

Poaching of green and hawksbill turtles appears to be perpetrated mainly by Chinese and Vietnamese turtle fishers operating in the Coral Triangle area, especially in the waters of Indonesia, Malaysia, and Philippines. The main regional trade route for whole turtles and turtle derivatives seems to originate from Indonesia, Malaysia, and Philippines. Such products are directed mainly towards East Asia, where the demand is on the rise. For example, the mainland Chinese markets demand for turtle meat and other parts for medicine, and the Japanese and Taiwanese markets demand for the turtle scutes (*bekko*) to be used for traditional crafts. Therefore, the establishment of strong cooperation among the countries is highly needed for combating sea turtle poaching, exploitation activities, as well as illegal trade of sea turtles and their derivatives.

Some countries in the region have enacted legislations to prohibit direct take and domestic trade in turtles and turtle derivatives, with a number of countries having increased fines or tightened prohibitions in recent years. However, there is still considerable room for improvement in some countries where existing fines are inadequate as a deterrent to illegal activity, where lack of harmonization of legislations across states or provinces induces domestic trade, and where there is existing legislation but this is poorly enforced.

### **3.3.2 Conservation and Management of Sea Turtles in Southeast Asia**

Recognizing the importance of protecting and conserving sea turtles and their foraging habitats, SEAFDEC/MFRDMD as a regional institution responsible for the conservation and management of sea turtles, developed the Regional Plan of Action (RPOA) of Sea Turtle Foraging Habitats in Southeast Asian Waters in 2014. The said RPOA has six objectives, and each Southeast Asian country could set their respective deadlines for carrying out the RPOA based on their capabilities. The objectives of the RPOA are to: 1) protect and conserve sea turtle foraging habitats; 2) reduce direct and indirect causes of sea turtle mortality in foraging habitats; 3) strengthen research and monitoring of sea turtle foraging habitats; 4) increase community participation through information dissemination and education; 5) strengthen integrated management of sea turtles; and 6) secure funding for Sea Turtle Conservation.

Several programs and actions had been proposed in order to achieve these objectives, which were prepared as guidelines for each AMS to carry out according to their own capability. The outputs and indicators of each activity are also proposed in the RPOA for the evaluation of the country's achievements.

### **3.3.3 Existing Measures Undertaken by Relevant AMSs**

Sea turtles are highly migratory species and inhabit the seawaters and foraging habitats in the Southeast Asian region. Sea turtles that forage in one particular habitat might have originated from several nesting sites located at several countries in the region. Hence, strengthening regional cooperation on protecting and conserving the sea turtles and the ecosystem in their foraging habitats is highly recommended. Regional cooperation and collaboration of expertise, manpower, and facilities is vital to ensure that the RPOA could be effectively implemented.

Most Southeast Asian countries had already established their respective national laws on protecting and conserving the sea turtles as well as developed their own National Plan of Action (NPOA) on Conserving and Protecting Sea Turtles and Their Habitats. In addition, all Southeast Asian countries had their own laws responding to the CITES regulation, considering that all sea turtles species are listed in Appendix I, meaning that international trade of the species for commercial purpose is prohibited. Moreover, the IUCN also listed the hawksbill turtle as critically endangered, while the green, olive ridley, and loggerhead sea turtles have been categorized as threatened.

Furthermore, most of the countries in the region have their own educational and awareness programs targeting various groups of communities for the conservation and protection of sea turtles and their habitats. Universities, NGOs, and local governments had been involved by assisting the national government in the implementation of such programs. For instance in Malaysia, at least 200,000 people had participated annually in the program conducted by provincial agencies with assistance from NGOs and universities. The establishment of national networking between federal and local agencies, NGOs, institutes of higher education, and local community groups is very essential for the implementation of the programs as well as to assist governments in the enforcement of the relevant national laws.

### **3.4. Sea Cucumbers**

Sea cucumbers are echinoderms and the most traded species, with leathery-like skin and elongated or cucumber-like body. There are more than 1,400 species worldwide but only less than 80 species are considered commercially-important (Purcell *et al.*, 2013). Sea cucumbers are more diverse in the tropical areas, particularly in Southeast Asia which is considered as the center of biodiversity, particularly the Indo-Malay-Philippine Archipelago, also known as IMPA (Carpenter and Springer, 2005). Fifty-two species, mainly from the Genus *Holothuria*, *Actinopyga*, *Bohadschia* and *Stichopus* are being actively exploited in the East and Southeast Asian region (Choo, 2008a).

Spatially, they are distributed from very shallow intertidal mangrove and sand or mud flats to sea grass beds and down to coral reefs and deep sea beds (Battaglene, 1999; Hamel *et al.*, 2001). Some sea cucumbers are filter feeders but many are benthic grazers, ingesting, processing, and excreting large amounts of benthic material which affords ecological benefits to the sea floor.

