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Selectivity and effectiveness of different gillnet mesh sizes used in ranau lake of Sumatra

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Abstract

Ranau Lake, the second biggest lake in Sumatra Indonesia, is inhabited by various freshwater fishes. The local people depend largely on fish resources for their life and use gillnet fishing gear for their fishing activity. The current research focused on selectivity and effectiveness of different gillnet mesh sizes as a tool to fisheries plan management in the lake. Research was carried out in twelve times of direct observation on fishing activity within two days per month from March to October 2013 and February to May 2014. The gillnets used for experimental fishing were constructed with seven different of mesh sizes such as: 3.5, 3.0, 2.5, 2.0, 1.75, 1.5, 1.25 inch. Total catch from each piece of gillnet, was recorded from five to ten selected fishers. Fish samples were collected for species identification and for length and weight measurement. Fish identification was done by comparing the morphometry and merystic characters of the sample to reference books. Results show that different gillnet mesh sizes succeeded to catch about 17 species of fish. As selective fishing gears, gillnet seems to be size selective rather than species selective. Gillnet mesh sizes are correlated negatively with the number of fish catch. The smaller mesh size succeeded to catch relatively high amount of fish, but the gear tends to be not selective. For sustainable fish utilization, it suggests that larger gillnet mesh sizes (> 2.0 inch) were encouraged to be used by the fishermen.

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Introduction

Indonesia is a large country occupied by great area of inland waters usually as open access waters, such as river, swamp, lake and reservoir (Dahuri, 2004). Lake ecosystem is an important water body of inland waters system, as source of various freshwater fish for local people as their foods. Ranau Lake of South Sumatra is the second largest lake in Sumatra after Toba Lake. This naturally formed lake is located in South Ogan Komering Ulu and West Lampung regency covering about 12,800 hectares with 16 km long and 8 km wide, in altitude 540 m a.s.l. surrounding by mountainous forest (Sulastri *et al.*, 1999), inhabited by many species of freshwater fish. Fishery activity in Ranau Lake consisted of capture fisheries and aquaculture (Makmur, 2009). Capture fisheries provide a valuable contribution to food security in any part of the developing countries including in Indonesia. Fish are in turn one of the most valuable wild foods provided by ecosystems and for many communities are a key component of both diet and income (Dugan *et al.*, 2010).

Fishing activity in Ranau Lake can be done all year round, involved more than 50 fishers, categorize as small scale fisher using non-motorize canoe with simple and traditional fishing gears. The local inhabitant depends largely on fish resources for their main protein need and it serves as a major income earner. Main fishery zones in Ranau Lake are situated within Banding Agung village and Talang Teluk village where wide littoral zone is found and closed to water outlet into Selabung River (Subagdja *et al.*, 2013). Studied on various of fishing gears in Ranau Lake had been done by Gaffar & Utomo (1991) which reported that fishermen commonly work individually using several fishing gears such as gillnet, drift net, pole and line, long line, and harpone.

Gillnet is very popular in the small scale fisheries in Ranau Lake with several mesh sizes, constituted the dominant gear deployed in the waters, over 50% of the gears deployed by fishermen. Because of simplicity in its design, construction, operation and low investment cost makes the gillnet preferred gear for the small scale fishermen. As a passive gear, gillnet catches under certain conditions could serve for estimating changes in fish abundance (Ollin *et al.,* 2009 *in* Bobori & Salvarina, 2010).

Since gear development is species targeted, while gillnet is the most popular gear used, it needs to understand the impact of gillnet mesh sizes. This research was conducted in Ranau Lake, focused on selectivity and effectiveness of different mesh size of gillnets as a tool to plan fishery management in the lake.

Materials and methods

Research was carried out in Ranau Lake of South Ogan Komering Ulu Regency, South Sumatra Province Indonesia (Fig. 1), in twelve times of direct observation on fishing activity within two days per month from March to October 2013 and February to May 2014.

Gillnets used in this research are made from nylon monofilament with 100 m long and 2 m depth. The gillnets were constructed with seven different of mesh size such as: 3.5, 3.0, 2.5, 2.0, 1.75, 1.5, and 1.25 inch.

