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Collaborative approaches to monitor and reduce sea turtle bycatch mortality in the French longline fisheries in the SWIO: latest data and insights

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ABSTRACT

This document presents the latest results on sea turtle bycatch in the French longline fisheries operating from Réunion Island in the Southwest Indian Ocean (SWIO). Longline bycatch is a recognised conservation concern in the region, and the Réunion fleet provides one of the few long-term datasets available for regional assessment. Data were compiled from complementary sources and integrated within the SaveTurtleRun (STR) framework: Kelonia Care Centre admissions (2000–2024), IRD/Ob7 observer and self-reporting programmes (2009–2023), IOTC fishing-effort datasets, and STR field records. Together, these sources document 845 bycatch events over 24 years. Loggerhead turtles (*Caretta caretta*) were the most affected species, followed by green (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), and leatherback (*Dermochelys coriacea*) turtles.

Since 2000, fishermen have become increasingly engaged in monitoring and mitigation, with 81% of captains now participating. Their contributions include reporting bycatch, bringing turtles to the care centre, releasing them alive at sea, and providing data on fishing practices (hook type, bait, GPS coordinates). In 2024 alone, among 86 bycaught turtles, 42% were released alive at sea, 40% were landed alive at Kelonia, and only 18% arrived dead for necropsy.

For turtles admitted to rehabilitation (N=420), survival rates varied by species but increased significantly, rising from about 45% in the early 2000s to more than 70% in recent years. This improvement reflects the impact of training, awareness, and safe handling protocols developed in partnership with fishermen.

The work carried out also enabled the collection of genetic samples, telemetry data, and necropsy findings (e.g. plastic ingestion), enhancing scientific understanding of turtle ecology and threats. Overall, the results confirm that longline fisheries remain a source of mortality for sea turtles but demonstrate that collaborative approaches with fishermen can reduce impacts, improve survival, and strengthen the evidence base for conservation and management.

INTRODUCTION

Bycatch of marine turtles in pelagic longline fisheries is a major conservation concern in the Indian Ocean (Lewison et al., 2014). Five species are regularly affected, including loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*), green (*Chelonia mydas*), and hawksbill (*Eretmochelys imbricata*) turtles. All listed on the IUCN Red List. Interactions with longline gear result in direct mortality (e.g., drowning) or indirect impacts (stress, injury, post-release mortality), undermining conservation efforts at both local and regional scales (Wallace et al., 2010).

The Indian Ocean Tuna Commission (IOTC) has adopted resolutions calling on Members and Cooperating Parties to improve bycatch monitoring and implement mitigation measures. However, reliable datasets remain scarce, especially in the southwest Indian Ocean (SWIO). Long-term information on turtle bycatch has been collected through the French longline fleet based in Réunion Island, contributing to regional knowledge.

In 2022, the Interprofessional Association of Fisheries and Aquaculture of Réunion (ARIPA) obtained Marine Stewardship Council (MSC) certification for its swordfish fishery. Building on two decades of collaboration between fishermen and scientists, and supported by the MSC

Science and Research Fund, the SaveTurtleRun (STR) two-year project was launched in 2023 as a multi-partner initiative involving Kelonia, ARIPA, CITEB, and the Fisheries Committee of Réunion. STR pursues four goals: (i) strengthen collaboration with fishermen, (ii) collect technical data on turtle bycatch, (iii) study environmental drivers and model turtle occurrence in fishing zones, and (iv) develop a guide of good practices for professional and recreational fisheries.

By integrating science, management, and fishing practices, STR aims to provide robust data and practical solutions to inform conservation and support decision-making in the SWIO.

MATERIALS AND METHODS

Data used in this study combined several complementary sources. Fishing effort statistics were obtained from the Indian Ocean Tuna Commission (IOTC) for 2009–2023, filtered to include only the EUREU fleet (Réunion-based longliners) and provided at a 1° × 1° spatial resolution. These data were used to describe the distribution of fishing effort and contextualise bycatch information.

