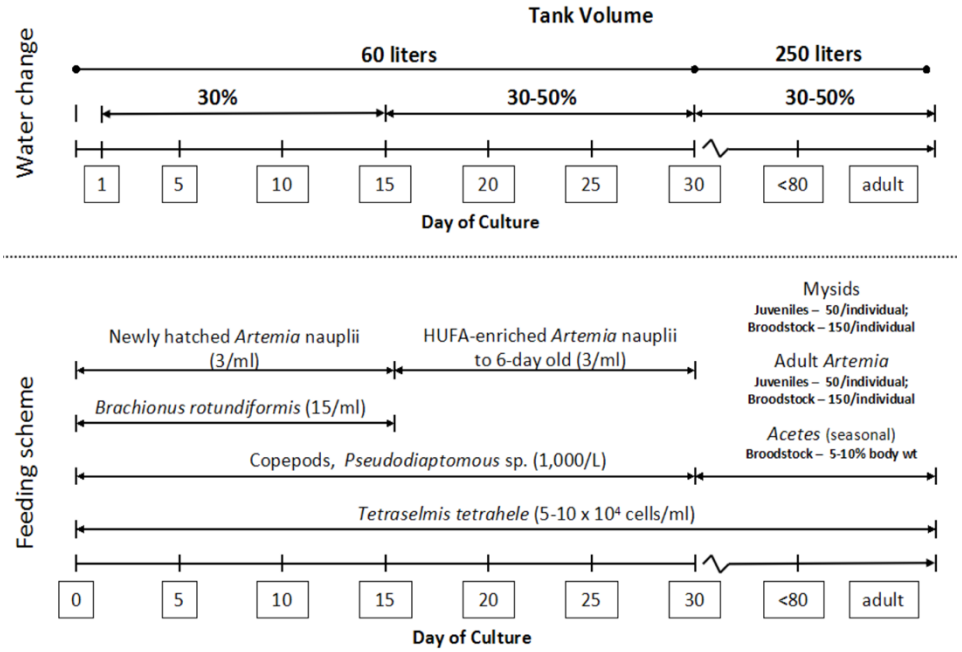

Figure 73. Feeding and water management scheme for seahorse culture

an important key factor that will help ensure the success of seahorse seed production. **Figure 73** shows the feeding and water management schemes for seahorse culture. Development of techniques for mass production of mysids and copepods as natural food to support seahorse seed production needs to be pursued to ensure available supply for seahorse hatchery maintenance. Furthermore, an efficient and reliable water supply system is important in maintaining maximum efficiency in the management of the seahorse hatchery. Significant breakthroughs at SEAFDEC/AQD on breeding and nursery rearing of tiger tail seahorse *H. comes* included improved reproductive performance and higher survival and growth rates in newborn and juvenile seahorses. Experiments also found that nursery and grow-out culture of seahorses in illuminated sea cages are feasible, and hence could also provide an alternative culture method to growing of seahorses in the hatchery.

Resource enhancement strategies for seahorses include assessment of the seahorse natural stocks to establish baseline information on the wild seahorse population. Such information will be useful contributions to marine conservation of seahorses to protect the natural resources and fisheries management. Participatory involvement of the communities in the management of the natural resources is important and needs to be promoted through dissemination of information, protection, and conservation of the coral and seagrass areas which are the natural habitats of seahorses.

3.6 Coral Reef Ornamental Species

Coral reef ecosystems are valuable source of food and income to coastal communities around the world. Yet destructive human activities have now put nearly 60 percent of the world's coral reefs in jeopardy, according to a 1998 World Resources Institute study (Bruckner, 2000). Pollution and sediments from agriculture and industry, and overexploitation of fishery resources are the biggest problems, but the fragility of reef ecosystems means that even less damaging threats can no longer be ignored. Prominent among these is the harvest of corals, fish, and other organisms for the aquarium, jewelry, and curio trades, as well as live fish for restaurants.

With more than 100,000 km^2 of coral reefs along the coastlines of Southeast Asia, the region has more coral reef area than any other parts of the world. The region's reefs contain the highest coral biodiversity in the planet. It contains over 3,000 species of fish comprising around 20% of the world's marine fish species, and over 50% of the world's coral species.