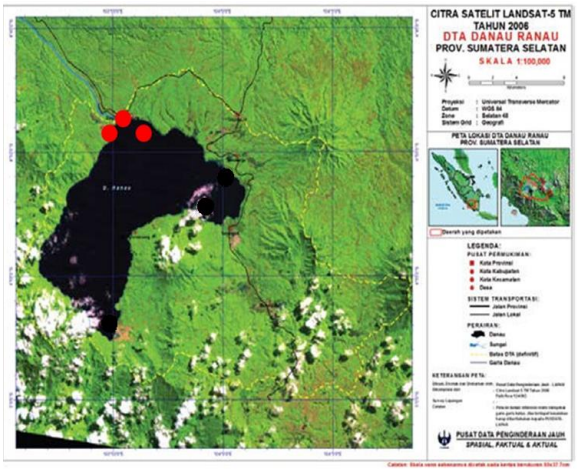

Fig. 1. Map of research location.

Field Sampling

Experiment on gillnet fishing was carried out by collaboration with five to ten fishermen using several

gillnet mesh sizes in different areas and sets along night time in moderately deep waters. Data on fish yield by each gillnet mesh sizes collected from gillnetting in two days monthly (the third week). Average of fish yield was recorded for each mesh size. Fish samples were collected for species identification, length and weight measurement. Selectivity was evaluated according to species and size variation, while effectiveness is total catch both in number and weight of fish. Sampling site was purposively selected according to different fishing village.

Fish weight was measured in the field as wet weight, while total length was measured on fish with a rounded caudal fin. Fish identification was done by comparing morphometry and merystic characters of the sample to reference books of Weber & Beaufort (1913) and Kottelat *et al.* (1993).

Environmental characters of lake water also recorded. Water sample analysis was done according to standard method made by APHA (1981), outlined in Table 1.

Table 1. Methods and instruments used on analysis of water quality in Ranau Lake.

No	Parameter	Method/Instrument
A	**Physics**	
1	Temperature	YSI 600 QS
2	Transparency	Secchi disc
B	**Chemistry**	
1	pH	YSI 600 QS
2	Dissolved Oxigen	YSI 600 QS
3	Carbondiokside	YSI 600 QS
4	Alkalinity	Titrimetry
5	Hardness	Titrimetry
6	Nitrate (NO_3-N)	Spectrofotometer
7	Ammonia (NH_3-N)	Spectrofotometer
8	Phosphate (PO_4-P)	Spectrofotometer

Results

Fish Composition

Composition of caught fish by different gillnet mesh size in Ranau Lake shows in Table 2 and Table 3 shows the number of every caught fish.

Table 2 shows that larger gillnet mesh sizes were more selective, both gillnet of 3.5 inch and 3.0 inch mesh caught only 2 and 3 fish species while the smaller mesh sizes (1.25 – 1.75 inch) caught more species composition. This finding indicated that fish community in Ranau Lake dominated by small fish during the period of the research.

Table 2. Fish composition catch by different gillnet mesh sizes in Ranau Lake.

Mesh size (inch)	Fish Species Composition
3.5	*Hemibagrus nemurus* (Baung/Asian redtail catfish), *Oreochromis mossambicus* (Mujair/Mozambique tilapia)
3.0	*Hemibagrus nemurus*, *Oreochromis mossambicus*, *Pristolepis grooti* (Kepor)
2.5	*Hemibagrus nemurus*, *Puntius* sp (Selibak), *Hampala macrolepidota* (Kemencut/ Hampala barb), *Osteochilus vittatus* (Palau/Bonylip barb), *Cyprinus carpio* (Mas/Common carp)
2.0	*Hemibagrus nemurus*, *Oreochromis mossambicus*, *Pristolepis grooti*, *Puntius* sp, *Hampala macrolepidota*, *Osteochilus vittatus*, *Mystacoleucus marginatus* (Kepiat), *Mastacembelus* sp (Tilan)
1.75	*Hemibagrus nemurus*, *Oreochromis mossambicus*, *Pristolepis grooti*, *Puntius* sp, *Hampala macrolepidota*, *Osteochilus vittatus*, *Cyclocheilichthys armatus* (Keperas), *Oreochromis niloticus* (Nila/ Nile tilapia), *Tor* sp (Semah)
1.5	*Hemibagrus nemurus*, *Oreochromis mossambicus*, *Pristolepis grooti*, *Puntius* sp, *Hampala macrolepidota*, *Osteochilus vittatus*, *Mystacoleucus marginatus*, *Mastacembelus* sp, *Oreochromis niloticus*, *Channa striata* (Gabus/Striped snakehead)
1.25	*Oreochromis mossambicus*, *Pristolepis grooti*, *Puntius* sp, *Hampala macrolepidota*, *Osteochilus vittatus*, *Mystacoleucus marginatus*, *Cyclocheilichthys armatus*, *Rasbora* sp (Seluang), *Notopterus notopterus* (Putak/ Bronze featherback), *Puntius tetrazona* (Aji/Sumatra barb), *Pterygoplichthys pardalis* (Sapu jagad)

