathe when out of water?	Yes	Yes
Reflexes (flexor, crossed extensor, cloacal, nociception) and tail movement	Normal	Normal
Cranial Nerve Assessment	No abnormalities detected	No abnormalities detected

Following fluid and dextrose administration, the animal became increasingly more alert and responsive over the course of approximately 60 to 90 minutes. No ectoparasites or epibiota were noted on the hawksbill, however, there was considerable algal growth along the dorsal midline and left side of the carapace of the loggerhead and numerous surface and burrowing barnacle colonies of varying sizes covered approximately 25% of its carapace, plastron and skin of the perineum, flippers, neck, head and periorbit (Figures 2b and 4a). An approximately 4cm x 2cm superficial, non-penetrating crack was also noted on the carapace, just right of the dorsal midline, in the caudal-most corner of the second central scute (Figure 4a).These findings suggested possible inactivity of the animal, likely close to the water surface, prior to stranding. The majority of the barnacles were removed over the first two weeks of rehabilitation using a combination of fresh water immersion and manual removal. The loggerhead initially presented with a mild cloacal prolapse (Figure 4b), which reduced spontaneously during the physical examination, but recurred two days later as a severe prolapse. The prolapsed cloacal mucosa was bathed in a supersaturated sugar solution followed by veterinary obstetric lubricant and was gently manually reduced. A purse-string suture was placed to prevent re-prolapse, but leaving an adequate orifice for the passage of faeces. Neither animal was observed to be passing faeces and digital examination of the rectum yielded only small amounts of yellow/green to cream gelatinous mucous in both cases (Figure 4b).

When placed in a marine tank, both animals floated high in the water and were asymmetrically buoyant. The hawksbill demonstrated slight caudal positive buoyancy (Figure 5a) and could not stay submerged on attempting to dive, thus demonstrating involuntary positive buoyancy. The loggerhead made strong, coordinated attempts to dive, but was also unable to submerge. A significant, persistent right-sided tilt (right side downward) was noted (Figure 5b). Both animals would quickly become exhausted following multiple dive attempts and would remain floating on the surface with their respective tilts evident, as described. In both cases, the centre of buoyancy was noted to shift periodically over the course of rehabilitation, consistent with what may be seen as gas moves through the gastrointestinal tract. This suggested that the animals may have been 'gastrointestinal floaters'.

Radiographic Evaluation

Radiographic findings were similar for both animals, with there being a presence of gas within the caudal loops of intestine (Figure 6). There was no evidence of gas trapped beneath the carapace or within the body cavity. These findings confirmed the diagnosis of the animals being gastrointestinal floaters, but the underlying cause of the accumulation of gas in the intestine was not discernible based on the radiographic images. No foreign bodies and no skeletal abnormalities were detected.

Medical, Dietary and Hydrotherapeutic Management

Based on clinical assessment and diagnostic findings, the aim in each case was to support a return to normal haematological parameters, provide antimicrobial coverage to prevent the development of systemic infection secondary to environmental stress and an immunocompromised state, to stimulate gut motility and the expulsion of the gas present in the caudal gastrointestinal tract, and to provide nutritional support by gradually reintroducing the animals to food via tube feeding and hand-feeding as tolerated and accepted by the animals. In both cases, animals were gradually re-introduced to larger quantities of food via tube feeding over a period of 10 weeks. The animals were tube fed a liquefied

