

Western Region of Indonesia: the Nucleus of Anguillid Eel Fisheries and Trade

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Recent statistical information indicates that Indonesia embraces a huge resource of anguillid eels in its western region, especially the areas in Sumatra Island and Java that face the Indian Ocean. There are a number of anguillid eel species in Indonesia, nine of which are the most common, *i.e.* *Anguilla bicolor bicolor*, *Anguilla bicolor pacifica*, *Anguilla nebulosa nebulosa*, *Anguilla marmorata*, *Anguilla celebesensis*, *Anguilla borneensis*, *Anguilla interioris*, *Anguilla obscura*, and *Anguilla megastoma*. The anguillid resources of Indonesia are being exploited mostly by small-scale fishers who are mostly temporary fishers, fishing eels from evening to midnight and doing other jobs in the morning until noon. Anguillid eels are traded as glass eels or yellow eels where they have high potentials for export to the regional market. The demand of eel products in Indonesia is still low as it is not a food preferred by the local people, although processed eel products are now being developed and promoted in the country. In order to sustain the fisheries and management of the anguillid eel resources, it is deemed necessary that capacity building is promoted for the sustainable capture fisheries and aquaculture of anguillid eels, advocacies initiated for the conservation of the eel resources, and human resource enhanced in product processing and development, and marketing of anguillid eels.

Presently, 19 species and sub-species of anguillid eels are found in the world (Castle & Williamson, 1974; Watanabe *et al.*, 2009), having wide global distribution from the tropical to subarctic zones. Although they do not occur along the west coasts of the North and South American continents, the west coast of Africa, and the east coast of South America, they are mostly found in the northern coasts along the Caribbean Sea (Kuroki & Tsukamoto, 2012) and in tropical waters, *e.g.* Indian Ocean. The Western Region of Indonesia that faces the Indian Ocean is one of the areas abundantly inhabited by anguillid eels.

Anguillid eel is a unique species of high economic importance, and is an important food for its nutritional value. Anguillid eel is a catadromous species that essentially lives in freshwater habitats during their growth stages but breeds in an oceanic environment (Muthmainnah *et al.*, 2019). Starting from eggs in the ocean, eels migrate to the shore as larvae (leptocephali) where they metamorphose into juveniles called “glass eels” and go up to the mouth of rivers where capture fisheries usually start. However, capture activity is not done every day, as glass eels are usually sold at high prices to big fish farm operators where they are cultured and the products are exported to foreign markets such as in Japan, South Korea,

and China. Those not caught as glass eels go further up the river systems and are called “elvers” (with pigmentation), then spend several years in freshwater environment as “yellow eel.” Mature and ready to spawn, the eels (called “silver eel”) swim downstream and head to the ocean to spawn (Muthmainnah *et al.*, 2016). However, information on the life history of anguillid eel, especially its reproduction is still completely limited (Kuroki & Tsukamoto, 2012), making this fish an interesting subject for research study, and for establishing the ways and means towards its sustainability.

Anguillid eel resources in the Western Region of Indonesia

Indonesia is an archipelagic country with huge anguillid eel resource, which is highly distributed in the western region of Sumatra Island (mainly in Bengkulu and Lampung) and Java Island (in Pelabuhan Ratu of West Java and in Central Java), as well as in Sulawesi Island, Mahakam River of Kalimantan Island, Maluku Island, and Papua Island. Sugeha *et al.* (2008) indicated that there are nine species found in 15 rivers of Indonesia, and identified as *Anguilla bicolor bicolor*, *Anguilla bicolor pacifica*, *Anguilla nebulosa nebulosa*, *Anguilla marmorata*, *Anguilla celebesensis*, *Anguilla borneensis*, *Anguilla interioris*, *Anguilla obscura* and *Anguilla megastoma* (**Figure 1**).

