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Investigating Sea Turtle Bycatch in Southern Cambodia

AMY L. JONES^{1,*}, RACHANA THAP¹, SAMNANG RY¹, VICHITH KONG¹, VEASNA NGET¹,
TANGUY FRENEAT¹, AND GILLIAN M. NOTMAN²

¹Marine Conservation Cambodia, Koh Ach Seh, Kep, 22101 Cambodia [amylaurajones1@gmail.com; thaprachana12@gmail.com; seahorseconservation@gmail.com; tanguy.freneat@gmail.com];

²University of Cumbria, Rydal Road, Ambleside, LA22 9BB, United Kingdom [gill.notman@cumbria.ac.uk]

*Corresponding author

ABSTRACT. – Preliminary bycatch reports from Kep and Kampot, Cambodia, confirm the presence of green turtles (*Chelonia mydas*) and highlight bycatch as a result of illegal, unregulated, and unreported bottom trawling as the most pertinent, perennial threat. Recommendations for conservation action emphasize the importance of a community-based approach, engagement, and education alongside continued extensive research, improved enforcement of current fisheries legislation, potential modification of fishing gear, and the development of Cambodian-led conservation initiatives to promote authentic environmental custodianship.

KEY WORDS. – bycatch; Cambodia; fisheries; green turtle; threats

Bycatch and habitat degradation are among the most pervasive anthropogenic threats to sea turtles globally, alongside coastal development, pollution, and climate change (National Research Council 1990; Diamond et al. 2012; Konsta et al. 2022). Bycatch rates of vulnerable marine megafauna including sea turtles, marine mammals, and sea birds have seen an increase in line with intensifying fishing efforts worldwide (Senko et al. 2014; Clay et al. 2019; Tolloch et al. 2020).

Global concern about declining sea turtle populations and increasing bycatch rates has driven some developed countries to impose more stringent fishing regulations, catch quotas, and modification of fishing gears such as the use of turtle excluder devices in trawl fisheries to mitigate against the impacts of bycatch (Squires and Garcia 2018). However, less economically developed countries in Southeast Asia such as Cambodia, Malaysia, Thailand, and Vietnam have not yet widely imposed similar mitigation strategies; bottom trawling, gillnetting, and long-line fisheries still pose serious risks to turtles (National Research Council 1990; Gilman et al. 2010; Diamond et al. 2012; Vong et al. 2018).

Sea turtles are listed under CITES Appendix I and the Convention of Migratory Species Indian Ocean South East Asian Marine Turtle Memorandum of Understanding, which aims to “protect, conserve and recover sea turtles and their habitat in the Indian Ocean and Southeast Asia”. The Sea Turtle National Action Plan for Cambodia (2016–2026) also aims to protect sea turtles and threatened habitats, in addition to working to reduce anthropogenic mortality. Within Cambodia, Marine Fisheries Management Areas (MFMA; marine protected areas) have been designated in Koh Rong (est. 2016) and Kep (est. 2018) to protect and restore coastal habitats and resources.

Published research regarding Cambodia’s sea turtle populations, particularly on abundance, distribution, and population trends, is scarce. Previously, social science methods have been employed within local fishing communities to gather information on occurrence of sea turtles, perceptions of fishers, and traditional practices relating to sea turtles and their capture (Try 1999; Longdy 2002; Diamond et al. 2012). Past research has identified Kep, Kampot, Koh Kong, and Preah Sihanouk as important sea turtle habitats (Try 1999; Longdy 2002). Recent provincial consultations in 2015 also highlighted the Kep and Kampot region as a hotspot for bycatch and intentional captures, potentially influenced by proximity to the Vietnamese maritime border, an area where trade in live turtles and turtle meat is reportedly widespread (Duffy et al. 2023).

This exploratory short note aims to contribute toward area-specific knowledge gaps and to more extensive, ongoing conservation and research efforts within the country. Here the incidences of sea turtle bycatch are investigated from southern Cambodia from October 2021 to October 2022.

