illegal, unregulated and unreported (IUU) fishing, and regions including Indonesia and Philippines have IUU catches that greatly exceed those from legal fishing (Anderson *et al*., 2011). On the other hand, in an attempt to start some regulatory foundation on sea cucumber harvesting in the Philippines, a national standard on the quality of dried product for sandfish was ratified in late 2013 (PNS/BAFPS, 2013). This includes specifications on moisture content (less than 15% by weight), salt content (less than 2.5%), acid soluble ash (2.5%), and a minimum length of 5 cm, among others. This minimum length of the dried product was taken as the minimum size acceptable for global export quality, and translates to at least 320 g of live specimen. So, future harvests should target animals that are more than this minimum size requirement.

Sea cucumber fishery has been a traditional culture of Southeast Asian countries for centuries, but aquaculture of these species is relatively young. The boom-and-bust nature of wild harvesting and the alarming decline in wild stocks put pressure on aquaculture to be developed and enhanced quickly. It is clear however, that there are many gaps in the production and culture technology, and many more aspects need modifications and enhancements. This does not only include protocols for domestication of breeders, larval or juvenile rearing, and grow-out phases of production, but importantly needs to cover post-processing component as well. This further encompasses areas involving the socio-economic and governance aspects to ensure equitable benefits among stakeholders and maintain a sustainable supply of wild and cultured stocks to meet the increasing global demand for *trepang*.

Management

In the light of the lack of strong local governance, international regulations that control trade, such as CITES Appendix II, could be one of the best hopes for the conservation of the highly valued sea cucumber populations (Anderson *et al*., 2010). Appendix II listing would require exporting nations to certify that their sea cucumber exports would not be detrimental to the survival of the species (Anderson *et al*., 2010). Alternatively, import tariffs can benefit the long-term conservation of renewable resources and usually benefit the exporting country (Brander and Taylor, 1998). Unfortunately, the process by which international regulations are developed is often too slow to react to the global expansion of high-value invertebrate fisheries to effect meaningful conservation (Berkes *et al*., 2006). Where sufficient governance exists, Anderson *et al*. (2010) suggested two important steps to manage existing and future holothurian fisheries. First, the expansion rate of new fisheries had to be best reduced to a level where management has time to react to early warning signs of resource depletion. Second, lacking of changes in the regulations, catch trajectory and patterns of serial spatial, species and size expansion or depletion are largely predictable. Knowledge of the impending sequence of events can therefore be pre-emptively incorporated into the management of new and existing high-value marine fisheries. Anderson *et al*. (2010) concluded that there is urgent need for better monitoring and reporting of catch and abundance data and proper scientific stock and ecosystem impact assessment to ensure more sustainable harvesting of sea cucumbers.

3.5 Seahorses

Seahorses (Family Syngnathidae) belong to genus *Hippocampus* consisting of 35 genera of pipefishes, pipehorses and seadragons and falling within the order Gasterosteiformes (Vincent, 1996). Of the 47 known species of seahorses in the world, nine species are

Table 63. Seahorses (*Hippocampus* spp.) identified in Southeast Asia

Scientific Name	FAO Common Name	Distribution in Southeast Asia	
		Confirmed	Suspected
Hippocampus barbouri	Barbour's seahorse	Indonesia, Malaysia, Philippines	
H. bargibanti	Bargiban's seahorse	Indonesia, Philippines	Malaysia
H. comes	Tiger-tail seahorse	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	
H. denise	Denise's pygmy seahorse	Indonesia, Malaysia, Philippines	
H. histrix	Spiny seahorse	Indonesia, Malaysia, Philippines, Viet Nam	Brunei Darussalam, Myanmar, Singapore, Thailand
H. kelloggi	Great seahorse	Indonesia, Malaysia, Philippines, Thailand, Viet Nam	Brunei Darussalam, Myanmar, Singapore
H. kuda	Black seahorse	Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam, Myanmar
H. mahnikei	Japanese seahorse		Thailand, Viet Nam
H. spinosissimus	Hedgehog seahorse	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam
H. trimaculatus	Flat-faced seahorse	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam

Source: *Lourie* et al. *(1999); Lourie* et al. *(2004); Koldewey and Martin-Smith (2010)* confirmed to be distributed in the Southeast Asian region with some species still not confirmed (**Table 63**).

