Seychelles Mariculture Master Plan

Aquaculture Fact Sheet

Sea Cucumber: Sandfish

Holothuria scabra

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by Advance Africa Management Services

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1. Background

Common names

Sandfish sea cucumber *English*
Kokonm *Seychelles Creole*

Biology and Ecology

The sandfish (*Holothuria scabra*) is a species of sea cucumber from the Holothuridae family. It is distributed throughout the Indo-Pacific between the latitudes of 30°N and 30°S, from the east coast of Africa and the Red Sea, to Australia, Micronesia and Tonga (Figure 1) (Hamel *et al.*, 2001, 2013). Sandfish are typically found in shallow waters at depths of up to 20m on sandy and muddy bottoms. They occupy a variety of habitats including reef flats, protected bays, coastal areas, mangrove areas, and seagrass beds (Skewes *et al.*, 2004; Purcell *et al.*, 2012b; Hamel *et al.*, 2013), where they burrow into the sediment and spend part of the day either fully or partially buried (Figure 2) (Conand, 1998, 2008; Cannon and Silver, 2002). Sandfish feed on detritus (organic matter) on the substrate (Agudo, 2006).

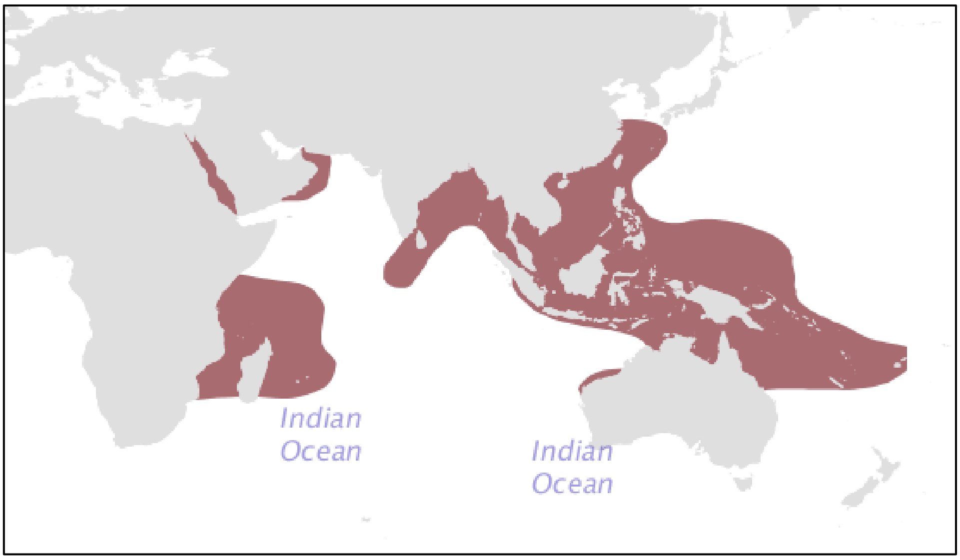

Figure 1: Distribution of sandfish (Source: FAO, 2019).

Figure 2: Typical sandfish habitat (Photo: G. Robinson).

The sandfish has an oval, slightly flattened, white or grey to light brown body with vertical wrinkles and dark markings along its length; the body is covered in spicules (Figure 3). This species of sea cucumber is fast-growing, reaching a length of 15cm in one to two years, and grows to a maximum length of 40cm and a maximum weight of 2kg (Fischer *et al.*, 1990; Purcell *et al.*, 2012b; Skewes *et al.*, 2000).

Figure 3: Profile of sandfish (Photo: G. Robinson).

Sandfish are gonochoristic, which means that each individual matures either as male or female and no sex change takes place. Sexual maturity occurs at around 120 to 180g, at an age of around one year (Conand, 1998; Purcell *et al.*, 2012b; Hamel *et al*., 2013). Sandfish spawn in warm waters either seasonally or year-round, depending on the region. It is a broadcast spawner, and releases eggs and sperm into the water column where eggs become fertilised (Fischer *et al.*, 1990; Conand, 1993, 1998; Skewes *et al.*, 2004; Choo, 2008; Kinch *et al.*, 2008; Robinson, 2014). Females have a high fecundity, releasing an average of 1.9 million eggs per spawning (Robinson, 2014). Following hatching, larvae of the species are planktonic, and settle initially on seagrass as small juveniles (up to 10mm) before moving to sandy habitats (Hamel *et al.*, 2013).