METHODS

Study Area. — Cambodia’s coastline stretches along the northeastern edge of the Gulf of Thailand (Fig. 1A), a shallow inlet in the South China Sea. Here we report on data collected from Cambodia’s Kep and Kampot provinces (Fig. 1B), which include 27 km and 45 km of Cambodia’s 443-km coastline, respectively. The nearshore water along this 72-km stretch of coastline is shallow, with a maximum depth of 12 m in Kep and 20 m in Kampot, and provides a variety of ideal sea turtle habitats

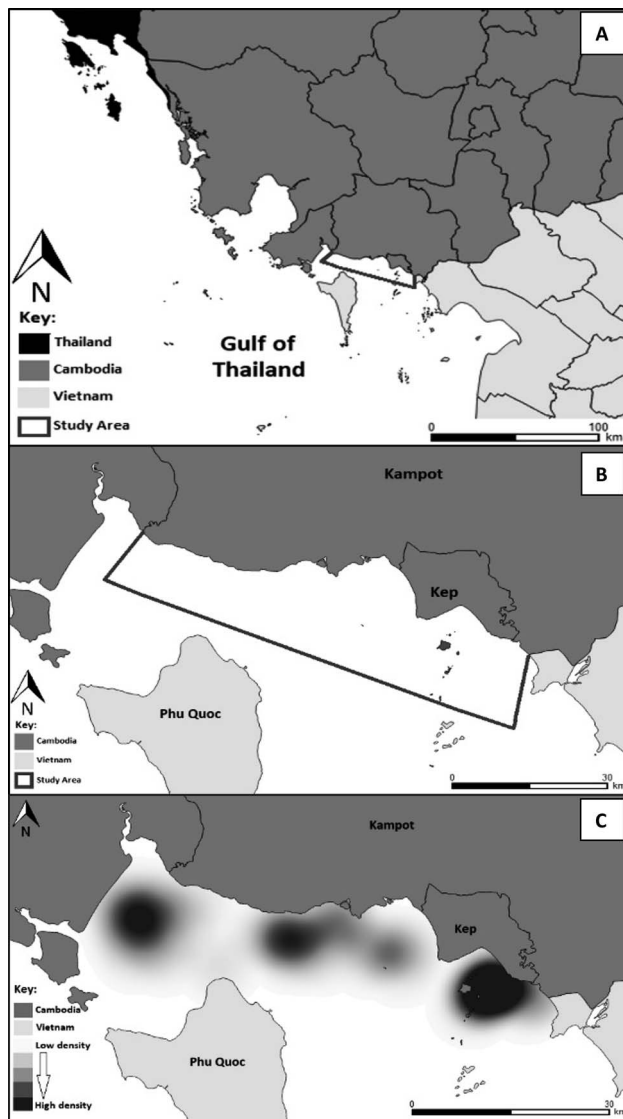


Figure 1. (A) Map of the Gulf of Thailand providing geographical context to the study area (highlighted in red). (B) The study area (outlined) covering Kep and Kampot provincial waters and extending to the furthest island of the Kep Archipelago, Koh Ach Seh. (C) Density map displaying approximate locations of green turtle bycatch incidences in Kep and Kampot, Cambodia.

including seagrass meadows, coral reefs, and mangrove forests (Reid et al. 2019). The northern coastal provinces, Koh Kong and Sihanoukville, have previously been identified as important nesting sites for sea turtles, notably green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) (Longdy 2002; Fauna & Flora International 2011; Duffy et al. 2023). Historically, Koh Tonsai in the Kep Archipelago has been identified as a hawksbill turtle nesting ground (Longdy 2002; Try 2002). However, more recent nesting surveys suggest this is no longer the case (Duffy et al. 2023).

Data Collection and Analysis. — Sea turtle bycatch data were recorded by the nongovernmental organization Marine Conservation Cambodia (MCC), from 25 October

