Fisheries Resource Survey in the Gulf of Thailand (Thai waters and Cambodian waters) by Using Bottom Trawl

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Abstract

The survey on fisheries resource in the Gulf of Thailand (GOT) was conducted in Thai and Cambodian waters during 17 August to 11 October 2018. Otter board trawl was used in the survey and operated by M.V. SEAFDEC 2. Trawling time was one hour per haul and trawl operations were done during daytime. The survey consisted of 49 stations in Thai waters, which were divided into five areas, i.e. Eastern, Inner, Upper Western, Lower Western, and Central GOT, and 24 stations in Cambodian waters.

The results showed that catch per unit effort (CPUE) in Thai and Cambodian waters were 43.29 and 26.27 kg/hr, respectively which was significant difference ($p<0.05$). In addition, the CPUE of each area in Thai waters was 32.11, 26.04, 39.55, 43.77, and 53.01 kg/hr, respectively which were not significant difference ($p>0.05$). Ratio of economic fish and trash fish in Thai and Cambodian waters was 51.55:48.45 and 78.79:21.21, respectively. The percentage of trash fish in each area in Thai waters were 18.70%, 20.88%, 31.69%, 57.84%, and 61.20% of the total catch respectively.

There were 299 species found during the survey in Thai waters divided into 190 economic species and 109 trash fish. Whereas, at least 134 species were found in Cambodian waters divided into 97 species of economic fish and 37 species of trash fish. The analysis of species composition for economic fish revealed that demersal fish, pelagic fish, and cephalopod were the main composition both in Thai and Cambodian waters. In Thai waters, doublewhip threadfin bream, *Nemipterus nematophorus*, was the highest composition of economic fish, 4.39% of the total catch, followed by obtuse barracuda, *Sphyraena obtusata*, and Japanese goatfish, *Upeneus bensasi*, 3.25% and 2.71% respectively. While, orangefin ponyfish, *Leiognathus bindus*, was the highest composition of trash fish, 18.42% of the total catch, followed by longfin mojarra, *Pentaprion longimanus*, and *whipfin ponyfish*, *Leiognathus leuciscus*, 13.60% and 2.70% respectively. In Cambodian waters, dark-barred goatfish, *Upeneus luzonius*, was the highest composition of economic fish, 9.44%, followed by doublewhip threadfin bream and pink ear emperor, *Lethrinus lentjan*, 6.99% and 6.70% respectively. Whereas, longfin mojarra was the highest composition of trash fish, 11.84% of the total catch, followed by orangefin ponyfish and live sharksucker, *Echeneis naucrates*, 3.16% and 0.74% respectively.

The measurement of fish length caught during the survey disclosed that, in Thai waters, the average length of 10 species was smaller than their length at first maturity (L_m); while, average length of three species was larger than their L_m. Meanwhile, in Cambodian waters, the average length of five species was smaller than their L_m; whereas, average length of five species was larger than their L_m. However, there is no length at first maturity of some low abundance species reported. Most average length of the species found in Cambodian waters was larger than those found in Thai waters.

Keywords: fisheries resource, Gulf of Thailand, Thai waters, Cambodian waters, otter board trawl

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Introduction

The Gulf of Thailand (GOT) is one of Large Marine Ecosystem (LME), located in Southeast Asia. It is a semi-enclosed gulf bounded by Vietnam, Cambodia, Thailand and Malaysia, and well known of its productive marine ecosystem and highly abundance of aquatic resources. The GOT is a part of South China Sea but separated by two underwater ridges that limit water exchanges with the open sea (Wattayakorn, 2006). Geographically, it may be divided into two subareas, the Inner GOT and the Outer GOT. The Inner GOT is U-shape like, located in the territorial waters of Thailand. It is generally influenced by river outflow, as the catchment basin of four large rivers of Chao Phraya, Bang Pakong, Tha Chin and Mae Klong rivers. Meanwhile, the Outer GOT is mainly influenced by sea water intrusion from the South China Sea which changes seasonally. Due to high nutrient input through the larger river runoffs and seasonal water circulation in the GOT, it made this area rich with fisheries resources and recognized as an important fishing ground in the South China Sea, especially for Thailand which is situated at the center of the gulf.

In order to review the status of fisheries resources in the GOT and improve the collaboration between Southeast Asian countries, Southeast Asian Fisheries Development Center (SEAFDEC) had organized the collaborative research survey on marine fisheries resources in the Gulf of Thailand which was conducted in 2018. The survey was carried out in Thai waters and Cambodian waters by M.V. SEAFDEC 2 in cooperation with the Department of Fisheries, authorities and academic institutions from Thailand, Cambodia and Vietnam. The overall objectives of this research are to explore the current status of fisheries resources in the Gulf of Thailand including Thai waters and Cambodian waters, and determine the exploitation status of some economic species that mainly caught by bottom trawl in the Gulf of Thailand.

