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Species composition and diel variation of fish caught by traditional longline fishing

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Abstract The study of fish species composition and diel variation of fish caught by traditional longline fishing was conducted during December 2020 to January 2022. Many sizes of circle hooks ranging from No. 9/0 – No. 18/0 attached with branch lines, main lines and baits (earthworm and small live fish) were used to collect fish samples from 3 stations along the middle Chi River, Maha Sarakham, Thailand. In the current study, a total 414 fish belonging to 9 families with 21 species were found. *Pangasius larnaudii* was the most dominant species in terms of number (15.2%) whereas *Chitala ornate* was the most dominant species in terms of weight (35.6%). The most dominant species in terms of %IRI was *Hemibagrus wyckioides* (16.7%). Total cacth per Unit effort of longline fishing ranged from 0.01 – 15.6 kg•day^{-1} with an average by 2.8 ± 0.31 kg•day^{-1}. Investigation of diel variation of caught fish during December 2021 to January 2022 found that *Hemibagrus wyckioides, Hemibagrus filamentus, Pangasius larnaudii* and *Mastacembelus armatus* were caught during both day and night. Four and 14 fish species were found during the day and night, respectively. Catch per unit effort during the night with an average of 1,845.5 ± 409.1 g. •12 hours^{-1} was significantly greater than the catch per unit effort during the day with an average of 264.4 ± 132.7 g. •12 hours^{-1} ($p< 0.05$). These results suggested that longline fishing should be operated during the night to gain more catch compared to fishing during the day.

Keywords: Longline fishing, Hook, bait, Species composition, Diel variation, CpUE

Introduction

Fishing is a human activity that is crucial to human life, culture, employment, and economy (Anticamara *et al.*, 2011). Many types of fishing gears have been continually invented and developed associated with fishing area, seasons, size and behavior of target species to increase catch efficiency,

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reduce bycatch and negative impact of fishing environment (He *et al.,* 2021; Ward and Hindmarsh, 2007). Longline is one of the most used fishing gears worldwide originally developed by Japanese (Watson and Kerstetter, 2006). There are many types of long line accordig to the target species. These include pelagic longline (drifting longline), bottom longline and (Domingo *et al.,* 2014; He *et al.,* 2021). The main reason of selection this fishing gear that in simply construction, low cost (Bose *et al.,* 2017) and mainly catch larger fishes with high market price (Gilman *et al.,* 2020). Each longline set consists of mainline, branch lines, and baited hooks. The mainline is horizontal line with considerable length depending on fishing area. The branch lines which also called snood or gangions are connected to the mainline with certain interval depending on the size of hook and the target fishes. Baited hooks were attached to the end of each branchline (Hovgard and Lassen, 2000). Longline can be used to fish both day and night times, moslty during the night (Poisson *et al.,* 2010).

Although, longline fishing has been investigated for many years, mostly focused on commercial marine fisheries which are mainly fished for tuna (*Thunnus* spp.) (Domingo *et al.,* 2014; Huang, 2011), swordfish (*Xiphias gladius*) (Amorim *et al.,* 2015), billfishes (*Istiorphoridae* spp.) (Gilman *et al.,* 2006; WCPFC, 2019). The investigation of longline fishing within inland fisheries are little known even the longline fishing gear is widely used in many countries like lower Sakarya River, Turkey (Reis and Cerim, 2020), River Tawa, India (Bose *et al.,* 2017).

The Chi River is the longest river in Thailand, approximately 765 km. This river is used for many purposes by surrounding people like agriculture, transportation and irrigation in particular for fishery. Fishing by local fishermen along the river has a long history through the diversity of fishing gears. They have developed and applied their gears with different characteristics and practices related to the season, species, and size of animals. The popular fishing gears were gillnets, lift nets, long line hooks, traps, and surrounding nets (Aengwanich, 1998). Many authors surveyed and reported the fish species diversity caught by many fishing methods, mainly gillnets (Aengwanich *et al.,* 1999; Aengwanich *et al.,* 1998; Leeraputhana, 1997; Nachaiperm *et al.,* 2004; Panchan *et al.,* 2013; Pilasemorn *et al.,* 2006). Investigation of longline fishing in the Chi River is still unknown.

