Fishermen perception on the sustainable utilization of freshwater glass eel (*Anguilla* spp.) on river estuaries in Sukabumi Regency

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**Abstract.** Glass eel (*Anguilla* spp.) are economically important commodities and being intensively exploited by fishermen in Sukabumi Regency, posing a high risk to overfishing and extinction. Socio-economic conditions are considered as the primary driving factor of such unmanaged utilization of these early life guilds. This study aimed to determine the socio-economic characteristics of glass eel fishermen affecting their perceptions and behavior in glass eel fishing. Primary data collection including in-depth interviews (n=30) and field observations was carried out at two main fishing areas in the estuary of Cimandiri and Cikaso river from July to August 2020. Whereas secondary data was literature inquiries based on previous research. The data collected was analyzed descriptively and with the Rank Spearman correlation test. The results showed that about 87.50% of fishermen have a high perception of glass eel stock is still can be utilized continuously so that their behavior in handling the catch is by modifying their fishing gears. In Cikaso estuary, fishermen developed the traps in addition lift net and scoop net as fishing gear, while in Cimandiri estuary is restricted to lift net. In the latter place, a community watching group (*pokmaswas*) has been established as community participatory in coastal ecosystem protection.

**Keywords:** behavior fishing; fishermen perception; glass eel; socio-economic

1. **Introduction**

Tropical eel is currently experiencing a high demand for international consumption markets as an ingredient in the production of kabayaki (Japanese food menu, grilled eel). The total world eel demand reached 58,000 tons in 2018, increased intensively by 55.9% in 2014 [1]. Sukabumi Regency is one of the areas that supply glass eel to meet the demand for eel cultivation companies in Indonesia. Fisheries and Marine Science Services of Sukabumi Regency in 2018, recorded that the production of glass eels caught in the Cimandiri River was 78% of the total production in Sukabumi Regency, reached 14,473,738 seeds [2]. Other potential catchment areas are Cibuni, Cibareno, Ciletuh, Cikarang, and Cikaso rivers with production in 2018 ranging from 12,050 to 1,897,944 seeds [2].
The fishermen catch as much as possible because the selling value is very high. A kilogram of glass eel has caught in 2019, the fishers paid around IDR 2,500,000 by the collectors. Fishing activity contributes to a decline of eel population [3]. The pattern of continuously using without paying attention to its sustainability has resulted in several species of eel that have been included in the critical list of IUCN (the International Union for Conservation of Nature). Tropical eels caught in Indonesian waters that from the species Anguilla bicolor and Anguilla marmorata have been categorized as Near Threatened [4] and Least Concern [5]. Arai [6] stated that all the population of eels will decline to exceed biologically safe limits and will be critically endangered due to current fishing trends for consumption.

Socio-economic characteristics create a diversity of perceptions and behavior of fishermen in the use of natural resources. Perception is defined as a person's view or understanding of something where people see things differently from one another [7]. Experience, behavior, and perception are three interrelated aspects, so changing one's behavior towards a predetermined goal can be facilitated by understanding the current perception of the individual towards the world [8]. Public perceptions of the emergence of potential objects actually reflect opinions, desires, hopes, assessments, evaluations, and responses to development activities in their area [9, 10]. Perception has important implications for behavioral structures, including social structures that affect social systems or the biogeophysical environment, in this case the ecosystem [11].

In accordance with the Sustainable Development Goals (SDGs) 12 and 15 agenda, which is to ensure consumption and production patterns sustainability as well as to protect, restore and promote terrestrial ecosystem use sustainability and reverse land degradation and halt biodiversity loss, it is important to carry out protection and sustainable management to maintain the existence of tropical eel populations in Indonesia. This study aimed to determine the socio-economic characteristics of glass eel fishermen and to consider the effect of their perceptions and behavior in glass eel fishing activity in Sukabumi Regency.

2. Methodology

This study used survey-based method to obtain data on recent facts and symptoms in the study location. The population on this study was freshwater glass eel fishermen in the main fishing area, Cimandiri and Cikaso estuary of Sukabumi Regency as shown in figure 1. Both of those fishing areas had similar fishermen socioeconomic characteristics, based on Central Berau of Statistics[12] reveal the population near the site area is relatively homogenous. Cimandiri estuary empties into Palabuhanratu Bay and it is a lowland area that has characteristics of a sandy and gentle beach. Fishing activities operated along 5 km vertically to the upstream. While Cikaso estuary flows into the South Java Sea, it has a sandy base substrate with an average depth is 0.5 m. Glass eel were caught by Cikaso fishermen with the fishing area is 10 km away from the estuary.

