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Cover: *Minervarya cepfi* & *Nyctibatrachus petraeus*—mix media. © P Kritika

INTRODUCTION

Marine bycatch refers to the incidental death and debilitation of marine life that is not within the legal remit of regulated fisheries (Davies et al. 2009). Marine bycatch of non-target fauna and their consequent entanglements lead to unnecessary mortality (Salagrama 1998; Mahesh et al. 2017, 2019). This problem is poorly studied for Indian coastal fisheries (Dineshbabu et al. 2022), especially those involving deep-sea trawling (Dineshbabu et al. 2010, 2012, 2014). Depletion of marine biodiversity is a widespread anthropogenic threat (Kumar & Deepthi 2006; Velip & Rivonker 2015; Madhu et al. 2017), and studies aimed at finding solutions are sparse (Azeez et al. 2021). Commercialisation and non-human consumption of bycatch are reported to be directly incentivising intensive fishing (Lobo et al. 2010; Aulia et al. 2024).

Sea snakes are commonly encountered air-breathing fauna that drown in submerged nets cast for fishing operations (Dsouza et al. 2021; Rao et al. 2021; Jana et al. 2024; Ganesh et al. 2026). The Indian coastline is home to 20 species of front-fanged, marine elapid snakes of the subfamilies Hydrophiinae, the true sea snakes, and Laticaudinae, the sea kraits (Ganesh et al. 2019). Sea snakes are not target species of fisheries as they are neither suitable for human consumption nor for poultry feed, hence snake bycatch is typically discarded. Sea snake bycatch is not well-studied in general, and little is known about this issue on the western Indian coast (Kumar et al. 2007; Ibrahima et al. 2019; Patel et al. 2022, 2024). To this end, we studied the frequency of sea snake bycatch in Malabar Coast, southwestern India and conducted awareness drives in attempts to improve the situation.

MATERIALS AND METHODS

Study Area

The study was conducted on the Malabar coast of southwestern India, politically covering parts of Kerala and Karnataka state jurisdictions, with sampling sites extended across Chombala harbour (Kannur District, Kerala) to Malpe harbour (Udupi District, Karnataka), across a distance of about 230 km (Table 1; Image 1). Samplings were concentrated in eight harbours (south to north) namely: Chombala, Mahe, Thalassery, Kannur, Nileshwaram, Kasaragod, Mangalore, and Malpe harbours.

Field Surveys

From September 2024 to January 2025, for five months, field surveys were conducted on the Malabar Coast, southwestern India, focussing on sea snake bycatches. A total of 15 weeks of field surveys were conducted across all the eight harbours. One and a half to two weeks with 2–3 hours per day were spent on field surveys in each harbour, based on the spatial expanse of harbour, fishing intensity, fishermen visitations and boating frequencies. We networked with fishermen to source photos of sea snakes on board and to circulate local language (Malayalam, Kannada) posters depicting awareness messages on sea snakes. Sea snake species were identified from photographs received following Ganesh et al. (2019).

RESULTS

During this five month-survey, lasting for 15 weeks of field days in eight harbours, we interacted with 141 fishermen and shared posters on 47 occasions. We also obtained photographic records of sea snake bycatches amounting to a total of 22 sightings comprising three species namely: Short Sea Snake *Hydrophis curtus* (n = 17), Annulated Sea Snake *Hydrophis cyanocinctus* (n = 4), and Hook-nosed Sea Snake *Hydrophis schistosus* (n = 1). Details of the awareness and photographic data collection aspects are detailed in the following.

i. Sea snake bycatch (Table 2; Image 2)

From all the harbour visits and awareness drives on sea snake bycatch, we received photographic records of a total of 22 bycatch of sea snakes, both dead and alive, from two harbours namely Malpe and Mangalore, both in Karnataka. Based on the photographs received from the fishermen, it was found that *Hydrophis curtus* was the most dominant species here, commoner than both *Hydrophis cyanocinctus* and *Hydrophis schistosus*. There were no records of sea snake bycatches based on the photographs shared by the fishermen, from all the six harbours in Kerala. Only those in the two harbours in Karnataka, shared sea snake photos. Just 1 (*H. cyanocinctus*) photo record was from Mangalore while the remaining 21 were all from Malpe harbour. The fishermen we engaged with used seine nets, gill nets, and cast nets usually deployed for half a day at roughly 0.7 km depth. About one fifth of the snakes that got caught were alive, while the vast majority were dead, as seen in the photos shared and also stated by fishermen. In Malpe, a case of mass mortality, with 10 dead snakes

