Technologies developed by SEAFDEC/AQD for the larval rearing of newborn and juvenile seahorse, *H. comes* include the use of UV-treated seawater and copepods as a replacement for brine shrimp as food for newborn seahorses (Buen-Ursua *et al*., 2011). The survival of 2–6 months old juveniles has also improved with mysid shrimps and *Acetes*. In Viet Nam, Troung (2011) reported feeding the seahorse with copepod three times per day from birth to 40 days old, while enriched *Artemia* nauplii were fed to fry from 10 days onwards. In India, Murugan *et al*. (2009) used copepodites to improve survival rates in 9 and 12 days old juvenile *H. trimaculatus*. Rearing *H. barbouri* in illuminated cages showed that the seahorse fed on copepods attracted to the night illumination (Garcia *et al*., 2012). From 2009 to 2011, the demonstration project in Sulawesi, Indonesia examined the potential to culture *H. barbourin* as an ornamental marine species for coastal management and conservation efforts (Williams *et al*., 2014). Culture units (8 m × 5 m) had been constructed in the family's yard areas to enhance the incomes for the families.

- *Resource Enhancement and Management*

SEAFDEC/AQD has conducted studies on the development of resource enhancement strategies for seahorses. Results of the transport trials for 5–7 cm in stretched height (SH) juveniles suggested an optimum stocking density of 3 ind/l for transport duration up to 12 h. In the Philippines, baseline assessment of the natural stock of seahorses showed an increasing number of stocks over the years (2012–2019), wherein the communities have played important roles in the stewardship of the protected areas. Appropriate protection of the natural habitat suggests the possible sustainability of the wild seahorse stocks. The fishing communities are being involved through information, education, and communication (IEC) and hands-on training during field sampling, seed production, and nursery rearing of seahorses (Buen-Ursua, unpublished).

The exploitation of seahorses is unsustainable, prompting urgent management of the natural resources. To reduce pressure on seahorse populations, management is required for both target fishers of seahorses and incidental catch. It is necessary to reduce the impact of the large trawl fleet which is consistently catching seahorses while simultaneously destroying habitats (Stocks *et al*., 2017; Foster *et al*., 2018). Marine reserves are also essential and should be well implemented. The Project Seahorse, an interdisciplinary and international organization committed to conservation and sustainable use of the world's coastal marine ecosystems, has made significant contributions to seahorse conservation being the first to study seahorses underwater, discover their huge trade, identify the threatened status of seahorses and the first to launch the seahorse conservation measures. One conservation measure targeting behavior to mitigate wildlife trade is reducing consumers' demand. On a smaller scale, seahorse conservation efforts could include persuading artisanal fishers to catch a minimum size of > 10 cm in height and release smaller sizes (Foster & Vincent, 2005).

Thailand has several fisheries regulations already in place, but conversations with local communities indicated that enforcement of these restrictions may still be an issue. Although the Government recently enacted strict measures against illegal commercial fishing, grounding unregistered trawlers, and banning illegal fishing gear, addressing these biodiversity losses would require extensive fisheries regulations, policy action, and enforcement of existing laws to protect natural resources (Loh *et al*., 2016).

In Viet Nam, exploitation of seahorses had caused declines in their populations, thus requiring the development of adaptive management measures (Giles *et al*., 2006; Stocks *et al*., 2017). Management interventions are necessary to reduce the impact of trawl fleet that catch seahorses and destroy habitats; surveys at major ports by border guards and fisheries surveillance officers; well implemented marine reserves; and reductions in fishing effort, whether seasonally or permanently (Foster & Vincent 2016; Stocks *et al*., 2019).

Way Forward

The exploitation for the trade of seahorses has led to the decline of their wild populations. Trade regulations had been undermined by the persistence of indiscriminate extraction as target species or by bottom trawls. Seahorses are vulnerable to exploitation due to their inherent biology of being slow-moving, limited home range, and low fecundity, which is further aggravated by various natural disasters that cause damage to the habitats. Urgent management of the natural resources is required to mitigate the exploitation of this species. Strict compliance with fishing regulations must be put in place such as the banning of trawlers and other illegal fishing gear. Reducing consumers' demand may also contribute to fishing pressure by implementing a minimum size of at least 10 cm. Survey and monitoring of seahorse catch need strong cooperation with concerned authorities of the respective AMSs. Measures would certainly require prompt cooperation and willing compliance by the fishers and the implementing authorities.