Materials and methods

The fisheries resource survey in the GOT was carried out by M.V. SEAFDEC 2 during 17 August to 11 October 2018. The survey was conducted in Thai waters and Cambodian waters. There were 73 stations in total divided into 49 stations in Thai waters and 24 stations in Cambodian waters. The survey stations in Thai waters were then separated into five areas, i.e. Eastern, Inner, Upper Western, Lower Western, and Central GOT, representing Thailand's fisheries statistical area 1-5 respectively (Figure 1). The bottom trawl of 40 mm codend was used in this survey. The operation was done during daytime. The trawling operation was set at towing speed of three knots, and towing time of one hour per station. Catches were sorted onboard and identified to species level based on Yoshida *et al*. (2013), Psomadakis *et al*. (n.d.), and FAO species identification guide for fishery purposes (Carpenter and Niem; 1998, 1999a, 1999b, 2001a, 2001b), then weighted in gram (g). The total length of fish and shrimp and mental length of squid were measured at 0.5 length intervals and recorded in centimeter (cm).

Catch per unit effort (CPUE) by areas, species composition and length of some economic species were analyzed. CPUE was calculated in kilogram/hour (kg/hr) as following equations;

$$CPUE_{T,C} = \frac{\sum_{i=1}^{n} C_{i\,T,C}}{\sum_{i=1}^{n} F_{i\,T,C}}$$

where

$CPUE_{T,C}$ = Catch per unit effort in Thai waters / Cambodian waters (kg/hr)

$C_{i\,T,C}$ = Catch in station i in Thai waters / Cambodian waters (kg)

$F_{i\,T,C}$ = Fishing effort in station i in Thai waters / Cambodian waters (hr)

i = Station 1, 2, 3, ..., n

CPUE in each area in Thai waters was analyzed as following equation

$$CPUE_j = \frac{\sum_{i=1}^{n} C_{ij}}{\sum_{i=1}^{n} F_{ij}}$$

where

$CPUE_j$ = Catch per unit effort of Area j in Thai waters (kg/hr)

C_{ij} = Catch in station i of Area j (kg)

F_{ij} = Fishing effort in station i of Area j (hr)

i = Station 1, 2, 3, ..., n

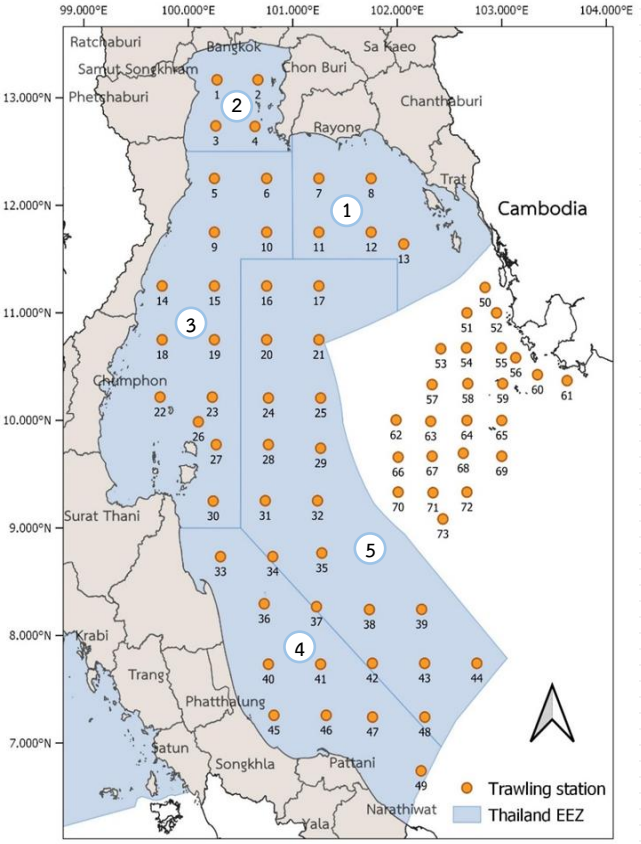

Figure 1 Survey stations in the Gulf of Thailand by M.V. SEAFDEC 2, 2018

Remark:
1. Eastern Gulf of Thailand
2. Inner Gulf of Thailand
3. Upper Western Gulf of Thailand
4. Lower Western Gulf of Thailand
5. Central Gulf of Thailand

CPUE was then statistically tested for the difference between two waters and five fishing areas in Thai waters. Kruskal – Wallis H Test, which is used for the test for several independent samples, was used in this study (Ruangpraphan, 2001).

Catch of each station was sorted and grouped to economic fish and trash fish by species level. Species composition in Thai waters and Cambodian waters was analyzed as following equation;

$$Comp_i = \frac{\sum_{j=1}^{n} w_{ij}}{\sum_{j=1}^{n} W_j} \times 100$$

where

$Comp_i$ = Composition of species / group i

w_{ij} = Weight of species / group i (kg) in station j in Thai waters / Cambodian waters

W_j = Total weight in station j in Thai waters / Cambodian waters

j = Station 1, 2, 3, ..., n

Species composition in each area in Thai waters was analyzed as following equation;

$$Comp_{ik} = \frac{\sum_{j=1}^{n} w_{ijk}}{\sum_{j=1}^{n} W_{jk}} \times 100$$

where $Comp_i$ = Composition of species / group i of Area K
w_{ijk} = Weight of species / group i (kg) in station j of Area k
W_{jk} = Total weight in station j of Area k
j = Station 1, 2, 3, ..., n

Lengths frequency of 13 selected species as following were analyzed and mean lengths were compared with their size at first maturity to determine the status of these species.

