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Assessment of Seine Net Selectivity in Lake Maninjau, Agam Regency, West Sumatra - Indonesia

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Abstract: Using small mesh sizes on the sein net in Lake Maninjau may lead to over exploitation. Research assessing selectivity of this fishing gear in this area has not been conducted yet. Thus, this research aims to determine the selectivity of seine net fishing gear operated in Lake Maninjau, Tanjung Raya District, Agam Regency, West Sumatra Province. There were seven units of seine net with 5 mesh sizes connected mesh sizes measuring 1.5 inches, 2 inches, 2.5 inches, 3 inches, and 3.5 inches that were assessed in this study. The results revealed that more than five species of fish were caught with various sizes, namely Nila (*Orheochromis niloticus*), Betutu (*Oxyeleotris marmorata*), Louhan (*Amphilophus trimaculatus*), Patin (*Pangasius* sp), and Sapu-sapu (*Hypostomus plecostomus*). Considering minimum landing size, 1,021 (81.54%) catches of Nila are suitable for catching meanwhile 231 (18.46%) are under minimum size for catch. However, based on the fishing gear selectivity criteria (CCRF), the seine net fishing gear selectivity level has a score of 1 (very low).
Keywords: Lake Maninjau, selectivity, seine net, sustainable fisheries

1. Introduction

Indonesia's fishery resources are renowned for their diversity encompassing thousands of fish species and abundant in numbers. This condition has made the fishery sector critical in multiple dimensions including environmental, social, and economic sectors. Management and utilization of fishery resources should be taken wisely by considering multiple perspectives to avoid over exploration that can bring a long-term negative impact for many parties.

Inappropriate utilization techniques for fish resources pose a threat to the sustainability of fisheries in the future. Therefore, strategies to conserve sustainability and prevent ecosystem damage must consider economic, environmental, and management aspects to ensure that fishery resources can be utilized sustainably [1].

Fishing activities and their potential are not limited to marine waters but also include public waters such as rivers, lakes, swamps, and others. The Food and Agriculture Organization (FAO) states that there are approximately 2,000 species of fish living in Indonesia's public waters. Many of these species have not yet been identified, resulting in an increasing number of documented species each year.

Lake Maninjau, one of Indonesia's public water areas, offers significant economic potential through its fisheries sector. Located in Tanjung Raya Subdistrict, Agam Regency, West Sumatra, the lake provides opportunities for aquaculture, floating net cages, and fishing activities [2]. For local communities, fishing activities serve as an alternative livelihood alongside the widespread floating net cage operations in Lake Maninjau. The diversity in fish species, sizes, and populations in such waters makes it necessary to carefully regulate fishing practices. For example, the wide range of species requires different types of fishing gear for effective and environmentally friendly fishing operations [3].

Fishing activities in Maninjau Lake are dominated by small-scale fisheries that apply traditional fishing gear to catch the fish. Fishermen simply decide the fishing method by considering the fish's behavior. There are several kinds of fishing gear used namely seine net, trawl, lift nets, and traps [4]. Seine nets are predominantly used by fishermen in the upstream areas of Lake Maninjau, primarily targeting Nila (*Oreochromis niloticus*). In contrast, in the downstream regions, traps (*bubu*) are the preferred gear, mainly targeting freshwater lobsters (*Cherax quadricarinatus*), while lift nets are used for catching Bada (*Rasbora argyrotaenia*) [5].

The seine nets used in Lake Maninjau are actively operated by pulling the gear using ropes and nets, aided by boats from the shoreline. This process often ensnares various aquatic organisms, including fish, shrimp, and other species encountered by the net. The wide variety of species caught raises concerns about potential overfishing and damage to the area's biodiversity structure [6]. Changes in diversity structure can be identified through dominant bycatch and discards. Trawl fishing in the Jambi estuary area shows that of the 41 species it is known that the bycatch and discards amount to 35 species [7].

The capture of bycatch can be a threat to species diversity and environmental sustainability because this part of the catch is usually not regulated [8]. The use of seine nets in Lake Maninjau is worrying due to the risk of overfishing, given the mesh sizes utilized, which range from small to large (1.5 inches, 2 inches, 2.5 inches, 3 inches, up to 3.5 inches). Until now, there has been no comprehensive assessment of the environmental impact and selectivity of these nets, so it raises questions about their ecological sustainability in the study area. This research aims to evaluate the selectivity of the seine nets operated in the waters of Lake Maninjau, Tanjung Raya Subdistrict, Agam Regency, West Sumatra Province, to better understand their impact on the local ecosystem.