The study was conducted from July to August 2020. Total of thirty respondents was purposively interviewed with the use of a questionnaire. Furthermore, supporting data were collected and a literature review was carried out to assess the potential of eel seeds based on previous research. Data obtained from interviews constitute nominal scale data such as age, education, income, and experience in fishing activities. Then the data was compiled and ranked to obtain an ordinal scale for analysis purposes. Data analysis was carried out descriptively and with non-parametric statistical tests. The statistical analysis used was the Rank Spearman correlation test to see the closeness of the relationship between fishermen's perceptions of the availability of seeds and their behavior in adjusting to changes in catch conditions. A significant correlation between individual characteristic variables and fishermen's perceptions of glass eels was also carried out.
Results and discussion

3.1. The potential of glass eel in Sukabumi Regency

Molecular phylogenetic research conducted on tropical eels revealed that they are the most basic species originating from the Indonesian region which spread out from the tropical to the temperate coast [6]. The origin of the eel seeds that enter the waters of the southern coast of Java and the west coast of Sumatra is thought to be eels that spawn from the Indonesian sea southwest of Sumatra [13]. The eel seeds are caught by fishermen in the estuary area with a distance of 5-10 km to the river. The species of eels that are generally caught in the estuary of Sukabumi Regency are *Anguilla bicolor bicolor* and *A. marmorata*. According to Sadili *et al.* [13] that *A. bicolor bicolor* has a meat texture similar to *A. japonica* (an eel found in Japanese waters) so that it becomes Japan main export commodity. Cimandiri River estuary has long been the center for catching glass eel with a catch of 8,416 seeds per night with the highest abundance in the rainy season [14]. In the same study with observation areas in other rivers of South Java Coast, other potential catches were found in Cibuni, Cibumiangeun, Bayah, and Bungur rivers (in Banten Province area) during the dry season while the Cikaso River is abundant in the rainy season.

In 2010, the utilization of tropical eels began to increase even though they were not used properly before. However, it must be a concern if we do not want the fate of tropical eels to be the same as Japanese and European eels that have listed Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Although the stock assessment and management of European eels is receiving increased attention from the scientific community and fisheries institutions, their assessment and management are still not going well [6]. Still lack information regarding the
historical record in tropical eels compared to European and Japanese eels. So that various researches on the biological information and the potential of tropical eels are continuing. Besides, the business sector, cultivation technology also needs to be improved for the success of cultivating eel from nature. Restocking is also carried out to help enrich natural populations.

The distribution records of both catch and cultivation levels are carried out to record the abundance pattern of eel as information in the management and utilization of eel fisheries in Indonesia [15], especially in Sukabumi Regency. Catch reports are usually recorded by collectors in each fishing area. Hereafter, the Office of Marine and Fisheries Services of Sukabumi Regency has just collected the data on catches from glass eel’s collectors starting in 2017 as shown in table 1. Since eel was made a priority fish resource in 2019, both government and non-governmental organizations have made conservation efforts and established policies.

Table 1. The catch of glass eel (kg) in some estuaries of Sukabumi Regency.

| Year | Cibareno | Cimandiri | Cikaso | Cibuni |
|------|----------|-----------|--------|--------|
| 2017 | 945.53   |           |        |        |
| 2018 | 5.07     | 710.21    | 205.29 | 164.46 |
| 2019 | 225.65   | 512.02    | 49.75  | 185.34 |
| 2020*| 0        | 13.01     | 1.55   | 2.10   |

*data obtained until March.

The catch data collected shows an annual trend in some main fishing area. Cimandiri estuary, as the first fishing center, supplies a large number of catches recorded each year. It has an area surrounded by the Palabuhanratu bay and close to densely populated settlements around its estuary and beaches. Data on the catch at the Cikaso estuary has the largest in 2018 but the following year was decreased. Cikaso, it is known that the condition in the dry season of the estuary is covered with sand so that it can form a fort as high as ±10 m consequences prevent the seeds from entering the river estuary waters. When the glass eel has entered the abundant season, many become seasonal fishermen in the estuaries. Because there is no regulation yet on who is allowed to become a fisherman and the glass eel fisheries management regime is open access. At least the Department of Maritime Affairs and Fisheries of Sukabumi Regency estimates that there are 67, 500, 70, 105 fishermen in Cibareno, Cimandiri, Cikaso, and Cibuni respectively.

