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Live Jellyfish-baited Small-scale Traditional Trap Fishery Operated off the Eastern Coast of Sri Lanka

KRISHAN D. KARUNARATHNE, G. W. A. DE ALWIS and M. D. S. T. DE CROOS*

Department of Aquaculture and Fisheries, Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila - 60170, Sri Lanka

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The jellyfish-baited trap fishery was studied at four fishing grounds off the eastern coast of Sri Lanka throughout the entire fishing season (February and March) in three consecutive years, from 2017 to 2019, due to its uniqueness of export-oriented small-scale fishery. The composition of catch and their respective stomach content analysis revealed that the highly expensive Malabar groupers, which are predominantly targeted for export markets get attracted to traps as the secondary catch because they predate on the primary catch, *e.g.,* filefishes, rabbitfishes, surgeonfishes and triggerfishes, and the bycatch, *i.e.,* angelfishes and butterflyfishes. The varieties of primary catch are attracted to the jellyfish-bait. Among the 24 species of fishes caught, medusivorous *Siganus javus* had the highest abundance (24%), followed by *Acanthurus mata* (21%). Family-wise, the maximum contribution to the total catch was by Siganidae (56%), followed by Acanthuridae (34%). The average CPUE (kg three-man group^{-1} boat^{-1} day^{-1}) ± SD of primary, secondary and by-catch during the fishing season was 87.0 ± 18.4 kg (~80%), 15.1 ± 3.4 kg (~14%) and 6.3 ± 1.4 kg (~6%) respectively, while the average total catch per trap was 7.2 ± 1.4 kg. The results of this study are important for utilizing the commonly available jellyfish bait to expand this trap fishery as well as to adapt the strategies for similar fisheries.

(***Key words:*** *Artisanal fisheries, Baited trap fisheries, Demersal fish, Stomach content analysis*)

Small-scale fisheries provide essential livelihoods to millions of people living in developing countries (Misund *et al*., 2002). Although artisanal fisheries are not easily categorised, common key features are the low levels of capitalisation, high diversification and the multitude of gear types and vessels; with dynamic patterns in their spatial and temporal usage, and the varying degree of participants, resources and ecosystem services (Misund *et al*., 2002; Palomares and Pauly, 2019; Rousseau *et al*., 2019). The modes of operation of diverse fishing gear and even the management systems of such fisheries are enriched with indigenous knowledge and experience. A trap fishery practised in the eastern waters of Sri Lanka uses such indigenous experience in operating the gear by a rarely used, but freely available bait, jellyfish (medusae), for targeting high-valued food fish species. In contrast to many trap fisheries practiced around the country, this jellyfish-baited trap fishery is unique as its main harvest caters to the export market. Such export-oriented small-scale fisheries are rare around the world (Rosales *et al*., 2017). It has been reported that jellyfishes have been used as baits in the traps for catching medusivorous fish species along the coastline of Gulf of Mannar and Palk Bay, India (Prabhu, 1954; Thomas, 1969; Varghese *et al*., 2008, 2017). The fishes belonging to around 37 families have been reported to predate on gelatinous zooplankton worldwide (Ates, 1988).

Although some of the export-oriented small-scale fisheries, such as sea cucumbers (Dissanayake *et al*., 2010; Nishanthan *et al*., 2019) and blue swimming crabs (Sivanthan *et al*., 2016; Tharmine *et al*., 2018) have been documented from Sri Lanka, there is no documentation on the jellyfish-baited trap fishery probably be due to its restricted regional and seasonal operations. On the other hand, unlike in the commonly used traps operated either with bait (Prabhu, 1954; Balasubramanyan, 1964) or without bait (Sachithananthan and Thevathasan, 1970) in shallow waters, these jellyfish-baited traps are rarely seen as they mostly operate off the coast in relatively deeper areas. Many of the jellyfish blooms that emerge around Sri Lanka are not commercially utilized. Moreover, these jellies are often reported creating a considerable economic loss for fishers when

**Corresponding author:* E-mail: dileepa_dc@yahoo.com/dileepad@wyb.ac.lk

they get entangled in mass quantities in fishing gear (Karunarathne and de Croos, 2020, 2021) and even adding cost for unentangling, cleaning and repairing the gear. As jellyfish have become one of the cheapest and affordable baits, fishers of eastern Sri Lanka use these jellies as live baits in traps for catching demersal fish species. However, no studies have been reported on this live jellyfish-baited trap fishery and its catch compositions. Moreover, it is important to investigate the fishery to adapt the operational strategies for similar small-scale fisheries and also to utilize the freely available jellyfish bait to expand potential fisheries. Therefore, the status of this fishery, the efficacy of using jellyfish-bait, the species composition of reef fish caught into traps and economic returns with jellyfish-bait are documented in this paper.

MATERIALS AND METHODS

Study area

Traps were reported to be operated in reef areas (on rocky bottom) and lagoon areas (on sandy bottom) of the eastern coast of Sri Lanka (Pulmoddai to Panama) from February to November, by using different baits. Four landing sites representing four main fishing grounds, viz., northern Trincomalee (NT), southern Trincomalee (ST), northern Batticaloa (NB) and southern Batticaloa (SB) reef areas (Fig.1) were selected for sampling, when jellyfish-baited traps are operated.

Field survey

A survey was conducted in all four study sites throughout the fishing season which falls within February and March, continuously in 4 day intervals, in 2017, 2018 and 2019. On each sampling day, data were gathered on reef fishes caught into jellyfish-baited traps. The survey was conducted with the support of three groups of trap fishers who were randomly selected from each fishing ground; and with the same fishers using the same fishing technique, the sampling process was repeated during all three years. The primary catch (commercial fish that were attracted to jelly-bait, and other commercial prey fish trapped), bycatch (non-commercial fish that were attracted to jelly-bait, and legally protected fish) and secondary catch (large commercial fish that were attracted to predate on trapped primary and bycatch species) were recorded in terms of species and numbers (N). Biomass of the non-target reef fish species (bycatch) was taken out from traps and weight was determined onboard using a digital hanging scale (WeiHeng A08). The biomass of the target species (primary catch + secondary catch) was determined at each landing site by using the same weighing scale. The total length (TL) of 10-15% of randomly picked individuals (n) of each species in the catch was measured onboard by using a ruler to the nearest 0.5 cm after weighing to the nearest 5g. From each species, ~25 individuals were randomly selected, preserved in 10% formalin solution and dissected out to record their stomach contents. The homogenised stomach contents were observed under a stereo zoom microscope (Olympus SZ 61) and the respective percentage compositions of jellyfish, fish and other food parts in the stomach contents were estimated using the gravimetric method on wet-basis (Hyslop, 1980; Zacharia and Abdurahiman, 2004). The primary catch, secondary catch and bycatch species were distinguished based on the stomach contents and market demand. All fish species were taxonomically identified by using FAO identification sheets (Fischer and Bianchi, 1984; Bruin *et al*., 1995), Smith and Heemstra (1986) and Munro (2000), and the general information on the fishery was gathered by interviewing fishers.