Fisheries

Sea cucumbers have been harvested for over 1000 years throughout most of the Indo-Pacific region to supply Asian markets; in recent decades, however, demand for sea cucumber has increased significantly following China's re-introduction into global markets in the 1980s (Hamel *et al.*, 2001). There are more than 30 species of sea cucumber harvested in the tropical Indo-Pacific, including sandfish (Purcell *et al.*, 2018). Global production is dominated by Japan, producing an average of 17 180 tonnes per annum (tpa) between 2010 and 2016, followed by South Korea, Canada, and Indonesia (Figure 4) (FAO, 2018). The majority of sea cucumber production is sold on Asian markets for bêche-de-mer (Purcell, 2014).

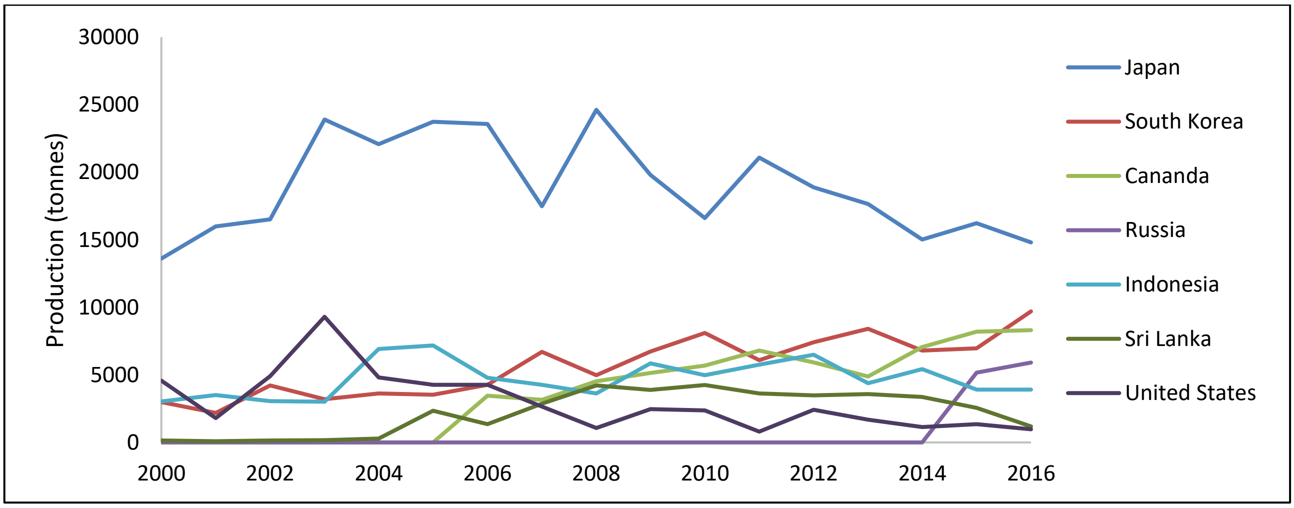

Figure 4: Sea cucumber fisheries production per country, 2000 to 2016 (FAO, 2018).

Sandfish is the highest value sea cucumber species on the global bêche-de-mer market, and has the highest demand in most regions (Toral-Granda, 2007; Conand and Muthiga, 2007; Conand, 2008). As a result, it has been intensely exploited throughout its distribution. Whereas sandfish previously comprised the majority of global sea cucumber production, in recent years, it has largely been replaced by lower-value species due to declining harvests (Bruckner, 2006; Toral-Granda, 2007; Kinch *et al.*, 2008; Purcell *et al.*, 2018; Hamel *et al.*, 2013). Nevertheless, sandfish is still heavily targeted, and is harvested by hand at low tide, or using SCUBA gear (Choo, 2008; Hamel *et al.*, 2013).

Sandfish is listed as 'Endangered' by the International Union for Conservation of Nature (IUCN) based on a 2010 assessment. It is estimated that in at least 50% of its range, its populations have declined by more than 90% (Hamel *et al.*, 2013).

