

Fish catches diversity of the glass eel fishery in Cikaso and Cimandiri estuaries, Sukabumi, Indonesia

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Abstract. Cikaso and Cimandiri estuaries are well known as the central area of glass eel fisheries in Sukabumi Regency. Local fishermen catch glass eels using two main fishing gears, namely traps and lift nets. Although both fishing gears' target operation is glass eels, many other fish species are also caught as bycatch. The present study aimed to identify glass eels and bycatch ichthyofauna in glass eel fisheries of the Cikaso and Cimandiri estuaries, Sukabumi. The research was carried out monthly from November 2020 to January 2021. Glass eels fishing gears collected a total of 21 fish species belonging to 15 families in both estuaries. According to the percentage ano-dorsal length measurement to total length (AD/TL), 3 species of glass eel were identified, i.e. *Anguilla bicolor bicolor*, *A. nebulosa*, and *A. marmorata*. These three species were the most abundant fish catches in both estuaries. More than 18 bycatch ichthyofauna were recorded and most of them are economically important fish, such as Ambassidae, Eleotridae, Engraulidae, Gobiidae, and Polinemidae. To sustain fishery management, the recording bycatch from glass eel fishery in the Cikaso and Cimandiri estuaries is necessary to be done regularly because they contribute to fishing mortality.

1 Introduction

The glass eels capture fishery business has been operated since the early 20th century in the world and was initiated in Indonesia in mid-1995 [1,2]. The glass eels capture fishery business aims to obtain a supply of seeds for eel aquaculture activities [3]. The high market demand for eel commodities from year to year is a positive opportunity for glass eel fishery activities, especially in Indonesia [4].

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Cikaso and Cimandiri estuaries are the main area of glass eel fisheries in Sukabumi Regency, Indonesia, which has a very high potential for glass eels capture fisheries [5]. Local fishermen in these two areas generally use two main fishing gears, namely traps and lift nets, to carry out glass eels fishing operations. Although both of these fishing gears target glass eels as their main catch, various other types of fish are also caught as bycatch. Until now, the recording and reporting of catches are still focused on glass eels as the main catch. The other bycatch has not been correctly recorded and reported [6,7].

Recording and reporting of catches is a very fundamental part of sustainable fisheries resource management activities. Good data collection is essential for further studies in determining the direction of fisheries management policies [8,9]. For example, collecting data on catches is needed in estimating the dynamics of stock availability of each fishery commodity from time to time [3,8,10]. The absence of recording and reporting of complete catch data is the first obstacle faced in sustainably managing glass eel fishery in the Cikaso and Cimandiri estuaries, Sukabumi, Indonesia. Therefore, this study described the catches composition and production of glass eel fisheries using both lift net and traps in the Cikaso and Cimandiri estuaries.

2 Materials and methods

2.1 Research time and locations

The research began with the observation and preliminary studies in September and October 2020. The initial stage was conducted to collect all factual information on the condition of the glass eel fishery in the two research areas. The operation of fishing gear and recording of catches were executed monthly from November 2020 to January 2021. The operation of fishing gear was performed on the 23rd of the lunar time.

