Eel (*Anguilla* spp.) fishing activity in Poso Area Central Sulawesi, Indonesia

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**Abstract.** Poso in Sulawesi, primarily the Lake Poso and Poso River, is known as eel (*Anguilla* spp.) fishing areas. Therefore, research of eel fishing is required as base information for evaluating and determining policies for its activities. The eel fishing research in the Poso area was conducted through primary data observations, secondary data traces, and interviews from April to June 2021. The fishing activities take place in the Lake Poso and Poso River shore and the rivers of the lake inlets. The fishing gear that contributed greatly to the catch was fence traps and spears. The local community's fence trap called waya is a unique gear only found in this area, and it is installed in Poso River around the lake outlets. The gears block the rivers to catch downstream migration eels. The spear is fishing gear (including for eels) operated at night in shallow waters, especially in the outlets of Lake Poso. The eel production recorded from the Poso areas for the last four years has been 6.7–15.5 tons per year, and the highest production was in Pamona Puselemba.

**1. Introduction**

Eels are a type of catadromous fish, which carry out a dominant pattern of life in freshwaters but to spawn, they migrate to marine waters [1]. Therefore, Indonesian waters are hypothesized as the 'ancestors’ area' of eels (*Anguilla* sp.) because out of the 18 species or subspecies in the world, seven are found in Indonesian waters, especially found in areas facing deep sea waters such as the west coast of Sumatra, the south coast of Java, the coast of Sulawesi, Maluku and Papua [2,3]. Meanwhile, the waters of Sulawesi and its surroundings are potential areas for the distribution of tropical eels and at least five species of eel found in this area, such as *A. marmorata*, *A. bicolor facifica*, *A. celebesensis*, *A. borneensis*, and *A. interioris* [3].

The lake and the Poso River are potential tropical eels’ areas supported by their proximity to deep-sea waters, namely the Tomini Bay. According to [2], the abundance of eel larvae (leptocephalus) in Tomini Bay is the highest compared to that in the other waters. Furthermore, the Poso River estuary has been known to be the entry point for eel larvae that hatch in the ocean and migrate upstream [4 – 6]. As stated by [5], the recruitment rate of eel larvae in the Poso River estuary reached 260 – 1,069 individuals/five seconds.

Poso waters, especially the Lake Poso and surrounding area, have long been known as eel fishing areas, especially around the lake's outlet, and the fisherman catches the migrating adult eels to the sea [7]. The main gear to catch these eels is in the form of traps known as ‘waya’ or ‘waya masapi’ (Waya...
= fence [the trap with fence system]; Masapi = eel), which is set towards the upstream of the river [8]. The Poso eel production in the 1970s reached 22 – 54 tons/year, which is estimated from 20 – 25 gears and counted by catches per gear per night [9]. The data of eel production in Poso Regency were recorded as much as 41.5 tons and 30.5 tons in 1990, 1998 respectively (Report of Fisheries Service DT II Poso; unpublished). The eel catches are dominated by species A. marmorata [10].

The research on the fishing activity of eels in the Poso area is highly required as a material for evaluating and determining policies and reviewing other activities that can affect eel capture. For this reason, the research on the level of fishing activity of eels in this area was carried out.

2. Materials and methods
The study includes observation on fishing activity in Lake Poso, Poso River, and tributaries that inlets of the lake, conducted by searching various information to obtain primary and secondary data and interviews (Table 1). The observations focused on ‘waya’ and spearfishing gear conducted in April, May, and June 2021.

Table 1. The required data and information, and methods used

| No. | Data and Information          | Methods                        |
|-----|-------------------------------|--------------------------------|
| 1   | Main fishing areas and methods| Observations & interviews      |
| 2   | Production of eel             | Primary and secondary data     |
| 3   | Catch sizes                   | Observations                   |
| 4   | Supporting data and information| Various sources                |

3. Result and Discussion

3.1. Area and gear of fishing activity
In general, eel fishing activities spread out from the waters of Lake Poso, especially in the shore areas, the Poso River, particularly in the outlet of the lake areas, and in the rivers that as the inlet of Lake Poso (Table 2; Figure 1).