Bycatch and fishing effort data were also provided by IRD through the *Observatoire des écosystèmes pélagiques tropicaux exploités* (Ob7) programme, implemented locally by CITEB. This programme included on-board observers and voluntary self-reporting by fishermen. Observer trips collected detailed information on fishing practices and turtle interactions, while captains reported data through standardised log sheets including species identification, condition at retrieval (alive or dead), release status, gear type, bait, hook size, and capture position. Temperature and Depth Recorders (TDRs) were also distributed to characterise gear behaviour and environmental conditions. For consistency, only data from 2009–2023 were retained.

Moreover, long-term data from the Kelonia Care Centre (2000–2024) were incorporated, filtered to retain only turtles incidentally caught by longliners. At admission, information such as species, size, capture position, hook type and clinical condition was recorded. Additional data on survival and health were collected during rehabilitation, along with biological samples (e.g., genetics, physiology).

Additional records were collected between October 2023 and December 2024 under the SaveTurtleRun project, covering both observer and self-reporting data. Each record included turtle species, morphometrics, condition, fate (released, landed alive, or dead), and fishing practices. Awareness sessions improved reporting accuracy.

Finally, to explore potential drivers of turtle bycatch, fishing and capture records were matched with twelve environmental variables considered ecologically relevant: sea surface temperature (SST) and SST gradient, mixed layer depth, salinity, eddy kinetic energy, bathymetry, distance to coast, distance to seamounts, sea surface height anomaly, primary production, zooplankton biomass, and micronekton biomass. These variables were extracted from global oceanographic datasets at the corresponding spatial and temporal resolution and linked to fishing effort and turtle interaction data to investigate environmental conditions potentially influencing bycatch rates.

RESULTS AND DISCUSSION

Fishing effort and incidental capture of sea turtles

Between 2009 and 2025, 702 valid records of incidental sea turtle captures were compiled (Fig. 1with loggerheads (*Caretta caretta*) representing about 70% of the total. Other species were reported in smaller proportions: green turtles (~10%), leatherbacks (~7%), olive ridleys (<7%), while hawksbills were rarely encountered, with only 17 individuals recorded over the entire period.

Spatial patterns of bycatch largely reflected fishing effort distribution. Mapping of IRD/Ob7 data against IOTC longline effort (Fig. 2) shows that loggerhead interactions were concentrated in pelagic waters between 19°S and 25°S, particularly in the zone between Madagascar and Réunion Island. Green turtle captures were more frequent along the east coast of Madagascar, consistent with the presence of multiple nesting sites for this species in the area.

Temporal distribution

Turtle bycatch exhibited a clear seasonal pattern, with most interactions occurring during the austral winter (May–August) and a consistent peak in July (Fig. 3). Interannual fluctuations were observed, but no overall increasing trend was detected, suggesting stable interaction levels despite variability in fishing effort.

Bycatch per unit effort (CPUE)

Catch per unit effort from the IRD/Ob7 datasets, expressed as the number of turtles per 1,000 hooks, provides an additional perspective on interaction levels. Based on nearly seven million hooks monitored by observers, the average CPUE was 0.049 turtles per 1,000 hooks, equivalent to one capture for approximately every 20,450 hooks deployed. No clear correlation was detected between declared fishing effort and the number of incidental captures (Fig. 4), suggesting that other factors, such as environmental conditions or turtle migratory behaviour, are more likely to drive the seasonal variations observed.

Size classes

Loggerhead and olive ridley turtles were predominantly juveniles or subadults, with curved carapace lengths generally between 65 and 75 cm (Fig. 5). Green turtles were mostly smaller juveniles, while leatherbacks were larger individuals but less frequently captured. This confirms the role of the southwest Indian Ocean as an important developmental area, particularly for loggerheads.

Mortality and survival

Based on IRD/Ob7 data for 2009–2023, a total of 301 sea turtles were recorded, of which 75.8% were released alive. For loggerhead turtles admitted to Kelonia after incidental capture (N = 371), survival rates improved significantly over time, increasing from around 50% in the early 2000s to over 80% for loggerheads in the last five years. Across all four species (green, loggerhead, leatherback, and olive ridley), the overall survival rate was 66% (n= 427).