Seychelles sea cucumber fisheries

Sea cucumber have been fished in the Seychelles for over 100 years. Increasing Asian demand for bêche-de-mer in the late 1990s led to the sea cucumber fishery developing from a traditional fishery, based on shore harvesting, to a semi-industrial fishery utilising motorised vessels and SCUBA diving (Robinson, 2014). Increasing fishing pressure has led to population declines of many species (Conand, 2008; Aumeeruddy and Conand, 2008; Robinson, 2014).

In Seychelles, sandfish is one of the most highly targeted sea cucumber species, with catches peaking at 9 120 tonnes in 2001 (Aumeeruddy, 2007; Robinson, 2014). In 2005, sandfish was classified as 'overexploited' in the region (Aumeeruddy *et al.*, 2005; Aumeeruddy, 2007). A closure of the sandfish fishery was thus imposed in 2005, however, harvesting of the species continued and catches averaged 1 292 tpa from 2006 to 2012 (Aumeeruddy, 2007; Robinson, 2014). Consumption of sea cucumber products in Seychelles is negligible; the vast majority of production is exported for the global bêche-de-mer market, with Hong Kong, Malaysia and Singapore providing the main markets (Aumeeruddy and Conand, 2008).

Aquaculture

The growing global demand for sea cucumber products, declining supply from capture fisheries, and their high value, has driven increased aquaculture of these species (Purcell *et al.*, 2012a, 2018; Juinio-Menez *et al.*, 2017). Sea cucumber aquaculture is increasingly viewed as a sustainable means to satisfy the growing bêche-de-mer market, as it takes pressure off wild stocks whilst potentially replenishing wild populations in certain cases (Lovatelli *et al.*, 2004; Bell *et al.*, 2007; Purcell *et al.*, 2018). Since 2004, aquaculture production has exceeded fisheries production; in 2016, aquaculture production was 206 956 tonnes, 79% of the total global production (Figure 5) (FAO, 2018). With the growing demand, sea cucumber aquaculture production is expected to continue increasing (Chen, 2003; Purcell *et al.*, 2018).

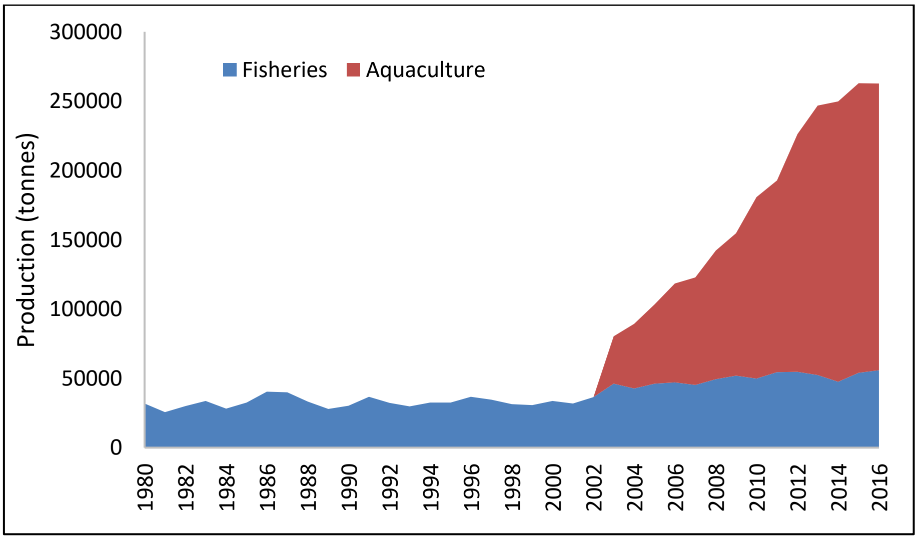

Figure 5: Global sea cucumber production, 1980 to 2016 (FAO, 2018).

China dominates aquaculture production of sea cucumbers (mostly *Apostichopus japonicus*) (Figure 6A) (Chen, 2003; FAO, 2018), followed by Indonesia which focuses on sandfish and golden sandfish (*H. lessoni*) (Figure 6B) (Tuwo, 2005).

