The Status of Gillnet, Stow-Net and Trawl Fishing in the Soc Trang-Bac Lieu Coastal Region, Vietnam

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ABSTRACT

Gillnet, stow-net and trawl are the three main fishing gears used by coastal fishers in Soc Trang and Bac Lieu provinces in the lower Mekong Delta, but catches from all three have been declining in recent years. We investigated the species composition of fish stocks along this coastline of Vietnam, and examined the current status of fishers and the gears they use, their fish catches, and the economic returns from each of the three net types. We also assessed the awareness of climate change among fishers, and the actions they take to adapt to its consequences. Annual fish catches were low: 11.9 $t \cdot boat^{-1} \cdot year^{-1}$ for stow-netters, 9.3 $t \cdot boat^{-1} \cdot year^{-1}$ for trawlers, and 4.4 $t \cdot boat^{-1} \cdot year^{-1}$ for gillnetters. Despite its low catch rate, the gillnet fishery provided the highest annual profit (4,364 $USD \cdot boat^{-1} \cdot year^{-1}$) because it caught higher value fish due to both their species and size. The rate of return was 0.52 for the gillnet fishery, 0.52 for the stow-net fishery and 0.33 for the trawl fishery. Overall, fishers had a low educational status and poor understanding of climate change, and only about two-thirds of them had short-term solutions to deal with changing weather and sea conditions. Current fishing practices, coupled with climate change are likely to lead to further declines in fish stocks and catches and threaten the livelihoods of near-shore coastal fishers.

Keywords: Gillnet, Small-scale fishing, Soc Trang-Bac Lieu coast, Stow net, Trawl

INTRODUCTION

Overfishing is becoming an increasingly serious problem (Boopendranath, 2008; FAO, 2016), leading to a reduction in fish stocks and, significantly, a decline in the populations of juvenile fish, which threatens the sustainability of coastal fishery resources worldwide (Benavides, 2018; Dias *et al*., 2020). The causes of overfishing are diverse, but include the wide range of fishing techniques employed, intensification of fishing activities, and changes in fish stocks and fishing conditions due to climate change (Boopendranath, 2008; FAO, 2016).

Soc Trang and Bac Lieu are adjoining coastal provinces on the eastern side of the Vietnamese Mekong Delta, with a combined coastline of 118 km facing the East Sea, and four major estuaries: Tran De and My Thanh in Soc Trang, and Cai Cung and Ganh Hao in Bac Lieu. In 2021, coastal fisheries landings from the Soc Trang-Bac Lieu region, including gillnets, trammel-nets, trawls, long-lines, purse-seines, and trap-nets reached 184,825 tonnes (Nguyen, 2022; Bac Lieu Department of Agriculture and Rural Development, 2022), equivalent to 7.7 % of total coastal fisheries landings in the lower Vietnamese Mekong Delta. There is evidence of a decline in coastal fisheries landings along this section of the coastline (Long, 2014). This could be linked to any or a combination of the factors reported to be associated with the global decline in fish stocks (e.g., Boopendranath, 2008; FAO, 2016).

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There is a broad range of literature describing the composition of fish populations in coastal and estuarine environments around the world (e.g., Segbefia *et al*., 2013; Ferreira *et al*., 2019), including data for the Soc Trang-Bac Lieu region (Nguyen and Pham, 2017). There are also a number of accounts describing the characteristics of fishing boats, fishing gears and the socio-economic aspects of coastal capture fisheries in different parts of the world (e.g., Hutchings *et al*., 2002; Mendonça and Pereira, 2014; Chi and Long, 2018; Tambunan *et al*., 2018), but similar data are not available for the Soc Trang-Bac Lieu region. Finally, there have been a number of studies on the awareness of climate change among coastal fisher-folk (e.g., Barange *et al*., 2018; Rahaman *et al*., 2020), and the strategies they use to cope with its consequences (Mahon, 2002; Salim *et al*., 2014; Diouf *et al*., 2020), but again, no such information is available for coastal fishers in the Soc Trang-Bac Lieu region.

In this paper, we aim to compare the use and features of the three main fishing gears for the coastal capture fishery in Soc Trang and Bac Lieu (gillnet, stow-net and trawl), and the quantity and species composition of fish caught using each technique. We also describe the socio-economic characteristics of coastal capture fisheries, and discuss awareness of issues related to both overfishing and climate change among coastal fishers. It is expected that this will provide key information for the management and conservation of fishery resources in the region.