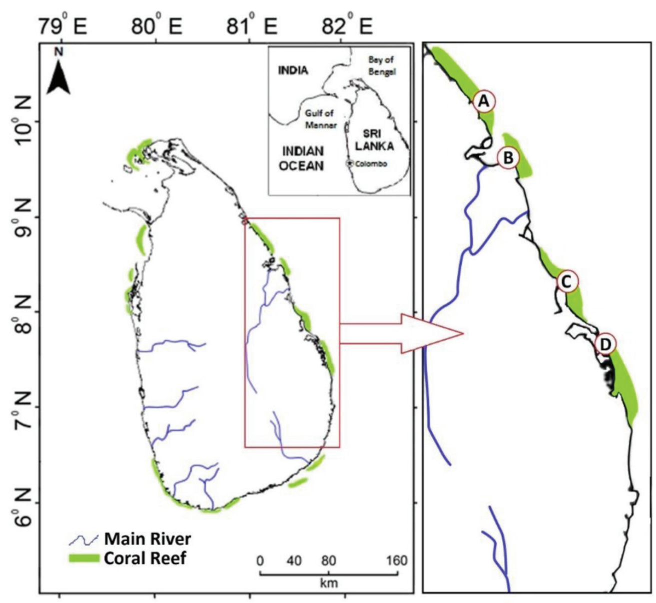

Fig. 1. *Distribution of coral reefs in coastal waters of Sri Lanka (adapted from Rajasuriya and White, 1995) and sampling locations of the jellyfish-baited trap fishery along the eastern coast* ***(A-D)****:* ***A.*** *Irakkandi, northern Trincomalee [8.73°N, 81.12°E];* ***B.*** *Mutur, southern Trincomalee [8.51°N, 81.28°E];* ***C.*** *Valachchenai, northern Batticaloa [7.94°N, 81.55°E];* ***D.*** *Navalady, southern Batticaloa [7.75°N, 81.70°E]*

Data analysis

Conventional diversity indices such as Shannon's diversity index H′ (log_2) (Shannon and Wiener, 1963); Margalef's richness index d (Margalef, 1958), Pielou's evenness index *J′* (Pielou, 1975) and Fisher's alpha index a (Fisher *et al*., 1943) were applied to compare the diversity of trapped fishes among the sampling locations (fishing grounds). K-dominance curve was also drawn (Lambshead *et al*., 1983; Clarke and Warwick, 2001) to compare the diversity of tapped fishes among fishing grounds.

The abundance data were fourth-root transformed and the similarity and cluster analyses for the diversity profile were performed using PRIMER-e (version 7) package developed by the Plymouth Marine Laboratory, UK (Clarke and Gorley, 2015). Bray-Curtis coefficient (Clarke, 1999) was calculated to study the similarity in species composition and non-metric multidimensional scaling (NMDS) was performed based on the Bray-Curtis similarity (Clarke and Warwick, 2001).

RESULTS AND DISCUSSION

The trap

Traps that were baited with jellyfish operated in eastern Sri Lanka were different in shapes, *e.g*., square, rectangular, semicircle, heart and semi-heart-shaped irrespective of the fishing ground. Most of the unfixed traps operated in estuaries had more or less similar dimensions: 1 m in length, 0.5 m in height and 0.75 m in width, while mesh size was 3-3.5 cm. Traps used at the sea were generally 2 m in length, 1.5 m in width, 1 m in height and had 4-6 cm mesh size, and even the opening mouth of a trap was large enough for a fish of 1 m length to enter (Fig. 2 A, B). These traps were made out of metal, cane or plastic wire panels.

The traps made with metal wires are durable to re-use throughout a fishing year in marine waters. However, all the wire traps have to be reconstructed for the following fishing year due to rusting under the extensive salty environment. Therefore, some fishers use canes or plastic-wired traps, which are more durable than metal-wired traps. Yet, fishers experience low catchability rates in cane and plastic-wired traps; and therefore, fishers have more tendency of using metal wired traps. Moreover, additional weights are not required as sinkers for the metal wired traps.

The bait

As observed by Karunarathne and de Croos (2021), the jellyfish *Acromitus flagellatus* and *Lychnorhiza malayensis* populations in brackish water bodies of eastern Sri Lanka increased with the increasing salinity at the end of the northeast monsoon (February and March). During this period, there is a high demand for jellyfish bait and a bucket of jellyfish, which consist of 300–350 individuals, is usually sold to reef trap fishers for 1000-1500 LKR (5-7.5 USD). This amount is sufficient for a single fishing trip (Fig. 2 C, D).

After March, jellyfish populations in the adjacent brackish water bodies on the eastern coast reduce and subsequently siganid-like fishes also get reduced in the catches. Therefore, most of the trap fishers have to use expensive baits such as squid and other small fish species for catching non-siganid species. Fishers who cannot afford to buy such expensive baits generally use algae and pieces of mouldy bread as baits. However, a considerable number of fishers (about 50%) shifts from traps to other fishing methods during the rest of the fishing period (April to November). Traps were found to be operated even in May and June with the same jellyfish-bait, also in some brackish water bodies of the eastern coast (*e.g*.,Valaichchenai Lagoon).

