Aquat. Living Resour. 2019, 32, 12

https://doi.org/10.1051/alr/2019009

Aquatic Living Resources
Available online at:
www.alr-journal.org

Research Article

Sea cucumber fishing pattern and the socio-economic characteristics of fisher communities in Sri Lanka

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Received 17 March 2018 / Accepted 28 March 2019

Handling Editor: Sean Pascoe

Abstract – Sea cucumber fishing pattern and the social and economic characteristics of sea cucumber fisher communities in the north, north-west and north-east regions of Sri Lanka were assessed using the data collected from November 2015 to January 2017. A total of 9 sea cucumber species is landed in these areas using three fishing methods; diving (SCUBA and breath-hold), gleaning and surrounding nets. SCUBA diving is the dominant fishing method and SCUBA divers do both day and night fishing reporting the highest catch rates (CPUE ± SD in numbers/person/day) than the other fishers ($p < 0.05$; ANOVA). Gleaning is entirely carried out by fisherwomen in the northern region whereas 28 surrounding nets are used targeting low-value *Stichopus naso*. CPUE found to be varied with respect to species, region and fishing method ($p < 0.05$; ANOVA). *Bohadschia vitiensis* made the highest percentage contribution (61.3%) to the total sea cucumber landings during the study period. Among all fishers, SCUBA divers reported the highest average net monthly income. Men play a dominant role in sea cucumber fishing (98%), processing (99%) and marketing (100%). Fishermen in the age range of 25–67 yr, having only primary education mainly involved in the sea cucumber industry. The sea cucumber value chain consists of fishers (~2000), middlemen (12), processors (16) and exporters (7). A significant increase in overall price development from fishers to the exporters was reported for all 9 species ($p < 0.05$; ANOVA). Fishers received a proportionally higher share of the end-market price mainly for low-value *Bohadschia* spp. Although fishers receive disproportionately low returns compared to other value chain players, 47.8% of fishers showed high satisfaction towards the prices they received from buyers. However, 83.6% of fishers are not satisfied with existing management measures. Apart from strengthening the existing management measures, this information is important to update the regional and global sea cucumber statistics.

Keywords: Price markup / value chain / satisfaction / sea cucumbers / Sri Lanka

1 Introduction

The exploitation history of sea cucumbers dates back to several centuries and sea cucumbers first became commoditized in China and India more than 1000 yr ago (James and James, 1994; Chen, 2003; Friedman et al., 2008). As there was a lucrative market for sea cucumber products, especially for *bêche-de-mer* throughout the world, fishing activities were rapidly expanded into new fishing grounds (Conand, 2001; Baine, 2004; Toral-Granda et al., 2008). Currently, more than 70 countries engage in sea cucumber fisheries targeting 66 sea cucumber species reporting an average annual catch of 100,000 tons of live animals (Purcell et al., 2016a). However, overharvesting of many commercial species is evidenced worldwide (Conand, 2018, 2008; Kinch et al., 2008).

The sea cucumber fishery was introduced to Sri Lanka by the Chinese and *bêche-de-mer* is one of the major commodities taken to China for centuries (Hornell, 1917). Sea cucumbers were initially harvested by hand during the low tide periods walking along the shallow coastal areas of northern and north-western coasts of Sri Lanka. With the introduction of breath-hold diving (snorkelling) and self-contained underwater breathing apparatus (SCUBA) diving in the early 1980s, fishers moved further offshore and expanded the fishing

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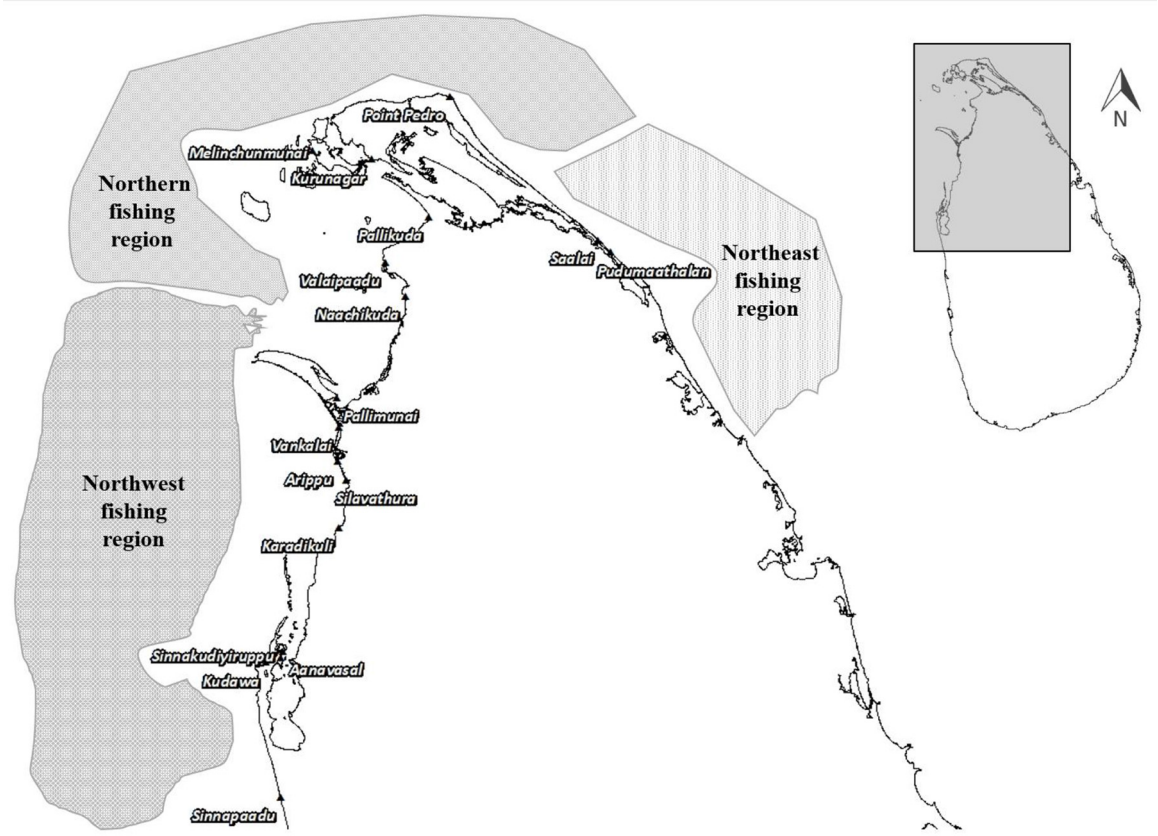

Fig. 1. Map showing the sea cucumber landing sites integrated into this study in the north, north-east and north-west regions of Sri Lanka.

activities to the east, north-east and south coasts. However, fishing activities did not sustain for a long period in the south and east coasts due to over-harvesting of sea cucumber resources. Currently, the sea cucumber fishing is confined to the north-west, north and north-east coasts of Sri Lanka (Dissanayake and Stefansson, 2010; Kumara et al., 2013). Although many sea cucumber species are commercially exploited in the coastal waters of Sri Lanka, there is no tradition of consuming them locally (Dissanayake and Stefansson, 2010, 2012). The entire harvest is processed as *bêche-de-mer* and exported to Singapore, Taiwan and Hong Kong. Sri Lanka has earned US$ 2.55 million in 2016 by exporting 136 Mt of *bêche-de-mer*[1].

Historical records of declining of high-value species and entry of new sea cucumber species to the fishery were evident from time to time (Dissanayake and Wijayarathne, 2007). A recent study also revealed the heavy depletion of sea cucumber stocks in the east and some parts of the north-west coasts of Sri Lanka (Dissanayake and Stefansson, 2010). However, more than 10,000 fishing families in the north, north-west and north-east coasts of Sri Lanka still depend on the sea cucumber fishery for their livelihood.

