per recruit (YPR) and spawning per recruit (SPR) analysis was undertaken in 2021 using 32 stocks of sharks and rays from six landing sites in Cambodia, Malaysia, Myanmar, and Thailand. The growth parameter estimation showed that 27 stocks had rapid growth rates, four stocks had average growth rates, and one stock of female whitespotted whipray (*Maculabatis gerradi*), the largest stingray found in this study, had a slow growth rate. The results of both YPR and SPR showed that in 5 stocks (16 %) current fishing mortality (F_{curr}) exceeded the limit biological reference points (BRPs), while 12 stocks (37 %) were acceptably exploited with F_{curr} lower than the limit BRPs, and 15 stocks (47 %) were identified as the low exploited stock with F_{curr} lower than all BRPs. For the selected stocks, the sub-region with the lowest exploitation rate was the South China Sea, represented by only one country with a specific fishing ground. Based on the study results, three management measures suggested: fishing gear adaptation, establishment of marine protected areas, and zonation improvement to adjust either age at first capture (tc) or fishing mortality (F) or both at the same time (Pattarapongpan, 2021).

Age determination of elasmobranchs

SEAFDEC/TD organized in 2019 the Training Course on Age Determination Using the Vertebra of Sharks and Rays with support from the Japanese Trust Fund. The training included lectures on the status of elasmobranch fisheries in Southeast Asia, sensitivity of the YPR model, and estimation of the growth parameters. The training also included practical sessions in groups to practice step by step including Species Identification (Species and Sex), Measurements (total length, precaudal length, and body width and weight), Vertebra Removal (boiling and bleaching to clean vertebra, vertebra staining, embedding in epoxy), and Sectioning.

Issues and Challenges

The studies and data on sharks and rays are limited in many countries in the region such as Brunei Darussalam, Myanmar, Cambodia, and Viet Nam. Only a few countries such as Indonesia, Malaysia, and Thailand have the historical data and more comprehensive studies on this group of aquatic species. Most countries in the region still record the landing of sharks and rays by groups (sharks and rays) not up to their species level. Some countries still do not include sharks and rays landings in their national statistics. Other information such as biological data, stock structure, and spatial and temporal distribution of sharks and rays are still lacking in some countries. Furthermore, there is a lack of information on trends in species composition of shark production, while utilization of shark fins and shark meat is not recorded in international trade, global utilization of products other than shark fins and shark meat, and in trade statistics.

Way Forward

For CITES, the Animals Committee had encouraged Parties to:

- provide information on any national management measures that prohibit the commercial take or trade of sharks and rays
- provide a report in accordance with their national legislation about the assessment of stockpiles of shark parts and derivatives for CITES-listed species stored and obtained before the entry into force of their inclusion in CITES to control and monitor their trade, if applicable
- inspect, to the extent possible under their national legislations, shipments of shark parts and derivatives in transit or being transshipped, to verify the presence of CITES-listed species and verify the presence of a valid CITES permit or certificate as required under the Convention or to obtain satisfactory proof of its existence; and
- continue to support the implementation of the Convention for sharks and consider seconding staff members with expertise in fisheries and the sustainable management of aquatic resources to the Secretariat.

In the Southeast Asian region, the ongoing project "Research for Enhancement of Sustainable Utilization and Management of Sharks and Rays in the Southeast Asian Region" (2020–2024) under the JTF VI Phase II project is being implemented by SEADEC/MFRDMD. The planned project activities include capacity development in taxonomy, new species/record identifications, and management of major shark species; confirmation of stock structures for at least two common species of sharks/rays (*Chiloscyllium hasseltii*, *Carcharhinus sorrah*) and one CITES-listed species (*Sphyrna lewini*) in participating countries; and development of socioeconomic studies for the collection of information on marketing and trade, and channels of sharks and rays, as well as the development of NDF documents for selected CITES-listed species that are widespread in the region.