MATERIALS AND METHODS

Data collection

Quantitative data on the species composition of fish were collected bimonthly in the Soc Trang-Bac Lieu coastal area over a period of two years from January 2018 to January 2020, using three types of net: gillnet, stow-net, and trawl. Fish samples were caught by all three gears in four sampling sites offshore from the Tran De, My Thanh, Cai Cung and Ganh Hao rivers (Figure 1). We collected data for a total of 13 sampling periods at each of the four sites. All fish samples were preserved in 4% formaldehyde until processed in the laboratory of the College of Aquaculture and Fisheries, Can Tho University.

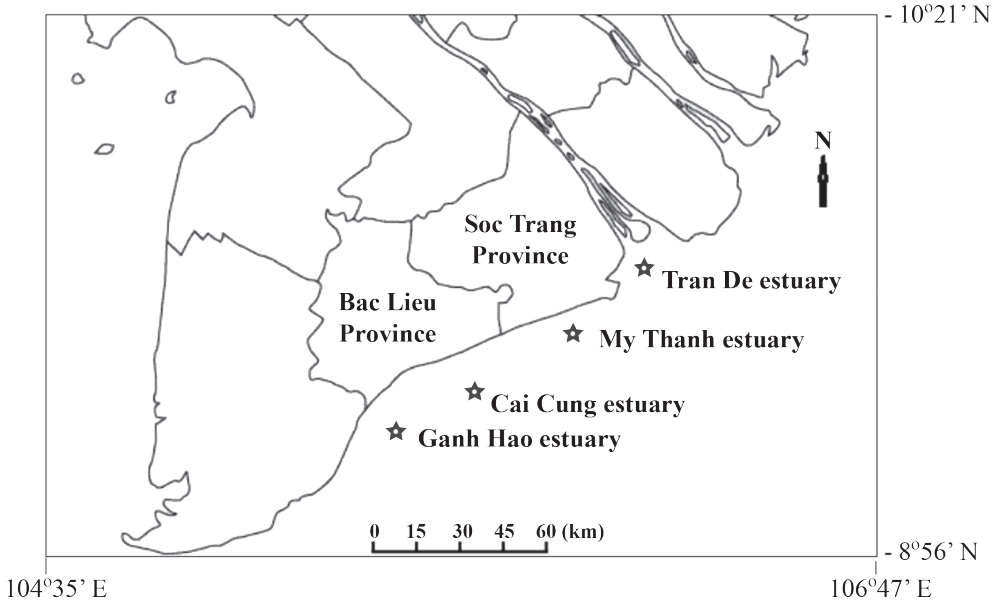

Figure 1. Sampling sites for gillnet, stow-net and trawl fishing in coastal areas of Soc Trang and Bac Lieu provinces, Vietnam.

A different fishing boat was operated with each fishing gear to collect samples in the four sampling sites. For gillnet operation, the gillnetter was 11 m in length overall (LOA) with a 24 hp engine, the net had mesh size of 30 mm (stretched mesh) with a total head-rope length of 400 m and net height of 2.5 m. The net was set perpendicular to the sea current at a distance of 3-10 km from the shoreline with a soaking time of 10 h (from 6 p.m. to 4 a.m. the next day) on three consecutive days. A total of 39 gillnet samples of the whole study area were collected.

The stow-netter used for sampling was 15 m in length overall (LOA), had an engine capacity of 45 hp, and a stow-net 20 m in length and 4 m in height, with a mouth size of 11 m and a cod-end mesh size of 24 mm. The stow-net was fixed in one place at a distance of 10 km from the shoreline, with its mouth facing the direction of the sea current. Sampling was carried out over a period of about 6 h (from high tide to neap tide) on three consecutive days. A total of 39 stow-net samples of the whole study area were collected.

Trawl samples were collected using a boat of 14 m in length overall (LOA), with engine capacity of 40 hp. The trawl was 12 m long, 1.5 m high, and had a 7 m mouth and a cod-end mesh size of 25 mm. Trawls were started about 1 km from the shoreline and continued in a seaward direction for a distance of about 10 km over a period of about 3 h. Sampling occurred on three consecutive days for each period, and a total of 39 trawl samples of the whole study area were collected.

Fish species in the collected samples from gillnets, stow-nets, and trawls were identified based on morphologic and meristic characteristics, and then assigned to family and order, based on existing reference information and keys (Carpenter and Niem, 1999a; 1999b; 2001a; 2001b; NAGAO, 2021; Froese and Pauly, 2022).