Inadequate information on the state of fisheries, the level of exploitation and impact on the social and economic well-being of fishers is one of the major challenges faced by fishery managers when trying to implement fisheries management plans (Perry et al., 1999; Orensanz et al., 2005; Purcell, 2010). Many authors have discussed the importance of up to date information on fisheries, stock status, ecology and biology of sea cucumbers for their sustainable management (Choo, 2008; Kinch et al., 2008). Thus, this study aims to evaluate the current status of the sea cucumber fishery, effectiveness of existing management measures and socio-economic characteristics of sea cucumber fisher communities of Sri Lanka in order to provide useful information to strengthen the existing management measures and secure the livelihood of coastal fishers. Further, this information will update the regional statistics, which are the main constraint to develop regional management programmes as now the trends in managing small-scale, spatially-structured, sedentary stocks are more towards regional than the national level.

2 Methodology

2.1 Study area

The study was conducted at the major sea cucumber landing and processing sites of the north-west, north and north-east coasts of Sri Lanka (Fig. 1) from November 2015 to January 2017.

2.2 Data collection

2.2.1 Fishery data

Catch data and the total number of active fishers in sea cucumber fishing (fishing effort) were collected at the major

[1] www.fisheries.gov.lk, 2016, Fisheries statistics of Sri Lanka.

sea cucumber landing sites in the north-west ($n = 8$), north ($n = 6$) and north-east ($n = 2$) regions of Sri Lanka (Fig. 1) by making fortnight field visits. On each sampling day, ~60% of the total fishers engaged in the sea cucumber collection were sampled randomly at each landing site. Information on fishing gear, details of fishing operations, total catch and its species composition (in numbers) was collected from each fisherman sampled. It was ensured to be at the landing site before boats were landed and also the landings were completed to get an accurate figure on the total number of active fishermen. Regional branches of the Department of Fisheries were visited to collect the sea cucumber catch statistics available with them in order to validate our catch and effort data. However, they did not have catch statistics of sea cucumber fisheries.

2.2.2 Socio-economic data

Socio-economic related data were collected using questionnaires, semi-structured interviews and focus group discussions as proposed by Bunce et al. (2000) and Torre-castro et al. (2007). Information were gathered from fishers ($n = 149$), processors ($n = 16$), middlemen ($n = 9$) and exporters ($n = 7$). Respondents were initially identified visiting the sea cucumber landing and processing sites. In this study, people who engage in sea cucumber processing were considered as 'processors' and those who pass the products to upward links of the value chain without any processing were considered as 'middlemen'. During the data collection, the gender-inclusive approach was used to interview women where possible and women were purposefully approached to incorporate their information into this study (Kleiber et al., 2015).

Three different questionnaires were used to interview fishers, processors and traders (middlemen and exporters). All three questionnaires consisted of some general information of fishers, processors and traders such as demography, location and the nature of their work. Additional questions like perceptions of their buyers, present status of the fishery and views on existing management measures were also included as common questions. Specific questions regarding the gear employed, species composition, catch rates, cost per operation, average daily and monthly income and their problems were included in the questionnaire of fishers. Information related to processing steps, processing quality and problems related to the processing were included into the processor's questionnaire while the exporters were asked for export prices, export destinations, major exported species, quantities and their problems. Group discussions were in the form of friendly chats mainly targeting a group of fishers at the landing sites. About 7.4% of fishers revealed very little information at the first encounter. However, they were more forthcoming with responses during the group discussions.

Several pre-trials were done before finalizing the questionnaires. Questions were often repeated or asked in an alternative way to confirm the respondents' understanding of the questions. Responses were recorded using a voice recorder with the permission of respondents to avoid any distractions during the interview especially between asking questions and writing responses. Interviews were done at respondent's residence, landing sites, processing plants or their office premises and an interview generally took 30–45 min.

2.3 Data analysis

Collected catch and effort data were used to calculate sea cucumber catch rates [catch per unit effort ± standard deviation (CPUE ± SD) in numbers/person/day]. The catch rates were calculated for both total catch and species-specific catch with respect to fishing region and fishing method. The total sea cucumber landing (nos) for the study period was calculated separately for each region considering the estimated total CPUE, total fishing effort and the total number of fishing days. The statistical significance of CPUE between fishing methods, species and the regions were compared using analysis of variance (ANOVA).

Descriptive statistics were used to analyze the socio-economic characteristics of fishers, processors and traders. A detailed value chain map was built using qualitative and quantitative approaches. The qualitative part involved identifying the key players in the value chain, their roles and the relationship among players, activities and processes along the chain. Under the quantitative analysis, price markup over the value chain of nine commercial sea cucumber species, *Holothuria scabra*, *Holothuria spinifera*, *Holothuria atra*, *Thelenota anax*, *Stichopus chloronotus*, *Stichopus naso*, *Bohadschia marmorata*, *Bohadschia vitiensis* and *Bohadschia* sp. 1 (listed in Dissanayake and Stefansson, 2010), was determined and compared using ANOVA. In price markup analysis, the average selling price of 1 kg dried product (*bêche-de-mer*) of each species was calculated at processors' and exporters' levels. As fishers sell their products in the fresh form on an individual basis, the number of fresh sea cucumbers required to make 1 kg of dried product was considered when selling price was calculated. As processors and exporters are common, regional data were considered when calculating price markup for each species. Operational costs were excluded in price markup analysis as it was found to be similar for all the species studied.

The level of satisfaction of fishers about their buyers (i.e. intermediary collectors) was measured on a five-point hedonic scale (0 – highly dissatisfied and 4 – highly satisfied). Ordinal regression was used to examine the relationships between socioeconomic factors of fishers and the level of satisfaction of fishers on their buyers. The model was prepared by considering the level of satisfaction of fishers on their buyers as the dependent variable. Several factor variables were used as independent variables (Tab. 1). Fishing regions, ethnicity and fishing methods were used as factor variables. Age, level of education and an annual income in thousand US$ were used as covariates. Logit function was used as the link function of this ordinal regression analysis.

A similar ordinal regression model was constructed to examine the level of satisfaction of fishers on the current sea cucumber management practices. The level of satisfaction of fishers about the management (i.e. government bodies) was measured on a five-point hedonic scale (0 – highly dissatisfied and 4 – highly satisfied). The same factor variables and covariates used in the model of buyer satisfaction were used as independent variables in this model. All statistical tests were performed in SPSS 24 for Windows statistical package.

Table 1. Variables and values used to construct ordinal regression models to analyze the level of satisfaction of sea cucumber fishers on their buyers and existing sea cucumber management measures in the three coastal regions of Sri Lanka.

Type of variable	Variable	Values
Dependent variables	Level of satisfaction of fishers on their buyers/Level of satisfaction of fishers on existing sea cucumber management measures management	0 – Highly dissatisfied 1 – Dissatisfied 2 – Not satisfied or dissatisfied 3 – Satisfied 4 – Highly satisfied
Independent variable		
Factor variables	Fishing regions	1 – North-west fishing region 2 – Northern fishing region 3 – North-east fishing regions
	Ethnicity	1 – Sinhala Buddhist 2 – Sinhala Christian 3 – Tamil Hindu 4 – Tamil Christian 5 – Muslims
	Fishing methods	1 – Snorkeling 2 – SCUBA diving 3 – Gleaning 4 – Using surrounding nets
Covariates	Age	In years
	Level education	0 – No school education 1 – Grade 1 to 5 2 – Grade 6 to G.C.E (O/L) 3 – Up to G.C.E A/L
	Annual income	In thousand US$

3 Results

3.1 Sea cucumber fishery

The sea cucumber fishing activities in Sri Lanka are highly seasonal due to the influence of the monsoon wind. Therefore, harvesting of the north-west and north coast occurs intensively from October to April (north-east monsoon period) and in the north-east coast, fishing is undertaken from May to September (southwest monsoon period).