3.1.2 Anguillid Eels

Anguillid eel resources are among the highest economically important inland fishery resources in Southeast Asia. Although Anguillid eels are migratory fish species, their life cycle is mainly spent in freshwater environments. Southeast Asia is home to several tropical Anguillid eel species (Arai *et al*., 1999). Among the total 19 species/subspecies (16 species and 3 subspecies) that exist worldwide (Pacific, Atlantic, and the Indian Ocean), 13 species/subspecies are distributed in the Indo-Pacific Region, of which eight species/subspecies inhabit in Southeast Asia region (**Figure 69**). The most economically important eel species in Southeast Asia are the *Anguilla bicolor* and *Anguilla marmorata*. In this region, six countries have anguillid eel

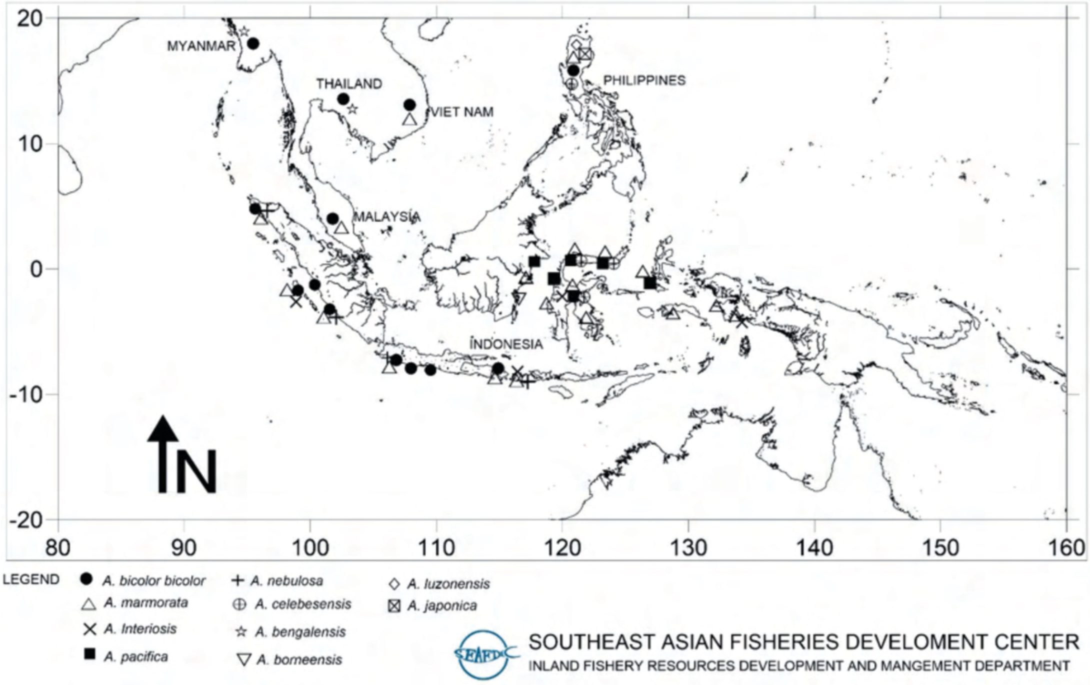

Figure 69. Distribution of *Anguilla* spp. in Southeast Asia

fisheries in place, namely: Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Viet Nam.

Studies and surveys on the fisheries and aquaculture of Anguillid eels are being carried out in the Southeast Asian region to conserve the Anguillid eel resources and ensure the sustainability of their fisheries management. Such studies are meant not only to save the Anguillid eel resources from getting extinct and prevent the listing of Anguillid eel species in the CITES Appendices as the demand for tropical Anguillid eels has been increasing in the world market but also to secure the economic benefits that the future generation could gain from this commercially important commodity.

Status and Trends

In the Southeast Asian region, information on eels is still very limited, especially for the Anguillid eels. Collecting information and data statistics on the production of Anguillid eels and their utilization is therefore critical and urgent. Nonetheless, despite limited data, the current status and recent trend of eel fisheries and eel resources in the Southeast Asian region could be established (**Figure 70**) focusing on eel landings in Indonesia and the Philippines. Moreover, through the efforts of SEAFDEC/IFRDMD, some information had been obtained regarding the amount and trend of eel trading in Indonesia, Philippines, Viet Nam, Myanmar, and Thailand (**Figure 71**).

