Understanding the Current Status of Anguillid Eel Fisheries in Southeast Asia

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Anguillid eels are economically-important species because of their good nutritional value and are utilized for the peculiar food culture in East Asian countries. However, due to its high rate of utilization, eel stocks have dramatically decreased worldwide. Research surveys were conducted to understand the current features of the Anguillid eel resources and their fisheries in the Southeast Asian region. Considering that these catadromous eels are produced mainly in three ASEAN Member States, the survey was carried out by direct observation of fishing activities in 2015 and 2016 in the inland waters of three countries, namely: Indonesia (Bengkulu Province, Palabuhan Ratu Regency and Cilacap Regency), Philippines (Aparri River, Cagayan Province), and Myanmar (Yangon and Mandalay). Results of the survey indicated that in each location, there is one kind of gear used for eel collection, such as Bubu, and pole and line without hook in Bengkulu and Cilacap; scoop net in Palabuhan Ratu; fyke net in Aparri River; and eel bamboo trap in Yangon and Mandalay. In addition, it is only in Palabuhan Ratu where the people catch glass eels, while in the other places, people tend to catch the yellow eel. Moreover, eel farms producing unagi kabayaki (processed/semi-processed eels) are only found in Indonesia where production is shipped to eel markets overseas. Regulations on trading of eels are in place in these three countries, *e.g.* exportation of eels smaller than 150 grams is prohibited in Indonesia, smaller than 15 cm in length in the Philippines, and closed season for capturing eels in Myanmar. However, information on the status of eel fisheries in the Southeast Asian region would be quite difficult to compile unless the system of collecting eel data and statistics is improved.

Anguillid eels (*Anguilla* spp: Anguillidae) are commercially popular as important food because of their good nutritional value with protein and fat contents, and its utilization in peculiar food culture of East Asian countries. Eels are also well known for their unique catadromous life history, breeding far from offshore after migrating thousands of kilometers from their growth habitats in freshwater and estuaries to their spawning areas in oceanic waters (**Fig. 1**). Catadromous eels start their lives in the ocean and migrate to the shore as larvae (leptocephali) that metamorphose into juveniles called "glass eels" and go up rivers with pigmentation (called "elvers") then spend several years in freshwater environment as "yellow eel."

Mature and ready to spawn, the Anguillid eels (called "silver eel") swim downstream and head to the spawning ground in the ocean, and after spawning they die. Unlike that of the other freshwater fishes, the morphology of Anguillid eels (yellow eel) displays a long cylindrical shape and continuous dorsal, caudal and anal fins, and they have pectoral fins but no pelvic fins. Anguillid eels are distributed throughout tropical and temperate waters, except for the Eastern Pacific and South Atlantic (Silfvergrip, 2009 in Crook & Nakamura, 2013). So far, most of the investigations on eels had been focused on the temperate species, in the northern hemisphere, such as *Anguilla japonica*, *A. anguilla* and *A. rostrata*. Based on results of recent studies on eels, there are at least 19 Anguillid eel species inhabiting the world's inland waters. These include: *A. ancentralis*, *A. anguilla*, *A. australis australis*, *A. asustralis schmidtii*, *A. borneensis*, *A. celebesensis*, *A. bicolor bicolor*, *A. bicolor pacifica*, *A. dieffenbachia*, *A. interioris*, *A. japonica*, *A. tominiensis*, *A. marmorata*, *A. megastoma*, *A. nebulosa nebulosa*, *A. nebulosa labiata*, *A. obscura*, *A. reinhardtii*, and *A. rostrata* (Aoyama, 2009). Ten of these species are known to inhabit the Indonesian waters and other waters in Southeast Asia. Recently, one species has been discovered as a new species in the Philippines, *i.e. Anguilla luzonensis* (Watanabe *et al*., 2009).