Different gillnet mesh sizes succeeded to catch about 17 species of fish in Ranau Lake, although gillnet was considered as selective fishing gears it seems to be a size selective rather than species selective.

Gillnet has fished about 1,509 individuals, which *Pristolepis grooti* was the most common species (659 individuals or 43.67%). Whereas, three species such

as *Tor* sp, *Channa striata* and *Pterygoplichthys pardalis* were caught only one individual or 0.07% (Table 3). This result might correlate to the community structure of fish in the lake, with the biggest population of *Pristolepis grooti*. Hay *et al.* (2002) also found great variation number of fish individuals caught by experimental gillnet fishing in Namibia.

Length Selectivity of Different Gillnet Mesh Sizes

The number of fish captured in each size for length from the different gillnet mesh sizes, is presented in Table 4. The different gillnet mesh sizes caught great variations both in fish catch and fish length. Bigger mesh size of 3.5 inch gillnet succeeded to catch bigger fish with average length 22.75 - 23.43 cm while mesh size 1.25 inch gillnet succeeded to catch the smallest fish with average length 3.60 cm.

Table 3. Species composition and number of fish caught by different gillnet mesh sizes in Ranau Lake.

Fish species	Number of fish (individual)	Perce-ntage
Hemibagrus nemurus	27	1.79
Oreochromis mossambicus	58	3.84
Pristolepis grooti	659	43.67
Puntius sp	72	4.77
Hampala macrolepidota	301	19.95
Osteochilus vittatus	134	8.88
Cyprinus carpio	74	4.90
Mystacoleucus marginatus	26	1.72
Mastacembelus sp	2	0.13
Cyclocheilichthys armatus	23	1.52
Oreochromis niloticus	5	0.33
Tor sp	1	0.07
Channa striata	1	0.07
Notopterus notopterus	5	0.33
Rasbora sp	4	0.27
Puntius tetrazona	116	7.69
Pterygoplichthys pardalis	1	0.07

Table 4. Average fish length size caught by different gillnet mesh sizes in Ranau Lake.

No.	Species	Mesh size of gillnets (inch)													
		3.5		3		2.5		2		1.75		1.5		1.25	
		n	L(cm)	n	L(cm)	n	L(cm)	n	L(cm)	N	L(cm)	n	L(cm)	n	L(cm)
1	*Hemibagrus nemurus*	4	22.75±6.19	2	27.60±1.56	4	23.81±4.98	6	22.18±1.67	3	22.84±3.67	8	17.93±2.34		
2	*Oreochromis mossambicus*	4	23.43±0.48	1	25.90			9	10.87±0.60	5	11.55±1.14	14	10.30±1.35	25	8.44± 1.27
3	*Pristolepis grooti*			24	15.78±1.87			67	10.61±0.89	82	11.35±1.14	99	10.09±3.34	387	8.21± 1.07
4	*Puntius* sp					8	10.67±1.87	2	9.90±1.50	5	11.40±1.96	50	11.58±2.31	7	9.92± 0.59
5	*Hampala macrolepidota*					16	26.20±2.33	55	18.66±2.65	61	18.37±1.26	50	15.33±1.74	119	11.22±0.85
6	*Osteochilus vittatus*					12	22.00±0.80	21	17.45±4.15	52	16.75±1.34	39	14.70±2.63	10	13.69±0.67
7	*Cyprinus carpio*					9	29.68±2.22			25	18.07±1.89	40	14.50±1.27		
8	*Mystacoleucus marginatus*							2	11.00±1.30			24	11.08±0.83		
9	*Mastacembelus* sp							1	34.00			1	34.00		
10	*Cyclocheilichthys armatus*									2	15.40±0.85	17	13.51±1.04	4	13.00±0.56
11	*Oreochromis niloticus*									3	12.07±0.40	2	9.45± 0.21		
12	*Tor* sp									1	19.20				
13	*Channa striata*											1	14.50		
14	*Notopterus notopterus*											3	16.10±0.66	2	20.45±2.34
15	*Rasbora* sp													4	6.18± 0.83
16	*Puntius tetrazona*													116	3.60± 1.80
17	*Pterygoplichthys pardalis*													1	14.00

