Catch composition and risk assessment of two fishing gears used in small-scale fisheries of Bandon Bay, the Gulf of Thailand (#72547)

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Catch composition and risk assessment of two fishing gears used in small-scale fisheries of Bandon Bay, the Gulf of Thailand

Tuantong Jutagate [1] , **Amonsak Sawusdee** [Corresp. 2]

[1] Faculty of Agriculture, Ubon Ratchathani University, Warin Chamrab, Ubon Ratchathani, Thailand

[2] School of Science, Walailak University, Thasala, Nakhon Si Thammarat, Thailand

Corresponding Author: Amonsak Sawusdee
Email address: samonsak@wu.ac.th

We examined catch compositions and vulnerability of target- and bycatch- species in two fishing gears, namely the bottom-set gillnet and collapsible crab trap, used in small-scale fisheries of Bandon Bay, Suratthani Province, Thailand. Both gears mainly target the blue swimming crab (BSC) *Portunus pelagicus*, and together contribute about half of Thailand's annual BSC catch of around 2.5 thousand tonnes. Field sampling was conducted from January to November of 2018. Specimens from bottom-set gillnets and collapsible crab traps comprised 111 and 118 taxa, respectively. Of these, 26 and 27 crab species and 41 and 46 fish species were collected by gillnets and traps, respectively. The index of relative importance of BSC was higher in gillnets (48.8 ± 16.6%) than in traps (25.0 ± 15.5%), where another swimming crab (*Charybdis affinis*) was more common. Cluster analysis revealed that catch compositions were seasonal and differed between the two monsoon seasons and the transition period. Potential impact from both fishing gears on various stocks was assessed by standard productivity susceptibility analysis. Vulnerability scores of the BSC stock, as the main target species, suggested it was at moderate risk. The impacts of both gears to stocks of the other species in Bandon Bay showed either low or moderate risk. Ten fish stocks, including two stingrays, six species of sole and two other bony fishes, were near the threshold of high risk from gillnet fishing.

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Tuantong Jutagate[1] and Amonsak Sawusdee[2]

[1] Faculty of Agriculture, Ubon Ratchathani University, Warin Chamrab, Ubon Ratchathani, Thailand

[2] School of Science, Walailak University, Thasala, Nakhon Si Thammarat, Thailand

Corresponding author:

Amonsak Sawusdee

Thasala, Nakhon Si Thammarat 80161, Thailand

Email address: samonsak@wu.ac.th

Abstract

We examined catch compositions and vulnerability of target- and bycatch- species in two fishing gears, namely the bottom-set gillnet and collapsible crab trap, used in small-scale fisheries of Bandon Bay, Suratthani Province, Thailand. Both gears mainly target the blue swimming crab (BSC) *Portunus pelagicus*, and together contribute about half of Thailand's annual BSC catch of around 2.5 thousand tonnes. Field sampling was conducted from January to November of 2018. Specimens from bottom-set gillnets and collapsible crab traps comprised 111 and 118 taxa, respectively. Of these, 26 and 27 crab species and 41 and 46 fish species were collected by gillnets and traps, respectively. The index of relative importance of BSC was higher in gillnets (48.8 ± 16.6%) than in traps (25.0 ± 15.5%), where another swimming crab (*Charybdis affinis*) was more common. Cluster analysis revealed that catch compositions were seasonal and differed between the two monsoon seasons and the transition period. Potential impact from both fishing gears on various stocks was assessed by standard productivity susceptibility analysis. Vulnerability scores of the BSC stock, as the main target species, suggested it was at moderate risk. The impacts of both gears to stocks of the other species in Bandon Bay showed either low or moderate risk. Ten fish stocks, including two stingrays, six species of sole and two other bony fishes, were near the threshold of high risk from gillnet fishing.

Keywords: Bandon Bay, Bottom set gillnet, Collapsible crab trap, Index of relative importance, Productivity and susceptibility analysis

Introduction

The Gulf of Thailand (GoT) is one of the world's most productive large marine ecosystems, and it mostly lies within Thai territory. The total catch from the GoT was around 1.04 million tonnes in 2019, which represented 74% of the country's marine harvest and 42% of the total fisheries and aquaculture production for the year (*Fisheries Development Policy and Planning Division, 2021*). Although the primary fishing targets of marine capture are pelagic and demersal finfishes, three other aquatic animals support valuable fisheries: Indian squid *Uroteuthis duvauceli*, banana prawn *Penaeus merguiensis* and blue swimming crab (BSC) *Portunus pelagicus* (*Kulanujaree et al., 2020*). Marine fisheries can be characterized as commercial and small-scale fisheries (SSF), of which the latter contributed about 16% of the total marine harvest in Thailand (*Derrick et al, 2017*). *Lymer et al.* (*2008*) mentioned that while the commercial fisheries target multiple species with all gear types, SSF in Thailand, though inevitably capturing a mix of species, are more focused on their target species. This specialization is reflected by the names of the gear; for example, mackerel gillnet, squid falling net and shrimp trammel net. Among the gears used in SSF, two types target crabs, particularly BSC; these are bottom-set gillnets and collapsible crab traps. These two fishing gears, hereafter "gillnets" and "traps", are also used for BSC fisheries elsewhere in the south and in other countries of Southeast Asia (*Prince et al., 2020*). In Thailand, the material used for both gears is 2.5 inch (6.4 cm) stretched mesh. Gillnets contain several layers of this mesh, each layer with length of around 180 m and height of 1.25 m. Trap frames are made from aluminum wire with dimensions of 35 x 55 x 17 cm.

Bandon Bay (9° 20' 00" N, 99° 25' 00" E; Figure 1) is in Surat Thani Province, the south of Thailand, and home to more than 130 fish species and more than 210 species of other aquatic animals (*Sawusdee, 2010*). The bay's area is 477 km^2, with 120 km of coastline and mean depth of 2.9 m. Weather patterns are influenced by the northeast and southwest monsoons, which are present almost year-round. Its waters are very productive, owing in part to nutrient inputs from the Tapee River and 18 other river channels (*Jarernpornnipat et al., 2003*; *Sawusdee 2010*). A 2020 fisheries census in Bandon Bay reported 12,120 fishers, of which 65% were small-scale fishers, operating vessels smaller than 10 gross-tonnes and fishing within 3 nautical miles from shore. The total estimated catch from this bay in 2019 was 31,291 tonnes from almost 30 fishing gear types targeting various groups of aquatic animals (*Surat Thani Provincial Fisheries Office, 2020*). The substrate of mixed mud, clay and sand, as well as a beach that reaches up to 2 km into the sea, make the bay suitable for numerous crustaceans and other benthic invertebrates, which constitute about 45% of landings from Bandon Bay (*Sawusdee 2010*; *Plongon and Salaenoi, 2015*). This is why the crustaceans are heavily targeted by small-scale fisheries here and why Bandon Bay has become the primary fishing ground for this aquatic animal group. Of the annual total catch of BSC in Thailand, which averages around 2.5 thousand tonnes, approximately half is from the SSF in Bandon Bay (*Fisheries Development Policy and Planning Division, 2020*). Moreover, this fertile bay is suitable for blood cockle cultivation, and some areas of the bay are dominated by extensive coastal aquaculture of this clam (*Jarernpornnipat et al., 2003*; *Kritsanapuntu and Chaitanawisuti, 2019*).

Fishing gears used in SSF by their nature impact the near-shore ecosystem, where various species of fishes and other aquatic animals reside, either permanently or temporarily. Small-scale fisheries are mostly indiscriminate and may have wide variation in bycatch numbers and rates, and thus, inappropriate operation of these fisheries may negatively impact the abundance, distribution and species composition of vulnerable taxa (*Pinnegar and Engelhard, 2008*; *Chester and Michel, 2011*). Moreover, the SSF may indirectly impact the ecosystem through habitat degradation, which could cause in decline of megafauna, e.g., marine mammals, sea turtles and chondrichthyans (*Temple et al., 2018*). *Chester and Michel (2011)* reported that ecological impacts by SSF varied according to gear types and habitat characteristics, but that the small size of fishing vessels employed would limit the range of the impacted area. Though SSF are recognized as having low ecological impact on coastal marine resources (*Pauly, 2006*), they still require appropriate management. Importantly, ensuring the sustainable utilization of resources by these fisheries also means supporting the livelihoods and food security of local fishing households (*Smith et al., 2021*). Managing SSF, however, is quite complicated due to the complexity of fishing patterns. Also, neither catch nor effort from SSF is included in the official reporting system, making stock assessment difficult and imprecise (*Pita et al., 2019; Song et al., 2019*). Therefore, evaluation of the impact of fishing using a semi-quantitative approach (i.e., Level-2; *Hobday et al., 2011*) is recommended for SSF (*Pita et al., 2019*).