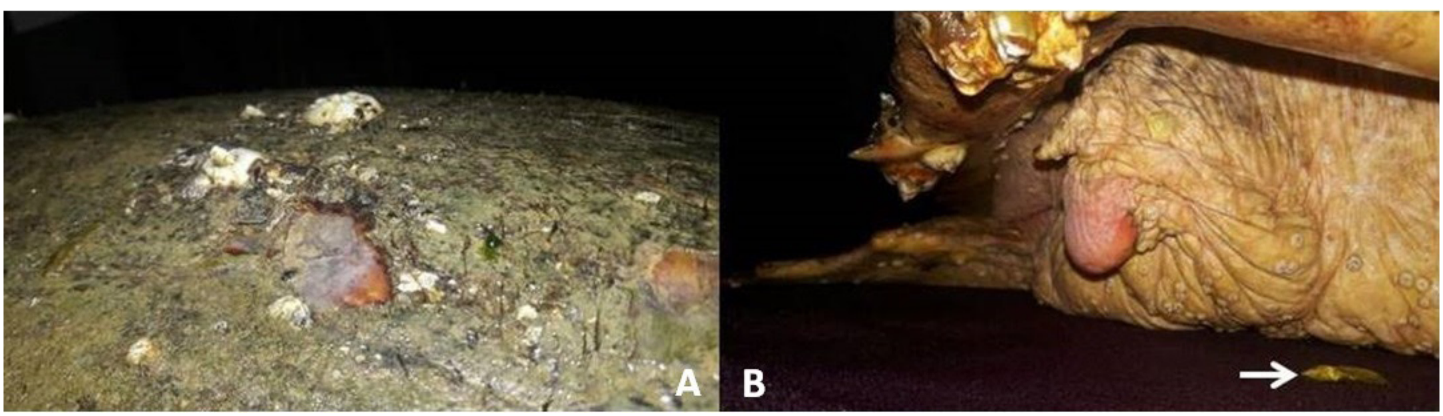

Fig. 4. Lesions observed on a stranded sub-adult loggerhead sea turtle *Caretta caretta* diagnosed with Floating Syndrome on June 30, 2017 in Trinidad and Tobago, West Indies. **(A)** An approximately 4cm x 2cm superficial, non-penetrating crack in the carapace was noted just right of the dorsal midline, in the caudal-most corner of the second central scute. **(B)** Mild cloacal prolapse observed on presentation. Digital examination of the rectum yielded only small amounts of yellow/green to cream gelatinous mucous ***(arrow)***. Similar faecal material was obtained from a hawksbill sea turtle *Eretmochelys imbricata* diagnosed with Floating Syndrome, which stranded on Campbleton Beach in northeast Tobago on July 3, 2013.

gelatin-based diet, modified from Wyneken *et al.* (2006) as shown in Table 1. Locally available ingredients were substituted as necessary and were well tolerated by both animals, ultimately yielding excellent results. Trout chow was replaced with tilapia grower pellets. Malabar spinach (*Basella alba* and/or *Basella rubra* L.) and Dasheen (Taro) (*Colocasia esculenta*) leaves constituted the leafy greens. A variety of canned, fresh, or thawed frozen seafoods were utilised. While an effective (if any) dosing regimen in aquatic species requires study, either fresh or powdered ginger (*Zingiber officinale*) root was included in the gelatin diet for its potential to have prokinetic, anti-inflammatory and antioxidant effects (Ghayur and Gilani 2005). Either oyster shell calcium or coral calcium was incorporated as a supplement for musculoskeletal support.

After 10 days of medical and dietary management, the hawksbill started passing faeces daily. Over the course of two weeks, the faecal material gradually transitioned from small amounts of yellow/green mucoid material to greater quantities of well-formed faeces of a normal consistency. The animal was placed in a freshwater tank daily, as described earlier, to further support correction of the positive buoyancy. Approximately 5 days after faecal elimination had normalised and freshwater therapy was