2021 to 25 October 2022. Bycatch events were reported to MCC by telephone or through social media either by independent fishers or by community leaders within Kep and Kampot provinces. Surveyors recorded the species, weight, curved carapace length, estimated location of bycatch, vessel type (trawler: a vessel > 5 m long with an inboard engine used to drag or pull a trawled net; electric trawler: similar to trawler with an electric current running through the net fibers; longtail: a traditional wooden vessel < 5 m long with an outboard engine, commonly used to deploy small-scale fishing equipment) and fishing gear (trawled net, electrified trawled net, gillnet, longline, unspecified net). Curved carapace length (CCL) was measured to the nearest 0.5 cm using a flexible tape measure. CCL was used as a proxy indicator to estimate approximate sexual maturity (adults, subadults, and juveniles). Based on previous carapace measurements (CCL) from neighboring Thailand, adults ≥ 75 cm, subadults = 40–75 cm, and juveniles ≤ 40 cm (Penyapol 1958; Hirth 1997). Where possible, turtles were tagged on the trailing edge of one fore-flipper with a uniquely coded Inconel identification tag (Style: 681IC, National Band and Tag Company, Newport, United States) and released directly back into the water.

A chi-square (χ^2) was used to test the statistical significance of seasonality data. Significance was tested at an alpha value of 0.05, F_{11} . To standardize calculations, sample mean (\bar{X}) of turtle bycatch per season was calculated as the number of months per season and ranged from 2 to 5 months. Seasons were categorized as post-monsoon (October to November), dry (December to February), premonsoon (March to April), and monsoon (May to September) according to regional rainfall characteristics and local circulation (Tsumimoto et al. 2018). A chi-square was also used to test the significance of fishing gear reported. Significance was tested at an alpha value of 0.05, F_4 .

Maps were created using QGIS 2.8.5 and kernel density estimation (QGIS Documentation 2023). To create the density heatmap (Fig. 1C), estimated bycatch locations were reported by fishers and given a 1-km radius. These locations were uploaded as point data to QGIS. A raster heatmap used these point data to create a secondary layer with a radius of 7000 layer units and a quartic (biweight) kernel shape. The point data were then removed to give clarity to the density-weighted heatmap layer.

RESULTS

Between October 2021 and October 2022, a total of 69 bycaught sea turtles was recorded (Fig. 2), with turtles ranging in CCL from 41 cm to 87 cm ($\bar{X} = 51.4$, $SD = 10.9$, $n = 56$, Fig. 3). Sea turtle bycatch data were recorded primarily from the waters adjacent to Kep and Kampot, with 2 reports from Vietnamese waters adjacent to northern Phu Quoc (Fig. 1C).

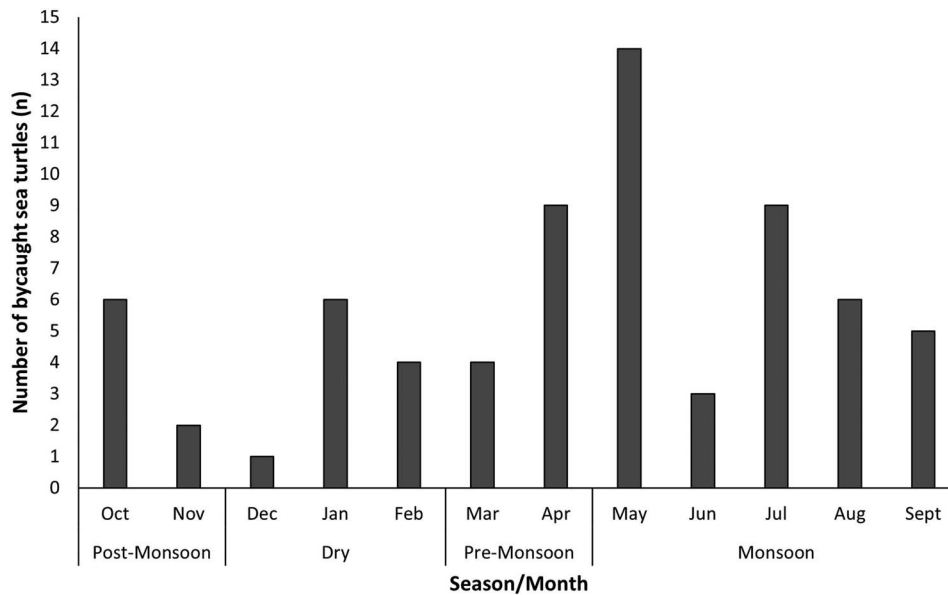


Figure 2. Seasonality of green turtle bycatch in Kep and Kampot, Cambodia. Seasons categorized according to rainfall (Tsumimoto et al. 2018).