In his study, Aoyama (2009) dubbed Indonesia as the central area of anguillid eel diversity, where *Anguilla marmorata* is the eel species that is widely spread in the provinces that face the Indian Ocean (Matsui *et al.*, 1970). Studies about anguillid eels in the Southeast Asian region are limited compared to the extensive studies on temperate eels conducted in Europe, United States, and Japan, making it necessary to carry out relevant studies in the region, especially in Indonesia. Thus, the Inland Fishery Resources Development and Management Department (IFRDMD) of the Southeast Asian Fisheries Development Center (SEAFDEC) based in Palembang, Indonesia in collaboration with the Research Institute for Inland Fisheries and Extension of the Marine Affairs and Fisheries Ministry of Indonesia, carried out the survey of anguillid eel resources in mouth of rivers and rivers of the western region of Indonesia facing the Indian Ocean, *i.e.* in the Provinces of Bengkulu, Lampung, West Java, and Central Java (**Figure 1**). During the survey, information were compiled on the fisheries of glass eels in the mouth of Cimandiri River (West Java Province); elver and yellow eel fisheries in Cimandiri River, and in the rivers in Bengkulu Province (*i.e.*



Figure 1. Map of Indonesia (left); and anguillid eel species that inhabit Sumatra Island, and West and Central Java (right) (modified from Sugeha *et al.* (2008))

Jenggalu, Kungkai and Manna Rivers), in Lampung Province (*i.e.* Muara Kelapai and Way Ngaras River) and in Central Java (*i.e.* Serayu River and its tributaries).

Anguillid eel capture fisheries in Western Region of Indonesia

Anguilla bicolor bicolor and *Anguilla marmorata* are the most abundant anguillid eel species in Indonesia, one of the biggest eel producers in the world. In fact, anguillid eel capture fisheries and farm culture activities are more active in Indonesia than in any other Southeast Asian countries (Suryati *et al.*, 2019). The eel capture fisheries in Indonesia are carried out by small-scale fishers. Records have shown that some companies from Japan import anguillid eels from Indonesia to meet their requirements for eel in their menus considering that the current production of temperate eels has been declining. This makes the tropical anguillid eels becoming more important in the global market (Muthmainnah, *et al.*, 2016). Findings from the baseline survey have shown that in 2017, the estimated production from capture fisheries for glass eel and yellow eel (or young eel) for *Anguilla bicolor* (including *A. bicolor bicolor*, *A. bicolor pacifica*) and *Anguilla marmorata* has remained at around 10 t in recent years for glass eels, and less than 80 t for elvers and yellow eels.

Glass eel capture fisheries

In Indonesia, glass eel capture activity is only practiced in Pelabuhan Ratu Sub-district in West Java Province. The capture activity is carried out from evening to midnight. Capture fisheries of glass eels are usually carried out with the presence of collectors who also serve as distributors for the aquaculture industry. The glass eels are mainly caught from the river mouths between September and December using scoop net (Figure 2). The glass eels usually come in groups of multi-species (Aoyama, 2009).

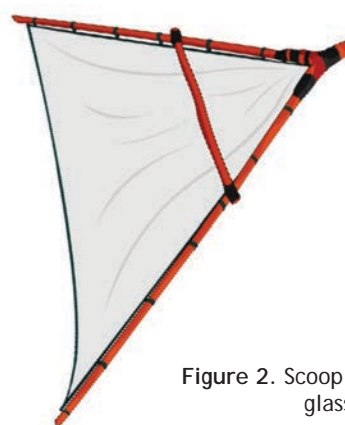


Figure 2. Scoop net for capturing glass eels

Elvers and yellow eel capture fisheries

Cilacap in Central Java Province is an important and one of the largest yellow eel fishing grounds in Indonesia. Most of the elvers and yellow eels cultured in eel farms in Indonesia are supplied from the fishing areas in Cilacap. The fishers catch the elvers and yellow eels (Figure 3) from the river mouth, pools, paddy fields, and swamp areas from October to November, using trap and scoop net or what is also known as the PVC trap (Figure 4).