Quantitative and qualitative data on the characteristics of fishers in Soc Trang and Bac Lieu, their fishing gears, fishing practices, and economic returns and costs were collected using a structured questionnaire. A total of 120 fishers in the Soc Trang-Bac Lieu coastal region were interviewed: 40 gillnet fishers, 40 stow-net fishers and 40 trawl fishers. Questions focused on the characteristics of their fishing boats and fishing gears, on-board labour, fisher's education level, and awareness and strategies for adapting to the impacts of recent changes in climate, fishing grounds and seasons, catch quantity, costs and returns.

Data analysis

Responses to items in questionnaires and interviews were first converted to standardised units, then entered into spreadsheet software for further analysis. Derived economic parameters were calculated as follows:

Gross income = Total sales of products

Total costs = Total fixed costs+Total variable costs

Total fixed costs = Annual opportunity cost of investment+ Annual depreciation (includes hull, engine, machinery and fishing gear costs)

Total variable costs = fuel+wages+food+ repairs+ice+ miscellaneous expenses

Profit = Gross income-Total costs

Rate of return = Profit/Total costs.

Differences in fishing characteristics and socio-economic aspects among the three fishing techniques were tested for statistical significance using one-way ANOVA with the Duncan test. Values of 0.05 or less were considered significant for all statistical tests.

RESULTS AND DISCUSSION

Characteristics of fishers

Fishing labour

The average crew size on gillnetters was 3.7±1.4 fishers·boat^{-1}, and approximately half (51 %) of them were family members. Similarly, the average crew size on stow-netters was 3.6±1.6 fisher·boat^{-1}, of which 56 % were family members. Compared to gillnetters and stow-netters, trawlers had significantly fewer crew members (3.0±1.0 fisher·boat^{-1}), and a much higher percentage (71 %) were family members (Table 1).

There was a wide range in age and experience among on-board fishers, but most were middle-aged or older, averaging 40.1±11.1 years of age (with an average of 18.1 years of experience) for gillnetters, 45.7±11.2 years of age (23.7 years of experience) for stow-netters, and 47.9±13.7 years of age (18.8 years of experience) for trawlers; there was no significant difference in average fisher age among boats with different fishing gears (Table 1). There was also no significant difference in years of experience among fishers using different fishing gears, despite the apparently greater experience of stow-net operators compared with those using gillnets and trawls. The tendency for many of the fishers to be middle-aged or older may reflect the difficulty of older fishers in finding employment elsewhere at a time when economic returns from coastal fishing are low, or it may simply be that they want to continue working in their traditional occupation.

Because coastal near-shore fishing in Soc Trang and Bac Lieu is largely artisanal and small scale, most of the on-board labour is provided by family members. In the past, when fishing in deeper water (more than 5 m depth), boat owners would usually hire from one to three employees. Now, however, boat owners are less likely to hire employees from outside the family because of declining fish stocks and decreasing income from fishing; instead, they use family labour to reduce costs and only fish when catches are likely to be high.

Educational status of fishers

Most coastal fishers interviewed in this study had a low level of education. More than 70 % had either not attended school or had only completed primary school, while a further 17-20 % had completed secondary school to Year 9 (Table 1).

Table 1. Crew size, age, experience and education level of fishers of gillnetters, stow-netters, and trawlers in the Soc Trang-Bac Lieu coastal region of Vietnam. (Values are mean±standard deviation for 40 boats of each net type).

Item	Gillnetter (n = 40)	Stow-netter (n = 40)	Trawler (n = 40)
Crew size (fishers·boat^{-1})	3.7±1.4^{a}	3.6±1.6^{a}	3.0±1.0^{b}
family members (fishers·boat^{-1})	1.6±0.8^{a}	1.7±0.6^{a}	2.1±1.0^{a}
- non-family employees (fishers·boat^{-1})	2.0±1.5^{a}	1.9±1.6^{a}	0.9±0.8^{b}
Age of fishers (years)	40.1±11.1^{a}	45.7±11.2^{a}	47.9±13.7^{a}
Experience of fishers (years)	18.1±11.3^{a}	23.7±14.2^{a}	18.8±9.8^{a}
Education level (%)			
no formal education	25.0	2.5	42.5
primary school	50.0	77.5	35.0
secondary school	20.0	17.5	17.5
high school	5.0	2.5	5.0

Note: Mean values in the same row with the same lowercase letters are not significantly different (p>0.05).