Average time spent on board before arrival at Kelonia was 2.9 ± 2.7 days (N = 168), and survival probability decreased significantly with longer periods on board ($\chi^2 = 14.919$, $p = 0.0049$). Survival also varied strongly by species: loggerheads had the highest survival rate (72%, N = 248), nearly three times higher than that of green turtles (26%, N = 13) or olive ridleys (22%, N = 33). For loggerheads, survivors were significantly larger and heavier than those that died, indicating that body size and condition are important predictors of post-capture survival.

This decline in mortality reflects fishermen's growing involvement and the adoption of improved handling and release practices, and the role of better-trained carers and veterinary protocols, which have contributed to higher survival rates.

Environmental parameters
Modelling of loggerhead (*Caretta caretta*) presence highlighted several significant associations with environmental conditions. Higher sea surface temperature reduced the probability of presence, while a thicker mixed layer and higher surface salinity increased it. In contrast, high values of net primary production, zooplankton biomass, epipelagic micronekton, and eddy kinetic energy were associated with lower probabilities of occurrence. A marginal effect was observed with distance to seamounts, with turtles slightly less frequent farther away. No significant relationship was detected with SST gradient, bathymetry, distance to the coast, or sea level anomaly.

Provenance and limitations of data
The annual distribution of marine turtle bycatch records between 2009 and 2025 shows that, prior to 2023, most data originated from IRD and the Kelonia Care Centre (CDS) (Fig. 6), while since the launch of the SaveTurtleRun (STR) project, new observations have significantly enriched the database, accounting for more than 50% of additional records in 2024. However, 20 turtles admitted to the Care Centre in 2024 were not included in the STR database, highlighting gaps in reporting or traceability between sources.

These three datasets present contextual disparities. IRD/Ob7 covered about 13% of the total fishing effort in the region, while CDS records concern only turtles voluntarily brought to the centre by fishermen (excluding leatherbacks), with no trace of those released directly at sea. STR data were designed to be more exhaustive, but currently cover a short period (2023–2024), limiting multi-year analysis. The absence of overlap between the three datasets suggests under-reporting and inconsistencies in data transfer despite their common origin.

CONCLUSION

The analysis of turtle bycatch in Réunion's longline fisheries confirms that loggerheads (*Caretta caretta*) are by far the most affected species, accounting for around 70% of all records between 2009 and 2025. This dominance is consistent with their distribution and ecology in the southwest Indian Ocean, where oceanic waters serve as important developmental habitats for juveniles, as previously highlighted by Dalleau et al. (2016). Other species—green, olive ridley, leatherback, and hawksbill turtles—were recorded in lower proportions.

Temporal analysis showed strong seasonality, particularly for loggerheads, with peaks in austral winter. No direct correlation was detected between fishing effort and bycatch levels, suggesting that environmental drivers and turtle migratory behaviour play a stronger role.

The combination of observer data, self-reporting, and care centre records provided one of the most robust long-term datasets for the region. Fishermen's active involvement increased reporting coverage and facilitated live returns to Kelonia, where rehabilitation, sampling, and post-release monitoring enriched scientific knowledge. Survival outcomes improved significantly, reflecting the impact of training, awareness, and better handling practices, though the adoption of IOTC-recommended mitigation tools (circle hooks, line cutters, de-hookers) still requires reinforcement.

From a governance perspective, the Réunion dataset represents a rare long-term time series for the SWIO, making it valuable for assessments and for guiding regional management. While environmental analyses remain preliminary, they highlight promising avenues for targeted mitigation. Overall, STR project demonstrated that collaborative approaches with fishermen are both feasible and effective, delivering tangible conservation benefits while strengthening the scientific basis for sea turtle management in the Indian Ocean.