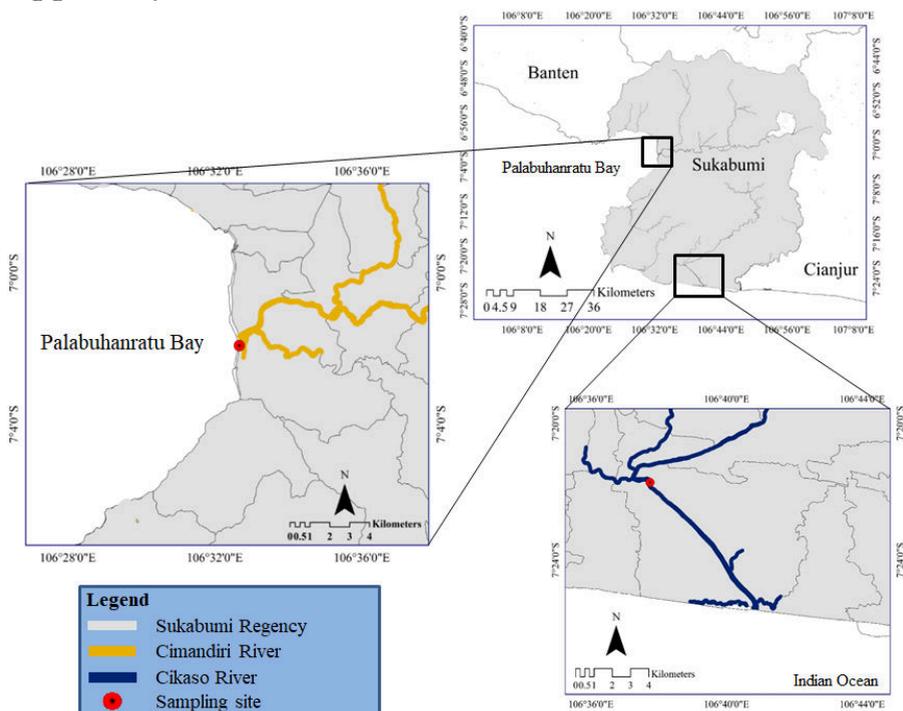


Fig. 1. Research locations of operating glass eel fishing gear in the Cikaso and Cimandiri estuaries, Sukabumi, Indonesia

The operation of fishing gear was performed in two bodies of water, namely the Cikaso and Cimandiri estuaries. The specific location of the operation of the fishing gear was based on the center of the fishing location, which local fishermen commonly do in both river estuaries. The center for catching glass eels in the Cikaso estuary is closer to the river with a slight tidal influence ($7^{\circ}21'37''$ S $106^{\circ}37'32''$ E). In contrast, the center for catching glass eels in the Cimandiri estuary is located right at the river mouth ($7^{\circ}01'42''$ S $106^{\circ}32'36''$ E) (Fig. 1).

2.2 Operation of fishing gear and preservation of catch

Trap and lift net fishing gears were operated for 3 hours of fishing duration at nighttime during the tide occurs. Local fishermen in two research areas also capture glass eels at high tide at nighttime. Glass eels enter the river mouth and move upstream into the river using the tidal flux [11,12].

The catches obtained were then preserved in a 10% formalin solution for 3 hours of immersion. After that, specimens were washed with flowing water and preserved in 80% ethanol solution [13,14]. This process was done to maintain fish color pattern (melanophore), one of the main characteristics of the morphological identification process.

2.3 Identification and recording of catches

Fish specimens were separated into the main catch group (glass eels) and bycatch fishes. Identification of glass eels was conducted based on the percentage of the ano-dorsal length to the total length ratio [15,16]. The identification of glass eels can be seen in Figure 2. Identification of bycatch fishes was accomplished using several fish identification books [17,18,19]. All fishes were then measured for their biomass and recorded. Biomass data were used to analyze productivity and catch composition of the two fishing gears at the two research sites.

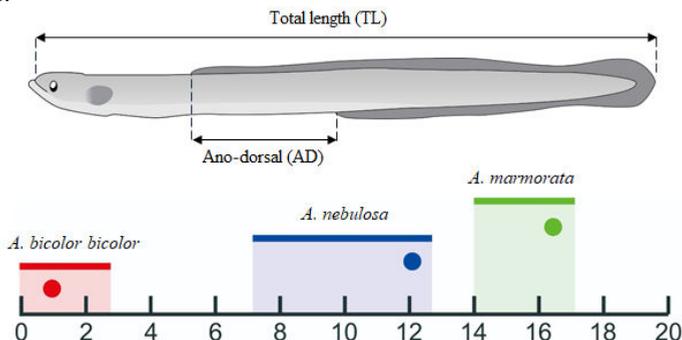


Fig. 2. Identification of glass eel morphology based on the percentage of ano-dorsal length to total length ratio.