A total of nine sea cucumber species belonging to four genera; Holothuria, Bohadschia, Thelenota and Stichopus was reported in commercial catches (Tab. 2). *H. spinifera* was recorded in all three regions and *T. anax* and *S. chloronotus* were recorded only in the north-west. *B. vitiensis* was common in both north-west and north-east catches. The highest sea cucumber species diversity was reported in the north-west catches (nine species) and only two species, *H. spinifera* and *B. vitiensis* were recorded in the north-east catches. Catches mainly consisted of low-value species and *H. scabra* is the only high-value species recorded. An average individual price of fresh *H. scabra* was 6.70 ± 2.38 US$ and it was 1.80 ± 0.25 US$ for medium-value fresh *T. anax*. The fresh individual price of all the other low-value species ranged from 0.25 ± 0.11 to 1.42 ± 0.54 US$.

Fiberglass reinforced plastic (FRP) boats powered by 8, 9.9, 15, 25 and 40 HP are the main vessel type used in the sea cucumber fishery. Fishers mainly use SCUBA and breath-hold diving to catch sea cucumbers but gleaning and netting are practised in some areas. Type of fishing method and its intensity found to be varied with regions. SCUBA diving was the only method used in the north-east region where the average of 372 ± 34 divers engaged in the sea cucumber collection daily. A daily average of 437 ± 12 divers employed in the sea cucumber fishery in the north-west region. The majority of the north-western divers were SCUBA divers (76.7%) and others were the breath-hold divers (23.3%). Breath-hold diving (71.3%) is the major fishing method practised in the northern region followed by SCUBA (15.9%), netting (6.5%) and gleaning (6.3%). The least number of SCUBA divers (68 ± 4) were reported in this region.

Only 10.5% of SCUBA divers had undertaken formal training and evaluation and were subsequently certified by an internationally recognized body. Due to lack of proper training as well as deep diving, SCUBA divers reported severe health-related issues and 4.7% of respondents have experienced in decompression sickness (bends). According to fishers, if proper treatment is given on time, there is a 10–20% chance of recovering the patients subjected to decompression sickness.

All the interviewed fishers revealed that the sea cucumber catches have declined considerably over the last 5 yr in terms of both size and quantity landed. Further, they highlighted they have to travel more distance and dive deeper than previously to collect sea cucumbers and many high-value species such as *H. fuscogilva* and *H. nobilis* are no longer in the fishing grounds. According to fishers, the current sea cucumber landings

Table 2. Scientific name, fishing time, fishing method, commercial value and the average price of the fresh individual (US$) of sea cucumber species in the commercial catches of the north-west (NW), north (N) and north-east (NE) coasts of Sri from November 2015 to January 2017.

No	Species	Area	Fishing method	Time	Wet weight price per individual (US$)	Value
01	*Holothuria scabra*	NW	SC, SN	D, N	6.70 ± 2.38	High
		N	SC, SN, GL	D, N		
02	*Holothuria spinifera*	NW	SC	D, N	1.09 ± 0.52	Low
		N	SC, SN	D, N		
		NE	SC	D, N		
03	*Holothuria atra*	NW	SC	D, N	0.22 ± 0.19	Low
		N	SC, SN	D, N		
04	*Bohadschia marmorata*	NW	SC	D, N	1.42 ± 0.54	Low
		N	SC	D, N		
05	*Bohadschia* sp. 1	NW	SC	D, N	1.34 ± 0.43	Low
		N	SC	D, N		
06	*Bohadschia vitiensis*	NW	SC	D, N	0.26 ± 0.19	Low
		NE	SC	D, N		
07	*Thelenota anax*	NW	SC	N	1.80 ± 0.25	Medium
08	*Stichopus chloronotus*	NW	SC	D, N	0.38 ± 0.04	Low
09	*Stichopus naso*	NW	SC	D, N	0.25 ± 0.11	Low
		N	SC, SN, NT	D, N		

Note: Fishing regions are abbreviated as NW: north-west, N: northern and NE: north-east, fishing methods are abbreviated as SC: SCUBA, SN: snorkelling, GL: gleaning and NT: netting and fishing times are abbreviated as D: day and N: night.

represent less than 50% of landings that they made before 5 yr. Around 15.3% of interviewed fishers are in the process of shifting to alternative jobs (i.e. tourism and sea cucumber culture) due to the high occupational risk and severe depletion of sea cucumber stocks.

SCUBA divers do both day and night fishing. Night diving was predominant in all three regions. Variations in fishing depths with respect to fishing time were recorded. Day diving was carried out down to a depth of 20 ± 5 m and night diving was restricted to the depth of 13 ± 5 m. Except in the northern region, SCUBA divers travelled around 30 km from shore to reach sea cucumber fishing grounds. As an average, 3 ± 1 divers are on board and each diver uses 4 ± 1 air tanks per trip. An average fishing time per tank is around 35–40 min.

Breath-hold diving is carried out only during the day time. Around 7 ± 1 divers are on board when they do breath-hold diving and the average diving depth is around 8 ± 1.5 m. This fishing method is practised only in the north-western and northern regions where divers travelled approximately 15 ± 5 and 8 ± 4 km, respectively, to reach their fishing grounds. Breath-hold divers mainly landed *H. scabra*, *H. spinifera*, *H. atra* and *S. naso*, while all nine species were reported in the catches of SCUBA divers (Tab. 2).

Gleaning is carried out by fisherwomen in northern Sri Lanka and they do fishing during the low tide period walking ~2 km from shore to shallow waters. Around 27 ± 4 fisherwomen involved in gleaning daily; however, gleaning was restricted to 4 ± 2 days per month (Tab. 3). Small (60 ± 12 g), medium (175 ± 80 g) and large (450 ± 236) size *H. scabra* inhabit in the shallow coastal waters are the main target of gleaning women.

In netting operation, a surrounding type net is used, and this method is practised only in northern Sri Lanka. Around 28 encircling nets are operated at present and 4 fishers involve in each net operation. They fix the net against the water current at around 17.00–18.00 h and haul it back next day morning 6.00–8.00 h. A drifted *S. naso* with the water currents and tidal fluctuation is the main target of net fishers.

Due to religious activities, almost all fishers (Muslims or Catholics) do not go for fishing 1 day per week (either Friday or Sunday). Hence, all the fishing operations except gleaning were restricted to 5–6 days per week and the active number of fishing days varies with the climatic conditions as it requires clear and calm seas for successful fishing. As an average, the fishing is carried out 5 ± 0.5 months per year in each region (Tab. 3).

Variations in CPUE, cost per operation, average daily and net monthly income of fishers were computed and compared with respect to fishing region and fishing method (Tab. 3). SCUBA divers always reported higher CPUE than the others and the SCUBA divers in the north-east region reported significantly higher CPUE than the SCUBA divers in the other two regions ($p < 0.05$, ANOVA). Gleaning fisherwomen resulted in the lowest CPUE. Except in the northern region, the operational cost of SCUBA diving was significantly higher than the other fishing methods ($p < 0.05$, ANOVA). All the interviewed SCUBA divers stated that this high operational cost is mainly due to fuel cost (32.0 ± 19.0 US$) and rental cost of diving equipment (7.49 ± 1.13 US$).

The average net monthly income of SCUBA divers was always higher than the other fishers and the SCUBA divers in north-east region (888.0 ± 68.8 US$) reported the highest monthly income ($p < 0.05$, ANOVA). The average monthly income of a breath-hold diver ranged from 205.6 ± 81.5 US$ to 288.1 ± 10.5 US$. A net fisher earned around 107.5 ± 18.6 US$ per month and the average monthly net income of gleaning

Table 3. Variations in fishing effort, CPUE (in nos/person/day), total landings, cost of operation, income and other fishery related information in the north, north-west and north-east coast of Sri Lanka from November 2015 to January 2017.