The study aimed to document the long line fishing operation, investigate the catch composition and the dominant fish species of longline fishing and compare catch per unit effort among hook sizes and between the day and the night. The result of this study will provide useful information on the fishery resources to support data related to sustainable management.

Materials and methods

Study sites and fishing gear

The current study was performed between December 2020 and January 2022. All data were collected from 3 sampling sites along a 20 km long section of middle Chi River, Mahasarakham province, the north-eastern region of Thailand (between 16° 11′ 43″ to 16°12′ 57″N and 103°13′ 27″ to 103°19′ 22″E) (Figure 1).

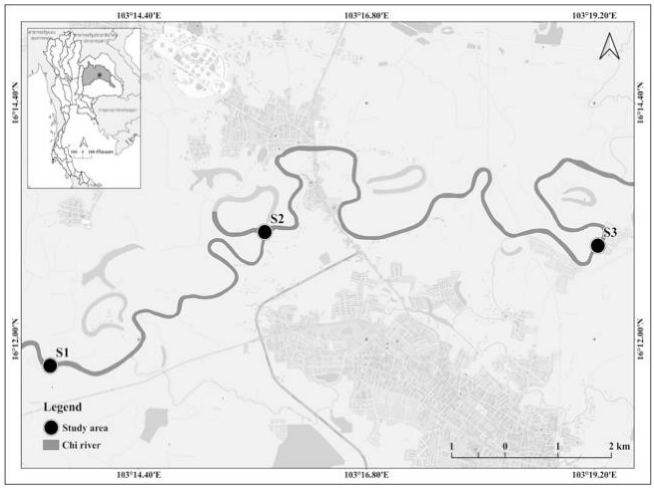

Figure 1. Sampling sites located at the middle Chi River (S1: Ban Huaychun, S2: Ban Nontoom and S3: Ban BungKha)

The current study was approved the license of the animal welfare No. IACUC-MSU-02/2021 by Mahasarakham University. Local fishermen at each station were assigned to be the data collectors. Before the project started, data collectors were trained on what the aims of the study and the obtained data. The study consited of 2 parts: 1) interview with the fishermen 2) fishing evaluation.

For the first part, we interviewed the fisherman during fishing operating to gather information about the method and technical characteristics of longline fishing. The second part is to obtain the total catch composition and diel variation of caught fish between day and night. The J-shaped hook with non-offset and 5 different sizes namely 9/0, 12/0, 14/0, 16/0 and 18/0 which were the commonly used by fishermen in the Chi River were used. Two longline sets per hook size (10 sets/ site) were installed for sampling the fish in each study site (Figure 2). The same fishing method and operation were performed at

each sampling sites. Each longline consisted of multifilament mainline of 3.2 mm. attached with monofilament branch lines. Each branch line was connected the baited hook, earthworm, or small alive fish as bait. The fishermen were free decision when to fish on each appointment fishing date. Total 59 days were the fishing days of the current study. On each fishing days, the fisherman at each sampling site set the long lines during 3-6 pm. The gears were then left to fish for about 12 hours. In the morning of the next day at 6-9 am, they came back to collect the fish from each set of longline. For the investigation of diel variation in catch composition, we performed the experiment at site 1 between December 2021 to January 2022. The gears were set for 24 hours in fishing area and fish samples were collected every 12 hours. The fish samples of both experiments were taxonomically identified into species (Rainboth, 1996), counted, measured the total lenght (nearest 0.1 cm.) and weighted (nearest 0.1g.) in each hook size and each fishing period.