1. Ornate threadfin bream; *Nemipterus hexodon*
2. Purple-spotted bigeye; *Priacanthus tayenus*
3. Slender lizardfish; *Saurida elongata*
4. Brushtooth lizardfish; *S. undosquamis*
5. Yellowtail scad; Atule mate
6. Torpedo scad; *Megalaspis cordyla*
7. Short mackerel; *Rastrelliger brachysoma*
8. Indian mackerel; *R. kanagurta*
9. Goldstripe sardinella; *Sardinella gibbosa*
10. Bigeye scad; *Selar crumenophthalmus*
11. Indian squid; *Uroteuthis chinensis*
12. Mitre squid; *U. duvaucelii*
13. Greasyback shrimp; *Metapenaeus ensis*

Mean length and standard deviation were analyzed as following equations;

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i f_i}{\sum_{i=1}^{n} f_i}$$

where $\bar{X}$ = Mean length (cm)
x_i = Mid length of class interval i
f_i = Frequency of class interval i
i = Class interval 1, 2, 3, ..., n

$$SD = \sqrt{\frac{\sum_{i=1}^{n} f_i (x_i - \bar{X})^2}{\sum_{i=1}^{n} f_i - 1}}$$

where SD = Standard deviation
f_i = Frequency of class interval i
x_i = Mid length of class interval i
$\bar{X}$ = Mean length (cm)
i = Class interval 1, 2, 3, ..., n

Results

1. Catch per unit effort (CPUE)

The trawl survey was conducted in a total of 73 stations in the Gulf of Thailand (GOT) including 49 stations in Thai waters and 24 stations in Cambodian waters. It was found that overall CPUE of the entire survey was 37.78 kg/hr. The CPUE in Thai waters was 43.29 kg/hr; while, it was 26.27 kg/hr in Cambodian waters which was significantly different ($p<0.05$) (Table 1).

The highest CPUE in Thai waters was found in the Central GOT, 53.01 kg/hr followed by Lower Western GOT, Upper Western GOT and Eastern GOT, 43.77, 39.55 and 32.11 kg/hr, respectively. The lowest CPUE was found in the Inner GOT, 26.04 kg/hr. The CPUE in each area in Thai waters was not significant different ($p>0.05$) (Table 1).

The GOT is influenced by several rivers. However, the main rivers which empty into the gulf are located in Thailand, e.g. Bang Pakong, Chao Phraya, Tha Chin and Mae Klong River at the northern gulf and Tapi, Pattani and Golok River in the southwest gulf. While, there are only few smaller rivers in Cambodia flowing into the gulf, e.g. Kah Bpow and Kampong Trak River, although the Mekong River and its tributaries, which form one of the largest river systems in the world, flow through Cambodia and to the South China Sea in Vietnam (Wikipedia, 2018; Wikipedia, 2020). These rivers

bring a large amount of nutrients in the GOT. The nutrients can be taken up by phytoplankton and enrich productivity in the gulf (Sigman and Hain, 2012). Therefore, fisheries resources in Thai waters may be more productive and biologically diverse than Cambodian waters due to high nutrient supply.

Table 1 Catch per unit effort (CPUE) from trawl survey in the Gulf of Thailand, 2018

Area	CPUE (kg/hr)		
	Thai waters	Cambodian waters	Entire survey
1) Eastern Gulf of Thailand	32.11[c]	-	-
2) Inner Gulf of Thailand	26.04[c]	-	-
3) Upper Western Gulf of Thailand	39.55[c]	-	-
4) Lower Western Gulf of Thailand	43.77[c]	-	-
5) Central Gulf of Thailand	53.01[c]	-	-
Total area	43.29[a]	26.27[b]	37.78

Remark: Different alphabets in each column and row present statistically significant different ($p < 0.05$)

The CPUE in each area from the survey in Thai waters rather corresponded CPUE from commercial trawlers. In 2018, the highest CPUE of commercial otter board trawlers was found in the Statistical Area 5, 40.86 kg/hr; whereas, the CPUE from the survey was 53.01 kg/hr. Meanwhile, CPUE in the Statistical Area 2 was quite similar, 28.07 kg/hr from commercial otter board trawlers and 26.04 kg/hr from the survey (DOF, 2019).

2. Catch composition

The catch in Thai waters composed of 51.55% economic fish and 48.45% trash fish; whereas, in Cambodian waters, the catch composed of 78.79% economic fish and 21.21% trash fish. In Thai waters, high proportion of economic fish was found in the Eastern GOT and Inner GOT, 81.30% and 79.12% of the total catch respectively; while, low proportion of economic fish was found in the Lower Western GOT and Central GOT, 42.16% and 38.80% of the total catch respectively (Table 2).

Table 2 Catch composition from trawl survey in the Gulf of Thailand, 2018

Area	Composition (%)	
	Economic fish	Trash fish
Thai waters	**51.55**	**48.45**
1) Eastern Gulf of Thailand	81.30	18.70
2) Inner Gulf of Thailand	79.12	20.88
3) Upper Western Gulf of Thailand	68.31	31.69
4) Lower Western Gulf of Thailand	42.16	57.84
5) Central Gulf of Thailand	38.80	61.20
Cambodian waters	78.79	21.21
All areas	57.69	42.31

Catch composition by station reflected the composition in the areas. For example, in the Central GOT, trash fish was the main composition about a half of total stations in the area. As a result, trash fish was dominant in the Central GOT. In contrast, more than three fourths of composition were economic fish in every station of the Eastern GOT contributing a total of 81.30% economic fish in the area (Figure 2).