Sea cucumber fishing is an important livelihood in coastal communities (Choo, 2008a), and harvesting of sea cucumbers from the wild has been a tradition in many Southeast Asian countries. Being ecologically-associated with the shallow intertidal areas like mangroves, mud or sand flats, sea grass beds, and shallow reefs, sea cucumbers have been quite easily gleaned off, a chore easily engaged in by women and children (Mills *et al.*, 2012; Siar, 2003). These are collected by hand or with simple tools like nets and spears in the tropical Indo-Pacific region (Mercier and Hamel, 2013).

The value of sea cucumbers for humans is not from their varied shapes and color as fresh or live commodities but maximized when they are dried and processed into *trepang* or *beche-de-mer*. Post-harvest processing of sea cucumbers require relatively simple and traditional technology that basically involves cleaning, boiling, and drying (Mercier and Hamel, 2013). These processed products are mainly reserved as exotic food ingredients in Chinese restaurants. Sea cucumbers have also been known and used for their many medicinal and therapeutic properties, making them important raw materials in pharmaceutical and nutraceutical products (Bordbar *et al.*, 2011). The status, trends, challenges, and prospects of sea cucumber fisheries and aquaculture presented here focus only on countries within Southeast Asia, even though recent advances in the production and culture of sea cucumbers have been done in other countries.

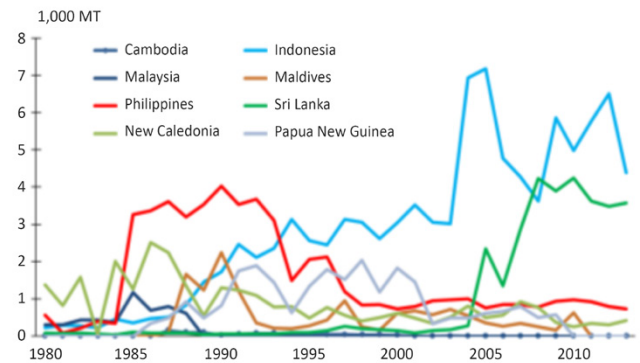
### 3.4.1 Status and Trends

Sea cucumber production is not particularly for the domestic market in most Southeast Asian countries but is primarily targeted for export to neighboring nations like Hong Kong, Taiwan, and China (Choo, 2008a). The extent of sea cucumber exploitation around the world is to



**Figure 66.** The route of Hong Kong sea cucumber market

Source: Anderson *et al.* (2011)



**Figure 67.** Sea cucumber production of selected countries in 1980-2013 by quantity

Source: FAO Fishstat J Database - Capture Production 1980-2013

supply the main market which is Hong Kong before being distributed to other consumers is shown in **Figure 66**.

Wild sea cucumber fisheries production was seen to be low before 1980s but increased more than six times in the 1990s (Anderson *et al.*, 2011). However, because of the relative ease in their harvesting and the increased demand for *trepang*, drastic decline in sea cucumber stocks throughout the region (Bell *et al.*, 2008; Choo, 2008a; Conand, 1993) has been felt with negative impacts on coastal livelihoods in some areas (Mills *et al.*, 2012). The FAO statistics can be quite underestimated (Choo, 2008b), nevertheless it shows the boom-and-bust trend of the sea cucumber fisheries (**Figure 67**).

The total production of sea cucumber in the Southeast Asian countries from 2000 to 2009 reported to be highly fluctuating, ranged from about 4,000 to 29,700 metric tons annually (SEAFDEC, 2012b). A regional inventory of sea cucumber species in Southeast Asia was consolidated by SEAFDEC, listing a total of 137 species from eight countries (SEAFDEC, 2009b). The top ten important species based on local market prices from the Southeast Asian countries is presented in **Table 62**. *Holothuria scabra*, commonly known as sandfish, ranked as the

**Table 62.** Top 10 important sea cucumber species in Southeast Asia

Scientific Name	Common name	Local price (US\$/kg, dried)
<i>Holothuria scabra</i>	sandfish	30-105
<i>Holothuria nobilis</i> / <i>H. whitmaei</i>	black teatfish	17-105
<i>Holothuria fuscogilva</i>	white teatfish	17-88
<i>Actinopyga lecanora</i>	stonefish	7-66
<i>Stichopus horrens</i>	dragonfish	24-58
<i>Stichopus hermanni</i>	curryfish	58
<i>Actinopyga echinites</i>	deepwater redfish	12-54
<i>Thelenota ananas</i>	prickly redfish	12-51
<i>Thelenota anax</i>	amberfish	4-51
<i>Bohadschia argus</i>	leopardfish	9-27

Source: SEAFDEC (2009b)

number one important species, commanding a local market price of more than US\$100/kg (SEAFDEC, 2009b). However, in Hong Kong and Guangzhou, China processed sandfish can reach up to more than US\$1,500/kg, coming in as a close second to the Japanese sea cucumber *Apostichopus japonicus* priced at more than US\$2,000/kg (Purcell, 2014). Black teatfish *H. nobilis* and *H. whitmaei*, as well as the white teatfish *H. fuscogilva* are also among the favored ones. The two black teatfish species are considered as allopatric – geographically isolated but historically the same species—*H. nobilis* is distributed in the Indian Ocean, while *H. whitmaei* occupies the Pacific Ocean (Uthicke *et al.*, 2004).