2.4 Data analysis

2.4.1 Descriptive analysis of both fishing gears

Descriptive analysis was conducted to describe the construction of trap and lift net fishing gear along with its operating procedures. Descriptions of fishing gear's construction and operating procedures can provide a complex picture for the reader about the appearance of the two fishing gears and an overview of the operational process. This information can also offer various reasons regarding the production and compositional structure of the catch obtained in the study. Descriptions of the construction and operating procedures of the two fishing gears are known based on direct observations during research activities.

2.4.2 Catch production

Catch production is calculated based on the Catch per Unit Effort (CPUE) formula. The catch-sharing unit (C) is fish biomass (grams), and the effort unit (f) is the duration of operation of fishing gear (3 hours). The production of the catch is calculated by the following formula [20]:

$$\left[\text{CPUE} = \frac{C}{f} \right]$$

2.4.3 Catch composition

The catch production data is used in calculating the catch composition. Analysis of catch composition was used to see the percentage of catch structure on the trap and lift net fishing gears in two research areas. The catch composition is calculated using a simple proportion function as follows [21]:

$$\left[\text{Catch composition (\%)} = \frac{b_i}{B} \times 100\% \right]$$

B_i is the biomass for type- i fish species, and B is the total biomass of all fish caught. Composition analysis was calculated for each structure of the main catch and bycatch of the two fishing gears in each study area.

3 Result and discussion

3.1 Result

3.1.1 Fishing gears description

There are striking differences in the construction and operating procedures of the two fishing gears. The construction characteristics and operating procedures of fishing gear are the main characteristics that distinguish it from other fishing gears [6,22,23]. The construction of the two fishing gears can be seen in Figure 3.

The construction of the lift net fishing gear consists of 4 bamboo slats with a length of 170 cm, each connected by a sheet of the fine net with a mesh size of 0.2 to 0.48 mm. A lift net as fishing gear for glass eels is generally operated at night with the help of a headlamp. The light beam from the spotlight becomes an attractor that can collect glass eels in the catchable area of the lift net fishing gear [24,25]. A fisherman operates a lift net on the water's edge.

In its operation, lift net fishing gear is applied to a certain depth with an orientation towards the sea and forming an angle of 45° to the water surface. The net is lifted shortly

after some of the water mass passes through the net to check the caught fish. The operating procedure is carried out repeatedly during the tide at night, which is a potential time for catching glass eels.