	North-west		North				North-east
Parameter	SCUBA	Snorkelling	SCUBA	Snorkelling	Gleaning	Netting	SCUBA
Fishing Effort (number of people/ operations per day)	335 ± 5^{a}	102 ± 12^{b}	68 ± 4^{c}	305 ± 51^{a}	27 ± 4^{c}	28 ± 4^{c}	372 ± 34^{a}
CPUE (catch per person per day)	88 ± 14^{a}	43 ± 17^{ab}	100 ± 5^{a}	31 ± 30^{b}	14 ± 10^{b}	35 ± 4^{ab}	558 ± 83^{c}
Distance to fishing ground (km)	29 ± 9^{a}	15 ± 5^{ab}	10 ± 3^{ab}	8 ± 4^{b}	2 ± 1^{b}	16 ± 1^{ab}	31 ± 8^{a}
Cost per person (US$) per day	39.9 ± 11.8^{a}	5.7 ± 4.7^{b}	8.9 ± 8.0^{b}	2.9 ± 1.7^{b}	0.08 ± 0.00^{b}	6.5 ± 1.9^{b}	38.4 ± 7.4^{a}
Total income per person (US$) per day	68.9 ± 28.6^{a}	23.2 ± 15.5^{b}	21.0 ± 7.7^{b}	12.1 ± 5.1^{b}	5.1 ± 4.9^{b}	9.8 ± 2.7^{b}	80.7 ± 25.3^{a}
Average number of fishing days per month	14 ± 3^{a}	15 ± 4^{a}	14 ± 3^{a}	15 ± 3^{a}	4 ± 2^{b}	20 ± 4^{a}	15 ± 4^{a}
Fishing months per year	5 ± 0.2^{a}	4.5 ± 0.1	4.5 ± 0.5^{a}	4.6 ± 0.4^{a}	5.0 ± 0.1^{a}	5 ± 2^{a}	4.5 ± 0.4^{a}
Net income per month (US$) per person	516.9 ± 43.7^{ab}	288.1 ± 10.5^{b}	209.7 ± 22.8^{ab}	205.6 ± 81.5^{b}	31.2 ± 17.8^{b}	107.5 ± 18.6^{b}	888.0 ± 68.8^{a}
Total landings per the study period (No $\times 10^{3}$)	2926.01		2016.75				12303.15

Note: Fishing effort is a measure of the number of divers per region for SCUBA, snorkelling and gleaning methods and the number of surrounding nets in netting method. Values in same raw bearing, different letters are significantly different (ANOVA, $p < 0.05$).

Table 4. Variation in CPUE (in numbers/person/day) of sea cucumber species and their percentage contribution (%) to the total landings in the north, north-west and north-east coast of Sri Lanka from November 2015 to January 2017.

Species	CPUE (in numbers/person/day) and % contribution of each species (%)						
	North-west		North				North-east
	SCUBA	Snorkelling	SCUBA	Snorkelling	Gleaning	Netting	SCUBA
Holothuria scabra	109 ± 5^{b3} (11.4%)	43 ± 17^{a} (100%)	3 ± 1^{b4} (3%)	10 ± 9^{b1} (32.3%)	14 ± 10^{b} (100%)	–	–
Holothuria spinifera	25 ± 11^{b2} (28.4%)	–	17 ± 2^{c3} (17%)	4 ± 4^{d1} (12.9%)	–	–	72 ± 45^{a2} (12.9%)
Thelenota anax	41 ± 20^{1} (46.6%)	–	–	–	–	–	–
Stichopus chloronotus	3 ± 1^{4} (3.4%)	–	–	–	–	–	–
Holothuria atra	1 ± 1^{c4} (1.1%)	–	32 ± 3^{a2} (32%)	6 ± 5^{b1} (19.4%)	–	–	–
Bohadschia marmorata	3 ± 1^{a4} (3.4%)	–	2 ± 1^{a4} (2%)	–	–	–	–
Bohadschia sp. 1	3 ± 1^{a4} (3.4%)	–	2 ± 1^{a4} (2%)	–	–	–	–
Bohadschia vitiensis	1 ± 1^{b4} (1.1%)	–	–	–	–	–	486 ± 86^{a1} (87.1%)
Stichopus naso	1 ± 1^{c4} (1.1%)	–	44 ± 5^{a1} (44%)	11 ± 10^{b1} (35.5%)	–	35 ± 4^{a} (100%)	–

Note: Values in same raw bearing, different letters are significantly different and values in same column bearing, different numbers are significantly different (ANOVA, $p < 0.05$).

woman was around 31.2 ± 17.8 US$ (Tab. 3). However, gleaning women reported very low operational cost compared with other fishers.

There are variations in species-specific CPUE with respect to species, region and fishing method (Tab. 4). In the north-west region, the highest species-specific CPUE was reported for *T. anax* (41 ± 20) and *H. scabra* (43 ± 17), respectively, for SCUBA and breath-hold diving. *S. naso* made the highest CPUE for SCUBA, snorkelling and netting in the northern region ($p < 0.05$, ANOVA). *B. vitiensis* (486 ± 86) marked the highest CPUE followed by *H. spinifera* (72 ± 45) in the north-east region. The percentage contribution of each sea cucumber species to their regional landings was compared. The results revealed that the highest contribution was reported from *H. scabra* (40.9%), *S. naso* (50%) and *B. vitiensis* (87.1%) from the north-west, north and north-east region, respectively (Tab. 4).

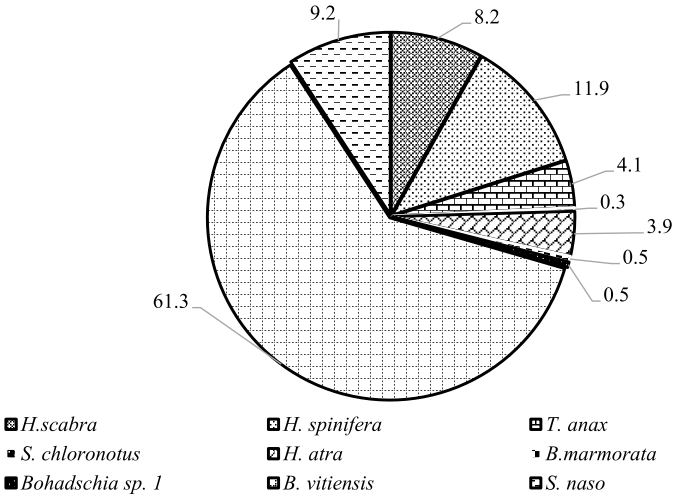

Fig. 2. Percentage contribution of each sea cucumber species to the total sea cucumber landings of north, north-west and north-east coasts of Sri Lanka from November 2015 to January 2017.

However, as a whole *B. vitiensis* made the highest percentage contribution to the total sea cucumber landings of these three regions (Fig. 2).

3.2 Local migration of sea cucumber fishers

Local migration of sea cucumber fishers was evident in some regions. The sea cucumber fishery is mostly carried out by local fishers in the north-west (91%) and northern (94%) regions. In the north-east region, the fishing activities are totally carried out by fishers who migrate from the north (~15%), north-west (~70%) and southern (~15%) regions.

This local migration requires migration passes issued by the Department of Fisheries in Sri Lanka. These passes are mainly obtained by large scale processing companies and exporters on behalf of fishers. Migrants settle at sea cucumber landing sites by making temporary huts. Both settlement cost and operational costs of fishes are borne by the processor or exporter under whom fishers are registered. These cost elements are deducted from fishers when they are paid their salary in each week.

Most of the fishing vessels owned by processors and exporters are shifted from area to area together with the migrant fishers and the balance is rented from local fishers at a daily fee of 60 ± 5 US$. The boatmen are hired from the locals and the boatman is paid 16 ± 2 US$ per day. Local women are also hired for processing activities such as cleaning, degutting and removal of chalky materials. For cleaning and degutting processes, a woman is paid 0.01 US$ per piece and a woman can clean and degut ~2000–3000 individuals per day. When removing chalky materials, a woman is paid 5.16 US$ per day including breakfast and lunch. Women are called for processing activities when their service is needed. At present, around 36 women solely depend on sea cucumber processing for their livelihood.