Similar to most of the small-scale fisheries elsewhere, data on the impacts of gillnets and traps in SSF in the Bandon Bay are incomplete, even though the fishery significantly contributes to the country's production of this BSC. Capacity to withstand fishing intensity varies by species (*Purcell et al., 2018*), thus, the vulnerability of both target species and non-target species must be known and integrated into fisheries management. This study, therefore, (i) examines the catch composition from gillnets and traps used by SSF in Bandon Bay, and (ii) evaluates the ecological risk of species vulnerable to each type of net. This work also complies with the UN's announcement of 2022 as Year of Artisanal Fisheries and Aquaculture and the indicator of UN-SDG-14 in securing sustainable small-scale fisheries.

Materials & Methods

Sampling stations and protocol

The Institute of Animals for Scientific Purposes Development gave approval for this research (U1-04118-2559). Field experiments were approved by the Agricultural Research Development Agency (public organization) (project number: PRP6405031070). Fourteen (14) sampling stations were established throughout Bandon Bay (Fig. 1). Sampling was conducted once a month in every sampling station, from January to November 2018, during a spring tide with the same sampling protocol. Sampling in December was skipped because of the effects of tropical cyclone "Plabuk". Gillnets and traps used in the field sampling are as explained in the Introduction. On each sampling day at 17:00, 3 tiers of gill nets and 90 traps were deployed at each sampling station and soaked for 12 hours before being recovered. All catches were taken back to the fish landing sites.

Catch composition analysis

Catches were ice-packed individually and taken back to Walailak University, 160 km from Bandon Bay. At the laboratory, the catches from each station and gear were identified taxonomically (in some cases only to genus or family level), and then weighed and counted. Taxonomy was based on *Nelson* (*2016*) and FishBase (*Froese & Pauly, 2021*) for fishes and *Carpenter and Neim* (*2001*) and SeaLifeBase (*Palomares & Pauly, 2021*) for other aquatic animals.

The index of relative importance (%IRI) (*Caddy & Sharp, 1989*) was used to express the contribution of individual species in the catches in each month, and calculated as

$$\%IRI = 100 \times {[(\%W_i + \%N_i) \times \%F_i]} \Big/ \left[\sum\left((\%W_j + \%N_j) \times \%F_j\right)\right]$$

where %W and %N are the percentages by weight and number of each species *i* in the total catch, %F is the percentage of occurrence of each species in the total sample, and the denominator is the total of all species *j*. Mann-Whitney U test was applied to examine whether the %IRI of BSC, i.e., the main target, was significantly different between gears. Similarity of the 20 species with highest %IRI for each gear among sampling months was graphically expressed by dendrogram cluster analysis, using Bray–Curtis dissimilarity matrix and average method. Analysis of similarity (ANOSIM) was used to test similarity among clusters. The data analysis was conducted using R (*R core team, 2021*).

Risk assessment

Productivity Susceptibility Analysis (PSA; *Hobday et al., 2011*), which is a practical semi-quantitative vulnerability assessment tool (*Hordyk & Carruthers, 2018*; *Lin et al., 2020*; *Faruque & Matsuda, 2021*) was used for assessing the risk of individual stocks from the BSC fisheries in Bandon Bay. The PSA applies two sets of attributes to characterize the fishery: (i) productivity, for determining the rate at which the species can recover from fishing and (ii) susceptibility, for determining the impact to the species caused by fishing. There were seven productivity attributes and four susceptibility attributes used in this study (Table 1; *FAO, 2014*). For each species, the information for each productivity attribute was from desk study of relevant reports from the GoT and from FishBase (www.fishbase.org; *Froese & Pauly, 2021*). In cases where age and size at maturity were not available but growth parameters were, the models were calculated using estimates of the attributes, as proposed by *Froese & Binohlan* (*2000*). Meanwhile, the information for each susceptibility attribute was from the observations and results of field sampling for catch composition, desk study, and meetings with experts (i.e., fishery scientists and fishers). The obtained information was converted to a rank score (Table 1; *FAO, 2014*), where 1 is high productivity or low susceptibility, 2 is medium productivity or susceptibility, and 3 is low productivity or high susceptibility (*Hordyk & Carruthers, 2018*). It is worth noting that the rank score for productivity attributes are adjusted to be suitable with tropical aquatic taxa (*FAO, 2014*). A focus group discussion among the researchers, fisheries scientists and fishers was conducted to discuss the rank scores of the catches, and in particular, maximum and maturity sizes, selectivity of gear types, as well as abundance and occurrence of individual species in the studied area. The total vulnerability (*V*) or risk score was then calculated by

$$V = \sqrt{P^2 + S^2}$$

where P is the overall productivity score (i.e., arithmetic mean of the productivity attributes) and S is the overall susceptibility score (i.e., geometric mean of the susceptibility attributes). The *V* score ranges between 1.41 and 4.24; values lower than 2.64 and above 3.18 are considered low- and high- vulnerability, respectively, while values in between indicate medium vulnerability (*Hobday et al., 2011*; *Hordyk & Carruthers, 2018*).

A data quality score (Table 2) was also estimated for each species for interpretation of the vulnerability scores (*Patrick et al., 2010*; *Ormseth & Spencer, 2011*). The mean quality score of P and S was interpreted as high (< 2), medium (≥2 and <3), or low (≥3). Difference in *V* scores between the two fishing gears for each species (or higher taxon) was tested by Mann-Whitney U test. All statistical tests were conducted by using R (*R core team, 2021*).

Results

There were 111 and 118 species of fish and other aquatic animals caught by gillnets and traps, respectively (Table 3). No endangered, threatened or protected (ETP) species were included in the catch composition throughout the study. Similar groups of marine invertebrates were caught in both fishing gears, albeit with some difference at genus or species levels. There were 26 and 27 crab species caught by gillnets and traps, respectively. Other marketable aquatic animals caught by both gears included gastropods, bivalves, cephalopods, mantis shrimps and sea cucumbers. Over 40 fish species were collected throughout the study (41 by gillnets and 46 by traps). Interestingly, sting rays were caught only by gillnets, while gobies were found only in traps. In total, the sampled animals comprised 7,880 individuals with a weight of 246,747 g. Catch compositions by percentages in numbers and weight are shown in Figure 2, meanwhile percentages of individual species are presented in Table 3.

The five most commonly caught species by number in gillnets were gastropod *Murex* sp. (26.6%), followed by BSC (22.2%), crab *Dorippe quadridens* (7.0%), sea urchin *Temnopleurus toreumaticus* (6.5%) and crab *Macrophthalmus* sp. (4.9%). Meanwhile, three out of the five most common species in traps were crabs, *Charybdis affinis* (37.2%), BSC (11.1%), and *D. quadridens* (4.1%), followed by *T. toreumaticus* (1.6%) and hermit crab *Clibanarius infraspinatus* (1.6%). In terms of weight, BSC was ranked first for both gears, and contributed over 50% in gillnets and about 27% in traps. Another species of swimming crab, *C. affinis*, was also common in traps; if its weight was added with BSC, their sum would represent over 50% of the catch. Notably, the two species in each gear with the highest overall mean %IRI had values over 15%; meanwhile, the remaining taxa were less than 5% (Table 3). Overall means (± SD) of %IRI for BSC in gillnets (48.8 ± 16.6%) and traps (25.0 ± 15.5%) were statistically different (Mann-Whitney U test, P = 0.005. Figure 3). Dendrogram clusters for each month showed that BSC was by far the dominant species in terms of %IRI in gillnets, followed by *Murex* sp. (Figure 4a). However, in traps, *C. affinis* was ranked first in %IRI, followed by BSC (Figure 4b). Catch compositions differed seasonally and were separated into three distinct clusters for each gear (ANOSIM, P = 0.02). Higher numbers of species were found in the catch during summer (March to April) in both gears. For gillnets, BSC dominated the catches during the northeast monsoon (October to February), while *Murex* sp. showed higher %IRI during the southwest monsoon (May to September). Meanwhile, highest %IRI for BSC in traps was observed during the southwest monsoon.