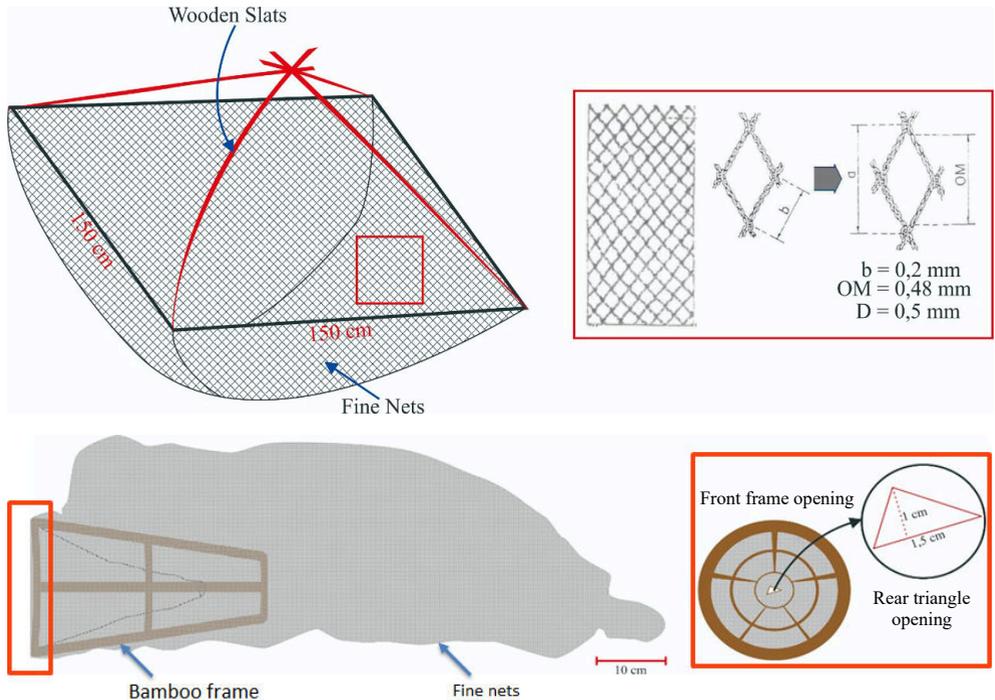


Fig. 3. Construction of lift net (A) and trap (B) fishing gears.

The construction of the trap consists of a tubular bamboo frame on the front as a support for the trap mouth opening. The bamboo frame is covered by a fine net that acts as a bag. The mouth opening of the trap consists of two levels: the front opening of the bamboo frame in the form of a circle with an 11 cm diameter and the rear mouth opening in the form of a triangle with an area of $\pm 0.75 \text{ cm}^2$. The traps are operated in shallow water areas with rocky bottom substrates. The trap is applied to rock crevices with the trap's mouth oriented toward the river's flow. The trap mouth opening is surrounded by dry grass to camouflage the fishing gear and concentrate the movement direction of the fish target to enter the trap mouth.

Traps can only be found in the Cikaso river estuary, characterized by rocky and sandy substrate. No any trap was used in the Cimandiri estuary because the fine sandy substrate characterizes this estuary. The trap is not suitable to be operated in the Cimandiri estuary. The operation of the lift net and trap fishing gear are presented in Figure 4.



Fig. 4. Documentation of the operation of the lift net (A) and trap (B) fishing gear

3.1.2 Catch production

The glass eels from the Cimandiri estuary were identified to species level by measuring the percentage of ano-dorsal to total length ratio, namely *Anguilla bicolor bicolor*, *A. nebulosa*, and *A. marmorata*. In addition, as many as 12 species of bycatch were identified and 9 species have an important economic value. The calculation of catch per unit effort (CPUE) showed that *A. bicolor bicolor* occupied the highest catch production.

Three species of glass eels were also identified as the main catches from the trap and lift net fishing gears in the Cikaso estuary. A total of 11 species of bycatch were also identified, of which 9 species were known as economically important fish species. *A. bicolor bicolor* was also the catch with the highest production per unit of effort using both fishing gears. A list of fish species caught in the glass eel fishery in the Cikaso and Cimandiri estuary can be seen in Table 1, meanwhile, the graph of glass eel production and bycatch fishes are shown in Figure 5.

Table 1. List of fish species caught in the glass eel fishery at Cikaso and Cimandiri estuary