Some occasional migration of sea cucumber fishers within the region was also reported in the north-west and northern regions. Divers who do not migrate usually carry out other fishing activities such as shrimp catching (8.6%), net fishing (68.6%) and crab fattening (11.4%). Gleaning fisherwomen migrate from landing site to landing site within the northern region. Their migration is mainly facilitated by the availability of sea cucumbers in shallow coastal waters and 65% of fisherwomen reported this localized migration pattern.

3.3 Socio-demographic characteristics of the sea cucumber fishers, processors and exporters

Men play a dominant role in sea cucumber fishing (98%), processing (99%) and marketing (100%) giving limited opportunities for women. Young adults (71.6%) and elderly people (28.4%) in the age range of 25–67 yr engage in the sea cucumber collection and their average household size is 5 ± 2. Around 78% of the respondents depend on sea cucumber fishing as their main source of income while others engaged in different activities such as net fishing and coastal aquaculture as a supplementary income source. Sea cucumber fishers are having different levels of fishing experiences and among them, fishers from the northern region reported the highest fishing experience (18.4 ± 12.8 yr; Tab. 5). This study revealed that 86.6% of sea cucumber fishers are married, 8.9% are single and the rest fall into other category represents separated, divorced or widows. Around 92.5% of fishers have primary education up to various levels (grade 6–11) and 4.8% of fishers did not have school education.

Even though processors and traders (middlemen and exporters) have fixed locations in each region, they purchase catches from more than one region. Males belonging to the age range of 22–78 yr are serving as the owners of sea cucumber processing plants and trading activities. Both processors and traders are having different levels of experiences in relation to their job and most of them (79.7%) have only primary education. However, one person with a business management degree is engaging in sea cucumber trade (Tab. 5).

A majority of fishers (54.78%), processors (62.50%) and exporters (52.86%) are Tamil Christians and most of the middlemen (55.6%) are Muslims. Sinhala Buddhists, Sinhala Christians and Tamil Hindus rarely (<2%) engage in sea cucumber related activities. Among these ethnic groups, Tamil Christian and Muslim fishers were found in all three regions. Sinhala Buddhist and Sinhala Christian fishers were restricted to the north-west and north-east fishing regions and Tamil Hindu fishers were reported only in the northern fishing region.

3.4 Sea cucumber value chain

The sea cucumber value chain consists of ~2000 of fishers, 12 middlemen, 16 processors, 7 exporters and 3–5 international buyers (Fig. 3). All the sea cucumbers are landed in the fresh form without having any postharvest processing and sold as pieces at the landing sites. The market price of fresh sea cucumbers varies from species to species (Tab. 2). Even within the same species, the price is quite variable depending on the individual size where larger individuals fetch a higher price than the smaller individuals. However, there is no any fixed local market price for any sea cucumber species and the

Table 5. Socio-demographic characteristics of sea cucumber fishers in the north-west, north and north-east coasts of Sri Lanka.

Fishing regions	Total respondents	% of Males	Average age (yr)	Age range (yr)	Average experience (yr)
North-west					
Fishers	44	100.0	40.68 ± 9.69	25–67	15.88 ± 9.98
Middlemen	4	100.0	49.0 ± 8.52	42–61	13.25 ± 5.38
Processors	7	100.0	30.0 ± 7.12	23–45	13.71 ± 7.04
North					
Fishers	33	86.96	41.48 ± 10.68	24–63	18.35 ± 12.82
Middlemen	2	100.0	57.5 ± 28.99	37–78	2.5 ± 0.71
Processors	6	100.0	40.17 ± 15.02	22–58	15.17 ± 11.82
North-east					
Fishers	72	100.0	37.00 ± 9.20	26–59	15.8 ± 8.68
Middlemen	3	100.0	35.67 ± 5.50	30–41	15.33 ± 0.58
Processors	3	100.0	32.0 ± 6.08	28–39	10.0 ± 6.24
Exporters	7	100.0	45.43 ± 14.73	29–66	21.43 ± 13.91

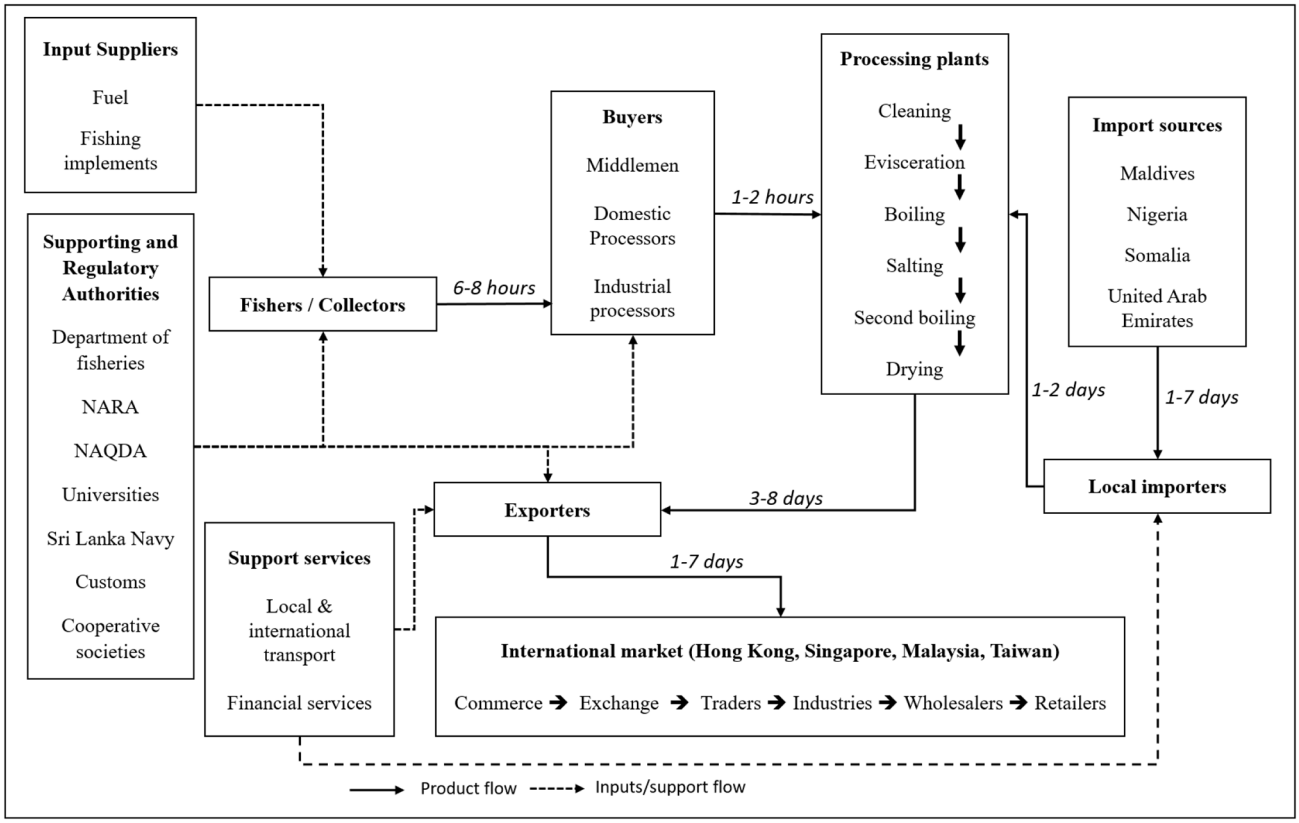

Fig. 3. The flow of sea cucumbers products, inputs and supporting services between main stakeholders of sea cucumber value chain in Sri Lanka.

individual price is determined by buyers. High operational cost, declining size and quantity of wild catch, conflict among sea cucumber fishers and sea cucumber farmers, lack of financial assistance and occupational risks are the main constraints faced by fishers.