The fishermen stated that an anomaly occurred when glass eels entered the estuary, since the early year of 2020 there were not many recorded catches. The high season of glass eels usually occurs in the rainy season. As of this writing, fishermen have not been able to catch them because no glass eels have yet entered the estuary. Figure 2 shows monthly catches recorded in 2018 and 2019, it can be seen what month the presence of the glass eel enters each estuary and when its peak.

Figure 2. Catch trend for the glass eels during 2018 (left) to 2019 (right) in estuaries of Sukabumi Regency.
3.2. Characteristics of Respondents

The characteristics of respondents in this study are explained by socioeconomic variables, which according to [16] include age, education, experience, equipment, participation in fishermen organizations, and season. The age of fishermen can influence perceptions and behavior towards the protection of fish resources, as older fishermen could be more opposed to change their catching habits [17]. Interviews were conducted at the estuary near Loji Village and Cibitung Village. as many as 50% of respondents are in the age range 41-59 years who were not from the young workforce with the latest education at elementary school level of 80%. The latest education taken by fishermen can be a factor that encourages fishermen to receive information, views, and responses to the environment. Each percentage of the respondent's socio-economic characteristics shown in Table 2.

Table 2. Socio-economic characteristics of glass eel fishermen in Sukabumi Regency.

| No. | Variable                    | Category          | Percentage (%) |
|-----|-----------------------------|-------------------|----------------|
| 1   | Age (year)                  | 22 - 40           | 33.33          |
|     |                              | 41 - 59           | 50.00          |
|     |                              | 60 - 78           | 16.67          |
| 2   | Education level             | Primary school    | 80.00          |
|     |                              | Middle school     | 3.33           |
|     |                              | High school       | 16.67          |
| 3   | Experiences (year)          | Low (1-7)         | 37.50          |
|     |                              | Average (8-14)    | 37.50          |
|     |                              | High (15-21)      | 25.00          |
| 4   | Fishing gears               | Scoop net         | 62.50          |
|     |                              | Lift net          | 25.00          |
|     |                              | Others            | 12.50          |
| 5   | Other jobs                  | Farmer            | 43.33          |
|     |                              | Seller            | 23.33          |
|     |                              | Labor             | 10.00          |
|     |                              | Others            | 23.22          |
| 6   | Income (IDR/month)          | Low (< 1 million) | 12.50          |
|     |                              | Average (1-2 million) | 50.00   |
|     |                              | High (>2 million) | 37.50          |

Processed data of 2020.

Experience determines the skills of fishermen in fishing, the more skilled the fishermen are, the better catch tends to be. It is shown by the length of time they have been fishermen. The factor of using suitable fishing gear in the activity of catching glass eels can be one of the abilities of fishermen to adapt to changes in uncertain environmental conditions. Most of the fishermen in Cimandiri estuary use scoop net, namely sirib, as fishing gear. When the glass eel goes up the estuary along with the rising tide. Other fishing gears that are also used are traps as passive fishing gear which only need to be stored in between rocks on the banks of the river estuary. In addition, some fishermen in Cikaso estuary also modified the fishing gear used to block the glass eel while they were actively using scoop net and lift net (anco). So that besides experience, other skills are needed to be able to increase their income. Most of the respondents have an income level of 1-2 million (IDR) per month from glass eel fishing activity with an average income of around 1.4 million (IDR) per month [2].

3.3. Fishermen perceptions of the glass eels abundance in the waters

To change one's behavior towards a predetermined goal can be facilitated by understanding the current perceptions of the individual. Consciously, the fishermen agree and even complain that the catch has a downward trend than before. Fishermen perceptions of glass eel resources in the waters can be formed
by the information obtained and observations about objects and phenomena that occurred. According to table 3, as many as 60% of respondents thought that the decline in glass eel catch occurred as a result of climate changes. The climate changes natural habitat conditions and causes a shift in the rainy and dry seasons. As in Cikaso estuary during the dry season experiences sand to cover up to 10 m high. As much as 23% of the respondents realized that overfishing was also one of the reasons for the absence of opportunities for seeds to migrate upstream to enlarge. Meanwhile, the rest of the respondents have complained about the activities around the river which disturbed the suitability of the seed habitat. The activities of the power plant near Muara Cimandiri, domestic waste, and garbage that has accumulated at the end of the estuary are the cause of obstruction of the glass eel from entering the water.