FIGURES

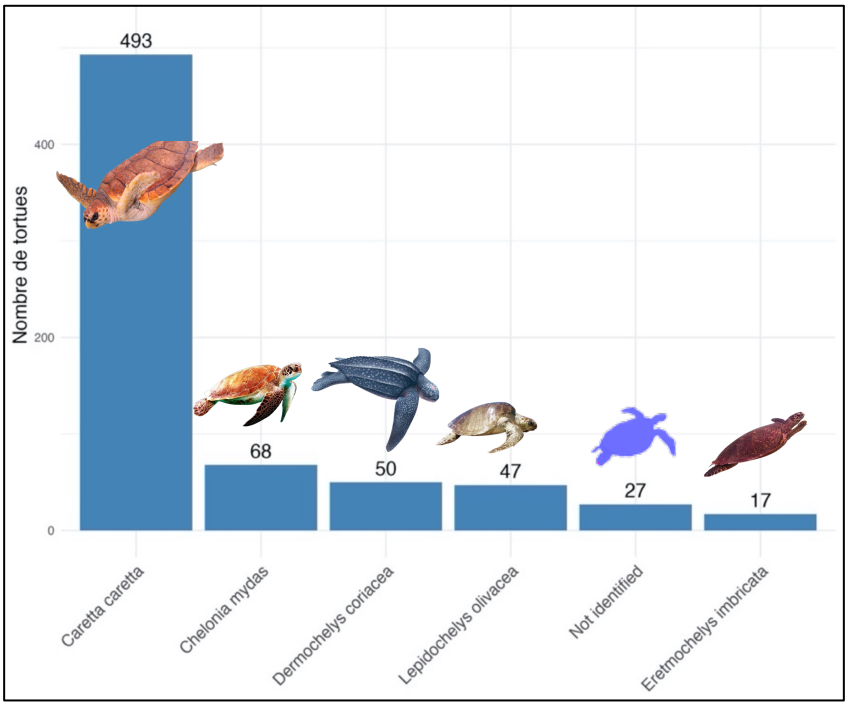

Figure 1: Number of turtles caught by species over the period 2009-2025 (IRD/Ob7-STR-CDS data; n=702)