Nevertheless, there are no regulations that prevent the overfishing of sea cucumbers (Choo, 2012). For instance, sea cucumber resources in Semporna, Sabah, Malaysia being at the center of the Sulu-Sulawesi-Mindanao Seas, appear to be heavily fished (Choo, 2012). In general, fishers have moved away from gleaning to free-diving at night, which indicates that overfishing is occurring on the shallow reef flats. Sea cucumber fishery in Semporna has also followed the boom-and-bust trend observed in neighboring countries, and species that are of high value (*e.g.* *Holothuria whitmaei* and *H. scabra*) and were abundant in the 1980s and mid-1990s are now rare, while medium-value and low-value species that were not fished before are now being harvested (Choo, 2012). *Actinopyga echinites* and *Bohadschia* sp. are caught in greater abundance compared with the other species.

Global decline in wild sea cucumber stocks has been evident in many countries and characterized by collection areas shifting from nearshore to offshore, harvested average body size decreasing, and target species changing from high-value to low-value (Anderson *et al.*, 2011). Clearly, the progressive decrease in sea cucumber populations was caused by overexploitation and overfishing, unsustainable fisheries management, and increasing market demand for *trepang* or *beche-de-mer* products worldwide (Gamboa *et al.*, 2004; Purcell *et al.*, 2013).

Although some sea cucumber fisheries have existed for centuries, catch trends of most individual fisheries following the boom-and-bust patterns since the 1950s, had been declining nearly as quickly as they had expanded (Anderson *et al.*, 2010). Regional assessments revealed that population declines from overfishing occurred in 81% of sea cucumber fisheries, the average harvested body size decreased in 35%, harvesters moving from nearshore to offshore regions in 51% and from high-value to low-value species in 76% (Anderson *et al.*, 2010). Thirty-eight per cent of sea cucumber fisheries remained unregulated, and illegal catches were of concern in half (Anderson *et al.*, 2010). Anderson *et al.* (2010) also suggested that development patterns of sea cucumber fisheries are largely

predictable, often unsustainable, and frequently too rapid for effective management responses.

#### *Brunei Darussalam*

Sea cucumber fisheries in Brunei Darussalam is only limited to two fishing licenses awarded in 1993, with combined reported production of 65 kg and peaking at 1,463 kg in 2005 but declined to only 193 in 2006 (Wahabs, 2009). Although catches were reported in bulk and generally termed as mixed sea cucumbers, Wahabs (2009) listed eight species of mostly deep water sea cucumbers. Among these, *Holothuria rigida* locally called *timun laut susu* was considered the most expensive at US\$80/kg when dried. Sea cucumber oil and other extracts are being sold locally, but most of processed sea cucumber meat is exported to Sabah in Malaysia and the Philippines.

#### *Cambodia*

Sea cucumbers locally known as teak, are known to be abundant in Koh Sdach and Koh Rong group of islands in Southern Cambodia, where collection commonly come in conflict with neighboring Phu Quoc islands of Viet Nam (Villanueva and Ut, 2007). Also called as *chhloeng*, sea cucumbers have been harvested more intensively starting in 2004 when compressor diving has been employed although more traditional collection has been recorded since 1985 (Sereywath, 2009). A famous market for sea cucumbers at Sihanoukville received dried products in the order of 500 kg per month from 2002 to 2004. In 2009 however, middlemen at this market stopped operation when landings of dried sea cucumbers considerably dropped to less than 30 kg per month. Sereywath (2009) added that only less than 10% from the markets of Sihanoukville is locally consumed, since most are sold to the capital city of Phnom Penh and eventually exported to Viet Nam and Thailand.

#### *Indonesia*

Indonesia is currently the top exporter of wild-caught sea cucumbers globally, after it surpassed the Philippines in mid-1990s (**Figure 67**). Collection of sea cucumbers in Indonesia was known even during the Dutch colonization period in the nineteenth century (Wiadnyana, 2009). Essentially, fishing for sea cucumbers in this country has more than 500 years history (Navarro *et al.*, 2014). According to Tuwo and Conand (1992), Indonesians harvest sea cucumbers traditionally using small boats with 2-4 fishers for a day trip, then process the animals at the shore. On the other hand, some fishers use bigger boats equipped with diving equipment that search for sea cucumbers for weeks and months, processing their harvest onboard. About 53 species of sea cucumbers were listed for Indonesia in the 1970s (Clark and Rowe,



1971 as mentioned by Wiadnyana, 2009) but only eight of these were considered as economically-important species, like the *Holothuria scabra* and *H. nobilis*. Recent studies have taxonomically verified 33 of the more than 50 species, however, country statistics from the Ministry of Marine Affairs and Fisheries still considered *trepang* as an aggregate single commodity (Setyastuti and Purwati, 2015). Dried sea cucumbers are mostly exported to Hong Kong and other East and Southeast Asian countries like South Korea, Singapore, Viet Nam, and some to Taiwan, Malaysia, and USA, but interestingly, not so much are exported directly to China (Tuwo and Conand, 1992; Wiadnyana, 2009).

