Developing responsible fishing technologies and practices

- The AMSs, relevant organizations, and institutions to continue the development of responsible fishing technologies and practices, *e.g.* selective fishing gears or fishing operations that minimize generation of by-catch and non-target species; energy efficiency technologies and systems that contribute to saving fuel in fishing operations; and adoption of the Low Impact and Fuel Efficient (LIFE) fishing technologies to mitigate the impacts of fishing gears on the resources and habitats.

- The AMSs, relevant organizations, and institutions to initiate research studies on fuel consumption and GHG emission in various types of fishing gears and operations. Technologies and innovations that aim to reduce energy consumption and GHG emission should be also be investigated and promoted not only to minimize the impacts of fisheries on climate change but also on the operational costs of fishing activities.

- The AMSs, relevant organizations, and institutions to continue developing and applying on-board fish handling technologies appropriate for the various fishing operations of the AMSs, including those for small fishing vessels, with the objective of improving the quality and freshness of the catch and enhancing their utilization for human consumption.

- The AMSs, relevant organizations, and institutions to continue the development and promotion of technologies that aim to reduce the number of fishing crew onboard fishing vessels, *e.g.* purse seiners, considering that the availability of fishing crew is a very important factor for fishing activities. Moreover, the adoption of such technologies would lead to better working conditions, safety at sea, and improved occupational health of the fishing crew in compliance with the relevant international requirements.

Addressing the issues on abandoned, lost or otherwise discarded fishing gears (ALDFG)

- The AMSs, relevant organizations, and institutions should consider the existing regional instruments, *i.e.* the Strategic Plan of Action for ASEAN Cooperation on Fisheries (SPA-Fisheries), the ASEAN Framework of Action on Marine Debris, and the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2030, as reference for their collaborative efforts in addressing the issues on ALDFG which is one of the sources of marine debris in the Southeast Asian region.

- The AMSs, relevant organizations, and institutions to continue exploring the sources, impacts, and the extent of impacts of ALDFG on aquatic species and their habitats, and also sustain investigation of the appropriate mitigation measures, particularly through fishing gear marking in cooperation with fishers, private sector, and other relevant sectors in accordance with the FAO Voluntary Guidelines on the Marking of Fishing Gear, and other measures to prevent and mitigate the impacts of the ALDFG.

5. Utilization of Fishery Resources

5.1 Status, Issues, and Concerns

5.1.1 Utilization of Fishery Resources

Fishery and aquaculture production is varied based on species, processing, and product forms, and result in the production of food or non-food uses. As of 2018, about 88 % of the 179 million mt of total global fish production was utilized for direct human consumption, while 12 % was used for non-food purposes (FAO, 2020d). Fish utilization and processing methods differ significantly across continents, regions, countries, and even within countries. In Asia, a large amount of fish production is sold live or fresh to consumers, unlike in Europe and North America where fish production is mainly sold in frozen and preserved forms. Fish commercialized in the live form are typically more appreciated in East Asian and Southeast Asian countries (**Box 14**).

Non-food utilization of fishery resources

Fishery resources are primarily utilized to provide food for humans. A portion of these; however, are used as raw materials in the production of fishmeal and fish oil, in the ornamental fish market, in the baitfish industry, as well as materials in the manufacture of pharmaceutical products, pet food, and for direct feeding of cultured aquatic and terrestrial animals (FAO, 2020d). In 2018, approximately 12 % of total global fish production, or approximately 22 million mt, was used for these purposes.