Data quality scores for the productivity attributes ranged between 1.0 and 4.0, with an average of 1.8 ± 1.4, implying relatively high quality of information used to interpret the vulnerability of stocks of fish and other aquatic animals by both fishing gears in SSF of Bandon Bay. Vulnerability (*V*) scores of individual species for both gears are presented in Table 3. The overall *V* score ranged from 1.81 to 3.16 (2.78 ± 0.28) for gillnets and from 1.70 to 2.93 (2.29 ± 0.33) for traps. Results indicated that the BSC was moderately at risk (*V* = 2.86) from both fishing gears, for which the *P* and *S* scores were 1.14 and 2.62, respectively. Eighty (80) species were at moderate risk from the gillnet fishery; meanwhile, the majority of species that are catchable by trap (96 out of 118 stocks) faced low risk from the trap fishery. Although no species were rated as high risk from either gillnets or traps in SSF of Bandon Bay, there were 10 fish species with high *V* scores (i.e., near the threshold of 3.18) in the gillnet fishery. These included two elasmobranchs (*Himantura imbricate* and *Maculabatis gerrardi*), two bony fishes (*Muraenesox cinereus* and *Hexanematichthys sagor*) and two families of soles (Family Soleidae and Cynoglossidae). A graphical PSA of selected individual stocks and stock-groups from gillnet and trap fisheries in Bandon Bay is presented in Figure 5. Results (Figure 6) revealed that there were non-significant differences between gears in levels of risk to bivalves (Mann-Whitney U test, P-value = 0.55), cephalopods (Mann-Whitney U test, P-value = 0.47) and mantis shrimp (Mann-Whitney U test, P-value = 0.05). However, significant differences were found for gastropods (Mann-Whitney U test, P-value < 0.001), prawns (Mann-Whitney U test, P-value = 0.04), crabs (Mann-Whitney U test, P-value < 0.001), sea cucumbers (Mann-Whitney U test, P-value = 0.03), and bony fishes ((Mann-Whitney U test, P-value <0.01)), for which more risk was found from the gillnet fishery. By averaging the *V* scores of both fishing gears (Table 3), results revealed that 57 taxa were at medium risk, i.e., *V* scores between 2.64 and 3.18, from the SSF of Bandon Bay.

Discussion

Risks by SSF are overlooked in assessments, which generally focus on commercial fisheries. This is unsurprising, as the uneven history of fisheries science was not conceived for multi-species SSF (*Smith et al., 2021*). Similar to most of the small-scale coastal fisheries elsewhere in the tropics, catches from the SSF of Bandon Bay are multi-species due to the productivity of the area and diversity of aquatic animals inhabiting this fishing ground. The roughly 100 species captured from both fisheries in Bandon Bay is considerably lower than the 170 species collected from the gillnet SSF in Pattani Bay, lower Gulf of Thailand, due to a much higher number of fish species in those catches (*Fazrul et al., 2015*). Meanwhile, there were 45 and 77 species of fishes and other aquatic animals collected from gillnet and trap SSF (which also target BSC) at Phu Quoc Island, Vietnam (*Ha et al., 2015*); however, no bivalves, starfish, mantis shrimp, horseshoe crabs or sea cucumbers were mentioned in the report. The number of crab species in SSF in Thai waters has ranged between 17 and 27. Besides *Portunus* spp., the mud crab *Scylla* spp. and crab *Charybdis* spp. are also market-valued species and can be caught in substantial numbers, comparable to BSC (*Fazrul et al., 2015*; *Kunsook & Dumrongrojwatthana, 2017*; this study). It is also clear that the fishes being caught in both SSF in Bandon Bay are mostly demersal species, as is the case with traps and bottom gillnets in fisheries elsewhere (e.g., *Fazrul et al., 2015*; *Ha et al., 2015*; *Öndes, Kaiser & Murray, 2018*). Attempts to reduce the non-targeted catch in these two fishing gears include a proposal to not allow gillnets to be operated in near-shore areas for a fishery in Indonesia (*Supadminingsih et al., 2018*). *Boutsan et al.* (*2009*) reported that a trap with escape vents could potentially reduce the number of non-target species; however, the number of the targeted BSC captured by the trap with escape vents was about three times lower than the conventional one, which would likely not be accepted by fishers.

Crabs, in particular BSC, remained a high proportion of the catch in both gears throughout the study period in Bandon Bay. The peak BSC catch in BSC fisheries in South Sulawesi, Indonesia, was observed from May to September and not during the two rainy seasons, which are from January to April and from November to December (*Wiyono & Ihan, 2018*). In this study, the %IRI of BSC in traps dropped during the northeast monsoon (November to February); meanwhile, %IRI of BSC in gillnets dropped from April to June. Because Bandon Bay is relatively shallow, water turbulence during the monsoon would make the crabs and other aquatic animals less gregarious and increase habitat rugosity, factors which are both negatively correlated with catchability by traps (*Robichaud et al., 2000*). Moreover, the turbulence itself might place the trap in an inappropriate position, in particular the entrance, and lead to lower catches of all species quantitatively and qualitatively. Gillnets, on the other hand, would still continue to function during the monsoon season due to the length of the nets and no significant difference in catches by different hanging ratio of the net (*Gray et al., 2005*). The higher number of species captured during summer in both gears, though many were non-target species, could be due in part to the good conditions for fishing operations. Variation in species composition between the monsoon and non-monsoon seasons were also observed in gillnets and traps in the lower and eastern Gulf of Thailand, respectively (*Fazrul et al., 2015*; *Kunsook & Dumrongrojwatthana, 2017*). Fewer fish species in catches during the monsoon could be caused by freshwater discharge to the bay, which forces marine fishes further offshore (*Jutagate et al., 2010*; *2011*).

Using PSA to assess the impacts of fisheries to fish stocks has increased recently, in particular for multi-species fisheries, where information on stock status of non-targeted species is always lacking or limited (*Hordyk & Carruthers, 2018*; *Lin et al., 2020*; *Faruque &Matsuda, 2021*). Although several attributes have been added to PSA recently, such as in extended PSA (*Hordyk & Carruthers, 2018*) and revised PSA (*Grewelle et al., 2020*), we chose to use the standard PSA (*Hordyk & Carruthers, 2018*) in this study since we were able to integrate available attribute data with local knowledge from fishers. Their knowledge is very crucial for the susceptibility attributes and also useful for identifying important local differences in stock susceptibility to fishing (*Jara et al., 2022*). *Robinson et al.* (*2014*) reported a good understanding and homogenous knowledge of susceptibility to fishing gears displayed by fishers that operate the same fishing gear, have access to the same fishing ground and have similar economic background. Moreover, rank scores of susceptibilities generated from documents, by the research team, and by other scientists were identical. For productivity attributes, *Lin et al.* (*2020*) mentioned that although maximum size and size at 50% maturity may show autocorrelation, they must both be kept in the model since they describe distinctly different biological components of a species' life history. The data quality scores for these attributes of fishes, BSC and some other aquatic animals (e.g., mud crab, prawns, sea cucumbers, some fishes) were available because of their market value, and hence, have received more study. However, as in other tropical marine fisheries, data quality scores were limited for species with little or no market value (*Lin et al., 2020*; *Faruque & Matsuda, 2021*).

Gillnets and traps cause considerably lower holistic environmental impacts than active fishing gears (*Uhlmann & Broadhurst, 2015*). Vulnerability of the BSC stock, as the main targeted species, to gillnets and traps in SSF of Bandon Bay was at a moderate level and similar to the BSC stock of Phu Quoc Island, Vietnam (*Ha et al., 2015*). Meanwhile, the stocks of fishes and other aquatic animals in Bandon Bay were more vulnerable to gillnets than traps. This is due to the fact that the discard mortality by gillnets is relatively high, with a reported mean of about

40% across the range of species, and considerably lower in traps (*Uhlmann & Broadhurst, 2015*). The low to moderate risk found for almost all species is likely due to their potential to recover their stocks, with recovery capacity ranges between 1 and 5 years for most tropical fishes (*Mohamed & Veena, 2016*). *Mohamed et al.* (*2021*) reported that most of the fish stocks along the coast of India were resilient-yet-vulnerable, and most crustaceans showed high resilience. Higher vulnerability of the two stingrays in this study is due to their life history; like most elasmobranchs, they have low fecundity, exhibit ovoviviparity, and are carnivorous (*Frisk et al., 2001*; *Mohamed et al., 2021*). Productivity attributes also make *M. cinereus* and *H. sagor* more vulnerable because of their elongate form with high maximum size and trophic level for the former and low fecundity, late maturity and carnivorous diet of the latter (*Kottelat, 2013*; *Sang et al., 2019*; *Froese & Pauly, 2021*). On the other hand, high risk to soles by gillnets is largely caused by their susceptibility, resulting in either moderate or high risk scores for all attributes.

A mesh size regulation (not less than 2.5 inch) is currently applied to both fishing gears. Other relevant measures to both SSF in Bandon Bay are a spatial closure and efforts at stock enhancement. The goal of the spatial closure is to create fishery refugia, and was established at Sed Island in 2021 (Figure 1). It is an attempt to restore the stocks of many species in Bandon Bay, because the area is important nursery habitat for a number of fishes and other aquatic animals, including the BSC (*Thongkhao, 2020*). In terms of enhancement, stocking has focused on the BSC through the "crab bank" project to preserve and disperse eggs post capture. The aim is to increase recruitment of BSC, which consequently sustains the gillnet and trap SSF in Bandon Bay

Conclusions

In Bandon Bay, over 100 species of fishes and other aquatic animals were caught in gillnets and traps, confirming the high productivity of this fishing ground and the multi-species nature of the SSF. Significantly higher %IRI of BSC compared to other species in both gears almost year-round suggest an abundance of BSC and the relative specificity of the gears. The PSA indicated low to moderate risk from BSC fisheries to the stocks of other species in the catches, implying that both fishing gears are less impacted and appropriate in SSF of the Bandon Bay Nevertheless, risk may be underestimated by applying PSA, as cautioned by *Grewelle et al.* (*2020*), and this should be taken into consideration when implementing the results for fisheries management. Catch monitoring and stock assessment of both targeted and non-targeted species should be regularly conducted (*Lin et al., 2019*; *Prince, 2020*). Impacts from other stressors (e.g., climate change, sea ranching and land uses) should be taken into consideration to sustain the fishery resources and the fisheries in Bandon Bay.