Middlemen and processors are the main sea cucumber buyers and each buyer has a group of fishers. Fishing vessels and diving equipment owned to these buyers are rented out to fishers who work under them at a fee and fishers are also supported during the off-season. However, fishers have to pay back what they have received from buyers during the fishing season or else buyers deduct this amount when fishers are paid their salary. Buyers decide the individual price of fresh sea cucumbers based on species and size. It was found that individual price of fresh sea cucumbers did not vary significantly from one buyer to another or even from one region to another region. Middlemen sell their catches to processors at a profit. Buyers complained that highly variable

Table 6. Price markup over the value chain of nine sea cucumber species common in the commercial catches of Sri Lanka.

Species	No. of individuals per kg	Prices (USD/kg)		
		Divers (USD)	Processors	Export
Holothuria scabra	15	117.46 ± 20.65^{a}	129.95 ± 12.03^{a}	240.86 ± 1.86^{b}
Holothuria spinifera	30	45.96 ± 2.99^{a}	82.79 ± 10.54^{b}	105.65 ± 20.29^{c}
Thelenota anax	20	40.86 ± 3.23^{a}	86.02 ± 7.45^{b}	140.86 ± 4.93^{c}
Stichopus chloronotus	40	16.07 ± 1.21^{a}	67.74 ± 20.06^{b}	94.62 ± 3.72^{c}
Holothuria atra	40	15.05 ± 4.58^{a}	17.2 ± 9.86^{a}	38.71 ± 5.27^{b}
Bohadschia marmorata	20	37.88 ± 6.31^{a}	44.09 ± 1.86^{a}	54.84 ± 3.23^{b}
Bohadschia sp. 1	20	32.04 ± 3.96^{a}	38.71 ± 6.45^{b}	53.76 ± 1.86^{c}
Bohadschia vitiensis	35	16.94 ± 5.1^{a}	26.88 ± 4.93^{b}	30.65 ± 4.27^{b}
Stichopus naso	120	29.56 ± 3.13^{a}	33.33 ± 10.37^{a}	50.53 ± 4.93^{b}

Note: Price values in same column bearing, different letters are significantly different ($p < 0.05$).

markets prices and low catch rates of sea cucumbers affect their business badly.

Sea cucumbers are processed into *bêche-de-mer* at processing plants following the steps of evisceration, boiling, salting, cleaning and sun drying. Currently, 16 processors (north-west = 7, north = 6 and north-east = 3) do large scale sea cucumber processing. Domestic level processing ($n = \sim 10$) is carried out in all three regions and domestically processed products (96%) are directly sold to the large-scale processors. High level of postharvest losses, increasing of all input costs related to processing, poor processing practices and declining of catches were identified as the major threats for processors.

Bêche-de-mer is not consumed by local people and the entire production is exported to Hong Kong (40%), Singapore (30%), Malaysia (10%) and Taiwan (18%). Imports and re-exports of sea cucumbers are frequently practised. Imports are mainly sourced from the Maldives (~85% of yearly quantities), Nigeria (~10%) and Somalia and the United Arab Emirates (5%). Exporters revealed that export price varied from species to species, but all 7 exporters denied revealing export prices of each species. However, they highlighted that poorly processed products, highly competitive marketing environment, huge fluctuations in market prices and lack of centralized market are the major constraints of them. All the exporters sell their products through middlemen and 85% of responded exporters do not have a clear idea about the real market price of *bêche-de-mer* in export destinations.

Regulatory authorities and supporting agencies play an important role in managing sea cucumber resources in a sustainable manner and improving the existing value chain. Department of Fisheries is the main regulatory body and its functions include issuing licenses for fishing, transportation and exports of sea cucumbers while the Department of Customs regulates the imports and exports. Sri Lanka NAVY supports the monitoring and surveillance activities. NARA, NAQDA and some state universities involve for research and development activities but, their interactions with value chain players are not direct.

3.5 Price markup over the value chain

Price markup over the value chain of 9 commercial sea cucumber species was studied and the results are summarized in Table 6. A significant difference in the sale price of sea cucumbers from fishers to exporters was evident for all the studied species ($p < 0.05$, ANOVA). *S. chloronotus* reported the highest price markup from fisher to exporter where exporters received 5.89 times higher sale price than the fishers. Similarly, the lowest price markup (1.45 times) over the value chain was reported for *B. marmorata.* Processors received a significantly higher sale price for *H. spinifera, T. anax, S. chloronotus, Bohadschia* sp. 1 and *B. vitiensis* species than fishers ($p < 0.05$, ANOVA). Among 9 species studied, fishers received a proportionally higher share of the end-market price mainly for *Bohadschia* spp. and lower share for *S. chloronotus* followed by *H. atra.* Fishers received the highest economic return when they sell high-value *H. scabra* to the processors (90.39%); however, the processor only received 54% of end market value for this species. In contrast, the average proportionate return to fishers for medium-value *T. anax* ranged from 47.3% of the net market value and 38.9–69.1% for low-value species.

3.6 Satisfaction of fishers' towards their buyers

The distribution of fishers' responses for the levels (highly dissatisfied–highly satisfied) of buyer's satisfaction (%) is given in Table 7. Around 32.8% of fishers' responses fall within highly dissatisfied to dissatisfied category and 47.8% fall within satisfied to the highly satisfied category. The results of the ordinal regression model constructed to examine the level of satisfaction of fishers on their buyers produced values of 199.099 and 155.066 for the intercept-only model and final model, respectively. The chi-square test performed to test the difference between the intercept-only model and the full model produced a statistically significant outcome (44.03, $p < 0.05$). This result indicates the final model gives a significant improvement over the baseline intercept-only model. The pseudo-R-square (Nagelkerke method) value of the model is 0.525 and this indicates that 52.5% of the dependent variable is explained by the predictor variables in the model. The parameter estimates, standard errors and significant values were given in Table 8.

The threshold outcomes suggest values below 2.43 indicating 'highly dissatisfied' preference ranking. Further, values above 7.35 represent 'highly satisfied' preferences. A

Table 7. Distribution of responses for fisher's satisfaction towards the buyers and management.

Values	Category	Distribution of responses for buyer's satisfaction (%)	Distribution of responses for management satisfaction (%)
0	Highly dissatisfied	13.43	64.18
1	Dissatisfied	19.4	19.4
2	Not satisfied or dissatisfied	19.4	14.93
3	Satisfied	26.87	1.49
4	Highly satisfied	20.9	0

Table 8. Output of parameter estimates of the ordinal regression model construct to analyze the level of satisfaction of sea cucumber fishers on their buyers in the three coastal regions of Sri Lanka.

Variable	Estimate	SE	*p*-value
Threshold			
0-1 (Highly dissatisfied − Dissatisfied)	2.43	2.92	0.406
1-2 (Dissatisfied − Not satisfied or dissatisfied)	4.33	2.96	0.143
2-3 (Not satisfied or dissatisfied − Satisfied)	5.46	2.98	0.068
3-4 (Satisfied − Highly satisfied)	7.35	3.04	0.015
Fishing regions			
1 − North-west fishing region	0.24	1.08	0.824
2 − Northern fishing region	1.97	1.40	0.160
3 − North-east fishing regions	0[a]	–	–
Ethnicity			
1 − Sinhala Buddhist	−24.72	0.00	–
2 − Sinhala Christian	−2.24	0.78	0.004
3 − Tamil Hindu	−0.34	1.47	0.819
4 − Tamil Christian	−0.19	1.11	0.859
5 − Muslims	0[a]	–	–
Fishing methods			
1 − Snorkeling	4.75	1.46	0.001
2 − SCUBA diving	4.57	1.86	0.014
3 − Gleaning	2.49	1.66	0.133
4 − Using surrounding nets	0[a]	–	–
Age	0.00.	0.03	0.958
Level Education	−0.53	0.46	0.247
Annual income in thousand US$	0.65	0.21	0.002

[a] This parameter is set to zero because it is redundant.

significance threshold value between 'satisfied' and 'highly satisfied' levels is evident from the model outcome ($p < 0.05$). Significantly positive estimates are reported when a fisher being an SCUBA diver (outcome value is 4.57) or a breath-hold diver (4.75 for snorkeling). Also, the results confirm that the fisher's level of satisfaction towards their buyers significantly increases when their annual income in US$ is increasing (0.65). A significantly negative estimate results when a fisher is representing the Sinhala Christian ethnic group (−2.24, Ordinal regression, $p < 0.05$).