Box 14. Utilization of fishery resources of the ASEAN Member States *(Cont'd)*
Brunei Darussalam: The aquaculture production had a positive increase from 983.5 million mt in 2015 to 3,501.3 million mt in 2020. The raw materials of processed fish and fishery products are from marine capture and aquaculture, and a portion are sent directly to local markets, while seafood required for exportation will go through preparation, processing, and packaging in facilities. Processers will convert whole fish or shellfish to various other products such as fish fillet or steaks, or other items like frozen products, breaded fish portions, and canned or smoked products (Estrebillo & Hiramoto, 2021).
Cambodia: Most of the inland fishery production are sold through wet markets in small villages and towns, and since the use of ice to keep the fish fresh is limited, most of the produce are sold live, or are preserved in fermented or turned into dried forms. Cambodia has a known history of traditional processing of freshwater fish into fish paste, fermented fish, dry salted fish, smoked fish, fish sauce, and dried fish, which are intended for both domestic and international markets. Cirrhinus fish species is particularly important in the production of processed fish products for the domestic market. Most marine fish commodities are dried, such as shrimp, crab, squid, octopus, cuttlefish, and lobster (FAO, 2011a).
Indonesia: Fishery production from capture fisheries and aquaculture had increased gradually during 2011–2015. About 85 % of the fishery production goes to the local market, while the remaining is exported to Asian markets. Production from small-scale fisheries is typically distributed to local markets for direct consumption or for processing. Medium to large-scale fishery production is generally processed into canned foods such as sardines or used as raw materials for processing of boiled fish, fish bait, or fortification products for export (Ariansyach, 2017). Approximately 55 % of fish are consumed fresh while the rest is consumed frozen, smoked, or canned. The traditional drying, salting, smoking, and canning are ways of post-harvest processing. However, due to the limitation of ice supply as well as refrigerated storage and transport facilities, the remaining amount are usually processed, and consumed as dried, salted, smoked, or fermented fish. Less than 2.0 % of the total catch are processed for canned products, with pelagic species being utilized most. They are usually utilized for the production of oil from sardines and skipjack. Some fish, shrimp, and tuna are frozen and exported, while a small percentage are made into fish oil, fishmeal products, and silage (FAO, 2011b). Additionally, fillet processing and canning industries often produce leftover products in the form of fish bones and skin. Even in some fish production centers which produce surimi and fillets, fish skin is left over as residual waste from the processing. The leftover materials are further processed into high-value products such as gelatin. The fillet industry produces bone and fish skin wastes of up to 3–4 mt per day, and the tuna and skipjack canning industry produces 5,803 mt of bones, 2,106 mt of skin and 9,641 mt of head. From the bones, 721.9 mt of gelatin (yield 12.4 %) can be obtained, and from the skin (9.6 % yield) 202.2 mt of gelatin can be obtained, for a total of 924.1 mt of gelatin from both types of wastes from fish processing. Apart from that, 2,277.1 mt of calcium (39.24 % yield) can be obtained from tuna bones, along with around 1392.7 mt of meat (24 % yield) containing 306.4 mt of protein (22 % tuna meat protein content).
Lao PDR: Capture fisheries and aquaculture in Lao PDR are based on water resource ecosystems, consisting mainly of rivers, streams, hydropower, irrigation reservoirs, diversion weirs, small water bodies, flood plains, and wet-season rice fields. Most of the fishes caught and cultured are consumed by fishers and fish farmers, while the development of fisheries is mainly to attain food security. A variety of fishes such as catfish (*Clarias macrocephalus*) and featherback (*Notopterus notopterus*) are mostly processed into sausage, patty, cracker, dried fish, and fermented fish. Popular processed fish products include deep-fried breaded fish patty as well as spicy fish sausage (FAO, 2006).
Malaysia: Local production of food fish in Malaysia was around 1.87 mt in 2019, with 1.19 mt coming from inshore capture fisheries and 0.26 mt from deep sea capture fisheries. An estimated 75 % of fish is used for food purposes, with the remaining 25 % being used for fertilizer, animal feed, and industrial purposes. A huge percentage of fish caught from the marine capture sector are sold in fresh and chilled forms. Mangrove crab, mollusks, and freshwater fishes caught in inland areas are typically sold in live form. Although the market for live fish is small, most fish farmers tend to market their products in live form to restaurants to acquire higher prices. Anchovies are sold in dried form, where they are usually cooked in brine and dried on land before being marketed. Traditional fish processing done by family operations in fishing villages produces preserved food, such as shrimp paste, pickled shrimp, salted fish, dried cuttlefish, fish sauce, fermented fish, fish crackers, fish balls, and fish cake. However, in recent years, commercial operations have steadily increased, resulting in many small family businesses being phased out. Moreover, fish balls and surimi are also being made industrially now. Additionally, shrimp and tuna meant for export are preserved by freezing in processing plants. Most of the trash fish caught are converted into fishmeal for incorporation into animal feeds (FAO, 2009a).
Myanmar: The extensive inland waters and coastlines possess abundant and unique freshwater species and marine resources, making Myanmar one of the most self-sufficient countries for fish and fishery products. Approximately 80 % of fish, mostly fresh and chilled, are for direct consumption and roughly 10 % of catch are processed into fishmeal. Among the freshwater fish species, rohu fish, a non-oily white fish, is the most popular fish. Other than being sold for local consumption, it is also the top exported fishery product. It is consumed locally and included in various menus, such as fried, minced, fish ball, fish stick, fish cracker, and fish curry. Some examples of rohu fish utilization include fish muruku and fish cracker. Fish muruku is a ready-to-eat fried, crispy snack added with a tinge of spice, while fish cracker is typically made by mixing fish meat with tapioca flour, salt, sugar, and monosodium glutamate, then formed into cylindrical shape, steamed, cooled, chilled, sliced, sun dried then deep-fried. Furthermore, rohu fish is exported as whole, gutted, back gutted, minced, cut, and formed into stick and finger (FAO, 2010b).
Philippines: Reports as of 2014 indicated that fish is typically consumed as fresh, fermented, dried, smoked, or canned (FAO, 2014). Approximately 70 % of the total catch are consumed fresh, while the remaining 30 % are processed into cured, canned, frozen products, or are discarded. Majority of the cured fish and fishery products are sold and consumed locally, with only a small quantity being exported. The majority of frozen fishery products are for export while canned products, especially tuna, are consumed locally in small quantities. Most of the processing plants manufacture traditional products, for example dried and smoked fish for domestic and foreign markets. Also, there have been improvements in handling methods for good quality fresh fish caught for exportation through the use of insulated containers and proper icing. There is also an increasing demand for modern freezing equipment in processing plants such as contact plate freezers for processing shrimps, as well as air blast and brine freezers for tuna. The primary exported frozen products include tuna loins, cephalopods, and shrimps. Moreover, fillets, comminuted, surimi-based products and ready-to-eat fish products have also gained popularity, with products like fish balls, fish sausage, squid balls, and fish nuggets being sold in local supermarkets. Additionally, some processors also convert the by-products of deboned milkfish into value-added products such as fish rolls and dumplings to reduce wastage. Traditional products like salted, dried, smoked, and fermented fish are usually manufactured when there is a steady supply of raw materials. Typically, they are processed by small-scale family businesses which may result in inconsistent quality and limited shelf life of the finished products.