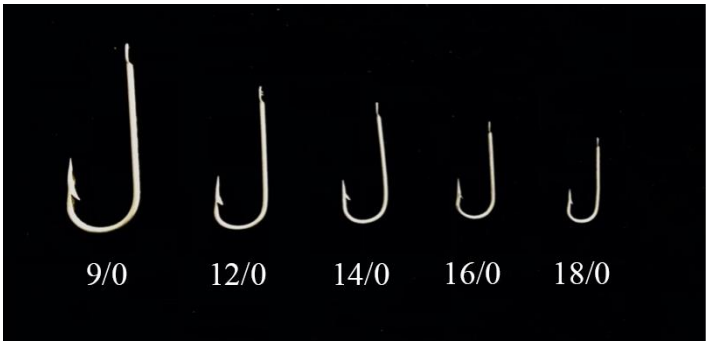

Figure 2. J-shaped hooks in different sizes ranging from 9/0 - 18/0 are commonly used in the Chi River

Data analysis

From the data the percentage of catch composition in term of family was analysed. Percentage weight, number and occurred frequency of each fish species in the total catch were used to calculate the index of relative importance (%IRI) (Pinkas *et al.*, 1971) as follow equation:

$$\%\mathrm{IRI} = \left(\frac{(\%\mathrm{W_i} + \mathrm{N_i}) \times \%\mathrm{F_i}}{\sum_{i=1}^{n}(\%\mathrm{W_i} + \%\mathrm{N_i}) \times \%\mathrm{F_i}}\right) \times 100$$

Where $\%W_i$ and $\%N_i$ are the percentage weight and number of the i^{th} species in the total catch and $\%F_i$ is the percentage frequency of occurrence of each species in the total number of species.

The catch per unit effort (CpUE) was expressed as kg.day^{-1} by each hook and kg.12 hrs^{-1} by each fishing period for 12 hours. Kruskal-Wallis chi-square test as non-parametric statistic was used to test the equal of median of CpUE among group of hook sizes and the fishing periods. Tukey's HSD was posteriori test when the difference among group of hook size was found. Wilcoxon-Mann-Withey U- test, a non- parametric statistic was used to test the different of median between the fishing period.

Results

Fishing operation

Firstly, fisherman installed the main line across the river and holded the line with either stone or tree at the riverbanks (Figure 3). The lenght of main line depended on the river width approximately 50-70 m. Secondly, each branch lines with lenght 1-2 m. with the baited hook were connected to the main line with certain interval between line approximately 2 - 4 m. Baits are usully the small alive fish and the earthworm (Figure 3). There were 10-15 hooks per long line set. Stones connecting the other lines were connected to the main line to set the depth of longline in the water during fishing. The depth of longline was relative the distance between the stone and mainline. The shorter distance was deeper in the water than the longer distance. The fisherman usually set the long lines in dusk at 3-6 pm. The gears were then left to fish for about 12 hours. They came back to collect the fish in the morning of the next day at 6-9 am. For the collecting process, each hook was checked without retrieving the gear from the water. The new bait was re-hooked when the lost bait was found. For collecting the caught fish, mostly the fish were cuaght by swallowing the baited hook into their mouth. Fishermen carefully removed the fish from the hook without cut off the branchline if the small fish was caught. However, the branchline with hook was probably cut off from the mainline to collect the larger fish on boat if they were unable easily remove the hook. Then, substitution of the new branch line with baited hook was installed. The total time spending of collecting fish was approximately 2-3 hours. The fishermen, moreover, reported that the target species of long line fishing were the larger fishes like *P. larnaudii*, *H. wyckioides* and *C. ornate* which were the economical important species.

Catch composition and the dominant fish species of longline fishing

In total 59 fishing date during December 2020 to January 2022, 414 fish belonging 9 families 17 genera and 21 species were found (Table 1).