Characteristics of fishing boats and fishing gears

Boat size and capacity

There was a statistically significant difference ($p<0.05$) in engine power among boats using different types of fishing gears (gillnetter, 26.3±14.5 hp·boat^{-1}; stow-netter, 32.7±13.9 hp·boat^{-1}; and trawler, 39.9±18.8 hp·boat^{-1}) (Table 2). However, the engine power for all three appears to be somewhat lower than the overall average of 41.3 hp·boat^{-1} reported for coastal capture fisheries boats in the whole lower Mekong delta (Chi and Long, 2018). On the other hand, it was substantially higher than the permissible upper limit of 20 hp·boat^{-1} for such boats set in Decree No. 12/VBHN-BNNPTNT by the Ministry of Agriculture and Rural Development of Vietnam (MARD, 2015). Nevertheless, despite the regulations, fishing boat owners usually install more powerful engines in the belief that they are better for fishing and travelling between fishing grounds and ports.

There was no significant difference ($p>0.05$) in average length or gross tonnage (GT) among boats using different types of fishing gears (gillnetter, 10.5±1.74 m·boat^{-1} and 3.4±2.2 t·boat^{-1}; stow-netter, 12.1±1.6 m·boat^{-1} and 5.5±4.0 t·boat^{-1}; trawler, 12.6±1.1 m·boat^{-1} and 5.6±2.9 t·boat^{-1}) (Table 2). In general, it appears that the size of boats in the coastal area of Soc Trang and Bac Lieu is similar to that of boats used elsewhere, as 86 % of the world's capture fisheries boats are usually under 12 m in length (FAO, 2018). Boats with a length of around 12 m or slightly less appear to be quite suitable for typically short, one- to three-day fishing trips in near-shore waters off the coast of Soc Trang and Bac Lieu.

Fishing gears

Gillnets are a selective gear for fishing, in which fish are captured by entangling in the mesh. The gillnets used by fishers in the Soc Trang-Bac Lieu region varied considerably in length, ranging from 1,500 m to 10,000 m, with an average of 3,613±2,269 m, but were fairly uniform in height, averaging 3.59±1.86 m (Table 2). Overall, however, these nets were considerably smaller in size than the average length of 8,044 m and height of 6.2 m for gillnets used in the entire lower Vietnamese Mekong Delta (Chi and Long, 2018). Gillnets used in Soc Trang and Bac Lieu also had a relatively small mesh size of 53.4±15.5 mm (Table 2), about two-thirds the average size for the lower Mekong Delta (Chi and Long, 2018). The small mesh size is likely to catch smaller fish and could adversely impact juvenile fish populations. The use of gillnets with a smaller mesh size in Soc Trang and Bac Lieu was most likely due to the fact that the majority of respondents in our survey were coastal artisanal, small-scale fishers.

Table 2. Characteristics of boats and fishing gears used in the Soc Trang-Bac Lieu coastal region, Vietnam. (All values are mean±standard deviation of 40 nets for each net type).

Item	Gillnet (n = 40)	Stow-net (n = 40)	Trawl (n = 40)
Onboard engine (hp·boat^{-1})	26.3±14.5^{a}	32.7±13.9^{b}	39.9±18.8^{c}
Boat length overall (m·boat^{-1})	10.5±1.74^{a}	12.1±1.6^{a}	12.6±1.1^{a}
Boat tonnage (GT) (t·boat^{-1})	3.4±2.2^{a}	5.5±4.0^{a}	5.6±2.9^{a}
Net length (m)	3,613±2,269	23.3±7.9	14.4±5.8
Net height (m)	3.59±1.86	5.35±2.71*	2.0±1.9*
Net-mouth width (m)	-	14.2±5.0	8.9±3.7
Mesh size (mm)	53.4±15.5	12.7±0.4**	21.2±7.0**

Note: * Net-mouth height; ** Cod-end mesh size; Values in the same row with the same lowercase letters are not significantly different ($p>0.5$).

A stow-net is a bag-net similar to a trawl, but is set up in a fixed place where water currents will bring fish into the net. On average, stow-nets used by fishers in Soc Trang and Bac Lieu were 23.3±7.9 m in length, had a net mouth width of 14.2±5.0 m, and a cod-end mesh size of 12.7±0.4 mm (Table 2). The cod-end mesh size is much smaller than the minimum size of 20 mm mandated by the Ministry of Agriculture and Rural Development in Circular No. 19/2018/TT-BNNPTNT (MARD, 2018). This smaller mesh would almost certainly kill many juvenile fish and other small marine pelagic animals, with serious adverse impacts to the sustainable development of coastal captured fisheries along the coastline of Soc Trang and Bac Lieu (Long, 2014; Chi and Long, 2018).