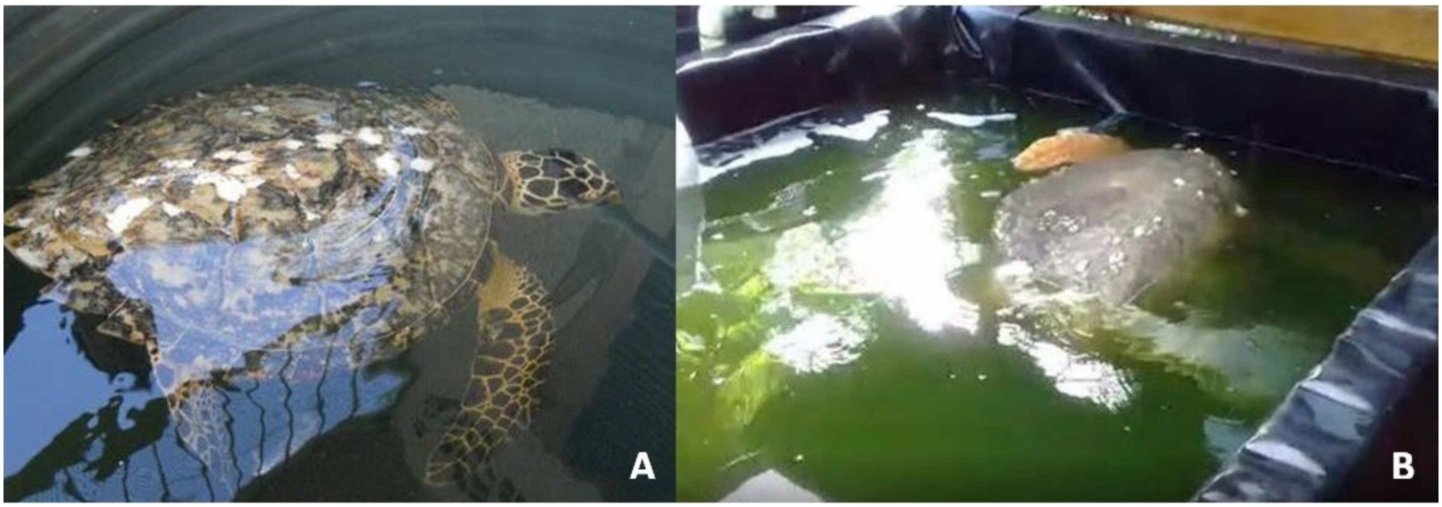

Fig. 5. Two stranded sea turtles diagnosed with Floating Syndrome in Trinidad and Tobago, West Indies. Both animals floated high in marine water and were asymmetrically buoyant. **(A)** The juvenile hawksbill sea turtle *Eretmochelys imbricata* demonstrated a slight upward pelvic tilt. **(B)** The sub-adult loggerhead sea turtle *Caretta caretta* demonstrated a significant, persistent right-sided tilt (right side downward).