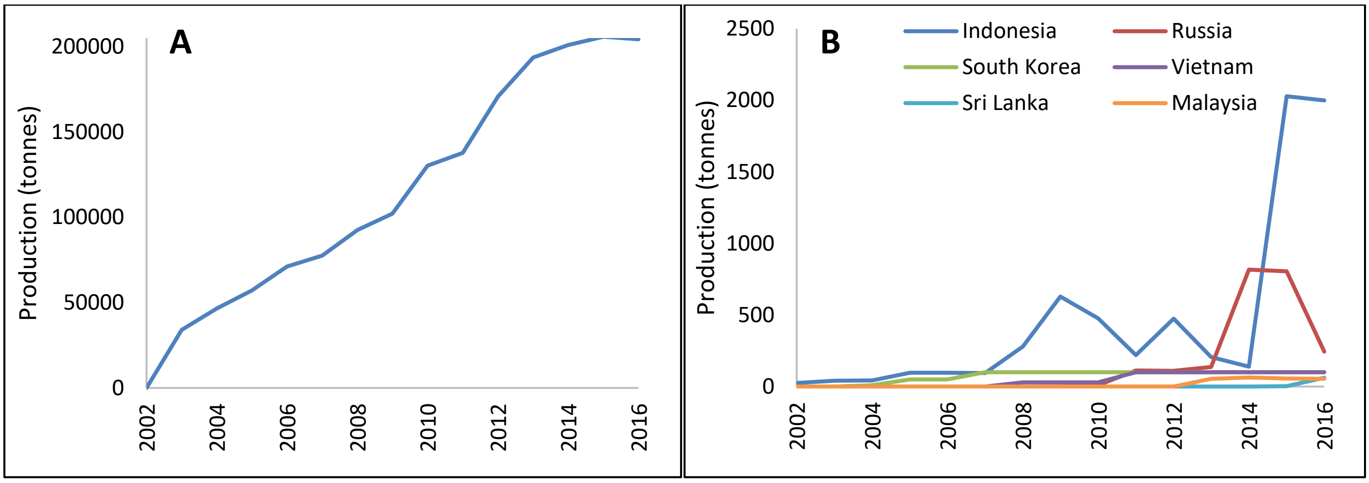

Figure 6: Sea cucumber aquaculture production by A) China; and B) Other top producing countries, 2002 to 2016 (FAO, 2018).

Due to its high value, there has been a significant focus on aquaculture of sandfish and it has become the most widely cultured sea cucumber species (Raison, 2008; Purcell *et al*., 2012a, 2018). Aquaculture technology for sandfish was first developed in India in 1998, prompted by the declining wild stocks, and has since expanded to other countries including Australia, Madagascar, Malaysia, Saudi Arabia and Sri Lanka (Juinio-Meñez *et al.*, 2014; FAO, 2018).

2. Technical approach to aquaculture production

Production Cycle

Sandfish are typically farmed on land or, as will be the case in Seychelles, through a combination of land- and sea-based phases. Adult fish (broodstock) are captured from the wild and held in land-based tanks, where they are spawn and produce eggs. After hatching, sandfish remain in land-based facilities during their larval and juvenile phases, followed by grow-out of juveniles to market size using both sea ranching and land-based pond culture methods (Figure 7).

The land-based tank systems are typically a combination of pump-ashore Recirculating Aquaculture Systems (RAS) and flow through systems. The water that is pumped ashore is filtered before entering the tanks to remove pathogens and to provide optimal water quality for the sea cucumbers. Similarly, effluent water leaving the tanks is cleaned in accordance with the relevant Seychelles Aquaculture Standard and global best practice.