In the last 50 years, Southeast Asia has undergone rapid industrialization and population growth. As human populations have grown, so have pressures on the natural systems that sustain us. Economic market expansion has stimulated the construction of ports, airports, cities, and other infrastructure—often in ecologically sensitive areas. As a result, coastal resources are being stressed at unsustainable rates. However, exploitation is not only local in nature, as trade in live reef food fish and ornamentals has fueled region-wide overexploitation of lucrative species, often using destructive capture techniques. Many of the region's reefs have already been severely damaged.

Malaysia's coral reefs cover an estimated 3,600 km^2, most of which are found in Sabah and Sarawak, and on the eastern coast of Peninsular Malaysia. Coral diversity is

highest in Eastern Malaysia, which is home to about 550 species. However, the country's coral reefs face a number of environmental threats. Agricultural development in Peninsular Malaysia contributes to sedimentation and nutrient runoff rates higher than would otherwise be the case. In East Malaysia, destructive fishing practices such as cyanide fishing are prevalent, particularly in Sabah. In Sarawak, the major threat that coral reefs face is river sedimentation. Overall, the major factors driving sub-optimal coral reef conservation are gaps in institutional capacity relating to management and enforcement, as well as resource-use conflicts (Asian Development Bank, 2014).

It is estimated that 14-30 million fish, 1.5 million live stony corals, 4 million pounds of coral skeleton, 65-110 thousand pounds of red and black coral, and 9-10 million other invertebrates are removed each year from ecosystems across the world to supply the aquarium, curio or home decor, and coral jewelry industries. Together, these three industries are known as the global trade in ornamental coral reef species. This trade has a collective annual value estimated in the hundreds of millions of dollars and is an extensive industry that involves over 45 source countries. Although collection of coral reef ornamental species primarily occurs in Southeast Asia, the majority (> 60%) of collected animals are exported to the United States (Thornhill, 2012).

3.6.1 Trade in Coral Reef Ornamental Species

Trade in coral reef ornamental species supports a multi-million dollar industry but in some places threatens vulnerable coral reef species and ecosystems due to unsustainable practices and lack of effective regulation. Trade includes over 1,800 species of fish, hundreds of species of corals, over 500 species of other invertebrates, and live rocks (Dee *et al*., 2014). To supply this trade, fishers deplete the fish populations as they rely on destructive fishing practices.

Destructive fishing practices and overexploitation of certain fish species cause significant effects on populations of coral reef fishes and other organisms, as well as on reef ecosystems. Nearly 25,000 metric tons of reef fish are harvested alive each year for the fish food trade, with an annual retail value of about US$1 billion (Bruckner, 2000). Unfortunately, cyanide fishing is the preferred method for capturing these fish, which currently occurs in at least 15 countries, including major exporters like Indonesia and Philippines (Dee *et al*., 2014). One of the most deadly poisons known, cyanide usually only stuns the fish, but it destroys coral reef habitats by poisoning and killing non-target animals, including corals. Other chemicals, including quinaldine and plant toxins, are also used to capture reef fishes alive. Field data on these practices are hard to come by because they are illegal, and thus fishers are secretive about them.

Destructive fishing practices probably figure in the high mortality rate of organisms while they are in transit. A 1997 survey of US retailers found that one-third to more than one-half of the aquarium fish imported from Southeast Asia die shortly after arrival (Bruckner, 2000). No conclusive studies on the reasons have yet been published, but these deaths are believed to be due to the poisons used in capture or the stress of handling and transport, or both. The need for replacements is one factor that keeps the demand high and thus contributes to overexploitation.

International trade in marine ornamental fishes has been going on for decades, but the growing popularity of reef aquaria has increased the types and the quantity of species in trade. More than a thousand species of reef fishes and hundreds of coral species and other invertebrates are now exported for aquarium markets. The coral reef wildlife trade targets species ranging from the foundation of coral reefs (*e.g.* corals and live rocks for aquariums and home decor) to top predators (*e.g.* sharks for teeth, jaws, and other curio items) (Dee *et al*., 2014). The vast majority of fishes come from the reefs in the Philippines and Indonesia, considered to be the world's most biologically diverse marine areas, and most stony corals come from Indonesia. But the commercial harvest of ornamental reef fishes and invertebrates (other than stony coral) occurs on reefs worldwide, including those under US jurisdiction. In 1985, the world export value of the marine aquarium trade was estimated at US$25 million to US$40 million per year. Since 1985, trade in marine ornamentals has been increasing at an average rate of 14 percent annually. In 1996, the world export value was about US$200 million. The annual export of marine aquarium fish from Southeast Asia alone is, according to 1997 data, between 10 million and 30 million fishes with a retail value of up to US$750 million (Bruckner, 2000).