Table 2. Area and gear of eel fishing activity in Poso Area, Central Sulawesi

| No. | Fishing gears     | Inlets of lake | Locations |
|-----|-------------------|----------------|-----------|
|     |                   | 1  2  3  4  5  6 | 7  8  9    |
| 1   | Pole and line     | v  -  v  -  -  - | v  v      |
| 2   | Fence trap        | -  -  -  -  -  v | v  v      |
| 3   | Spears            | v  v  v  v  v  v | v  -      |
| 4   | ‘Bubu’ (bamboo trap) | v  v  v  v  v  v | -  -  -   |
| 5   | Electrofishing    | -  -  v  v  -  - | -  -      |

Notes: Location: 1. Tokilo; 2. Bancea; 3. Meko; 4. Tonusu; 5. Dulumai; 6. Peura; 7. Sangele; 8. Tendeadongi; and 9. Saojo; v) Eel fishing activities available; -) No those fishing gear activities; *) No eel fishing activities currently

Based on [11], the fishing gear commonly used were poles and lines; this seems to follow the fishing area condition dominated by rivers. The use of fishing gear seems to adjust to the conditions of the waters in their area. For example, in Tokilo, Bancea, Meko dan Tonusu, traps that the local people call “Bubu” (Figure 2) are mainly used because the gears were suitable for the rivers that flow in their areas. In these areas flow the Rivers of Kodina, Panjo, Towini, Meko, and Toinas as the major inlets of Lake Poso [12-13].

‘Waya’ (fence fence) is used in the Poso River around the outlet of the lake only (Figure 3). The condition of the Poso River waters in this area is reasonably sloping and not very deep; it is about 1.5 – 3.5 meters in depth so that the community can install the ‘waya’. Spearfishing gear is mainly used in shallow waters, both in streams and lake banks. Since Dulumai and Peura only had shore of the lake, so
the fishing gear recorded was spear (Figure 1). Based on the recent observations, the fishing gear that is widely used and relatively contributes to eel production is the ‘waya’ and spear.

![Figure 1. Map of eel fishing area and fishing gears used.](image1)

**Figure 1.** Map of eel fishing area and fishing gears used.

**Figure 2.** Trap (‘bubu’) is the eel fishing gear used in the tributary.

**Figure 3.** ‘Waya’ (fence trap) the eel fishing gear used in Poso River around the outlet of Lake Poso.

### 3.2. Technical and Operational of Main Fishing Gear

“Waya” is a fishing gear in the form of a large trap that blocks the upstream water flow. It is made of bamboo arranged in a standing position (similar to the fence) with 10-20 m long in a triangular shape with a mouth width of 5 m and narrows towards the downstream with a width of the end about one meter (Figure 4). The bottom part of the ‘waya’ below the water's surface is made of bamboo sticks, and a rectangular trap with a size of 1 x 1 m is located at the downstream end of the ‘waya’. The ‘waya’ is operated in the Poso River around the outlet of Lake Poso primarily to catch eels that downstream migrate to the sea (Figure 5).
The fishing gear also widely used to catch eels is a five-edged spear with a 5-7 m long bamboo stalk (Figure 6). Fishing using spears is a traditional activity of the local community known as ‘monyilo’, while the fishermen who catch the eels are called ‘toponyilo’. ‘Monyilo’ activity is conducted at night from 6 pm to 5 am so that petrol lamps are used for lighting. This activity is generally conducted in shallow water areas, especially in the Poso River around the outlet of Lake Poso and on the shores around Lake Poso.

3.3. Eel fishery production
The recorded eel fishery production from the Poso area in the previous four years was in the range of 6.7 – 15.5 tons/year, and this production was far above the production data for 2004 – 2009, which was in the range of 5.8 – 8.9 tons/year (Figure 7). The capture of eels by ‘waya’ in the Poso area focuses on live eels that are generally exported, and the ‘waya’ fishing areas are dominantly located in Tendeadongi Village (4 units) Sangeli (4 units) of Puselemba Pamona District. The fishing with ‘waya’ has been greatly reduced right now, and this is related to the Poso Energi hydropower activity, which conducted the river deepening in these areas. Based on previous reports, the total number of ‘waya’ recorded in Sangele, Tendeadongi, and Saojo villages were 11 units, 2 units, and 10 units, respectively [10].