2. Material and Methods

2.1. Type and Location Research

This research was conducted in Sungai Rangeh Village, Bayua Nagari, Lake Maninjau, Tanjung Raya Subdistrict, Agam Regency, West Sumatra Province (Figure 1). The study took place from May 1 to May 31, 2023. The materials supporting this research included seven units of seine nets with mesh sizes ranging from 1.5 inches, 2 inches, 2.5 inches, 3 inches, to 3.5 inches (Figure 2). The number of fishing gear used as samples was 7 units. The fishing gear has the same specifications. Then the number of data collection was carried out on 15 trip. The catch from the pull seine fishing gear is classified into three categories: main catch, bycatch, and discard. These classifications were determined based on interviews with the local fishers.

Figure 1. Map of The Research Location in Lake Maninjau

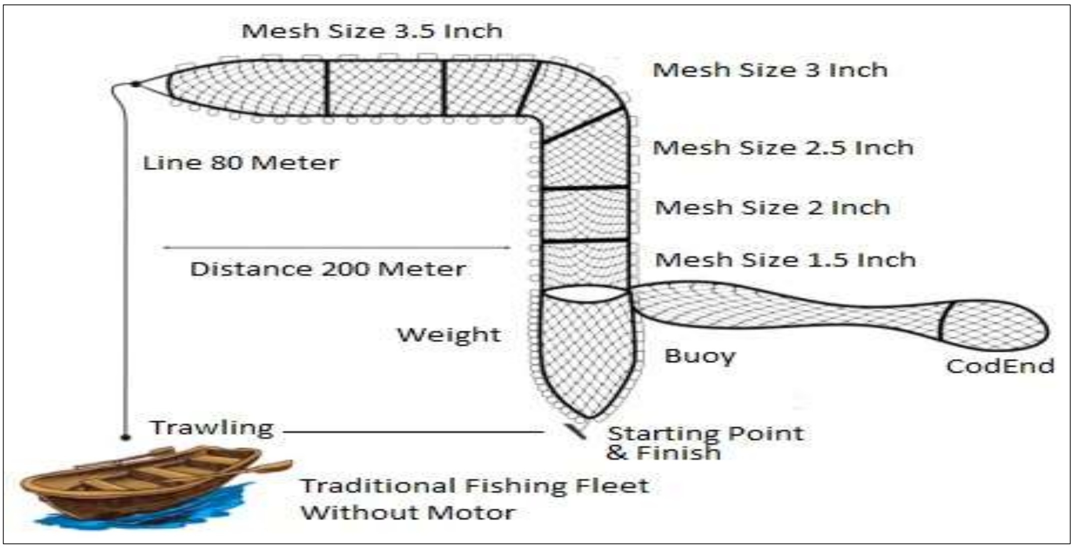

Figure 2. Construction of Seine Net Modification in Lake Maninjau

The survey method used in this study was purposive sampling. There was a total of 26 fishing gear units located at the research site, of which seven units had the same mesh size. The survey was conducted by directly observing the fishing ground, identifying fish species, and counting the number of species caught during the fishing activities using seine nets (Figure 2). For this study, fishing operations using seine nets in Lake Maninjau were conducted over 15 fishing trips, scheduled according to agreements with the fishermen. Each fishing trip lasted approximately 4.5 hours.

As shown in Figure 2, the construction of the modified seine nets used by the fishermen influences their operation. Utilizing ropes attached to both wings, the net is pulled towards the anchored boat or the boat that will land on the shore. This operation is conducted at various levels of surface, midwater, and the bottom of the water body to target both demersal and pelagic fish species [6].

2.2. Data Analysis

Collected data were analyzed using descriptive statistical analysis and presented in tables to illustrate field conditions. The catch data were depicted through class tables of fish length size, standard minimum size for Nila, percentages of catchable fish, and the selectivity levels of the seine nets operated in Lake Maninjau's waters.