Cyprinidae was the most frequent occurence in terms of family, which comprised 6 fish species (28.6%), followed by Bagridae (19.0%) and Siluridae (14.3%), respectively (Figure 4). *P. larnaudii*, *C. ornata and H. wyckioides* were the most dominant species in terms of number at 15.2%, 14.0% and 11.1%, respectively (Table 1). *C. ornate*, *H. wyckioides and W. Attu* were the most dominant species in terms of weight at 35.6%, 29.8% and 9.6%, respectively (Table 1). According to percentage index of relative importance (%IRI) *H. wyckioides was the dominant species caught by longline fishing at 16.7% followed by P. larnaudii*, *H. filamentus*, *C. ornate* were equally %IRI by 12.8% (Figure 4).

Consideration catch composition by the fishing period during December 2021 to January 2022 (Table 2), H. *wyckioides*, *H. filamentus, P. larnaudii* and *M. armatus* were caught during both day and night. Four and 14 fish species were found during the day and night, respectively.

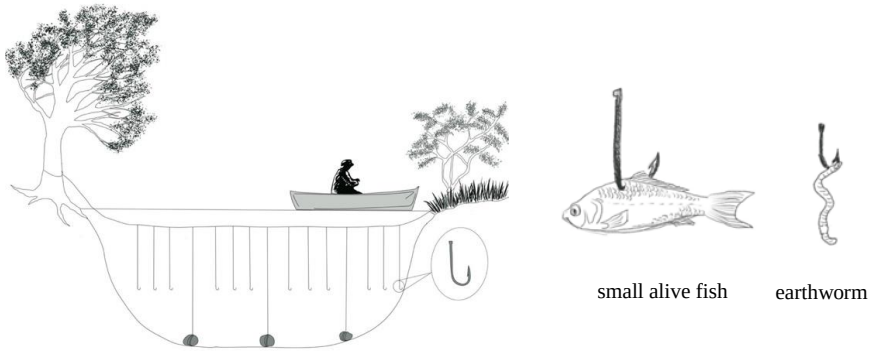

Figure 3. Schematic represents the operation of longline fishing between the riverbanks in the Chi River with using small alive fish and earthworm as bait

Catch per unit effort (CpUE)

The investigation of CpUE among hook size throughout the study period ranged from 0.01 and 15.6 kg• day^{-1} with an average by 2.8 ± 0.31 kg •day^{-1} (Table 3). The largest hook size No. 9/0 revealed the greater CpUE than the others hook ($p<0.05$) (Table3 and Figure 5a). Consideration CpUE in term of different fishing period, catch per unit effort during the night with an average of 1,845.5 ± 409.1 g.•12 hours-^{1} was significantly greater than the catch per unit effort during the day with an average of 264.4 ± 132.7 g. •12 hours-^{1} ($p< 0.05$) (Table 3 and Figure 5b).

Table 1. Species composition by different hook size and percentage index of relative importance (%IRI) of longline fishing in the Chi River. Bold letters in species colunm refer to family

