Study on effect of hooking location and injuries to the survival of Indonesian snakehead *Channa micropeltes* using treble hook in recreational fishing

[1]Fazrul Hisam, [1]Mun C. Chong, [2]Sukree Hajisamae, [1]Nik A. N. Aziz, [1]Muhamad Naimullah, [3]Marina Hassan

[1] School of Fisheries Science and Aquaculture, Malaysia Terengganu University, Kuala Nerus, Terengganu, Malaysia; [2] Faculty Science and Technology, Prince of Songkla University, Pattani, Thailand; [3] Institute of Tropical Aquaculture, Malaysia Terengganu University, Kuala Nerus, Terengganu, Malaysia. Corresponding author: F. Hisam, fazrulpsu@gmail.com

Abstract. In recreational fishing, catch and release has been broadly implemented among recreational anglers. However, information regarding post-release survival of Indonesian snakehead (*Channa micropeltes*) using artificial bait with treble hook is lacking. The purpose of this study is to evaluate relationship between hooking position, hooking injuries and post-released survival of fish. The study was conducted at Kenyir Lake, Terengganu, Malaysia with four sampling stations nearby Kiang River, Terengganu, Malaysia. *C. micropeltes* were kept in cages for 24 hours for post- released survival evaluation based on hooking injuries represent by bleeding level and hooking positions after angling. The survival rate of fish was 94% (32 out of 34 fish). Survival of fish were significantly influenced by hooking injuries ($p = 0.031$). Smaller fish (<39.9 cm) have more bleeding tendency (5 out of 9 bleed). Survival of fish were not significantly influenced by hooking positions ($p = 0.313$). Majority of fish was hook at superficial hooking positions (82.35% superficial, 5.88% internal, 11.76% external, respectively). Our finding suggests that reduction of hook size could reduce the external hooking of smaller fish and correct fish handling is crucial.
Key Words: freshwater, recreational anglers, hooking injuries, conservation, catch and release.

Introduction. Recreational angling is defined as a type of fishing where catches are not to feed the anglers and are usually not sold and not for trading on export, black markets, and domestic usage (FAO 2012). In almost every part of the world, recreational angling is an economically and socially important utilization of fisheries resources (Cooke & Schramm 2007). Almost 11.5% of the world's population participates in recreational angling if recreational angling partaking percentages of Canada mirror global trends (Cooke & Cowx 2004).

In many parts of the world, catch-and-release (C&R) angling has grown and turns out to be progressively common among recreational anglers (Lennox et al 2014). C&R has become broadly implemented as a management guideline to conservation, which is important in maintaining the catch rate (Camp et al 2015). C&R is defined as the action of freeing catches that were captured by recreational anglers (Cooke & Wilde 2007). Snakehead is the name for all the species in the genus *Channa* this is because of their head are looking like the head of a snake (Norainy 2007). The aggressive nature of this species due to its biological features makes it a sensational game fish for recreational anglers (Norainy 2007).

There are many factors that control the fate of a released fish such as angling process, environmental, ecological and the species itself (Brownscombe et al 2017). Hooking location is one of the most important factors causing hooking mortality for many species (Bartholomew & Bohnsack 2005). Higher mortality is shown when the fish got hooked in a critical region (Bartholomew & Bohnsack 2005). There are about 60% of fish are released annually (Cooke & Cowx 2004). Most of the fish released by anglers only die after some time, but usually mortality is highest within 24 hours (Muoneke & Childress 1994).

Therefore, understanding the post-release mortality of *Channa micropeltes* can provide better survival of the fish and development of effective regulation. This study is therefore conducted with the aims to determine the post-released survival based on hooking location and injuries of *C. micropeltes* using artificial bait with treble hook.

Material and Method

Study Site. The study was conducted at Kenyir Lake, Terengganu, Malaysia. The main site of fishing for the sampling was Kiang River. Four sampling stations; Station 1 (05°08'25.7"N 102°45'32.7"E), Station 2 (05°08'26.6"N 102°44'04.0"E), Station 3 (05°07'49.0"N 102°44'24.4"E) and Station 4 (05°06'35.3"N 102°44'35.2"E) were chosen within and nearby Kiang River (Figure 1).