According to an analysis of one year US import records, damselfish (Pomacentridae) constitute over 50% of the quantity of fish in trade. This is followed by wrasses (Labridae), angelfish (Pomacanthidae), gobies (Gobiidae), surgeonfishes and tangs (Acanthuridae), cardinalfishes (Apogonidae), wormfishes (Microdesmidae), butterflyfish (Chaetodontidae), dragonets (Callionymidae), and sea basses and groupers (Serranidae) as the top 10 families of marine aquarium fishes imported to the US (Thornhill, 2012).

Malaysia has a relatively small ornamental fishery industry. In 2000, up to 50,000 fishes were exported annually at an export value of around US$100,000. In 2010, ornamental fish output totaled 3.5 million individuals, most of which were freshwater species, but the value and trade for marine

aquarium fish is still unknown (Asian Development Bank, 2014).

Despite the potential impacts of collection, the stock status and sustainable harvest levels of most ornamental species remain largely unknown and unmonitored. The life history, demographic, and population data required for traditional stock assessments are typically unavailable. In general, stock assessments for many species in the trade may be difficult because rare species are targeted. Furthermore, it often targets juveniles, affecting the population's age structure, and brightly-colored males, potentially skewing the sex ratios of the population (Dee *et al*., 2014).

3.6.2 Impact of Trade in Coral Reefs Ornamental Species

It is widely known, that collection of marine tropical fishes for the ornamental fish industry has caused extensive damage to coral reef environments throughout Southeast Asia. Although there are no firm estimates of the impact that trade is having on overall coral reef health, it is unlikely that it is minimal, as some believe. Indeed, although the diversity, standing stock and yield of coral reef resources are extremely high, most coral reef fisheries have not been sustainable for long when commercially exploited. Indonesia, the world's largest exporter of coral reef organisms, is a case in point. Because of overfishing and destructive practices such as using cyanide to stun fish for capture, coral mining, and blast fishing, only five to seven percent of Indonesia's reefs were estimated in 1996 to have excellent coral cover. Unfortunately, because of the growing international demand for aquarium organisms and live food fish, overharvesting in nearshore waters has simply pushed commercial ventures to expand their harvesting into more remote ocean locations.

Corals in trade may be live specimens, skeletons or "live rock" which is a coral skeleton with coralline algae and other coral reef organisms attached. Often broken out of the reef with crowbars, live rock is a reef structure and removing it harms the habitat for other species. Extraction of stony corals and live rock is known to increase erosion, destroy habitat, and reduce biodiversity. It is likely that the destruction of coral reef ecosystems will continue unless conservation efforts are improved.

The stony coral trade is dominated by exports from Southeast Asia and the South Pacific. In 2005, Indonesia supplied about 91% of international market demand, while the rest is distributed among countries such as Fiji, Bahamas, Solomon Islands, and Tonga (Timotius and Shahrir, 2009). The United States either prohibits or strictly limits the harvest of stony corals in most of its own waters not only because of the key role that corals play in the ecosystem but also of the widespread concern that the organisms are vulnerable to overexploitation. But the lucrative US market remains open to foreign corals, and over the period of 2000-2010, the US accounted for an average of 61% of global trade, while the European countries took 31% (Wood *et al*., 2012).

Until about a decade ago, more than 90% of the corals harvested for international markets were sold for decoration; these were harvested live, bleached, and cleaned to remove tissues, and exported as skeletons. Although the trade in coral skeletons has remained fairly constant since 1993, the quantity of live specimens for the aquarium trade has grown at a rate of 12% to 30% per year during the 1990s. In 1997, live corals constituted more than half of the global trade (Bruckner, 2000). Trade of live corals continued to show an overall increasing trend, rising from nearly 600 thousand pieces in 2000 to 1.1 million in 2009 (Wood *et al*., 2012).

Aquarium coral specimens are typically fist-sized colonies that represent six months to ten years of growth, depending on the type of coral. Most often, these are slow-growing, massive species with large fleshy polyps, many of which are uncommon or are vulnerable to overexploitation because of their life history characteristics. The flowerpot coral (*Goniopora* spp.) and the anchor or hammer coral (*Euphyllia* spp.) are the most abundant corals in trade, partly because they must be continually replaced. Surviving poorly in captivity, these species are also easily damaged during collection, susceptible to diseases, and acclimate badly to artificial conditions.