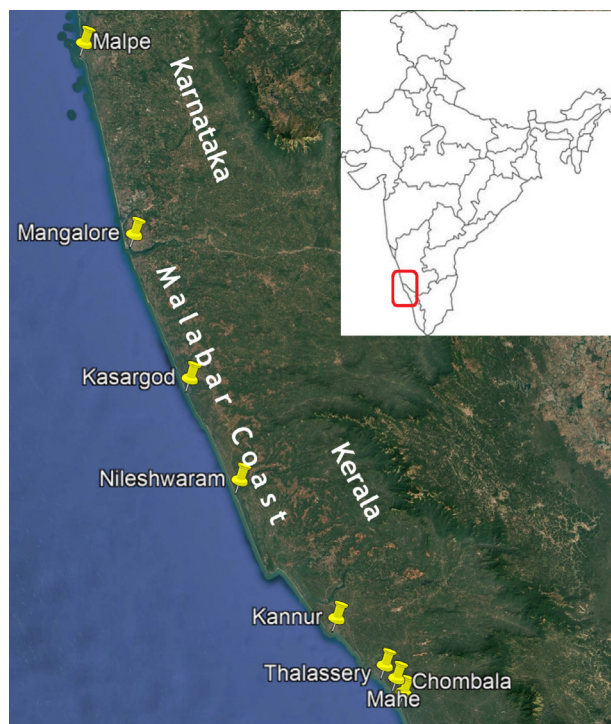


Image 1. Map of southwestern India showing the eight harbours sampled in Malabar Coast, with inset showing the sampled area within India (earmarked in red).

belonging to two species (*H. curtus*, *H. cyanocinctus*), was noted. The sea snakes caught in the bycatch all appeared to be adults, approaching 1 m in total length, as deduced from the photographs. To the best of our knowledge, no evident injuries could be seen on the snakes from the photographs.

ii. Awareness Events with Posters (Table 3)

During the interactions, many fishermen misidentified eels as sea snakes, especially the younger inexperienced people. They noted that they greatly benefited from the posters and photographs of the marine snakes shown during the discussions. Many fishermen were unaware of the toxic and venomous nature of sea snakes and their differences in appearance compared to other marine snakes like acrochordids and homalopsids, both of which have normal tapering cylindrical tails just like any other snake.

A total of 141 fishermen were interviewed and posters were shared with 47 fishermen across the different harbours. The number of fishermen interactions per harbour ranged from 6 (4.2%) in Kasargod harbour, to 49 (34.7%) in Thalassery harbour; and that of poster shares per harbour ranged from 2 (4.2%) in Kasargod to nine (19.1%) in Mangalore. There were differences in the maximum numbers of both the aspects studied. The

Table 1. Sampling sites of the eight harbours in Malabar Coast, Kerala and Karnataka, India.

Harbour name	District, State	Latitude °N	Longitude °E
Chombala	Kannur, Kerala	11.6658	75.5500
Mahe	Puducherry, Puducherry	11.7022	75.5311
Thalassery	Kannur, Kerala	11.7351	75.5006
Kannur	Kannur, Kerala	11.8574	75.3726
Nileschwaram	Kasargod, Kerala	12.2145	75.1160
Kasargod	Kasargod, Kerala	12.4772	74.9832
Mangalore	Dakshina Kannada, Karnataka	12.8508	74.8335
Malpe	Udupi, Karnataka	13.3482	74.6958

Table 2. Details of dead and live sea snakes recorded as bycatches in sites where seen.

Site/Snake species	<i>H. curtus</i>	<i>H. cyanocinctus</i>	<i>H. schistosus</i>
Mangalore live	0 (0%)	0 (0%)	0 (0%)
Mangalore dead	0 (0%)	1 (4.5%)	0 (0%)
Malpe live	4 (18.1%)	0 (0%)	0 (0%)
Malpe dead	13 (59.0%)	3 (13.6%)	1 (4.5%)

Table 3. Details of the fishermen interacted and posters shared in each site.

Harbours surveyed	No. of weeks surveyed	No. of fishermen interacted (in %)	No. of posters shared (in %)
Chombala	1.5 weeks	21 (14.8%)	8 (17.2%)
Mahe	1.5 weeks	20 (14.1%)	8 (17.2%)
Thalassery	2 weeks	49 (34.7%)	6 (12.7%)
Kannur	2 weeks	12 (8.5%)	4 (8.5%)
Nileschwaram	2 weeks	12 (8.5%)	8 (17.2%)
Kasargod	2 weeks	6 (4.2%)	2 (4.2%)
Mangalore	2 weeks	13 (9.2%)	9 (19.1%)
Malpe	2 weeks	8 (5.6%)	4 (8.5%)
Total: 8 sites	15 weeks	141	47

maximum number of fishermen that were interacted with by our team were 49, while the second and third highest ones numbered less than half the first value (i.e., $n = 21, 20$). During interactions, the fishermen reported no sea snake bite instances at least within the last three decades, in the sampled areas.