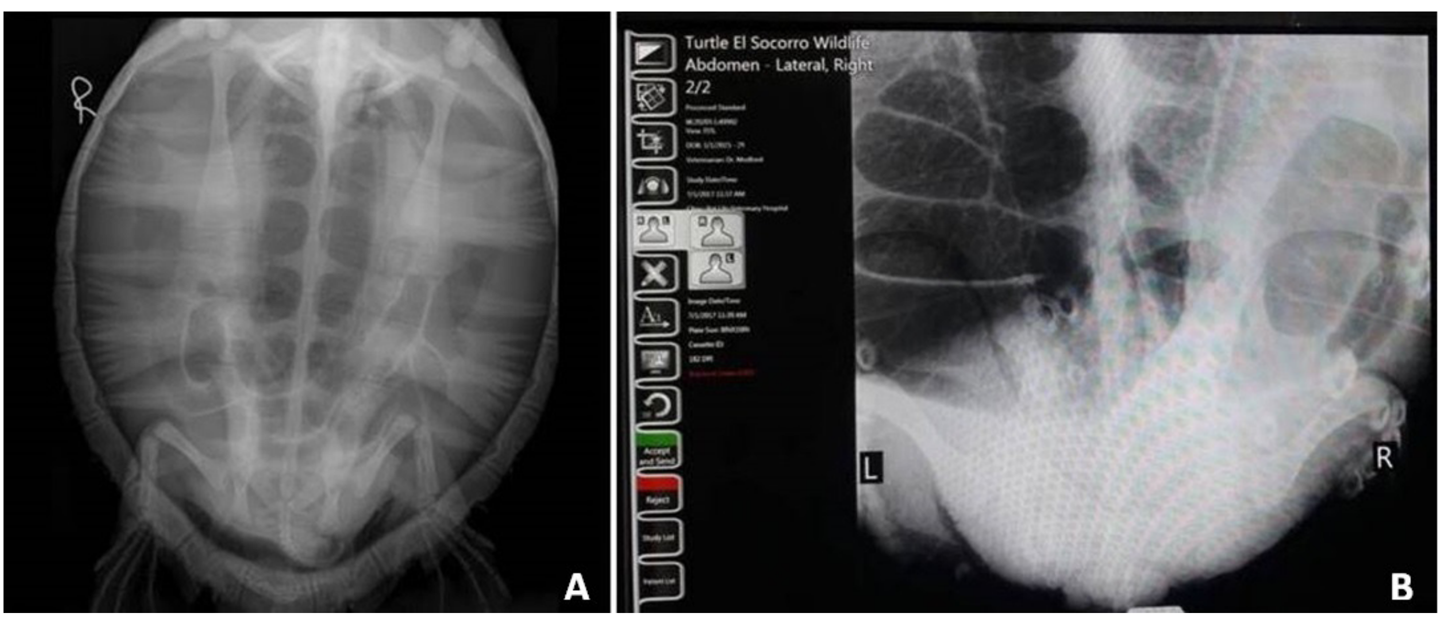

Fig. 6. Dorsoventral radiographs of two stranded sea turtles diagnosed with Floating Syndrome in Trinidad and Tobago, West Indies. Significantly distended, gas-filled caudal loops of intestine were observed in both animals. **(A)** Juvenile hawksbill sea turtle *Eretmochelys imbricata* which demonstrated a caudal positive buoyancy in marine water. **(B)** Sub-adult loggerhead sea turtle *Caretta caretta* which demonstrated a significant, persistent right-sided tilt (right side downward) in marine water.

initiated, the caudal positive buoyancy completely resolved and the animal could quickly submerge and rest comfortably at the bottom of both the freshwater and the marine tanks. The animal consistently showed no interest in shellfish, fish or vegetation offered, perhaps due to the almost exclusively spongivorous nature of the hawksbill diet in this region. After a total of ten weeks (six weeks in Tobago and four weeks in Trinidad), the hawksbill, though it refused to eat on its own, had gained 0.7kg, was consistently diving to full tank depth, was comfortably regulating its buoyancy and was therefore cleared for release.

After five weeks of fluid therapy, nutritional supplementation, and antimicrobial and anthelminthic coverage, the loggerhead had gained 4kg and was also gaining strength, but was only periodically passing small amounts of yellow-tinged mucoid faecal material. There was a general absence of faeces. The animal intermittently showed an interest in hand fed fish and shrimp and ate a maximum of 850g on its own on one occasion, making ongoing tube feeding necessary. Radiographs were repeated, revealing that gas-distended loops of intestine were still prominent. Intestinal obstruction was suspected. A mineral oil gavage was performed along with a KY Jelly enema. Two days later, no faeces had passed. The animal was therefore tube-fed Lactulose Sandoz (3.3g/5ml) oral solution (Sandoz Inc., New Jersey, USA) to promote catharsis. Twenty-four hours later, the cloaca was distended, hyperaemic and a faecal mass was visible at the cloacal orifice. The purse-string suture was removed and a 40g well-formed faecal mass was passed. The mass contained primarily coarse crushed shell material and fish bone fragments. Lactulose administration was continued once daily as part of the daily feeding regimen for a total of 5 days to ensure continued smooth, regular passage of faeces. The animal was also offered whole fish and shrimp daily to encourage self-feeding. Following the passage of the impacted material, faeces were either passed during tube feeding or were observed floating in the animal's tank daily thereafter. Within 10 days, the animal was readily diving to full tank depth, regulating its buoyancy and eating a variety of fish and shrimp on its own. After 10 weeks of rehabilitation, the animal was deemed releasable.