3.1.5 Corals

Coral reefs are the most structurally complex and taxonomically diverse marine ecosystems on earth (Knowlton, 2001; Jackson *et al*, 2001), and occur in more than 100 countries and territories (Souter *et al*., 2020a). Although coral reefs cover only 0.2 % of the seafloor, they support at least 25 % of marine species, providing habitat for tens of thousands of associated fishes and invertebrates (Knowlton, 2001; Jackson *et al*., 2001) and underpin the safety, coastal protection, well-being, food, and economic security of hundreds of millions of people (Souter *et al*., 2020a).

Southeast Asia is the global center or the heart of this incredible diversity and a global hotspot for coral reefs (Kelleher *et al*., 1995), embracing the largest area of coral reefs, *i.e.* nearly 100,000 km^2, almost 34 percent of the world total (Tun *et al*., 2008) but cover only 2.5 % of the earth's ocean surface (Chou, 1994). The region's coral reefs hold more than 77 % or over 600 of the almost 800 reef-building coral species that have been described by scientists (Burke *et al*., 2002, Tun *et al*., 2008), and more than 1300 reef-associated fish species. Most coral reefs within Southeast Asia are located on the continental Sunda and Sahul Shelves, which also have all types of reefs, *i.e.* fringing, platform, barrier reefs, and atolls. More than 60 % of the 557 million people of Southeast Asia live within 60 km of the coasts, many of which are intrinsically linked to natural resources, especially coral reefs. Although many cities in Southeast Asia are developing and growing rapidly, most people of Indonesia, Philippines, Thailand, Viet Nam, and Cambodia remain highly dependent on coastal resources for their livelihoods, especially through fisheries (Tun *et al*., 2008).

The Coral Triangle which includes some or all of the land and seas of three Southeast Asian countries, namely: Indonesia, Malaysia, and the Philippines, and together with Papua New Guinea, Solomon Islands, and Timor-Leste, comprises a biodiversity 'hot spot' that harbors 76 % of the 798 known coral species (Veron, 2000) or at least 590 species of corals (ADB, 2014) and 37 % of the 6,000 worldwide coral reef fish species (Allen, 2008) or 2,057 species of fish (ADB, 2014). Although the Coral Triangle occupies only about 1.6 % of the world's oceans, it covers the largest single coral reef extent of nearly 73,000 km^2 or 29 % of the global coral reef area (Burke *et al*., 2012). This high diversity and extensive habitat, and its associated ecosystems support the lives and livelihoods of an estimated 120 million people.

Coral Reef Diversity

Hard coral diversity remains high in Indonesia, the Philippines, Malaysia, and Viet Nam, with almost 600 species recorded in Indonesia. Many site-specific hot spots of coral diversity (with more than 200 species of hard coral) occur in all Southeast Asian countries, with most hot spot areas occurring on deeper offshore reefs (Tun *et al*., 2008). Veron *et al*. (2009) found that the highest zooxanthellate coral species richness is found at the Bird's Head Peninsula in Raja Ampat archipelago of Indonesia, with 553 species (equivalent to 69 % of the world's total species complement) and individual reefs supporting up to 280 species/ha. Compared with some adjacent areas of the countries bordering the South China Sea, the scleractinian reef-building corals in the south of Viet Nam are diverse and more or less similar to those found in the west of Luzon (433 species) and the south of Palawan (398 species) of the Philippines, and the east of Peninsular Malaysia with 398 species (Huang *et al*., 2014).

Status of Coral Reefs in the Southeast Asian Region

The trends in hard coral cover among the different areas in the regions are varied, indicating some heterogeneity in exposure to disturbance and subsequent recovery. Average hard coral cover in all areas except in the Andaman Sea and Western Sumatera are undergoing considerable fluctuations, while the Andaman Sea and Western Sumatera subregions show a progressive increase in coral cover. In general, the cover of algae had decreased regionally, *i.e.* a substantial decrease in the Philippines until the Straits of Melaka subregion, and a progressive decline in the southern Java until the Andaman Sea subregion (Souter *et al*., 2020b).