The results suggest a fisher will fall into 'neither satisfied nor dissatisfied' zone if the fisher using SCUBA diving (4.57 estimate score) or breath-hold diving (4.75 estimate score) as the fishing method. However, if the fisher is from the northern fishing region and using SCUBA diving ($4.57 + 1.97 = 6.54$ estimate score) or breath-hold diving ($4.75 + 1.97 = 6.72$ estimate score) as the fishing method, then the estimate scores put that individual to the satisfied zone. Further, an SCUBA diver from northern fishing region getting an annual income of thousand US$ ($6.54 + 0.65 = 7.19$ estimate score) falls close to the 'highly satisfied' zone. When a breath-hold diver is from the northern fishing region and earning thousand US$ annually, the total estimate score of 7.37 ($6.75 + 0.65$) clearly puts him into 'highly satisfied' zone.

As the Sinhala fishers are found only in north-west and north-east fishing regions, the ethnic variable does not influence the satisfaction levels of northern fishers. However, if the fisher is from Sinhala Buddhist ethnicity (−24.72 estimate score), he/she will fall into the 'highly dissatisfied' zone regardless of fishing region or fishing method or the income. Further, a fisher representing Sinhala Christian ethnic group and using SCUBA ($4.57 - 2.24 = 2.33$ estimate score) or breath-hold diving ($4.75 - 2.24 = 2.51$ estimate score) as the fishing method will fall close to 'dissatisfied' zone regardless

of fishing region or income. The gleaning as a fishing method was recorded only by fisherwomen from the northern fishing region. Therefore, a northern fisher using gleaning ($2.49 + 1.97 = 4.46$) falls into 'neither satisfied nor dissatisfied' zone regardless of their ethnicity (either Tamil Christian or Tamil Hindu) and annual income. However, based the model outcomes there are no any other independent variables which significantly influences the fisher's level of satisfaction towards their buyer.

3.7 Satisfaction of fishers' towards existing management measures

The sea cucumber fishery in Sri Lanka is regulated by the Department of Fisheries under the purview of Fisheries and Aquatic Resources Act no. 02 in 1996. The Department of Fisheries is responsible for regulating sea cucumber collection, transport and exports. Fishers who collect sea cucumbers by diving should obtain a diving pass from the Department of Fisheries. This pass is normally issued free of charge and it should be renewed annually. The diving pass is valid to fish only within the specified area/s and if diver wants to do fishing outside this area he needs to obtain a new pass. A separate pass is needed to keep and transport of sea cucumbers, and it is also issued by the Department of Fisheries by free of charge.

Sea cucumber exports are managed by the regulation of gazette notification no.1665/16 in 2010. According to this regulation, all exporters should obtain an export license from the Department of Fisheries and this export license is valid only for 3 months from the date of issue. A fee of 0.01 US$ is charged for each kilogram of *bêche-de-mer* exported and a minimum of 500 kg of *bêche-de-mer* should be exported within this 3-month period in order to renew the license for the next 3 months. The maximum number of 200 pieces per kilogram of *bêche-de-mer* is maintained for all the exports as a precautionary approach to avoid catching of undersized individuals.

The descriptive statistics indicate 83.6% of the fishers were 'highly dissatisfied' or 'dissatisfied' with the existing management measures (Tab. 7). The second ordinal regression model focuses on explaining the perception of fishers on the management aspects of the fishery. The log likelihood values of the ordinal regression model constructed to examine the relationships between socioeconomic factors of fishers and level of satisfaction of fishers on the management are 123.537 and 110.843 for the intercept-only model and final model, respectively. The chi-square test performed to test the difference between the intercept-only model and the final model is not statistically significant (12.694, $p > 0.05$). Compared to the model constructed to examine the relationships between socioeconomic factors of fishers and level of satisfaction on their buyers, the second model does not fit adequately as seen in pseudo-R-square (Nagelkerke) value of 0.212. Therefore, the coefficients are not interpreted for the ordinal regression model constructed for the fisher's satisfaction towards the current management aspects of the fishery.

More than 90% of interviewed fishers expect the direct involvement of government in this business. Fishers suggest developing a system for price regulations (78%), implement minimum landing size for each species (41%), control of fishing effort (58%), total closure of the fishery (27%), provide alternative income opportunities (26%) and manage fisher's welfare (64%). None of the interviewed exporters satisfied with current management practices, but 16% of processors and middlemen were happy about it. More than 85% of interviewed exporters claimed that small scale exporters are discouraged by imposing minimum export quantity regulation as it is favourable for a limited set of exporters to maintain their monopoly. Exporters and traders suggest that regulatory bodies should be more transparent (86%) and should have a room for stakeholders in decision making (66%).

4 Discussion

Seasonality of the sea cucumber fishing due to the influence of monsoon winds has been reported in many tropical countries as stated in this study. According to Dissanayake and Stefansson (2012), sea cucumbers have been exploited in Sri Lanka only using SCUBA and breath-hold diving methods; however, this study reveals the use of gleaning and surrounding nets to catch sea cucumbers in the northern region. Gleaning is a common method used by fisherwomen to catch sea cucumbers in the shallow coastal waters and the high level of women's involvement in gleaning was reported in the Pacific Island countries (Kinch et al., 2008; Purcell et al., 2016a, b). According to Purcell et al. (2016a), breath-hold diving is another common method used by women to catch sea cucumbers, but such practice is not yet recorded in Sri Lanka.

Although bottom trawling, dredging, spears, hooks, scoop nets and hookah are widely used to exploit sea cucumbers in many other countries (Bruckner et al., 2003; Purcell, 2010), use of surrounding net as a sea cucumber fishing method was not well documented.

Similarly to Sri Lanka, SCUBA diving is the main method used to exploit sea cucumbers in most of the Pacific Island countries, i.e. Kiribati, Tongo and Fiji (Purcell et al., 2016a). However, as SCUBA divers have much easier access to sea cucumbers than the other fishers, this method has resulted in overfishing of many sea cucumber stocks. Therefore, countries like Kenya, New Zealand and New Caledonia have taken measures to limit or ban the use of SCUBA diving in sea cucumber fisheries (Ochiewo et al., 2010; Purcell et al., 2016, b).

Very low involvement of women in the sea cucumber collection and processing was reported in this study. This is a common phenomenon, not only in the sea cucumber fisheries but also in all other fisheries (Choo, 2008; Eriksson and Clarke, 2015). According to FAO (2016), around 10.75 million women involved in fishing and fishery-related activities globally, but this accounts for only 19% of the total world fisher population. Compared to the other countries, the considerably high number of women's engagement in sea cucumber fishing and related activities was reported in the Pacific Island countries. Cultural limitations of Asians could be one of the reasons for less contribution of women in fisheries as noted in this study (Purcell et al., 2016a).

The observed significantly high CPUE of SCUBA divers could be due to the exhaustive search of sea cucumbers, including younger ones staying underwater for a long time period while accessing to deeper areas where other fishing

methods cannot be deployed. A similar range of CPUE values has been recorded by SCUBA divers in Fiji and Kenya (Ochiewo et al., 2010; Purcell et al., 2016a). SCUBA diving is the only method used to catch sea cucumbers in the north-east region. This is probably due to the lack of shallow coastal areas in this region where other fishing methods can be easily employed. Although high fishing effort exists, a higher abundance of *H. spinifera* and *B. vitiensis* was reported in the north-east region than the other regions, but it is difficult to find out the exact reason for this observation.