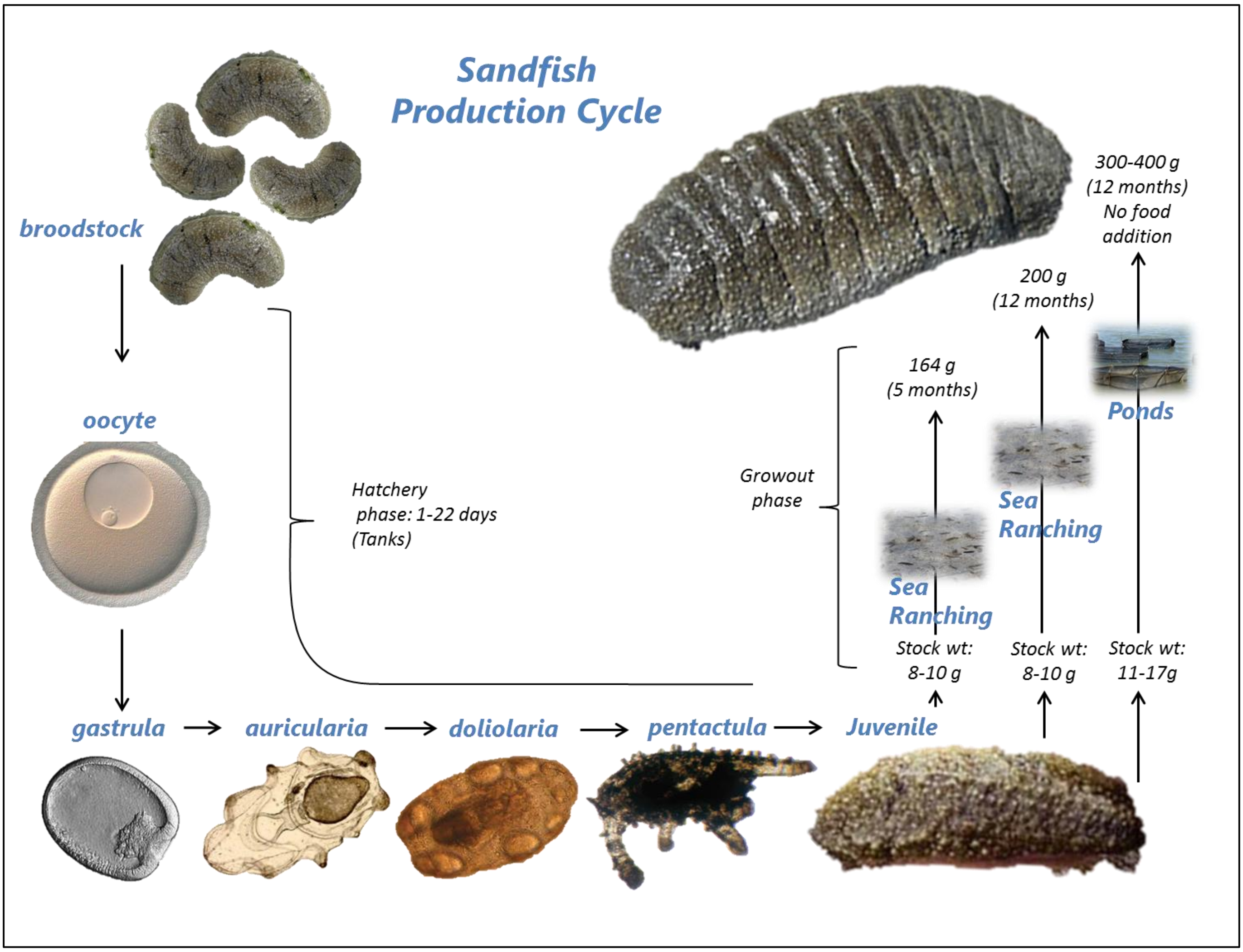

Figure 7: Production cycle of sandfish.

Broodstock

Mature adult sandfish broodstock are collected from wild populations during the spawning season and transported back to the broodstock acclimation and quarantine facility. They are placed first into quarantine tanks for one to four weeks to ensure that no disease or parasites enter the system and infect other fish. During this phase they are held in tanks with a combination of RAS and flow-through design for up to three months, during which water is regularly exchanged (Tonn *et al.*, 2016; Ito, 2018). When the quarantine process is complete, broodstock are transferred to broodstock holding tanks with a layer of sand or mud lining the bottom, at a density of 15 to 30 sandfish per 1000L, and fed with fish and/or vegetable matter such as seagrass and algae (Agudo, 2006). It is not possible to determine the sex of live sandfish when they are not spawning, so a large number (n >30) are stocked into broodstock facilities to ensure both mature males and females are present (Agudo, 2006).

Once broodstock have acclimated to captivity, 30 to 40 broodstock are transferred to a spawning tank. They can be induced to spawn using a number of treatments, including thermal stimulation which involves controlling water temperatures, dry treatment and water pressure treatment, or a combination of methods (Agudo, 2006).

Larviculture and nursery phase

One hour after spawning, eggs are collected from spawning tanks by siphoning and transferring them to larval tanks. After hatching, sandfish larvae metamorphose over a period of 12 to 16 days, after which they are juveniles of 5-10mm long, resembling the adults. Juveniles remain in larviculture tanks until day 25 to 30, and are then transferred to nursery tanks. After another 30 days, when juveniles have reached a size of 20mm (or 1g), they are able to ingest sediment, and can be moved to tanks with a layer of sand for them to feed from (Agudo, 2006). They remain in nursery tanks until they are large enough to be moved to grow-out facilities; 8-10g for sea ranching and 11-17g for pond culture.

