NATURAL AND COMBINATION FISH AGGREGATING DEVICES (FADS) AS TOOLS FOR FISH AGGREGATION IN LAKE KENYIR, TERENGGANU, MALAYSIA

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ABSTRACT

A study on the effectiveness of natural and combination Fish Aggregating Devices (FADs) as tools for fish aggregation was conducted in freshwater Lake Kenyir, Terengganu, Malaysia. Four FADs of which two having natural materials (coconut fronds) as appendages and the other two having natural and synthetic materials (canvas pieces) as appendages were installed. Samplings for fish were conducted temporally before and after the installations of the FADs using various sizes of gillnets set in square patterns around each FAD. Eleven species of fish were caught at the FADs, the most dominant being Lampam Sungai, *Puntius schwanenfeldii*. The result of the study also shows the following: (1) natural and combination FADs managed to attract more fish, (2) highest attraction of fish to the FADs occurred approximately three months after first immersion, (3) natural FADs attracted more fish than combination FADs, and (4) attraction of fish to the FADs were higher at night than during the day. The findings are of importance to fishermen, entrepreneurs and fishery-related agencies for consideration of future freshwater FAD installation programs.

1. INTRODUCTION

Kenyir Lake which houses a hydroelectric power generating station was constructed in 1985 and is the largest freshwater man-made lake (reservoir) in Malaysia with a total surface area of 36,900 hectares. It has a maximum depth of 145m at normal full containment and an average depth of 37m. The lake replenishes its water supply from nine main rivers that flow into the lake. The rivers are Belimbing, Kenyir, Kerbat, Ketiar, Lasir, Leper, Pertang, Tembat and Trenggan Rivers. The reservoir is an important freshwater fish source in the country with more than 38 species of which some are of very high commercial value such as Kelah, Baung, Sebarau, Toman and Lampam Sungai. The Lake is presently an important site for aquaculture activities, which include fish breeding, and rearing activities.

The use of FADs as a means of aggregating and facilitating the catch fish using certain gears has been practiced mainly in the marine environments. Although fishermen in Thailand have been known to deploy FADs in freshwater environments to facilitate fish harvesting, none has been documented. In Malaysia, traditional Fish Aggregating Devices (FADs) which are locally known as 'unjam' comprise underwater appendages made of natural materials such as coconut fronds secured to an anchor line which is connected to a float such as floating bamboo pole or polyethylene float. The whole structure is then anchored by a sandbag anchor[1]. Due to the short endurance period of unjam of approximately 3 months[2], deployment of traditional unjam is costly. This leads to attempts by fishermen and fishery-related agencies to increase the endurance period of FADs by introducing cheap and durable materials for the underwater appendages. However, this may have implications on the fish aggregating abilities of the FADs. This study was thus conducted in freshwater environments to; (1) determine the abundance of fish at natural and combination FADs before and after the FADs installation, and (2) determine the dominant fish species attracted to the natural and combination FADs.

2. MATERIALS AND METHODS

Four FADs comprising two combination FADs (Unjam A and Unjam C) and two natural FADs (Unjam B and Unjam D) were installed at two stations in freshwater Lake Kenyir, Terengganu. The FADs were installed in an area called Sungai Kiang with Latitude 05° 09'N and Longitude 102° 44'E (Figure 1). Station 1 was installed with Unjam A and Unjam B while Station 2 was installed with Unjam C and Unjam D. The appendages or aggregators of natural FADs were made of coconut fronds (Figure 2) while the appendages of combination FADs were made of coconut fronds and canvas pieces of dimensions 25cm x 300cm (Figure 3). Prior to the installation, the area was sampled for fish using gillnets to serve as controls. After the installation, the area was then sampled for fish every two weeks for five months.

Samplings were conducted temporally using gillnets of equal lengths and depths having various mesh sizes set in a square pattern enclosing each of the FADs. The areas enclosed by the gillnets at all the FADs were roughly equal. The number and species of fish caught were recorded. Other environmental parameters in the area such as water temperature, dissolved oxygen, visibility and water current were also recorded using a Hydrolab Data Sonde 3, a Secchi Disc and a digital direct reading Current Meter (OSK 3210).