SEAFDEC/IFRDMD has also been conducting regular surveys, field observations, and interviews of relevant stakeholders from the AMSs. Although Indonesia, Myanmar, Philippines, and Viet Nam are the contributors

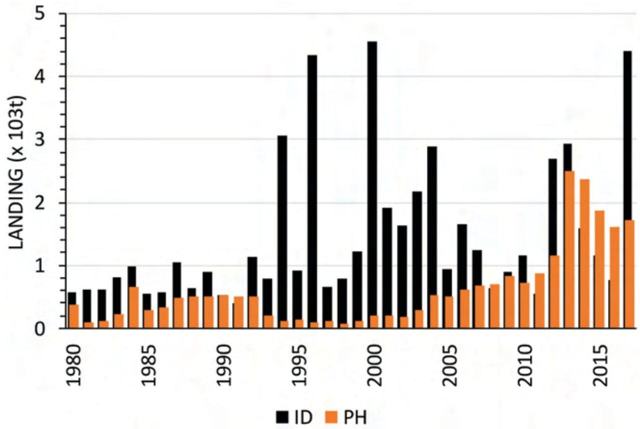

Figure 70. Annual landing data of Anguillid eels nei in Indonesia and Philippines

Source: *SEAFDEC (2019)*

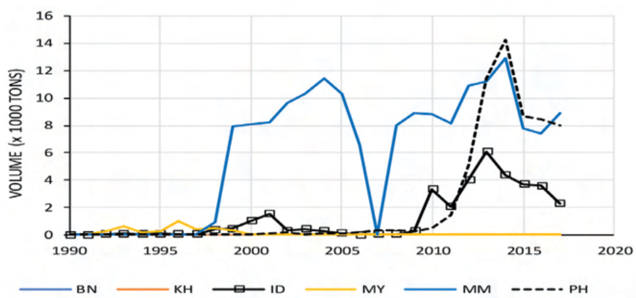

Figure 71. Annual export of eels and live elvers by some ASEAN Member States during 1990-2017

Source: *SEAFDEC (2019)*

of data from wild Anguillid eel fisheries, but the data could not be used to conclude any trend on the status or condition of the fisheries in each AMS due to a number of missing data. Nevertheless, some baseline information could be drawn to strengthen the collaborative efforts in assessing the status and trend of the tropical Anguillid eels in some AMSs, as described in the following.

Indonesia

In Indonesia, Palabuhan Ratu in Sukabumi Regency is the main fishing ground for the glass eel of *A. bicolor*, while Poso Lake and its adjacent waters are located in the Central Sulawesi Province is the main fishing ground for *A. marmorata*. The estimated catch in Palabuhan Ratu ranged from 0.09 million to 1.5 million g/year (**Figure 72**), and the seven-year data on landing indicated that the average daily landing was higher during the early and last quarter than during the other parts of the year except in 2018 when high catch occurred in the middle of the year (**Figure 73**).

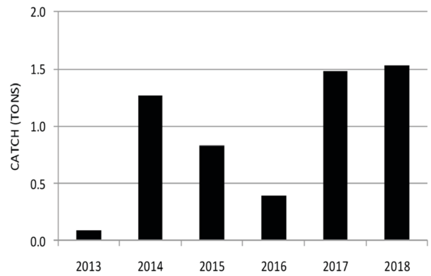

Figure 72. Annual catch of glass eels in Palabuhan Ratu, Indonesia

Source: *SEAFDEC (2019)*

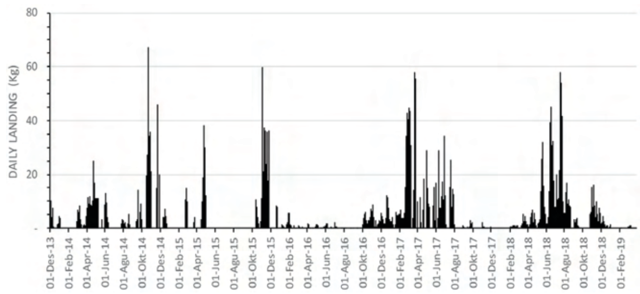

Figure 73. Daily landings of glass eels in Palabuhan Ratu, Indonesia

Source: *SEAFDEC (2019)*

In Poso Lake and its adjacent waters, the fifteen-year harvest data indicated that the volume had decreased during the last two years (**Figure 74**). Although the maximum volume of monthly harvest decreased, the data on glass eels available

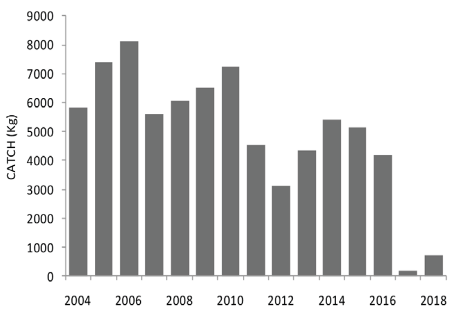

Figure 74. Annual trend of the catch of elvers and yellow eels in Poso Lake, Indonesia