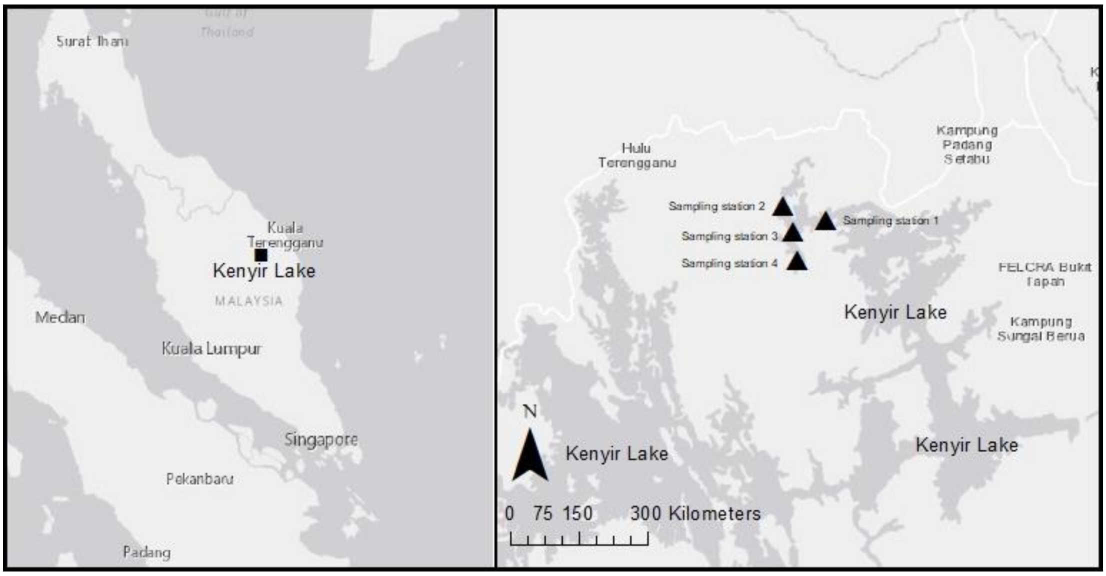

Figure 1. Location of four sampling stations at Kenyir Lake, Terengganu.

Equipment. The treble hook that was used for sampling is VMC 9625 - O'shaughnessy 2X black nickel size 4 and VMC 9625 - permasteel coating treble hooks size 4 (Figure 2).

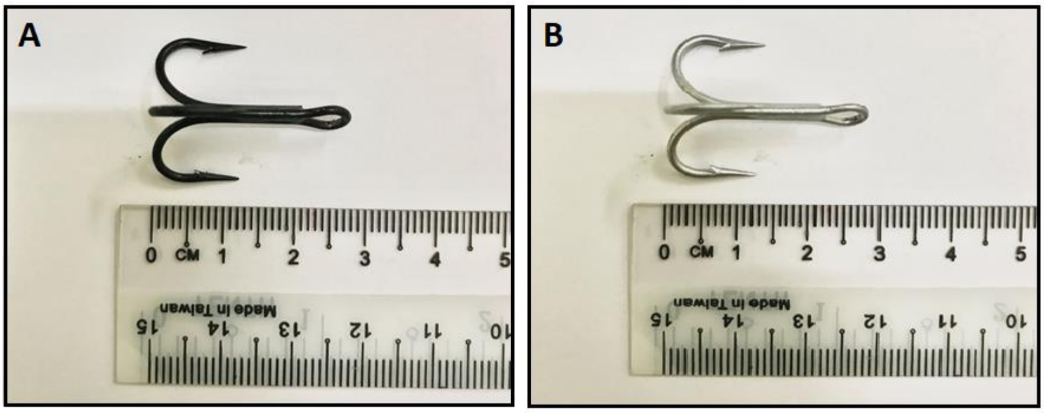

Figure 2. The treble hooks used during the sampling at Kenyir Lake; (A) VMC 9625 - O'shaughnessy 2X black nickel coating treble hook and (B) VMC 9625 - O'shaughnessy 2X permasteel coating treble hook.

There are two top water artificial baits that were used during the study; Rebel jumpin minnow 90 and Storm chug bug 90. The Rebel jumpin minnow is bait weighted 11 g and is 90 mm in length. The Storm chug bug is bait weighted 10 g and is 90 mm in length. Both lure was equipped with 2 treble hooks. For the fishing rod, Kuying Conqueror with 9.07 kg rating bait and 2.1 m long casting rod was used. The fishing reel used was bait-casting reels from Shimano and Daiwa. A Sufix 832 braided (9.07 kg breaking strain) was used as main line and was knotted to Mustad fluorocarbon line leader (13.60 kg breaking strain).