Box 14. Utilization of fishery resources of the ASEAN Member States *(Cont'd)*
Singapore: Being a small country state with limited space for fish farming, the country is dependent heavily on importation of fresh seafood. Nevertheless, the food fish farming industry is thriving with 123 fish farms which accounts for 9 % of annual live and chilled food fish consumed locally. This local food fish production comes from coastal farming in floating net cages along the northern coast of Singapore. For sea-based farms, there are 110 sea-based farms in coastal and southern waters, in which the majority are sited in the Straits of Johor with two deep sea farms in the Southern Waters (WAS, 2020). These farms culture various fish species including milkfish, mullet, snappers, groupers, tilapia, threadfin, and sea bass which are then supplied to live fish markets and supermarkets. Local production of seafood in Singapore was 4,567 mt in 2020 (DOS, 2021).
Thailand: About 81 % of the total fish production in 2006 was directed for human consumption, while the remaining 19 % was used for animal feed (FAO, 2009b). As for marine fish, 22 % were trash fish and used for non-food purposes, mostly for the fishmeal industry. The remaining 78 % were used for human consumption, and 24 % of it were consumed as fresh fish, while the remaining were channeled for processing, such as chilling, freezing, canning, smoked, dried, salted, or converted into shrimp paste or fish sauce. In particular, the fish processing industry has grown exponentially over the years, especially freezing and canning, to increase export. Cultured fish are sold either live or dead. Fish that are intended to be sold alive are typically transported by trucks and kept in water-filled metal boxes.
Viet Nam: Viet Nam has a vast system of rivers, canals, natural reservoirs, artificial reservoirs, and ponds. Tra fish, grass carp, carp, and tilapia are some of the traditional aquaculture species found in the north of Viet Nam. Tra fish is one of the main exported freshwater aquaculture species processed into fish ball, sausages, smoked fish, and fillets for domestic consumption and export.