Recently, there has been an increasing interest to culture seahorses not only to address unsustainable trade for traditional medicine, aquarium fishes, and curios, but also mainly to reduce the pressure on the wild stocks. Seahorses have been harvested from Asian waters for use in traditional medicines such as *jamu* medicine in Indonesia and the Philippines, *kanpo* in Japan, *hanyak* in Korea, as well as traditional Chinese medicines (TCM) which require an estimated 20 million seahorses every year (Vincent, 1996). In May 2004, all species of seahorses were listed in Appendix II of the Convention on International Trade of Endangered Species of Flora and Fauna (CITES), which implies that 'sustainable' trade is still allowed but must be controlled in order to ensure that their use is compatible with their survival.

3.5.1 Trade in Seahorses

Since the mid-1980s, seahorses have been collected and traded internationally to supply the aquarium, curio and home decor, and traditional medicine industries. Trade has grown rapidly, including a ten-fold increase in quantity from the mid-1980s to the mid-1990s. As of 1995, over 20 million seahorses and 32 countries were involved in the seahorse trade (Vincent, 1996). Since the mid-1990s, seahorse collection and export continued to grow both in quantity and in the number of countries involved (at least 72, including 46 exporting and 45 importing nations). However, in recent years, trade has ebbed slightly, possibly as a result of a collection ban in the Philippines (Vincent *et al*., 2011).

Since 1996, Thailand has been a major exporter of seahorses, but the role of other countries has varied with time over the past 15 years. India, Philippines, Viet Nam, Mexico, Tanzania, and China have all been major sources of dried seahorses at various times. Indonesia, Viet Nam, Sri Lanka, and Philippines until 2005, were the major source countries for live seahorses, the dominant markets of which are similar to the rest of the coral reef wildlife trade, *i.e.* the US and the European Union as the primary markets (Vincent *et al*., 2011).

Tracking the seahorse trade is a significant challenge. Seahorses are collected by either small-scale, artisanal operations (approximately 5% of trade) or as the result of by-catch from shrimp and demersal fish trawling (approximately 95% of trade) because they have similar size and habitat requirements with shrimps, and are slow swimmers. In both capture methods, catch data are rarely recorded, making it difficult to monitor the exploitation patterns over time. When seahorses are declared on import and export systems, they are rarely differentiated by species and mixed species assemblages are often shipped together in the same container (Vincent *et al*., 2011). Listing of seahorses in Appendix II of CITES has improved such a situation in recent years. According to CITES trade data, 28 out of 48 known species are involved in trade, including 18 species harvested for traditional medicine and/or curios whereas 27 species are used in home or public aquariums (Vincent *et al*., 2011).

3.5.2 Impact on Wild Seahorse Population

There have been few scientific studies on the ecological impacts of seahorse collection by comparing similar locations with and without collection. As an alternative to this approach, a number of scientists, most notably *Ms. Amanda Vincent* and the non-profit organization Project Seahorse, have inferred the status of seahorse populations through examination of trade data and catch reports, as well as interviews with fishers from various countries. Results from the interviews with fishers and exporters commonly indicate declining abundances and catches in many countries across the world. From such results, Vincent (1996) concluded that seahorse catch declined by 15-20% between 1990 and 1995 in Southeast Asia. At that time, large size seahorses had become increasingly rare, which drove collection to less desirable small size individuals, including juveniles.

Vincent *et al*. (2007) also studied the impacts of seahorse fishing in central Philippines by examining the catch per unit effort (CPUE) from 1996 to 1999. The analysis found that between 2.94 and 3.43 seahorses were collected per fisher per night. These values are considered to be very low and are likely indicative of depleted populations. Comparisons between CPUE data and information gleaned from interviews with fishers and buyers indicated that there were major declines in seahorse populations over time. Fishers reported that 50-100 seahorses were collected per fisher per night during the 1960s and 1970s, but this number declined to 10-50 seahorses per fisher per night from 1980-1985 to less than 4 seahorses per fisher per night in 2000. The diminished CPUE suggested that seahorses are overfished in central Philippines.

