Report: Risk assessment of the main two fishing gears used in the blue swimming crab fisheries in Suratthani, Thailand[1]

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1. Introduction

The annual total catch of BSC in Thailand averages around 2.5 thousand tonnes, of which roughly half is from the Bandon Bay fishing ground in Surat Thani Province (Fisheries Development Policy and Planning Division, 2020). Bandon Bay (9° 20' 00" N, 99° 25' 00" E; Fig. 1) is in Surathani Province and home to more than 130 fish species and more than 210 species of other aquatic animals (Sawusdee, 2010). The bay area is 477 km^2, with 120 km of coastline and mean depth of 2.9 m. The two main fishing gears used are bottom-set gillnets and collapsible crab traps, hereafter "gillnets" and "traps." 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. Gillnet and trap fisheries are indiscriminate, and therefore management should focus not only on their primary target (BSC), but also consider secondary and bycatch species. Therefore, in this report, the ecological risk of species vulnerable to each type of fishing gear was evaluated through the Productivity Susceptibility Analysis (PSA; Hobday et al., 2011)

2. Materials and Methods

2.1 Sampling stations and protocol

Fourteen (14) sampling stations were established throughout Bandon Bay (**Fig. 1**). Sampling was conducted once a month from January to November 2018, during a spring tide. Sampling in December was skipped because of the effects of tropical cyclone "Plabuk". On each sampling day, 3 tier of gill nets and 90 traps were deployed during 05.00 pm and soaked for 12 hours before being recovered. All catches were taken back to the fish landing sites.

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2.2 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 and Pauly, 2021) for fishes and Carpenter and Neim (2001) and SeaLifeBase (Palomares and Pauly, 2021) for other aquatic animals.

2.3 Risk assessment

Productivity Susceptibility Analysis (PSA; Hobday et al., 2011), which is a practical semi-quantitative vulnerability assessment tool (Hordyk and Carruthers, 2018) was used for assessing the risk of individual stocks from the BSC fisheries in Bandon Bay. The PSA consists of the attributes of two characters: (i) productivity, for determining the rate at which the species can recover from fishing and (ii) susceptibility, for determining he impact to the species caused by fishing. There were seven productivity attributes and four susceptibility attributes used in this study (Table 1). 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 and 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 and 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), where 1 is high productivity or low susceptibility, 2 is medium productivity or susceptibility, and 3 is low productivity or high susceptibility (Hordyk and Carruthers, 2018). 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 y 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 and Carruthers, 2018).

Results

There were 111 and 118 species of fish and other aquatic animals caught by gillnets and traps, respectively (Table 2). 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). In total, the sampled animals comprised 7,880 individuals with a weight of 246,747 g. From 7,880 sample, one Hippocampus sp., which is considered as endangered, threatened and protected (ETP) species was caught by gillnet.

Results for the PSA are provided in Appendix 1 and 2. The overall *V* score ranged from 1.81 to 3.16 (2.76 ± 0.28) for gillnets and from 2.11 to 3.07 (2.64 ± 0.21) for traps. Results indicated that the BSC was moderately risk ($V = 2.86$) from both gears, for which the *P* and *S* scores were 1.14 and 2.62, respectively. The ETP species as *Hippocampus* sp. was also low risk by this gillnet fishery ($V = 2.41$). None of taxa was ranked "high risk" by both gears. Seventy-five (75) species were at moderate risk from the gillnet fishery; meanwhile, the majority of species that are catchable by trap (55 out of 118 stocks) faced low risk from the trap fishery. Although no species were rated as high risk from BSC gillnets or traps in 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 a group of sole species (Family Soleidae and Cynoglossidae). There were 11 and 9 taxa, which have incomplete information, i.e. not assessing the *V-score*, which future biological studies are required. However, based on the general biology of the relatives of these animals, they are all expected to be high resilience. A graphical PSA of selected individual stocks and stock-groups from gillnet and trap fisheries in Bandon Bay is presented in Fig. 2.