Group of catches	Families	Local Name	Scientific name	Cimandiri	Cikaso		Important Economic Value
				Lift net	Lift net	Traps	
Main target	Anguillidae	Glass eels	<i>Anguilla bicolor bicolor</i>	√	√	√	√
			<i>Anguilla nebulosa</i>	√	√	√	√
			<i>Anguilla marmorata</i>	√	√	√	√
Bycatch	Gobiidae	Bobosoh	<i>Glossogobius giuris</i>		√	√	√
		Menga	<i>Sicyopterus sp.</i>	√			√
	Eleotridae	Belosoh	<i>Eleotris melanosoma</i>	√	√	√	√
		Nyereh	<i>Eleotris fusca</i>	√	√	√	√
		Keleng	<i>Butis butis</i>		√	√	√
		Penja/payangka	<i>Giuris margaritaceus</i>		√	√	√
	Mugilidae	Kada	<i>Osteomugil cunnesius</i>	√	√	√	√
	Syngnathidae	Tangkur buaya	<i>Microphis brachyurus</i>	√	√	√	√
	Terapontidae	Kerong-kerong	<i>Terapon jarbua</i>	√			
	Ambassidae	Seriding	<i>Ambassis vachellii</i>	√			√
	Engraulidae	Bulu ayam	<i>Thryssa setirostris</i>	√			√
	Megalopidae	Bulan-bulan	<i>Megalops cyprinoides</i>	√	√	√	√
	Polynemidae	Lajan/kuro	<i>Eleutheronema tetradactylum</i>	√			√
	Poeciliidae	Cere	<i>Gambusia affinis</i>	√			
	Kuhliidae	Gadidi	<i>Kuhlia marginata</i>		√	√	√
	Tetraogonidae	Goblin	<i>Neovespicula depressifrons</i>		√	√	
Tetraodontidae	Buntal bintik hijau	<i>Dichotomyctere nigroviridis</i>		√	√		
Callionymidae	Kengkel	<i>Callionymus sagitta</i>	√				

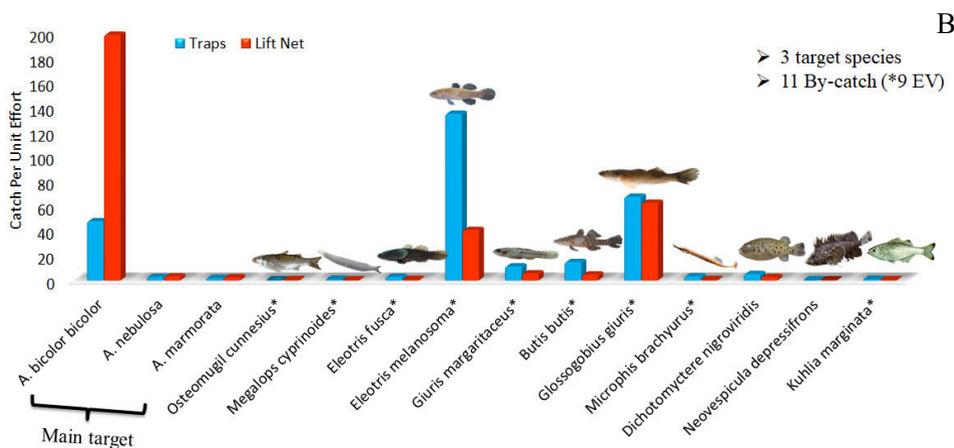
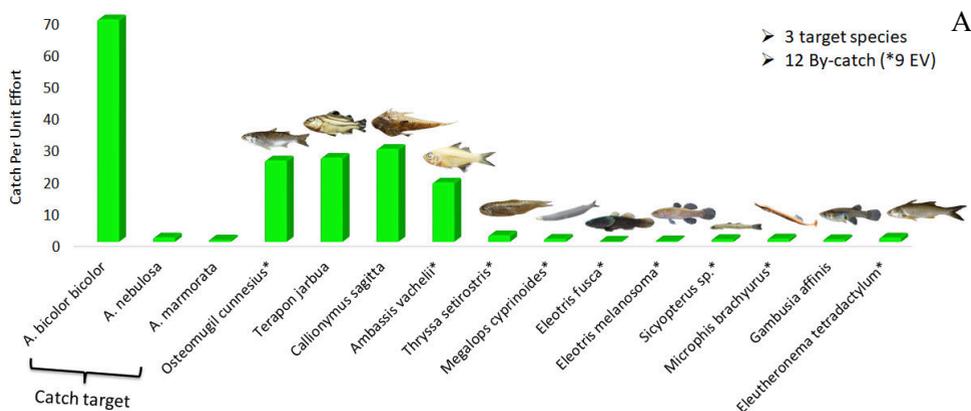


Fig. 5. Catch production of glass eel fishery on Cimandiri (A) and Cikaso (B) estuaries (CPUE mean the number of fish production per 3 hours of fishing gear operated duration).