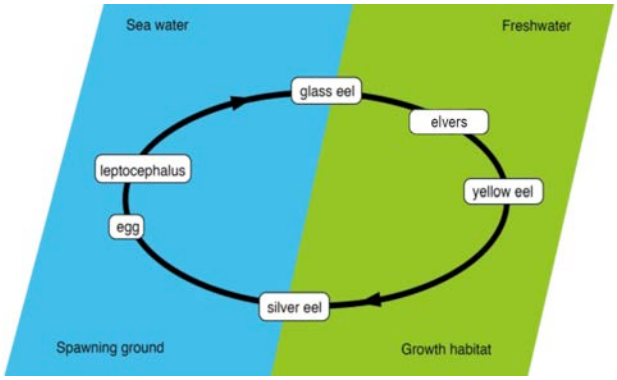


Fig 1. Typical life history of catadromous Anguillid eels (Adapted from Arai, 2015a)

Issues and Concerns

Reports have indicated that the international market for cultured eels in 2000 exceeded 200,000 metric tons (MT) and reached the peak at 275,014 MT in 2009 (FAO, 2015). In Japan, the Japanese eel (*Anguilla japonica*) has long been esteemed as an important food fish, and as much as 130,000 MT of this eel is consumed per year. Nevertheless, most of this production is based on the exploitation of wild adults and rearing of wild-caught juvenile glass eels. However, capture activity of the glass eels since the mid-1990s has increased rapidly (Jacoby *et al*., 2014), and recently, juvenile abundance has declined dramatically by 99% for the European eel and by 80% for the Japanese eel (Dekker, 2003).

While the current population of temperate eels has dramatically decreased due to overfishing, habitat loss and migration barriers, as well as increased natural predation, parasitism, ocean climate variation, and pollution (Arai, 2014), the tropical Anguillid eels become more important in the global market. There is however, limited knowledge on the distribution of the tropical Anguillid eel species in the southern or tropical zones. As the population of several species of Anguillid eels worldwide had been declining, there has been a call for the development of effective conservation and management measures of eel species to ensure their sustainability, noting also that several eels had been listed as species of international concern, *e.g.* the European eel (*Anguilla anguilla*) under the Appendix II of CITES and as critically endangered on the IUCN Red List; the American eel (*A. rostrata*) and Japanese eel (*A. japonica*) as endangered in IUCN Red List; while several tropical Anguillid eels have also been included in the IUCN Red List as near threatened or vulnerable species. Concerns have also been expressed recently on the need to ensure the sustainable utilization of tropical Anguillid eels to avoid possible listing of the species in the CITES Appendices or imposition of other instruments that may impact on the utilization and trade of the species in the future (CITES, 2015). When the European eel, *A. anguilla* had been listed in CITES Appendix II since 2009 virtually prohibiting their export and import, tropical Anguillid eels such as the Indian mottled eel (*A. bengalensis*), Indonesian shortfin eel (*A. bicolor*), and marbled eel (*A. marmorata*) became economically-important Anguillid eel species in the Southeast Asian region. With such a situation, it has become necessary to ensure that these resources should be conserved and managed properly in order that they would not be critically endangered and end up listed in the CITES Appendices as a consequence. Conservation and management of these eel species have become necessary for the sustainability of the tropical Anguillid eel species to compensate for the shortage of supply of the temperate Anguillid eels.

Nonetheless, the catch statistics of the species which are the most important basic data for assessing the current status and trend of the eel resources remain very inadequate. Therefore, in order to evaluate the relative abundance of eel resources, the need to develop the catch statistics on eels had been raised in many fora, especially for the tropical Anguillid eels in Southeast Asia. Since data on catch statistics of Anguillid eels in the region are insufficient, an inventory system needs to be established as soon as possible for the conservation, management and sustainable utilization of the tropical Anguillid eel resources and also for future development of the eel industry in the region. SEAFDEC has initiated measures to address the issues on data collection on eels. Through the SEAFDEC Inland Fishery Resources Development and Management Department (IFRDMD), the First Workshop on Enhancement of Sustainability of Catadromous Eel Resources in Southeast Asia was organized on 27-29 April 2016 in Palembang, Indonesia. Attended by various stakeholders from Southeast Asia, the Workshop served as an avenue for exchanging information on the status of eel fisheries/ eel farming in the Southeast Asian countries. The Workshop also discussed the important and controversial issues regarding the eel industry in Southeast Asia and came up with recommendations and the way forward, as shown in **Box 1**.