All bycaught individuals were identified as green turtles. Of the 69 turtles bycaught, 1 was found dead in an electrified bottom-trawling net; the remaining 68 were discovered and released alive. Based on CCL measurements, 4 individuals were classified as adult. The remaining 65 individuals were categorized as subadults. None were juveniles. The dead turtle was a subadult. Of those tagged and released alive ($n = 58$), 4 turtles were recaptured, and 1 turtle was caught 3 times. Of those recaught ($n = 4$), all 4 were by the same methods of fishing (trawled net and electrified trawled net) and within the same area (within ca. 10 km radius). The minimum time between recapture was 2 days, whereas the maximum time was 59 days.

Bycaught sea turtles were reported to MCC every month of the year (Fig. 2). Incidences were most commonly reported in May ($n = 14$) and least commonly reported in December ($n = 1$). A chi-square (χ^2) test found that there was a significant seasonal difference in

turtle bycatch ($\chi^2 = 24.39$; $CV = 19.68$; $p \leq 0.05$), with significantly more turtles bycaught during the monsoon season ($n = 37$; $\bar{X} = 7.4$) than postmonsoon ($n = 8$; $\bar{X} = 4.0$), dry ($n = 11$; $\bar{X} = 3.7$) and premonsoon season ($n = 13$; $\bar{X} = 2.6$).

An analysis of vessel type and fishing gear found that 52% of bycaught turtles were caught by trawling vessels and in trawled nets. Electrified trawled nets were the second-most common gear type to bycatch turtles (22%), with gillnets, longline, and unspecified nets bycaught at similar levels (10%, 7%, and 7%, respectively). Anecdotal evidence from Kep's marine harvesting network suggests that trawling vessels accounted for 30%–45% of the vessel activity within the region. Data collected between 2018 and 2019 found that 84% of trawling vessels were actively trawling (deployed outriggers/booms), while 16% were transiting through the region (outrigger/booms stowed; Bohm 2019). Traditional long-tails and subsistence fishing practices including crab boxes, casting

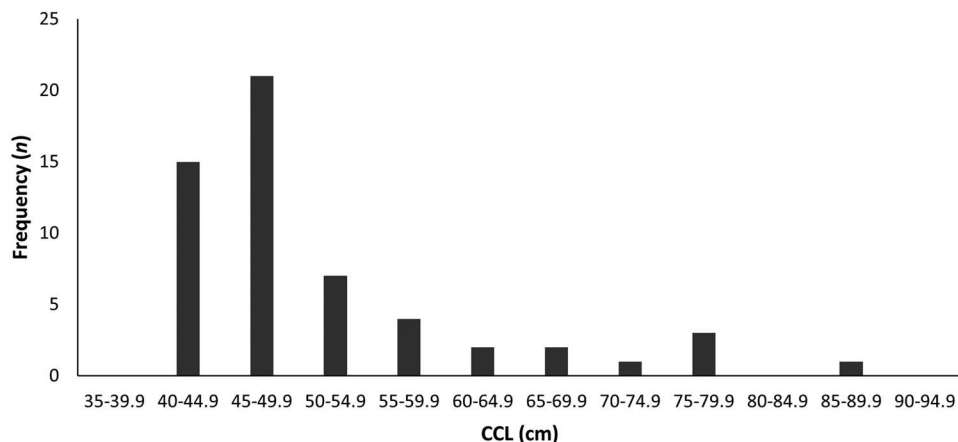


Figure 3. Curved carapace length (CCL; $n = 59$) of bycaught green turtles in Kep and Kampot, Cambodia.

nets, and line fishing accounted for approximately half of the fishing effort within the Kep region (Bohm 2019). This study found that none of these traditional fishing practices were responsible for sea turtle bycatch, despite accounting for more than half of the fishing effort within the region.

Bycatch hotspots appear at 4 key locations, 1 in the northeast of the Kep Archipelago and 3 along the Kampot coastline (Fig. 1C). While outside of the provincial waters of Kep and Kampot, 2 turtles were bycaught to the north of Phu Quoc, extending the range outside of Cambodian territorial waters; although the true levels from Vietnamese waters are likely to be underestimated for this study given that the data collection targeted only southern Cambodian fishing communities.