Figure 3. Yellow eel captured from Central Java Province

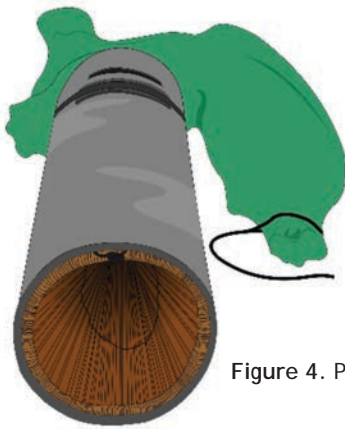


Figure 4. PVC trap for capturing elvers and yellow eel

Moreover, eel capture fisheries in Bengkulu Province in Sumatra Island (**Figure 1**) make use also of the PVC trap to capture the yellow eels from the middle basins of rivers and swamps. They do not scoop the glass eel at the river mouth. In Bengkulu Province, Suryati *et al.* (2018) found two species of anguillid eels, these were *A. bicolor bicolor* and *A. marmorata*.

The biggest potential of eel fisheries is in the area along the western part of West Coast Regency (Muara Kelapai and Way Ngaras River) in Lampung Province (Sumatra Island). Muara Kelapai was identified as the location where *Anguilla bicolor bicolor* are captured while in Way Ngaras River, *Anguilla marmorata* could be captured. Most fishers do not prefer to catch the elvers, while eel collectors receive the eel juveniles or yellow eel from fishers to be sent to rearing ponds in West Java (**Figure 5**).



Figure 5. Yellow eels captured from West Java

The fishing gear used to capture the elvers and yellow eel is the fishing line without hook (**Figure 6**), trap, and fyke-net (**Figure 7**). Eels captured from the West Coast Regency of Lampung Province (**Figure 8**), are transported to Bengkulu and Jakarta, although the data on eel traffic in Lampung Province could not be obtained. Based on interviews with local fishers and collectors, the fishing activity is carried out around swamps surrounding the rice fields. Usually, the elvers are captured during the floods, high tide, or rainy season. In one week, the local fishers could catch approximately one quintal (equivalent to 100 kg) of elvers per week, which



Figure 6. Fishing line without hook for capturing elvers and yellow eels

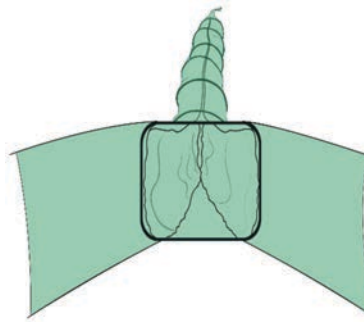


Figure 7. Fyke net for capturing elvers and yellow eels



Figure 8. Elvers captured from Lampung Province, Sumatra

are then transferred to the collectors. Every two weeks, the collectors will send the elvers to buyers in Jakarta. In Cilacap District, intensive fishing activities for elvers have become the primary source of fishers' income. The catch is bought by collectors and sent to various districts and cities in Java.

Utilization of anguillid eels

In 2017, the recorded eel production of Southeast Asia comes from Indonesia and the Philippines. Indonesia reported its production at 4,407 t valued at USD 16.3 million while the Philippines produced 1,718 t valued at USD 4.1 million. It should be noted that most Indonesians do not like to eat eels, and as a result the demand for eels in the country is still low. In the Southeast Asian region in general, many people prefer to eat other fishes but not the anguillid eels may be because of its appearance which is like a snake. However, in Viet Nam about 50 % of its eel production is consumed by the local people (Suryati *et al.*, 2019).

Thus, most of the eels produced in the region are bound for the export market. Domestically, eels are not yet widely known as a nutritious food fish notwithstanding the market price that seems to be unaffordable by the local people. Nonetheless, eel products could be promoted in many processed forms and the prices reduced so that many people would patronize the products. Nowadays, efforts to introduce eel products to local communities in Indonesia are starting to take shape by producing processed food that is suited to the Indonesian taste, *e.g.* shredded eel meat, chips, and crackers, eel-sourced vitamin mixed with honey for children. Product development strives to change the look of anguillid eels in packaging to make sure that the food fish does not appear like a snake. This way, the Indonesians would be attracted to the processed food and increase their preference for consuming the anguillid eels. Recently, a good supply of *unagi kabayaki* can be found in big markets in Indonesia.