Research Study Sites

To form part and parcel of compiling information on eel fisheries, SEAFDEC/IFRDMD spearheaded the conduct of a study survey in the major eel producing countries of Southeast Asia. Although a number of studies had been previously conducted by many researchers to collect data on eels, this recent research survey was aimed at obtaining better understanding on the current features of the catadromous eel resources and also their fisheries in the inland waters of Indonesia, Philippines, and Myanmar. The research was carried out in 2015 and 2016 through direct observation of the eel fishing activities in the inland waters of Indonesia (Bengkulu (1), Palabuhan Ratu (2) and Cilacap (3)), the Philippines (Aparri River, Cagayan (4)), and Myanmar (Yangon(5) and Mandalay (6)). The research study sites are shown in **Fig. 2**.

Fig 2. Map of study sites: 1.Bengkulu, 2.Palabuhan Ratu, and 3. Cilacap (in Indonesia); 4.Aparri River, Cagayan (in Philippines); 5.Yangon and 6. Mandalay (in Myanmar)

Bengkulu Province is located in the west coast of Sumatra facing the Indian Ocean, while Palabuhan Ratu is located in Sukabumi Regency, West Java Province. Cilacap is one of the regencies in Central Java Province. Palabuhan Ratu and Cilacap also face the Indian Ocean and are in the southwest coast of Java Island. Cimandiri River in Palabuhan Ratu is a famous fishing ground for glass eels that usually gather at the River's mouth every year. Cilacap Regency is a fishing ground of yellow eels through its rivers and swamps that have varying areas.

The Aparri River in Cagayan Province of Northern Luzon in the Philippines is inhabited by various eel species and is already known as an important eel habitat. Yangon and Mandalay are in Myanmar, where Yangon (formerly Rangoon) is the largest city in Myanmar (formerly Burma). Based on local reports, fishers send their harvest of Anguillid eels to a collector, while in Mandalay also in Myanmar collectors transfer the Anguillid eels to some farms for rearing before these are sent to the markets.

Under the research study, the necessary data were collected by interviewing the fishers, fish collectors, officers of local governments, as well as Fish Quarantine Stations to obtain the official statistics on catch and shipment of eels and understand the commodity chain of the eel seeds. The statistical data were collected assuming that the concerned local government officers had been collecting catch data on eel from eel collectors using the same method. However, the respondents could not confirm the detailed methods they used for data collection.

Results and Discussion

Fishing Gears

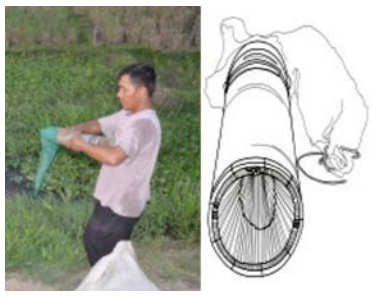
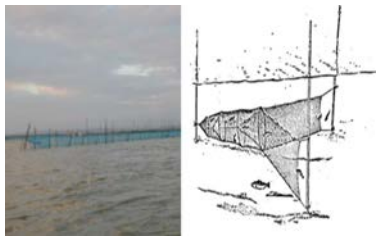
Results from the research survey indicated that there is one type of fishing gear used for eel fisheries in each location site as shown in **Table 1**.

Eel Capture Activities: Indonesia

Bengkulu Province

In Bengkulu, fishers catch the yellow eels at the middle basin of the river but nobody scoops the glass eels at the river mouth. As described in **Table 1**, "bubu" trap is used by fishers to catch the yellow eels. The Local Government of Bengkulu Province reported that in 2014, the highest number of yellow eels was collected in August as recorded in the Province's yearly statistics of yellow eel catch (**Fig. 3**). The peak of eel capture in August could be related to the shifting from dry season to

