TWO DECADES OF REHABILITATION DATA REVEAL THREATS FACED BY SEA TURTLES IN REUNION ISLAND

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Sea turtles face a range of anthropogenic and natural pressures that threaten their survival globally (Wallace *et al.*, 2011). All seven species of sea turtles are listed on the International Union for Conservation of Nature Red List (IUCN, 2024) with habitat destruction, climate change, marine debris, bycatch, and diseases among the primary challenges (Bolten *et al.*, 2010; Donlan *et al.*, 2010). Since 2006, Kelonia, the Marine Turtles Observatory on Reunion Island, has led conservation efforts by integrating public education, scientific research, and rehabilitation.

Four of the five species inhabiting the southwest Indian Ocean - loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*) turtles - are regularly admitted to the Kelonia Care Centre, where the primary goal is to rehabilitate sick or injured turtles for release back into the wild when and if their condition allows (Bluvias & Eckert, 2010; Feck & Hamman, 2013).

Between 1998 and 2023, Kelonia admitted 558 sea turtles, with annual admissions increasing from an average of 22 cases (1998–2019) to over 43 cases per year since 2020 (Figure 1). This rise is primarily attributed to Kelonia's recognition as a rehabilitation centre in 2009, extensive outreach initiatives, and consistent engagement of professional longline fishermen. Both live and deceased turtles are systematically transported to Kelonia.

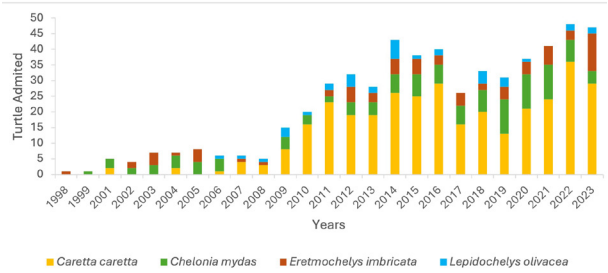

Figure 1. Annual sea turtle admissions by species (n=558).

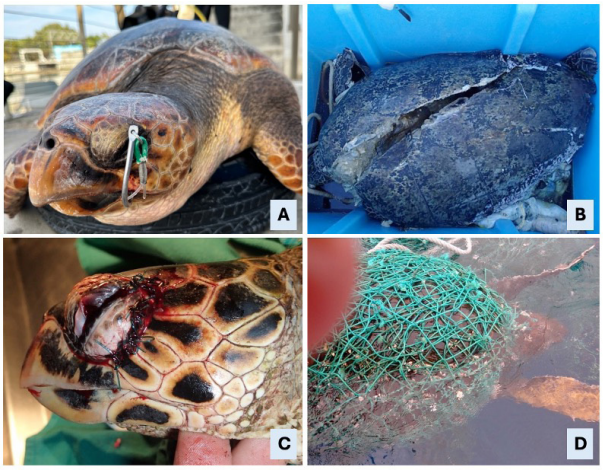

Figure 2. Examples of injuries observed upon admissions. (A) Bycatch injury on a loggerhead with a hook embedded in the oral cavity; (B) A severe carapace fracture typical of foil strikes on a green turtle; (C) Head trauma observed following the removal of a harpoon that had pierced the eye of a hawksbill; (D) A loggerhead entangled in ghost fishing gear. (Photo credits: Mathieu Barret (A, B and C); Alain Bourrel (D))

REASONS FOR TURTLE ADMISSIONS AND SPECIES DISTRIBUTION

Admissions were classified into four main categories—hook ingestion, trauma, entanglement, and debilitation (Table 1; Figure 2)—based on a framework adapted from Orós *et al.* (2016). Data collection included biometrics, clinical examinations, advanced diagnostics (e.g., radiology, blood tests, bacteriology, parasitology, histopathology), and findings from necropsies.

Hook ingestion accounted for 398 cases (71.5%), predominantly resulting from bycatch in longline or traditional handline fishing. Loggerhead turtles represented 82% of these cases, followed by olive ridley (9%), green (5%), and hawksbill (4%) turtles. Radiographic examinations revealed that some hawksbill turtles had ingested multiple hooks, with up to three detected in a single individual.