Similar indicators of seahorse decline have been reported in other areas of Southeast Asia. In Viet Nam, for example, seahorses are collected as by-catch from shrimp and demersal fish trawling. Seven species are collected including *Hippocampus spinosissmus*, *H. trimaculatus*, and *H. kuda* being the most common species in trade. From 1980 to 2001, trawling effort increased 250% and the associated by-catch concomitantly increased as a result. Around 2.3 million seahorses were collected each year from Viet Nam, with most animals exported through unofficial channels to China for TCM. CPUE was estimated to range from 0.33 to 2.50 depending on the region and year. These consistently low CPUE values indicate a seahorse population that is dispersed, patchy, and declining. Overall, seahorses were estimated to have declined by 30-60% during the preceding two to five years.

Fishers and traders also reported decreasing seahorse abundance in nearby Malaysia and Thailand (Perry *et al*., 2010), where in Malaysia, fishers indicated population declines of 68±24% over 12.5 years. Most interviewees simply stated that there were now considerably fewer seahorses than in the previous years, however, some indicated that the reductions resulted from overfishing. In Thailand, 81% of the interviewed seahorse collectors and traders suggested that seahorse catches were declining and none of the interviewees thought that seahorse populations had grown. Fishers and traders estimated that the seahorse catch had declined by 22-96% over 2.50-15.00 years in Thai waters. As was the case for central Philippines and Viet Nam, the causes of seahorse declines in Malaysia and Thailand were attributed to over-exploitation and habitat degradation.

3.5.3 Breeding and Rearing of Seahorses

The first efforts to breed seahorses commercially started in China in 1970s, and in 1980s literature from mainland China conveyed the impression that seahorse culture was well understood. Technical problems encountered were vulnerability to diseases and the need to provide the right diet for seahorses. However, economic crisis in 1980s led to widespread closure of seahorse farms in China. Also in 1970s and 1980s, experimental breeding and rearing of seahorses were tried in small-scale systems in research institutions in Australia, Japan, and Venezuela (Fan, 2005). Commercial development of seahorse aquaculture, particularly the big-bellied seahorse *H. abdominalis* was undertaken in 1990s in Australia, New Zealand, and the USA. In Southeast Asia, Viet Nam showed growing interest for the culture of *H. kuda* (Pham, 1993).

In late 1990s to early 2000s, considerable research efforts were carried out leading to the publication of additional information on breeding and rearing of seahorse. Research was conducted on increasing the scale of operations in the rearing of *H. trimaculatus* in India using 2,000 L tanks for broodstocks and 30 L rearing tanks (Murugan *et al*. 2009). In the Philippines, illuminated floating bamboo and nylon mesh cages were used for grow-out rearing of juveniles (Garcia and Hilomen-Garcia, 2009). Globally as of 2010, at least 13 species of seahorses have been used in commercial culture or in ongoing research studies. Nonetheless, technical challenges in the areas of diseases, nutrition, and species-specific rearing techniques still remain (Koldewey and Martin-Smith, 2010).

Broodstock management and larval rearing

Most of the recent studies on seahorses have focused on establishing suitable technologies for effective broodstock development and maintenance as well as captive breeding through improvement in the husbandry techniques, particularly on feeding. Seahorses are ambush predators that feed on a variety of mobile preys consisting mostly of planktonic crustaceans such as mysid shrimps, amphipods, copepods, or any tiny larvae that can fit into their elongated snouts (Woods, 2002; Kendrick and Hyndes, 2005; Kitsos *et al*., 2008). In Malaysia, Nur *et al*. (2015) reported that the best reproductive performance was obtained in *H. barbouri* broodstock fed with post-larvae shrimp, although frozen mysids can also be used in its culture. This observation corroborates with findings of SEAFDEC/AQD that the reproductive performance of *H. comes* markedly improved when fed with mysid shrimp alone or in combination with *Artemia* (brine shrimp) and *Acetes* (Buen-Ursua *et al*., 2015). Significantly higher brood sizes were obtained from seahorses fed with mysid shrimps as a single diet or combined with the other natural food than *Artemia* only, *Acetes* only and *Artemia*+*Acetes* (107-152 broods). Shorter parturition interval was also observed in seahorses fed single diet of mysid, or mysid in combination with other natural food (13-26 days) than those fed with single diet of *Artemia* (60 days). In Viet Nam, Troung (2011) reported on a successful culture of seahorse with total production of about 30,000 animals from three small hatcheries in Khanh Hoa Province. Broodstocks were collected by divers or taken from F1 generation. Seahorses were fed on frozen mysids and *Acetes* with vitamin A, C, and E added to the feed, to improve gonad quality and strengthen fish larvae. In India, Murugan *et al*. (2009) observed significantly higher reproductive efficiency when the three spotted seahorse *H. trimaculatus* were fed with amphipods than seahorses fed with sergestid shrimp. Furthermore, lower number of deformed larvae was observed in seahorses fed with amphipods.