Table 1. Fishing gears used in eel fisheries in each survey site

Site	Location	Fishing gear	Description
1.	Bengkulu		Bubu is made of split bamboo sticks forming a tube. The tube has a wide mouth fixed by a bamboo ring and a body that tapers down to the closed end. The trap is operated in shallow waters and river branch where the eels are usually swept by water current into the trap.
2.	Palabuhan Ratu		Scoop net is a kind of hand net for sweeping the bottom of waters. It is made of bamboo frames and mounted with fine mesh netting panel. Its width is about 1.5 m.
3.	Cilacap		Bubu in Cilacap is similar with the bubu in Bengkulu but the Cilacap bubu is made of plastic pipe instead of bamboo.
4.	Philippines		Fyke net is a fishing net that hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats.
5.	Myanmar		Eel trap is a vertically positioned bottle-shaped trap with entrance on the sides near the base. Small bait basket is hung inside the trap. It is operated in floodplains and rice fields during the rainy season.

rainy season and in March which is the end of rainy season. This implies that eel capture increases during the overlapping period of the dry and rainy seasons.

Transport of eel from Bengkulu occurs the whole year and peaks in August, which is about 53% of the total eel transported. Fish collectors send the yellow eels by air to Java Island for nursing and rearing to marketable size prior to processing these into *unagi kabayaki* and exported to other countries. Local reports also mentioned that aside from Bengkulu Province in the west coast of Sumatra, eels are also found in Enggano Island, sub-district of North Bengkulu Regency.

Palabuhan Ratu

The mouth of Cimandiri River in Palabuhan Ratu is one of the fishing grounds frequented by local people to collect glass eels (*Anguilla bicolor* and *A. mamorata*) as the glass eels approach the coastal areas through the ocean currents which transport the young eels (transparent body) back to the coast for foraging, growing and gradually becoming mature while ascending upstream. The fishers collect glass eels using a hand-held scoop net described in **Table 1**. **Fig. 4** shows that glass eel catch increases in the fourth quarter then reaches its peak at year-end. The Local Government of Sukabumi Regency collects the monthly catch statistics of glass eels.

Glass eel collection is carried out between 18.00 until 06.00 the next morning. A pressurized kerosene lamp is used to provide lighting while functioning also as luring light to attract the glass eels. The depth of the capture area is only less than 30 cm. However, during the lean season, fishers could only capture 10-20 g (60-80 individuals) of glass eels every night. These are then transferred to another buyer, for rearing to reach an average weight of 200 g before transporting them to eel farmers for rearing to marketable size.

Cilacap Regency

Serayu River of Cilacap Regency is one of the most important and largest yellow eel fishing grounds in Indonesia. Most of the yellow eels cultured in eel farms in Indonesia come from this River. Fishers catch the yellow eels using bubu (**Table 1**). The Local Government of Cilacap Regency collects the yearly statistics of yellow eel catch (**Fig. 5**). The peak season to catch the yellow eels is from December to January of the following year. Eel fishers collect the yellow eels then transport them by land to eel farms, where the eels are cultured until product size and finally shipped to the market.

Eel Capture Activities: Philippines

The peak season for glass eels in Aparri River, Cagayan Province is from October to March. Fyke net is mainly used to collect glass eels in the estuary, set from 17.00 to 06.00 the following day throughout the year. Fyke net consists of cylindrical or cone-shaped netting bags mounted on rings

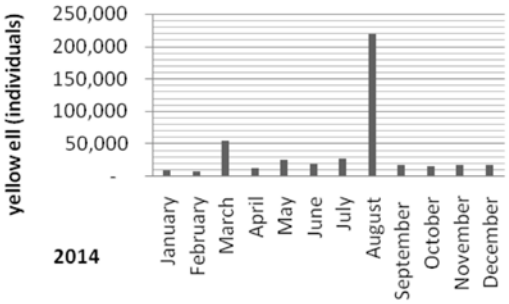


Fig. 3. Monthly catch of yellow eel in Bengkulu Province in 2014 (Local Government of Bengkulu Province, 2015)

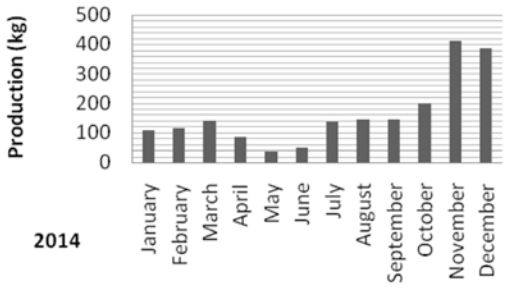


Fig. 4. Monthly catch statistics of glass eels at each stage in Sukabumi Regency (Sukabumi Local Government, 2014)