Trawls are bag-nets towed by boat, mostly capturing demersal fish species that are pushed into the net. Trawls were an average of 14.4±5.8 m in length and 2.0±1.9 m in height, had a mouth width of 8.9±3.7 m, and the cod-end mesh size averaged 21.2±7.0 mm (Table 2). As in the case with the small cod-end mesh size of stow-nets used in Soc Trang and Bac Lieu, the small mesh size of the cod-end of trawls is also likely to catch juvenile fish and small benthic animals, with adverse long-term impacts to the sustainability of fisheries in the area.

Fishing activity and catches

Fishing grounds

Fishing grounds used by all three fishing gears were shallow, near-shore waters with a depth of 3-10 m. The bottom of inshore waters along the coast of Soc Trang and Bac Lieu tends to be flat and is predominantly muddy mixed with sand, and the water is relatively turbid. The flat sea bottom and shallow water is suitable for fishing both during the day and at night.

Fishing seasons

Fishing using all three fishing gears typically takes place almost year round, but the peak season is usually from October to December for gillnet fishing, between March and May for stow-net fishing, with a longer season from April to November for trawl fishing. However, weather conditions and the size of catches play important roles in determining when fishing boats are put to sea, as they do in most coastal capture fisheries (Mendonça and Pereira, 2014).

Species composition of fish samples

Overall, a total of 122 fish species belonging to 45 families and 16 orders were identified in the Soc Trang-Bac Lieu coastal region. About half (53.3 % or 65 species) were members of the order Perciformes, 15 species (12.3 %) belonged to the order Clupeiformes, 11 species (9 %) to the order Pleuronectiformes, with between one and six species in each of the remaining 13 orders. However, there was a differentiation in the number of fish species collected by each fishing gear: 46 fish species by gillnet, 81 fish species by stow-net, and 55 fish species by trawl (Table 3). The number of species recorded in our study was lower than the 161 species (68 families and 18 orders) reported by Nguyen and Pham (2017). This might have been due to differences between the two studies in the area surveyed or the fishing techniques used. However, fish populations are dynamic and species diversity varies with time of year, with the highest diversity usually occurring in the months from July to November. This appears to have changed with changing weather conditions in recent years (Ching-Hsien *et al*., 2016) and, according to fishers surveyed in our study, fish species such as *Scomberoides lysan*, *Netuma thalassina* and *Leptomelanosoma indicum* have become increasingly rare over the past 10 years (2007-2017). It is therefore likely that the lower number of species recorded in our study, compared to that recorded by Nguyen and Pham (2017), also reflects the disappearance of some species from the coastal waters of Soc Trang and Bac Lieu.

Catches

Overall, catches from three fishing gears were quite low, 29.5±14.3 kg·boat^{-1}·day^{-1} (4.4±2.2 t·boat^{-1}·year^{-1}) for gillnets; 191.9±152.8 kg·boat^{-1}·day^{-1} (11.9±10.0 t·boat^{-1}·year^{-1}) for stow-nets; and 70.1±32.1 kg·boat^{-1}·day^{-1} (9.3±6.2 t·boat^{-1}·year^{-1})

for trawls (Table 4). Most fishers we interviewed agreed that capture yields had fallen by around half in recent years, more or less in line with the estimated reduction of 46.6 % in capture yields worldwide compared to ten years ago, as reported by the Organisation for Economic Co-operation and Development (OECD, 2021). Most fishers (90 %) were dissatisfied with their current capture yields, and predicted that they would continue to decline unless overfishing was stopped immediately.

Causes of decreasing harvest

Overfishing was ranked the main cause for declining fish stocks along the coastlines of Soc Trang and Bac Lieu by over 60 % of gillnet and stow-net fishers but, interestingly, only 45 % of trawl fishers ranked overfishing as the main cause of declining catches (Table 5). Climate change was ranked the second most important cause of declining fish stocks by 27.5 % of gillnet fishers,

Table 3. Fish species (number) in samples captured by gillnet, stow-net and trawl in the Soc Trang-Bac Lieu coastal region from March 2018 to January 2020.