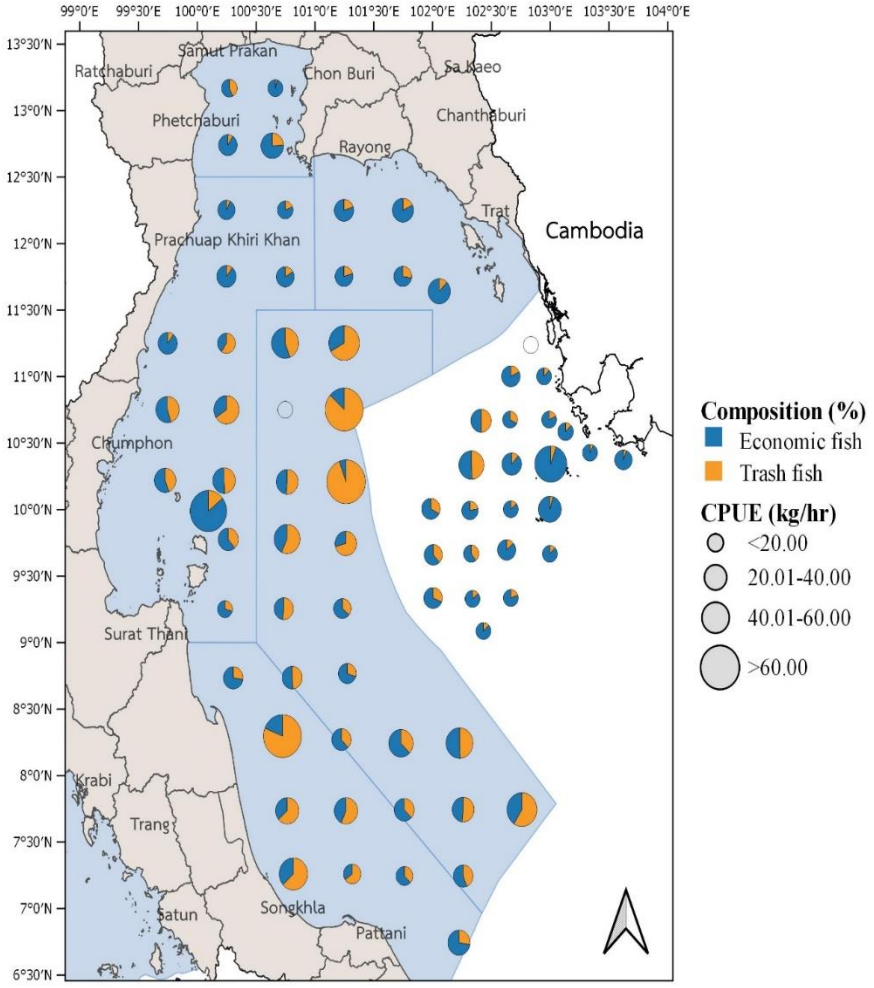

Figure 2 CPUE and composition of economic fish and trash fish in the Gulf of Thailand by station surveyed by otter board trawl, 2018

Remark: Trawl survey in Station 20 and 50 were cancelled because of muddy bottom which is not suitable for trawl operation

Demersal fish was the major group of fisheries resources from the survey both in Thai and Cambodian waters, 33.17% and 57.97% of the total catch respectively, followed by pelagic fish, 8.61% and 9.33%, and cephalopod, 7.79% and 8.45%, respectively. Shellfish, crab and shrimp were also found during the survey with few percentages. On the other hand, 44.14% of fish species was found in trash fish in Thai waters; while, only 20.43% of fish species was found in trash fish in Cambodian waters (Table 3).

Table 3 Catch composition (%) in the Gulf of Thailand surveyed by otter board trawl, 2018

Group		Thai waters						Cambodian water
		Area 1	Area 2	Area 3	Area 4	Area 5	Total	
Economic fish	Total	81.30	79.12	68.31	42.14	38.80	51.55	78.79
	Demersal fish	47.47	37.84	45.36	23.22	28.50	33.17	57.97
	Pelagic fish	17.50	21.87	9.40	6.29	6.20	8.61	9.33
	Cephalopod	10.78	16.81	11.72	9.85	3.13	7.78	8.45
	Shellfish	4.07	1.58	0.74	0.87	0.44	0.93	2.53
	Crab	0.76	0.24	0.35	1.01	0.27	0.48	0.31
	Shrimp	0.14	0.57	0.59	0.52	0.15	0.35	0.03
	Mantis shrimp	0.13	0.03	0.13	0.08	0.04	0.07	0.06
	Others	0.45	0.17	0.01	0.31	0.08	0.15	0.11
Trash fish	Total	18.70	20.88	31.69	57.86	61.20	48.45	21.21
	Fish	14.60	4.29	28.42	47.76	60.53	44.14	20.44
	Shellfish	0.00	0.17	0.10	0.04	0.01	0.04	0.00*
	Crab	0.60	6.22	1.71	1.20	0.36	1.15	0.22
	Others	3.49	10.20	1.47	8.85	0.31	3.11	0.54