Reduction into fishmeal and fish oil

Fishmeal and fish oil are key components of compound animal feed because they contain high levels of protein, essential amino and fatty acids, and other nutrients required for growth, development, and reproduction. Thailand and Viet Nam are among the world's major fishmeal producers, as well as the dominant players in Southeast Asia, accounting for roughly 90 percent of the region's total output over the last 15 years as shown in **Figure 96** (Indexmundi.com, 2021). In 2020, these two countries produced 460,000 mt and 340,000 mt of fishmeal, respectively. These are far in excess of the 108,000 mt output of Malaysia, Indonesia, and the Philippines combined. The output of Thailand was close to 500,000 mt from 2006 to 2014, before falling to less than 400,000 mt in 2015. Leadbitter (2019) attributed this decline to the current push to eliminate the use of illegal, unregulated, and unreported (IUU) fishes for raw materials in the supply chain, as well as a drop in domestic demand due to major shrimp disease outbreaks. In contrast, while the upward production trajectory of Viet Nam fishmeal has slowed in recent years, the annual outputs remain above 400,000 mt with no signs of decline. The majority of Thai and Vietnamese fishmeal is utilized domestically, with the remainder exported to China, Japan, India, Taiwan, Bangladesh, and other AMSs.

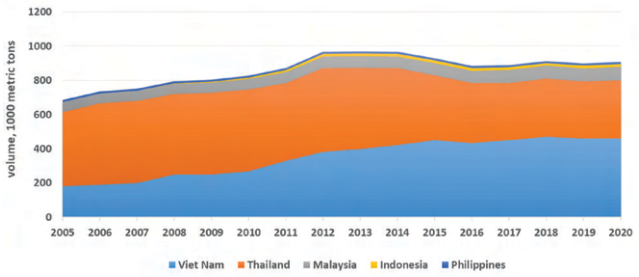

Figure 96. Fishmeal production of Southeast Asia from 2005 to 2020 by quantity (mt)

In terms of raw materials, fishmeal from Southeast Asia differed from that produced in South America and Europe. The fishmeal from these regions are typically composed of a single or few species, often of low-value fish specifically targeted for reduction fisheries, while fishmeal produced in Southeast Asia has been primarily made from trash fish or feed fish composed of multiple species. However, beginning in the late 1990s, fish trimmings from the seafood processing industry had been used in fishmeal production. According to recent data, up to 75 % of total production came from fish trimmings, primarily tuna, small pelagics, and *Pangasius* sp.

Ornamental fish trade

Fishkeeping is a popular hobby enjoyed by millions of people all over the world. This fascination with ornamental fish has created and sustained a multibillion-dollar industry involving the import and export of over 2,500 freshwater and marine fish species in over 125 countries (Dey, 2016). Southeast Asia has been the world's leading supplier of both freshwater and marine ornamental fish since 1989 (**Figure 97**). The AMSs exports totaled 128.4 million USD in 2018, accounting for more than 39 % of the total global value (United Nations Statistics Division, 2021).

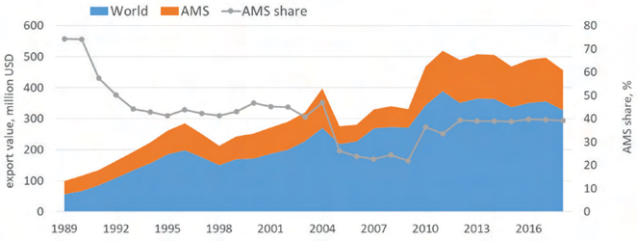

Figure 97. Export value (USD million) of ornamental fish in the world and the ASEAN Member States from 1989 to 2018

Singapore remains one of the world's top exporters and Asia's main trading hub for ornamental fish. It held the top spot for many years, albeit with a gradually decreasing trend. Singapore had a market share of 58.0 percent in 1989,

but it fell to 32.0 percent in 1995, 25.0 percent in 2000, 15.0 percent in 2013, and 11.5 percent in 2018. Nonetheless, this value remains enormous, given that at least 70 countries share the export market in 2018, compared to less than 20 in 1989.