Mode of operation

Trap fishery operation in the reef areas of eastern Sri Lanka is a group activity. Usually, three fishers are engaged in fishing operations using a small (5.5 m in length) fibreglass boat having a 20-40 hp outboard engine. Generally, one fisher group sets10-20 traps per day. These traps are placed on reefs, 0.5-5 km away from the coast at different depths ranging from 5 to 40 m, usually at 0.5-1 km apart from each other. Every morning, from 6 a.m. to 12 noon, catches are emptied and the traps are reset with new baits. The placement of traps in the sea depends on the availability of fish schools and desirable bottom characteristics. After setting a trap, the location is marked with a float attached to the trap by a rope. Frequent pouching of these catches have become one of the main problems faced by these trap fishers. However, some fishers were found to be using scuba diving apparatus and GPS technology for marking the trap set locations instead of using ropes and floats. The use of GPS technology enables easy recovery of traps and more importantly protection against poachers due

Fig. 2. *The components of trap fishery operated off the eastern coast of Sri Lanka **(A-H)**: **A.** plastic-striped trap; **B**. metal-wired trap with jellyfish-bait; **C**. the live bait before collecting (in the wild), and **D**. jellyfish after collecting for bait (in the bucket); **E**. fishers heading towards the fishing ground using a GPS machine; **F**. a team of fishers with trap; **G.** fishers including scuba diver; **H**. some catch and bycatch of the traps in life*

to the absence of floats attached to traps (Fig. 2 E, H).

In estuaries, the entire fishing operation is done by individual fishers using non-motorized fibreglass canoes. Small traps are set in 1-4 m depth in these waters generally in the morning by diving with goggles, walking on the bottom, and by using a hook and rope from the canoe. After setting a trap, the location is marked with a float attached to the trap by a rope. Traps are set for 24 hrs in water and they are lifted and the harvest is collected on the following morning during 6-9 a.m. on daily basis. Single fisher operates 10-20 traps and the total catch (excluding bycatch) per day is 5-8 kg (catch per trap ~0.5 kg). About 90% of the total catch (by weight) represents juvenile siganids when using jellyfish-baits. However, some fishers expressed that they even seldom catch Asian sea bass *Lates calcarifer* from traps, which has an export market value.

Catch composition

A total of 24 species of reef fishes belonging to 8 families under two orders were collected from jellyfish-baited traps operated in eastern Sri Lanka (Table 1). Here, the traditional knowledge and experience of trap fishers on natural food webs and prey-predator relationships is evidently playing a significant role in catching these species.

As revealed from the stomach content analysis, once the medusivorous fish get caught into traps, they become live baits for groupers-like, reef-associated, large carnivorous fish. A total of 21 ray-finned fish species belonging to 6 families, *viz*., Acanthuridae, Balistidae, Chaetodontidae, Monacanthidae, Pomacanthidae and Siganidaewere found to have a high percentage of jellyfish parts in their stomachs indicating that they primarily feed on jellies. The stomach contents of two species of groupers belong to the family Serranidae, which represent higher trophic levels, reveal that they predominantly feed on the fishes which were attracted to jelly-bait (Fig. 3). The stomach contents of these groupers consisted of partially or non-digested primary and bycatch fishes but no jellyfish pieces. Also, *Lethrinus lentjan* was trapped together with medusivorous fish but in their stomach contents, jellyfish pieces were not found. Prabhu (1954) reported that in the Gulf of Mannar and Palk Bay, India, *Lethrinus cinereus* (= *Lethrinus lentjan*) was a common species caught in perch-traps, irrespective of the type of bait used. He also reported that when jellyfish-baits were used, the percentage of this species to the total catch was considerably low. Such non-medusivorous small fish species may probably be driven into the traps together with the other coral fishes but not attracted to the bait. However, most of the under-sized species could escape through the meshes of the traps. Apart from jellyfish and fish, some other food items such as algae, crustaceans, molluscans, worms and detritus were also commonly found in the stomachs of the fishes in this study.

Family-wise estimates revealed that Siganidae represented the highest dominance (by abundance 56%) in the catches attracted to the jelly-baited traps, followed by Acanthuridae (34%), Chaetodontidae (7%) and Pomacanthidae (2%) (Fig. 4). Each of the family Balistidae, Monacanthidae, Serranidae and Lethrinidae contributed less than 2% of the total catch. *Siganus javus* represented the highest abundance (24%) of the landings followed by *Acanthurus mata* (21%). Two other species

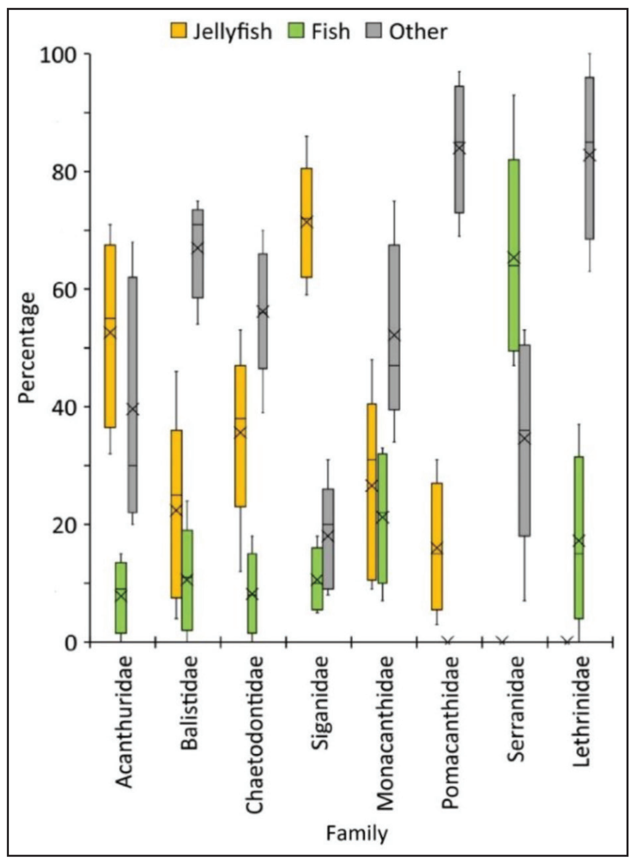

Fig. 3. *The average percentage of stomach contents composition of different families of fishes caught in the traps. Note: Jellyfish, fish and other food particles in the stomach contents were weighted on a wet-basis*

Table 1. *Commonly trapped fish species (under the Class Actinopterygii), the number of individuals measured (n) for the total length range (TL) and the average weight (AW) of each species. Note: Only the fishes that did not contain pieces of jellyfish in their stomachs are asterisked*