Noted: * less than 0.005

There were at least 299 species found during the survey in Thai waters divided into 190 economic species and 109 trash fish. Meanwhile, at least 134 species were found in Cambodian waters divided into 97 species of economic fish and 37 species of trash fish. Species composition of demersal fish in Thai and Cambodian waters were fairly similar. Common demersal fish found were threadfin breams, goatfishes and lizardfishes. In Thai waters, doublewhip threadfin bream (*Nemipterus nematophorus*), Japanese goatfish (*Upeneus bensasi*) and brushtooth lizardfish (*Saurida undosquamis*) were the highest composition of demersal fish in Thai waters, 4.39%, 2.71% and 2.02% of the total catch respectively. While, in Cambodian waters, dark-barred goatfish (*U. luzonius*), doublewhip threadfin bream and pink ear emperor (*Lethrinus lentjan*) were the highest composition of demersal fish, 9.44%, 6.99% and 6.70% of the total catch respectively. However, pelagic species were quite diverse. In Thai waters, obtuse barracuda (*Sphyraena obtusata*), yellowtail scad (*Atule mate*) and black pomfret (*Parastromateus niger*) were the main composition, 3.25%, 1.66% and 1.34% of the total catch respectively. While, Japanese scad (*Decapterus maruadsi*), Indian anchovy (*Stolephorus indicus*) and blackbanned trevally (*Seriolina nigrofasciata*) were the main composition, 1.23%, 1.15% and 1.11% of the total catch respectively. Squids (*Uroteuthis duvaucelii* and *U. chinensis*) were also the main composition of otter board trawl survey accounted for 5.19% and 7.72% of the total catch in Thai and Cambodian waters respectively (Table 4 and 5).

For trash fish, orangefin ponyfish (*Leiognathus bindus*) and longfin mojarra (*Pentaprion longimanus*) were the two highest composition made up 18.42% and 11.84% of the total catch in Thai and Cambodian waters respectively (Table 4 and 5).

The proportion of economic fish and trash fish in Thai waters was similar between this survey and commercial otter board trawlers. The proportion of economic fish and trash fish from this survey was 51.55:48.45; whereas, it was 55.45:44.55 for commercial otter board trawlers. In addition, top two highest proportion of economic fish was found in the same areas. The percentage of economic fish in the Eastern and Inner GOT from this survey were 81.30% and 79.12%, respectively; whereas, it was 61.39% and 71.52% from commercial otter board trawlers in Area 1 and 2 respectively (DOF, 2019).

Table 4 Species composition of trawl survey in Thai waters, 2018

Common name	Scientific name	Overall composition (%)	Within group (%)
Economic fish		**51.55**	
Demersal fish		**29.92**	
Doublewhip threadfin bream	*Nemipterus nematophorus*	4.39	14.69
Japanese goatfish	*Upeneus bensasi*	2.71	9.07
Brushtooth lizardfish	*Saurida undosquamis*	2.02	6.75
Five-lined threadfin bream	*Nemipterus tambuloides*	1.94	6.48
Slender lizardfish	*Saurida elongata*	1.68	5.62
Shortjaw saury	*Saurida isarankurai*	1.26	4.20
Silver-cheeked toadfish	*Lagocephalus sceleratus*	0.99	3.30
Other demersal fishes		14.93	49.89
Pelagic fish		**11.86**	
Obtuse barracuda	*Sphyraena obtusata*	3.25	27.43
Yellowtail scad	*Atule mate*	1.66	14.02
Black pomfret	*Parastromateus niger*	1.34	11.25
Narrow-barred Spanish mackerel	*Scomberomorus commerson*	1.16	9.79
Imposter trevally	*Carangoides talamparoides*	0.71	5.96
Blackfin scad	*Alepes melanoptera*	0.58	4.88
Bigeye scad	*Selar crumenophthalmus*	0.53	4.49
Other pelagic fishes		2.63	22.18
Cephalopod		**7.79**	
Indian squid	*Uroteuthis duvaucelii*	2.67	34.35
Mitre squid	*Uroteuthis chinensis*	2.52	32.37
Koi squid	*Loliolus sumatrensis*	0.52	6.65
Shortclub cuttlefish	*Sepia brevimana*	0.48	6.22
Other cephalopods		1.60	20.41

Table 4 (Cont.)

Common name	Scientific name	Overall composition (%)	Within group (%)
Shellfish		**0.93**	
Asian moon scallop	*Amusium pleuronectes*	0.64	69.19
Indian volute	*Melo melo*	0.08	8.25
Noble volute	*Cymbiola nobilis*	0.07	8.00
Half-propellor ark	*Trisidos semitorta*	0.05	5.26
Other shellfishes		0.09	9.30
Crab		**0.48**	
Crucufix crab	*Charybdis feriatus*	0.20	41.01
Blue-swimming crab	*Portunus pelagicus*	0.09	19.75
Ridged-swimming crab	*Charybdis natator*	0.09	18.3
Other crabs		0.10	20.94
Shrimp		**0.35**	
Whiskered-velvet shrimp	*Metapenaeopsis barbata*	0.11	31.10
Velvet shrimp	*Metapenaeopsis* spp.	0.08	22.64
Ridgeback shrimp	*Solenocera* spp.	0.03	8.91
Greasyback shrimp	*Metapenaeus ensis*	0.03	8.02
Banana shrimp	*Penaeus merguiensis*	0.02	6.91
Other shrimps		0.08	22.42
Others		**0.22**	
Flathead lobster	*Thenus orientalis*	0.15	66.51
Mantis shrimp	*Oratosquilla nepa*	0.02	10.70
Mantis shrimp	*Oratosquilla woodmasoni*	0.01	6.92
robber harpiosquillid mantis shrimp	*Harpiosquilla harpax*	0.01	3.67
Other invertebrates		0.03	12.20
Trash fish		**48.45**	
Fish		**44.14**	
Orangefin ponyfish	*Leiognathus bindus*	18.42	41.72
Longfin mojarra	*Pentaprion longimanus*	13.60	30.8
Whipfin ponyfish	*Leiognathus leuciscus*	2.70	6.11
Pig faced leather jacket	*Paramonacanthus choirocephalus*	2.44	5.54
Other trash fishes		6.98	15.83

Table 4 (Cont.)