Other AMSs that made significant contributions include Indonesia (9.8 %), Thailand (6.9 %), Malaysia (5.5 %), Myanmar (3.8 %), and the Philippines (1.7 %), with the exports in 2018 totaling USD 32.2 million, USD 22.5 million, USD 18.0 million, USD 12.4 million, and USD 5.6 million, respectively. While the UN database did not include the 2018 export data for Brunei Darussalam, Cambodia, Lao PDR, and Viet Nam, these AMSs have been reported to have also engaged in the breeding, production, and trade of ornamental fishes, particularly freshwater species (Mutia *et al*., 2017). In 2003, the export of Viet Nam was valued at USD 42.3 million, making it one of the highest in the region for that year. Its exports in 2017 totaled USD 3.2 million.

Singapore was also the top importer in Southeast Asia and the world in 2018, with imports valued at USD 13.0 million, followed by Malaysia (USD 4.9 million), Thailand (USD 2.6 million), Indonesia (USD 1.8 million), Brunei Darussalam (USD 0.5 million), and Myanmar (USD 0.1 million). While also producing the majority of its traded fish, Singapore imports more than 30 % of its supply from other countries, primarily from its neighboring AMSs (Evers *et al*., 2019; Yue, 2019; Monticini, 2010).

Freshwater species accounted for more than 90 % of the total volume traded globally, 90 % of which was bred and raised in farms and hatcheries, and the remainder wild-caught (Evers *et al*., 2019). Freshwater ornamental fish farming is a well-established industry in Southeast Asia, with various species raised in earthen ponds, concrete/fiberglass tanks, or vertically stacked glass tanks (Ng, 2016; Yue, 2019). Singapore, as the trade capital, leads in ornamental fish research, breeding, husbandry, packaging, and transportation, although the other AMSs such as Indonesia, Thailand, and Malaysia have made significant strides as well (Mutia *et al*., 2007; Ng, 2016; Yue, 2019). Meanwhile, the Philippines produced freshwater ornamental fishes through captive breeding as well, but trading is restricted to the domestic market (Muyot *et al*., 2019).

Marine species accounted for only a small portion of the ornamental fish trade, with 98 percent coming from the wild fishery (Dey, 2016). The Philippines and Indonesia are two of the few countries that supply marine ornamentals to major markets like the United States, Europe, China, and Canada (Livengood & Chapman, 2007; Muyot *et al*., 2019; Biondo & Burki, 2020). However, the trading of marine ornamentals is still a contentious issue, because breeding technology for many species is either underdeveloped or non-existent so that harvesting from the wild is frequently the norm (Muyot *et al*., 2019; Akmal *et al*., 2020). This practice, however, is deemed unsustainable and puts a strain on the natural environment's ecological balance, considering that fish collectors often employ destructive harvesting techniques such as the use of sodium cyanide (Livengood & Chapman, 2007; Mutia *et al*., 2007). While cyanide fishing and other destructive methods have been prohibited in the Philippines and Indonesia, nearly 15 % of marine ornamentals exhibiting evidence of cyanide poisoning continue to enter the EU markets (Vaz *et al*., 2017), indicating the need for more stringent measures to completely eradicate such illegal activities.

Other uses of the fishery resources

Bait fishing, whether for recreation or livelihood, is popular all over the world, especially in Southeast Asia. This activity frequently involves the use of low-value fish as bait. Aquaculture of carnivorous marine fish such as sea bass and grouper as well mangrove crab is also widely practiced in the region, and while formulated feeds are now commercially available for these species, "wet feeds" such as trash fish (fish food) or mollusks continue to play important role in the feeding regimen (Aquino, 2018; Chankakada *et al*., 2020).

Moreover, bioactive organic compounds from crustacean shells, phycocolloids (*e.g.* agar, carrageenan, and alginates) from seaweeds, gelatin and collagen from fish skins, and pigments (*i.e.* carotenoids) from microalgae, and a variety of other marine organisms have all been used in biotechnological, pharmaceutical, and industrial applications (Pangestuti & Kim, 2015; Younes & Rinaudo, 2015, Serive & Bach, 2018). Fish silage and hydrolysates derived from byproducts of fish processing (*e.g.* viscera) are also finding applications in the food and feed industries as well as in agriculture (He *et al*., 2013; Mamauag & Ragaza, 2017).

