Seychelles Mariculture Master Plan

Aquaculture Fact Sheet

Brown-Marbled Grouper

Epinephelus fuscoguttatus

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by Advance Africa Management Services

Table of contents

List of figures

1. Background

Common names

Brown-marbled grouper; tiger grouper	*English*
Vyey masata	*Seychelles Creole*

Biology and ecology

The brown-marbled grouper (*Epinephelus fuscoguttatus*) is a tropical and sub-tropical, reef-associated fish of the Serranidae family. It is widely distributed throughout the tropical and subtropical Indo-Pacific, from the east coast of Africa to the oceanic islands of the western Pacific Ocean (Heemstra and Randall, 1993), including the waters of Seychelles (Figure 1). It inhabits shallow coral reefs and rocky areas at depths of up to 60m, with juveniles typically found in inshore areas, particularly in seagrass habitats (Heemstra and Randall, 1993; Sommer *et al*., 1996).

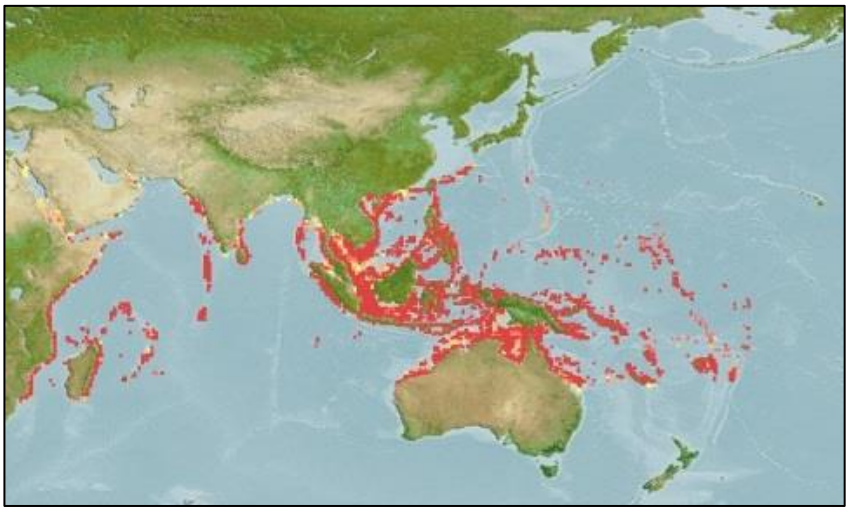

Figure 1: Natural distribution of brown-marbled grouper *(Source: FAO, 2019)*.

The species is distinguished by its light yellow-brown body patterned with five vertical series of irregular dark brown blotches (Allen and Erdmann, 2012), with smaller close-set brown spots covering its head, back and sides (Figure 2). It has a maximum recorded length of 120cm TL (total length) (Chan *et al*., 1974; Heemstra and Randall, 1993) and a maximum weight of 18kg (Pears *et al.*, 2006). Brown-marbled grouper are slow-growing, long-lived (max. age 42 years), carnivorous fish, with a diet that includes fishes, crabs and cephalopods (Heemstra and Randall, 1993; Pears *et al.,* 2006; Mapleston *et al*., 2009).

Figure 2: Brown-marbled grouper (Photo: Erik Schlogl).

Brown-marbled groupers are protogynous i.e. individuals change sex from female to male during their life cycle. All juveniles mature as females, and sex change typically occurs at 68cm TL when they transition into mature males. Males smaller than 70cm TL have not been recorded (Pears *et al*., 2007), and not all females undergo sex-change. Mature females as large as 85cm TL have been recorded (Pears *et al*., 2006; 2007). The species is late-maturing, with 50% of females reaching sexual maturity at around 56cm at 9 years of age (Pears *et al*., 2006).

The brown-marbled grouper spawns in large aggregations at (fixed) spawning sites for between two and five months of the year, often together with other grouper species (Figure 3) (Domeier and Colin, 1997; Johannes *et al*., 1999; Pears *et al*., 2007; Robinson *et al*., 2008). These spawning aggregations are closely linked to the lunar cycle and differ in timing, duration, size, and species structure (Johannes *et al*., 1999). Spawning aggregations occur between November and February in Seychelles waters (Robinson *et al*., 2008; Bijoux *et al*., 2013), with aggregations of over 1 000 fish having been recorded (Robinson *et al*., 2008).

Figure 3: Spawning aggregation comprising two grouper species, brown-marbled grouper and camouflage grouper (*E. polyphekadion*) (Source: wildencounters.net, 2015).