Trauma, another significant cause of admissions, primarily resulted from vessel strikes, predation, and

Table 1: Rehabilitation and overall survival rates by cause of admission and species during the period 1998-2023. Rehabilitation success and comprehensive survival rates below 50% are highlighted in bold on the figure.

Primary Cause of Admission	Details	Turtle	# Individuals	Admitted Alive In Care	Rehabilitation Success Rate (%)	Comprehensive Survival Rate (%)
Hook ingestion	Longline	Loggerhead	326	307	80	75
		Green	14	6	66	**28**
		Hawksbill	2	2	100	100
		Olive ridley	2	2	**36**	**22**
Trauma	Traditional fishing	Green	7	7	85	85
		Hawksbill	14	11	63	50
	Vessel strike	Green	40	13	**38**	**12**
		Hawksbill	6	0	-	**0**
	Predation	Green	6	2	100	**33**
		Hawksbill	8	3	67	**25**
Entanglement	Hunting	Loggerhead	2	1	**0**	**0**
		Green	3	2	**0**	**0**
		Hawksbill	7	5	**40**	**28**
		Green	22	14	78	50
		Hawksbill	17	14	57	**47**
Debilitation		Loggerhead	7	7	**42**	**42**
		Green	16	11	54	**37**
Unknown		Hawksbill	7	5	**40**	**28**
		Green, Hawksbill	25	11	82	**36**

poaching. Green turtles were the most impacted by vessel strikes (40 cases). Collision frequency increased significantly since 2015, reaching an average of 6 cases per year, with injuries evolving from propeller marks to foil-induced cuts. Predation injuries (15 cases), included shark bites, also contributed to trauma admissions, with three requiring flipper amputations. Poaching, although rare (10 cases), involved harpoon injuries, with the latest incident recorded in 2022.

Entanglement in ghost fishing lines or nets affected 38 turtles, primarily green turtles, with some cases requiring amputations. Most injuries, however, were less severe. Thirty-two turtles were categorised as debilitated, showing symptoms such as poor body condition, cachexia, lethargy, algae overgrowth, and infectious disease confirmed by microbiological or histopathological analyses. These cases indicated underlying health issues, with no visible external injuries. Other causes of admission included oil pollution (3 cases) and 25 unexplained cases where no clear cause could be identified.

A final cause of admission can be attributed to the rescue of 208 hatchlings, referred to as live in nest, nest bottoms or stragglers, trapped in sand columns in nests due to

weakness, injuries, or deformities. Monitoring efforts are highly active due to reproductive challenges on Reunion Island, where sea turtle nesting activity remains critically low (Ciccione & Bourjea, 2006). Since 2004, only two green females have been documented nesting on the island (Lauret-Stepler *et al*., 2023). These cases were excluded from survival rate analyses due to their high specificity.

CHARACTERISTICS OF RESCUED TURTLES

Among the 558 admitted turtles, 10.2% were stranded, 19.5% recovered at sea, and 70.3% brought in directly, primarily by fishermen. Notably, 20.8% were already deceased upon arrival. Mean curved carapace length (CCL) varied by species. Most individuals were juveniles, although adults were occasionally recorded (Table 2). Secondary conditions, such as buoyancy disorders, anorexia, and parasitic infections, were common, particularly in turtles found near the coastline. Plastic ingestion was particularly prevalent in loggerheads with a 70% occurrence rate (Hoarau *et al*., 2014; Thibault *et al*., 2023).

Trends in rehabilitation and survival rates

The rehabilitation success rate, as defined by Baker *et al*. (2015), represents the proportion of turtles that either died in rehabilitation, were euthanised, were successfully released, or were permanently kept in captivity. To provide a broader perspective, a comprehensive survival rate was introduced, accounting for 116 turtles that died before admission. This metric offers deeper insight into the impact of specific threats on turtles in the coastal waters of Reunion.

Disparities in rehabilitation and survival rates across threats

Average comprehensive survival rate (57%) is lower than rehabilitation success rate (71%) underscoring our limitations in addressing certain threats, emphasising the importance of timely intervention, proper handling of turtles before their arrival, and an effective rescue network. Outcomes vary significantly by threat type and species (Table 1).