### Malaysia

Sea cucumber fishing in Peninsular Malaysia and Sarawak is mostly small scale where collection is being done manually by hand through gleaning or diving (Ibrahim, 2009). However, some are unintentionally caught in nets of shrimp trawlers operating in the waters of Sabah. Collection of sea cucumbers in Malaysia has been mostly from the eastern regions of Sabah in the island of Borneo. Forty-four species of sea cucumbers are known to be found in Malaysia, with *Holothuria scabra* or *bat putih* and *H. nobilis* commanding the highest commercial value (Ibrahim, 2009). Sea cucumbers, generally called *gamat*, have been traditionally exploited mainly for its medicinal benefits (Vaitilingon *et al.*, 2016) and used to produce soap and other cosmetic products. Sea cucumbers for this purpose are mostly from the Genus *Stichopus* like the curry fish *Stichopus hermanni* and warty sea cucumber *S. horrens* (Choo, 2004). Another species important for local food consumption is the *Paracaudina* sp. or *beronok*,

commonly harvested from mudflats and mangroves. The annual import and export quantity and value of sea cucumber in Malaysia are shown in **Figure 68**.

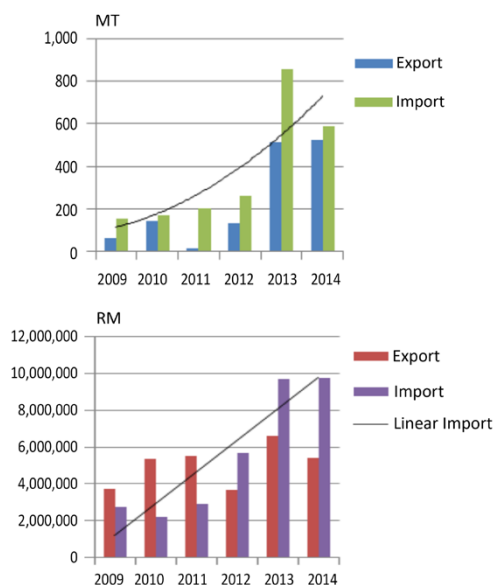
In Malaysia, sea cucumbers genera other than *Stichopus*, e.g. *Holothuria*, *Actinopyga*, *Pearsonothuria*, *Bohadschia*, *Thelenota*, and order Molpadiida are commonly known as *bat*, *balat*, and *timun laut*. The *Stichopus* species, frequently used as main ingredients in traditional medicine (i.e., *gamat* oil and *gamat* water) especially in Peninsular Malaysia, are locally known as *gamat*. The same commercial name is used by Sabah and Sarawak residents, although in Sabah, sea cucumbers inclusive of *gamat* are commercially marketed as food, and there are minor uses as fishing poison (e.g. holothurins from *Holothuria atra*) and in traditional medications. Few studies related to sea cucumbers (Echinodermata: Holothuroidea) in Malaysia were reported and published until the year 2005.

### Myanmar

*Pin-lai-myawt* is the local name of sea cucumbers in Myanmar which have been traditionally harvested for many years in the southern region of Tanintharyi. While in the northern regions of Ayeyarwardy and Rakhine, harvesting only began in 1989 when the Open Market Economy was declared (Pe, 2009). About 10 species of sea cucumbers are known in Myanmar with *Stichopus* and *Thelenota* species being mostly considered as highly valuable. Like many countries worldwide, sea cucumber capture fishery production is declining in Myanmar, resulting in most fishers risking to fish the sea cucumbers for long duration up to months in the farther islands of the Andaman Sea using old boats (Pe, 2009).

### Philippines

In the Philippines, collection of sea cucumbers started more than 100 years ago (Gamboa *et al.*, 2004; Trinidad-Roa, 1987). Women have been engaged in this activity by gleaning for shellfish including sea cucumbers in shallow intertidal shores (Siar, 2003). Of the more than 100 sea cucumber species in the Philippines, about 25 are targeted regularly and processed as *trepang* (Schoppe, 2000). Sea cucumber fishing provides an important source of income to many poor fishers in coastal communities (Choo, 2008b). Total sea cucumber exports are valued at an average of more than US\$2 million per year, making it one of the country's major export commodities (Gamboa *et al.*, 2004; Juinio-Meñez *et al.*, 2012). Sea cucumber fishery in the country involves a multi-species collection, and among the various species, *Holothuria scabra* is the most expensive, commanding a price of up to US\$105/kg in the local market (Labe, 2009). Capture production dramatically increased from about 300 metric tons in 1984 to more than 3,000 metric tons in 1985, and reached the



**Figure 68.** Sea cucumber export and import in Malaysia from 2009 to 2014 by quantity (metric tons) (*above*) and value in Malaysian Ringgit: RM (*below*)

Source: Department of Fisheries Malaysia (2009-2014)

highest annual harvest of about 4,000 metric tons in 1990. However, the following decade saw a steady decline and since 1998 production from wild catch had an average of between 700-800 metric tons per year (FAO Fishstat 1950-2014).