Threats to Coral Reefs and Corals

Large-scale coral bleaching events are the greatest disturbance to the world's coral reefs. The mass bleaching event in 1998 wiped out approximately 8 % of the world's corals. Subsequent disturbance events that occurred between 2009 and 2018 have killed about 14 % of the world's corals, more than all the corals currently inhabiting the Australian coral reefs (Souter *et al*., 2020a), and killed up to 100% of corals in several areas in Indonesia (Setiasih *et al*., 2014). Since 2011, the amount of algal cover on the world's coral reefs has increased by about 20 %, mirroring the decrease in hard coral cover. However, Southeast Asia includes the Coral Triangle and contains 30 % of the world's coral reefs, and is the center of global hard coral diversity, showing distinctly different trends from all other regions. This is the only region where the coral cover is substantially greater in 2019 (36.8 %) than when the earliest data contributed to this analysis were collected in 1983 (32.8 %). Also, in contrast with other regions, the cover of algae progressively decreased, resulting in an average of five times more corals than algae on these reefs (Souter *et al*., 2020a).

The influences of local or regional disturbances, such as coral diseases, crown-of-thorns starfish outbreaks, tropical storms, overfishing and destructive fishing, and poor water quality resulting from land-based pollution have undoubtedly also played certain roles in the decline of coral reefs (Souter *et al*., 2020a). Widespread destruction of Southeast Asia's coral reefs was reported throughout the last half of the past century (McManus 1988; Wilkinson *et al*., 1993; Chou, 2000). The 2004 Asian tsunami showed that coral reefs provided some level of coastal protection by absorbing some of the tidal energy while damage to the reefs depended very much on the location and coastal bathymetry (Wilkinson *et al*., 2005). Most of the Southeast Asian reefs escaped the impact, except for those in the Andaman Sea closer to the earthquake's epicenter that started off Sumatra (Chou, 2013).

Overfishing, destructive fishing (blast and poison fishing), sedimentation and pollution, coastal development, and global climate change are threats to the coral reefs (Setiasih *et al*., 2014). Overfishing and unsustainable fishing practices have led to declining fish stocks in almost all Southeast Asia countries, pushing many fishers to resort to destructive fishing practices like the use of dynamite (bomb) and cyanide fishing to obtain food and fish to sell. This is especially evident in Indonesia, Philippines, Thailand, Malaysia (Sabah), and Viet Nam (Tun *et al*., 2008). The poison causes mortality to corals and anemones at low dosages, and brief exposure could result in long-term damage to corals and their zooxanthellae (Cervino *et al*., 2003).

Corals Listed in CITES Appendices

Appendices I, II, and III to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) contain the list of species afforded different levels or types of protection from over-exploitation. The CITES lists some species of corals including the stony corals as well as other types of corals such as the blue corals, organ-pipe corals, and deep-sea corals, as shown in **Table 63**.

Table 63. Species of corals listed in the CITES Appendices

Species	CITES Appendix*	Distribution**	Trade Purpose**
Black corals			
Antipatharia spp.	II	nearshore zones of islands and continents; cosmopolitan in distribution in temperate and tropical areas	Aquarium trade; bycatch of trawls; impacted by global climate change
Red and pink corals			
Corallium elatius (China)	III	West Coast of Japan; Western Pacific	For curio and jewelry trade; used in preparation of traditional medicines in Asian countries; impacted by dredges and trawls
Corallium japonicum (China)	III	West Coast of Japan; Western Pacific	For curio and jewelry trade; used in preparation of traditional medicines in Asian countries; impacted by dredges and trawls
Corallium konjoi (China)	III	West Coast of Japan; Western Pacific	For curio and jewelry trade; used in preparation of traditional medicines in Asian countries; impacted by dredges and trawls
Corallium secundum (China)	III	West Coast of Japan; Western Pacific	For curio and jewelry trade; used in preparation of traditional medicines in Asian countries; impacted by dredges and trawls
Blue corals			
Heliopora coerulea (Fossils are not subject to the provisions of CITES)	II	Shallow reef, exposed reef locations, reef flats and intertidal zones; Indian Ocean – eastern & western; Pacific – eastern central, northwest, southwest & western central	For curio and jewelry trade, and aquarium trade; impacted global climate change
Stony corals			
Scleractinia spp. 13 genera and 42 species (Fossils are not subject to the provisions of CITES)	II	Primary reef-builders; shallow tropical waters; restricted to shallow, well-lit, warm water with moderate to brisk turbulence and abundant oxygen; Indo-West Pacific	For curio and jewelry trade, and aquarium trade; impacted by global climate change
Organ-pipe corals			
Tubiporidae spp. 1 genera and 10 species (Fossils are not subject to the provisions of CITES)	II	Indo-West Pacific; west Pacific, to the south of Japan, west to Africa's east coast, and throughout the Red Sea	For ornaments and jewelry; popular species in aquariums and fairly tolerant of aquarium conditions; impacted by destructive fishing methods that physically devastate the reef
Fire corals			
Milleporidae spp. 1 genera and 29 species (Fossils are not subject to the provisions of CITES)	II	Tropical and subtropical waters; Indian, Pacific and Atlantic Oceans and the Caribbean Sea	For curio and jewelry trade, and the aquarium trade; impacted by global climate change
Lace corals			
Stylasteridae spp. 46 genera, 3 subgenera and 422 species (Fossils are not subject to the provisions of CITES)	II	Pacific -temperate southwest, tropical southwest & northwest Atlantic; Arctic; Antarctic sector of the Indian Ocean & Mediterranean	For curio and jewelry trade, and the aquarium trade; impacted by global climate change