Order	Family	Species	Common name	*n*	*TL* (cm)	*AW* (kg)	Remarks
Perciformes	Acanthuridae	*Acanthurus mata*	Elongate surgeonfish	4261	12.3-31.1	0.22	Commercial species
		Acanthurus thompsoni	Thompson's surgeonfish	3550	10.7-24.4	0.19	*Do*
		Naso vlamingii	Bignoseunicornfish	156	14.5-51.5	0.98	*Do*
	Chaetodontidae	*Chaetodon auriga*	Threadfin butterflyfish	810	9.6-17.5	0.06	Bycatch species
		Chaetodon gardineri	Gardiner's butterflyfish	912	8.6-15.5	0.04	*Do*
		Chaetodon vagabundus	Vagabond butterflyfish	874	7.8-19.4	0.05	*Do*
		Forcipiger flavissimus	Longnose butterflyfish	789	10.4-18.5	0.06	*Do*
		Heniochus acuminatus	Pennant coralfish	673	9.1-17.5	0.06	*Do*
		Heniochus pleurotaenia	Phantom bannerfish	734	10.6-15.2	0.03	*Do*
	Pomacanthidae	*Apolemichthys xanthurus*	Indian yellowtail angelfish	1049	8.6-14.0	0.04	*Do*
		Pomacanthus imperator	Emperor angelfish	216	12.1-32.1	0.34	*Do*
		Pomacanthus semicirculatus	Koran angelfish	194	12.3-32.7	0.30	*Do*
	Serranidae	*Cephalopholis sonnerati**	Tomato hind	164	25.4-41.0	0.60	*Do* (legally protected)
		*Epinephelus malabaricus**	Malabar grouper	215	27.9-99.5	4.91	Commercial species
	Lethrinidae	*Lethrinus lentjan**	Pink ear emperor	276	10.0-43.3	0.35	*Do*
	Siganidae	*Siganus canaliculatus*	White-spotted spinefoot	4506	12.2-29.1	0.15	*Do*
		Siganus javus	Streaked spinefoot	4812	15.9-34.1	0.40	*Do*
		Siganus lineatus	Golden-lined spinefoot	3816	13.0-33.5	0.28	*Do*
Tetraodonti-formes	Balistidae	*Balistapus undulatus*	Redlined triggerfish	278	10.5-28.0	0.40	*Do*
		Balistoides viridescens	Bluefin filefish	605	13.6-55.1	1.20	*Do*
		Odonus niger	Redtoothed triggerfish	596	13.4-36.6	0.44	*Do*
		Sufflamen fraenatum	Masked triggerfish	513	11.9-32.7	0.24	*Do*
	Monacanthidae	*Abalistes stellaris*	Starry triggerfish	385	14.1-51.6	0.59	*Do*
		Aluterus scriptus	Scrawled filefish	152	18.2-73.5	1.13	*Do*

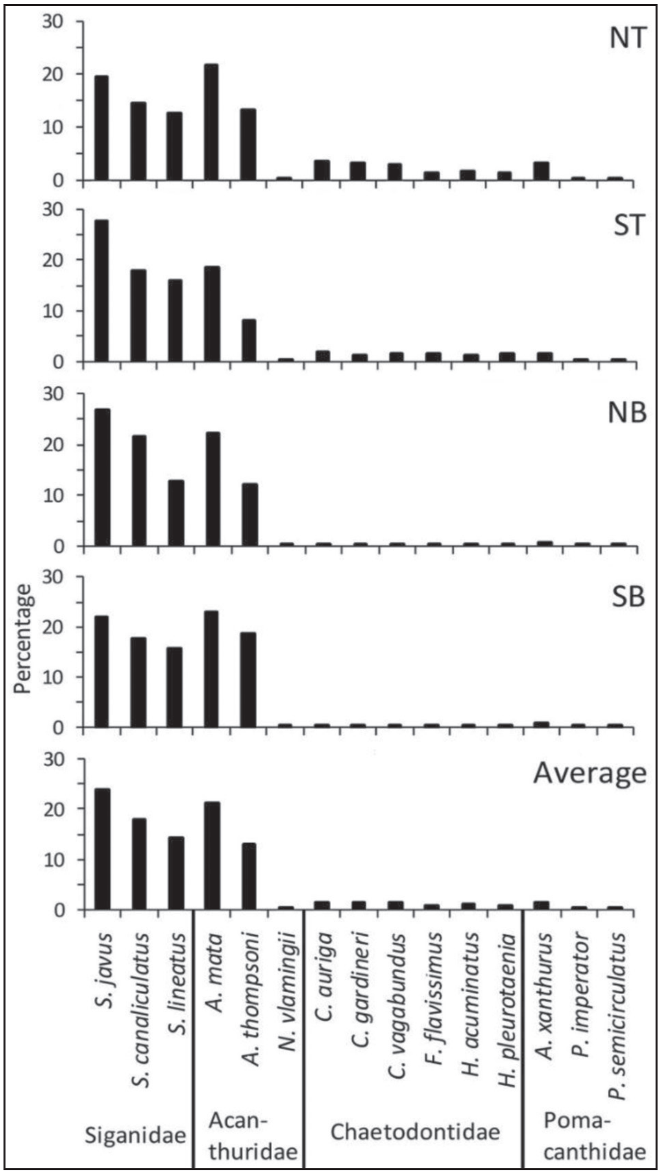

Fig. 4. *Species-wise percentage dominance (by abundance) among total reef fishes caught at each fishing ground (NT – northern Trincomalee; ST – southern Trincomalee; NB – northern Batticaloa; SB – southern Batticaloa) of eastern Sri Lanka from jelly-baited traps in February and March 2017–19. Note: The least dominant families (<2%) are not shown*

of Siganidae, *viz*., *Siganus canaliculatus* and *Siganus lineatus* contributed 17% and 14% to the total abundance respectively. The other Acanthuridae species, *Acanthurus thompsoni* had 13% contribution while all other species was less than 2% of the total catch. Though *S. javus* was the most dominant species in general, *A. mata* registered high catches at NT and SB fishing grounds. In the Gulf of Mannar, India, the maximum contribution to the trap fishery (28%) was from *S. canaliculatus* when the traps were baited with miscellaneous baits, and the high catches of *S. canaliculatus* occurred predominantly when more jellyfish-baits were used (Varghese *et al*., 2017). Prabhu (1954) has estimated about 60% and 65% of *Teuthis* species (= *Siganus* sp.) in the total fish counts of two traps set with jellyfish-baits in Palk Bay, India.