Angling procedures. Angling was performed from a boat with 2 fishing sessions/day. Each fishing session lasted 4 hours. The first fishing session was from 08:00 to 12:00. The second fishing session was from 15:00 to 19:00. Casting technique was used for sampling purposes, this means anglers cast the lure out and retrieve the artificial bait and repeat the cycle again until a fish attack the bait. There were 2 anglers on a boat at the same time. Once the fish was hooked, the angler played the fish until the fish was tired by observing that the fish was not shaking and running in the water but retaining its balance. The played time is depending on the fish size. The fish was then landed by using a knotless net. The fish was then secured for ease of handling by using a lip grip. The fish's belly was supported by hand when it was held in the air.

The hooking position was then recorded, and picture was taken to show hooking injuries. The hook was removed by using a pair of long nose pliers. However, for fish that was hooked deeply in the critical hooking location, the hook was cut by using a pair of cutters. Then, the total length (cm) of the fish and hook type was recorded. The fish was then tagged by using T-bar anchor tag. All the procedure of recording, including hook removing was done in a tank with aeration for minimizing the air exposure. Once all the data were recorded, the observation of short-term mortality was started by recording the time for each individual fish. After the first fishing session for the day, catches of first session will be transferred into a half-submerged fish cage. For fish under the observation for short-term mortality of 24 hours (Kerr et al 2017), observation was done every 2 hours. After 24 hours live fish were released back into the lake.

Data collection for hooking locations. This method of data collection was based on Kerr et al (2017). The hooking positions of fish were separated into 3 categories (Figure 3). If the hook location was on premaxillary, maxillary, corner of the jaw and on the lower jaw of fish, it was considered as "superficial" position. If the hooking position was inside the mouth, such as palate, tongue and gill, it was considered as "internal". If the hooking location was on the external features such as body, fin, and operculum of the fish, it was considered as "external". The hooking location for different treatments was then recorded.

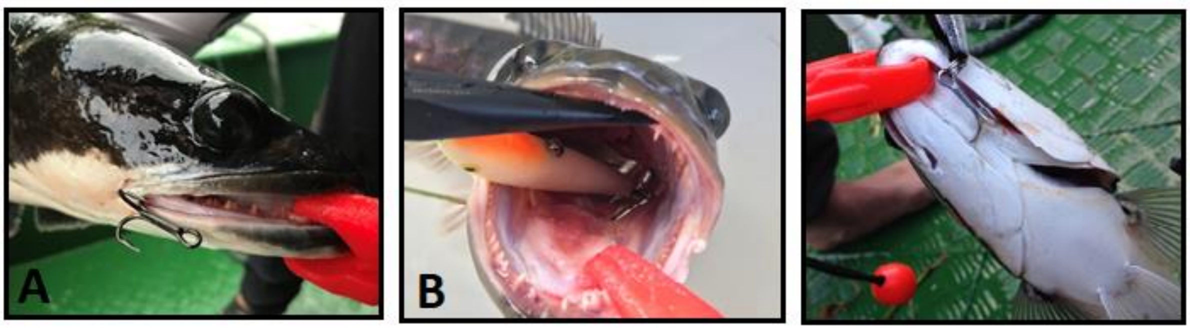

Figure 3. The hooking positions of fish were separated into 3 categories; (A) superficial, (B) internal and (C) external.

Data collection for injuries. The bleeding of fish was used to represent the seriousness of injuries (Arlinghaus et al 2008). According to Stålhammar et al (2014), there are three levels of bleeding to represent the seriousness of injuries: no bleeding, moderate and substantial (Figure 4 & Table 1).

Figure 4. Three levels of bleeding to represent the seriousness of injuries; (A) no bleeding, (B) moderate and (C) substantial.

Table 1

Description of bleeding levels by Stålhammar et al (2014)

Level of bleeding	*Description*
No bleeding	Bleeding is undistinguished from hooking
Moderate	Continuous bleeding, but mild
Substantial	Bleeding heavily and continuously

Statistical analysis. Fisher's exact test was used to test the relationships between degree of hooking injuries (represents by bleeding levels) and the survival of fish. This is to find out whether the seriousness of injuries affects the post-released survival of the fish. Besides, the Fisher's exact test was also used to test the relationship between hooking location and the survival of fish. Fisher's exact test was used because of expected count in some cell was less than 5 (Gargan et al 2015). For analysis, 0.05 was chosen as the α value to reject the null hypothesis. $\alpha<0.05$ was considered as significant, $\alpha<0.01$ as highly significant and $\alpha<0.001$ as very highly significant (Alȯs 2009).