#### *Singapore*

Singapore acts more of an importer for sea cucumber products rather than a producer. Singapore is known as one of the top three markets for sea cucumbers, together with Hong Kong and Taiwan (Conand, 2001). It is also considered as one of the major re-exporting countries for sea cucumbers.

#### *Thailand*

Munprasit (2009) listed 102 species of sea cucumbers found in Thailand, of which 11 species are edible and *H. scabra* is considered the most important species. These are traditionally harvested in shallow coasts, mainly by hand picking. Fishing is also active and can take days and weeks in the Andaman Sea, while processing is done onboard fishing boats. Although processing method in Thailand is slightly different among species and areas, like in Phangnga and Chonburi Provinces, such processes commonly involve gutting, cleaning, boiling, smoking, and drying. Dried sea cucumber products are mainly exported to Hong Kong, Japan, and China, while Thailand also receives sea cucumber imports from countries like Madagascar and Tanzania (Munprasit, 2009).

#### *Viet Nam*

A total of about 90 species of sea cucumbers are found in Viet Nam (Hung, 2009). Sea cucumbers are abundantly harvested especially in the Provinces of Khan Hoa, Con Dao, Truong Sa, Bin Thuan, and Kien Giang in southern Viet Nam, particularly in Phu Quoc Islands (Hung, 2009; Villanueva and Ut, 2007). More than ten edible species are sold, particularly in the southern region and Ho Chi Minh City markets, including the highly priced sandfish *H. scabra* (US\$50/kg). Decline in wild capture production has been reported especially that Scuba diving has been employed as a main fishing equipment for fishers. For example, Phu Quoc Islands deliver about 3 metric tons of fresh sea cucumbers per day in late 1990s but this volume was reduced to only 300 kg/day a decade after. Production of sandfish has been augmented by aquaculture in ponds in the Nha Trang region, where sea cucumber culture has been done since mid-2000, commonly in alternate cropping with shrimps (Pitt and Duy, 2003; Pitt *et al.*, 2001).

### **3.4.2 Issues and Challenges**

#### **Conservation**

##### *Sea Cucumbers as Protected Species*

In Malaysia, the present Fisheries Regulations on the Control of Endangered Species of Fish 1999 under Fisheries Act 1985 protects the following marine species: dugong, six species of whales, thirteen species of dolphins, one species of whale shark, and four species of giant clams. Sea cucumbers are not included in the list of endangered species in Malaysia, neither are they considered as endangered by IUCN (Mohd Nizam Basiron and Zahaitun Mahani Zakariah, 2004). Without research on the status of sea cucumber resources in Malaysia and the level of its exploitation it would be difficult to evaluate the resource status. However, in the long term it would be of interest to the country to undertake research studies before making any decision to include sea cucumbers in the list of protected species (Mohd Nizam Basiron and Zahaitun Mahani Zakariah, 2004).

Lack of data on the status of sea cucumber resources and its level of exploitation in Malaysia is a serious impediment to the management of this valuable natural asset (Mohd Nizam Basiron and Zahaitun Mahani Zakariah, 2004). It is therefore through the Fisheries Research Institute (FRI) in cooperation with local universities that research activities in this area are intensified to better prepare Malaysia for the conservation and management challenges of sea cucumbers.

Nonetheless, some sea cucumber fisheries have been successfully managed through fisheries laws, rights systems, permits and fishery cooperatives. Japan for example, has succeeded in drawing back overfishing of sea cucumber resources and restocking the resource' depleted areas (Akamine, 2004). Holothurian fishery in southeast Alaska, United States is carefully controlled, where harvest levels are set based on the lower 90% bound of a biomass estimate, and areas are fished on a 3-year rotation schedule and separate areas are left closed as controls (Clark *et al.*, 2009). Sea cucumber fishery in British Columbia, Canada initially followed the typical boom-and-bust pattern, but management stepped in, reduced quotas, added license restrictions, and implemented adaptive management (Hand *et al.*, 2008), and as a result, the CPUE and catches recovered (Hand *et al.*, 2008). Although still confronting problematic corruption and declining abundance, implementation of a co-management regime in the Galapagos has increased the effectiveness of license and quota control, and reduced conflict between management and fishers (Shepherd *et al.*, 2004).