Biodiversity

The diversity indices of the catches among the four fishing grounds of eastern Sri Lanka did not deviate considerably from each other (Table 2). This may be because the adjoining localities of the respective fishing grounds were within a short distance (less than 200 km along the entire coastline). However, the highest Shannon index of diversity H' (log_2) (2.71) and the least Simpson's dominance of species *1-Lambda* (0.08) were reported from NT while, the least Shannon's diversity (2.48) and the maximum dominance of species (0.12) were from SB. Margalef's richness (*d*) and Fisher's alpha (*a*) showed the highest values in NT (2.14 and 2.43 respectively) whereas the lowest were from NB (2.10 and 2.37 respectively). Another major component of diversity, Pielou's evenness or equitability (J') was maximum in NT (0.85) and the lowest was from SB (0.78). A gradual reduction of diversity was observed with four fishing grounds from north to south along the coastline.

The dominance plot (K-dominance curve; Fig. 5) was a moderately inclined curve. In intact ecosystems, the K-dominance curve is typically S-shaped. The total number of fish species reported in the jellyfish-baited fishery of eastern Sri Lanka was similar (n = 24) among the four fishing grounds having a minimum variation among the pattern of the four curves was observed.

The degree of relationship in diversity and abundance among the catches of four fishing grounds were estimated using the Bray-Curtis similarity coefficient. The most similar fishing grounds were NT and ST with 97.50% similarity and the lowest similarity was found between NT and NB (93.67%). Trincomalee fishing grounds and Batticaloa fishing grounds formed two separate groups with a maximum similarity percentage of 94.62% and the dissimilarity of species composition of catches between the four fishing grounds is shown in the NMDS plot (Fig. 6).

Table 2. *Diversity indices of fishes between four fishing grounds of the jelly-baited trap fishery. Abbreviations used: S (number of species); N (number of individuals); H'(log$_2$) (diversity / Shannon index); 1-Lambda' (dominance / Simpson index); d (Richness / Margalef index); J'(Evenness / Pielou index); a (Fisher's alpha index)*

Fishing ground	*S*	*N*	*H'(log$_2$)*	*1-Lambda'*	*d*	*J'*	*a*
Northern Trincomalee (NT)	24	46,800	2.71	0.08	2.14	0.85	2.43
Southern Trincomalee (ST)	24	50,310	2.65	0.09	2.12	0.83	2.41
Northern Batticaloa (NB)	24	58,410	2.55	0.11	2.10	0.80	2.37
Southern Batticaloa (SB)	24	51,615	2.48	0.12	2.12	0.78	2.40

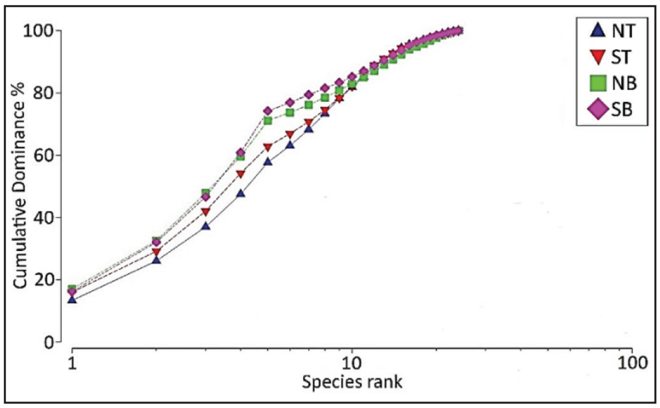

Fig. 5. *K - dominance plot for fishes caught into traps at four fishing grounds (NT - northern Trincomalee; ST - southern Trincomalee; NB - northern Batticaloa; SB - southern Batticaloa) of eastern Sri Lanka in February and March 2017-19*

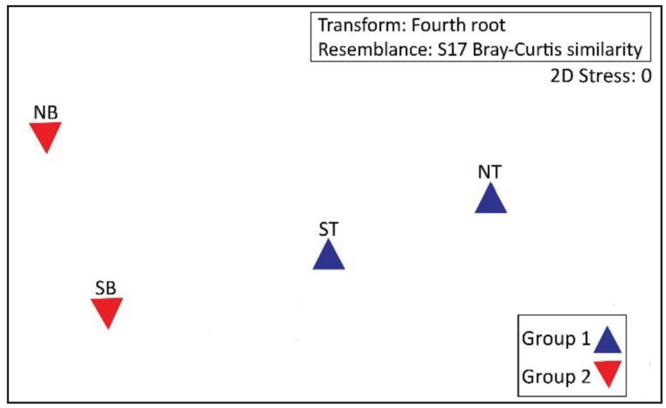

Fig. 6. *NMDS plot for fishes caught into traps at four fishing grounds (NT - northern Trincomalee; ST - southern Trincomalee; NB - northern Batticaloa; SB - southern Batticaloa) of eastern Sri Lanka in February and March 2017-19*

Biomass

Among the cumulative average catch per unit effort (CPUE) of jellyfish-baited traps, the maximum contribution of 134.0 kg operation^{-1} (31%) was from the NB area and a minimum of 86.7 kg operation^{-1} (20%) was from NT reef area. Therefore, the mean (± standard deviation) total catch (primary catch + secondary catch + bycatch) is 108.4 ± 20.6 kg operation^{-1} boat^{-1} day^{-1} and it was 7.2 ± 1.4 kg trap^{-1} operation^{-1} day^{-1} (Fig. 7). This mean CPUE was compared with the CPUE estimated for other passive gear; fyke nets and brush piles, operated in the Negombo Estuary on the west coast of Sri Lanka based on a comprehensive sampling survey design (De Croos and Stefansson, 2011). The mean CPUE of the present analysis was in a similar range of CPUE estimated for fyke nets and brush piles, operated in the Negombo Estuary (De Croos and Palsson, 2013). However, the mean catches per trap operated at the Gulf of Mannar, India estimated from previous studies, *e.g.*, 0.14 kg (Prabhu 1954), 0.48 kg (Lal Mohan, 1985) and 1.59 kg (Varghese *et al.*, 2017), were lower than the estimated CPUE of the present study. These differences in catches may probably be due to the size and types of traps employed, diversity in the fishing ground and different types of baits used (Prabhu, 1954; Varghese *et al.*, 2017). According to Prabhu (1954), use of jellyfish as a bait gave a better yield over the other baits such as dried holothurians and pieces of crabs for catching medusivorous fishes in the Palk Bay, India.