Survival rate calculation. The survival rate of 24 hours was calculated by using the following formula:

$$\text{Survival rate (\%)} = \frac{X-Y}{X} \times 100\,\%$$

Where: X = Total number of fish caught and Y = Mortality of fish caught after 24 hours.

Results. There were 35 specimens of *C. micropeltes* caught during the experiment. But only 34 specimens of *C. micropeltes* (25-71 cm total length, 50.2±12.5 cm) were included into the analysis of injuries and hooking locations. The 35th individual was badly injured and dead during the hauling process. In this study, survival rate of fish was 94% (32 fish) and 6% (2 fish) of fish died in the study. One specimen (73 cm body length) from the data was excluded where the fish shows barotrauma symptom such as hyper inflated gas bladder. According to Hall et al (2014), barotrauma is the reduction of ambient pressure, which causes expansion of gases in blood and tissues at a rate that is faster than the fish can expel. Due to this situation the specimen cannot balance and floating on the water surface.

For level of injuries (represent by the level of bleeding), there were 24 specimens of *C. micropeltes* fall at category of no bleeding. Besides, eight specimens of *C. micropeltes* fall at moderate bleeding level and two specimens fall into substantial bleeding category (Table 2).

Table 2
Description and number of *Channa micropeltes* specimens in each level of bleeding

Level of bleeding	*Description*	*Number of fish*
No bleeding	Fish in the category did not show any sign of bleeding	24
Moderate bleeding	Fish in this category had mild bleeding and was continuously in short time, in some fish bleeding can only be seen after the fish was immersed into the water	8
Substantial bleeding	Fish in the category bleed heavily and large amount of blood came out from the wound	2

For statistical analysis, Fisher's exact test shows that the post-release survival of fish is significantly influenced by level of bleeding ($p<0.05$). The purpose of the analysis was to analyze whether post-release survival is related to the degree of injuries (Table 3).

Table 3
Result of Fisher's exact test for level of bleeding and post-released survival of *Channa micropeltes* specimens

Value		*df*	*Asymo. Sig. (2-sided)*	*Monte Carlo Sig. (2-sided)*		
				Sig.	*95% Confident Interval*	
					Lower bound	*Upper bound*
Pearson Chi-Square	9.164	2	0.010	.031	0.028	0.035
*Fisher's Exact Test	6.802			.031	0.028	0.035
Linear-by-Linear Association	7.843	1	0.005	.031	0.028	0.035

df = degree of freedom; Asymo. Sig. = Asymptotic Significant; Monte Carlo Sig. = Monte Carlo Significant
*Statistical analysis that was used in the study.

In no bleeding category, all specimens of *C. micropeltes* survive in the short-term mortality observation (Figure 5).