Release

The hawksbill was transported from Trinidad back to its stranding site in Tobago. Inconel tags were applied and the animal was successfully released at nearby Hermitage beach, a short distance from Campbleton Beach where it initially washed ashore (Figure 7a). The loggerhead was prepared for release by first applying Inconel tags, followed by the application of a satellite telemetry tag (ARGOS- CLS

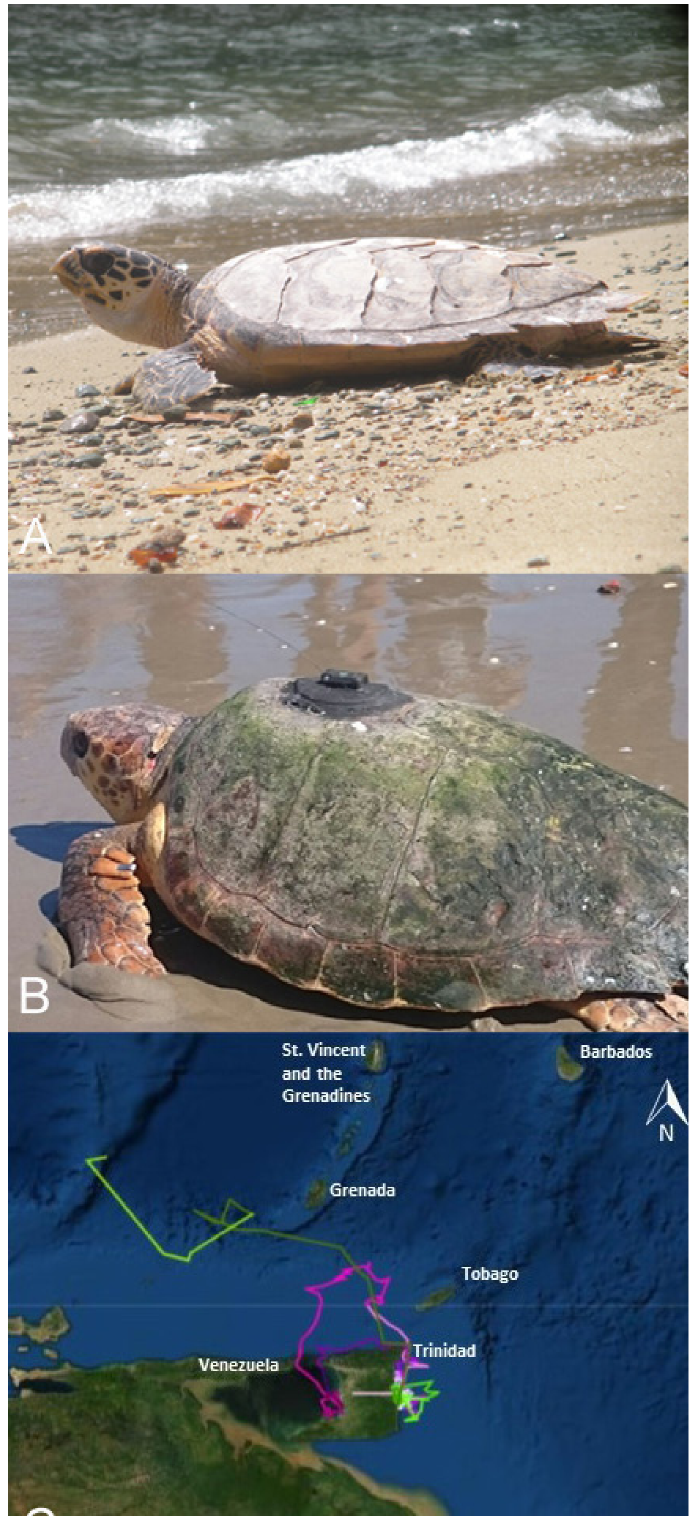

Fig. 7. Release of two stranded sea turtles diagnosed with Floating Syndrome, after successful rehabilitation in Trinidad and Tobago, West Indies. **(A)** Juvenile hawksbill sea turtle *Eretmochelys imbricata* was flipper tagged and released on Hermitage beach, Tobago. **(B)** Sub-adult loggerhead sea turtle *Caretta caretta* was flipper tagged and satellite telemetry tagged and released on Manzanilla Beach, Trinidad. **(C)** Path of the loggerhead sea turtle from the time of release (September 2017) to January 2018, as recorded by the satellite telemetry tag.