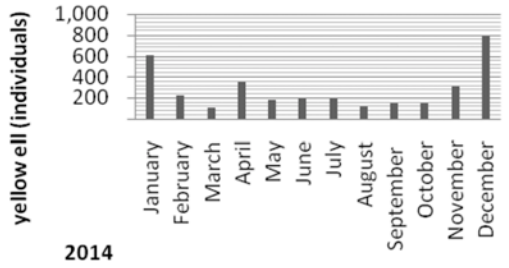


Fig. 5. Monthly catch statistics data of yellow eel in Cilacap Regency in 2014 (Local Government of Cilacap Regency, 2015)

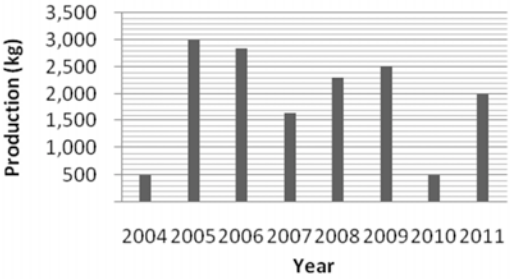


Fig. 6. Annual production (kg) of elvers in Aparri, Cagayan Province during 2004 to 2011 (Source: LGU Aparri through the Municipal Agriculture Office)

or other rigid structures. The wings or leads guide the fish towards the entrance of the bags. Length of the wing is usually 30 to 50 m and the bag is about 20 m. Fyke net is fixed on the bottom by anchors, ballast or stakes. Records have shown that the price for one kg of glass eels from fishers is PHP 2,000.00 (US $44.82). Two to three fishers set 2-3 fyke nets every day and the eel catch comprises less than 50 individuals sorted from a total catch of 1.0 kg of fish. The catch data on elvers production during 2004 to 2011 are shown in **Fig. 6**. It was noted during the research survey that fishers stopped catching

glass eels from Aparri River in 2014 because the price had gone down. Before this period, the price of glass eels reached PHP 30,000/kg. Fishers have however indicated willingness to catch glass eels again if there are orders, in which case the price should be more than PHP 5,000/kg.

Eel Capture Activities: Myanmar

In Myanmar, *Anguilla bicolor* commands the best price compared with the other Anguillid eels. The peak season for eel capture is from August to November, and eel breeding season coincides with the rainy season. Usually, small-sized eels are collected in April. The national production during this period is about 15 metric tons/day. Eel collectors or fishers use bamboo traps (**Table 1**) to collect eels using crabs or earthworms as bait, and rear the catch for about one week. **Fig. 7** shows the annual export data of eels during 2011 to 2016. Almost (98%) of the country's eel production are for export, with only around two percent intended for the domestic market and this activity is reported to have been stable for the past 20 years. Reports also indicated that price of eels depends on the season, during the rainy season (May to August), the price is US$ 3.50/kg and increases to US$6.50/kg during the lean season.

Results from the research survey indicated that one collector from Myanmar receives around 15 metric tons of eels each year, which he could sell live or frozen. There are actually two types of trade routes for eels in Myanmar. In the normal trade, the collected eels are sold to Japan and Korea, and in the border trade, eels are sent to Mandalay and later to China. In both cases, health certificates which are required are issued by the country's Quarantine Office. Some eels are also transported to other domestic markets within Myanmar.

Trend of Eel Fisheries

According to certain eel farmers in Indonesia, the mouth of Cimandiri River is one of the largest glass eel fishing grounds while Cilacap Regency is one of the largest yellow eel fishing grounds in Indonesia. In Palabuhan Ratu, there are more than 1,500 part-time fishers scooping glass eels during the peak season but concentrating only in collecting glass eels.