Fish order	Species captured by Gillnet	Species captured by Stow-net	Species captured by Trawl	Species captured by all three fishing gears
Perciformes	26	44	24	65; (53.3 %)
Clupeiformes	6	14	9	15; (12.3 %)
Pleuronectiformes	2	7	6	11; (9.0 %)
Siluriformes	2	3	5	6; (4.9 %)
Anguilliiformes	1	3	3	5; (4.1 %)
Cypriniformes	0	1	2	3; (2.5 %)
Mugiliformes	3	3	2	3; (2.5 %)
Myliobatiformes	2	0	0	2; (1.6 %)
Aulopiformes	2	2	1	2; (1.6 %)
Gadiformes	0	2	0	2; (1.6 %)
Scorpaeniformes	1	1	0	2; (1.6 %)
Tetraodontiformes	1	0	0	2; (1.6 %)
Batrachoidiformes	0	1	0	1; (0.8 %)
Beloniformes	0	0	1	1; (0.8 %)
Elopiformes	0	0	1	1; (0.8 %)
Gasterosteiformes	0	0	1	1; (0.8 %)
	46	81	55	122

Table 4. Average daily and yearly catch per boat for gillnets, stow-nets and trawls in the SocTrang-Bac Lieu coastal region. (Data are mean±standard deviation of 40 boats using each fishing gear).

Item	Gillnet (n = 40)	Stow-net (n = 40)	Trawl (n = 40)
Daily catch ($kg \cdot boat^{-1} \cdot day^{-1}$)	29.5±14.3	191.9±152.8	70.1±32.1
Annual catch ($t \cdot boat^{-1} \cdot year^{-1}$)	4.4±2.2	11.9±10.0	9.3±6.2

20.0 % of stow-net fishers, and 40.0 % of trawl fishers (Table 5). Pollution and the use of other more extreme fishing techniques that catch fish of all sizes, for example trammel-nets, or fence-nets and baited trap-nets with extremely small mesh sizes (<1 cm) were mentioned by some fishers. Factors that were not considered important causes of declining fish stocks included the loss of a large area of coastal forest that destroyed juvenile nurseries, and increasingly long periods of fishing. The perception by coastal fishers in the Soc Trang-Bac Lieu region that overfishing is an important cause of declining fish stocks is consistent with its impact on small-scale fisheries elsewhere (Gough *et al*., 2020). Moreover, the decreased catches have encouraged fishers to continue to overfish by increasing the intensity of their fishing, and by using nets with smaller mesh size, sometimes below the legal limit, resulting in a further decline in fish stocks and especially in the number of juveniles, which are essential for the long term sustainability of coastal fisheries. On the other hand, the low education level of coastal fishers in Soc Trang and Bac Lieu, and their lack of awareness of (or access to information related to) climate change and pollution may lead them to underestimate the impact of climate change and pollution on fish stocks (Jönsson, 2019). Despite their perception that overfishing was a key factor in declining fish stocks and catches, many coastal fishers in Soc Trang and Bac Lieu nonetheless continue to use fishing gears and other fishing practices that are outside the limits imposed by authorities to ensure the sustainability of capture fisheries. This augurs badly for the sustainability of coastal fisheries resources and the longer-term economic well-being of coastal fishers in the region.

Cost-benefit analysis

Capital costs and depreciation

The capital costs for boat and fishing gear ranged from 5,364±2,727 USD·boat^{-1} for trawlers to 5,955±3,364 USD·boat^{-1} for gillnetters (Table 6). The average cost for the boat hull and engine was similar for gillnetters (395±259 USD·boat^{-1}) and stow-netters (337±191 USD·boat^{-1}), but somewhat higher for trawlers (464±273 USD·boat^{-1}), which tend to need larger engines (see Table 1) because they have to drag a heavy net across the sea bottom. In the case of nets, the average costs of gillnets (1,000±636 USD·set^{-1}) and stow-nets (932±591 USD·set^{-1}) were similar, but the average cost of trawls (341±182 USD·set^{-1}) was substantially lower (Table 6). Thus the hull and motor account for approximately 65 % of the capital cost for boats using gillnets and stow-nets, but over 85 % of the capital cost of boats using trawls. The overall average depreciation rate for boats equipped with gillnets (1,727±1,273 USD·year^{-1}·boat^{-1}) was over two-fold higher than that of boats equipped with stow-nets (682±364 USD·year^{-1}·boat^{-1}) and boats equipped with trawls (591±318 USD·year^{-1}·boat^{-1}) (Table 6), chiefly because gillnets are easily damaged and typically have to be replaced after 1-2 years.