The eel’s production fluctuated seasonally, with its high production occurred in April, May, and June. However, in the last months of the year, the eel production decrease, and in August, October and November, there was no catch (Figure 8). Based on the data from PT. Poso Energi, the water level of Lake Poso was relatively high in the 16th to 28th week of the year or from April to July [12]. Therefore, from 2000 to 2002, the monthly catches of eels migrating downstream from Lake Poso would increase when the water level was high [7]. This condition confirms that the eel production from the Poso area

Figure 4. Scheme of ‘waya’ fishing gear.

Figure 5. Installation of ‘waya’ in the Poso River around the Lake Poso outlets.

Figure 6. Five-edged spear for monyilo activities in the Poso area.
is mainly sourced from ‘waya’ fishing. Thus, fluctuations in eel production are thought to be related to lake water level fluctuations.

Figure 7. Eel production in Poso Area on the period of 2004-2009 (Source: Fisheries Board of Poso District, 2007 in [9]) and 2017-2020 (Source: Fisheries and Marine Board of Poso District; unpublished).

Figure 8. Eel production in Poso Region in 2004, 2005, and 2006 (Source: Fisheries Branch Office, Pamona District, 2007 in [9]).

Figure 9. Eel production from the main fishing areas in Poso.

Table 3. Catches of eels in the Poso area using ‘waya’ and spear.

| Month | ‘Waya’ Weight (kg) | ∑ind. | Spear Weight (kg) | ∑ind. | Total Weight (kg) | ∑ind. |
|-------|-------------------|-------|------------------|-------|------------------|-------|
| April | 667.4             | 127   | 472.5            | 106   | 1139.9           | 233   |
| May   | 660.6             | 119   | 518.2            | 119   | 1178.8           | 238   |
| June  | 443.2             | 90    | 440.4            | 95    | 883.6            | 185   |
| Total | 1771.2            | 336   | 1431.1           | 320   | 3202.3           | 656   |
| %     | 55.3              | 51.2  | 44.7             | 48.8  |                  |       |
| Average | 590              | 112   | 477              | 107   | 1067             | 219   |
| Average of weight | 5.27 | 4.47 | 4.88 |

Source: Primary data

The eel catches in the Poso area in the previous four years (2017 – 2020) were in the range of 6.7 – 15.5 tons/year, in which the catch production was dominated by Pamona Puselemba District (Figure 9). Pamona Puselemba area is the central district of Sangele Village, the primary location for ‘waya’ fishing. Based on the current data (March – June 2021), the catches of eels in the Poso area were in the range of
above 1 ton per month, and approximately 219 eels were caught, while the average size of the caught eels was between 4.47 and 5.27 kg/individual (Table 3).

The catches from the ‘waya’ and spearfishing gear almost did not differ. However, those from the ‘waya’ seemed to be higher both in terms of weight and amount. Based on the observations from April to June 2021, the weight size of the eels caught was 0.8 – 10.2 kg, with a length in the range of 68 – 135 cm. The enormous eel ever caught weighed 20.2 kg and was 144 cm long, although this size is an occasional size. Based on the report of [14], the catches from the ‘waya’ from May to September 2007 were 0.2 – 5.6 kg and 50 cm – 130 cm in length.

Lake Poso is a habitat and distribution area of eel that is reasonably strategic and has become a concern both from its scientific view and economic potential. The lake, which has an area of 368.9 km² and is located at an altitude of 500 m above sea level [11], is essential for supporting the eel development, populations, and eel fisheries. The large inland waters with many rivers that become the lake's inlets and are close to the deep sea of Tomini Bay is the perfect mix for the development of eels. According to [15], the Poso River, with its reasonably large flow, is a potential source of giant silver eels for Tomini Bay, although the spawning area may not be in this bay. It is estimated that the eel requires migration of up to 1,000 – 3,000 km to reach the spawning site.