Larval rearing of newborn and juvenile seahorses (0 day-6 months old)

Technologies have been developed by SEAFDEC/AQD for the larval rearing of newborn and juvenile seahorse, *H. comes*. The use of UV-treated seawater for rearing of newborn seahorses gave better survival and growth than when sand-filtered and chlorinated seawater are used. The use of copepods as replacement for brine shrimp as food for newborn seahorse was also evaluated since brine shrimp is expensive and copepods are abundant in brackishwater ponds. However, depending on the source, the copepods sometimes harbor high bacterial load. Newborn seahorses fed with copepods treated with formalin bath had better survival than those stocks fed with untreated copepods. Survival of two-six months old juveniles is more stable mainly due to their ability to feed on mysid shrimps and *Acetes*. In Viet Nam, Troung (2011) reported that seahorse fry were fed with copepod three times per day from birth to 40 days old. In addition, enriched *Artemia* nauplii (DHA Selco, INVE) were fed to fry from 10 days onwards. In India, Murugan *et al.* (2009) observed higher survival rates in nine and 12 days old juvenile *H. trimaculatus* fed with copepodites compared to those fed *Artemia* nauplii. On the other hand, higher survival was observed in zero to six days old juveniles fed with copepod nauplii than those fed rotifers. Survival of pelagic phase juveniles was higher under continuous lighting conditions with light intensity of 2000 l×. Juvenile and adult *H. trimaculatus* can tolerate salinity not lower than 26 and 17 ppt, respectively.

Nursery and grow-out in illuminated sea cages

Garcia and Hilomen-Garcia (2009) reared juvenile *H. kuda* in illuminated sea cages using thawed *Acetes* as feed. After 10-12 weeks of rearing, body weight and stretch height of seahorse fed with *Acetes* in the lighted cage were heavier and longer. Survival in all groups ranged from 9% to 74%. Survival of seahorse in lighted cages with *Acetes* feeding was consistently lower as a likely result of crustacean and piscine predators being attracted by light and the odor of left-over *Acetes*. The protocol may be improved to provide possible alternative livelihood to seahorse fishers.

The diet composition and feeding periodicity of *H. barbouri* reared in illuminated sea cages showed that adult seahorses consumed more variety of prey (copepods, larvae of decapods, polychaetes, fish, and euphausid shrimps) than juvenile seahorses (Garcia *et al*., 2012). The gut of seahorses was generally full at daytime but declined in the evening, particularly among juveniles. Lighting of cages at midnight increased the number of filled guts at dawn (0400 h). Results showed that *H. barbouri* may be cultured in cages feeding on copepods attracted by night illumination.

Troung (2011) reported that during grow-out, seahorses held in recirculating tanks were fed *ad libitum* twice a day with frozen feed such as mysids and *Acetes* collected from the wild. Adult enriched *Artemia* was also used in combination with frozen feed. Seahorses are susceptible to diseases from bacteria and viruses, while antibiotic treatment is not effective in many cases.

In 2009 until 2011, a *H. barbouri* demonstration project was conducted in the Spermonde Islands in Sulawesi, Indonesia to examine the potential of culturing the species as ornamental marine species for coastal management and conservation efforts (Williams *et al*., 2014). Culture units (8 × 5 m) constructed in a family's yard area produced 200-400 animals/month/unit. At allowable quota of 200 animals/month, price paid by exporters (Indonesian Rupiah Rp$30,000/animal) and at exchange rate of Rp11,000 ~ US$1, the profit is seven times the monthly income (~US$350/month profit *vs* < US$50) for a male head of a Pulau Badi household. Ownership, dedication, and ability of owners to solve problems are critical factors in the early phase of the project. Solar energy system was used to lower maintenance cost and sustainable feed systems was established to ensure availability of feed when local wild harvests of mysid shrimps were low in supply.