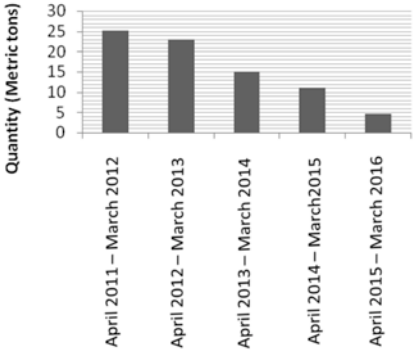


Fig. 7. Annual data of yellow eel export of Myanmar during 2011-2016 (Government of Myanmar, 2016)

Although it has been reported that eel fishery in Bengkulu Province targets the yellow eels as they could command good prices, some small eel farmers also reported that rearing glass eels into elvers needs high-level eel culture technology. Nowadays, there has been a constant demand for yellow eels as seeds for eel farming. However, since there is no eel farm in Bengkulu, eel seed stocks are transported from Bengkulu to eel farms in Java Island.

Similarly in Cilacap Regency, yellow eels are targeted for temporary rearing before these are sent to eel farms by land. Large-scale eel farms, many of which are funded by foreign investors, have been established mainly in Java Island since late 2000s and have been culturing the tropical eels (Fahmi, 2014). Meanwhile, the Philippines is exporting live Anguillid eels mostly to China as well as to other countries such as Taiwan and Hong Kong (Ame, 2016). To restore the natural population of eels, communities near the Aparri River in the Philippines, stock the upstream river with 200,000 glass eels every year. Likewise, Myanmar also exports eels to China through the border trade since about a decade ago. Eel trading is very common in Myanmar but big amounts of eels are meant for the export market only. Live eels are collected from collection centers at the township and district levels by fishers and sent by collectors to Yangon and Mandalay.

Concerns on Resource Enhancement

Since eel populations in the temperate zone have been diminishing due to the rising demand of glass eels, capture activity of glass eels also tends to increase significantly. In order to avoid the over-exploitation of glass eel resources, the Indonesian Government issued a regulation prohibiting the export of eels weighing less than 150 g per individual from the country's territory. In 2009, the decree was revised to include a provision that prohibits the export of eel seed stocks unless these are used for research purposes. In 2012, the decree was again revised making such provision more conservative, *i.e.* prohibiting the export of eel seed stocks for any reason.

In the Philippines, a regulation on trading of eels is also in place. The issuance of Fisheries Administrative Order No. 107 on 23 February 1973 resulted in the total stop of marketing elvers from the country. The said Order specified that exportation of elvers not smaller than 15 cm in length is totally banned. In Myanmar, closed season for eel fishery has been promoted to facilitate eel recruitment and in order that silver eels could go back to the ocean and glass eels could get into the rivers. During the First Workshop on Enhancement of Sustainability of Catadromous Eel Resources in Southeast Asia in April 2016 in Palembang, Indonesia, it was reported that the Government of Myanmar considers closed season as more appropriate than closed area. For the region and considering the migratory nature of eels, measures such as closed season or closed area would depend on what is most appropriate in each country.

Arai (2015b) mentioned that to enhance eel stocks and promote commercial production for human consumption, studies related to the establishment of commercial glass eel production should be carried out. He also mentioned that the Japanese eel population size has already been considered to be outside of safe biological limits, and its current fishery is no longer sustainable. Since the Japanese eels are not protected under local or international laws, these eels are currently seriously threatened with extinction. Meanwhile, stock assessments of the Japanese eels have not yet been seriously considered. Currently, the development of eel conservation and management policy measures has become fundamental in Southeast Asia for the sustainability of eel resources that have high economic and strategic value. Therefore, the Southeast Asian region should establish management policies that would balance the utilization and sustainability of the region's eel resources. As a result of Indonesia's ban on export of eel seeds, farming activities rose in Indonesia since 2009, and many Indonesian fish farmers have already started culturing eels using simple technologies. At the same time, foreign companies have also started to invest in Indonesia's eel culture industry where advanced eel culture technologies have been introduced.