Different gillnet mesh size was caught different size of fish. Because of gillnet is a passive gear, the fish have to encounter the net, enter the net and get retained by it. More active fish species are more likely to encounter the net. The fish enters the net, it depends on its size, body shape and the gillnet mesh size.

The fish, *Hemibagrus nemurus* with length variation from 17.93 cm to 22.75 cm was caught by mesh size of 1.75 inch to 3.5 inch. *Oreochromis mossambicus* and *Hemibagrus nemurus* were caught by almost all gillnet mesh sizes, while *Rasbora* sp and *Puntius tetrazona* caught only by small mesh size of gillnet. The mesh size of 3.5 inch could catch bigger fish,

Hemibagrus nemurus with average length of 22.75 and *Oreochromis mossambicus* with average length of 23.43 cm, while mesh size 1.5 inch could catch fish with average length of 17.93 cm and 10.3 cm, respectively. *Cyclocheilichthys armatus* with average length of 13.0 cm to 15.4 cm were only caught by gillnet with mesh sizes ranging from 1.25 to 1.75 inch, and *Rasbora* sp with average length of 6.18 cm was only caught by the smallest mesh of 1.25 inch.

Chindah & Tawari (2001) also found that different gillnet mesh sizes caught great variation in their size class catch distribution of fish. Hamely (1975) stated that selectivity of fishing gear influence directly on the exploited stock. Gillnet selectivity may be estimated based on the proportions of fish caught from different size population with known length distribution (Sparre & Venema, 1992). Emmanuel *et al.* (2008) stated that the study of the selectivity and efficiency of the fishing gears constitute a tool of great importance for the fishery management, who will used this information to control fishing mortality through the size of fish. Akongyuure *et al.* (2012), also stated that monofilament gillnets with mesh sizes 3-5 cm could have increase pressure on juvenile population, and a legal minimum mesh size of gillnets of 8 cm may be appropriate for conservation and sustainable exploitation in lake waters.

Effectiveness of Different Gillnets Mesh Sizes

The effectiveness of gillnets mesh sizes is demonstrated in Table 5. The catches from different mesh sizes show significant variation of average fish weight caught by every piece in one day.

Table 5. Effectiveness of different gillnet mesh sizes in Ranau Lake.

Mesh size (inch)	Average caught kg/piece/day	Number of Fish Caught (individual)	Percentage
3.5	1.46±0.51	8	0.53
3.0	2.73±0.82	27	1.79
2.5	7.74±0.95	49	3.25
2.0	8.65±1.10	163	10.80
1.75	12.18±0.62	239	15.84
1.5	10.13±0.43	348	23.06
1.25	9.19±0.48	675	44.73

The effectiveness of fishing is commonly expressed in terms of number or mass of fish captured by a fishing gear in a unit of time (Meye & Ikomi, 2012). Gillnets mesh sizes of 1.5 and 1.75 inch were more effective, with higher average catches of 10.13 and 12.18 kg/piece/day respectively, while the large mesh size obtained lower yield as shows by 3.5 inch mesh size that only caught about 1.46 kg/piece/day indicating only small portion of fish community of large size. Gillnet mesh sizes correlated negatively with the number of fish caught, meanwhile the smaller mesh size succeeded to catch bigger amount of fish. The largest gillnet mesh size caught only eight fish of two different species while the smallest gillnet mesh size caught 675 fish.

This finding indicated that fish community in Ranau Lake is dominated by small fish that are usually considered as cheap species. The finding was parallel with Hay *et al.* (2002) that catch per unit effort decreased with an increasing mesh size.

Water Quality Ranau Lake

Quantitative values of some water quality parameters of lake waters were outlined in Table 6.