Economic aspects

In Sri Lanka, the medusivorous fish such as siganids are sold in the local market, and a kilogram of fish is sold for around 150-350 LKR (0.75-1.75 USD), while the groupers which are in export quality are purchased directly from trap fishers for 920-2,400 LKR (4.5-12 USD) kg^{-1} by seafood exporting companies. Thus, the value of the one kilogram of the secondary catch is usually more than five times higher than the kilogram of the primary catch.

This is relatively a high-cost fishery, because, usually a three-man group of fishermen spend 5,000-7,500 LKR (25-37.5 USD) per trip in a day for fuel, bait and other expenses, but this cost can reach up to

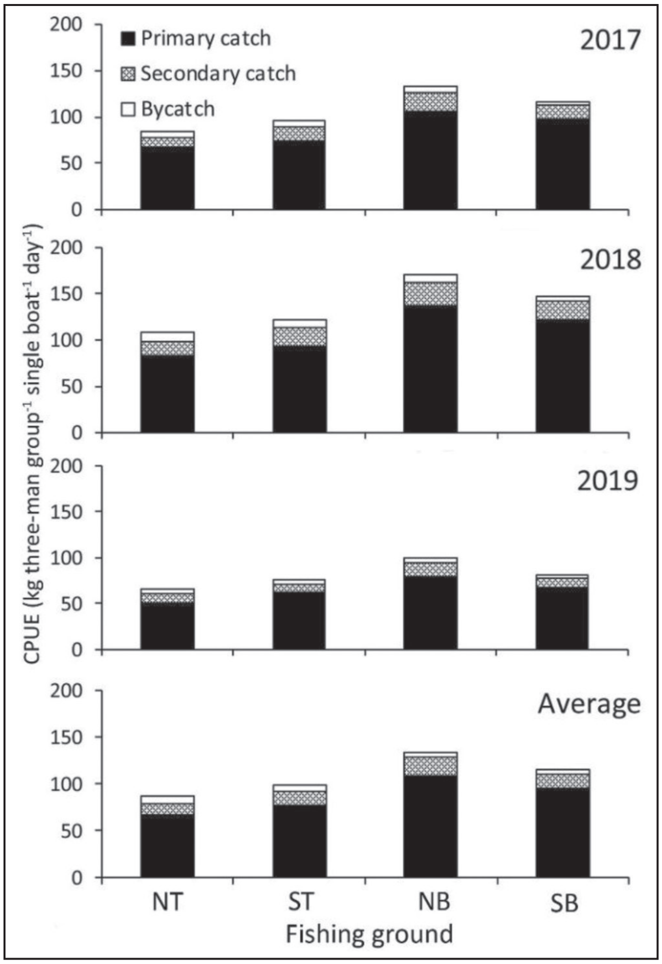

Fig. 7. *The mean CPUE (kg three-man group^{-1}single boat^{-1} day^{-1}) at each fishing ground (NT - northern Trincomalee; ST - southern Trincomalee; NB - northern Batticaloa; SB – southern Batticaloa) of eastern Sri Lanka in February and March 2017-19*

10,000 LKR (50 USD) when fishers use scuba diving apparatus for fishing. The average number of Malabar groupers caught per trip was 3, having a market value varying from 13,050 to 30,450 LKR (65-152 USD). This is approximately the same as the total value of primary catch day^{-1}. The profit of this short-time fishery is relatively high [5,000-20,000 LKR (25-100 USD) day^{-1} fisher^{-1} of a three-man group].

Environmental impacts

Uncontrolled harvesting is one of the major issues that arose at reef areas of Batticaloa and Trincomalee in eastern Sri Lanka (Rajasuriya, 1997). The bycatch reported from all four fishing grounds showed high similarity and included a threatened species *Cephalopholis sonnerati* (Supplementary Fig. 1). As traps are generally considered as non-selective fishing gear, and a variety of fish is caught depending on their construction (Misund *et al*., 2002). However, catching of juveniles and undersized individuals in these traps is rarely reported. Further, bycatch caught into traps is often released alive. Therefore, traps seem to be imposing a minimal impact on the marine ecosystems compared to gillnet and seines which are operated off the eastern coast of Sri Lanka. On the other hand, traps, which could become snagged on the bottom or lost, may later contribute to “ghost fishing” (Guillory, 1993; Al-Masroori *et al*., 2004). However, this is not a common occurrence in the jellyfish-baited fishery of eastern Sri Lanka. Even though there are least adverse impacts on the environment through the jellyfish-baited trap fishery, management strategies and regulations are required to minimise any adverse effects to ensure sustainable utilisation.

The findings of the present study will be important for initiating in-depth studies on the catch composition; maturity, size and age structure of the catches, especially for groupers. This study also highlighted the possibility of earning fisheries income targeting high-valued species as a secondary catch through the attraction of medusivorous fish using a jellyfish-bait.

CONFLICTS OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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REFERENCES

Al-Masroori, H., Al-Oufi, H., McIlwain, J.L. and McLean, E. (2004). Catches of lost fish traps (ghost fishing) from fishing grounds near Muscat, Sultanate of Oman. *Fisheries Research* **69**(3): 407-414. doi:10.1016/j.fishres.2004.05.014.

Ates, R.M.L. (1988). Medusivorous fishes, a review. *Zoologische Mededelingen* **62**(3): 29-42.

Balasubramanyan, R. (1964). On the use of different natural baits for sea-fishing in India. *Fishery Technolgy* **1**(1): 41-47.

Clarke, K.R. (1999). Nonmetric multivariate analysis in community-level ecotoxicology. *Environmental Toxicology and Chemistry: An International Journal* **18**(2): 118-127. doi:10.1002/etc.5620180205.

Clarke, K.R. and Gorley, R.N. (2015). *PRIMER v7: User manual / Tutorial. PRIMER-E*, Plymouth, UK.