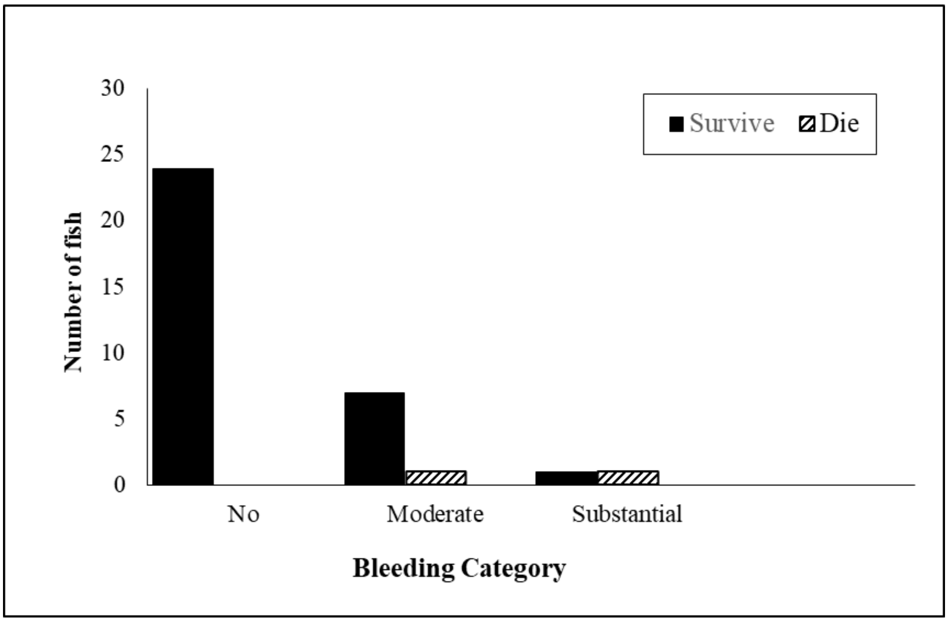

Figure 5. Relationship between level of bleeding (No, Moderate, and Substantial) and post- release survival (Survive and Die) of *Channa micropeltes* specimens.

In moderate bleeding category, one of eight specimens died. The condition of the specimen was bad; had pierced skin and meat from the upper jaw. Besides, in substantial bleeding category, one of two specimens of *C. micropeltes* died. This may be due to bad injuries and bleed a lot, a chunk of meat behind the operculum was pierced out and some of the internal organs were exposed.

In the comparison of bleeding categories and length of *C. micropeltes* specimens, all the length groups have the highest number of fish fall in no bleeding categories (4 fish out of 9 in <39.9 cm; 9 fish out of 13 in 40-55.9 cm; 11 fish out of 12 in >55.9 cm respectively). Besides, in the moderate bleeding category, all length groups have fish fall in the category (3 fish out of 9 in <39.9 cm; 4 fish out of 13 in 40-55.9 cm; 1 fish out of 12 in >55.9 cm, respectively). Whereas in substantial bleeding category, only one length group fall in the category (2 fish out of 9 in <39.9 cm). The trend of the graph indicates that smaller fish (<39.9 cm) tend to have higher bleeding occurrence than bigger fish (40-55.9 cm; >55.9 cm respectively) (Figure 6).

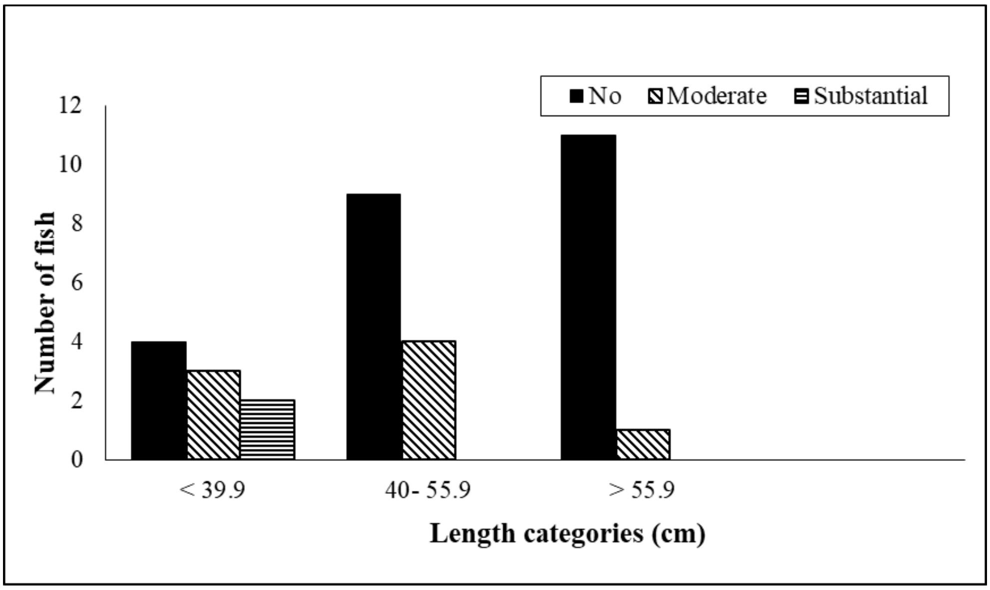

Figure 6. Trend of bleeding based on length categories of *Channa micropeltes* specimens.

For hooking positions, there were 28 specimens of *C. micropeltes* fall at the category of superficial hooking location, two specimens was included in the internal hooking location and four specimen in the external hooking location (Table 4). Most of the fish was hooked at the superficial hooking location and only small numbers of fish were hooked at the internal and external hooking locations.