Species	Frequency					%	Weight (g)					%	%IRI
	9/0	12/0	14/0	16/0	18/0		9/0	12/0	14/0	16/0	18/0		
Notopteridae													
Chitala ornata	15	12	8	11	-	11.1	41.9	26.6	10.80	3.50	-	35.6	12.8
Notopterus notopterus	1	-	1	-	-	0.5	0.13	-	0.1	-	-	0.1	1.3
Cyprinidae													
Cyclocheilichthys enoplos	8	2	-	9	-	4.6	12.0	2.00	2.95	-	-	7.3	5.1
Puntioplites proctozysron	-	-	2	-	1	0.7	-	-	0.27	-	0.01	0.1	1.9
Barbonymus gonionotus	1	-	3	-	-	1.0	0.02	-	0.59	-	-	0.3	2.6
Probarbus jullieni	-	-	1	-	-	0.2	-	-	1.88	-	-	0.8	0.6
Barbonymus altus	-	-	-	-	3	0.7	-	-	-	-	0.10	0.04	0.6
Labeo chrysophekadion	-	1	-	-	-	0.2	-	1.10	-	-	-	0.5	0.6
Bagridae													
Hemibagrus wyckioides	19	4	32	-	3	14.0	47.80	8.80	7.47	-	5.3	29.8	16.7
Hemibagrus filamentus	2	13	21	-	14	12.1	0.22	2.99	1.65	-	1.56	2.8	12.8
Mystus nigriceps	-	-	2	39	-	9.9	-	-	0.27	5.41	-	2.4	4.5
Mystus bocourti	-	2	-	-	-	0.5	-	0.08	-	-	-	0.03	0.6
Siluridae													
Wallago Attu	10	1	6			4.1	20.8	1.20	0.46	-	-	9.6	5.1
Ompok bimaculatus	1	-	13	-	1	3.6	0.10	-	0.69	0.06	-	0.4	3.2
Micronema micronema	5	7	10	8	3	8.0	1.20	2.03	1.35	1.30	0.58	2.8	10.9
Pangasiidae													
Pangasius larnaudii	13	13	6	9	2	15.2	2.56	4.27	2.45	0.40	0.65	4.4	12.8
Pangasius macronema	-	10	-	-	-	2.4	-	0.13	-	-	-	0.1	0.6
Clariidae													
Clarias batrachus	-	-	1	-	-	0.2	-	-	0.74	-	-	0.32	
Mastacembelidae													
Mastacembelus armatus	-	1	36	-	1	9.2	-	0.11	2.77	-	0.01	1.3	3.8
Eleotridae													
Oxyeleotris marmorata	1	-	3	-	1	1.2	0.20	-	0.21	-	1.00	0.6	1.9
Chaniuidae													
Channa striata	-	2	-	-	-	0.5	-	2.00	-	-	-	0.9	0.6
Total	**76**	**88**	**145**	**76**	**29**		**126.9**	**51.3**	**31.7**	**13.6**	**9.3**		

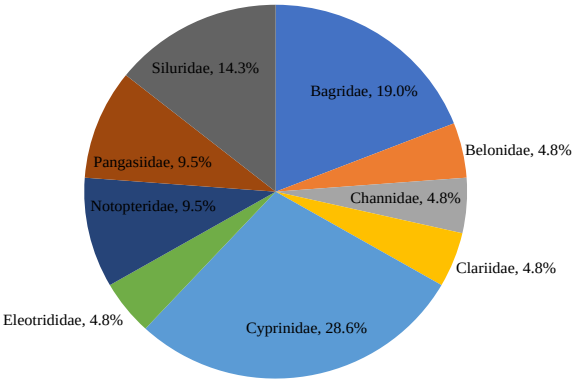

Figure 4. Percentage of fish species in each family caught by longline fishing

Table 2. Species composition caught by longline fishing between day and night in the Chi River. Bold letters in species columm refer to family

Species	Frequency		%		Weight (g)		%	
	Day	Night	Day	Night	Day	Night	Day	Night
Cyprinidae								
Puntioplites proctozysron	2	0	1.64	0	268	-	1.59	-
Barbonymus gonionotus	3	0	2.46	0	589	-	3.49	-
Probarbus jullieni	1	0	0.82	0	1,880	-	11.14	-
Barbonymus altus	3	0	2.46	0	96	-	0.57	-
Bagridae								
Hemibagrus wyckioides	17	7	13.93	5.74	4,851	323	28.74	1.91
Hemibagrus filamentus	11	5	9.02	4.10	401	165	2.38	0.98
Mystus nigriceps	1	0	0.82	0	67	-	0.40	-
Siluridae								
Wallago Attu	6	0	4.92	0	456	-	2.70	-
Ompok bimaculatus	14	0	11.48	0	746	-	4.42	-
Micronema bleekri	5	0	4.10	0	530	-	3.14	-
Pangasiidae								
Pangasius larnaudii	5	1	4.10	0.82	2,213	505	13.11	2.99
Clariidae								
Clarias batrachus	1	0	0.82	0	740	-	4.38	-
Mastacembelidae								
Mastacembelus armatus	23	14	18.85	11.48	1,719	1,122	10.18	6.65
Eleotridae								
Oxyeleotris marmorata	3	0	2.46	0	208	-	1.23	-
Total	**14**	**4**			**14,764**	**2,115**		