The maximum percentage of fishermen community that engaged with the awareness posters was at Mangalore harbour (19.1%), followed by Chombala,



Image 2. Sea snake bycatch photos forwarded by fishermen during the present study. © 2a—Sreedhar | b & d—Raviraj | c—Kumar.

Mahe, and Nileschwaram (17.2% each), with the lowest at Kasargod (4.2%) (Table 3). The numbers of poster shares were rather constant, with the topmost one logging nine shares, while the second and third highest ones were comparable values with marginal differences ($n = 8, 6$). One third (47 out of 141; 33.33%) of the

fishermen engaged with the survey team well enough and shared contacts to enable mutual sharing of posters and bycatch photos. Despite the limited time allocated to each harbour (< 2 weeks), and the first-time contact of the survey team with the fishermen community, it is remarkable to get an engagement level 33.33%. There

was no direct positive correlation between the harbours having the highest interviewees, poster shares, and sea snake bycatch photo shares.

DISCUSSION

Kumar et al. (2007) reported Cochin Banded Sea Snake *H. ornatus* from central and southern Kerala Coast and Palot & Radhakrishnan (2010) recorded Yellow-bellied Sea Snake *H. platurus* from northern Kerala. There is a record of Viperine Sea Snake *H. vieprinus* from the northern Karnataka Coast (Mondal et al. 2023). However, in our study, these species were not recorded. During our survey we found, *H. curtus* was the commonest among the three species that we recorded during the study. Padate et al. (2009), Dsouza et al. (2021), and Rao et al. (2021) reported *H. schistosus* to be more common than *H. curtus* in Goa and the northerly Malvan beach, of southern Maharashtra, in Konkan Coast, respectively. However, Lobo et al. (2004) reported that *H. curtus* outnumbered the records of *H. schistosus*, from studies done in the more northern coast of Goa.

Kumar et al. (2007) studied sea snake bycatches associated with trawl fisheries in five harbours in central and southern Kerala Coast and reported 62 instances of four species, as follows: *H. schistosus* (n = 43), *H. cyanocinctus* (n = 10), *H. ornatus* (n = 1), and *H. curtus* (n = 8). This is perhaps one of the very few studies that reported other snake species, apart from *H. schistosus* and *H. curtus*. A study was done on the trophic ecology of *H. curtus* in Goa Coast (Lobo et al. 2005). As for *H. schistosus*, three studies, one from Kerala (Jeyabaskaran et al. 2015), one from Goa (Tambre et al. 2020), and one from south Maharashtra (Dsouza & Rao 2021) coasts reported this species. Dsouza & Rao (2021) even remarked that *H. schistosus* to be a rather resilient species as regards the bycatch problem, based on their sampling in Malvan beach. These studies were done in beaches situated further north of Malabar Coast and it is understandable to get varied results, given the inter-regional variations.

Some studies on sea snake bycatches have been conducted in northern (Patel et al. 2022, 2024) and southern parts (Padate et al. 2009; Tambre et al. 2020; Dsouza et al. 2021; Dsouza & Rao 2021; Rao et al. 2021) of Konkan Coast and southern part of Malabar Coast (Kumar et al. 2007; Jeyabaskaran et al. 2015). To the best of our knowledge, there is no such study from northern part of Malabar Coast covering southern Karnataka and northern Kerala. Those that exist are not based on bycatch problems of sea snakes but generally on sighting

records. Citizen science posts of sea snakes also reported the same three species, viz., *H. schistosus*, *H. curtus* and *H. cyanocinctus* from southern Karnataka–northern Kerala coasts (Blessy & Ganesh 2026). Hence this study fills the void in research bycatch kills of sea snakes.

This study gathered insights into the status of sea snake bycatch and local perceptions of it. The one case of mass mortality involving the commonest species *H. curtus* and a rarer species *H. cyanocinctus* constituting over 10 dead snakes within a single net, raises conservation concern. As our major focus during the present survey was to make first-time contact and create awareness among the fishermen community regarding sea snakes and their mortality in marine bycatch, we did not collect morphometric data, the gender, the reproductive status nor the presence of young ones inside the dead snakes. More data on net type, haul duration would also hint of their potential correlation if any with the bycatch. More such studies on sea snake bycatch and awareness drives need to be conducted along the coastline of India for the conservation of sea snakes and other fauna that get into the marine bycatch.

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