3.1.3 Catch composition

The catch composition using lift net in the Cimandiri estuary showed that bycatch fishes occupied the highest catches with 62% of total catches. The highest bycatch was *Callionymus sagitta*, followed by *Terapon jarbua*, *Osteomugil cumnesius*, and *Ambassis vachelii*. Meanwhile, there was a difference in the proportion of catches on lift net and traps in the Cikaso estuary. In trap fishing gear, the proportion of bycatch was higher with 82% of total catches and dominated by species from the families of Eleotridae and Gobiidae. As for lift net fishing gear was higher for the glass eel as the main catch for lift net fishing gear. The graph of the composition of catches in the two research areas is presented in Figure 6.

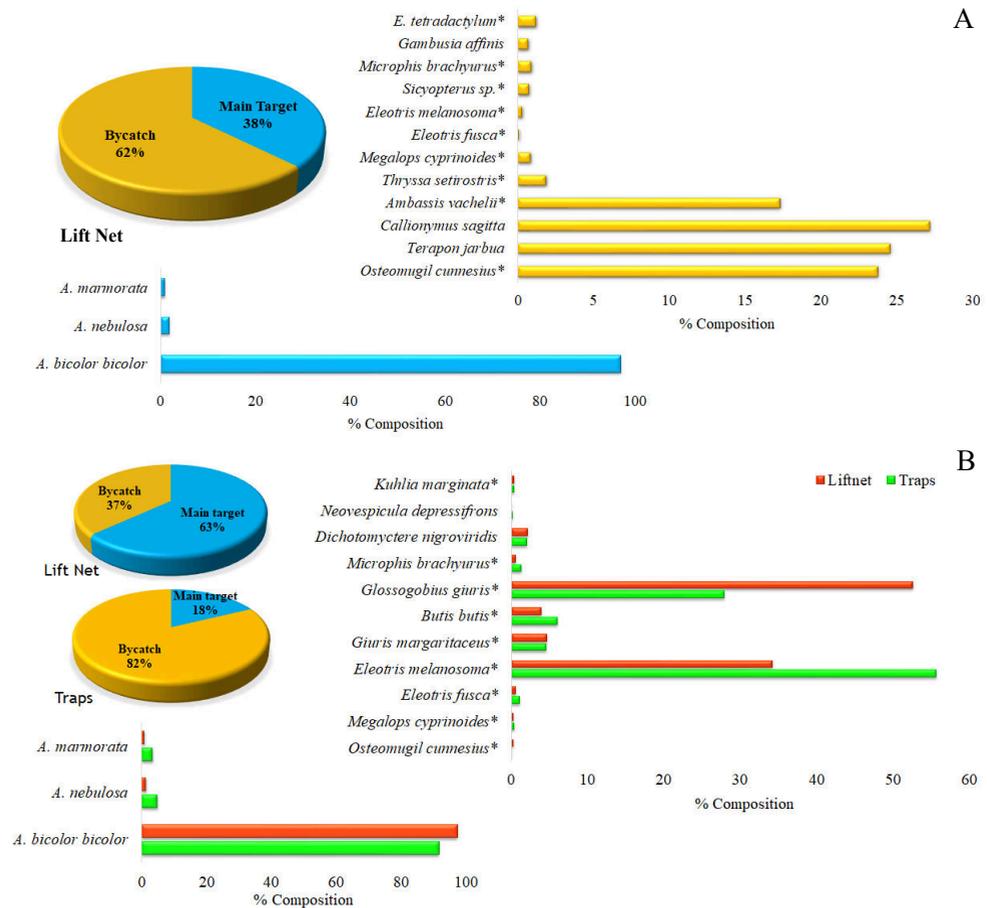


Fig. 6. Catch composition in the Cimandiri (A) dan Cikaso (B) estuaries.