Clarke, K.R. and Warwick, R.M. (2001). *Changes in Marine Communities: An Approach to Statistical Analysis and Interpretation*. PRIMER-E, Plymouth, UK.

De Bruin, G.H.P., Russell, B.C. and Bogusch, A. (1995). *FAO Species Identification Field Guide for Fishery Purpose: The Marine Fishery Resources in Sri Lanka*. FAO, Rome.

De Croos, M.D.S.T. and Palsson, S. (2013). Present status of the multi-gear shrimp fishery off the west coast of Sri Lanka: gear-based species diversity and selectivity. *Journal of Applied Ichthyology* **29**(1): 93-107. doi:10.1111/j.1439-0426.2012.02043.x.

De Croos, M.D.S.T. and Stefansson, G. (2011). A case study of sampling strategies for estimating the length composition of commercial catches: the Sri Lankan shrimp trawl fishery. *Crustaceana* **84**(12-13): 1581-1591. doi:10.1163/156854011X607024.

Dissanayake, D.C.T., Athukorala, S. and Amarasiri, C. (2010). *Present Status of the Sea Cucumber Fishery in Sri Lanka*. SPC beche-de-mer information bulletin 30, Coastal Fisheries Programme, Pacific Community (SPC). pp 14-20.

Fischer, W. and Bianchi, G. (eds.) (1984). *FAO Species Identification Sheets for Fishery Purposes*: *Western Indian Ocean* (Fishing Area 51), Vol. 4. FAO, Rome.

Fisher, R.A., Corbet, A.S. and Williams, C.B. (1943). The relation between the number of species and the number of individuals in a random sample of an animal population. *The Journal of Animal Ecology* **12**: 42-58. doi:10.2307/1411.

Guillory, V. (1993). Ghost fishing by blue crab traps. *North American Journal of Fisheries Management* **13**(3): 459-466. doi:10.1577/1548-8675(1993)013<0459:GFBBCT>2.3.CO;2.

Hyslop, E.J. (1980). Stomach contents analysis: a review of methods and their application. *Journal of Fish Biology* **17**(4): 411-429. doi:10.1111/j.1095-8649.1980.tb02775.x.

Karunarathne, K.D. and De Croos, M.D.S.T. (2020). First records of three cepheid jellyfish species from Sri Lanka with redescription of the genus *Marivagia* Galil and Gershwin, 2010 (Cnidaria: Scyphozoa: Rhizostomeae: Cepheidae). *Sri Lanka Journal of Aquatic Sciences* **25**(2): 45-55. doi:10.4038/sljas.v25i2.7576.

Karunarathne, K.D. and De Croos, M.D.S.T. (2021). Jellyfish species used as live baits in traditional trap fishery of Sri Lanka: *Acromitus flagellatus and Lychnorhiza malayensis* (Cnidaria: Scyphozoa). *Journal of the Indian Society of Coastal Agricultural Research* **39**(2): (in press).

Lal Mohan, R.S. (1985). A note on the changing catch trend in the traditional trap-fishery of Keelakarai and Rameswaram. *Indian Journal of Fisheries* **32**(3): 387-391.

Lambshead, P.J.D., Platt, H.M. and Shaw, K.M. (1983). The detection of differences among assemblages of marine benthic species based on an assessment of dominance and diversity. *Journal of Natural History* **17**(6): 859-874. doi:10.1080/00222938300770671.

Margalef, R. (1958). Information theory in ecology. *International Journal of General Systems* **3**: 36-71.

Misund, O.A., Kolding. J. and Fréon, P. (2002). Fish capture devices in industrial and artisanal fisheries and their influence on management. *Handbook of Fish Biology and Fisheries* **2**: 13-36. doi:10.1002/9780470693919.ch2.

Munro, I.S.R. (2000). *The Marine and Freshwater Fishes of Ceylon*. Narendra Publishing House, New Delhi, India.

Nishanthan, G., Kumara, A., Prasada, P. and Dissanayake, C. (2019). Sea cucumber fishing pattern and the socio-economic characteristics of fisher communities in Sri Lanka. *Aquatic Living Resources* **32**: 12. doi:10.1051/alr/2019009.

Palomares, M.L.D. andPauly, D. (2019). Coastal fisheries: the past, present, and possible futures. In: *Coasts and Estuaries*, P.A. Montagna and C. Simenstad (eds.), Elsevier. pp 569-576. doi:10.1016/B978-0-12-814003-1.00032-0.

Pielou, E.C. (1975). *Ecological Diversity*. Wiley and Sons, New York.

Prabhu, M.S. (1954). The perch fishery by special traps in the area around Mandapam in the Gulf of Mannar and Palk Bay. *Indian Journal of Fisheries* **1**(1&2): 94-129.

Rajasuriya, A. (1997). Coral reefs of Sri Lanka: current status and resource management, Proceedings Regional Workshop on the *Conservation and sustainable management of coral reefs*, Proceedings No. 22, CRSARD, Madras, Tamil Nadu, India.

Rajasuriya, A. and White, A.T. (1995). Coral reefs of Sri Lanka: review of their extent, condition and management status. *Coastal Management* **23**(1): 70-90. doi:10.1080/08920759509362257.

Rosales, R.M., Pomeroy, R., Calabio, I.J., Batong, M., Cedo, K., Escara, N., Facunla, V., Gulayan, A., Narvadez, M., Sarahadil, M. and Sobrevega, M.A. (2017). Value chain analysis and small-scale fisheries management. *Marine Policy* **83**: 11-21. doi:10.1016/j.marpol.2017.05.023.

Rousseau, Y., Watson, R.A., Blanchard, J.L. and Fulton, E.A. (2019). Defining global artisanal fisheries. *Marine Policy* **108**: 103-634. doi:10.1016/j.marpol.2019.103634.

Sachithananthan, K. and Thevathasan, A. (1970). *Sirahu Valai - A Passive Fishing Gear in Ceylon*. Bulletin of the Fisheries Research Station, Ceylon. **21**: 87-95.

Shannon, C.E. and Wiener, W. (1963). *The Mathematical Theory of Communication*. University of Juionis Press, Urbana.