Table 5. Rate of agreement (%) among coastal fishers on the different causes for low fish catches in the Soc Trang-Bac Lieu coastal region, and their rank in terms of importance.

Item	Gillnet fishers	Stow-net fishers	Trawl fishers	Rank
Overfishing (%)	62.5	67.5	45.0	1
Climate change (%)	27.5	20.0	40.0	2
Extreme* fishing gears (%)	7.5	2.5	5.0	3
Polluted coastal environment (%)	2.5	10.0	5.0	4

Note: *extreme fishing gears are those that catch fish of all sizes, such as trammel-nets or baited traps with very small mesh

Variable costs

Variable costs include fuel, wages, food, ice, repairs, and some other smaller miscellaneous costs. Of the average total variable cost for each day of a gillnetter (46.1±17.9 USD·day^{-1}), fuel accounted for 36 %, wages 32 %, food 16 %, repairs 8 %, ice 4 % and miscellaneous expenses 4 % of the total (Table 6). For stow-netters, the average total variable cost per day was 61.8±0.1 USD·day^{-1}, consisting of 39 % for fuel, 29 % for wages, 16 % for food, 8 % for repairs, 3 % for ice, and 5 % for miscellaneous expenses (Table 6). The average total variable cost for trawlers was 66.3±24.6 USD·day^{-1}, of which 58 % was for fuel, 14 % was for wages, 9 % was for food, 8 % was for repairs, 6 % was for ice, and 5 % was for miscellaneous expenses (Table 6).

In the past, employees were paid either in cash, or with a share of the catch (usually 10-20 % of total catch per employee), which was converted to cash when the catch was sold. However, nowadays, because of uncertainty about the size of the catch, most employees are paid directly in cash (usually 9.0-14.0 USD·day^{-1}).

Gross income, total costs, profit and rate of return

The average annual gross income of gillnetters was 12,727±5,318 USD·year^{-1}·boat^{-1}; with average costs of 8,364±4,227 USD·year^{-1}·boat^{-1}, their average annual profit was 4,364±3,409 USD·year^{-1}·boat^{-1}, yielding a rate of return of 0.52±0.8. Stow-netters, on the other hand, had a much lower average annual gross income (6,409±3,136 USD·year^{-1}·boat^{-1}) and, although their average annual costs (3,395±2,545 USD·year^{-1}·boat^{-1}) were also lower than those of gillnetters, they were the least profitable (1,773±1,000 USD·year^{-1}·boat^{-1}) of the three fishing methods. Despite their low profit, they still had a rate of return of 0.52±0.4, which was similar to that of gillnetters, but substantially higher than trawlers. The average annual gross income of trawlers was 12,727±6,227 USD·year^{-1}·boat^{-1}, similar to that of gillnetters, but they had significantly higher total costs (9,591±5,000 USD·year^{-1}·boat^{-1}) than gillnetters, and as a consequence were less profitable (3,136±2,000 USD·year^{-1}·boat^{-1}), with a very low rate of return (0.33±0.4) (Table 7).

Table 6. Fixed (capital) costs; variable costs and depreciation rate for gillnetters, stow-netters, and trawlers in the Soc Trang-Bac Lieu coastal region.

Item	Gillnetter (n = 40)	Stow-netter (n = 40)	Trawler (n = 40)
+ Total of fixed costs (USD·boat^{-1})	5,955±3,364	5,636±2,455	5,364±2,727
- hull and engine cost ((USD·year^{-1}·boat^{-1})	395±259; (63 %)	337±191; (67 %)	464±273; (87 %)
- fishing gear cost (USD·set^{-1})	1,000±636; (37 %)	932±591; (33 %)	341±182; (13 %)
+ Annual depreciation rate (USD·year^{-1}·boat^{-1})	1,727±1,273	682±364	591±318
+ Total of variable costs (USD·day^{-1})	46.1±17.9	61.8±0.1	66.3±24.6
- fuel (USD·day^{-1})	15.1±6.5; (36 %)	24.0±18.7; (39 %)	39.3±19.3; (58 %)
- wages (USD·day^{-1})	16.4±14.0; (32 %)	22.2±21.9; (29 %)	9.5±9.5; (14 %)
- food (USD·day^{-1})	7.4±4.8; (16 %)	8.4±5.1; (16 %)	5.0±4.2; (9 %)
- repairs (USD·day^{-1})	3.9±4.7; (8 %)	3.6±1.7; (8 %)	5.3±3.1; (8 %)
- ice (USD·day^{-1})	2.0±1.8; (4 %)	1.3±0.8; (3 %)	4.1±3.4; (6 %)
- miscellaneous expenses (USD·day^{-1})	1.5±0.8; (4 %)	2.2±2.0; (5 %)	3.1±4.5; (5 %)

Note: Values are mean±standard deviation for 40 boats of each net type

Table 7. Annual gross income, annual costs, annual profit, and rate of return per boat for gillnets, stow-nets, and trawls in the Soc Trang-Bac Lieu coastal region, Vietnam.