Sugeha, et al. [13 – 14] have observed eels (elver phase) entering Poso River Estuary between 1997 and 1999. One of the species caught is A. marmorata, the dominant one [13][9]. This species can live in various habitats and high-elevation areas. Moreover, A. marmorata inhabits and undergoes a phase of life in various habitats, from salt bays or brackish estuaries, in rivers to upstream rivers and lakes [17]. In tropical rivers, A. marmorata is a species with a reasonably high abundance compared to other Anguilids species and can be found in areas with elevations 300 m above sea level (asl) [18]. Meanwhile, the distribution of European eels is only limited to lakes with an altitude below 295 m asl [19]. This condition is supported by the better swimming ability and more active migration of A. marmorata species than others [20]. The species A. marmorata was also found in waters with an altitude of 700 m asl., i.e., in Lake Rana, Buru Island [21].

The use of ‘waya’ on eel fishing in outlets of Lake Poso is an activity that catch of the eel down migration and has been conducted for a long time. In other area in Indonesia, there are several places where the communities also run the eel fishing effort by catching the eel down migration, such as in Bupoli on the Wainibe River, Buru Island. The people catches migrating eels from Lake Ranau to the sea. Their fishing techniques were still traditional and still artisanal fisheries [21]. Other eel fishing activities are in the Lasolo River, Lalindu River, and Konawe River in Southeast Sulawesi. They are small and limited-scale fisheries efforts but are carried out intensively throughout the year to meet the export needs so that there is an indication of overexploitation [22].

Eel fishing activities in the Poso area that contribute significantly to eel production are ‘waya’ and spears. ‘Waya’ fishing gear is more to catch silver eel because the gear especially catches downstream migrate eels, while spearfishing gear is more dominant in catching the yellow eel, which is generally sedentary. Thus, the catches in the Poso area are similar to those in the Rivers of Lasolo and Lalindu, i.e., yellow eels and silver eels, although silver eels are more dominant catch in Lasoro and Lalindu [22].

‘Waya’ fishing gear tends to be environmentally unfriendly because its installation almost blocks the migration path, and the catches were over 70 cm long on average. The ‘waya’ catch data from May to September 2007 show that eels of >70 cm in length made up almost 80% of the catches [15]. The eels that downstream migrate from Lake Poso occur throughout the year with a size of >70 cm have gonads that are already developed and show early vitellogenesis [23 – 24]. The spawning condition of eels in Lake Poso suggested has considerably high gonadosomatic index values with histologically fully developed gonads [16].

At this time the threat to the eel population from fishing activities in this area can be stated to decrease. The activities of Poso Energi Power Plant that deepens the river channel at the outlet of the Lake Poso causes the use of ‘waya’ fishing gear has reduced significantly. Meanwhile the use other gears are relatively passive (traps; pole and line) and the fishing area were limited enough (spears;
electrofishing). So that if viewed from the aspect of fishing gear used will not have impact on the eel fisheries sustainability in the Poso area. Moreover, it will be threatened mainly due to habitat changes.

Habitat change that is very likely to occur is shifting the aquatic-terrestrial transition zone (ATTZ), which is generally from wetland to dry land and agriculture. Vegetated waterfront areas are one of the preferred habitats for eels [18]. These wetland areas are mostly seen on the west side of Lake Poso, which implies lake water level fluctuations [11], and in the river mouths such as the mouth of the Kodina River in the southern part of the lake. If there is an arrangement of the flow of water coming out of Lake Poso for hydropower purposes or other purposes, it will affect the fluctuation of the lake water level and impact the ATTZ.

Another habitat change is the damming of the Poso River flow for hydropower purposes, which will interfere with the downstream migration of silver eels or upstream migration of young eels as recruitment into the lake. Currently, the hydropower plant has built a fishway to facilitate the migration of the eels, although its effectiveness is still being tested.

4. Conclusion

The Poso area, especially the Lake Poso and Poso River, are Indonesia’s main eel fishing areas. The fishing gear which contributes greatly to the capture is the ‘waya’ (the fence system trap) and spears. The recorded eel fishery production from the Poso area in the previous four years was in the range of 6.7 – 15.5 tons per year, and average > 1 ton/month with the average of length > 70 cm. However, the sustainability of eel fisheries in this area will be threatened, especially with changes in habitat, either due to the reduced ATTZ or disruption to eel migration.

Acknowledgments

The author would like to thank the Ministry of Finance, the Republic of Indonesia, through the LPDP RISPRO INVITASI program 2020, which contributed to funding this research activity. The author also thanks fishers of eel in Lake Poso, Central Sulawesi, and all parties involved and participated in conducting the research.

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