Table 3. Catch per Unit effort of longline fishing in the Chi River

Hook size	CpUE (kg•day^{-1})		Fishing period	CpUE (g. •12 hours^{-1})	
	Min - Max	Average ±SE		Min -Max	Average ±SE
No. 9/0	0.1-15.6	4.1 ±0.6	Day	0 – 106	264.4 ±132.7
No. 12/0	0.2 - 11.7	2.6 ±0.7	Night	321 – 4000	1.845.5 ±409.1
No. 14/0	0.3 - 4.9	1.7 ±0.3	**Total**	**0 – 4000**	**264.4 ±132.7**
No.16/0	0.8 - 6.9	2.7 ±1.1			
No.18/0	0.01 - 3.5	1.0 ±0.4			
Total	**0.01 – 15.6**	**2.8 ±0.31**			

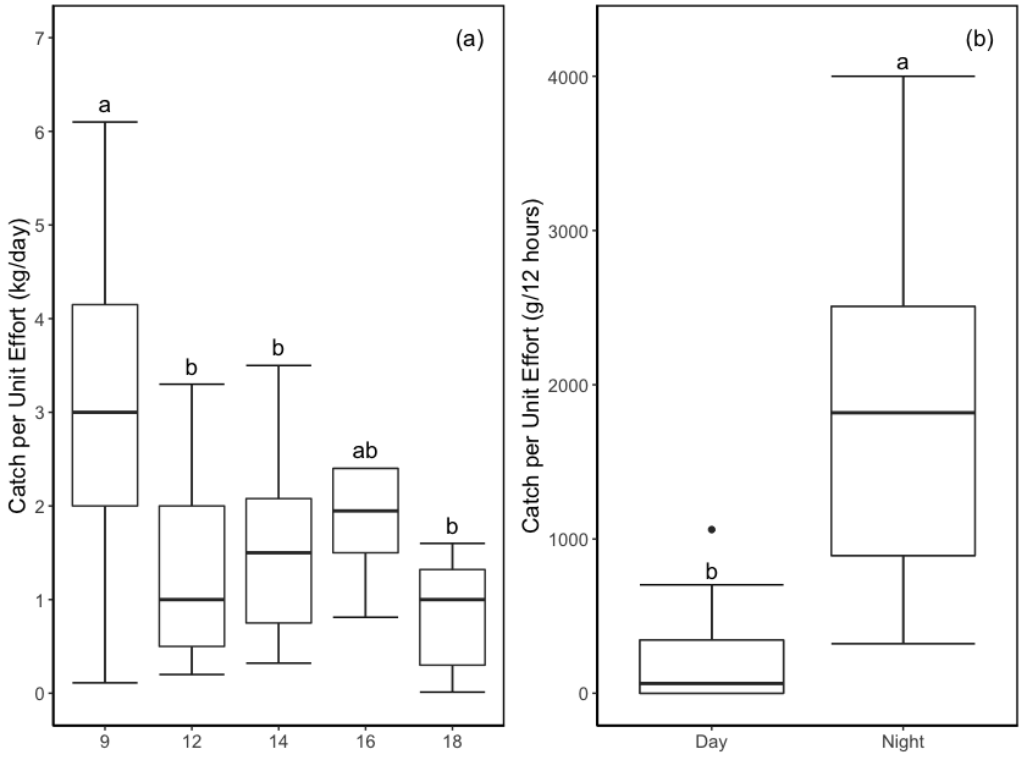

Figure 5. Summary of statistical testing of CpUE at different hook size (a) and the fishing period (b). The same letter above the boxes indicate that the values are not statistically different ($\propto = 0.05$)