Source: *SEAFDEC (2019)*

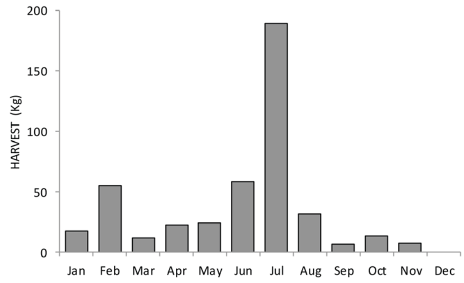

Figure 75. Monthly catch of glass eels in Poso, Central Sulawesi, Indonesia

Source: *SEAFDEC (2019)*

for 2018 indicated that the highest monthly data on harvest occurred in July with a volume of around 1900 kg, while during the other months the volume fluctuated from 7 to 55 kg/month (**Figure 75**).

Myanmar

In Myanmar, the available information from 2017 to 2018, and until early 2019 showed that the total estimated catch was relatively maintained at the same volume. However, further analysis of these data indicated that the landings of A. marmorata were more than that of *A. bicolor* (**Figure 76**). There is a regulation in Myanmar on closed season regarding inland capture fisheries (including Anguillid eel fisheries).

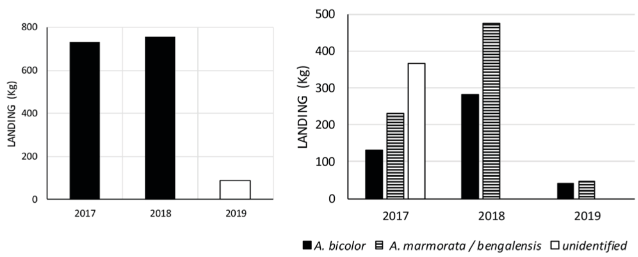

Figure 76. Annual landings of *Anguilla* spp. *(left)*, and annual landing by species *(right)* in Myanmar

Source: *SEAFDEC (2019)*

Philippines

The Philippine data on glass eels was available from 2007 to 2018 except from 2012 to 2015. The monthly data in 2007–2011 and 2016–2018 indicated the maximum catch in different months, while the highest catch occurs in November 2011 at 394 kg, and the estimated maximum CPUE of 1.9 kg/fisher was also noted in November 2011 (**Figure 77** and **Figure 78**). Although there is limited information on the catch of glass eels from the Cagayan River in the northern Philippines, the trend could be established for 2017–2019 (**Figure 79** and **Figure 80**).

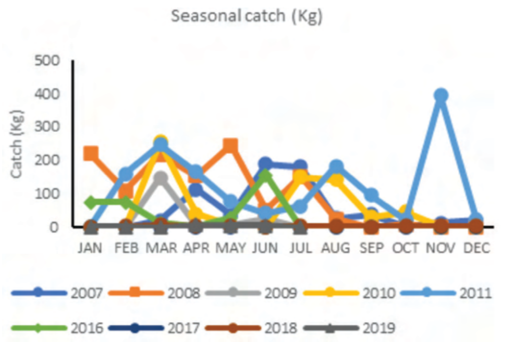

Figure 77. Seasonal catch of glass eels in the Philippines

Source: SEAFDEC (2019)

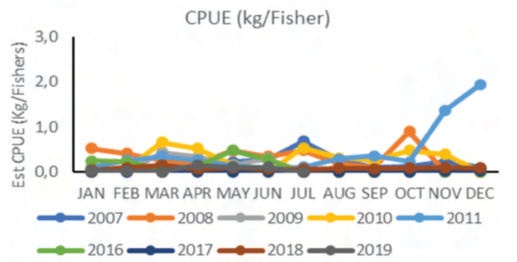

Figure 78. CPUE (kg/fisher) of glass eels in the Philippines

Source: SEAFDEC (2019)

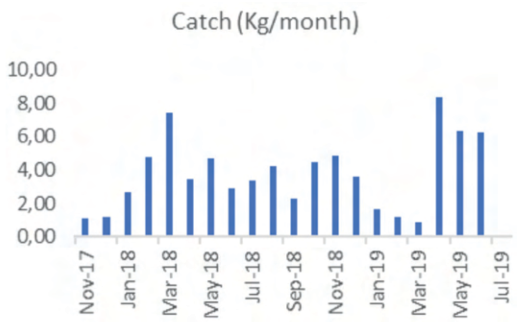

Figure 79. Catch data (kg/month) of glass eels in Cagayan River in 2017-2019

Source: SEAFDEC (2019)