Sivanthan, S., Dissanayake, D.C.T. and De Croos, M.D.S.T. (2016). Community archive higher economic return but neglects ecological sustainability: a case from a coastal trap-net fishery in Mannar, Sri Lanka. *Sri Lankan Journal of Marine Environmental Science* **1**: 17-27.

Smith, M.M. and Heemstra, P.C. (1986). *Smith's Sea Fishes*. Springer-Verlag, Berlin. doi:10.1007/978-3-642-82858-4.

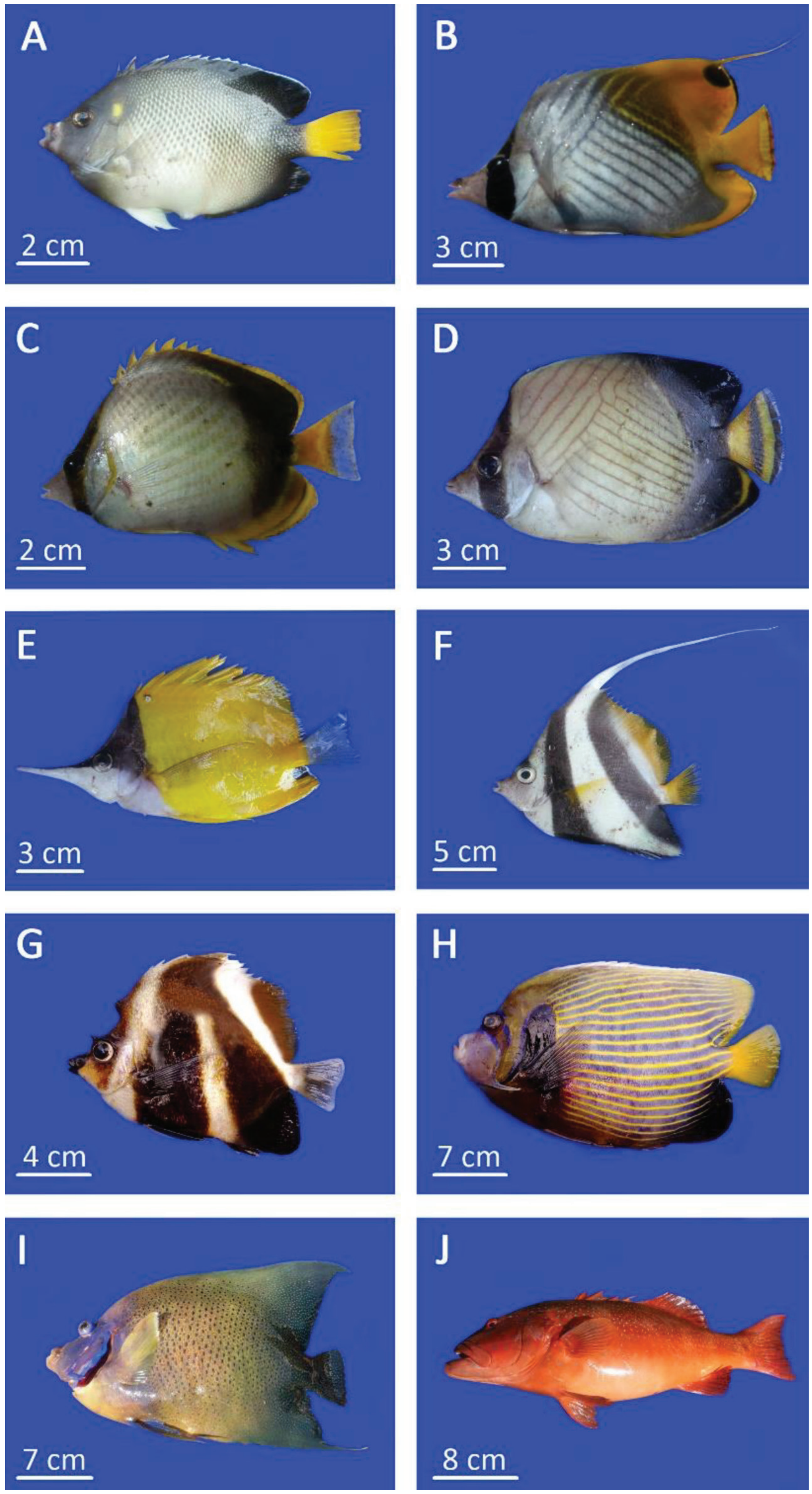
Tharmine, A., Sivashanthini, K. and Edrisinghe, U. (2018). Socio economic status of crab fishers and marketers in Navanthurai fishing village in Jaffna estuary, Sri Lanka. *Tropical Agricultural Research* **29**(3): 322-329. doi:10.4038/tar.v29i3.8271.

Thomas, P.A. (1969). Goat fishes (Family Mullidae) of the Indian Seas. *Marine Biological Association of India Memoirs* **3**: 1-174.

Varghese, M., Kasinathan, C. andGandhi, A. (2008). Trap fishing in the Gulf of Mannar and Palk Bay. *Marine Fisheries Information Service T & E Series* **197**: 7-8. doi:10.21077/ijf.2017.64.1.53263-04.

Varghese, M., Ranjith, L. and Joshi, K.K. (2017). Diversity of reef fishes in trap fishery at Keelakarai, Gulf of Mannar, southeast coast of India. *Indian Journal of Fisheries* **64**(1): 23-30.

Zacharia, P. and Abdurahiman. K. (2004). Methods of stomach content analysis of fishes. In: Winter School on *Towards Ecosystem Based Management of Marine Fisheries - Building Mass Balance Trophic and Simulation Models*, K. Mohamed (ed.), ICAR-CMFRI, Cochin, Kerala, India. pp 148-158.



Supplementary Fig. 1. *Bycatch species of fish in the jelly-baited trap fishery operated at eastern Sri Lanka* ***(A-J)****:* ***A.*** *Apolemichthys xanthurus,* ***B.*** *Chaetodon auriga,* ***C.*** *Chaetodon gardineri,* ***D.*** *Chaetodon vagabundus,* ***E.*** *Forcipiger flavissimus,* ***F.*** *Heniochus acuminatus,* ***G.*** *Heniochus pleurotaenia,* ***H.*** *Pomacanthus imperator,* ***I.*** *Pomacanthus semicirculatus,* ***J.*** *Cephalopholis sonnerati*