3. RESULTS AND DISCUSSION

The ability of floating objects to attract fish in the open ocean has long been recognized[3] and the effect also applies in the fresh water environments as has been practiced by fishermen in Thailand. Results of the samplings conducted for fish around the FADs are shown in Tables 1, 2, 3 and 4. The total number of fish caught before and after the installation of the FADs was found to vary significantly and this shows that FADs are equally effective in attracting fish in freshwater environments. However, the number of fish caught at all FADs after immersion were found to increase gradually during subsequent samplings and having

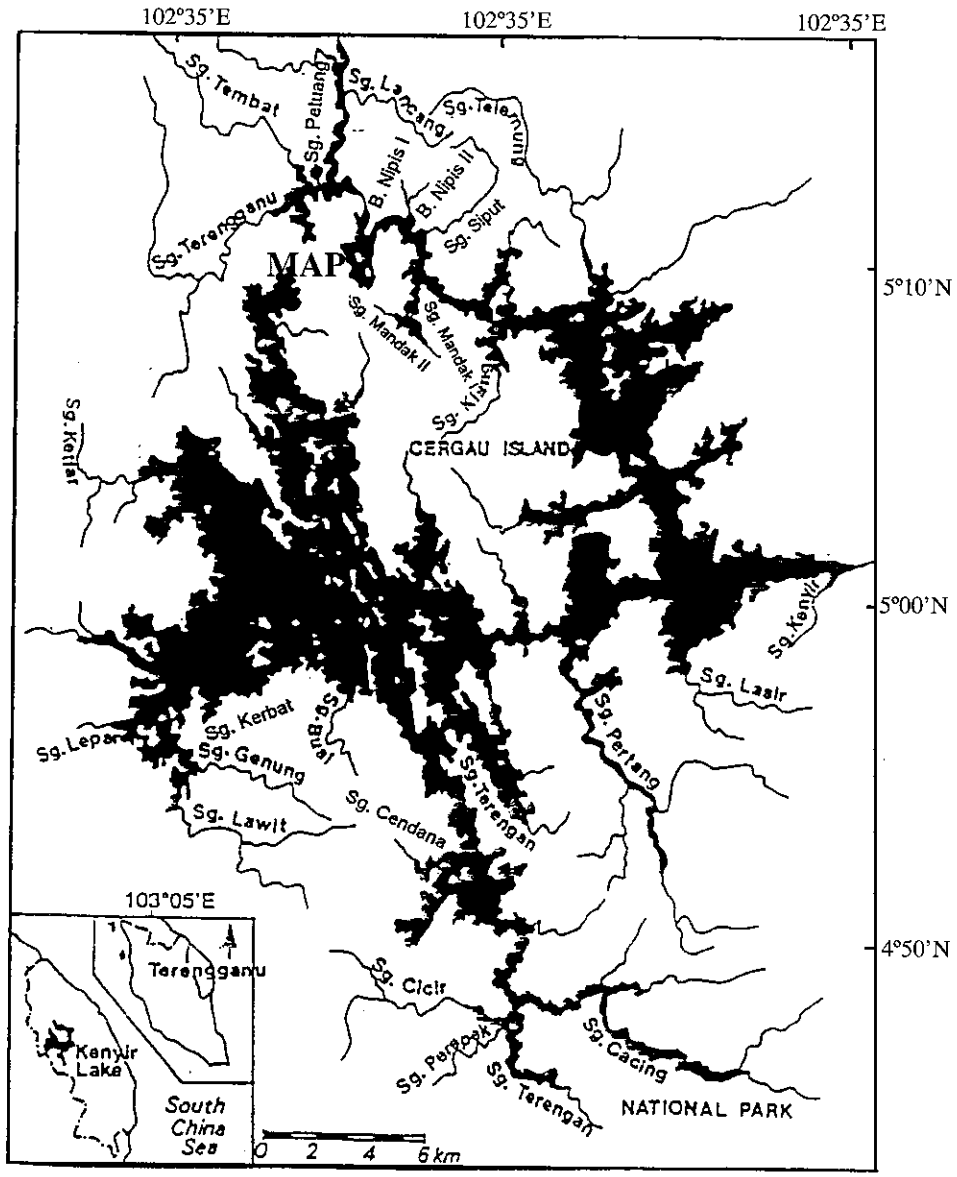

Figure 1: Map of Kenyir Lake in Terengganu, Malaysia, the sampling area is in Sungai Kiang (05° 09'N, 102° 44'E).