A variety of food is provided during the larviculture and nursery stages (Figure 7). During the auricularia stage (two to 10 days after hatching), larvae feed on microalgae available in the water column that simulate the species' natural wild diet. In the subsequent dolioria stage (10 days after hatching), larvae do not feed but diatom plates lined with microalgae are provided in tanks. Twelve days after hatching, larvae settle on these surfaces when they enter the pentactula phase. Fifteen days after hatching, larvae have metamorphosed into juveniles that feed on macroalgae off the tanks' surfaces (Skewes *et al.* 2004; Agudo, 2006; Ivy & Giraspy, 2006; Robinson, 2014; Militz *et al.*, 2018).

Grow-out

Sea ranching

Sea ranching involves stocking nursery-reared sandfish juveniles onto the ocean substrate for their grow-out phase, to be harvested once they reach market size (Hair *et al*., 2016). Areas suitable for sea ranching are usually shallow (<25m), intertidal areas with sandy or muddy substrates, a sufficient level of organic matter for feeding, and a relatively low abundance of sandfish predators. The carrying capacity of each potential seeding site is assessed to determine appropriate stocking numbers. Juveniles are stocked at a size of 8 to 10g, usually into enclosed structures, such as hapa nets or sea pens, to reduce the risk of predation. At 50g, the sea cucumbers are moved into open areas and harvested by divers when they reach a market size of approximately 400g.

Juveniles can also be stocked below sea cages holding finfish, such as snapper and grouper, or below pearl oyster long lines in a form of integrated multi-trophic aquaculture (IMTA). The organic waste from the fish cages, such as uneaten food and by-products, provide high-nutrient food for sandfish feeding from the sediment, improving growth and survival as well as residency of sandfish (Mills *et al*., 2012; Robinson, 2014). This co-culture makes grow-out of sandfish more efficient, and is ecologically beneficial as the sandfish provide bioremediation of the sediments below the cages by using excess nutrients from cage culture for energy and growth (Chopin *et al*., 2012; Buck *et al*., 2018).

Pond culture

In pond culture systems, sandfish juveniles from the nursery facility are initially stocked into hapa nets within land-based ponds (Figure 8A) until they reach a size of 8-10g, after which they are transferred to grow-out ponds (Juinio-Meñez *et al.*, 2014). Sandfish feed on organic matter from the substrate of ponds, which can be supplemented and enriched by the addition of feed (Figure 8B) (Robinson, 2014). They are harvested from ponds once they have reached market size of 400g, after approximately 14 months (Duy, 2012; Robinson, 2014).

Sandfish under pond culture conditions have shown high yields and rates of survival and growth, due to a number of factors including lower predation, high nutrient levels, and the closed nature of the system preventing sandfish moving away. Costs associated with land-based pond aquaculture are, however, higher than sea ranching, involving building, maintenance, labour and feed costs (Purcell *et al*., 2012a).

Figure 8: A) Hapa nets inside a pond; and B) Adult sandfish partially burrowed in sediment in a pond (Source: www.thefishsite.com; Purcell, 2012a).

Sandfish health

It is important to provide a clean and hygienic hatchery environment, to prevent diseases, infections and parasites in hatchery-reared sandfish (Yin-Geng *et al*., 2004). To ensure the health of sandfish within the land-based system, and that all juveniles used for stocking are healthy, controls are enforced including disinfection of tanks and equipment, removal of excess food, faeces and other organic matter, and maintaining a high level of water quality (James *et al.*, 1994; Yin-Geng *et al*., 2004; Ivy and Giraspy, 2006). Skin ulceration disease caused by bacterial species (such as *Vibrio* and *Bacteroides* spp.) is commonly reported in sandfish in land-based facilities (Becker *et al*., 2004; Lavitra *et al*., 2009). Such infections can largely be prevented by maintaining high standards of hygiene, but can be treated by use of antibiotics administered at correct dosages and contained within land-based systems (Yin-Gen *et al*., 2004).