Common name	Scientific name	Overall composition (%)	Within group (%)
Crab		**1.15**	
Leaf porter crab	Dorippidae	0.37	31.78
Blunt-tooth crab	*Charybdis truncata*	0.23	20.22
Portunid crab	*Charybdis variegata*	0.11	9.76
Other trash crabs		0.44	38.24
Shellfish		**0.04**	
Axe shell		0.02	49.35
Spine murex shell		0.01	23.11
Other trash shellfishes		0.01	27.54
Others		**3.12**	
Sea urchins		1.96	63.00
Sea Cucumbers		0.31	10.00
sponges		0.19	6.18
Other invertebrates		0.66	20.82

Table 5 Species composition of trawl survey in Cambodian waters, 2018

Common name	Species	Overall composition (%)	Within group (%)
Economic fish		**78.79**	
Demersal fish		**57.97**	
Dark-barred goatfish	*Upeneus luzonius*	9.44	16.28
Doublewhip threadfin bream	*Nemipterus nematophorus*	6.99	12.05
Pink ear emperor	*Lethrinus lentjan*	6.70	11.56
Brown-banned bambooshark	*Chiloscyllium punctatum*	5.13	8.86
Brushtooth lizardfish	*Saurida undosquamis*	4.86	8.39
Slender lizardfish	*Saurida elongata*	3.13	5.41
Unicorn leatherjacket filefish	*Aluterus monoceros*	3.00	5.18
Fivelined threadfin bream	*Nemipterus tambuloides*	2.65	4.56
Other demersal fishes		16.07	27.71

Table 5 (Cont.)

Common name	Scientific name	Overall composition (%)	Within group (%)
Pelagic fish		**9.33**	
Japanese scad	*Decapterus maruadsi*	1.23	13.19
Indian anchovy	*Stolephorus indicus*	1.15	12.27
Blackbanned trevally	*Seriolina nigrofasciata*	1.11	11.88
Yellowtail scad	*Atule mate*	0.92	9.85
Blackfin scad	*Alepes melanoptera*	0.84	9.04
Narrow-barred Spanish mackerel	*Scomberomorus commerson*	0.83	8.87
Bigeye scad	*Selar crumenophthalmus*	0.79	8.49
Other pelagic fishes		2.46	26.41
Cephalopod		**8.45**	
Indian squid	*Uroteuthis duvaucelii*	4.92	58.19
Mitre squid	*Uroteuthis chinensis*	2.80	33.11
Pharoh cuttlefish	*Sepia pharaonis*	0.35	4.23
Other cephalopods		0.38	4.47
Shellfish		**2.53**	
Asian moon scallop	*Amusium pleuronectes*	1.81	71.35
Indian volute	*Melo melo*	0.40	15.83
Other shellfishes		0.32	12.82
Crab		**0.31**	
Crucufix crab	*Charybdis feriatus*	0.23	72.73
Blue-swimming crab	*Portunus pelagicus*	0.08	25.67
Other crabs		0.00*	1.60
Shrimp		**0.03**	
Hardback shrimp	*Trachypenaeus* spp.	0.02	52.15
Green tiger prawn	*Penaeus latisulcatus*	0.01	47.85
Others		**0.17**	
Flathead lobster	*Thenus orientalis*	0.11	66.28
Mantis shrimp	Squillidae	0.06	33.72
Trash fish		**21.21**	
Fish		**20.44**	
Longfin mojarra	*Pentaprion longimanus*	11.84	57.95
Orangefin ponyfish	*Leiognathus bindus*	3.16	15.45
Filefish	Monacanthidae	0.95	4.64

Table 5 (Cont.)

Common name	Scientific name	Overall composition (%)	Within group (%)
Live sharksucker	*Echeneis naucrates*	0.74	3.63
Cockato righteye flounder	*Samaris cristatus*	0.68	3.32
Other trash fishes		3.07	15.01
Crab		**0.22**	
Hermit crab	Diogenidae	0.07	31.04
Box crab	Calappidae	0.02	8.13
Other trash crabs		0.13	60.83
Shellfish		**0.00***	
Spine murex shell		0.00*	
Others		**0.55**	
Sea snakes	Hydrophiidae	0.15	27.47
Sea Cucumbers		0.01	1.53
Others		0.39	71.00

Noted: * less than 0.005

3. Length of some economic species

Length of 18 economic species in Thai waters and 14 economic species in Cambodian waters were studied. Average lengths were analyzed and compared with their length at first maturity (L_m). The results showed that, in Thai waters, the average length of 10 species was smaller than their L_m and three species were larger than their L_m. There are no L_m reported in the Gulf of Thailand for other five species, i.e. pink ear emperor (*Lethrinus lentjan*), doublewhip threadfin bream (*Nemipterus nematophorus*), five-lined threadfin bream (*N. tambuloides*), Japanese goatfish (*Upeneus bensasi*) and dark-barred goatfish (*U. luzonius*). Meanwhile, in Cambodian waters, the average length of only five species were smaller than their L_m and another five species were larger than their L_m (Table 6 and 7).