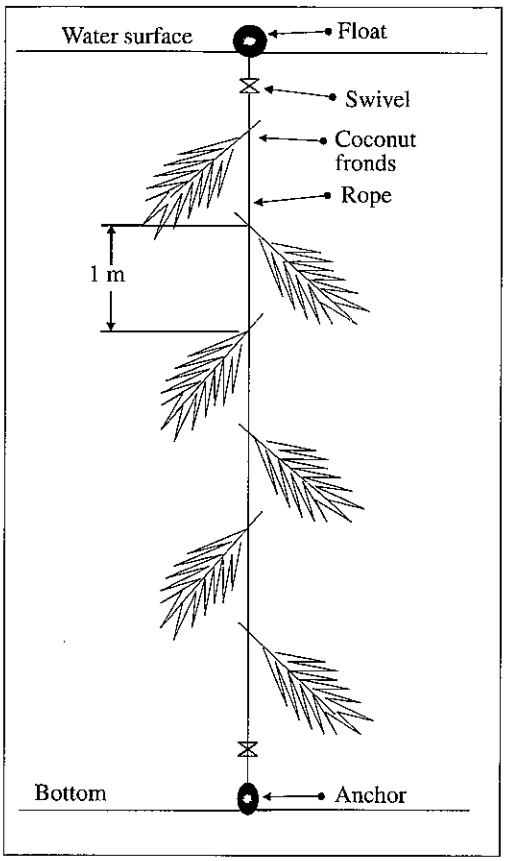

Figure 2: Natural FADs.

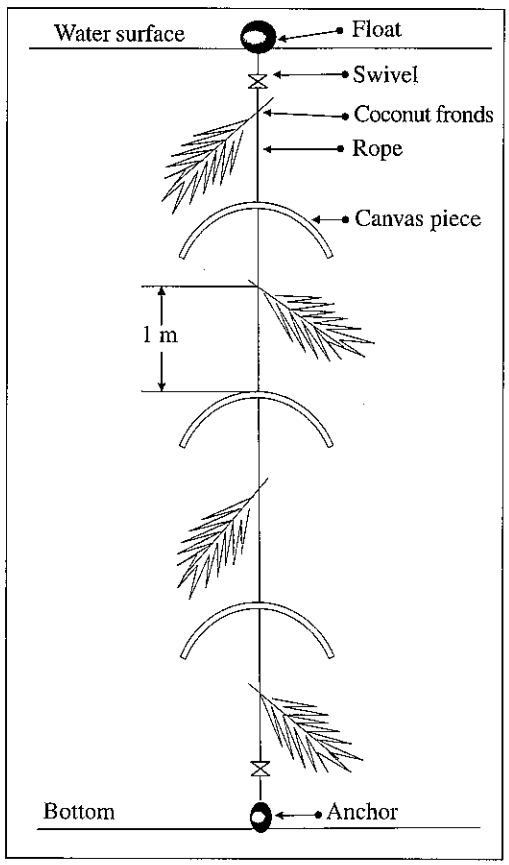

Figure 3: Combination FADs.