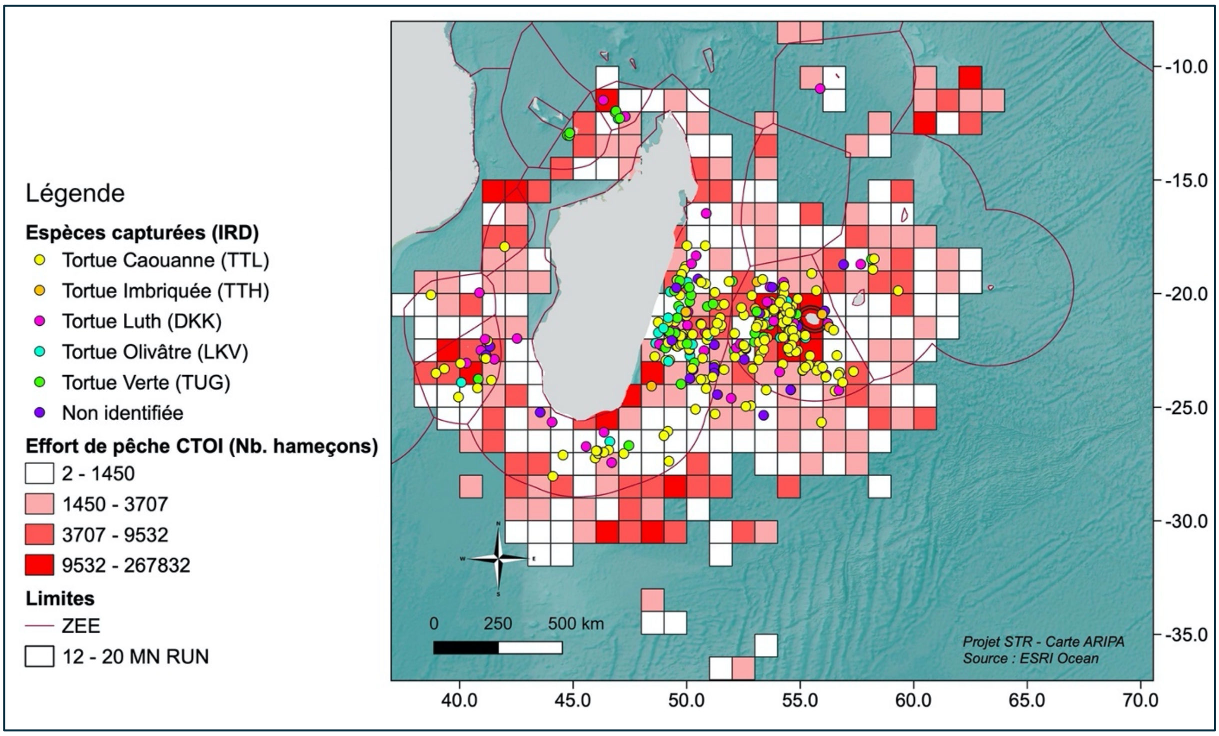

Figure 2: Sea turtle bycatch (IRD/Ob7 data) on IOTC fishing effort for the period 2009–2023

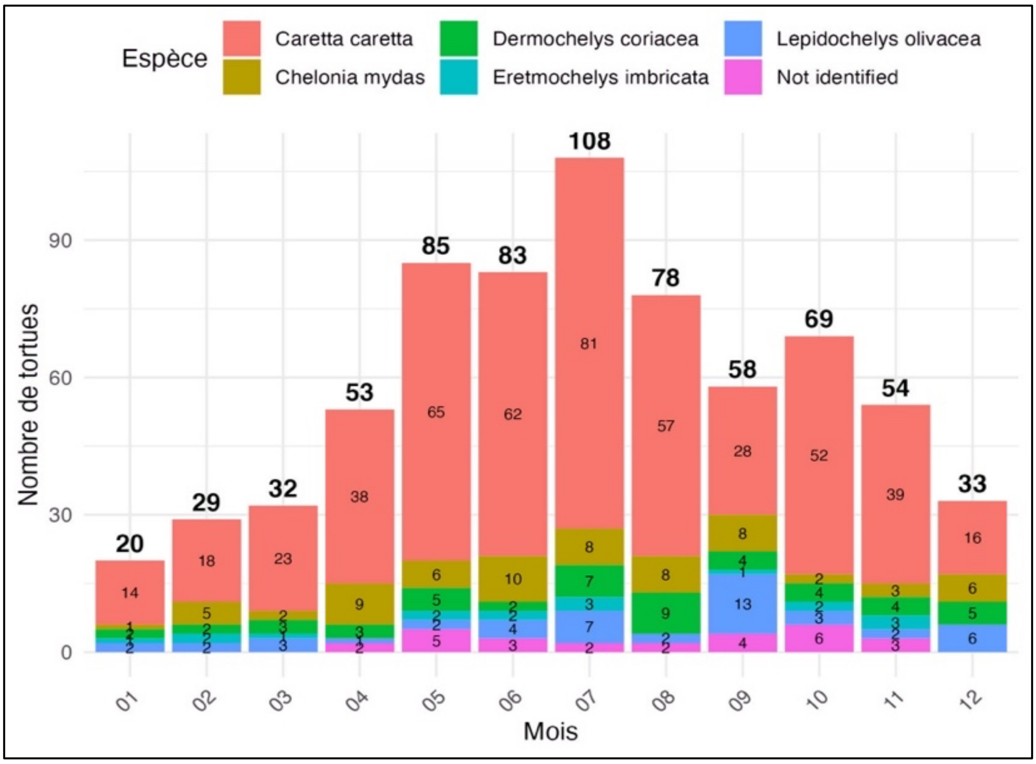

Figure 3: Number of turtles caught by species and month between 2009 and 2025 (IRD/Ob7-STR-CDS data)