Previous studies reported that low-value species abundant in shallow coastal waters are the main target of snorkelling and gleaning fishers (Claereboudt and Al-Rashdi, 2011; Purcell, 2014). But present findings are not fully supported for their findings as high-value *H. scabra* was the most abundant species in their catches. This is probably the most preferred shallow coastal seagrass habitat of *H. scabra* (Purcell et al., 2012) is rarely targeted by SCUBA divers.

Most of the fishers pointed out that they are experiencing rapid depletion of sea cucumber resources and this could be due to existing high fishing pressure probably the use of SCUBA diving with motor boats. As there was no any previously published information on the sea cucumber fishery in the north and north-east coasts of Sri Lanka, it is difficult to make any comparisons with current findings. However, some signs of resource depletion can be seen in the north-west coasts of Sri Lanka. Though the presence of 11 sea cucumber species in the commercial catches was reported previously (Dissanayake and Stefansson, 2012), this study reports only nine species and no any landings of previously reported high-value *H. fuscogilva* and two medium-value *Actinopyga echinites* and *A. miliaris*. Further, low-value species are dominant in the commercial catches and previously unexploited *S. naso* has become a target species. The estimated total CPUE values were in the similar range of the Galapagos Islands (Shepherd et al., 2004) but it is higher than the Southern Kenya, where CPUE ranged from 8 to 21 no/fisherman/day (Ochiewo et al., 2010). However, the degree of confidence in CPUE as an index of abundance varies with the type of behavioural interactions between fish and fishers (Purcell, 2010). In the sea cucumber fishery, divers are more selective towards certain species (high-value species) and sizes of individuals (larger individuals) and fishing conditions may have a major impact on the productivity of divers. Hence, the CPUE estimates of this study need to be interpreted with much caution as we have limited data. A comprehensive fishery independent survey will be more useful in the future to assess the abundance and stock status of sea cucumbers.

All the sea cucumber fishers, except those who are carrying out gleaning and netting, earn relatively high monthly net income when compared with the other small-scale coastal fishers of Sri Lanka (117.96 US$; Jeyarajah and Santhirasegaram, 2015). Though sea cucumber fishing is a seasonal activity, most of the fishers are able to maintain a high level of income throughout the year as they perform the local migration. According to Mmbaga (2015), the average monthly income of a sea cucumber fisher in Tanzania is in the range of 264.0–932.8 US$ and this is much similar to the values recorded by Sri Lankan fishers. Though SCUBA divers have to bear a high operational cost, their monthly income is also high as they have high catch rates compared to other fishers.

Local migration of sea cucumber fishers with respect to monsoon pattern is a common practice and reported in Ghana (Marquette et al., 2002), Tanzania (Eriksson et al., 2012; Mmbaga, 2015) and Kenya (Ochiewo et al., 2010). This local migration makes benefits for both migrants and locals in the areas where migrants settle as both can strength their livelihood. According to Ochiewo et al. (2010), young to elderly people with primary education are the main employees in sea cucumber fishing industry in Asian and Pacific countries and this study also confirms their findings.

Hourglass shaped value chain was evident for sea cucumber fisheries in many countries those who export their products mainly to Asian markets (Brown et al., 2010; Wamukota et al., 2014; Purcell et al., 2017). This study also proved the similar shape of the value chain. Although this type of a value chain is generally common in food and agriculture commodities, it affects the well-being of low level of actors as market prices are largely controlled by few intermediate actors due to low-level competitions among them (Purcell et al., 2017).

Most of the Sri Lankan fishers sell their catches to intermediate buyers or processors without doing any processing and a similar pattern was reported in Kenya, Tanzania, Hong Kong, Taiwan, Singapore and Tonga (Baine, 2004; Ochiewo et al., 2010; Purcell et al., 2016b). No or very limited local consumption of sea cucumbers was reported in many coastal nations with high sea cucumber production as revealed in this study. For example, sea cucumbers are not consumed by Kenyans (Ochiewo et al., 2010) and cooked sea cucumbers are rarely consumed by the Pacific Island countries (Purcell et al., 2016b) though these countries have a productive fishery for sea cucumbers.

This study revealed that fishers reap a small proportion of end market value for low-value *S. chloronotus* and *H. atra* while the higher proportionate returns for *Bohadschia* spp. and *S. naso* who also come under the low-value category. The exact reasons for this price discrepancy gained by the fishers for different species of the same value category are not much clear. However, this is probably due to the very low price paid for fresh *S. chloronotus* and *H. atra* because of their external appearance and processing difficulties. Further, low catch rates of these species in the commercial catches could be another possible reason. Purcell et al. (2017) reported that the proportion of the end market value captured by fishers mainly depends on the market demand of sea cucumber species and they reported high price markups for high-value species based on the study carried out at Fiji and Kiribati. However, the findings of this study do not fully support their findings as some low-value species showed distinctly larger price development along the value chain. As stated by Purcell et al. (2017), lack of price transparency and cooperation among the value chain actors could be some possible reasons for the observed price discrepancies among the value chain actors. Therefore, improvement of price transparency could be a better solution to improve the revenue shared by lower-level actors of the value chain as this will increase the bargaining power of fishers (Mol, 2015). Further, as proposed by fishers, implementation of minimum price limit for each species is

another possible mechanism to overcome the unfair revenue share to the lower level value chain actors.

Fishers and domestic level processors reported a low level of dissatisfaction (32.8%) towards their buyers. But the much higher level of buyers' dissatisfaction (46%) than this study was reported in the Pacific Island countries (Purcell et al., 2016b). The lower parameter estimates of Sinhala Christian and Sinhala Buddhist fishers on their buyers could be governed by psychological factors where none of these recorded buyers is Sinhala Christian or Sinhala Buddhist origin and most of the Sinhala fishers claim that they are paid less. The result of the ordinal regression model clearly shows that fishers' satisfaction towards the buyers mainly depends on the fishing region from where the fisher was coming from, ethnicity of the fisher is representing, and fishing method employed by the fisher.

Rapid overexploitation of sea cucumber resources is the main problem highlighted by the fishers in three regions. Though some management measures such as licenses for sea cucumber fishing, processing and exporting have been implemented in Sri Lanka, very high level of dissatisfaction was reported by fishers on existing sea cucumber management measures. Management of sea cucumbers seems to be highly challenging in Sri Lanka especially due to poor enforcement and surveillance of existing management measures as well as the absence of accurate and reliable statistics as in China, Cook Islands, Indonesia, Kiribati, Malaysia, Vietnam and Solomon Island (Baine, 2004).

However, it needs to implement much strong management measures to avoid further depletion and even a collapse of sea cucumber stocks in the coastal waters of Sri Lanka. The simplest management measure would be the ban or limit of the commercial exploitation of all the species whose stock densities are well below some critical level, such as 30 individuals ha^{-1} as proposed by Purcell et al. (2009). However, such a decision will badly effect on the livelihood of many coastal fishers. Therefore, implementation of alternative management strategies such as closure and area limitation (Australia, Ecuador and Mexico), gear limitation, permit system (Australia and Papua New Guinea), setting TAC limit (Australia, Ecuador and Tongo), export restrictions (Fiji, Vanuatu) and closed seasons can be considered[2] in Sri Lanka with the available data and information. The extensive surveys will be useful in the future to gain a better understanding of stock status.

The information gained through this study provides an update on the current status of the sea cucumber fishery and the socio-economics of sea cucumber fishers in Sri Lanka. Further, this information is important for updating the regional and global sea cucumber catch statistics and for the implementation of regional management programmes.

Acknowledgements. The authors gratefully acknowledge the financial support received from the National Research Council (NRC) Grant No 15-50. Support was given by the Suganth International (Pvt.) Ltd. during the data collection is highly appreciated.

[2] www.environment.gov.au, 2018, Assessment of the Queensland Sea Cucumber Fishery (East Coast).

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Cite this article as: Nishanthan G, Kumara A, Prasada P, Dissanayake C. 2019. Sea cucumber fishing pattern and the socio-economic characteristics of fisher communities in Sri Lanka. *Aquat. Living Resour.* 32: 12