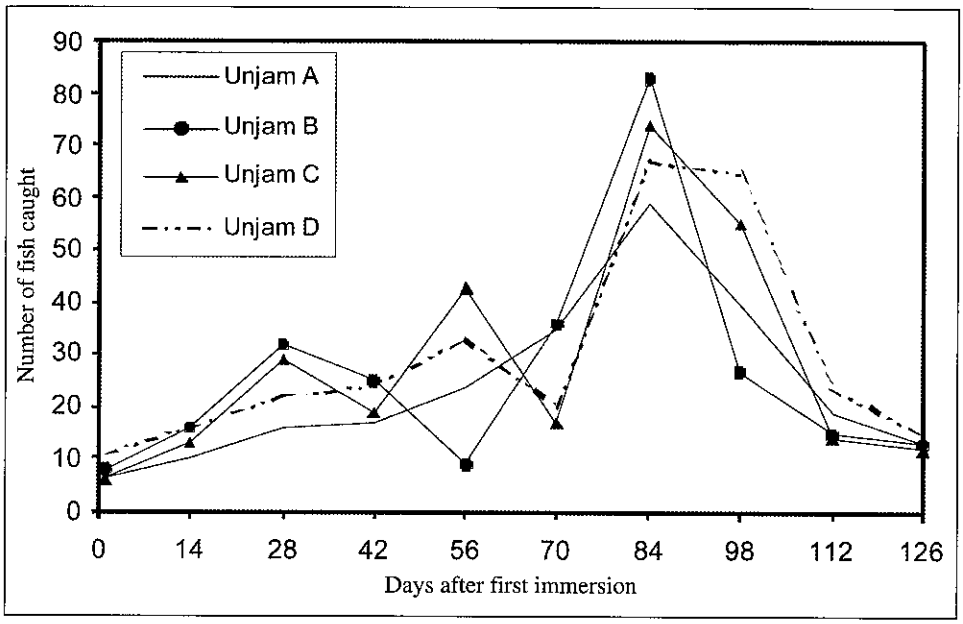

Figure 4: Number of fish sampled at each FAD (Unjam) after the installation of FADs.

its peak during the 7th sampling (Day 84) after which the number decreases gradually (Figure 4). This could be attributed to the short endurance period of the FADs and the colonization of sessile organisms to the appendages that is important in enhancing the aggregating abilities of the FADs. The density of organisms encrusted on the FADs relates closely with the short endurance periods of the FADs of approximately three months. It increases with immersion period until the quality of the substrate diminishes and could no longer sustain high density of the organisms[4, 5, 2].

A total of 11 species of fish were caught during the whole sampling periods. The species were Lampam Sungai *Puntius schwanenfeldii*, Sebarau *Hampala macrolepidota*, Temperas *Cyclocheilicthys apogon*, Rung *Osteochilus vittatus*, Terbol *Osteocheilus hasselti*, Kawan *Labiobarbus festiva*, Belida *Notopterus chitala*, Baung *Mystus nemurus*, Tengas *Acrossocheilus hexagonolepis*, Jemerong *Lobocheilus cornutus* and Kelah *Tor tombroides*. The most dominant species caught at all the FADs were P. schwanenfeldii (68.4%) and *H. macrolepidota* (15.1%) while *A. hexagonolepis, L. cornutus and T. tombroides* were the least dominant species. Other reports stated the existence of 38 species of fish in Lake Kenyir with the most dominant being *H. macrolepidota, M. nemurus* and *P. schwanenfeldii* [6, 7]. As fish species are known to have habitat preferences and the fact that this study was conducted in one single river, the result from this study reflects a fair scenario of the distribution and composition of fish in the lake.

The results also show that Natural FADs at both stations managed to aggregate more fish than Combination FADs ($P < 0.05$). The underwater appendages of FADs that are usually made of perishable materials such as tree fronds and leaves form the most important part of the structures. The size of these appendages determines the effectiveness of the FADs in attracting fishes[8]. Chemical substance could also be a cue in the aggregation of fish to

the FADs. An odor substance, being soluble, will diffuse into the surrounding water and its origin will be detected by surrounding fish over a long period of time[9]. Murdy[10] believed that decayed fronds and leaves would give off sour smells which attract fish and that the leaves would be colonized with algae which in turn attract fish. In Panay Island, the Philippines, dried palm fronds are preferred because of their sweet flavor which is believed by local fishermen to be attractive to fish[11]. In the present study, each coconut frond used as an aggregator for the FADs has a relatively bigger area (approximately 1.50m^2) as compared to the area of each canvas piece (approximately 0.75m^2) used and this leads to the difference in aggregating abilities between Natural and Combination FADs.