## Aquaculture

Decline in wild populations of sea cucumbers, particularly of the commercially valuable species like the sandfish *Holothuria scabra* has driven a revolution towards aquaculture. Production technology for the sandfish started early in 1980s in India (James, 1996). Enhancement and adoption followed in many countries, including Australia and the Pacific islands like New Caledonia and Solomon Islands with projects spearheaded by the WorldFish Center. Early adaptors in Southeast Asia were Viet Nam with hatchery production and pond culture (Duy, 2012) while sea-based nursery systems and community-based sea ranching have been initiated in the Philippines (Juinio-Meñez *et al.*, 2012; Juinio-Meñez *et al.*, 2013), with research support from the Australian Centre for International Agricultural Research (ACIAR). Other countries in the region also have production trials mostly supported by universities and governmental fisheries agencies like those in Malaysia, Thailand, and Indonesia.

An important requirement for a successful spawning run is having a group of healthy mature broodstock, and conditioning these breeders is essential (Agudo, 2006). At the Research Institute for Aquaculture No. 3 in Nha Trang, Viet Nam, broodstocks are collected from nearby holding ponds and conditioned for about one month in indoor tanks with sand (Duy, 2010). However, sandfish stored in tanks for longer durations tend to shrink with accompanying decline in reproductive performance as observed in experiments conducted at SEAFDEC/AQD in the Philippines. Returning the breeders to their natural habitats, usually in holding pens or sea ranch areas, provides better recovery of the animals. Stability in production has been difficult to implement, mainly because of limited sources of healthy wild breeders and inconsistent health and condition of these broodstocks.

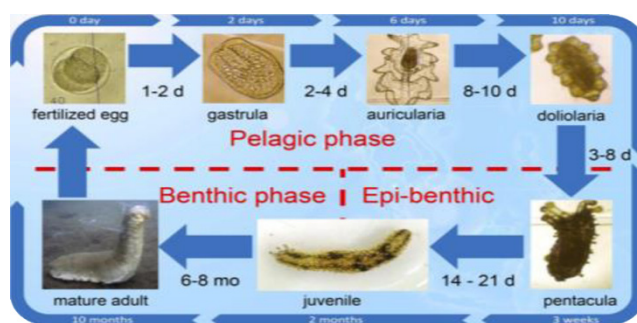
Hatchery technology is being established, especially for the sandfish *Holothuria scabra*. In the Philippines, SEAFDEC/AQD has done experimental production since 2008. Since then, the life cycle and duration of

developmental phases have been established for local conditions (**Figure 69**).

Sea cucumbers commonly aggregate and spawn synchronously in the wild, so that groups of 20-60 breeders are commonly used for spawning in hatcheries as well. Spawning induction through desiccation and thermal shock is generally used, which is the most practical method that provides quite reliable results with mature breeders. Hatchery management and protocols (*e.g.* feeding) are fairly established as well (Agudo, 2006; Duy, 2010). The main limitation in hatchery production is the availability of good quality live algal feed. For this reason, sea cucumber hatcheries require a dedicated phycology laboratory to produce live feeds for the developing sea cucumber larvae that usually takes 30-45 days. *Chaetoceros calcitrans* or *C. muelleri* are species of algae that are commonly used in sea cucumber hatcheries, although the benthic diatom *Navicula* is also fed to early settled juveniles. Spirulina which is commercially available in dry powdered form is used to coat settlement plates. In most cases, success in hatchery operations is dependent on the capacity and efficiency in producing and upscaling these essential algal food items.

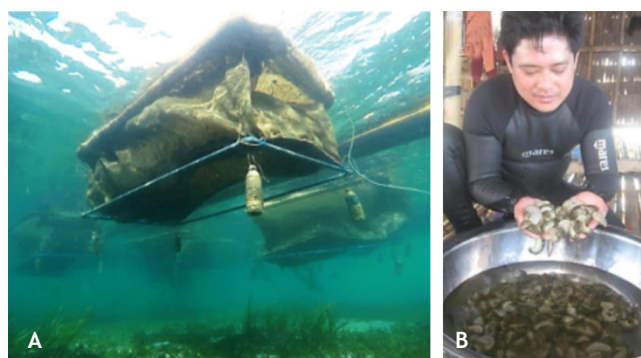
Development of larvae and their ultimate survival into juveniles had been unstable in many hatcheries. Purcell *et al.* (2012) reviewed the global hatchery production for sandfish and reported generally poor survival of early larval stages that commonly hovers around 1%. In Kedah, Malaysia, sandfish spawning runs produced generally high settlement (survival) rates at 23.70% during settling of pentactula (15 days old) larvae but steeply reduced to only 0.47% at 45 days during the early juvenile stage (Vaitilingon *et al.*, 2016).