Before release of juveniles into grow-out areas, strict checks for disease and parasites should be carried out to avoid introduction of harmful organisms to the wild stock (Robinson, 2014). Efforts are taken to ensure minimal stress of sandfish at all stages of production, including during transportation and acclimation, by maintaining optimal environmental parameters, stocking density and cleanliness of facilities, to reduce the risk of infection.

3. Market for sea cucumber products

Sea cucumber is marketed in various product forms (Figure 9), although bêche-de-mer products comprise 90% of the trade. The product is consumed differently in different regions; in some areas it is consumed whole, while in other areas the intestines and/or gonads are consumed as a delicacy (Hamel *et al.*, 2013). Fresh, frozen and canned products are also sold in much smaller quantities. Bêche-de-mer is the processed product of processed and dried sea cucumber **Error! Reference source not found.**(Muthiga and Conand, 2014), and is a very high value product in Asian markets (Toral-Granda, 2007; Han *et al.*, 2016).

The process in the Seychelles (Figure 10) is as follows. On board the fresh sea cucumbers are gutted, washed and salted and stored on ice until they are landed ashore. In the factory, the salt is washed off and they are graded for size. Next, they are boiled for about 1 hour, where after they are placed in drying ovens for up to 3 days. After the drying process they are boiled again in salt water and then sun dried, where upon they are packed for export (Andrew Espadon, SFA, pers. comm., March 2019).

Figure 9: A) High-value bêche-de-mer on sale in jars in Hong Kong; and B) Dried Madagascan sandfish (Source: Purcell, 2014).

Figure 10: Processing of White teat fish, Sandfish and Flower teat in Seychelles. A) Washing; B) Boiling; C) Sun drying; and D) Product ready for export (Source: Andrew Espadon, SFA).

The market demand and retail price for sea cucumber products in the dominant Chinese markets are both increasing (Purcell *et al.*, 2018). Sandfish is among the highest value sea cucumber species in the global market and processed dry product can fetch retail prices of up to USD 1 668/kg in Hong Kong, and wholesale prices of up to USD 200/kg in Guangzhou markets (Figure 11) (FAO, 2012; Robinson, 2014).

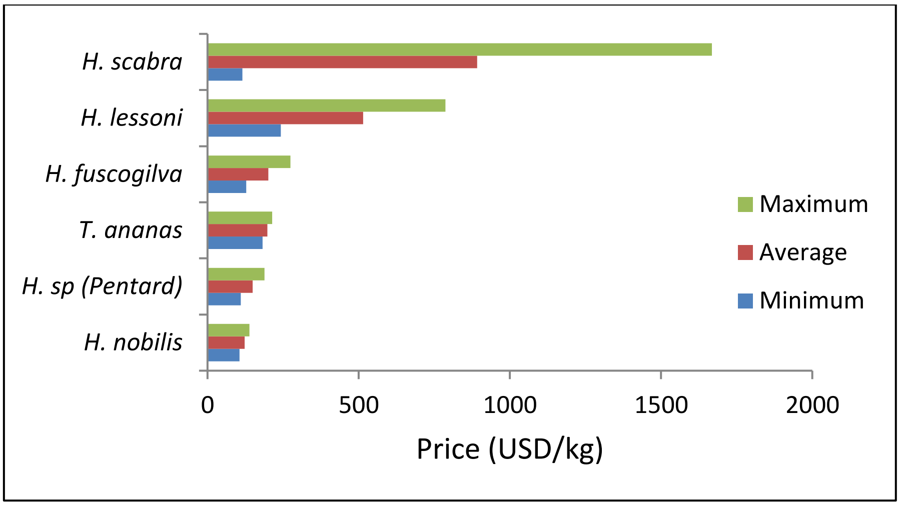

Figure 11: Retail prices of bêche-de-mer products in the main international marekt, Hong Kong (Robinson, 2014).

The current global production of sea cucumber, particularly sandfish, from both aquaculture and fisheries is insufficient to meet the growing demand of the Asian bêche-de-mer market (Muthiga and Conand, 2014). Chinese sea cucumber production has suffered recent declines, following high temperatures in 2018 that led to high water temperatures and stock losses of around 68 000 tonnes (equivalent to USD 1 billion) in Northern Chinese pond and shallow water (less than 7m) culture operations (Global Times, 2018; Shumin and Zuwei, 2018). This gap in the market is expected to result in imports and an increasing value of sea cucumber products (Leow, 2018; Shen, 2018). There is thus an excellent opportunity for increased aquaculture to supply this market, particularly though sea ranching which is less likely to be affected by high temperature anomalies than culture in shallower water.