The number of fish caught at night around the FADs was observed to be higher than the number caught during the day by an approximate ratio of 4:1. This could be due to factors such as fish moving freely in water column at night[12], fish avoiding high intensity of light[13] and the low visibility of gillnets to the fish at night.

Temperature, dissolved oxygen, visibility and water current measurements taken during the experiment showed little fluctuation, and changes in the abundance and composition of fish caught during the immersion period could not be explained in terms of these environmental factors.

4. CONCLUSION

Samplings conducted for fish around the FADs in freshwater environments indicate that natural FADs attracted more fish than combination FADs, aggregation of fish around all FADs was highest approximately 6 weeks (84 days) after immersion and the aggregation of fish to the FADs were higher at night than during the day. The findings are of importance to recreational fishers and those involved in freshwater FADs installation programs.

5. ACKNOWLEDGMENTS

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Table 1: Abundance and composition of fish sampled at Unjam A (Combination FADs at Station 1) (D = Day samplings, N = Night samplings).

Species	**Sampling (days) after first immersion**																							
	Controls		1		14		28		42		56		70		84		98		112		126		**Total**	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Lampam Sungai *Puntius schwanenfeldii*	1	1	-	2	1	3	1	4	1	6	2	15	2	23	3	46	1	30	-	9	1	4	13	143
Sebarau *Hampala macrolepidota*	-	1	-	2	-	2	1	9	2	3	1	2	-	8	1	6	1	3	1	4	1	3	8	43
Temperas *Cyclocheilichthys apogon*	-	-	-	-	1	-	-	-	-	1	-	1	1	-	-	1	-	1	-	1	-	1	2	6
Rung *Osteocheilus vittatus*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Terbol *Osteocheilus hasselti*	-	-	-	-	-	-	-	-	1	1	-	1	-	-	-	1	-	4	-	-	-	-	1	7
Kawan *Labiobarbus festiva*	1	-	1	-	3	-	-	-	-	-	-	1	-	1	-	-	-	-	1	2	-	-	6	4
Belida *Notopterus chitala*	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Baung *Mystus nemurus*	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	5
Tengas *Acrossocheilus hexagonolepis*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	2
Jemerong *Lobocheilus cornutus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kelah *Tor tombroides*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**2**	**2**	**1**	**5**	**5**	**5**	**2**	**14**	**5**	**12**	**3**	**21**	**3**	**32**	**4**	**55**	**2**	**38**	**2**	**17**	**2**	**11**	**31**	**212**
Total for each sampling	4		6		10		16		17		24		35		59		40		19		13		243	

Table 2: Abundance and composition of fish sampled at Unjam B (Natural FADs at Station 1) (D = Day samplings, N = Night samplings).

Species	**Sampling (days) after first immersion**																							
	Controls		1		14		28		42		56		70		84		98		112		126		**Total**	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Lampam Sungai *Puntius schwanenfeldii*	-	1	-	2	1	5	1	8	3	11	1	3	3	23	5	68	2	20	-	7	1	9	17	157
Sebarau *Hampala macrolepidota*	2	1	-	2	2	3	2	14	1	5	1	3	1	3	-	2	-	2	2	2	-	1	11	38
Temperas *Cyclocheilicthys apogon*	-	-	-	-	-	2	-	2	1	1	-	-	-	2	-	1	-	-	-	1	-	1	1	10
Rung *Osteocheilus vittatus*	-	-	-	1	-	-	-	1	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	5
Terbol *Osteocheilus hasselti*	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	2	-	1	-	-	-	1	-	7
Kawan *Labiobarbus festiva*	-	1	2	-	2	-	-	1	-	1	-	-	-	1	-	2	1	-	1	-	-	-	6	6
Belida *Notopterus chitala*	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	1	-	1	-	1	-	-	-	5
Baung *Mystus nemurus*	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3
Tengas *Acrossocheilus hexagonolepis*	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Jemerong *Lobocheilus cornutus*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Kelah *Tor tombroides*	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Total	**2**	**3**	**2**	**6**	**5**	**11**	**3**	**29**	**5**	**20**	**2**	**7**	**4**	**32**	**5**	**78**	**2**	**24**	**3**	**12**	**1**	**12**	**35**	**234**
Total for each sampling	5		8		16		32		25		9		36		83		27		15		13		269	

Table 3: Abundance and composition of fish sampled at Unjam C (Combination FADs at Station 2) (D = Day samplings, N = Night samplings).