Table 3. Fishermen perception of glass eel resources in Sukabumi Regency.

| No. | Objects                                      | Percentage (%) |
|-----|----------------------------------------------|----------------|
| 1   | Climate changes                              | 60             |
| 2   | Overfishing                                  | 23             |
| 3   | Other activity disruption around the river   | 17             |

Processed data of 2020.

The formation of the organization and participation of fishermen are expected to have a positive impact on the sustainability of glass eel resources. The form of participation of glass eel fishermen in the implementation of management and support for the sustainability by being involved in community groups that are also formed by the Sukabumi Regency Marine and Fisheries Services or called Pokmaswas in Bahasa acronyms. In the Pokmaswas group, fishermen are involved with estuary restoration activities by planting mangroves and monitoring activities that can damage fish habitats. Respondents who are involved in the community are automatically aware by choosing to release glass eel when the seeds are in high abundance. The selling price of glass eels makes it cheaper for collectors to buy because of the inability to accommodate them in temporary ponds before they are sent to cultivation.

As shown in table 4, the fishermen behavior that observed being grouped in two factors which are biodiversity conservation, and flexibility and adaptability. Fishermen who depend on catching glass eels and other fish show an adaptive attitude by modifying their fishing gear to increase the chances of catching seeds and other fish. Meanwhile, as many as 90% of fishermen switch to other jobs to fulfill their daily needs. The fishermen switch to other jobs by selling, gardening and farming, some also become construction workers while not carrying out fishing activities.

Table 4. The involvement of fishermen in changes in glass eel abundance.

| No. | Objects                                      | Percentage (%) |
|-----|----------------------------------------------|----------------|
| 1   | Biodiversity conservation                    |                |
|     | Keep on catching glass eel                    | 87.50          |
|     | Released back glass eel to nature            | 12.50          |
| 3   | Flexibility and adaptability                 |                |
|     | Divert to another activity                   | 83.33          |
|     | Modify fishing gear                          | 16.67          |

Processed data of 2020.

3.4. Correlation between socio-economic characteristics and fishermen perceptions
The value of the correlation coefficient using the Rank Spearman statistical test on the variables that show internal characteristics such as age, education, and income variables have a positive correlation with fishermen's perceptions of the availability of eel. Meanwhile, the experience variable has a negative relationship with fishermen's perceptions as shown in Table 5 below. According to table 5, the age
variable with a coefficient value of 0.66 has a real influence on fishermen's perceptions. This is because the workforce who become fishermen are mostly from the older age group which allows an understanding of the trend of catches to influence perceptions of involvement in the sustainable use and management of eel fisheries.

Table 5. The correlation value between individual characteristics and fishermen perceptions.

| No. | Characteristics | Correlation value (ρ)* |
|-----|----------------|------------------------|
| 1   | Age            | 0.66                   |
| 2   | Education      | 0.06                   |
| 3   | Income         | 0.21                   |
| 4   | Experience     | -0.02                  |

Processed data of 2020.

*Note: The significance test at the 5% level was carried out by comparing the value of ρ (rho) calculated with the ρ table (0.364). Correlation values > ρ table shows significantly different values.

4. Conclusion

Fishermen’s characteristics that observed mostly in the average age (range 41-59 years) with the latest education at the primary school. In Cikaso estuary, fishermen developed the traps in addition lift net and scoop net as fishing gear, while in Cimandiri estuary is restricted to lift net. Fishermen's perception assumes that the cause of the decline in glass eel catch is due to climate changes. So that fishermen chooses to continue catching glass eels instead of releasing them back into the wild to increase their income. While in Cimandiri, a community watching group (pokmaswas) has been established as a community participatory in coastal ecosystem protection. Furthermore, the correlation value between socio-economic characteristics and fishermen perceptions influence by age.

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