**https://cites.org/eng/app/appendices.php*
***Krishnakumar* et al., *2013*

Challenges and Future Direction

Southeast Asia harbors some of the world's most important and extensive coral reefs. Yet they are the most threatened coral reefs in the world — a threat that imperils the social and economic well-being of millions of people. Action is urgently needed to reverse the current trends, reduce degradation, and move toward sustainable management of coastal resources. In order to reverse the decline of coral reefs, governments, the private sector, resource users, and the general public must be well-informed and assured of the value of well-managed reefs (Burke *et al*., 2002). Efforts at local, national, and international levels are therefore needed to address the problems plaguing the Southeast Asian reefs and for the successful management of the region's coral reefs (**Box 5**).

Box 5. Measures to address the issues that plague the Southeast Asian coral reefs

Management and Planning

- **Improve Management and Conservation Measures**
  - status of coral reefs is largely unknown, therefore mid- to long-term plans should be established to assess the coral reefs, and recommend management measures to conserve these reefs
  - assistance should be provided for mid- (5 years) to long- (10 years) term monitoring programs supported by in-country commitment
  - conservation strategies should be undertaken, focusing on safeguarding, restoring and rehabilitating marine habitats and species, should be implemented
- **Improve Management of Coastal and Fisheries Resources**
  - implement a broad approach for management of coral reefs that is ecosystem-based, respecting biophysical boundaries so that efforts to conserve coral reefs are comprehensive
  - no single management strategy will be right for all locations under all conditions, but it is crucial to enhance the participation of a variety of stakeholders
  - strengthen the existing although few coral reef management plans that also assess the management, performance indicator, impact evaluation, and systematic evaluation as many management plans focus more on ambient monitoring and are mostly ecological
  - avail of the variety of management strategies coordinated and implemented across larger spatial scales that can provide an effective network to enhance all efforts at arresting and reversing reef degradation
- **Establish a Scientific Basis for Sustainable Use and Management of High-Priority Coral Reef Areas**
  - the role of science in the management of coral reefs should be improved
  - make use of the advances in the scientific understanding of coral reef processes to support the more effective management strategies
  - studies to improve understanding and build a scientific basis for coral reef management at a range of locations should be carried out
  - facilitate better understanding of the structure, functions, ecological processes, and causes of coral reef degradation as these are important for increasing coral reef management effectiveness
- **Strengthen Research Capacity and sustainable Management of Coral Reef Resources**
  - resources for sustainable coral reef management should include personnel, property, and finances for supporting research activities and management
  - close the large gaps in knowledge by compiling the coral reef inventory data that have largely been collected as part of small projects
  - ensure that technical facilities and equipment for coral reef research are adequate
  - build capacity for existing coral reef management and research offices by modernizing research equipment, recruiting additional research personnel, and enhancing management capacity for agencies at all levels
- **Improve the Management of Existing MPAs**
  - build the capacity of the staff and resources for effective management notwithstanding the many marine protected areas have been created in Southeast Asia
  - enhance community involvement, capacity for monitoring, and enforcement of regulations
- **Expand the Protected Areas Network**
  - expand the extent of coastal waters under protection — whether through marine reserves or multiple-use MPAs — to protect an ecologically representative sample of the region's biodiversity, sources of larvae, and habitat essential to fisheries
  - ensure that MPAs can protect valuable goods and services and provide a regional resource critical to ecosystem recovery in other areas following major impacts through proper administration and management
- **Establish Management Models and Coral Reef Monitoring System**
  - establish a management approach to improve management and to monitor coral reef status
  - undertake an assessment and monitoring of coral reef status to increase awareness and to support the minimization of negative impacts to coral reef ecosystems