Table 4

Description and number of *Channa micropeltes* specimens in each hooking locations categories

Hooking location	*Description*	*Number of fish*
Superficial	Fish in the category include those hooked in the corner of the mouth, lips, upper jaw and lower jaw	28
Internal	Fish in this category include those which are hooked in the mouth, such as palate and tongue	2
External	Fish in this category include those fish hooked in the fin, operculum, eye, and body	4

For statistical analysis, Fisher's exact test shows that the post-release survival of fish was not significantly influenced by hooking locations (p>0.05). The purpose of the analysis was to analyze whether post-release survival is related to the hooking locations (Table 5).

Table 5

Result of Fisher’s exact test for hooking locations and post-released survival of *Channa micropeltes* specimens

	Value	*df*	*Asymo. Sig. (2-sided)*	*Monte Carlo Sig. (2-sided)*		
				Sig.	*95% Confident Interval*	
					Lower bound	*Upper bound*
Pearson Chi-Square	3.036	2	0.219	.322	0.313	0.331
*Fisher’s Exact Test	3.449			.322	0.313	0.331
Linear-by-Linear Association	0.486	1	0.486	.322	0.313	0.331

In the superficial hooking location category, one of 28 specimens of *C. micropeltes* died. Whereas, in the internal hooking location category, all two specimens survived. Moreover, in external hooking location category, one of four specimens died (Figure 7).

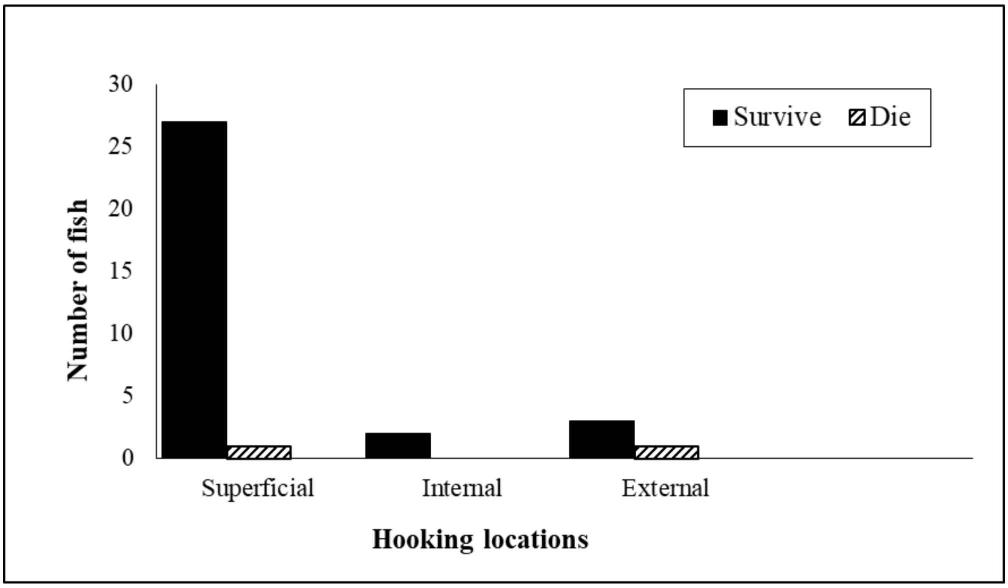

Figure 7. Relationship between hooking location (Superficial, Internal, and External) and post-released survival (survive and die) of *Channa micropeltes* specimens.

In the comparison of hooking locations and length of *C. micropeltes* specimens, all the length groups have the highest number of fish fall in superficial hooking location (6 fish out of 9 in <39.9 cm; 11 fish out of 13 in 40-55.9 cm; 11 fish out of 12 in >55.9 cm respectively). Besides, in the internal hooking location, only one length groups have fish fall in the category (2 fish out of 13 in 40-55.9 cm). Whereas, in external hooking location, there are two length groups fall in the hooking location (3 fish out of 9 in <39.9 cm; 1 fish out of 12 in >55.9 cm). The trend of the graph indicates that smaller fish (<39.9 cm) tend to hook more externally (Figure 8). As the length of the fish increase, fish tend to hook at superficial category more than other hooking location such as external and internal hooking locations.