Fisheries

The brown-marbled grouper is targeted by commercial and artisanal fisheries throughout its distribution (Tupper and Sheriff, 2008). Groupers, including brown marbled grouper, are especially sought after for the live reef fish food trade (LRFFT) in Southeast-Asia and Hong Kong (Figure 4), with wild-caught brown-marbled grouper carrying an average wholesale value of USD 52.50/kg in 2016 (Sadovy, 2000; Sadovy *et al*., 2003; Rhodes *et al*., 2012; HK Fish Net, 2017). This accounts for approximately 20% of the global grouper production (Sadovy de Mitcheson *et al*., 2012), and is the largest source of pressure on wild stocks of brown-marbled grouper (Rhodes *et al*. 2016). Approximately 66% of groupers in the LRFFT trade are from wild-caught fisheries, with the remainder coming from aquaculture. Groupers are important food fish species globally, and approximately 80% of grouper production from fisheries and aquaculture is processed (chilled, fresh, frozen, whole, filleted) for markets in the USA, EU and Asia.

Figure 4: Live groupers for sale in a restaurant in Singapore (Photo: Chris Johnson).

Brown-marbled grouper is classified as 'Vulnerable' by the International Union for Conservation of Nature (IUCN) based on a 2016 assessment of the species (Rhodes *et al.*, 2018). This is due to a combination of factors including the level and nature of fishing pressure it experiences, and its low resilience to fishing pressure (Jennings *et al.*, 1999; Sadovy, 2001; Pears *et al.*, 2006). A host of factors render the species susceptible to overfishing including slow growth rate and late sexual maturity. Moreover, spawning aggregations have historically been subject to intense fishing pressure as fish in these aggregations are particularly vulnerable to capture; as a result, certain aggregations are reported to have declined in size while others have disappeared completely (Johannes *et al.*, 1999; Sadovy and Domeier, 2005; Sadovy de Mitcheson and Erisman, 2012). In 2009, the Islands Development Company introduced fisheries management measures banning fishing on spawning aggregations around some of the Seychelles Outer Islands.

Aquaculture

Globally, grouper aquaculture production has increased considerably since 2000 (Figure 5). From 2012 to 2016 a total of between 28 and 33% of grouper production was derived from aquaculture. In 2016 a total of 154 011 tonnes of grouper were produced globally by aquaculture (Figure 5) (FAO, 2018).

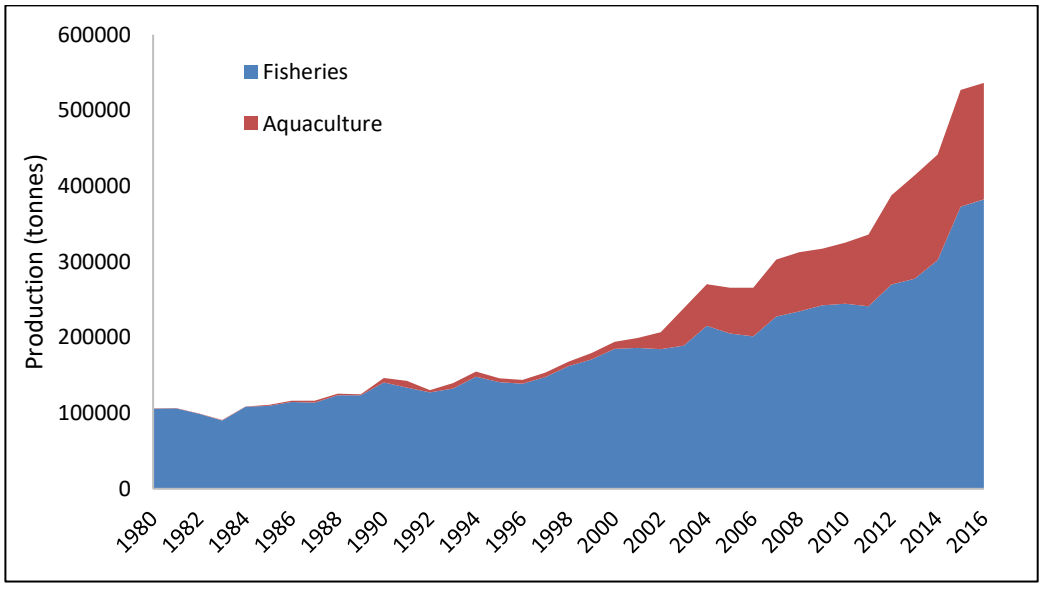

Figure 5: Global grouper production, 1980 to 2016 (Source: FAO, 2018).