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Conflict of interest

The authors declare no competing interests.

Author contribution

TJ and AS equally contributed in Conceptualization, Methodology, Analysis, Visualization, Original Draft, Writing –Review & Editing and Funding Acquisition.

Data Availability

The datasets generated for this study are available upon request to the corresponding author.

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Location and map of Bandon Bay, Surratthani, Thailand. Red dots indicate sampling sites, where fishing gears were deployed.

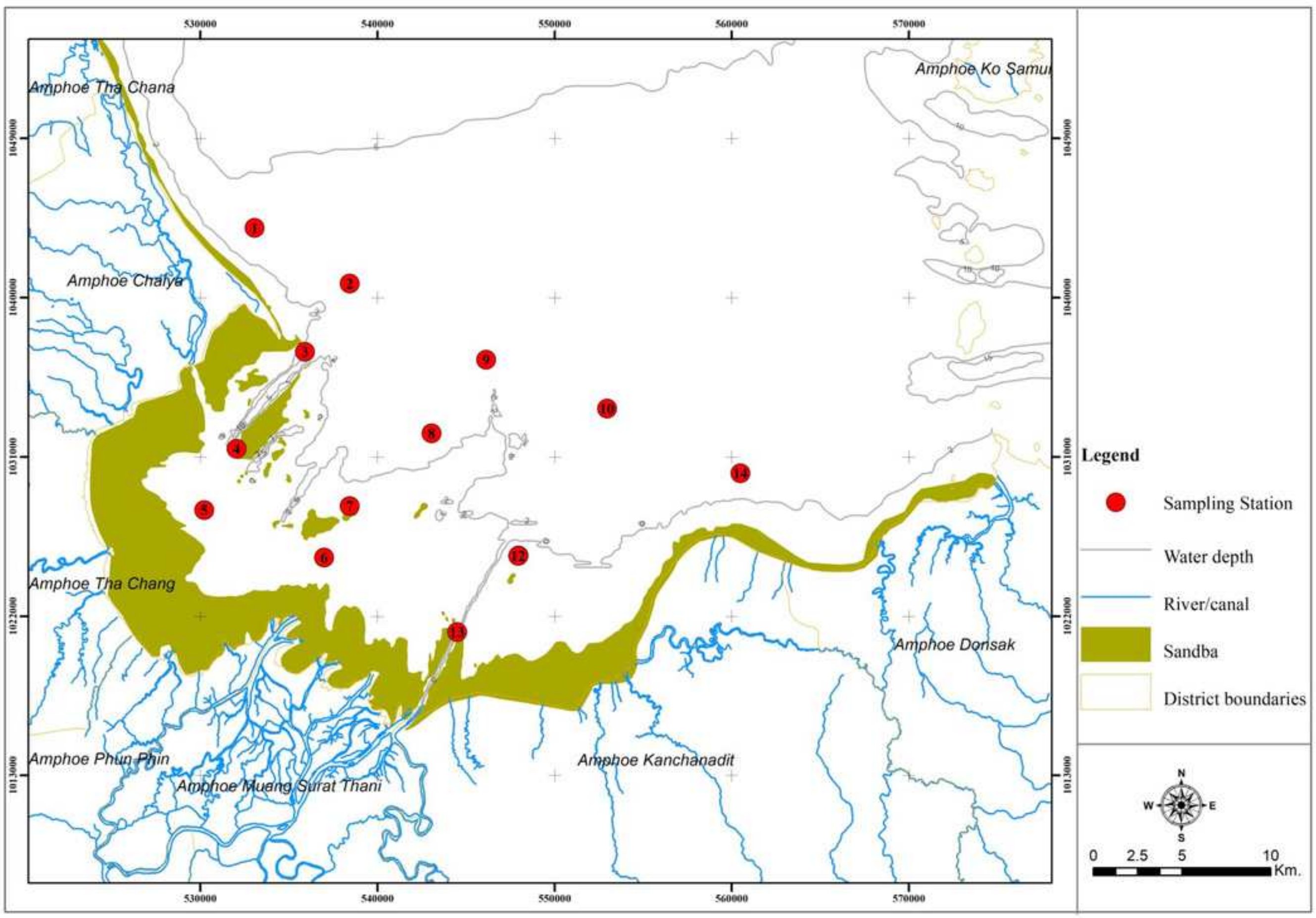
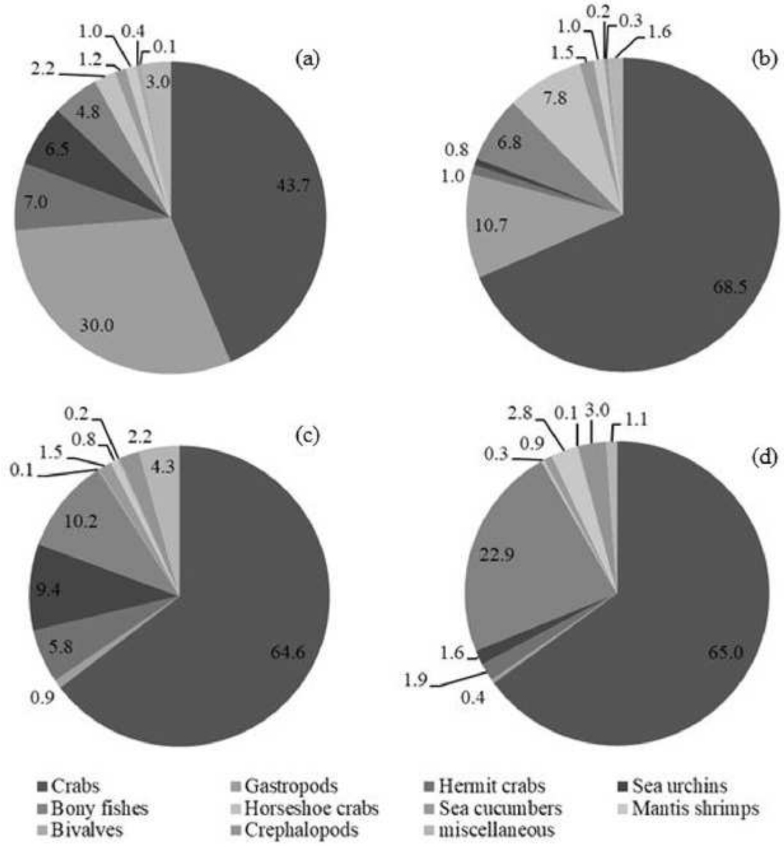


Figure 2

Catch composition by percentages of (a) number and (b) weight in bottom-set gillnets and by percentages of (c) number and (d) weight in collapsible crab traps in Bandon Bay, Surratthani, Thailand.