Box 1. Recommendations and Way Forward developed during the First Workshop on Enhancement of Sustainability of Catadromous Eel Resources in Southeast Asia, 27-29 April 2016, Palembang, Indonesia

Issues	Recommendations and Way Forward
1. Improving data collection and statistics on Anguillid eels	• Considering that information on status and trends of eel resources are necessary for management to ensure sustainability of the species, and since data collection on status and trends of eels which inhabit the deep ocean is not possible, production trends of eel juveniles caught for aquaculture purposes should be monitored as these could provide some pictures on the trend of eel population in natural habitats. • To facilitate data collection by the countries, a standardized template should be developed by harmonizing the existing templates currently used by the countries, and data compiled on eels should be categorized as: 1) glass eels = transparent/non-pigmented; 2) elvers (kuroko) = pigmented, up to 50 grams; and 3) yellow/silver eels = above 50 grams • Catch data should be collected by weight, which could be used for calculating the number of juveniles caught, fishing hours, fishing gears, etc. • Data on production of eels from aquaculture should also be collected. • For marketable size eels, difficulties have been encountered by many countries in reporting eel catch statistics because Anguillid eels are recorded under the group of "eels" together with the other eels or "others" together with other unidentified fish, thus, efforts should be made to improve the statistics on eels in the future.
2. Increasing the survival rate during culture of glass eels to elvers	• The most critical stage in eel aquaculture in the region is from glass eels to elvers, which takes 3-4 months and survival rate has been recorded to be very low, but records in Japan showed that survival of cultured *A. bicolor* from glass eels to elvers was as high as 90% and in Indonesia up to 55% (in a company supervised by Japan), and up to 90% in laboratory-scale. Therefore, existing eel aquaculture technologies should be improved and extended to concerned stakeholders to enhance survival rate in culture farms, and optimize the utilization of glass eels which could eventually lead to increased eel production in the region. • In glass eels, particularly for *A. bicolor*, 5-7 cm in length are the most appropriate size for aquaculture to attain high survival and growth, and since it had been difficult to regulate the catching size of glass eels, other measures should be developed, *e.g.* identification of appropriate geographical areas for catching, appropriate collecting season, etc. while R&D in culture of eels should be continued, *e.g.* optimum water quality (physical and chemical), feeding/nutrition (*e.g.* appropriate protein and lipid content requirement), disease management, etc.
3. Compilation of existing information/ research results from Southeast Asian countries	• Considering that several studies relevant to Anguillid eels have been undertaken and published by many researchers in several Southeast Asian countries, including those published in national languages, such information should be collected and compiled to facilitate further research studies and undertake activities towards the conservation and management of the eel species.
4. Mitigating problems on unregulated trade of eels	• Regulations on trading of eels should be established taking into consideration those that are already available in several countries, *e.g.* exportation of eels smaller than 150 grams is prohibited in Indonesia and smaller than 15 cm in length in Philippines. • Considering that Anguillid eels command high price while demand had been increasing, large quantities of glass eels are being traded without proper regulation and recording in some cases. Therefore, measures should be developed and imposed to prevent illegal trade and laundering of glass eels, and such measures should focus on those that could be undertaken by exporting countries.
5. Development of restocking and resource enhancement measures	• Considering the migratory nature of Anguillid eels, from the deep ocean to freshwater rivers, of which the migratory route along the river could be long with obstacles/conditions that hinder their migration, *e.g.* fishing activities, cross-river obstacles, and habitat degradation, therefore, habitat restocking of eel species should be considered as an option.

Conclusion and Recommendations

At this point in time and based on the results of the research survey, information on catch data and statistics on eel fisheries in Southeast Asia is still very limited. It is therefore necessary that the system of collecting data and information on eel fisheries in the region, especially in major eel producing countries, should be improved. Specifically, collection of eel data and statistics should be done at species level for the purpose of conducting stock assessment of certain species of eels. However, such approach would require capacity building on the part of enumerators or data collectors, especially on eel species identification. With these aspects in place, management measures could be developed for the sustainability of the tropical eel resources. The experience of Indonesia, Philippines and Myanmar as the most potential countries in the region for intensified promotion of eel conservation and management could be used as reference for the other Southeast Asian countries in the conservation and management of their respective eel resources.

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