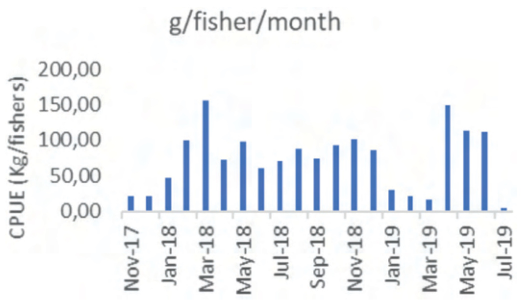

Figure 80. CPUE (g/fisher/month) in Cagayan River in 2017-2019

Source: SEAFDEC (2019)

Viet Nam

Based on the available information from January 2018 up to early 2019, there is not sufficient data to determine the status and trend based on the two-year limited data of Viet Nam. However, the catch data on glass eels and elvers/yellow eels could be established as shown in **Figure 81**.

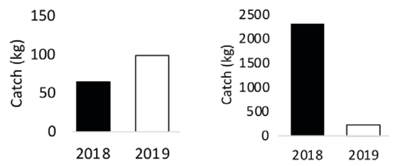

Figure 81. Catch data on glass eels *(left)* and elvers/yellow eels *(right)* of Viet Nam

Source: SEAFDEC (2019)

Issues and Challenges

- *Conservation of Anguillid Eel as Protected Species*

Restocking activities could be an option to preserve the eel stocks in nature, as it could also enhance the stakeholders' awareness of the need to conserve the eel resources. Many factors led to the deteriorating state of the habitats of eels, such as the conversion of their habitats into other development structures and installations, overexploitation, diseases, climate change, and water pollution. The construction of dams/weirs in many rivers to supply the water needed for crop irrigation and for running the hydroelectric power plants creates a blockage of the water flow. Some of the factors that threaten the Anguillid eel population include overexploitation due to the use of non-selective fishing gears and unsustainable fishing methods and practices. The absence of any regulatory management on the maximum number and the distance between the gears would lead to the decreasing populations of the Anguillid eels that migrate to the oceans.

A region-wide study on the population structure of *A. bicolor pacifica* by Marini *et al.* (2021) showed that there is no significant genetic structure of *A. bicolor pacifica* among the three sampling areas in the Southeast Asian region using mt-DNA control region sequences, suggesting that the populations are panmictic. However, such genetic study was limited to the use of a single marker, and given the pronounced genetic divergence, the genetic mosaic may indicate cryptic species. Thus, the use of other strategies like nuclear markers, such as microsatellites, or next-generation sequencing, which may be more sensitive in detecting genetic population structure, could be explored.

The Southeast Asian countries are undertaking sustainable management measures for the tropical Anguillid eel resources. Several regulations had been enforced to prohibit the exportation of eel seeds, including glass eels, to avoid overexploitation of the species. However, several issues on the conservation and management of tropical eels that have been identified by many Southeast Asian countries should be addressed. These include inadequate statistical data on utilization of the eel resources such as catch data as well as a systematic data collection scheme, limited information on eel aquaculture, insufficient data on the geographic range of the Anguillid eels, limited stock assessment studies, inadequate effective conservation and management measures, and mixed statistical data on international trade of eel species.

- *Aquaculture of Anguillid eels*

Although technically feasible, the current status of the technology for artificial seed production of *A. japonica* is not yet economically viable due to the very low survival of the larval stages in the hatchery. Research is still ongoing to address the problems in artificial seed production of the species. The culture industry of anguillid species is still dependent on the supply of glass eels in the wild. In Southeast Asia, Viet Nam, Indonesia, and Philippines are the dominant countries that culture the tropical Anguillid eels from the glass eel stage. Other countries like Myanmar and Cambodia start their culture using yellow eel, also sourced from the wild.

In the Philippines, many glass eel fishers could be found in the northern part of the country, particularly in Cagayan Province where the mouth of the Cagayan River in Aparri Municipality is the traditional fishing ground for glass eels. In the south, among the dominant sources of glass eels are the rivers in Sarangani Province, North Cotabato, and Zamboanga del Sur. Other areas in the Philippines where eels are known to be abundant are in Albay and Camarines Norte (eastern Luzon), and in Iloilo and Negros Occidental (central Philippines). Glass eel consolidators who act as middlemen collect glass eels from the fishers for eventual distribution to buyers. The number of glass eels per kilogram could range from 5,000 to 6,000 pcs.