Species	**Sampling (days) after first immersion**																							
	Controls		1		14		28		42		56		70		84		98		112		126		**Total**	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Lampam Sungai *Puntius schwanenfeldii*	-	2	-	2	1	8	2	11	-	12	3	28	1	11	4	61	1	47	1	9	1	5	14	196
Sebarau *Hampala macrolepidota*	1	1	-	2	1	1	1	7	1	2	1	2	1	1	-	2	2	1	2	-	2	2	12	21
Temperas *Cyclocheilicthys apogon*	-	-	-	-	-	-	-	4	-	1	-	2	-	-	-	2	-	1	-	1	-	-	-	11
Rung *Osteocheilus vittatus*	-	-	-	-	-	-	-	1	-	-	-	2	-	1	-	-	-	1	-	1	-	-	-	6
Terbol *Osteocheilus hasselti*	-	-	-	-	-	-	-	1	-	2	-	-	-	1	-	3	-	2	-	-	-	1	-	10
Kawan *Labiobarbus festiva*	-	-	1	-	1	-	-	1	-	1	-	3	-	-	-	1	-	-	-	-	-	-	2	6
Belida *Notopterus chitala*	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2
Baung *Mystus nemurus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Tengas *Acrossocheilus hexagonolepis*	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	1
Jemerong *Lobocheilus cornutus*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-
Kelah *Tor tombroides*	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
Total	**1**	**3**	**2**	**4**	**3**	**10**	**3**	**26**	**1**	**18**	**5**	**38**	**2**	**15**	**4**	**70**	**3**	**52**	**3**	**11**	**4**	**8**	**31**	**255**
Total for each sampling	4		6		13		29		19		43		17		74		55		14		12		286	

Table 4: Abundance and composition of fish sampled at Unjam D (Natural FADs at Station 2) (D = Day samplings, N = Night samplings).

Species	**Sampling (days) after first immersion**																					
	Controls		1		14		28		42		56		70		84		98		112		126		**Total**	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Lampam Sungai *Puntius schwanenfeldii*	-	2	2	4	3	8	1	10	1	9	3	26	1	13	2	47	3	50	-	17	1	10	17	196
Sebarau *Hampala macrolepidota*	1	1	2	2	1	2	-	1	1	3	-	2	-	3	4	3	-	2	2	1	-	2	11	22
Temperas *Cyclocheilicthys apogon*	-	-	-	-	-	1	-	4	-	3	-	1	-	-	-	1	-	2	-	1	-	2	-	15
Rung *Osteocheilus vittatus*	-	-	1	-	-	-	-	1	-	2	-	-	1	-	-	1	-	2	-	1	-	-	2	7
Terbol *Osteocheilus hasselti*	-	-	-	-	-	-	-	2	1	1	-	-	-	1	-	6	-	4	-	-	-	-	1	14
Kawan *Labiobarbus festiva*	1	-	-	-	1	-	-	2	-	1	-	-	-	-	1	1	-	2	2	-	-	-	5	6
Belida *Notopterus chitala*	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Baung *Mystus nemurus*	-	1	-	-	-	-	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	1	3
Tengas *Acrossocheilus hexagonolepis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jemerong *Lobocheilus cornutus*	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1
Kelah *Tor tombroides*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**2**	**4**	**5**	**6**	**5**	**11**	**2**	**20**	**4**	**20**	**3**	**30**	**2**	**18**	**7**	**60**	**3**	**62**	**4**	**20**	**1**	**14**	**38**	**265**
Total for each sampling	6		11		16		22		24		33		20		67		65		24		15		303	