The majority of grouper, including brown-marbled grouper, are farmed in Asia, with China and Taiwan being the biggest producers (Figure 6). Most aquaculture operations in this region are small-scale farms, using wooden cages in

the inshore region, or land-based ponds for the grow-out of fish to market size (Sadovy, 2000; Kongkeo *et al*., 2010). In many cases, these operations grow fish to market size from wild-caught fingerlings, contributing to the pressure on wild stocks (Sadovy, 2000; Pierre *et al*., 2004; Tupper and Sheriff, 2008).

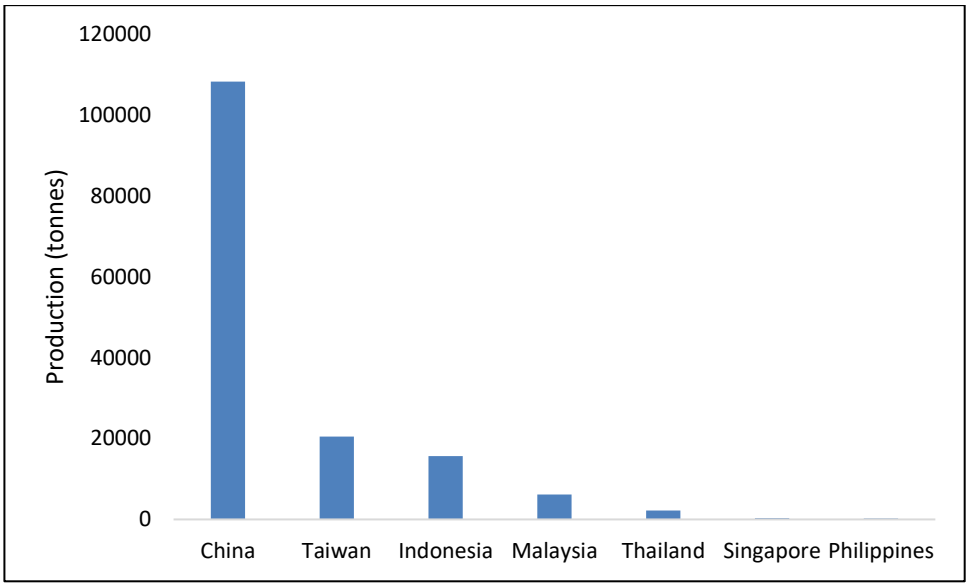

Figure 6: Grouper aquaculture production in 2016 of the top producing countries (Source: FAO, 2018).

The increasing demand for grouper products, in addition to stagnating or declining supply from capture fisheries and environmental concerns surrounding their exploitation, has led to the development of aquaculture technologies for a number of species including:

1. Red-spotted grouper (*E. akaara*)
2. Orange-spotted grouper (*E. coioides*)
3. Giant grouper (*E. lanceolatus*)
4. Brown-marbled grouper (*E. fuscoguttatus*)
5. Malabar grouper (*E. malabaricus*)
6. Camouflage grouper (*E. polyphekadion*)
7. Greasy grouper (*E. tauvina*)
8. Mouse grouper (*Cromileptes altivelis*)
9. Coral trout species (*Plectropomus spp.*)

(Sadovy, 2000; Rimmer *et al*., 2004; Sugama *et al*., 2016).

Brown-marbled grouper has proven to be a successful candidate for aquaculture due to its high market price and demand, ability to tolerate and thrive under culture conditions, and its relatively high growth rate compared to similar species (Shapawi *et al*., 2014).

2. Technical approach to aquaculture production

Production cycle

Brown-marbled grouper can be farmed entirely on land or, as will be the case in Seychelles, through a combination of land- and sea-based phases (Figure 7). Adult fish (broodstock) are captured from the wild and held in land-based tanks, where they spawn and produce eggs. After hatching, fish remain in a land-based facility during their larval and juvenile

phases, after which they are transferred to cages in the sea for their grow-out phase, where they remain until they reach market size and are then harvested (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 fish. Similarly, effluent water leaving the tanks is cleaned in accordance with the relevant Seychelles Aquaculture Standard and global best practice.