Item	Gillnet (n = 40)	Stow-net (n = 40)	Trawl (n = 40)
Gross income (USD·year^{-1}·boat^{-1})	12,727±5,318	6,409±3,136	12,727±6,227
Total costs (USD·year^{-1}·boat^{-1})	8,364±4,227	3,395±2,545	9,591±5,000
Profit (USD·year^{-1}·boat^{-1})	4,364±3,409	1,773±1,000	3,136±2,000
Rate of return (times)	0.52±0.8	0.52±0.4	0.33±0.4

Note: Values are mean±standard deviation for 40 boats of each net type

Of the three fishing methods we studied, gillnet fishing was by far the most profitable, chiefly because the price for fish species caught by gillnets was higher than that for fish caught by stow-nets and trawls, and because less trash fish were caught by gillnets compared to the other two methods. Nevertheless, the rate of return from coastal gillnet fishing in Soc Trang and Bac Lieu (0.52±0.8) was substantially lower than that reported for gillnet fishing in the entire Vietnamese Mekong Delta (Chi and Long, 2018), most likely because the fishers in our study were mostly artisanal and small scale, and because of lower fishery stocks and smaller catches along the coastlines of Soc Trang and Bac Lieu compared to elsewhere in the Mekong Delta.

Awareness of climate change and adaption strategies

Awareness of climate change

Only 45 % of the 120 fishers interviewed in this study said they had heard of climate change via mass media, but many of these did not have a clear understanding of climate change or its implications. For instance, only 35 % of all fishers interviewed thought that rainstorms had become more intense, only about 13 % thought that the frequency of typhoons was increasing, about 13 % said that the frequency of extremely hot weather was increasing, and less than 3 % were aware of the link between climate change and rising sea levels. In most cases, these views were related more to the intuition of the fishers rather than to any clear understanding of the issues involved or the impacts that climate change might have on coastal fisheries in the long term.

Adaptation strategies

The strategies of fisherfolk for adapting to climate change vary with geographical location and the nature of the fishery industry (Badjeck *et al*., 2010; Halls, 2011; King, 2015). In our study, most fishers believed that changing weather patterns associated with climate change had negative impacts on their life and livelihoods, but none had clearly formulated strategies to deal with the consequences of climate change. In the short term, when weather conditions were unsuitable for fishing at sea, around 50 % of fishers interviewed earned income from other fisheries activities like catching crabs or collecting snails and other benthic invertebrates, similar to the response of fishers in the Andaman Sea of Thailand (Panjarat, 2008). In the longer term, any further deterioration in the livelihoods of fishers is likely to be exacerbated by their poor understanding of the implications of climate change and their lack of strategies to deal with them. More general adaptive strategies to deal with adverse weather conditions included (i) maintaining and reinforcing their boats, (ii) investing in or improving existing marine safety equipment like lifebuoys, walkie-talkies, and GPS navigation devices, (iii) taking out insurance against navigation accidents, and (iv) checking the weather forecast before going out to fish. These could all be considered short-term measures to deal with unfavourable weather conditions, rather than long-term strategies to adapt their livelihoods to the consequences of climate change.

CONCLUSION

The capture fishery in near-shore waters along the coast of Soc Trang and Bac Lieu is artisanal and small-scale in nature, and is usually carried out using one of three kinds of fishing gear: gillnets, stow-nets, or trawls. Catches and income from fishing are declining, with severe adverse impacts on the livelihoods of fishers. We therefore suggest that Soc Trang and Bac Lieu collaboratively (i) make greater efforts to reduce overfishing, (ii) implement more comprehensive policies to protect and enhance coastal aquatic resources, (iii) proactively and as widely as possible disseminate information on climate change and advice on how to adapt to it, and (iv) provide development assistance to enable fishers to improve their livelihoods or find alternative ways to support their families.

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