3.5.4 Resource Enhancement and Restoration Initiatives

Founded in 1996, the Project Seahorse is a marine conservation organization committed to the conservation and sustainable use of coastal marine ecosystems in general and seahorses in particular, and has been considered the foremost authority on seahorses. Project Seahorse was the first to study seahorses underwater, discover their huge trade, identify the threatened status of seahorses, and the first to launch seahorse conservation measures such as marine protected areas, fisheries management, selected aquaculture ventures, trade regulation, improved governance, and consumer engagement. Since 1998, ecological changes have been monitored around no-take reserves in Danajon Bank in Bohol, Philippines for a total of eight reserves and five distant water reference sites.

As part of resource enhancement strategies for seahorses, SEAFDEC/AQD conducts activities that focus on the refinement of breeding and seed production techniques and development of release strategies such as selection of release sites, assessment of the release micro habitat, collection of baseline data on wild populations, and development of tagging techniques that are essential to evaluate the survival and efficiency of stocking strategies. Studies were also done to develop appropriate transport techniques from the hatchery to release site. Preliminary results showed 100% survival of juvenile *H. comes* at stocking density of three individuals per liter for up to 12 h of transport duration. Furthermore, the use of fluorescent visible implant elastomer (VIE) tags was tested and found to be an appropriate tagging technique for seahorses (Woods and Martin-Smith, 2004).

3.5.5 Challenges and Way Forward

Captive breeding of seahorses aims to produce seeds for stock release to protect these internationally threatened and overexploited species in Southeast Asia. Breeding and seed production techniques have been developed; however, these still need further refinements. UV sterilization of water and formalin treatment of natural feed resulted in higher survival of the newborn seahorses, which is crucial for stable mass production of seahorse juveniles. Timely and sufficient supply of the necessary food organisms is

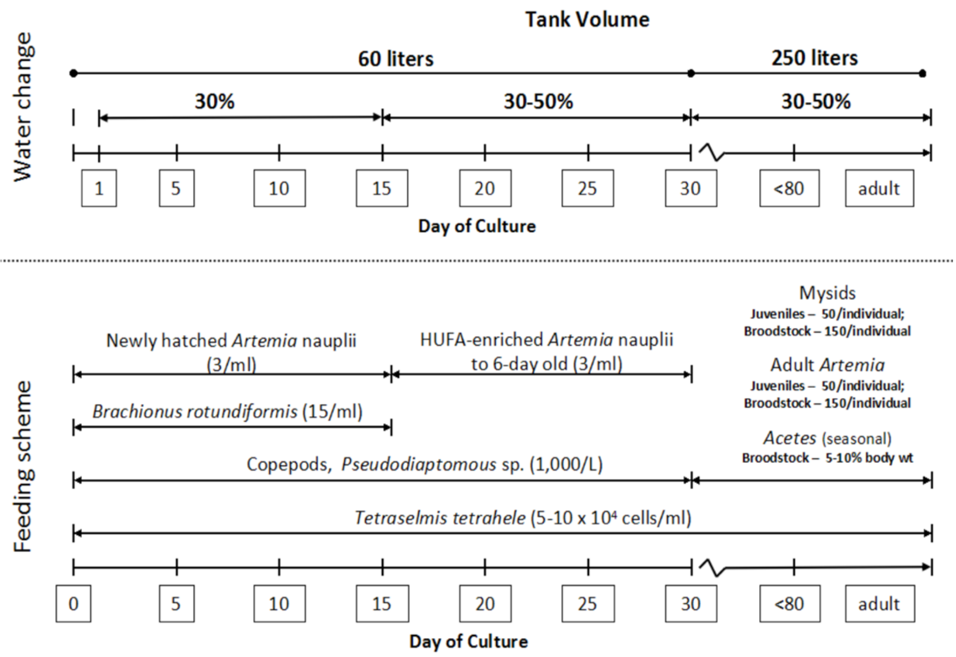

Figure 73. Feeding and water management scheme for seahorse culture

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