Maximizing the utilization of fishery resources

Fishery resources are mostly utilized for food purposes, with 88 % of total fish production being used for direct human consumption (FAO, 2020b). Fish not used for direct human consumption are reduced to fishmeal and oil to be used as feed, for raising carnivorous aquatic species such as salmon, shrimp, sea bass, sea bream, and others.

For fish destined for human consumption, fresh fish is the most important product, followed by frozen, canned, and cured fish. Fish represents a valuable source of proteins and nutrients in the diet of many countries. With over one-third of world fish production currently being traded internationally, quality and safety assurance has become a major issue. In addition, post-harvest handling, processing, and transportation of fish require particular care to ensure proper quality and safety. The physical loss of the value

of fish is caused by many reasons such as poor handling and preservation or discarding of bycatch. Economic losses happen when spoilage of wet fish leads to the decrease in value or when there is a need to reprocess cured fish resulting in a raised cost of the finished product. Additionally, inadequate handling and processing methods can also lead to reduced nutrients and nutritional losses. Hence, the conversion of large quantities of fish catches into animal feeds can be considered as a "loss" to human food security.

In the Southeast Asian region, the volume of low-value fish catch depends on the fishing season, fishing grounds, and fishers' efforts in sorting out the catch. Low-value fishes are grouped into those of deteriorating quality unsuitable for human consumption, which is used to produce feeds, and low-value small-sized fish, which are acceptable for human consumption. The quality of fish tends to deteriorate due to poor methods and unavailability of facilities to preserve fish onboard fishing vessels as well as the long period spent at sea.

Thus, it is of utmost importance that fish catches are utilized responsibly and post-harvest losses are minimized to attain food security for the Southeast Asian region. SEAFDEC/MFRD has conducted post-harvest projects on small pelagic marine and freshwater species in the region to maximize utilization by collaborating with the National Centre for Quality Control and Product Development (NCQC) of Indonesia to examine the utilization of small pelagic fish species, and with the Fisheries Administration (FiA) of Cambodia for the utilization of freshwater fish catch.

SEAFDEC/MFRD has conducted several activities that include the utilization of underutilized marine and freshwater fish species for the development of surimi and value-added fish products to produce fish jelly products such as fish balls and cakes, which are popular traditional products in the Southeast Asian region. The development of the surimi industry has offered markets to what was considered before as low-value fishes. Fish species such as threadfin bream, lizard fish, big-eye snapper, croaker, and goatfish or red mullet are often regarded as being of low economic value due to poor consumer preference and poor quality, but their usage in the surimi industry had indicated their importance in producing value-added products for human consumption such as fish sausage, fish burger, fish tofu, fish floss, fish siew mai, and many others.

A project on the utilization of low-value freshwater fish species was carried out in Cambodia in collaboration with FiA. Three fish species that are considered low-value and underutilized, namely: featherback fish (*Notopterus* spp.), snakehead fish (*Channa* spp.), and soldier river barbs (*Cyclocheilichthys enplos*), are used in the study. The results had allowed the development of a new range of value-added fish products from these underutilized freshwater fishes and helped to promote the conversion of underutilized freshwater fishes for human consumption while also improving the socioeconomic conditions of people dependent on freshwater fisheries. Featherback and snakehead fishes are used to produce fish bak kwa, fish cracker, fish siew mai, and fish tofu, while soldier river barbs are utilized to produce snacks such as fish muruku and fish satay.

These technological approaches have allowed the maximum utilization of fishery products, ranging from low-value small demersal and pelagic fish species to underutilized freshwater species, and the technology would be transferred to the AMSs. These value-adding technologies have also helped to minimize wastage and losses, thus contributing to food security and the economy of the AMSs.

5.1.2 Management of Food Losses and Wastes

Food loss is defined as any food that is lost in the supply chain between the producer and the market that leads to a decrease in the quantity or quality of the food. Food waste is defined as a safe and nutritious food that is discarded, whether by choice or due to spoilage as a result of negligence. As the global population is projected to grow to 9.7 billion by 2050, there are concerns that food production will be unable to keep up with rising demand. By minimizing food losses and wastage, improvements to food security could be achieved as this would ensure that more food is available instead of being lost or wasted throughout the supply chain. The impact of food loss and waste vary widely among the AMSs, so as the management strategies employed to reduce food losses and wastage (**Box 15**).