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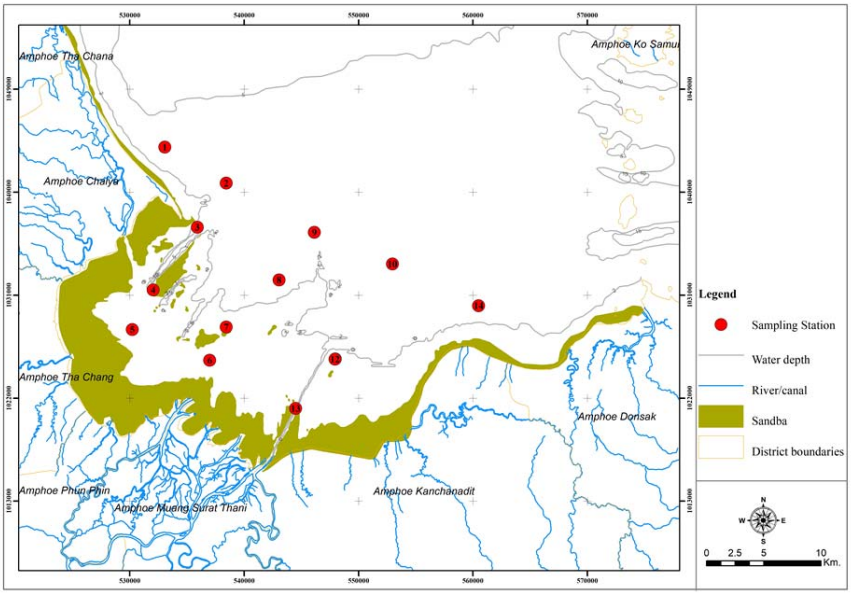
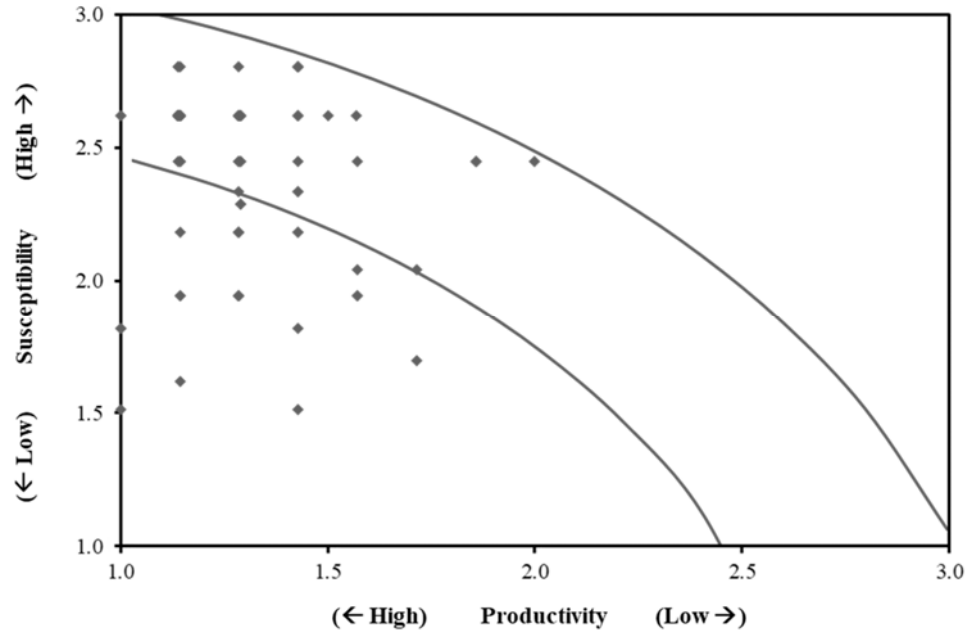


Fig. 1 Location and map of the Bandon Bay, Surratthani, Thailand. Red dot indicates sampling site, where fishing gears were deployed.

(A) bottom-set gillnets



(B) collapsible crab traps

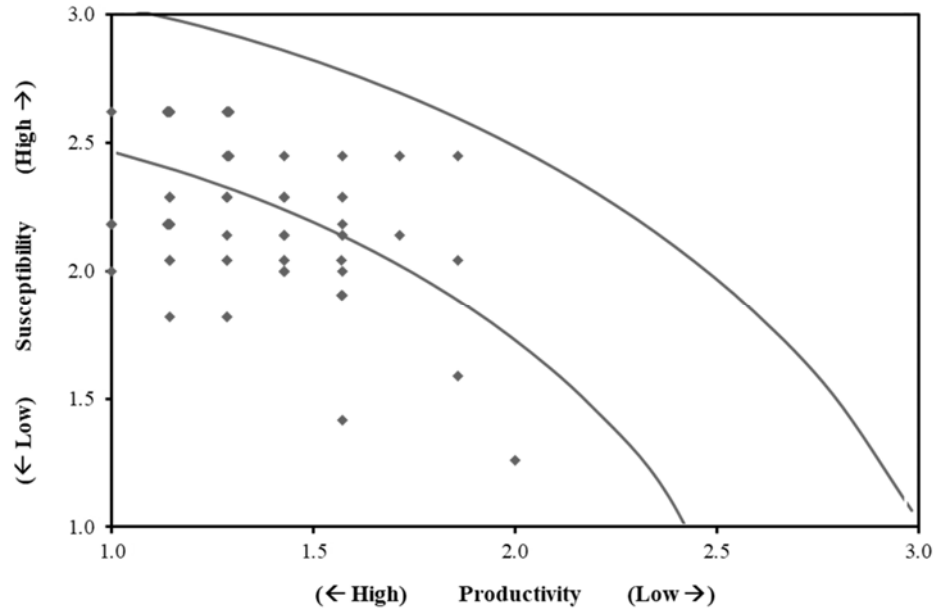


Fig. 2 Productivity-susceptibility plot for the catches by (A) bottom-set gillnets and (B) collapsible crab traps in Bandon Bay, Surratthani, Thailand. The two lines in the figure indicated the threshold for low- and medium- risks as the lower- and upper- lines, respectively.

Table 1 List of attributes used for Productivity-Susceptibility Analysis 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)	> 15	5 to 15	< 5
Average maximum age (years)	> 25	10 to 25	< 10
Fecundity (eggs/spawning)	< 100	100 to 20,000	> 20,000
Average maximum size (cm)	> 300	100 to 300	< 100
Average size at maturity (cm)	> 200	40 to 200	< 40
Reproductive strategy	Live bearer, mouth brooder or significant parental investment	Demersal spawner or "berried"	Broadcast spawner
Mean trophic level	> 3.25	2.75 – 3.25	< 2.75

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 %