Maintenance of good water quality for larval rearing also affects growth, development, and survival of sea cucumber larvae in the hatcheries. For sandfish *H. scabra*, Agudo (2006) recommends maintaining the following water parameters: temperature at 26-30°C; dissolved oxygen at 5-6 ppm; salinity at 27-35 ppt; pH 6-9; and ammonia at 70-430 mg/m<sup>3</sup>. Similar recommendations were made for rearing *H. spinifera* larvae: water temperature at 28-32°C; salinity at 35 ppt; and pH at 7.8 (Asha and Muthiah, 2005). Deviations from these ideal water conditions usually result in delayed larval development and high mortality. Problems in maintaining good water quality are often associated with high costs of infrastructure, capital, and operations especially with related equipment like pumps, filtration and disinfection lines, and life support systems like aeration, heating and cooling, and pH control.



**Figure 69.** Life cycle and development of sandfish *Holothuria scabra*





**Figure 70.** (A) Sea-based floating nursery hapa nets used for rearing sandfish juveniles until 3-6 g; (B) 1-2 month-old sea cucumbers for stocking in sea ranching areas in the Philippines

After 30-45 days in hatchery, sea cucumber larvae like those of the sandfish, settle on conditioned plates. In order to reduce the time spent of early juveniles in the hatchery, various nursery systems have been tested and developed. In Viet Nam, marine ponds with sandy substrate are being used as nursery areas with fine hapa nets (usually 1×1×1 m) held by wooden sticks or tree branches (Duy, 2010). In the Philippines, some nursery systems were also tested but floating sea-based hapa nets (1×2×1 m) were found to be the most practical (Juinio-Meñez *et al.*, 2012). Floating nursery nets are fine-meshed and are suspended just below the water surface by floats (PVC pipes or bamboos) and weighed down by sinkers (**Figure 70A**). However, problems and challenges still remain, especially in addressing issues of net fouling, predation, and unpredictable weather. In the Philippines, 1-2 month-old sea cucumbers (**Figure 70B**) are harvested for stocking in sea ranching areas.

Various grow-out options are available, especially for the sandfish. Ponds were proven to be useful in Viet Nam where sandfish growth of 1-3 g per day is common, reaching more than 300 g in 9-14 months, translating to more than 2.5 metric tons/ha (Duy, 2012). Similar growth was also observed in nursery trials in Malaysia where sea cucumber juveniles reaching 20-30 g in weight in 3-4 months in floating nets suspended in brackish water pond (**Figure 71**). Problems in Viet Nam are limitations in density (1 individual/m) and long duration culture. These are the reasons why most farmers still resort to

culturing shrimp (mainly *Penaeus vannamei*) because of higher annual returns by culturing at least two batches per year. In the Philippines, typical ponds are not conducive for full grow-out culture of sandfish because of various constraints that include: 1) tendencies of low salinity (typically brackishwater); 2) substrate being too muddy and silty, having been converted from mangrove areas and used mainly for shrimp or milkfish culture; 3) being typically shallow (less than 1 m); and 4) unpredictable weather that limits culture duration.

Nonetheless, sea ranching of sea cucumbers, particularly of the sandfish *H. scabra*, has shown good prospects in terms of community-based production and restoring wild stocks through natural spawning as demonstrated in a pilot site in Bolinao, Pangasinan, Philippines supported by the University of the Philippines-Marine Science Institute (Juinio-Meñez *et al.*, 2013; Olavides *et al.*, 2011). However, there were problems associated with sea ranching which include the long culture duration of one to two years and the relatively low survival and recovery rates of stocks at 20-30%, mainly because of predation and unstable conditions at sea ranch sites. In other countries like Malaysia and Thailand, farming of sea cucumbers especially in pens at shallow coasts has been limited only to collection of wild juvenile sea cucumber stocks. Similarly in Indonesia, the two main problems of sea cucumber farming are the long farming period and the low number of seeds available from the wild (Tuwo, 2004).

### 3.4.3 Future Directions

#### Aquaculture

Declining wild population of sea cucumbers because of overfishing has been made clear (**Figure 67**) and collection of wild juveniles for attempts to rear sea cucumbers in captivity in pens and ponds further threatens the supply of wild stocks. Future efforts should be geared towards developing and enhancing hatchery and aquaculture production. It is along this basic objective that research, like the ACIAR-funded project involving Philippines, Viet Nam, and Australia (ACIAR-FIS-2010-042), focused on the expansion and diversification of production systems for sea cucumbers.