Table 6. Range values in water quality parameters of Ranau Lake waters.

No.	Parameters	Results
A	**Physics**	
1	Temperature (°C)	27.0 - 28.2
2	Transparency (m)	4.0 - 6.0
B	**Chemistry**	
1	pH	8.3- 8.5
2	Dissolved Oxigen (mg/l)	8.30 - 9.12
3	Carbondiokside (mg/l)	0.026 - 0.088
4	Alkalinity (mg/l)	42 – 55
5	Hardness (mg/l)	66 – 74
6	Nitrate (NO_3-N) (mg/l)	0.067 - 0.088
7	Ammonia (NH_3-N) (mg/l)	0.014 - 0.072
8	Phosphate (PO_4-P) (mg/l)	0.075 - 0.120

Water quality in Ranau Lake is considered as warm and clear, slightly alkaline and categorize as soft water (Boyd, 1990). According to phosphate contents

the lake waters is categorized as oligotrophic which oligotrophic characterized by a low accumulation of dissolved nutrient salts, supporting but a sparse growth of algae and other organisms, and having a high oxygen content owing to the low organic content (McColl, 1972).

The water quality factors influence spawning success, growth and great fluctuation in number and biomass of fish. Demergan *et al.* (1988) stated that water quality influences the fish production. Water quality in Ranau Lake is in a range values to support fish life and there is no indication of pollution during the period of the research.

Discussion

Different gillnet mesh size succeeded to catch about 17 species of fish in Ranau Lake. Gillnet fishing gears seems to be a size selective rather than species selective. Gillnet mesh size is correlated negatively with the number of fish catch, the smaller mesh size might catch bigger amount of fish compared to the larger mesh sizes in fish catching.

The ecological implication of this result is that using the smaller size of gillnet might be non selective fishing gear. Therefore, it suggest to encourage using the larger gillnet mesh sizes (> 2.0 inch) as standard fishing gear to maintain the sustainable use of fish resources, especially in Ranau Lake.

Appendix 1. Average fish sizes caught by different gillnet mesh sizes in Ranau Lake.

No.	Species	Mesh size of gillnets (inch)																					
		3.5			3			2.5			2			1.75			1.5			1.25		
		n	W (g)	L (cm)	n	W (g)	L (cm)	n	W (g)	L (cm)	n	W (g)	L (cm)	n	W (g)	L (cm)	n	W (g)	L (cm)	n	W (g)	L (cm)
1	*Hemibagrus nemurus*	4	148.1	22.75	2	159.7	27.6	4	95.99	23.81	6	80.65	22.18	3	87.02	22.84	8	42.44	17.93			
2	*Oreochromis mossambicus*	4	217.5	23.43	1	136.9	25.9				9	27.88	10.87	5	35.88	11.55	14	23.97	10.3	25	14.35	8.44
3	*Pristolepis grooti*				24	94.91	5.78				67	28.72	10.61	82	31.84	11.35	99	21.69	10.05	387	15.17	8.21
4	*Puntius* sp							8	18.15	10.67	2	11.98	9.9	5	22.14	11.4	50	19.91	11.58	7	13.92	9.92
5	*Hampala macrolepidota*							16	193.54	26.20	55	71.67	18.66	61	64.59	18.37	50	38.56	15.33	119	16.6	11.22
6	*Osteochilus vittatus*							12	142.65	22	21	85.85	17.45	52	62.15	16.75	39	35.29	14.7	10	39.54	13.69
7	*Cyprinus carpio*							9	273.82	29.68				25	62.34	18.07	40	43.48	14.5			
8	*Mystacoleucus marginatus*										2	17.85	11				24	15.43	11.08			
9	*Mastacembelus* sp										1	131.6	34				1	140	34			
10	*Cyclocheilichthys armatus*													2	52.8	15.4	17	36.18	13.51	4	32.05	13
11	*Oreochromis niloticus*													3	38.25	12.07	2	12.29	9.45			
12	*Tor* sp													1	73.81	19.2						
13	*Channa striata*																1	26.01	14.5			
14	*Notopterus notopterus*																3	30.94	16.1	2	75.08	20.45
15	*Rasbora* sp																			4	2.07	6.18
16	*Puntius tetrazona*																			116	1.53	3.6
17	*Pterygoplichthys pardalis*																			1	23.87	14

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