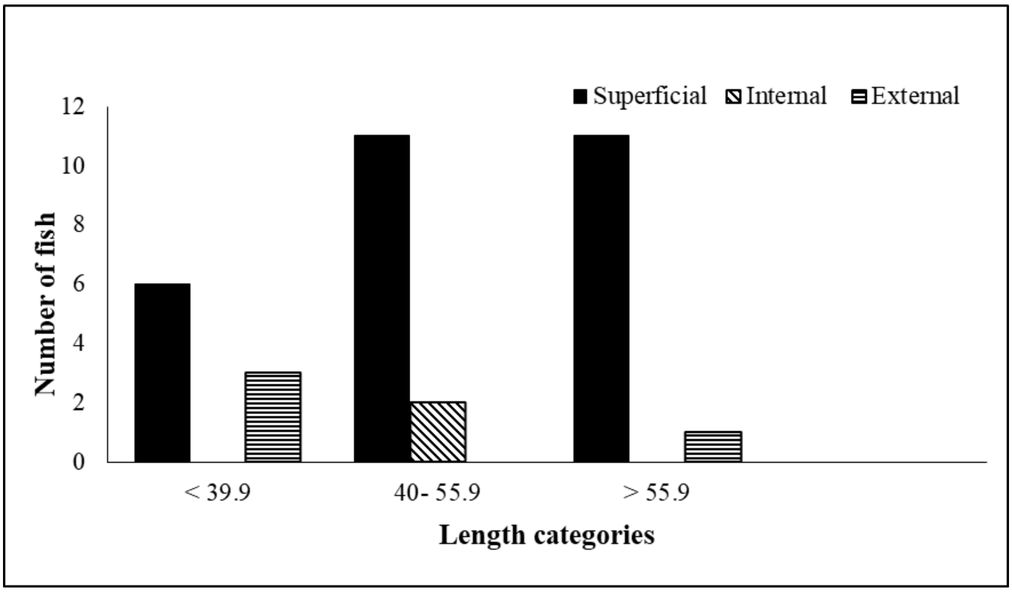

Figure 8. Trend of hooking locations based on length categories of *Channa micropeltes* specimens.

Discussion. In this study the survival rate of fish was 94%; this might be due to experiment design of minimizing air exposure, and suitable fish handling method such as handling with wet hands which can decrease the stress of fish (Brownscombe et al 2017). However, Skrzynska et al (2018) stated that hormone such as cortisol and adrenaline value increase after air exposure of 3 minutes. Besides, Brownscombe et al (2017) suggested that handle fish with wet hands can decrease the possibilities of bacterial infection. These handling methods are extremely important to reduce stress and degree of injuries to the fish which leads to higher survival rate of fish.

Whereas, for hooking injuries (represented by bleeding levels) most of the specimens had no bleeding and only 10 specimens were bleeding. The outcome of this study agreed with Mario et al (2014), in the experiment with peacock bass (*Cichla ocellaris*), where only 7 fish bleed out of 162 different species of *C. ocellaris*. Besides, another study also agreed with the outcome of this experiment. Stålhammar et al (2014) found that 87% of the fish fall in the no bleeding category. Additionally, this study revealed that the hooking injuries were related to the post-release survival of the fish. This finding agrees with previous finding which is Arlinghaus et al (2008), had also found that level of bleeding, which represents hooking injury severity was related to the hooking mortality. Moreover, Weltersbach & Strehlow (2013) also proposed that bleeding was significantly related to mortality. These findings indicate the degree of injuries and blood loss cause mortality of fish.

In the present experiment, there were two post-release mortalities recorded. One of the *C. micropeltes* in internal hooking location category had a hook at the superficial hooking location and another hook in the body where substantial bleeding occurred. This might due to when an angler is fighting the fish, the fish turn its body violently, and causing the other hook penetrate the body of the fish. The situation agrees with Muoneke & Childress (1994) and Bartholomew & Bohnsack (2005), where their studies found that fish might get hooked unintentionally in critical or sensitive tissue such as stomach, eyes, or body. Another fish in the categories that died was a 29.5 cm fish that bleed moderately and was hooked on the upper jaw where it has pierce meat and skin. The death of the fish might arise from 2 factors which might be the physical injuries and the effect of stressors. Cooke & Sneddon (2007), state that these factors can induce mortality and the effect of stressors depends on several factors including fish size.