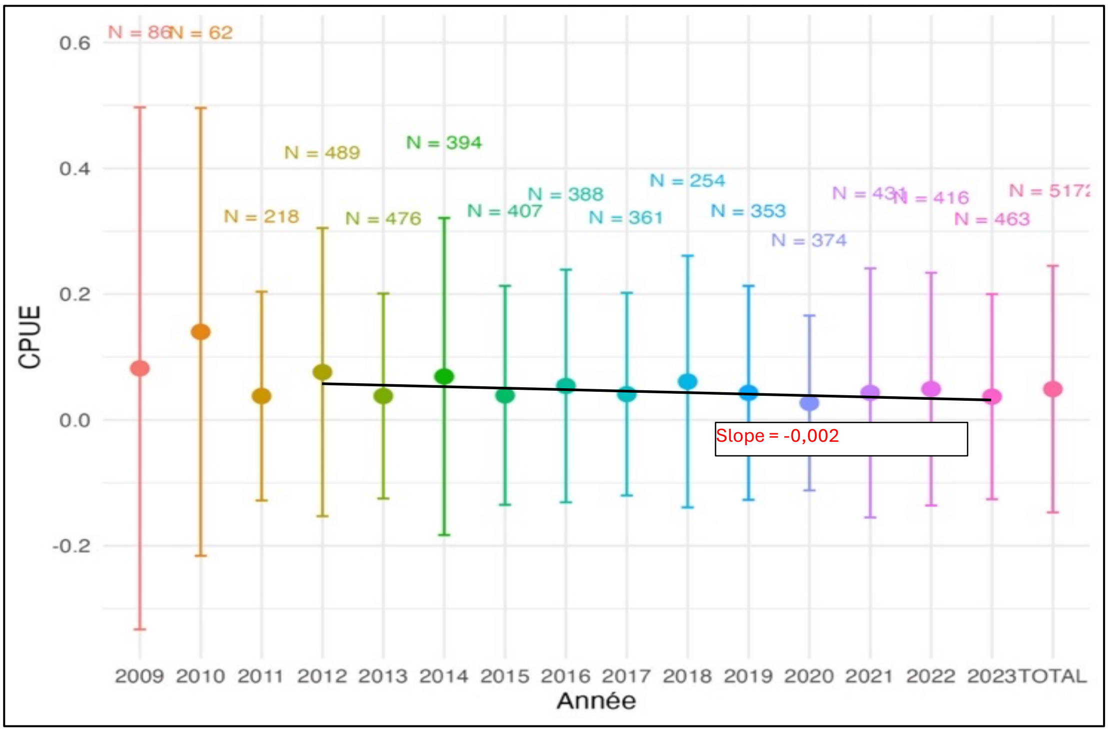

Figure 4: Mean catch rate per unit effort (CPUE) (IRD data). (a) Cumulative time series by year with standard deviation (measuring the dispersion of individual observations) and trend line. The data do not follow a normal distribution (Shapiro test, pvalue < 0.05) and, despite the visual impression of the trend line, show no significant difference between them (Kruskal-Wallis, pvalue > 0.05).

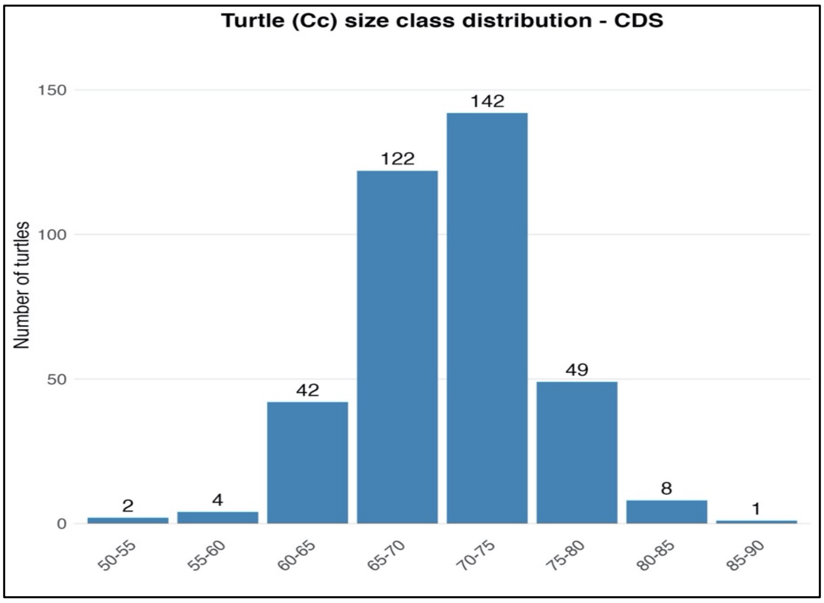

Figure 5: Turtle size distribution (n=370) over the period 2010-2024 (CDS data).