Among 14 economic species in Cambodian waters, the average length of nine species was larger than those species found in Thai waters; while, the average length of only five species was smaller than in Thai waters. In addition, the minimum size of eight species found in Cambodian waters was larger than those species found in Thai waters. It can be concluded that, in general, the size of fishes in Cambodian waters was larger than in Thai waters (Table 6 and 7).

The evaluation of fisheries resource utilization by comparing the length frequency of each species with their L_m found that, in Thai waters, a huge proportion of small-sized fishes, which is smaller than their L_m, was utilized. Ten species out of 13 species in Thai waters, including all demersal fish species, showed that main proportion of fish caught was small-sized fish. There were only three species that the main proportion was mature fish, i.e. Indian mackerel (*Rastrelliger kanagurta*), goldstripe sardinella (*Sardinella gibbosa*) and greasyback shrimp (*Metapenaeus ensis*). In contrast, in Cambodian waters, only five species showed high proportion of small-sized fish including two demersal fish, one pelagic fish and two squid species; while, other five species showed high proportion of larger fish (Table 6 and 7).

Table 6 Length of some economic species in Thai waters surveyed by otter board trawl, 2018

Scientific name (Common name)	Range (cm)	Average (cm)	n	L_m* (cm)	% of immature fish	% of mature fish	References
Lethrinus lentjan (Pink ear emperor)	16.75 - 26.25	20.60 ± 2.53	27	n/a	n/a	n/a	-
Nemipterus hexodon (Ornate threadfin bream)	8.25 - 27.25	16.47 ± 4.88	104	18.77	65.38	34.62	Sritakon *et al*., 2007
Nemipterus nematophorus (Doublewhip threadfin bream)	7.25 - 24.25	13.00 ± 2.58	2,902	n/a	n/a	n/a	-
Nemipterus tambuloides (Five-lined threadfin bream)	10.25 - 29.25	19.57 ± 4.02	374	n/a	n/a	n/a	-
Priacanthus tayenus (Purple-spotted bigeye)	4.25 - 29.75	10.69 ± 5.23	120	14.83	82.50	17.50	Puntuleng *et al*., 2018
Saurida elongata (Slender lizardfish)	7.25 - 41.25	25.44 ± 6.88	216	31.62	82.41	17.59	Vibunpant *et al*., 2012
Saurida undosquamis (Brushtooth lizardfish)	8.25 - 29.75	18.56 ± 4.14	744	28.26	99.73	0.27	Vibunpant *et al*., 2011
Upeneus bensasi (Japanese goatfish)	4.75 - 16.25	10.62 ± 1.68	3,401	n/a	n/a	n/a	-
Upeneus luzonius (Dark-barred goatfish)	14.25 - 23.25	18.50 ± 2.26	32	n/a	n/a	n/a	-
Atule mate (Yellowtail scad)	6.75 - 31.75	14.35 ± 4.09	759	21.25	91.57	8.43	Premkit *et al*., 2004
Megalaspis cordyla (Torpedo scad)	6.25 -19.75	12.51 ± 3.49	39	21.55	100.00	0.00	Songkaew *et al*., 2009
Rastrelliger brachysoma (Short mackerel)	15.25 - 19.25	17.05 ± 0.93	66	17.95	86.36	13.64	Krajangdara *et al*., 2007
Rastrelliger kanagurta (Indian mackerel)	14.25 - 23.75	19.61 ± 2.24	79	17.12	11.39	88.61	Krajangdara *et al*., 2007
Sardinella gibbosa (Goldstripe sardinella)	10.75 - 17.75	13.27 ± 1.52	109	10.35	0.00	100.00	Nasuchon *et al*., 2010
Selar crumenophthalmus (Bigeye scad)	9.25 - 24.25	17.28 ± 3.22	152	18.25	66.45	33.55	Phuttharaksa *et al*., 2008
Uroteuthis chinensis (Mitre squid)	2.75 - 38.25	13.00 ± 5.76	529	17.71	80.91	19.09	Suppaniran *et al*., 2011
Uroteuthis duvaucelii (Indian squid)	3.25 - 16.25	8.28 ± 2.23	2,359	9.04	65.96	34.04	Suppaniran *et al*., 2011
Metapenaeus ensis (Greasyback shrimp)	10.25 -16.75	13.44 ± 1.69	21	11.24	4.76	95.24	Pinputtasin *et al*., 2012

Table 7 Length of some economic species in Cambodian waters surveyed by otter board trawl, 2018