In addition, the development of simple culture method should be considered a priority way forward so that the market price of eels could be reduced. Currently, the prices of glass eels could be around IDR 1.0-3.0 million/kg glass eels or USD 70-250/kg, while the availability of glass eels depends on the catch from the wild which is correlated with the season and location. Moreover, the distance between the fishing area and collection of the glass eel to the center of aquaculture is quite far, so that mortality during transport is still high although this could be addressed by developing improved eel transport technology. While hatchery research for the production of eel seeds is still in progress, another concern is the price of feeds for the cultured eels which could be expensive at about USD 2.5-4.0/kg. This is because eels require high protein content feeds (40-50 %) and some components of feeds are still imported. To decrease the price, the use of high protein ingredients could be minimized while carbohydrates are maximized through the improvement of feed technology, culture medium, and eel health.

Marketing of anguillid eels

The price of glass eels actually depends on the demand, and for this reason it is important that coordination with collectors is done prior to the capture of glass eels to make sure that the catch is collected. Glass eel fishers are usually temporary fishers only from evening to midnight, when they become the man for catching the glass eel. Most of them have other jobs from morning to noon. Nonetheless, they get their fishing gears from collectors.

A major concern that affects small-scale fisheries is, in general, the poverty of fishers. This condition deprives them from having considerable access in utilizing the fishery resources. Fishers usually do not have sufficient catching ability to produce fish, because of the lack of capital for acquiring the necessary fishing gear. As a result, their catch is directly sold to

middlemen who have lent them some money or who provided them the fishing gear. In the Provinces of Bengkulu and Lampung, the middlemen are also the collectors, responsible for sending the eel catch to Java Island.

Eel farming could provide a solution to the unstable supply of eel products and create prospects for increasing income and sustainable livelihoods for fishers. The leading eel farming areas of Indonesia are on Java Island *i.e.* in Sukabumi and Banyuwangi Provinces. The companies operating the eel farms in these provinces export frozen fresh eel meat and frozen processed eel, *e.g.* *unagi kabayaki* (grilled eel). The value of the anguillid eel exported to Japan during the last four (4) years could easily average USD 2.3 million per year.

Sustainable management of anguillid eel resources

Regulations on the trading of eels are available in Indonesia, that the exportation of eels smaller than 150 grams is prohibited. However, considering the high price and demand for anguillid eels, a large quantity of the glass eels is traded without proper regulation and record in some cases. Measures should, therefore, be enforced to prevent the illegal trade and smuggling of glass eels, especially focusing on those persons that could be playing the role as exporters. Consequently, glass eel importing countries should also be made aware of the enforcement of such measures.

Anguillid eels are becoming much important food fish in the global market and the global demand for anguillid eels has been increasing. It is therefore necessary that the stakeholders are aware of the need to manage the anguillid eel resources for the sustainability of eel fisheries. It should also be considered that in the anguillid eel supply chain, gender issue plays an important role. Women are very much involved in the eel industry, acting as collectors. Specifically in the case of eel fisheries in Bengkulu and Cilacap, the women have been tapped to manage the financial aspects and bookkeeping as they were found to possess much better capabilities than the men.

The migratory nature of anguillid eels make them travel a long route from the deep ocean to freshwater rivers, not only in terms of distance but also in time. While migrating to the rivers, the anguillid eels could take a long time as they could encounter various obstacles/conditions that hinder their migration, *e.g.* fishing activities, cross-river obstacles, and habitat degradation. For maintaining the natural stocks, restocking could be considered, besides, restocking could also contribute to enhancing the awareness of stakeholders on the need to conserve the eel resources. For resource enhancement, closed season, *e.g.* for certain periods, should be established as it is more appropriate than closed areas, but this should be based on what is most appropriate in particular eel fishing areas.