Seychelles exports wild-caught dried sea cucumber to Asian markets, and in 2014 was ranked 9th in producing countries supplying Hong Kong bêche-de-mer markets in terms of quantity and value (Robinson, 2014). From 2006 to 2008, the quantity of Seychelles' sea cucumber export decreased by 55%, however value of imports increased by 43% over the same period (Table 1) (Robinson, 2014). Despite its high market price, sandfish makes up a small portion of the total sea cucumber export due to population declines, accounting for only 0.31% of total recorded sea cucumber catches (MRAG, 2012; Robinson, 2014). Aquaculture of sandfish in Seychelles can increase the value of sea cucumber exports whilst relieving pressure on wild sea cucumber stocks.

Table 1: Trends in the quantity and value of bêche-de-mer exported from Seychelles to Hong Kong (Robinson, 2014).

	2006	2007	2008
Quantity (tonnes)	51.0	41.0	28.0
Value (Hong Kong Dollars)	11,915,000.00	10,189,000.00	9,339,000.00
Value (USD)	1,537,419.35	1,314,709.68	1,205,032.26
Price per kilogram (USD)	30.10	32.10	43.00

4. Suitability for aquaculture in Seychelles

The species

Sandfish is indigenous to Seychelles waters and as such is permitted for aquaculture production. This species has a high market value, and a growing demand which cannot be met by capture fisheries as its wild populations have become overexploited. Aquaculture of sandfish to supply the market is thus an opportunity for economic development.

Sandfish is the most widely cultured tropical sea cucumber species. Its reproductive cycle in captivity is well understood, and hatchery, nursery and grow-out technologies and practices have been well-developed (Morgan, 2000; Robinson, 2014). It is demonstrated to grow well in a variety of culture systems, including pond culture and sea ranching (Pitt and Duy, 2004; Agudo, 2006; Robinson, 2014).

Sea ranching inevitably results in enhancements of natural populations, due to spill-over and larval recruitment effects (Purcell, 2010; Robinson, 2014). Sea ranching of sandfish in the Seychelles thus has the potential to assist in the recovery of the overexploited population (Robinson, 2014).

Environmental and oceanographic conditions

Yields from sea ranching are dependent on identifying optimum sites. High food availability is required for growth and survival, and to prevent sandfish moving away from the ranching area. Seychelles waters offer optimum habitats and environmental conditions for the survival and growth of ranched sandfish (Robinson, 2014).

A number of potential sites have been identified that are suited to farming of sandfish, including on the outer islands; there is an opportunity for both pond-culture and small-scale sea ranching on Coëtivy, and for large-scale sea ranching on Poivre Island (Robinson, 2014).

Seychelles waters are also well suited to sea-based cage culture of marine finfish species, and longline culture of pearl oysters, due to ideal oceanographic conditions, which allows for Integrated Multi-Tropic Aquaculture (IMTA). The substrate under finfish cages and pearl oyster longlines serves as an ideal location for ranching of sandfish as excess organic matter from cages (such as faeces, and uneaten food in the case of finfish) can provide a nutrient-rich environment for high growth and survival rates in sandfish. Ranching of sandfish below sea cages and longlines also allows for bioremediation of the sediments below these cages and improves the sustainability of finfish farming (Chopin *et al*., 2012; Purcell *et al*., 2012a; Robinson, 2014; Buck *et al*., 2018).

Access to markets

Seychelles' level of transport infrastructure and location in the middle of the western Indian Ocean makes it ideal for aquaculture production; it has access to markets in Europe, the USA and Asia, via air and sea transport, and is able to receive imports of supplies, such as feed and technical equipment, from high-quality suppliers around the world. It also has access to local markets as products can be transported within and between islands.

Seychelles is among the top exporters of sea cucumber products to Asian markets, and a high-value export market for high-quality products is already established (Aumeeruddy and Conand, 2008; Robinson, 2014). This provides an opportunity to increase the supply of products to these markets, while increasing the value with the addition of increased quantities of valuable sandfish bêche-de-mer.

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