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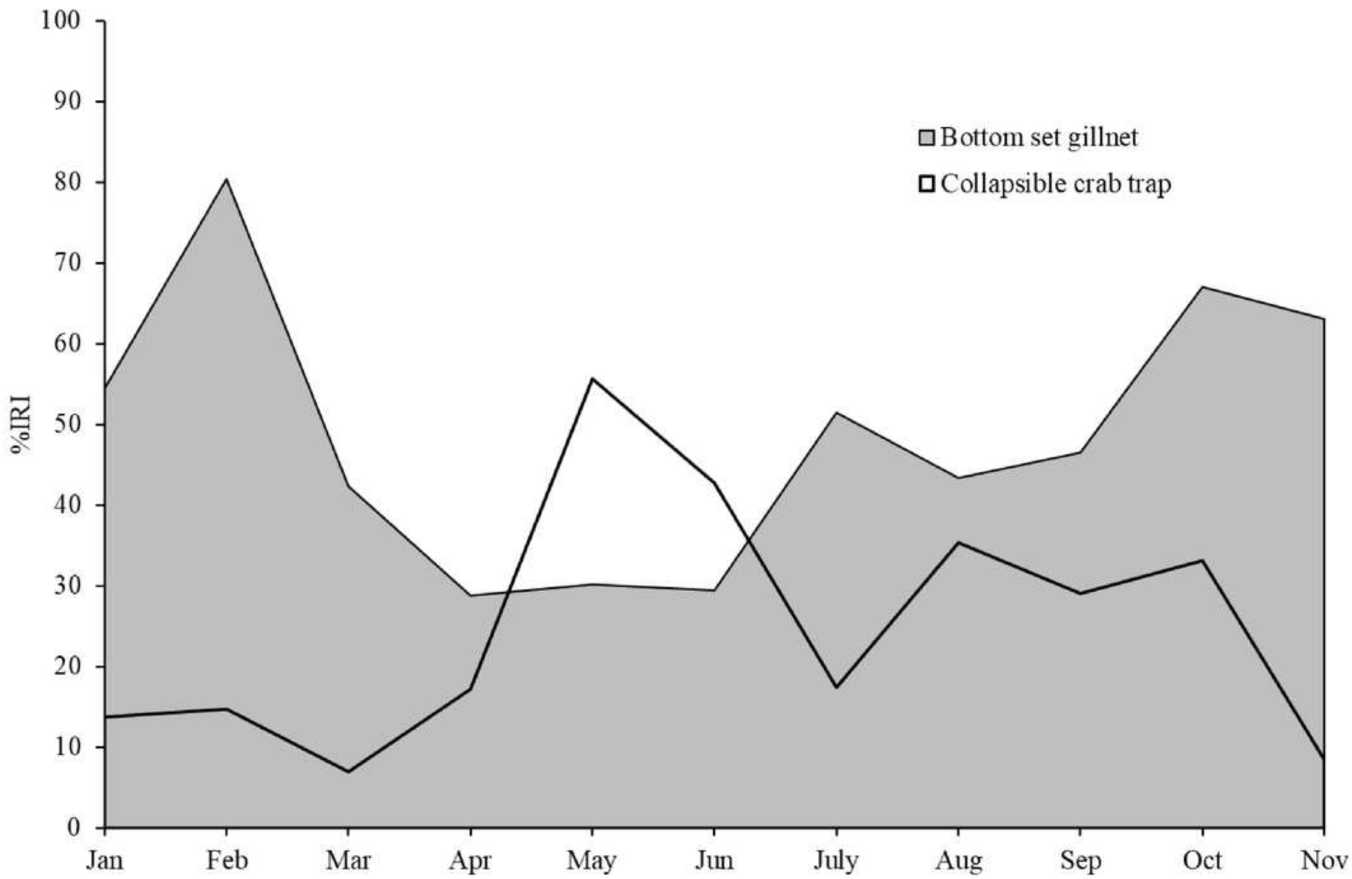

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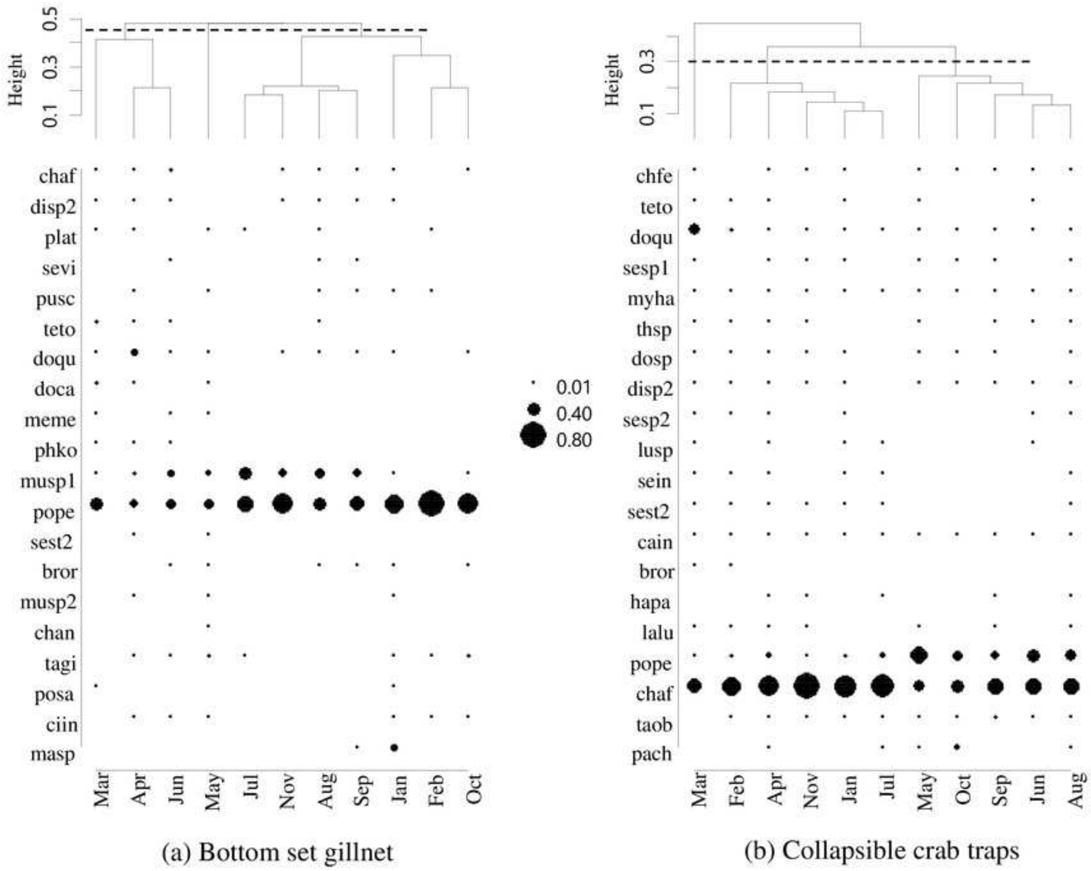
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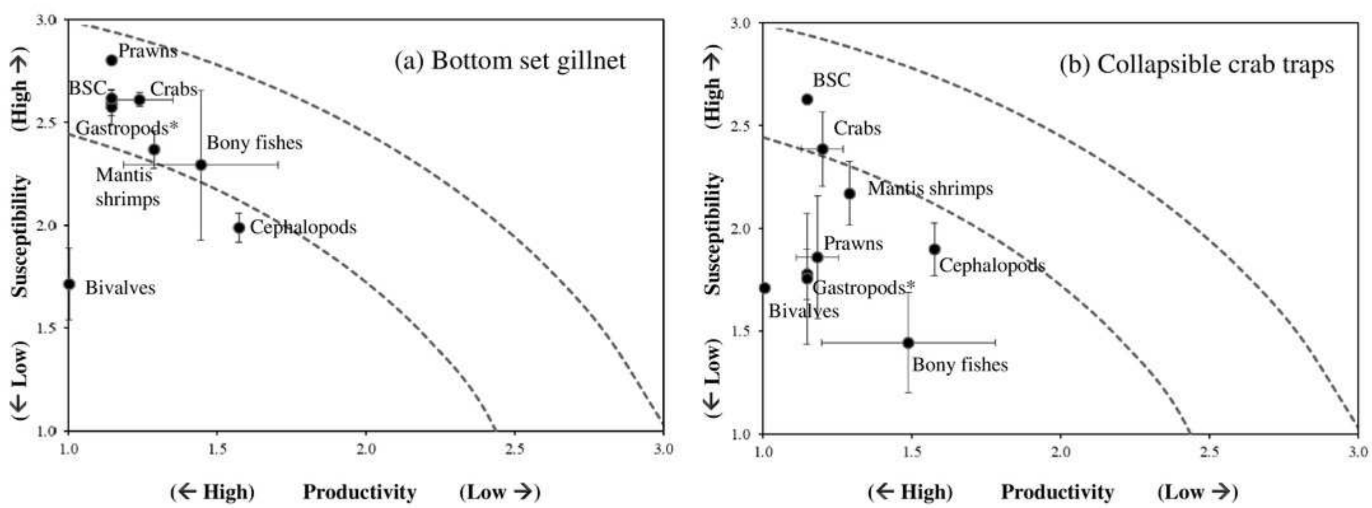
(b) Collapsible crab traps

Figure 5

Productivity-susceptibility plot for blue swimming crab and other catch-groups by (a) bottom-set gillnets and (b) collapsible crab traps in Bandon Bay, Surratthani, Thailand. Lines indicate standard deviations of productivity and susceptibility attributes



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Box-plots showing the vulnerability scores between two fishing gears for each group of aquatic animals. Gillnet = bottom-set gillnet and Trap = collapsible crab trap. Number in parentheses is the P-value from Mann-Whitney U test.