Scientific name Common name	Range (cm)	Average (cm)	n	L_m* (cm)	% of immature fish	% of mature fish	References
Lethrinus lentjan (Pink ear emperor)	13.75 - 26.25	20.62 ± 2.02	235	n/a	n/a	n/a	-
Nemipterus hexodon (Ornate threadfin bream)	16.25 - 23.25	20.15 ± 2.97	5	18.77	40.00	60.00	Sritakon *et al*., 2007
Nemipterus nematophorus (Doublewhip threadfin bream)	6.75 - 22.25	13.19 ± 2.05	1,303	n/a	n/a	n/a	-
Nemipterus tambuloides (Five-lined threadfin bream)	6.75 - 26.75	17.46 ± 3.28	255	n/a	n/a	n/a	-
Priacanthus tayenus (Purple-spotted bigeye)	17.25 - 26.25	20.96 ± 2.75	21	14.83	0.00	100.00	Puntuleng *et al*., 2018
Saurida elongata (Slender lizardfish)	15.75 - 38.75	27.37 ± 4.91	121	31.62	81.82	18.18	Vibunpant *et al*., 2012
Saurida undosquamis (Brushtooth lizardfish)	10.75 - 29.75	20.72 ± 3.88	380	28.26	98.16	1.84	Vibunpant *et al*., 2011
Upeneus luzonius (Dark-barred goatfish)	6.25 - 16.25	12.03 ± 1.34	2,153	n/a	n/a	n/a	-
Atule mate (Yellowtail scad)	7.25 - 24.75	16.18 ± 3.10	98	21.25	92.86	7.14	Premkit *et al*., 2004
Rastrelliger kanagurta (Indian mackerel)	13.75 - 22.25	19.22 ± 2.22	33	17.12	18.18	81.82	Krajangdara *et al*., 2007
Sardinella gibbosa Goldstripe sardinella	11.25 - 17.25	12.92 ± 1.12	75	10.35	0.00	100.00	Nasuchon *et al*., 2010
Selar crumenophthalmus Bigeye scad	12.75 - 24.25	18.48 ± 2.02	59	18.25	47.46	52.54	Phuttharaksa *et al*., 2008
Uroteuthis chinensis Mitre squid	3.75 - 36.25	13.19 ± 5.42	192	17.71	82.81	17.19	Suppaniran *et al*., 2011
Uroteuthis duvaucelii Indian squid	2.25 - 29.75	7.24 ± 4.73	2,386	9.04	83.57	16.43	Suppaniran *et al*., 2011

Noted: *Length at first maturity of female

Discussion

The abundance of fisheries resources of two countries' waters may be assumed by the different in catch per unit effort (CPUE). The assumption is due to that the CPUE is one of the indicators that used for indicate the status of fisheries resources (Supongpan, 2001). The higher CPUE implies the more fish that can be caught in a specific period of time. According to the results of this study, the total CPUE in Thai waters was significantly higher ($p<0.05$) than the total CPUE in Cambodian waters. The CPUE of economic species were similar but it was different in trash fish CPUE, which was found pretty high in Thai waters. Although, trash fish is generally referred to non-economic species or small fish that have low market demand, such as ponyfish, cardinal fish and non-economic crab species, they are important to the ecosystem as low trophic level species which are food for higher trophic level fish or bigger fish in the food chain. The more of low trophic level species means the more productivity in the ecosystem. Therefore, the present of high amount of trash fish catch in Thai waters indicates that this area is highly abundance with fisheries resources than Cambodian waters.

Regarding species composition, it was shown that the fish species in both two countries' water are not much difference. The common species found in Thai waters were similar to the species found in Cambodian waters, e.g. threadfin breams, goatfishes, lizardfishes and squids. However, the fish community structure seems to be clearly distinct between two waters. According to catch composition and size of selected species found in this study, the fish community in Cambodian waters comprised more percentage of economic species and tend to have larger fish than in Thai waters. The majority of economic species in Cambodian waters were bigger, especially for demersal fish. Besides, since length is related to maturity size, the percentage of the mature fish was found higher in Cambodian waters, 5 of 10 species in Cambodian waters while it was 3 of 13 species in Thai waters. Hence, it can be speculated that the fish in Cambodian waters seem to be appropriate exploited than fish in Thai waters by considering its size.

It could be concluded that the current demersal fishery resources in Thai waters have higher abundance than in Cambodian waters, but they are exploited inappropriate ways since approximately a half of the total catch was trash fish. As well as the average length of most selected species found in Thai waters was smaller than their length at first maturity. This indicates that there is need to keep into account more effective fisheries management measures. The situation seems to be better in Cambodian waters which economic fish were the majority in the catch and greater number of mature fish, but it should be cautious in fisheries management plan.

It is also important to note that the current status of fisheries resources in Cambodian waters is better than in the past. Cheuapun and Chanrachkit (n.d.) reported that marine fisheries resource survey in 10 stations of Cambodian waters was conducted in 2005 by M.V. SEAFDEC 2 equipped with an otter board trawl with 25 mm mesh size. The result revealed that CPUE was 15.70 kg/hr. While, the CPUE in 2018 was 26.27 kg/hr even though 40 mm codend mesh size was used in this survey. It can be observed that current CPUE was much higher than in 2005, even if codend mesh size used in this survey is larger than in the past.

In addition, this survey emphasized the demersal resource survey. It did not cover all fisheries resources that have been currently exploited including pelagic resources, and also not cover all areas in the Gulf of Thailand. There is a recommendation that it should be carried out another collaborative survey which covers all fisheries resource and all countries in the Gulf of Thailand including Vietnam, Cambodia, Thailand and Malaysia in order to have broader perspective of fisheries resources status in the gulf.

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