To analyze fish species and composition, descriptive analysis was performed. The local fish names were identified based on information from the local fishermen, while scientific names were determined using data from the official website FishBase. Fish composition analysis was conducted using a catch ratio (CR) method. The catch ratio calculations followed the formulas [9;10;11]:

$$HT\ (\%) = \frac{\text{Number of Fish per Species}}{\text{Total Number of Catches}} \times 100\%$$

The parameters calculated in fish structure and size include maximum, minimum, average fish, and the most frequently occurring length. The frequency distribution analysis of fish sizes from the catch is presented descriptively. This analysis aims to determine the size of fish caught in seine nets with mesh sizes ranging from 1.5 to 3.5 inches. To analyze the size distribution of caught fish, data grouping is conducted using the formula [11;12]:

r = maximum data-minimum data

k = i + 3.3 log n

$i = \frac{r}{k}$

Description of Parameters**:**

- n : Number of data points
- r : Range (difference between the minimum and maximum data values)
- k : Number of classes
- i : Class interval

The standard minimum landing size for Nila is based on data from FishBase, stating that Nila reach gonadal maturity at a size of 18.6 cm. The percentage of catchable and non-catchable fish can be calculated using the following formula [13]:

$$\text{Percentage (\%)} = \frac{\text{Fish numbers}}{\text{Total of fish numbers}} \times 100\%$$

Criteria selectivity of fishing gears based on CCRF, FAO (1995):

A responsible procedure for fishing activities based on FAO (1995) is presented in CCRF (Code of Conduct for Responsible Fisheries) in which one of the indicators is fishing gear selectivity [14]. FAO (1995) stated that selective fishing gear can catch fish under three species (Table 1).

Table 1. Selectivity Criteria of Fishing Gears (FAO, 1995)

Criteria	Classification
Catches more than three species with very diverse size	1 (very low)
Catches three species with very diverse size	2 (low)
Catches under three species with average similar size	3 (medium)
Catches on species with similar size	4 (high)

3. Results and Discussion

3.1 Catches Classification of Seine Net

The catch from the pull seine fishing gear in Lake Maninjau, Nagari Bayua, Agam Regency, West Sumatra, is classified into three categories: main catch, bycatch, and discard. These classifications were determined based on interviews with the local fishers.

The main catch refers to the targeted species desired by fishers when designing and deploying the seine net. This type of catch holds relatively high economic value. The bycatch consists of non-targeted species that are not specifically sought after by fishers but may still have some economic value, although lower than that of the main catch. These species are sometimes consumed by the fishers themselves. Finally, the discard includes species that are neither targeted nor economically valuable, often thrown away by fishers, either alive or dead [15].

Table 2. The Frequency of Fish Catches

Catches	Freq (trip)	Catches Percentage (%)
Nila (*Orheochromis niloticus*)	15	100
Betutu (*Oxyeleotris marmorata*)	7	46.67
Louhan (*Amphilophus trimaculatus*)	2	13.33
Patin (*Pangasius* sp)	1	6.67
Sapu-sapu (*Hypostomus plecostomus*)	1	6.67

Table 2 shows that, out of 15 fishing trips using seine nets, the highest catch probability was observed for Nila (*Oreochromis niloticus*), with a catch frequency of 15 trips and a percentage of 100%. Other catches were categorized as discards due to their low catch percentages. For instance, Betutu (*Oxyeleotris marmorata*) was caught in only 7 trips, representing 46.67%, Louhan (*Amphilophus trimaculatus*) was caught in just 2 trips (13.33%), Patin (*Pangasius* sp) in only 1 trip (6.67%), and Sapu-sapu (*Hypostomus plecostomus*) also in 1 trip (6.67%). These findings indicate that the highest catch percentage in seine net fishing in Lake Maninjau is associated with the target species, Nila (*Oreochromis niloticus*).

3.2 Catch Composition of Seine Net

During the study, five species were captured, namely Nila (*Oreochromis niloticus*), Louhan (*Amphilophus trimaculatus*), Betutu (*Oxyeleotris marmorata*), Sapu-sapu (*Hypostomus plecostomus*), and Patin (*Pangasius* sp). The catch composition of the seine net is presented in Table 3 below:

Table 3. Catch Composition of Seine Net

Local Name	Latin Name	Total (Ind)	%	Total (kg)	%	Description
Nila	*Orheochromis niloticus*	1,252	97.97	274	99.19	*Main catch*
Betutu	*Oxyeleotris marmorata*	18	1.41	1.4	0.52	*Discard*
Louhan	*Amphilopus trimaculatus*	6	0.47	0.5	0.19	*Discard*
Patin	*Pangasius* sp	1	0.08	0.2	0.08	*Discard*
Sapu-sapu	*Hypostomus plecostomus*	1	0.08	0.07	0.03	*Discard*
Total		1,278	100	277	100	