Figure 9. Silver eel from Bengkulu Province, Sumatra

In initiating the launching of such measure, the Ministry of Marine Affairs and Fisheries, Indonesia restocked the anguillid eel resources of Serayu River, Wonosobo Regency in October 2018. Another activity was the restocking of eel seeds (fingerlings) by a watchers communal group. In Bengkulu, the collectors always remind the fishers to restore the silver eel resource (Figure 9).

Issues and constraints

Across the world, anguillid eels are important food and cultural resource (Kuroki *et al.*, 2014a), but their populations have drastically decreased worldwide over the past few decades. The International Union for Conservation of Nature (IUCN) evaluated 13 species of anguillid eels and categorized *A. anguilla* as a critically endangered species, *A. japonica* and *A. rostrata* as an endangered species, *A. borneensis* as a vulnerable species, and the remaining species as nearly threatened, least concern or data deficient species in the list (IUCN, 2019). After the IUCN evaluation, the endangered status of *Anguilla* species has become a frequently broadcasted topic by the mass media and, hence, common names have also been used frequently. In addition, the shortage of temperate eel resources induced new exploitation of tropical eels in temperate regions.

For the sustainability of the utilization and management of the anguillid resource, information on the status and trends of eel resources is very important. However, to date data on catch statistics on anguillid eels in the Southeast Asian region are still incomplete. Data collection should therefore be enhanced as it is the way of ensuring the sustainable utilization of tropical anguillid eels. While the data collection scheme for anguillid eel fisheries is still being developed, and considering that the anguillid eel resources are very dynamic, the most appropriate management program should be developed for keeping the sustainability in place. Policy makers could also initiate establishing suitable fisheries management policies for the benefit of the fishers as well as of the anguillid eel resources. One promising solution for sustainable small-scale fisheries could be for the government to support the fishing gears and advocate the necessary catch management system as well as the prospect of providing capital grants. This could contribute to efforts of increasing the eel stock either by allowing natural recruitment or by aquaculture.

Way Forward

Capture fisheries development could be enhanced by providing assistance to fishers in terms of eel fishing gear. Advocacy on the use of environment-friendly fishing gear should be intensified, as well as other schemes such as socializing fishing methods and proper handling of seeds (glass eels) after capture. Collection of capture fisheries statistics should also be improved for the sustainability of the eel fisheries.

Aquaculture development can be promoted by developing some pilot cultivation of eels (glass eels to elvers, and elvers to consumption size), improving the technical guidance and training on eel cultivation, training on processing eel feeds, and providing the facilities and infrastructure of eel cultivation (seeds, feed, permanent ponds, plastic ponds). Traceability of the produce should be assured which could include the need to obtain aquaculture certification, while collaboration on eel cultivation research and improvement of the statistical collection systems for aquaculture statistics should be enhanced.

Conservation could be promoted by releasing glass eels or cultured juveniles into inland waters, identifying the important eel habitats, and maintaining the eel habitats (from sedimentation, wastewater, and constructing water fishways). Furthermore, product processing and marketing could be enhanced through training and human resource development while business development could include eel product development and credit.

Acknowledgement

This research was funded by the Japan Trust Fund VI through SEAFDEC/IFRDMD of 2015-2019 and the Research Institute for Inland Fisheries under National Annual Research Budget of 2015-2016 fiscal year, of which we are very grateful. We also thank the members of the research team for their cooperation and support, and especially to *Dr. Satoshi Honda* (Deputy Chief of SEAFDEC/IFRDMD from January 2015 to September 2017) and *Dr. Takuro Shibuno* (Deputy Chief of SEAFDEC/IFRDMD from January 2018 to March 2020). The authors also acknowledge the assistance of *Ms. Diana Luspa* in proofreading this article. The authors, *Dina Muthmainnah* and *Ni Komang Suryati* are the main contributors of this article.

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