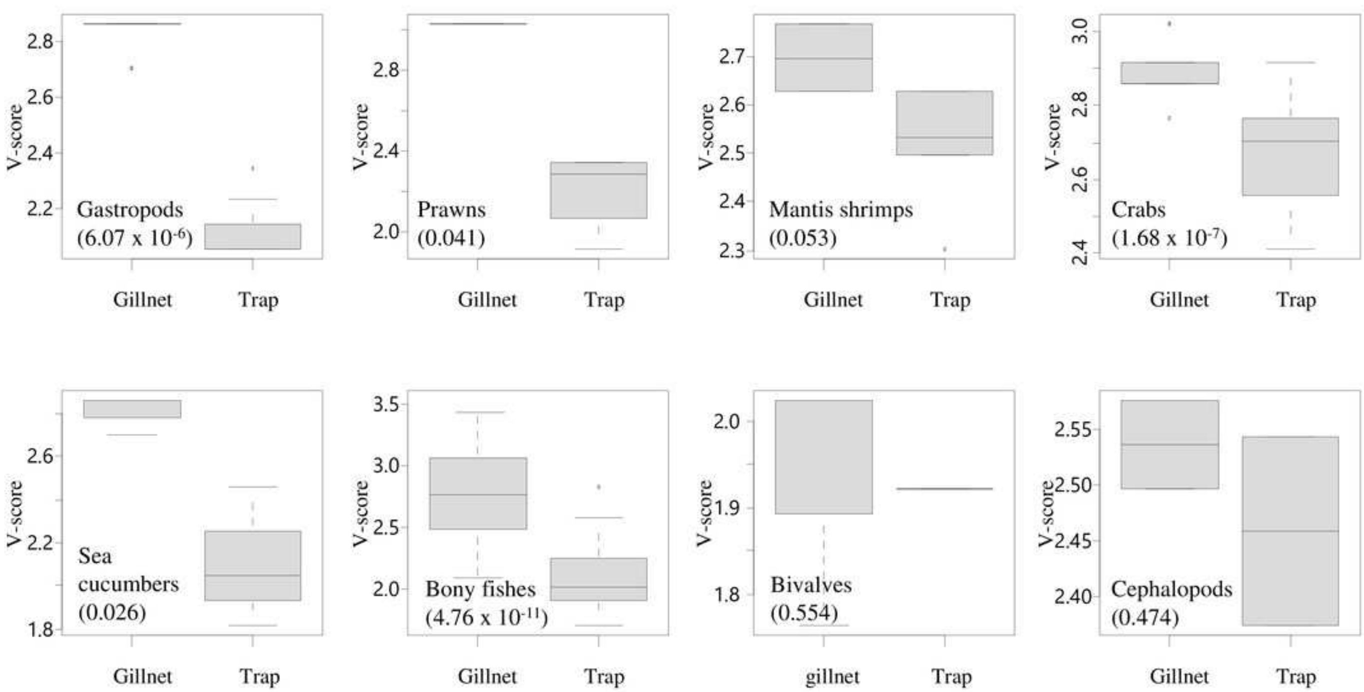

Table 1(on next page)

List of attributes used for Productivity Analysis (a) and Susceptibility Analysis (b) of the BSC fisheries in Bandon Bay.

Table 1 List of attributes used for Productivity Analysis (a) and Susceptibility Analysis (b) of the BSC fisheries in Bandon Bay.

a) Productivity

Productivity attributes	Productivity / Risk		
	Low productivity / High risk (Score = 3)	**Medium productivity/ Medium risk (Score = 2)**	**High productivity/ Low risk (Score = 1)**
Average age at maturity (years)	> 4	2 to 4	< 2
Average maximum age (years)	>30	10 to 30	< 10
Fecundity (eggs/spawning)	< 1,000	1,000 to 10,000	> 10,000
Average maximum size (cm)	> 150	60 to 150	< 60
Average size at maturity (cm)	> 150	30 to 150	< 30
Reproductive strategy	Live bearer, mouth brooder or significant parental investment	Demersal spawner or "berried"	Broadcast spawner
Mean trophic level	> 3.25	2.5 – 3.25	< 3.25

b) Susceptibility

Susceptibility attributes	Susceptibility / Risk		
	High risk (Score = 3)	**Medium risk (Score = 2)**	**Low risk (Score = 1)**
Availability I: Overlap of adult species range with fishery	> 50% of stock occurs in the area fished	25% and 50% of stock occurs in the area fished	< 25% of stock occurs in the area fished
Availability II: Distribution	Only in the country/ fishery	Limited range in the region	Throughout the region / global
Encounterability I: Habitat	Habitat preference of species make it highly likely to encounter gears	Habitat preference of species make it moderately likely to encounter gears	Depth or distribution of species make it unlikely to encounter gears
Encounterability II: Depth range	High overlap with fishing gears	Medium overlap with fishing gears	Low overlap with fishing gears
Selectivity	Species >2 times mesh size	Species 1 or 2 > mesh size	Species < mesh size or too large to be selected
Post capture mortality	Probability of survival <33 %	Between 33 % and 67 % probability of survival	Probability of survival > 67 %

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Table 2(on next page)

Rank scores for data quality used for the Productivity-Susceptibility Analysis of the small-scale fisheries in Bandon Bay, Suratthani, Thailand (adapted from Faruque and Matsuda, 2021).

Table 2 Rank scores for data quality used for the Productivity-Susceptibility Analysis of the small-scale fisheries in Bandon Bay, Suratthani, Thailand (adapted from Faruque and Matsuda, 2021).

Score	Data quality	Description
1	Best data	Information is based on collected data for the stock and area of interest that is established and substantial
2	Adequate data	Information is based on limited coverage and corroboration, or for some other reason is deemed not as reliable as tier-1 data
3	Limited data	Estimates with high variation and limited confidence, and may be based on studies of similar taxa or life history strategies
4	Very limited data	Information based on expert opinion or general literature reviews from a wide range of species, or from outside of region, or data derived by equation using the correlated life history parameters
5	No data	No information available

Table 3 (on next page)

List of taxa captured, their contribution in catches and risks in the small-scale fisheries of the Bandon Bay, Thailand

Table 3 List of taxa captured, their contribution in catches and risks in the small-scale fisheries of the Bandon Bay, Thailand

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
Sea Anemone	Sea animone (unidentified)	0.30	0.03	0.13	0.01	0.05	0.01	NA	4.14	1.26	NA	1.26	NA
Gastropods	*Doxander vittatus*	0.04	< 0.01	NA	NA	0.01	NA	1.14	3.57	2.62	2.86	NA	NA
	Bufonaria crumena	0.22	0.12	NA	NA	0.10	NA	1.14	3.57	2.62	2.86	NA	NA
	Natica vitellus	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.14	2.57	NA	NA	1.70	2.05
	Lataxiena blosvillei	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.14	3.57	NA	NA	1.70	2.05
	Murex trapa	0.04	0.01	NA	NA	0.02	NA	1.14	2.57	2.62	2.86	NA	NA
	Murex sp.1	26.60	4.23	0.07	0.02	17.69	< 0.01	1.14	2.57	2.62	2.86	1.70	2.05
	Murex sp.2	1.09	0.38	0.02	0.01	0.40	< 0.01	1.14	2.57	2.62	2.86	1.91	2.23
	Indothais sp.	0.22	0.04	0.48	0.05	0.07	0.01	1.14	2.57	2.45	2.70	1.70	2.05
	Rapana rapiformis	0.04	0.10	NA	NA	0.01	NA	1.14	2.57	2.62	2.86	NA	NA
	Nassaria pusilla	0.09	< 0.01	0.23	0.11	0.01	0.01	1.14	3.71	2.62	2.86	1.70	2.05
	Nassarius siquijorensis	NA	NA	0.04	0.02	NA	< 0.01	1.14	3.71	NA	NA	1.70	2.05
	Hemifusus sp.	0.43	0.35	0.04	0.03	0.19	< 0.01	1.14	3.14	2.62	2.86	2.04	2.34
	Pugilina Schumacher	0.96	2.64	0.02	0.03	1.46	< 0.01	1.14	3.14	2.62	2.86	1.70	2.05
	Pleuroploca sp.	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.14	3.71	NA	NA	1.91	2.23
	Cymbiola nobilis	0.04	0.89	0.02	0.11	0.16	< 0.01	1.14	1.86	2.45	2.7	1.70	2.05
	Melo melo	0.17	1.91	NA	NA	0.40	NA	1.14	1.86	2.62	2.86	NA	NA