Based on Table 3, the catch composition of seine net consists of the main catch and discard. The main catch is Nila (*Oreochromis niloticus*), while the discard includes Louhan (*Amphilophus trimaculatus*), Betutu (*Oxyeleotris marmorata*), Sapu-sapu (*Hypostomus plecostomus*), and Patin (*Pangasius* sp). The percentage of the main catch, measured in kilograms, is 99.19%, while the percentages of the discard species are as follows: Louhan (*Amphilophus trimaculatus*): 0.19%, Betutu (*Oxyeleotris marmorata*): 0.52%, Sapu-sapu (*Hypostomus plecostomus*): 0.03%, Patin (*Pangasius* sp): 0.08%.

Table 3 indicates that the largest catch was Nila, reaching 1,252 individuals and comprising 97.97% of the total catch using seine net. This suggests that Nila is the most abundant species caught in Lake Maninjau, indicating its likely dominance in the lake's population. The dominance of Nila can be attributed to its rapid reproduction rate. Nila can spawn 6-7 times a year in tropical regions or approximately once every two months [16]. When Nila reaches 1.5 to 2 years of age, with an average weight of 500 grams per individual, their spawning becomes highly productive. This is further supported by the findings of [17], who noted that Nila (*Oreochromis niloticus*) is the most frequently caught species using nets with a mesh size greater than 3 inches. These characteristics highlight Nila's reproductive capacity and its adaptability, making it a predominant species in the Lake Maninjau ecosystem. The discard in the fishing gear was 18 Betutu (*Oxyeleotris marmorata*) with a percentage of 1.41%. This can explain why catfish have not been caught by seine nets. This can be caused by the catfish population in the fishing area not being large due to the condition of the waters which are far from the cages and not yet overgrown with many aquatic plants to become a habitat for catfish. The population of catfish can be caused by the presence of floating net cages and the presence of many aquatic plants, namely E. *crassipes* and H. *verticillata* [18].

The next catch was 6 Louhan (*Amphilophus trimaculatus*) with a percentage of 0.47% of the total catch. The existence of Betutu (*Amphilophus trimaculatus*) in Lake Maninjau has not been widely utilized by fishermen. This small catch can also be caused by the fact that the fishing gear in Lake Maninjau immediately releases these fish back into the lake if they are caught, so that when the catch is collected, only a few fish reach the surface and are ultimately discard by fishermen. The next catch was Patin (*Pangasius* sp) which was 1 fish with a percentage of 0.08% of the total catch of the fishing gear. The next catch was Sapu-sapu (*Hypostomus plecostomus*) which was 1 fish with a percentage of 0.08% of the total catch of the fishing gear. This fish also had the lowest percentage of catches from all its catches. This was also triggered by the lack of interest of the fishermen in catching sapu-sapu fish since it had no economic value, and could not be consumed.

The total catch during 15 trips was relatively small because at the time of the study, the water conditions just experienced upwelling which occurs every year. In fact, previous research stated that under normal conditions in 1916 it was reported that there were 33 species of fish in Lake Maninjau [19] and in 1978 only 18 species were found [20]. In 2008, it was known that there were only 14 species, however, six of these species were species that had never been reported [21]. The comparison of the catch of the seine net in Lake Maninjau which had been classified into main catch and discard was found to have a main catch of 97.97%, and the discard was 2.03%. In this case, the main catch is more dominant in number compared to the discard. However, the combined bycatch and discard exceed the main catch, indicating low selectivity of the fishing gear. This could potentially lead to changes in biodiversity within the aquatic ecosystem [22].

3.3 Catch Size Structure

The size of the catches and the mesh size of the seine net are interrelated. The larger the mesh size of the seine net, the larger the size of the fish caught. However, the larger the mesh size of the seine net, the smaller the catch [23]. The mesh size of a net will affect the catch obtained. The size structure of Nila caught using the seine net fishing gear is presented in Table 4.