Discussion

The results revealed the basic information regarding the catch composition and catch per unit effort of the long line fishing in the Chi River, which have not been investigated ever. The interview about fishing operation,

hook size 9/0, 12/0, 14/0 16/0 and 18/0 with small alive fish and earthworm as bait were mostly used to fish by fishermen. The most important factors effecting long line efficiency were hook size and bait type. The hook size and bait type would be selected for fishing depending on the needed target species (Løkkeborg and Bjordal, 1992). In Chi River, the fishermen reported that the target species of long line fishing were the larger fishes like *P. larnaudii, H. wyckioides* and *C. ornate* which were the economical important species.

The results of fishing observation were found 414 fish belonging 9 families 17 genera and 21 species which differ to the previous study (Leeraputhana, 1997; Aengwanich *et al*., 1998; Nachaiperm *et al.*, 2004; Pilasemorn *et al*., 2006; Panchan *et al.*, 2013). This might be due to the different fishing method and location to sampling the fishes. However, family Cyprinidae was the pre-dominant group similar to the previous studies. Aengwanich *et al.*, 1999; Nachaiperm *et al*,. 2004; Jutagate, 2009 reported that fish in the Cyprinidae family are the predominant fish species found in the Chi River and are commonly found within Thai riverine habitats.

Longline fishing gear is classified as highly selectivity like the selectivity of gillnets. Both gears were catch specific by species and size. The selectivity of species specific depends on either the fishing strategies or fishin gears including the fish distribution, both horizontal and vetical distributions (Løkkeborg and Bjordal, 1992). The study, the long lines were installled in the mid- water depth. The result revealed that *H. wyckioides, P. larnaudii, H. filamentus* and *C. ornate* were the dominant species caught by longline fishing. These species live between mid-water and bottom area. The result differed to gillnet fishing, mostly the pelagic fishes were caught (Nachaiperm *et al.*, 2004; Pilasemorn *et al*., 2006; Panchan *et al*., 2013).

Catch per unit effort (CpUE) is one of the important indicators on the status of fish abundance related to usable stocks and fishing methods (Bishop, 2006). In the study, CpUE among hook sizes period ranged from 0.01 – 15.6 with an average by 2.8 ± 0.31 kg•day^{-1}. Differently, the investigation of traditional longline set used in the lower Sakarya River revealed that the average daily catch was between 5- 10 kg.(Reis and Cerim, 2020). Moreover, the result differed from the previous studies in the Chi River by gillnet like 2.1 ± 0.4 kg•fisherman $^{-1}$• day^{-1} (Panchan *et al.*, 2013), 147.80 g•100m^2•hr^{-1} (Pilasemorn *et al.*, 2006) and 6.80 g•180m^2•hr^{-1}(Nachaiperm *et al.*, 2004). Generally, fishes were caught by swallowing the baited hook in the mouth or penetrating their flesh. The hook characteristic and the biological charactertistic of fish affected the catch performance (Løkkeborg and Bjordal, 1992). Structure of large hook was stronger and gab wider and consequently more effective catch than smaller hook. Likewise, the highest catch per unit effort

was found at hook size 9/0, ranging from 0.11 - 15.6 kg•day^{-1} (an averge 4.1 ± 0.6 kg•day^{-1}).

Catch per unit effort (CpUE) of long line fishing during the night with an average of 1,845.5 ± 409.1 g•12 hours^{-1} was significantly greater than the catch per unit effort during the day (an average of 264.4 ± 132.7 g •12 hours^{-1}). There are many factors affecting the performance of longline fishing, whether external or internal factors of fish like hunger state, food habit and feed abundance (Løkkeborg *et al.*, 2014). Moreover light level as the external factor affects visibility of fishing gear and bait of the fish (Stoner, 2003), resulting in low CpUE during the day. Fourteen fishes were found in both fishing periods, however, might be due to hunger state of fish.

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