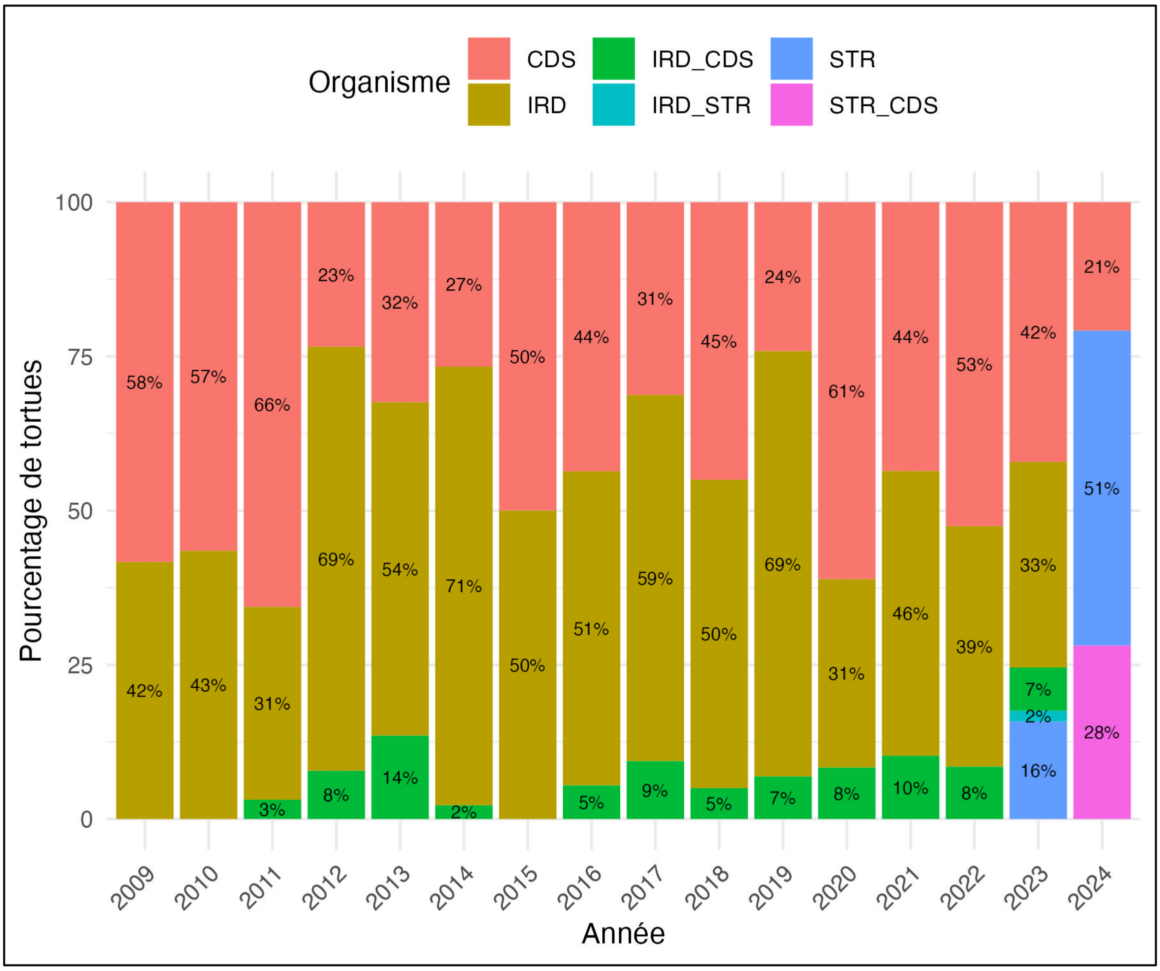

Figure 6: Percentage of turtles caught per data origin and per year between 2009 and 2024 (IRD-STR-CDS data)