Table 4. Length Size of Catches

No	Species	Scientific Name	Length (cm)		Average
			Min	Max	
1	Nila	*Orheochromis niloticus*	12	33.2	24.7
2	Betutu	*Oxyeleotris marmorata*	12	25.2	18.6
3	Louhan	*Amphilhopus trimaculatus*	13.5	17.4	15.4
4	Patin	*Pangasius* sp	27	27	27
5	Sapu-sapu	*Hypostomus plecostomus*	19.4	19.4	19.4

Based on Table 4, there are fish length measurements in cm, including maximum, minimum, and average length. The maximum length of Nila (*Orheochromis niloticus*) during 15 captures was 33.2 cm, while the minimum length was 12 cm. This is not much different from the opinion of [17] who stated that the size of the fish first caught in a net with a mesh size of 3; 3.5 and 4 inches was 19; 22 and 25 cm. The total length of the smallest fish caught was 12 and 12.5 cm which were caught in a mesh size of 1.5 inches. The average length of Nila during 15 captures was 24.7 cm and the length that was most caught during 15 captures ranged from 25.77-27.73 cm, which meets the size criteria for Nila that are first mature gonads (Lm) at a size of 18.6 cm from data https://www.fishbase.org fish catches that are smaller than the Lm value will have smaller biomass and economic results [17].

3.4 Appropriate Catch Size for Nila

To reduce bycatch (non-target species), evaluating the selectivity of fishing gear is essential in fisheries resource management. The appropriate mesh size significantly determines the size of captured fish [17]. The size of caught fish is closely related to the selectivity of the fishing gear [24]. The total length at first gonadal maturity (Lm) is used to determine the permissible size for fish exploitation [25]. This measure aims to prevent overfishing of immature individuals [26]. Catches will be optimized, and fisheries resources will be sustainable if the minimum catch size is regulated appropriately [17;26]. Freshwater fisheries management faces challenges due to the lack of data on catch records, fish sizes, and stock assessments [27]. The appropriate catch size for Nila (*Oreochromis niloticus*) using seine net is presented in Table 5.

Table 5. Size Class Intervals for Nila (*Oreochromis niloticus*)

Class Interval (cm)	Numbers (Ind)	>Minimum Landing Size (Ind)	Undersize (Ind)
12-13.94	21		21
13.95-15.91	22		22
15.92-17.88	137		137
17.89-19.85	96	45	51
19.86-21.82	84	84	
21.83-23.79	76	76	
23.8-25.76	170	170	
25.77-27.73	221	221	
27.74-29.7	207	207	
29.71-31.67	202	202	
31.68-33.64	16	16	
Total	1,252	1,021	231
Percentage (%)	100	81.54%	18.46%

Based on Table 5, the largest number of Nila (*Oreochromis niloticus*) caught falls within the size class of 25.77–27.73 cm, totalling 221 individuals, while the lowest count is in the size class of 31.68–33.64 cm, with only 20 individuals. The percentage of fish that reached minimum landing size for Nila was 81.54%, whereas 18.46% of the catch, or 231 individuals, were undersized meaning that it should not be caught. Effective fisheries management occurs when 90% of the captured species have reached reproductive maturity or their optimal size [28]. The presence of 18.46% of Nila below the minimum landing size suggests space for improvement in selectivity to enhance sustainable fishing practices. Fish species that are below minimum landing size can cause a reduction in the potential of fisheries resources [29]. Furthermore fishing which is dominated by minimum landing size can indicate a high rate of exploitation which can result in no restocking of fishery resources in a water area [30].

3.5 Scoring Level of Selectivity

Based on size selectivity, 81.54% of the catches fall under the moderate selectivity criterion. This is by the statement by Saranga et al. (2019) [28] who argued that effective fisheries management with high selectivity criteria occurs when 90% of the catches have reproduced or reached their optimal size. Meanwhile, according to the size selectivity criteria of fishing gear (FAO, 1995), five species were caught, including Nila (*Oreochromis niloticus*), Louhan (*Amphilophus trimaculatus*), Betutu (*Oxyeleotris marmorata*), Sapu-sapu (*Hypostomus plecostomus*), and Patin (*Pangasius* sp). The size selectivity criteria based on FAO (1995) are aimed at making fishing activities targeting a specific species or organism.