SEAFDEC/AQD has done rearing trials in 2019 to improve growth and survival. Since eel culture from glass eels to elvers is done in tanks, site selection is not as restrictive compared to earthen pond production systems. Like any aquaculture facility, a sufficient source of good quality water is essential to enable appropriate management.

Nursery of glass eels to elvers can be done in freshwater. Rearing tanks can be circular or rectangular. Size and volume depend on target production. In the Philippines, tank sizes range from as small as 4 m^3 to 500 m^3. Tank materials vary depending on the available capital. Tanks may be made of concrete, polyethylene, and fiberglass or marine plywood lined with canvass or tarpaulin. Concrete tanks are the most common type. Volume depends on the farm area as well as the target volume of production.

Nursery farms in the Philippines have a wide range of initial stocking densities from 1 pc to 12 pcs per liter. However, stocking no more than 5 pcs per liter (1 kg glass eel in 1,000 L of water) is recommended. Natural food is the preferred feed of newly stocked glass eels. Nurseries give live blood worm, *Tubifex* sp. up to the first two weeks or until glass eels reach 0.3 g body weight before being gradually weaned to commercially formulated diets. Feeding minced octopus flesh to *A. marmorata* glass eels as an alternative starter feed to blood worms is practiced in Chinese eel farms. Brine shrimp or *Artemia* nauplii is also used when available although growth rates of glass eel given this live feed is not satisfactory.

Commercially formulated diets for eels are available from a local fish feed manufacturer. Many farms import feeds from Japan, Korea, Taiwan, and China as the growth performance is better than locally manufactured feed, based on experience by local farmers. The daily feed ration for glass eels using dry feed is at 5 % to 10 % of total biomass. Using moist feed, the daily feed ration is at 50 % of total biomass. However, depending on the water temperature and feed consumption, the feed ration should be adjusted accordingly. *A. bicolor pacifica* grow well at 30 °C while *A. marmorata* requires a temperature of 28 °C for optimal growth.

Way Forward

- *Aquaculture*

Success in the culture of eels is dependent on nutritional needs, feeds, and feeding practices. Information on the nutrient requirements of tropical anguillid eels is limited. Therefore, the development of an artificial diet for tropical anguillid eels may be based on the known nutrient requirements of closely related species. Most of the information on vitamin requirements has been derived from experiments using juveniles. Using DL-a-tocopheryl acetate as the dietary vitamin E source, a vitamin E requirement has been estimated to be between > 21.2 mg/kg diet and < 21.6 mg/kg diet. The dietary vitamin C requirement of eels, using L-ascorbyl-2- monophosphate as vitamin C source, ranges from 41.1–43.9 mg/kg diet.

Glass eels are reared to an elver size of about 15 mm (approximately 10 g) and survival may vary depending on-farm management. The most common cause of mortalities in the nursery are poor water quality management and diseases. Growth of glass eels to 15 mm elvers typically takes from 6 to 8 months. *A. bicolor pacifica* grows faster than *A. marmorata* and has better survival rates. Anguillid eels can be infected with parasites, fungi, bacteria, and viruses such as *Trichodina* spp., monogeneans, *Ichthyopthirius multifilis*, *Aeromonas* spp., *Pseudomonas* spp., *Vibrio* spp. The most common fungal disease in eel culture is Saprolegniasis, also known as water mold, skin fungus, or cotton wool disease. It is caused by a group of oomycetes fungi consisting of *Saprolegnia*, *Aphanomyces*, *Achyla*, *Pythium*, and *Dichtyuchus*. Based on researches, the three most common viruses which cause disease in Anguillid eels are Eel Virus European (EVE), Eel Virus American (EVA), and Eel Virus European X (EVEX) and Anguillid Herpesvirus 1 (AngHV1).

- *Management*

The world market demand for Anguillid eel is high, which is reported to be around 58,000 mt. Since the Japanese eel and European eel are under the control of the IUCN, the development of sustainable Anguillid eel fisheries could be an excellent prospect to increase the source of income of small-scale fishers. The eel fishery business chain could be connected institutionally between supply and demand. However, the challenge that needs to be confronted is the damage created to the watersheds threatening the sustainability of eel seeds for aquaculture, which is still capture-based. The critical point that policymakers need urgent attention to is the protection of the eel ecosystems by minimizing the injuries to lakes or watersheds, pollution of public waters, development of dams, and controlling seed consumption.