3.2 Discussion

Glass eel fishing activities in the Cikaso and Cimandiri estuaries are generally carried out between the 20-27th of the lunar calendar. At that time, there is a dark moon phase where the light rays reflected by the moon tend to thin out. In addition, during the dark moon phase, the highest tides tend to occur. Glass eels use tidal flux to migrate into freshwater areas of the river. The thinning moonlight allows the glass eels to hide the sight of predators

during their night migration. Meanwhile, the highest tidal energy of seawater is utilized by glass eels to move upstream into freshwater areas through river mouths [26-28].

Glass eels of the *A. bicolor bicolor* species are the most commonly caught commodity species from the two fishing gears in the Cikaso and Cimandiri estuaries. This phenomenon is related to the population of *A. bicolor bicolor* in nature. The population of *A. bicolor bicolor* along the southern coast of Java Island is higher than that of its two close relatives. The high population in nature will increase the chances of being caught. Therefore, *A. bicolor bicolor* has the highest rank of glass eel catches in Cikaso and Cimandiri estuaries [29-31].

There are differences in the composition of the catch from the two fishing gears used in the Cikaso estuary. The difference in the catch composition of trap and lift nets in the Cikaso estuary may be caused by the technical differences in the operation of the two fishing gears. The traps are operated in rock crevices which are shelters for various other types of fish. This results in a relatively high chance of catching others bycatch [6, 32-37]. This reason can explain the high proportion of bycatch on traps in the Cikaso estuary.

For example, trap fishing gear generally obtains bycatch which is dominated by Gobiidae (goby) and Eleotridae (sleeper). Both fish families are freshwater fish and generally make nests in rock crevices. The nest is used for shelter and laying eggs. The operation of traps in the rock crevice area, which is also a nest of these two species, will certainly increase the possibility of capturing goby and sleeper as bycatch [38-40].

Meanwhile, lift net fishing gear has generally operated on the water's edge by using lights. Not all types of fish have properties that tend to be captivated by beams of light. Glass eels have positive phototaxis properties to light beams with low intensity and negative phototaxis to light beams with too high intensity [41-43]. This explains that the composition of the catch of glass eels is more dominant in the lifting net fishing gear, which is supported by the light attractor from the headlamp used by fishermen.

Based on the technical operation of fishing gear supported by bycatch data, lift nets are more selective fishing gear in carrying out glass eels catching operations. For this reason, lift net has always been the main choice of fishing gear for local fishermen in catches glass eels catching operations. The minimum bycatch from fishing gear can also make it easier for fishermen to sort their catch [24,44-46].

Until now, reporting on catches in glass eel fisheries is still focused on glass eels as the main catch target. In fact, various other fish species are also caught as bycatch and have not been adequately reported. Thus, it needs to get more serious attention. In the concept of sustainable fisheries management, data collection and reporting of catches is necessary. All catches have to be reported to be used as a database for monitoring the dynamics of changes in the stock of each fishery commodity from time to time [3, 8-10, 45, 47]. In addition, the fact that every fish caught will contribute to the rate of population mortality due to fishing activities is a reason to reinforce the importance of recording and reporting bycatch [3, 8-10, 48-50].

4 Conclusion

A total of 22 fish species from 15 families were identified as captured by glass eels in the Cikaso and Cimandiri estuaries. There are 3 species of glass eels identified i.e *Anguilla bicolor bicolor*, *A. nebulosa*, and *A. marmorata*. 18 bycatch ichthyofauna were recorded which were fish species of important economic value, such as Ambassidae, Eleotridae, Engraulidae, Gobi, and Polinemidae. The existence of bycatch in glass eels fishery activities encourages the need to improve the recording of catches.

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