The seine net operated in Lake Maninjau captured more than three different species with significantly varying sizes. In this case, the selectivity score is 1 (Very Low). In the same case, it was found that fishing gear like a seine net in Pangandaran Regency, West Java Province had a selectivity value of 1 (very low) [31]. Selectivity of fishing gear is the property of fishing gear to be able to reduce or exclude unwanted catches of a certain size. The nature of selectivity depends on the principles used in fishing and the design parameters of the fishing gear such as mesh size, thread elasticity, type of material and thread size, hanging ratio, speed, and duration of operation of the fishing gear [32].

4. Conclusion

The selectivity of seine net in Lake Maninjau, Nagari Bayua, Agam Regency, West Sumatra Province, falls into the low category. The gear captures more than three species of fish with significantly varying sizes. Nevertheless, the percentage of catches reaching out minimum landing size for main catch (Nila) is 81.54%, higher than the percentage of undersized fish 18.46%. However, based on the fishing gear selectivity criteria (CCRF), the seine net fishing gear selectivity level has a score of 1 (very low).

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Author Contributions

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References

[1] Akoit MY, Nalle M. Pengelolaan sumberdaya perikanan berkelanjutan di Kabupaten Timor Tengah Utara berbasis pendekatan bioekonomi. Jurnal Agribisnis Indonesia. 2018;6(2):85–106.
[2] Soejarwo PA, Koeshendrajana S, Apriliani T, Yuliaty C, Deswati RH, Sari YD, Sunoko R, Sirait J. Pengelolaan Perikanan Budidaya Keramba Jaring Apung (KJA) Dalam Upaya Penyelamatan Danau Maninjau. Jurnal Kebijakan Sosial Ekonomi Kelautan dan Perikanan. 2022;(1):79-87.
[3] Hadi EP. Bahan dan alat tangkap penangkap ikan. Yogyakarta: Kementerian Pendidikan dan Kebudayaan Direktorat Pembinaan Sekolah Menengah Kejuruan; 2019.
[4] Sipayung EP, Bustari B, Syofyan I. Uji coba penggunaan berbagai macam bahan bubu untuk penangkapan lobster di Danau Maninjau. [Disertasi]. Riau: Riau University; 2016.
[5] Mustaruddin M, Wiyono ES, Khotib M, Asnil A, Bahri S. Pola pencemaran lokasi penangkapan dan ikan hasil tangkapan akibat berkembangnya aktivitas ekonomi di sekitar Danau Maninjau. Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan. 2018;8(2):134–42.
[6] Ramlan SH. Penggunaan alat tangkap bagi nelayan yang benar. Kumpulan Jurnal Dosen Universitas Muhammadiyah Sumatera Utara. 2018.
[7] Ramadan F, Ramdhani F, Deni Efizon N. Ancaman keanekaragaman hayati (Biodiversity) terhadap ekosistem daerah penangkapan pukat hela. Dinamika Lingkungan Indonesia. 2020; 7(2):129-36.
[8] Ramdhani F, Nofrizal N, Jhonnerie R. Studi hasil tangkapan bycatch dan discard pada perikanan udang mantis (Harpiosquilla raphidea) menggunakan alat tangkap gillnet. Marine Fisheries: Journal of Marine Fisheries Technology and Management. 2019;10(2):129-39.
[9] Rofiqo IS, Kurniawati N, Dewanti LP. Tingkat keramahan lingkungan alat tangkap jaring insang