DISCUSSION

While this paper contains the first-ever quantitative sea turtle bycatch data for the southern Cambodian region and confirm the continued presence of green turtles in these waters, the data are spatially and temporally limited and may therefore be anomalous, inaccurate, or unrepresentative. Long-term and wide-reaching sea turtle datasets must be collected to corroborate the findings within.

These data suggest that Kep and Kampot provide important seagrass habitat and foraging grounds for green turtles, and that Kep and Kampot may also highlight an overlap in ecological and anthropogenic area use, increasing the likelihood of interactions between sea turtles and fisheries resulting in bycatch; this concurs with approximate bycatch data reported within (Fig. 1C), and recent turtle sightings data reported by Duffy et al. (2023). The prevalence of bycatch events during monsoon season could be explained by green turtle dietary preferences and the seasonally enhanced input of nutrients from nearby riverine systems such as the Giang River and Kampot River during flooding events. Spatial and temporal fluctuations in fishing efforts have not been locally quantified; however, fishing effort typically increases after deluges and during favorable fishing conditions. While interesting to speculate, these patterns should be considered with caution due to this spatially limited and time-restricted data set. More extensive, long-term research is being conducted by Fauna and Flora International and MCC to provide more reliable data.

Along the Kep and Kampot coastline multiple fisheries were implicated in the bycatch, with illegal bottom-trawling vessels accounting for more than 70% of reported turtle bycatch incidences despite accounting for less than half of the fishing effort within the region (Bohm 2019), highlighting bottom trawling as the most impactful practice. Elsewhere reducing the tow duration of trawled nets has also been shown to reduce rates of turtle bycatch (Casale et al. 2017) and increase survival rates (Oravetz 1999). Although this is difficult to police and directly impacts commercial catch rates (Lucchetti et al.

2019) and may therefore reduce compliance amongst fishers. Within legal trawling fisheries, the implementation of bycatch reduction devices (BRDs) and turtle excluder devices (TEDs) has proven successful in Australian, European, and North American fisheries (Brewer et al. 2006; Cox et al. 2007; Lucchetti et al. 2016). With financial aid and local innovative thinking, similar bycatch mitigation devices could be used within Southeast Asian fisheries.

Our data also highlight that most trawling activity took place within the provincial waters of Kep and Kampot, which do not exceed 20 m depth (Fig. 1A and 1B). Trawling in waters shallower than 20 m is illegal under Article 49 of the Cambodian fisheries law. Similarly, electric fishing gear, which accounted for 22% of the reported turtle bycatch, is also illegal under Article 20 and is punishable by imprisonment and fines. Despite this, both shallow bottom trawling and electric trawling are consistent and widespread year-round within the Kep and Kampot region (Bohm 2019; R. Thap *pers. comm.* 2022), highlighting an urgent need for improved fisheries law education and enforcement by local fisheries administrations and overseen by the Ministry of Agriculture, Forestry and Fisheries (MAFF).

Conclusions and Recommendations. — Initial limited findings suggest trawled nets and illegal, unreported, and unregulated fishing as a key threat to regional populations. These results concur with previous social science research regarding the status of sea turtles within the region and offer empirical evidence to support the anecdotal statements made by fishers during recent provincial consultations (Duffy et al. 2023). These data, alongside previous research on local sea turtle species and their habitat use, confirm the Kep and Kampot region of Cambodia as an important area for green turtles (Longdy 2002; Sereywath and Sokhannaro 2003; Duffy et al. 2023).

The reported presence of green turtles in Cambodian waters, despite decades of increasing anthropogenic threat, is encouraging. However, this also highlights the need for continued extensive research and protection of nesting females and coastal-dwelling turtles in Cambodia (Fauna & Flora International 2011; Duffy et al. 2023). This can be achieved by improving bycatch reporting, compliance with existing legislation, roll-out of bycatch reduction technology, knowledge exchange between fishing communities, conservation practitioners and law enforcement, and continued long-term data collection. Implementation of these strategies can protect against further decline of green turtles and allow Cambodian coastal communities to be the true informed custodians of their marine environment.

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