Hook ingestion (longline) cases showed the best results, with loggerhead turtles achieving 80% success and hawksbill turtles 100%. However, olive ridley (36%) and green turtles (22%-28%) were particularly vulnerable. Vessel strikes, one of the most lethal threats, resulted in 0% survival for hawksbill and 12% for green turtles. Predation led to low survival rates, with 0% for loggerhead and 25%-33% for green and hawksbill turtles, often attributed to severe injuries or significant blood loss. Entanglement was less fatal but still challenging, with green turtles achieving 50% survival and hawksbill turtles 47%. Debilitation showed moderate rehabilitation success (40%-54%), but comprehensive survival rates remained low (28%-37%).

Species-specific vulnerabilities

Hawksbill and loggerhead turtles demonstrated greater resilience, particularly in hook ingestion cases. though hawksbill turtles were vulnerable to vessel strikes and predation. Conversely, green turtles and olive ridleys were consistently more vulnerable. Green turtles have low survival rates for vessel strikes (12%), though they fare better in entanglement cases (50%). Olive ridley turtles

Table 2. Characteristics of sea turtles admitted to Kelonia Care Centre between 1998 and 2023 (n=531), including morphometrics and maturity stages across four species. CCL: curved carapace length; SD: standard deviation.

Turtle	Biometrics		Life stage		
	Weight (kg) Mean±SD (Range)	CCL (cm) Mean±SD (Range)	Juvenile (n)	Sub-adult (n)	Adult (n)
Loggerhead (n=332)	45.3±10.7 (0.8-76.2)	70.0±7.4 (18.5-85.0)	205	126	1
Green (n=101)	34.4±43.5 (0.3-170.0)	58.4±24.0 (14.5-119.0)	71	12	18
Hawksbilll (n=63)	12.6 ± 13.6 (2.6-74.9)	45.9±11.9 (31.0-85.5)	59	-	4
Olive ridley (n=35)	20.8±8.6 (5.5-41.3)	56.5±8.1 (35.0-68.0)	26	6	3

are also vulnerable, with only 22% survival in longline bycatch.

REHABILITATION ACHIEVEMENTS AND AWARENESS EFFORTS

Veterinary care at rehabilitation facilities has become an increasingly integral aspect of sea turtle conservation, aiding outreach and education (Norton & Walsh, 2012). Since 1998, Kelonia has rehabilitated and released 316 turtles (71.5%) into the wild, while 119 (26.9%) have died during rehabilitation. Public releases, involving children and local communities, serve as educational opportunities. Seven turtles (1.6%) with severe impairments (e.g., missing flippers, blindness), remain in captivity, playing a key role in raising public awareness about the challenges faced by sea turtles (Feck & Hamann, 2013).

KEY THREATS AND CONSERVATION RECOMMENDATIONS

Some threats severely limit survival, while others can be mitigated with early intervention. Vessel strikes (<15% survival) represent the most critical threat, underlying a critical issue: some injuries result in immediate mortality or are so severe that they prevent any possibility of rehabilitation. Preventive measures, including speed regulations in turtle habitats, are therefore crucial. Additionally, fishing-related threats also pose significant risks. Entanglement in ghost nets or fishing lines necessitates removal efforts and awareness campaigns involving fishermen. While bycatch remains the primary cause of turtle admissions, two decades of collaboration with fishermen have led to improved handling practices by longliners, which are considered crucial for mitigating sea turtle mortality (Parga, 2012). Lastly, although rare, cases of illegal take (1.7%) require continuous monitoring and enforcement.

Systematic data collection by care centres provides valuable complementary insights for research and conservation strategies. Thus, Kelonia collaborates with key stakeholders, including local authorities, scientists, fishermen, and the public, to implement various initiatives such as regulatory measures, long-term partnerships, habitat protection, citizen science, and public outreach. Together, these initiatives support a dynamic and adaptive approach to sea turtle conservation.

CONCLUSION

The findings highlight the severe threats faced by sea turtles at Reunion Island, with vessel strikes emerging as the most lethal. Survival outcomes depend on the nature of the threat, rescue efficiency, and species-specific characteristics. While hook ingestion cases demonstrate the best outcomes with prompt care, debilitation and entanglement remain persistent challenges. A holistic conservation strategy integrating preventive measures, public awareness, and specialised care -data-driven approaches, skilled personnel, and sustained investment- is essential for mitigating threats, improving survival rates and ensuring the long-term preservation of sea turtle populations in the region.

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