In order to establish effective and sound conservation and management of tropical anguillid eel resources in the ASEAN region, the ASEAN Member States and SEAFDEC should address several issues that were identified during the Regional Meeting on Enhancing Sustainable Utilization and Management Scheme of Tropical Anguillid Eel Resources in Southeast Asia organized in October 2018 (**Box 4**).

Box 4. Issues that identified during the October 2018 Regional Meeting on Enhancing Sustainable Utilization and Management Scheme of Tropical Anguillid Eel Resources in Southeast Asia
Inadequate statistical data on eel resource utilization and systematic data collection scheme Harmonized data on catch, species, life stages, fishing gear, and fishing effort (*e.g.* duration of fishing operation, number of fishing gears, number of fishers, biological data) should be compiled to understand the current status of glass and elver/yellow eel fisheries, and for stock assessment
Limited information on eel farming and the quantity of glass eels used Data collection system for eel aquaculture activities (*e.g.* number of eel farmers, eel culture production, quantity of glass or elver eels used as inputs) should be established by developing and promoting registration schemes including licensing and reporting system for eel farmers
Geographic range of information on tropical anguillid eel species is insufficient Information on natural habitat, spawning ground, and migration routes are fundamental for conservation and management of the eel stocks, thus, the geographic range of the tropical anguillid eel species in the region should be examined based on the description of fishing areas, reproductive biology, and migration patterns
Limited stock assessment studies on tropical anguillid eels Stock assessment, *e.g.* using CPUE analysis as an abundance index, should be conducted for tropical anguillid eels, and that the appropriate level of exploitation and indicators for managing eel stocks should be established
Limited effective conservation and management measures for tropical anguillid eels Development of conservation and management measures for tropical anguillid eels should be established for each country taking into consideration the results of the abovementioned stock assessment studies
Mixed statistics on international trade of tropical anguillid eels Existing trade data on anguillid eel species under the UN Comtrade Database include other eel species like swamp eel and snake eel, there is a need to disaggregate such data to improve the trade statistical data reports by harmonizing trade data collection, coding, and reporting and by segregating tropical Anguillid eels from other eel species which require capacity building on eel species identification

3.1.3 Sea Cucumbers

Sea cucumbers are commercially important marine invertebrates. Dried sea cucumbers or *beche de mer* or *trepang* fetch high prices in Chinese markets, especially in Hong Kong, Taiwan, and Singapore. The prices are primarily based on the type of species, size, and processing quality. However, during the COVID-19 pandemic, sea cucumber prices went up due to the decreasing supply and high demand (Godfrey, 2019). Efforts on the sustainable management of wild sea cucumber resources have become more crucial than ever. Purcel *et al*. (2013) mentioned that the ineffective management of sea cucumber fisheries has led to the decline of stocks, especially in developing tropical countries where sea cucumber fisheries are considered small-scale. High demand and prices in global markets for luxury seafood, like *trepang*, caused extra pressure on wild harvest which is anticipated to even increase in the near future.

Sea cucumber production

- *Capture fishery*

According to the current data from FAO (2019) for Southeast Asia, only Indonesia and Philippines have shown consistent and active capture fisheries production of sea cucumbers since 1950. At present, Indonesia is the top producer of wild sea cucumbers, with a generally increasing trend since 1986 at record high harvests of more than 7,000 mt in 2005 and 2017 (**Figure 82**). Tuwo (2004) highlighted that harvesting sea cucumber rapidly increased after the 1990s, where the number of fishing vessels targeting sea cucumbers multiplied by more than 10-fold in 2003; however, the catch per unit effort (CPUE) decreased from about 500 sea cucumbers per vessel per day in 1997 to only about 33 sea cucumbers per day in early 2003. In terms of total volume, however, Indonesia still holds a significant chunk in global exports, although not consistently increasing year after year.

From 1985 to 1993, Philippines was the top producer of wild sea cucumber at 3,000–4,000 mt (**Figure 82**). This high production has contributed about 16 percent to the volume of the globally traded sea cucumbers at that time (Akamine, 2005). However, wild sea cucumber production declined