Besides, our study also found that the smallest *C. micropeltes* category (<39.9 cm) have higher chances in terms of occurrence of bleeding. Huehn & Arlinghaus (2011) stated that degree of hooking injuries of fish is based on few factors including size of fish. Our finding is in contrast with Stålhammar et al (2014), who found that the larger the pike (*Esox lucius*) is, the higher is the occurrence of substantial bleeding. This might be due to different feeding mechanism of fish. Different species have different feeding mechanisms. According to Ferry et al (2015), *E. lucius* usually has its mouth stay open when moving forward to its prey before it attacks the prey. Besides that, *C. micropeltes* is more likely to be a predator that uses biting strategy to attack its prey. Therefore, this might be the reason why larger *C. micropeltes* didn't bleed too much because this species will bite the prey at first, then only move the prey into its mouth and when angler feel the bite of the fish it is most probably when the snakehead is biting the lure and the angler is already set the hook. It is recommended that if fishing for smaller fish, hook and artificial bait size should be reduced to avoid hooking the fish at external locations.

In the experiment, most of the fish was hooked at the superficial position: 2 hooked internally and 4 hooked externally. This finding agreed with previous finding of Gargan et al (2015), where there were only 2 salmon hooked at the internal hooking location. Moreover, Stålhammar et al (2014) found that 81.4% of fish was hooked at the superficial hooking location. Our study also found that hooking location is not influencing the post-release survival of the fish. Previous studies state that hooking injuries is one of the main reasons that cause hooking mortality (Muoneke & Childress 1994; Cooke & Wilde 2007; Huehn & Arlinghaus 2011). However, in previous study Veiga et al (2011), stated that anatomical hooking location causing mortality of fish because of deep hooking at critical hooking locations such as esophagus and stomach causes most of these fish bled and died in the experiment. In the context of this study, because of using hard body artificial bait, the hooking location does not matter. It is the degree of injuries that cause hooking mortality, there is no deep hooking incidence such as in the stomach and esophagus. In our study there is a fish that hook deeply at the gill and the hook was cut by using a pair of cutters where the fish survive the 24 hours post-release survival observation. According to Fobert et al (2009), bluegill (*Lepomis macrochirus*) with hook left in the fish by cutting the line off has higher survival rate than *L. macrochirus* that have the hook removed. Only 8% of *L. macrochirus* dies in the line cutting treatment. 71.4% of *L. macrochirus* in the treatment expelled the hook during the study duration.

In the experiment, fish that was internally hooked was due to loosen drag of the reel and passive moving artificial bait. When fish strike the bait next to the boat, the bait was sitting passively on the water and hook setting was delayed because of the loose drag. Additionally, Lennox et al (2015), stated that passive fishing method often leads to deep hooking. Previous study suggests that using suitable hook size and other terminal tackles is important because hooks that are too large or too small can also be responsible for the hooking injuries of fish (Sullivan et al 2013; Lennox et al 2015). Therefore, when fishing for smaller *C. micropeltes*, smaller hooks and bait can be used to avoid hooking external location of fish.

The study shows that degree of injuries is an important factor compare to hooking location when using artificial bait with treble hook for *C. micropeltes*. *C. micropeltes* usually will hook at superficial hooking position. Smaller fish have more possibilities of hooking the fish with both hooks which can cause serious injuries. It is recommended for anglers to use smaller bait with smaller treble hook when fishing for smaller fish. Besides, it is important to handle fish correctly in the context of artificial bait fishing for *C. micropeltes*. Wrong fish handling methods such as too much air exposure and removing hook if the fish is hook deeply could cause more mortality of fish since fish that hooked more deeply could bleed more intensively.

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Authors:
Fazrul Hisam, Malaysia Terengganu University, School of Fisheries Science and Aquaculture, Malaysia, Terengganu, 21030 Kuala Nerus, e-mail: fazrulpsu@gmail.com
Mun Chan Chong, Malaysia Terengganu University, School of Fisheries Science and Aquaculture, Malaysia, Terengganu, 21030 Kuala Nerus, e-mail: easonmunchanchong@gmail.com
Sukree Hajisamae, Prince of Songkla University, Faculty Science and Technology, Thailand, Pattani, 94000, e-mail: hsukree@hotmail.com
Nik Ali Nik Aziz, Malaysia Terengganu University, School of Fisheries Science and Aquaculture, Malaysia, Terengganu, 21030 Kuala Nerus, e-mail: nikaznikal.umt@gmail.com
Muhamad Naimullah, Malaysia Terengganu University, School of Fisheries Science and Aquaculture, Malaysia, Terengganu, 21030 Kuala Nerus, e-mail: naimullahikhwanuddin@gmail.com
Marina Hassan, Malaysia Terengganu University, Institute of Tropical Aquaculture, Malaysia, 21030 Kuala Terengganu, e-mail: marina@umt.edu.my

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