The preferred corals for the curio market are the "branching" species as they grow faster than most corals destined for the aquarium trade. However, they are traded at a significantly larger size. Colonies in trade are often more than a meter in diameter, representing a growth of a decade or more. In addition, these species are most susceptible to crown-of-thorns sea star predation, physical damage from storms, and bleaching.

3.6.3 Efforts to Improve Conservation

Several exporting countries have recognized the potential threats associated with the marine ornamental trade and have taken steps to address them. Some have implemented various measures to protect coral reef species, including marine protected areas (MPAs), harvest regulations (*e.g.* gear type, permits, quotas), and/or required documentation (*e.g.* quarantine certification). For instance, Philippines banned the collection of giant clams, seahorses, and black and scleractinian corals (Dee *et al*., 2014).

Instead of banning coral collection, Australia has developed an effective management strategy designed to ensure sustainability of the resource. Coral reef habitats

have been zoned for different uses, including no-take areas. Collectors are licensed and collection of coral is permitted only in selected areas that amount to less than 1% of the reefs in a region. Collectors have harvested 45 to 50 metric tons of corals per year for 20 years, with no noticeable impact on the resource (Bruckner, 2000).

Although there are no harvest quotas for most ornamental species, Indonesia has established collection quotas for many scleractinian corals. Approximately one million pieces of live corals are permitted for export annually, including a growing number of farmed corals (Dee *et al*., 2014).

In Malaysia, the lack of stock assessments and quotas for the many species leave MPAs as the most widely used measure for coral reef and fish conservation.

3.6.4 International Efforts

The primary international mechanism regulating the coral reef wildlife trade is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which is an agreement among 175 countries. All stony corals including live rocks are listed in Appendix II of CITES. Commercial trade in Appendix II species is permitted under CITES, provided that the exporting country finds that the take does not constitute a significant risk to the species in the wild or its role in the ecosystem. Statistics on the type and number of coral reef species in trade, sources, and importers have been available since 1985. However, most of the ornamental marine fishes involved in trade were not CITES listed (Dee *et al*., 2014).

3.6.5 The Role of Mariculture

One way to reduce the pressure on coral reef ecosystems is to improve the ability to farm desirable organisms for trade. This would make it possible to create a stunning reef aquarium using only captive-bred or cultured organisms, including live rock, stony and soft corals, giant clams, fishes, and algae. Mariculture can be an environmentally sound way to increase the supply of such organisms, and it has proven successful for many invertebrates and certain fishes.

There is now a growing trend towards fragmentation and propagation of corals. Most branching corals, for instance, can be propagated from small clippings taken from a parent colony and achieve a five-fold to ten-fold increase in biomass in a year or less. More than 75 species of corals can be captive-bred, but only fast-growing corals such as *Acropora*, *Pocillopora*, *Seriatopora*, *Hydnophora* and *Montipora* appear to be economically profitable. Until now Indonesia is the biggest exporter of ornamental corals from both wild and cultured (Timotius and Shahrir, 2009; Wood *et al*., 2012).

Although mariculture of coral reef fishes has proven more complicated, a number of farmed fish species are being made available to hobbyists. While mariculture operations make up only a small fraction of the total current market, captive-bred fish currently account for less than 2% of the market and include only two or three dozens of the 800 or so species in trade. Wild-harvested coral reef invertebrates and fishes are still widely available, cheaper, and are often larger than cultured organisms.

3.6.6 Management Approaches

The impact of the marine ornamental trade must be reevaluated and additional strategies should be developed and implemented to better manage the detrimental impacts on harvested species and the ecosystem. Ensuring sustainability will require action, capacity-building, and education at each step of the trade, from harvest, through export and import, to the consumer market.

Ensuring a sustainable trade in coral reef organisms will require long-term international commitment to a policy that protects them from overexploitation and prohibits destructive harvest practices. The key step is for exporting and importing countries to establish data-gathering and monitoring systems to obtain accurate species-specific information on the trade in ornamentals, including both numbers of organisms traded and the extent of their survival from harvest to consumer.