Interventions

- **Halt the Use of Destructive Fishing Practices**
  - stop the practice of destructive fishing as is most damaging to the coral reefs of Southeast Asia, putting an estimated 50 percent of the region's reefs at risk
  - enhance the enforcement and awareness as well as educate fishers, train them to use alternative fishing methods, and provide them with options for alternative livelihoods, which are essential components in reducing the prevalence of destructive fishing practices

Box 5. Measures to address the issues that plague the Southeast Asian coral reefs *(Cont'd)*
• **Reduce Overfishing** - mitigate the effects of overfishing by making sure that major endeavors are focused on not only on reducing fishing effort but also developing alternative livelihoods for fishers considering that overfishing is the most pervasive threat evaluated for Southeast Asia - reducing the fishing effort as this would result in higher catches per fishing hour and higher incomes for those still engaged in fishing. In some cases, no-take zones need to be established around breeding areas and fish migration paths
• **Regulate the International Trade in Live Reef Organisms** - Regulating the trade in live reef organisms must be done at many levels: at the local level, by retraining fishers on the disadvantages of using destructive fishing practices; and at the national level, testing and monitoring are essential and should be improved in both exporting and importing countries so that regulators can identify and endorse "sustainably" caught species
Management and Planning
• **Develop Tourism Sustainably** - properly implement tourism projects as these can provide important incentives for effective management and conservation of coral reefs - promote the development and use of certification schemes, accreditation, and awards that facilitate best practices for hotels, dive operators, and tour operators as these could provide incentives for eco-friendly development
• **Adopt Policies to Reduce Greenhouse Gas Emissions and Climate Change** - adopt measures that reduce coral bleaching for although most corals are already living in water temperatures near the upper limit of their tolerance, climate change threatens to push water temperatures to levels at which the frequency of mass coral bleaching and mortality could increase - take actions to reduce greenhouse gas emissions as this is critical to mitigating the effects of global climate change on Southeast Asian reefs considering the uncertainty associated with climate projections
Information and awareness
• **Improve Mapping, Monitoring, and Networking of Information on Coral Reefs to Support Better Management** - ensure that managers and communities receive the information and management tools necessary to make sound management decisions - monitoring programs on coral reefs should be linked with monitoring of population and development, including upland activities, because this integration of information is a key to understanding changes in coral reef status and to managing the resources - better organization and collection of information, including the establishment of a centralized information node, is crucial as this would enable the whole region to adopt to improved strategic approaches to protecting reefs
• Raise Public Awareness - ensure that the economic and ecological values of coral reefs and the degree to which corals are currently being damaged by human activities are widely understood - the use of models in the implementation of sustainable coral reef management is largely ineffective because of inadequate education and awareness of laws, management strategies, and general understanding of marine resource management issues - introduce to - promote major awareness-raising campaign to change behavior and create political will among the managers and general public on the aspects of policy change

3.1.6 Inland Species

Irrawaddy Dolphin

The Irrawaddy dolphin (*Orcaella brevirostris* Owen in Gray, 1866) is a species of dolphin found near the coasts and in estuaries in some parts of Southeast Asia. It is usually 1.0 m long weighing about 10 kg at birth but could reach 2.3 m long at full maturity. An adult can weigh more than 130 kg and its life span is about 26–30 years (Tun, 2007). Due to its decreasing population, urgent conservation measures are appropriate and being called for to ensure their sustainability. Irrawaddy dolphins are listed as globally endangered by the IUCN Red List Authority (Minton *et al*., 2017). The Irrawaddy dolphin is also in Appendix I of CITES which disallows all commercial trade in species that are threatened with extinction.

The Irrawaddy dolphin belongs to a group of migratory mammals in foraging habitats in the Southeast Asian region and India. The species' movement is seasonally changing depending on the water level and food supply. These freshwater dolphins inhabit the far upstream not only in nearshore marine waters, as opposed to the other members of their species. In Southeast Asia, their distribution is in the Mekong River in Cambodia and Lao People's Democratic Republic, the Ayeyarwady River in Myanmar, Mahakam in Kalimantan of Indonesia, and two brackish lagoons in Songkhla, Thailand (**Figure 84**). Spatial distribution of freshwater dolphin in East Kalimantan, Indonesia is found in Kaman, Pela Kecil, Bank of Pela Besar Rivers, Semayang, and Melintang Lakes. Freshwater dolphins have been used as ecotourism attractions for local and foreign tourists. Some efforts have been made to conserve the freshwater dolphins in East Kalimantan, Indonesia, namely: habitat protection from pollution and sedimentation, fisheries area protection to provide natural food, and increased local people's role in conserving the existence of these dolphins (Dharmadi *et al*., 2008).