**Figure 71.** Floating nets for sea cucumber juveniles in brackishwater pond (*left*), and juveniles weighing 20-30 g in 3-4 months (*right*) for stocking in ponds

Successful and sustainable production in hatchery primarily involves good quality broodstock. Currently, dependence on breeders that are conditioned in the natural habitat is common, although some hatcheries like those in Viet Nam maintain good supply of breeders in nearby ponds. Still, sea cucumber broodstock conditioning, at least for the sandfish, is a major bottleneck in most hatcheries that needs to be given due importance. Efforts at SEAFDEC/AQD in the Philippines, for example, are addressing some of these concerns by conducting research and experiments on conditioning management protocols, as well as looking into suitable maturation diets for sandfish to ensure good quality gametes and optimize fecundity of adult female broodstock. Maturity detection and use of biopsy techniques to ensure only individuals with ripe gonads are selected for spawning trials, are the aspects for research and development. Spawning induction is straightforward and even simple techniques like desiccation or temperature shock yield successful releases of male and female gametes from mature and ready individuals. However, some batches of fertilized eggs can still be of low quality. Detection and separation of “bad eggs” or a protocol to decide whether to discard an entire batch is crucial to minimize risks of low quality production.

Optimal larval development is a key to ensuring good quality juveniles, and in order to attain this, algal feed and feeding protocol as well as good water quality parameters are established. However, dependence on live feed is often a limitation in hatcheries. Currently, promising results have been shown in larval rearing of sandfish solely fed with commercial concentrated algal pastes (Duy *et al.*, 2015). Moving forward, exploration of algal food substitutes is important. Larval settlement into pentactula phase was shown to be high at more than 20% survival from sandfish eggs. However, those that are eventually harvested as stage 1 (S1) or early juveniles (4-10 mm) are common only at 1%. There are critical cues and requirements between these development stages that need further investigation and research in order to optimize survival of larva to juveniles and maximize hatchery production of sea cucumbers.

Grow-out culture of sea cucumbers whether in ponds, pens, or tanks is mainly challenged by the limitation in terms of stocking density and long duration culture period. In basic aquaculture, these problems are often addressed by developing suitable alternative and supplemental feeds at various phases of culture. This is an area where a huge gap in knowledge of the tropical species exists, although for other species like the temperate eel *Anguilla japonica*, formulated feeds had been developed and used in aquaculture production in Japan and China. One drawback of using formulated feeds is the inappropriateness of its use in a sea ranch system like in the Philippines where natural and often protected, sea grass areas are being utilized. So, a careful protocol that would enhance production

and promote environmental conservation should be put in place.

Aside from direct environmental damage due to intensification of culture, it is widespread that some aquaculture practices result in habitat modification, wild seedstock decline, and population genetic diversity disruption (Naylor *et al.*, 2000). Particularly for sea cucumbers, pond and pen constructions alter coastal ecosystem dynamics, while translocation of stocks may change the unique genetic composition among native populations. In New Caledonia, genetic diversity similarities among sea cucumber populations rapidly changed after a few hundred kilometers along the same coast (Uthicke and Purcell, 2004). Similar initial results, from a sea cucumber genetics study being conducted by the University of the Philippines in Diliman, Philippines show distinct genetic populations of sea cucumbers being restricted in localized areas of the country (Ravago-Gotanco and Juinio-Meñez, pers comm). Therefore, future culture production should consider using only locally-produced stocks from locally-sourced broodstock.

The full economic value of sea cucumbers is not realized until these are processed into its dried form called *trepang* or *beche-de-mer*. In a local market in Palawan, Philippines, a single processed sandfish commands 300% more value than selling it fresh or live (**Figure 72**). Therefore, to optimize commercial benefits from aquaculture of sea cucumbers, its post-processing component needs to be incorporated into the production cycle. In addition, since prices for *trepang* are also dependent on species, size, and processing quality, regulations need to be established and enforced in order to minimize, if not stop, harvesting of undersized and undesirable sea cucumbers.



**Figure 72.** (A) Fresh and (B) processed sandfish in Palawan, Philippines

Most countries in Southeast Asia do not have specific regulations for sea cucumbers. Some licenses are issued for fishing boats catching (but not targeting) sea cucumbers in countries like Brunei Darussalam and Thailand. In a review conducted among 37 countries and states globally, 38% of fisheries are unregulated, while 51% reported



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
<i>Hippocampus barbouri</i>	Barbour's seahorse	Indonesia, Malaysia, Philippines	
<i>H. bargibanti</i>	Bargiban's seahorse	Indonesia, Philippines	Malaysia
<i>H. comes</i>	Tiger-tail seahorse	Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	
<i>H. denise</i>	Denise's pygmy seahorse	Indonesia, Malaysia, Philippines	
<i>H. histrix</i>	Spiny seahorse	Indonesia, Malaysia, Philippines, Viet Nam	Brunei Darussalam, Myanmar, Singapore, Thailand
<i>H. kelloggi</i>	Great seahorse	Indonesia, Malaysia, Philippines, Thailand, Viet Nam	Brunei Darussalam, Myanmar, Singapore
<i>H. kuda</i>	Black seahorse	Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam, Myanmar
<i>H. mahniikei</i>	Japanese seahorse		Thailand, Viet Nam
<i>H. spinosissimus</i>	Hedgehog seahorse	Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam	Brunei Darussalam
<i>H. trimaculatus</i>	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)