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
Bivalves	*Anadara inaequivalvis*	0.09	0.13	0.11	0.08	0.04	< 0.01	1.00	2.71	1.82	2.07	1.70	1.97
	Tegillarca nodifera	0.30	0.03	0.09	0.02	0.07	< 0.01	1.00	2.71	1.82	2.07	1.70	1.97
	Chlamys sp.	NA	NA	0.02	< 0.01	NA	< 0.01	1.00	3.14	NA	NA	1.70	1.97
	Mimachlamys sp.	0.04	0.01	0.02	< 0.01	0.01	< 0.01	1.00	2.57	1.51	1.81	1.70	1.97
Cephalopods	*Sepia* sp.1	0.09	0.26	0.66	1.17	0.05	0.15	1.57	1.71	2.04	2.57	2.00	2.54
	Sepia sp.2	NA	NA	0.36	0.70	NA	0.08	1.57	1.71	NA	NA	2.00	2.54
	Sepiella inermis	NA	NA	1.17	1.08	NA	0.56	1.57	1.71	NA	NA	1.78	2.37
	Octopus sp.	0.04	0.02	0.04	0.10	0.01	< 0.01	1.57	1.57	1.94	2.5	1.78	2.37
Horseshoe crabs	*Carcinoscorpius rotundicauda*	0.35	0.54	< 0.01	< 0.01	0.24	< 0.01	1.71	2.14	2.45	2.99	NA	NA
	Tachypleus gigas	1.87	7.30	0.05	0.32	4.78	0.02	1.71	2.14	2.62	3.13	1.70	2.41
Mantis shrimps	*Harpiosquilla harpax*	0.26	0.48	0.47	1.59	0.18	0.24	1.29	1.86	2.45	2.77	1.91	2.30
	Harpiosquilla raphidea	0.04	0.09	0.13	0.47	0.03	0.02	1.29	1.86	2.29	2.63	2.14	2.50
	Oratosquillina interrupta	0.35	0.18	0.09	0.64	0.12	0.01	1.29	1.86	2.29	2.63	2.29	2.63
	Oratosquilla nepa	0.39	0.24	0.05	0.07	0.31	< 0.01	1.29	1.86	2.45	2.77	2.18	2.53
	Oratosquilla woodmasoni	NA	NA	0.04	0.01	NA	< 0.01	1.29	1.86	NA	NA	2.29	2.63
	Thenus indicus	0.13	0.31	NA	NA	0.17	NA	1.29	3.43	2.62	2.92	NA	NA
Prawns	*Metapenaeus* sp.	NA	NA	0.04	< 0.01	NA	< 0.01	1.14	1.14	NA	NA	2.04	2.34
	Penaeus semisulcatus	< 0.01	< 0.01	0.04	0.01	< 0.01	< 0.01	1.1	1.14	2.80	3.03	1.91	2.23

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
								4					
	Penaeus silasi	NA	NA	0.07	0.04	NA	< 0.01	1.14	1.14	NA	NA	2.04	2.34
	Macrobrachium rosenbergii	NA	NA	0.02	0.06	NA	< 0.01	1.29	1.14	NA	NA	1.41	1.91
Hermit crabs	*Diogenes* sp.1	1.13	0.06	1.04	0.23	0.36	0.19	1.29	2.71	2.62	2.92	2.18	2.53
	Diogenes sp.2	4.65	0.37	0.30	0.02	2.33	0.03	1.29	2.71	2.62	2.92	2.04	2.41
	Clibanarius infraspinatus	1.17	0.53	4.30	1.57	0.55	0.96	1.29	2.71	2.45	2.77	2.45	2.77
	Dardanus lagopodes	NA	NA	0.13	0.07	NA	< 0.01	1.29	2.71	NA	NA	2.29	2.63
Crabs	*Dorippe quadridens*	7.04	1.78	10.77	4.08	4.52	4.92	1.14	2.00	2.62	2.86	2.45	2.70
	Neodorippe callida	NA	NA	0.02	< 0.01	NA	< 0.01	1.14	2.16	NA	NA	2.29	2.56
	Seulocia vittata	1.74	0.2	0.39	0.02	0.66	NA	NA	4.00	2.62	NA	2.45	NA
	Matuta planipes	0.04	0.05	0.22	0.20	0.02	0.01	1.29	2.29	2.62	2.92	2.04	2.41
	Matuta victor	< 0.01	< 0.01	0.22	0.13	< 0.01	0.02	1.29	2.29	2.62	2.92	2.04	2.41
	Doclea armata	0.30	0.10	0.30	0.03	0.09	0.04	1.14	2.86	2.62	2.86	2.62	2.86
	Doclea canalifera	0.65	1.33	0.34	0.29	1.28	0.04	1.14	2.86	2.62	2.86	2.62	2.86
	Doclea rissoni	NA	NA	0.13	0.11	NA	0.01	1.14	2.86	NA	NA	2.45	2.70
	Doclea sp.	0.26	0.16	0.95	0.72	0.08	0.16	1.14	2.86	2.62	2.86	2.18	2.46
	Galene bispinosa	0.26	0.41	0.02	0.07	0.17	< 0.01	1.29	4.00	2.62	2.92	2.18	2.53
	Halimede ochtodes	0.26	0.17	NA	NA	0.15	NA	1.29	4.00	2.62	2.92	NA	NA

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
	Rhinolambrus sp.	0.70	0.26	NA	NA	0.21	NA	NA	4.14	2.62	NA	NA	NA
	Lupocycloporus gracilimanus	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.14	1.00	NA	NA	2.45	2.70
	Portunus haanii	0.04	0.01	< 0.01	< 0.01	0.01	< 0.01	1.14	1.00	2.62	2.86	2.62	2.86
	Portunus pelagicus	22.21	58.65	11.08	26.84	48.85	24.98	1.14	1.00	2.62	2.86	2.62	2.86
	Portunus sanguinolentus	0.48	1.08	0.13	0.09	0.46	0.02	1.14	1.00	2.62	2.86	2.45	2.7
	Scylla olivacea	NA	NA	0.04	0.65	NA	0.01	1.14	1.00	NA	NA	2.45	2.7
	Xiphonectes hastatoides	0.04	0.01	NA	NA	0.01	NA	1.14	1.00	2.62	2.86	NA	NA
	Charybdis affinis	3.52	1.52	37.16	24.14	1.98	56.61	1.29	1.86	2.45	2.77	2.62	2.92
	Charybdis anisodon	0.74	0.29	0.32	0.15	0.47	0.04	1.29	1.86	2.62	2.92	2.18	2.53
	Charybdis feriata	0.13	0.46	0.91	3.82	0.15	0.68	1.29	1.86	2.62	2.92	2.45	2.77
	Charybdis natator	0.09	0.31	NA	NA	0.09	NA	1.29	1.86	2.62	2.92	NA	NA
	Charybdis truncata	NA	NA	0.02	< 0.01	NA	< 0.01	1.29	1.86	NA	NA	2.62	2.92
	Thalamita crenata	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.14	1.86	NA	NA	2.29	2.56
	Thalamita spinimana	0.04	0.05	0.70	0.84	0.01	0.10	1.14	1.00	2.62	2.86	2.29	2.56
	Thalamita sima	NA	NA	0.13	0.13	NA	0.01	1.14	1.86	NA	NA	2.29	2.56
	Podophthalmus vigil	< 0.01	< 0.01	NA	NA	< 0.01	NA	1.14	1.00	2.62	2.86	NA	NA
	Myomenippe hardwickii	0.13	0.08	0.65	2.48	0.02	0.24	1.14	4.14	2.62	NA	2.45	2.7
	Halimede ochtodes	NA	NA	0.09	0.13	NA	0.01	1.29	4.14	NA	NA	2.29	2.63

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
	Macrophthalmus sp.	4.91	1.25	NA	NA	1.88	NA	1.50	3.57	2.62	3.02	NA	NA
	Varuna yui	NA	NA	< 0.01	0.08	NA	< 0.01	NA	3.57	NA	NA	2.18	NA
Brittle star	*Ophiocnemis marmorata*	< 0.01	< 0.01	NA	NA	< 0.01	NA	NA	4.00	2.80	NA	NA	NA
	Ophiocnemis sp.	NA	NA	0.02	< 0.01	NA	< 0.01	NA	3.86	NA	NA	2.45	NA
	Luidia sp.	0.04	0.02	0.63	0.34	0.02	0.14	NA	3.86	2.45	NA	2.45	NA
Sea star	Sea Star 1 (unidentified 1)	< 0.01	< 0.01	0.11	0.01	< 0.01	< 0.01	1.14	3.86	2.45	NA	2.29	2.56
	Sea star 2 (unidentified 2)	1.91	0.24	2.96	0.51	0.92	0.88	1.14	3.86	2.18	NA	2.29	2.56
Sea cucumber	*Acaudina* sp.1	0.52	0.22	0.88	0.46	0.22	0.08	1.14	2.86	2.62	2.86	2.18	2.46
	Acaudina sp.2	0.13	0.18	0.22	0.06	0.09	0.01	1.14	2.86	2.62	2.86	1.70	2.05
	Phyllophorella kohkutiensis	0.43	1.09	0.36	0.39	0.59	0.06	1.14	2.86	2.62	2.86	1.41	1.81
	Sea cucumber (unidentified)	0.09	0.01	0.04	< 0.01	0.01	< 0.01	1.14	2.86	2.45	2.70	1.70	2.05
Sea pens	Sea pen (unidentified)	0.48	0.4	0.16	0.12	0.24	0.01	1.00	4.43	2.14	2.36	1.26	NA
Sea urchins	*Temnopleurus toreumaticus*	6.48	0.76	9.37	1.59	2.86	1.62	1.00	3.71	2.62	NA	2.62	2.80
	Schizaster lacunosus	0.04	0.02	NA	NA	0.01	NA	1.50	4.33	2.29	2.74	NA	NA
	Arachnoides placenta	NA	NA	0.18	0.01	NA	0.03	1.00	3.57	NA	NA	1.82	2.08
Fishes	*Himantura imbricata*	0.17	0.63	NA	NA	0.23	NA	2.00	1.86	2.45	3.16	NA	NA
	Maculabatis gerrardi	0.09	0.23	NA	NA	0.05	NA	2.00	2.43	2.45	3.16	NA	NA
	Muraenesox cinereus	0.04	0.44	< 0.01	< 0.01	0.29	< 0.01	2.00	1.86	2.45	3.16	1.41	2.57
	Sardinella gibbosa	NA	NA	0.13	0.04	NA	0.01	1.14	1.71	NA	NA	1.41	1.81