(gillnet) terhadap hasil tangkapan ikan tongkol (Ethynnuss sp) di Perairan Pekalongan. Jurnal Perikanan Kelautan. 2019;10(1).
[10] Dewanti LP, Rahmahningrum SF, Rizal A, Khan A, Rostika R. Length catch and growth analysis of hairtail fish (Trichiurus sp.) in southern off West Java Sea (Case study: Pangandaran fishing base). Int J Fish Aquat Res. 2019;4(1):13–6.
[11] Ramadhan P, Prihantoko KE, Kurohman F, Suherman A. Komposisi ikan hasil tangkapan dan distribusi ukuran ikan tertangkap pada jaring nila 3 inchi di Perairan Rawa Pening. Jurnal Perikanan Tangkap. 2023;7(2):53–62.
[12] Walpole RE. Pengantar statistika. Edisi ke-3. Jakarta: Gramedia Pustaka Utama; 1995.
[13] Wujdi A, Suwarso S, Wudianto W. Biologi reproduksi dan musim pemijahan ikan lemuru (Sardinella lemuru Bleeker 1853) di Perairan Selat Bali. BAWAL Widya Riset Perikanan Tangkap. 2016;5(1):49–57.
[14] FAO. Code of conduct for responsible fisheries. Rome: FAO; 1995.
[15] Nofrizal R, Yani AH, Alfin. Hasil tangkapan sampingan (bycatch dan discard) pada alat tangkap gombang (filter net) sebagai ancaman bagi kelestarian sumberdaya perikanan. J Mar Fish Technol Manage. 2018;9(2):221–33.
[16] Amir K, Khairuman. Budidaya ikan nila secara intensif. Jakarta: Agro Media Pustaka; 2008.
[17] Warsa A, Astuti LP. Ukuran pertama kali matang gonad dan selektivitas jaring insang ikan nila (Oreochromis niloticus) di Waduk Jatiluhur, Jawa Barat. Berita Biologi. 2019;18(3):283–93.
[18] Siagian. Keanekaragaman dan kelimpahan ikan serta keterkaitannya dengan kualitas perairan di Danau Toba Balige Sumatera Utara. [Tesis]. Medan: Sekolah Pascasarjana USU; 2009.
[19] Weber MG, de Beaufort LF. Fishes of the Indo-Australian Archipelago. Vol. III. Leiden: E. J. Brill; 1916.
[20] Wargasasmita S. Ikan air tawar endemik Sumatra yang terancam punah. J Iktiol Indon. 2002;2:41–49.
[21] Roesma DI. Evaluasi keanekaragaman spesies ikan danau Maninjau. Prosiding Semirata. 2013;1(1).
[22] Ramdhani F, Nofrizal N, Jhonnerie R. Studi hasil tangkapan bycatch dan discard pada perikanan udang mantis (Harpiosquilla raphidea) menggunakan alat tangkap gillnet. Marine Fisheries: Journal of Marine Fisheries Technology and Management. 2019 Nov 1;10(2):129-39.
[23] Irpan A, Djunaidi D, Hertati R. Pengaruh ukuran mata jaring (mesh size) alat tangkap jaring insang (gill net) terhadap hasil tangkapan di Sungai Lirik Kecamatan Jangkat Timur Kabupaten Merangin Provinsi Jambi. Semah Jurnal Pengelolaan Sumberdaya Perairan. 2018;2(2):22–32.
[24] Huse I, Løkkeborg S, Soldal AV. Relative selectivity in trawl, longline and gillnet fisheries for cod and haddock. ICES J Mar Sci. 2000;57(4):1271–82.
[25] Ogutu-Ohwayo R. Management of the Nile perch, Lates niloticus fishery in Lake Victoria in light of the changes in its life history characteristics. Afr J Ecol. 2004;42(4):306–14.
[26] De Graaf M, Machiels M, Wudneh T, Sibbing FA. Length at maturity and gillnet selectivity of Lake Tana's Barbus species (Ethiopia): implications for management and conservation. Aquatic Ecosystem Health & Management. 2003;6(3):325–36.
[27] Suuronen P, Bartley DM. Challenges in managing inland fisheries-using the ecosystem approach. Boreal Environ Res. 2014;19:245–55.
[28] Saranga R, Simau S, Kalesaran J. Ukuran pertama kali tertangkap, ukuran pertama kali matang gonad dan status pengusahaan Selar boops di Perairan Bitung. J Fish Mar Res. 2019;3(1):67–74.
[29] Dewanti LP, Burhanuddin MA, Yustiati A, Ismail MR, Apriliani IM. Selektivitas Alat Tangkap Purse Seine Waring di Pelabuhan Perikanan Pantai (PPP) Dadap Kabupaten Indramayu. Gorontalo Fisheries Journal. 2023;6(2):108-18.
[30] Handayani M. Karakteristik biologi dan teknologi daerah penangkapan ikan karang di perairan Karimunjawa. Paper Knowledge. Toward a Media History of Documents. 2018.
[31] Dewanti LP, Mahdiana I, Zidni I, Herawati H. Evaluasi selektivitas dan keramahan lingkungan alat tangkap dogol di Kabupaten Pangandaran Provinsi Jawa Barat. Jurnal Airaha. 2018 Jun 25;7(1):30-7.
[32] Fridman A. Calculation for fishing gear designs. Rome: FAO, Agriculture Organization of the United Nations; 1986.