America Inc., Maryland, USA). The animal was transported back to its stranding site on Manzanilla Beach and was successfully released (Figure 7b). This is the first loggerhead sea turtle to be satellite tagged in Trinidad and Tobago. The animal's path from the time of release (September 2017) to January 2018 is shown in Figure 7c. The last recorded signal from the satellite tag was on 23 January, 2018, consistent with the approximate battery life of the tag. At that time, the animal was recorded in the Caribbean Sea, over 120km to the west of the northwestern tip of Grenada, West Indies. The satellite tag data provided a brief glimpse into the possible role of Trinidad and Tobago's waters as a foraging habitat or a migratory pathway for loggerheads.

DISCUSSION

In the wild, healthy turtles are known to float periodically, perhaps as a behavioural thermoregulatory mechanism, referred to as 'basking', or perhaps simply to rest. However, weak sea turtles can also be found floating at the surface, likely as a behavioural response to prevent drowning (Manire *et al*. 2017). Conversely, floating may be involuntary. Possible underlying causes include excess gas in the stomach and/or intestines. Most commonly, this may occur secondary to gastroenterocolitis; ileus secondary to dehydration, foreign bodies including fishing hooks and lines, systemic disease, spinal cord injury, gastroenterocolitis and malnutrition; impactions consisting of vegetation or indigestible ingested materials secondary to gastrointestinal stasis (Manire *et al*. 2017). Floating may also be precipitated by pneumocoelom; a condition where gas is trapped within the coelomic cavity but outside of the gastrointestinal tract and lungs. This is most commonly associated with lung tears secondary to blunt force trauma, but may also be linked to ruptured pulmonary lesions such a bullae, or due to pneumonia, which result in leakage of air into the coelom . Neurological disease (traumatic or non-traumatic) may also result in involuntary positive buoyancy, with traumatic causes such as boat strike being more common (Manire *et al.* 2017). Depending on the nature of the nerve injury sustained due to such trauma, there may be disruption of the animal's fine buoyancy control, there may be rear flipper paralysis, or it may cause ileus, thus leading to gas accumulation in the gastrointestinal tract, further exacerbating positive buoyancy (Manire *et al.* 2017). Another more recently described cause of positive buoyancy in sea turtles is decompression sickness, in which floating is presumably caused by gas emboli in the cardiovascular system and within viscera (García-Párraga *et al.* 2014; Manire *et al.* 2017). It is therefore important to carry out a full diagnostic evaluation to correctly identify the underlying cause of the animal's positive buoyancy, although in some cases, the underlying cause is never elucidated.

Floating Syndrome in the cases discussed was ultimately demonstrated to be the result of excess gas in the gastrointestinal tract ('gastrointestinal floaters'). However, the cause of the accumulation of gastrointestinal gas differed. Gas accumulation in the hawksbill was ultimately presumed to be secondary to gastroenterocolitis. This was suspected based on the animal's relatively rapid response to medical therapy and dietary management. The condition in the loggerhead, however, was due to ileus following faecal impaction with shell fragments and other indigestible components of the animal's prey. These cases represent the first two instances of animals with Floating Syndrome reported in Trinidad and Tobago. A third case, a juvenile green sea turtle *Chelonia mydas*, was reported in March 2020, however, despite initial signs of improvement during treatment, this animal died suddenly 1 week after being admitted to the UWI-SVM, AAH Unit. The underlying cause of this animal's buoyancy disturbance was undetermined. Other presentations of buoyancy abnormalities can be less amenable to treatment, including free gas in the coelomic cavity from tears in the lung, or carapace fractures transecting or compressing the spinal cord leading to expanded caudal lung fields and/or persistent lower gastrointestinal atony (Manire *et al.* 2017)