Countries should complement trade statistics with *in situ* monitoring. Information on the life history of the species of concern, including its distribution, abundance, and role in the ecosystem; the life stage at which it is harvested; its longevity in captivity; and potential threats that affect the species and its habitat must be evaluated in order to determine sustainable harvest levels. It is unlikely that this will be practical for more than a handful of the most abundant coral reef species currently in trade. However, management plans that apply a precautionary approach and are linked with monitoring of collection sites can provide warnings about the more egregious signs of environmental deterioration or overharvesting. Management plans must include the limitation of harvesting to a geographic subset of each potentially harvested habitat. Geographic areas designated for harvesting may be combined with temporary closures or rotation of areas, as long as a significant percentage of areas remain permanently closed to harvest. Without effective law enforcement, the management plans will be useless. Choosing appropriate collection areas, education, and partnerships with local communities can enhance the effectiveness of enforcement.

Ultimately, any decision on whether a country should allow exports of coral reef species–and if so, at what level–must take into account the economic and social importance of the industry, the capacity of the resource to sustain harvests, and the effects of harvesting on the activities of other reef users. It is critical that the total quantity of organisms in trade does not exceed the natural rate of replacement, that the methods of collection should be as benign as possible, and that significant areas of habitat set aside for non-extractive uses. Mariculture alternatives must be critically examined to ensure that they do not contribute to additional coral reef losses through spread of disease or introduction of non-native species that can out-compete native organisms. By improving collection, handling, and transport, mortality will decline throughout the chain of custody. Improved survival in captivity would translate to a manageable demand for wild specimens, thereby diminishing the negative effects of the trade on the threatened coral reef ecosystems of the world.

The development of management plans that result in sustainable harvests is essential to the marine ornamental industry. But more importantly, such plans could also provide a crucial boost to local economies. Once it has become a sustainable industry, the trade in marine ornamentals could provide steady and permanent income for coastal communities in the Southeast Asian region.

3.7 Challenges and Future Direction

Throughout the past decades, the Southeast Asian countries have been confronted with even more stringent requirements that aim to ensure the sustainable utilization of fishery resources. Among several measures toward such direction are those that point towards conserving and assuring the existence of species that are possibly under threat, such as those specified under the framework of the Code of Conduct for Responsible Fisheries (CCRF), particularly the IPOA for Conservation and Management of Sharks, and transboundary and highly migratory species that are being managed by RFMOs.

In addition, CITES is another important Convention that aims to regulate the international trade of species that are listed under its Appendices. During the past decade, several proposals for listing of commercially-exploited species have been accepted for the CITES Appendices. Listing of aquatic species into the CITES Appendices could result in several problems in trading and sustainable utilization of the species, because of difficulties in identifying look-alike species and some species that are being traded only in part, or in processed forms. Furthermore, difficulties in issuance of Non-Detriment Findings (NDF) document to allow trading of some specimens could face problems due to several requirements, while down-listing or delisting of species from the CITES Appendices could also be complicated or almost impossible.

Moreover, listing of the commercially-exploited species of Southeast Asia into the CITES Appendices would result in discontinuity of data collection. Most developing countries tend to follow the results from the CITES Conference of Parties and add the said species into their respective list of protected species at the national level. As catching of such species is no longer allowed, catch data would no longer be recorded by the countries in any formal data collection system. This results in difficulties in monitoring the status and trends of such species in the future. While several aquatic species, either target or non-target species, have already been listed in the CITES Appendices, several commercially-exploited aquatic species are under consideration by the CITES Conference of Parties and could be accepted for listing in the near future. This concern therefore needs to be closely monitored and countries should be well prepared for any circumstance.

In order for the countries in the region to be always well prepared, monitoring of the status of relevant species that may be subject to international conservation and management measures should be enhanced. Countries may need to consider incorporating long-term data collection of such species in their respective national statistical systems. This would also facilitate the development of science-based management measures for such species at the national and regional level, as well as in coming up with common or coordinated positions that could be used during discussions on the species at international fora, particularly at CITES Sessions organized biennially. Furthermore, establishment of a mechanism in obtaining joint positions of the Southeast Asian countries towards CITES proposals needs to be considered. Other management measures that aim specifically at assuring sustainable utilization of the species as well as enhancing the wild population for species under international concern (*e.g.* from development of breeding and nursing technologies and stock enhancement strategies, etc.) should also be explored and documented for future reference.

4. UTILIZATION OF FISHERY RESOURCES

4.1 Status, Issues, and Concerns

The Codex Alimentarius Commission (2004) defines traceability or product tracing as "the ability to follow the movement of a food through specified stages of production, processing, and distribution." In an increasingly complex food system, traceability has become the most important tool to deal with issues and problems associated with food safety and quality assurance, thus allowing business to avoid the risks and gain the consumers' trust.