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
	Thryssa kammalensis	NA	NA	0.04	< 0.01	NA	< 0.01	1.43	1.86	NA	NA	1.26	1.90
	Hexanematichthys sagor	< 0.01	0.01	NA	NA	< 0.01	NA	2.00	1.86	2.45	3.16	NA	NA
	Batrachomoeus trispinosus	NA	NA	0.16	0.66	NA	0.02	1.86	1.71	NA	NA	1.78	2.57
	Hippocampus sp.	0.04	< 0.01	NA	NA	< 0.01	NA	1.86	2.71	1.70	2.52	NA	NA
	Vespicula trachinoides	NA	NA	0.16	0.02	NA	0.04	1.57	2.00	NA	NA	1.26	2.01
	Platycephalus indicus	0.09	0.24	0.07	0.10	0.19	< 0.01	1.57	1.86	2.62	3.06	1.59	2.24
	Platycephalus sp.	0.61	1.43	NA	NA	0.92	NA	1.57	2.29	2.62	3.06	NA	NA
	Ambassis sp.	NA	NA	0.23	0.01	NA	0.01	1.29	1.86	NA	NA	1.26	1.80
	Epinephelus coioides	NA	NA	< 0.01	< 0.01	NA	< 0.01	2.00	1.71	NA	NA	1.26	2.36
	Epinephelus sexfasciatus	NA	NA	0.04	0.06	NA	< 0.01	1.43	1.86	NA	NA	1.26	1.90
	Terapon jarbua	NA	NA	0.32	0.13	NA	0.05	1.57	1.86	NA	NA	1.26	2.01
	Terapon puta	0.04	0.03	0.25	0.03	0.01	0.05	1.14	1.86	2.62	2.86	1.59	1.96
	Terapon theraps	NA	NA	0.11	0.01	NA	0.01	1.29	2.00	NA	NA	1.59	2.04
	Priacanthus tayenus	0.09	0.07	NA	NA	0.03	NA	1.29	1.86	1.94	2.33	NA	NA
	Ostorhinchus fasciatus	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.71	2.14	NA	NA	1.26	2.13
	Sillago sihama	0.09	< 0.01	NA	NA	< 0.01	NA	1.29	1.86	2.18	2.53	NA	NA
	Alepes djedaba	NA	NA	0.25	0.05	NA	0.05	1.43	2.00	NA	NA	1.41	2.01
	Carangoides praeustus	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.4	2.00	NA	NA	1.26	1.90

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
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	Carangoides sp.	NA	NA	NA	NA	NA	NA	2.00	2.57	NA	NA	1.26	2.36
	Megalaspis cordyla	0.02	< 0.01	NA	NA	< 0.01	NA	1.43	2.29	1.94	2.41	NA	NA
	Eubleekeria splendens	0.09	0.21	NA	NA	0.05	NA	1.14	1.86	1.62	1.98	NA	NA
	Gazza minuta	0.22	0.03	0.07	< 0.01	0.01	0.02	1.14	1.71	1.94	2.26	1.26	1.70
	Nuchequula gerreoides	0.04	0.02	0.27	0.06	0.01	0.02	1.14	1.86	1.94	2.26	1.26	1.70
	Secutor hanedai	NA	NA	< 0.01	< 0.01	NA	< 0.01	NA	1.86	NA	NA	1.41	1.81
	Lutjanus russelli	0.04	0.04	< 0.01	< 0.01	0.03	< 0.01	1.57	2.00	2.45	2.91	1.26	2.01
	Gerres macracanthus	< 0.01	< 0.01	NA	NA	< 0.01	NA	1.29	1.86	2.18	2.53	NA	NA
	Pomadasys kaakan	NA	NA	0.09	0.04	NA	< 0.01	2.00	2.00	NA	NA	1.26	2.36
	Pomadasys maculatus	NA	NA	< 0.01	< 0.01	NA	< 0.01	1.86	2.00	NA	NA	1.26	2.24
	Eleutheronema tetradactylum	< 0.01	< 0.01	NA	NA	< 0.01	NA	2.00	1.43	2.33	3.07	NA	NA
	Johnius amblycephalus	0.09	0.08	0.13	0.07	0.03	0.01	1.29	2.00	2.62	2.92	1.26	1.80
	Pseudosciaena soldado	0.48	0.38	0.04	0.09	0.22	< 0.01	1.86	1.71	2.18	2.87	1.26	2.24
	Otolithes ruber	0.65	0.65	< 0.01	< 0.01	0.33	< 0.01	1.43	1.43	2.18	2.61	1.26	1.90
	Pennahia anea	0.13	0.03	0.05	0.02	0.04	< 0.01	1.29	1.43	2.18	2.53	1.59	2.04
	Panna microdon	0.04	0.01	NA	NA	0.01	NA	1.29	2.00	2.62	2.92	NA	NA
	Upeneus sulphureus	< 0.01	< 0.01	0.07	0.05	< 0.01	< 0.01	1.14	2.00	2.18	2.46	1.26	1.70

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
	Upeneus sundaicus	NA	NA	0.25	0.28	NA	0.02	1.29	2.00	NA	NA	1.41	1.91
	Drepane punctata	0.74	0.74	NA	NA	0.38	NA	1.57	1.86	2.62	3.06	NA	NA
	Ephippus orbis	< 0.01	< 0.01	NA	NA	< 0.01	NA	1.29	2.14	2.45	2.77	NA	NA
	Scatophagus argus	NA	NA	0.04	< 0.01	NA	< 0.01	1.14	1.29	NA	NA	1.41	1.80
	Sphyraena jello	NA	NA	0.11	< 0.01	NA	0.01	2.14	2.00	NA	NA	1.26	2.49
	Pampus chinensis	< 0.01	0.06	NA	NA	0.01	NA	1.29	1.86	2.33	2.67	NA	NA
	Petroscirtes sp.	NA	NA	0.02	0.01	NA	< 0.01	1.29	2.71	NA	NA	1.26	1.80
	Acentrogobius caninus	NA	NA	0.05	0.01	NA	0.01	1.43	2.00	NA	NA	1.26	1.90
	Siganus canaliculatus	NA	NA	0.23	0.25	NA	0.02	1.14	1.86	NA	NA	1.41	1.81
	Siganus javus	0.04	0.09	0.32	0.46	0.01	0.06	1.14	1.86	2.62	2.86	1.41	1.81
	Scomberomorus commerson	0.04	0.09	NA	NA	0.08	NA	2.00	1.86	2.04	2.86	NA	NA
	Cynoglossus arel	NA	NA	0.04	0.01	NA	< 0.01	1.43	2.00	NA	NA	2.14	2.57
	Cynoglossus trulla	0.04	0.05	0.02	0.01	0.02	< 0.01	1.43	2.00	2.80	3.15	1.59	2.14
	Cynoglossus sp. 1	0.04	0.09	0.07	0.02	0.02	0.01	1.43	2.57	2.80	3.15	2.14	2.57
	Cynoglossus sp.2	0.04	0.01	0.02	0.07	0.01	< 0.01	1.43	2.57	2.80	3.15	1.91	2.39
	Brachirus orientalis	0.87	1.63	0.36	0.49	0.98	0.13	1.43	2.00	2.8	3.15	1.59	2.14
	Brachirus harmandi	0.09	0.11	0.09	0.02	0.03	< 0.01	1.29	2.00	2.8	3.08	1.91	2.3
	Synaptura commersonnii	< 0.01	< 0.01	NA	NA	< 0.01	NA	1.4	2.14	2.8	3.15	NA	NA

Groups	Scientific name	% N (G)	%W (G)	%N (T)	%W (T)	%IRI (G)	%IRI (T)	P	QP	S (G)	V (G)	S (T)	V (T)
								3					
	Paramonacanthus choirocephalus	NA	NA	1.22	0.16	NA	1.60	1.29	2.00	NA	NA	1.41	1.91
	Chelonodon sp.	NA	NA	0.09	0.42	NA	0.02	1.57	2.57	NA	NA	1.26	2.01
	Lagocephalus lunaris	< 0.01	< 0.01	1.67	0.36	< 0.01	1.06	1.57	2.00	1.94	2.5	1.41	2.11
	Takifugu oblongus	< 0.01	< 0.01	2.94	18.79	< 0.01	3.62	1.43	2.14	1.82	2.31	1.41	2.01

Note G and T are stood for gillnet and trap, respectively. %N, %W and %IRI are percentages in number, weight and index of relative importance, respectively. The scores from Productivity-Susceptibility Analysis are P = overall productivity score, QP = data quality score for productivity attributes, S= overall susceptibility score and V= total vulnerability score.