There are presently no aquatic wildlife rehabilitation facilities in the country, thus making long-term management of such cases, particularly for larger animals, especially challenging. Physical and financial resources were entirely donated by rescuers, care takers and other volunteers. In the absence of sophisticated machinery and a constant availability of adequate manpower, there was an absolute need for ingenuity in devising techniques for the safe handling of these animals throughout the rehabilitative process, especially as the animals showed physiological improvement and as they gained strength. Further, local and international interagency collaborations were imperative to these sea turtle conservation efforts, with governmental and non-governmental organisations in Trinidad and Tobago, Florida, USA and Scotland, UK playing vital supportive roles that collectively influenced the positive outcome of each case. It is anticipated that as further aquatic wildlife health assessments are conducted and continued rehabilitation success is achieved, aquatic wildlife conservation efforts in Trinidad and Tobago will garner even greater support, and ultimately result in the establishment of a designated, well-equipped facility suited for long term housing and rehabilitation of these and other protected aquatic megavertebrates of the Southern Caribbean.

ACKNOWLEDGEMENTS

These cases were a success thanks to the collaborative efforts of numerous local and international governmental and non-governmental sea turtle and wildlife conservation organisations, community groups, tertiary educational institutions and volunteers. The authors wish to thank the regulatory authorities: the Wildlife Section, Forestry Division - Ministry of Agriculture, Land and Fisheries of the Government of the Republic of Trinidad and Tobago, and the Wildlife Unit of the Tobago House of Assembly-Department of Natural Resources and the Environment (DNRE), for granting the required permits to handle and carry out medical interventions on protected species, and for overseeing all stranding response activities to ensure that all animals were humanely handled. Very special thanks to Dr. Douglas Mader and the staff of the Marathon Sea Turtle Hospital, Marathon, Florida USA, and Dr. Raymond Carthy of the United States Geological Survey (USGS) - Florida Cooperative Fish and Wildlife Research Unit, University of Florida, Gainesville, FL, USA and Mrs. Ann Marie Lauritsen, Regional Sea Turtle Coordinator at the U.S. Fish and Wildlife Services North Florida Ecological Services Office for their valuable advice, efforts and willingness to facilitate transfer of the turtles to the US, had it become necessary. Thank you to Mr. Romano Macfarlane and Mr. Renardo Daniel of the regulatory agencies in Trinidad and in Tobago, respectively. Special thanks to Mr. Grant Walker, Ms. Mairi Hilton and all the visiting zoology undergraduate students from the University of Glasgow, Scotland who rescued and initially cared for the hawksbill. Thank you to Mr. Devon Eastman and members of North East Sea Turtles (NEST) Tobago for participating in the hawksbill rehabilitation and for providing and applying flipper tags prior to the animal's release. Very special thanks to Mr. Dennis Sammy and Mr. Ryan P. Mannette for their critical roles in rescuing the loggerhead, and to Mr. Mannette for his invaluable contributions throughout the entire rehabilitative process. We especially thank Mr. Ricardo Meade and the staff of the El Socorro Centre for Wildlife Conservation (ECWC), Ms. Kathryn Audroing and Turtle Village Trust (TVT) for facilitating the rescue and for providing constant support in the form of physical resources and financial contributions throughout the duration of the loggerhead rehabilitation. Many thanks to Drs. Wade Seukeran and Sanjay Ramdath for providing veterinary relief support and for their donations of medical supplies during the loggerhead rehabilitation. Thank you to animal welfarist, Ms. Kristel-Marie Ramnath, for her support and donations toward the loggerhead rehabilitation. Thank you to Mr. Len Peters and the members of the Grande Riviere Nature Tour Guides Association (GRNTGA) and again to Turtle Village Trust for their valuable assistance, especially for the provision and application of the satellite tag on the loggerhead. Thank you to Pet Life Veterinary Clinic, Trinidad, for performing the initial radiography on the loggerhead. Many thanks to the staff and students of the University of Trinidad and Tobago (UTT) Marine Sciences Programme, Mr. Rakesh Bhukal, Mr. Stephen Jairam, Mr. Roger Malcolm, the staff and students of the University of the West Indies, School of Veterinary Medicine and the more than 100 volunteers who generously offered of their time, finances and physical assistance throughout the rehabilitative process in these cases.

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