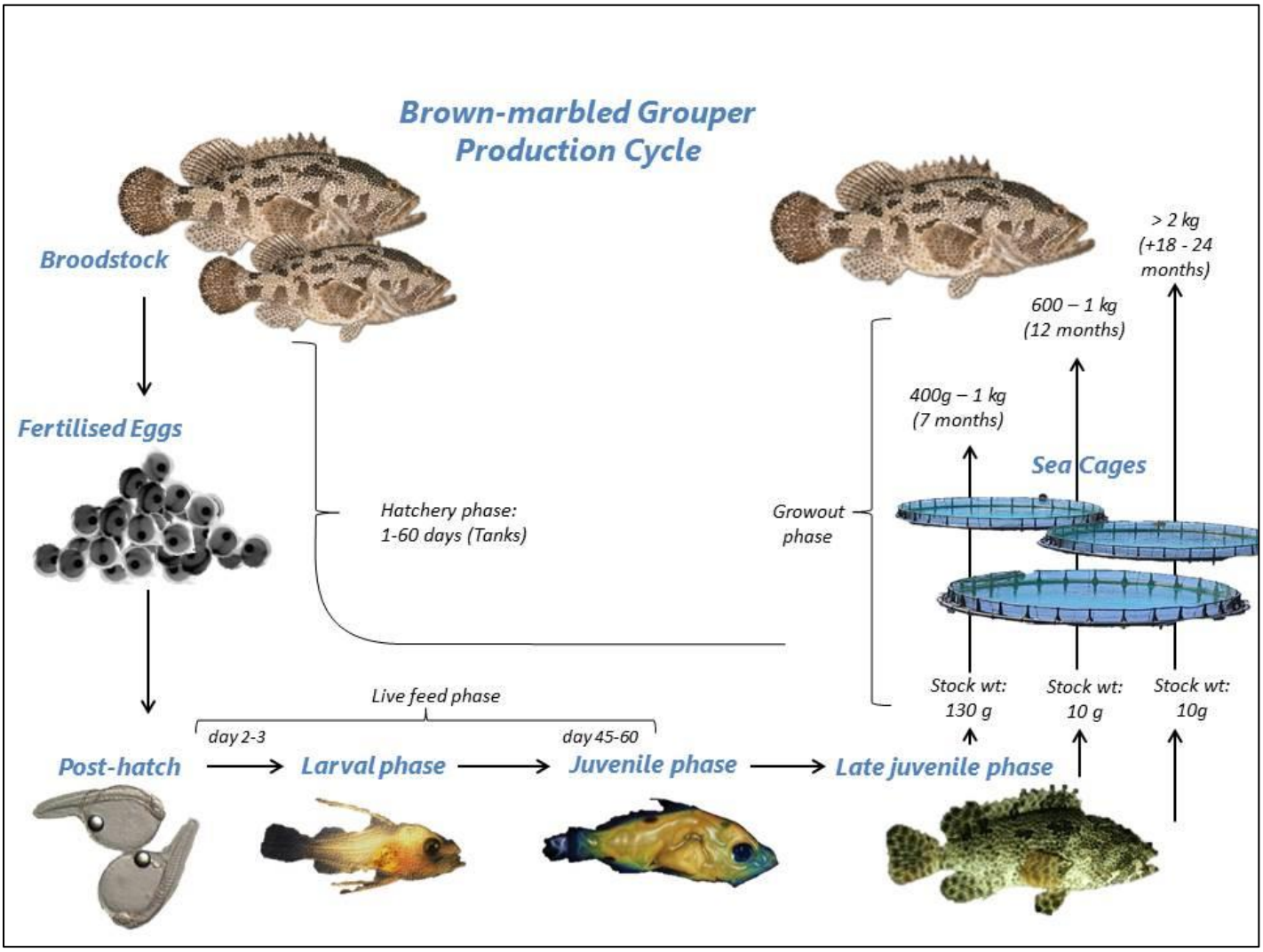

Figure 7: Production cycle of brown-marbled grouper.

Broodstock and spawning

Brown-marbled grouper broodstock are captured from the wild and transported back to the broodstock acclimation and quarantine facility in specially designed broodstock transport tanks. 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 exposed to regular freshwater baths to remove any parasites they may be carrying (Koesharyani *et al*., 2005; Sugama *et al*., 2012). When the quarantine process is complete, broodstock are moved into broodstock holding tanks, where they are fed daily on a natural diet of squid and fish, often enriched with vitamins to maintain fishes' health (Figure 8A) (Sugama *et al*., 2012).

Once broodstock have acclimated successfully to captivity, they are moved to spawning tanks (Figure 8B). The sex ratio in the tanks is around one female to two males. Natural reproduction in groupers follows the lunar cycle and, in most cases, groupers spawn for several nights over a period of months, peaking during spring, when water

temperatures exceed 25°C (Sugama *et al*., 2012). Male and female fish release sperm and eggs, respectively, and the eggs are fertilised in the water by the sperm and (live eggs) float to the surface. Millions of eggs can be spawned each night; fertilized floating eggs are checked for daily in the spawning tanks and harvested by surface skimming instruments (Caberoy and Quinitio, 1998; Sugama *et al*., 2012).

Broodstock acclimation and spawning tanks are cleaned regularly to maintain a high level of water quality and prevent disease or infections in broodstock and eggs (Sugama *et al*., 2012).

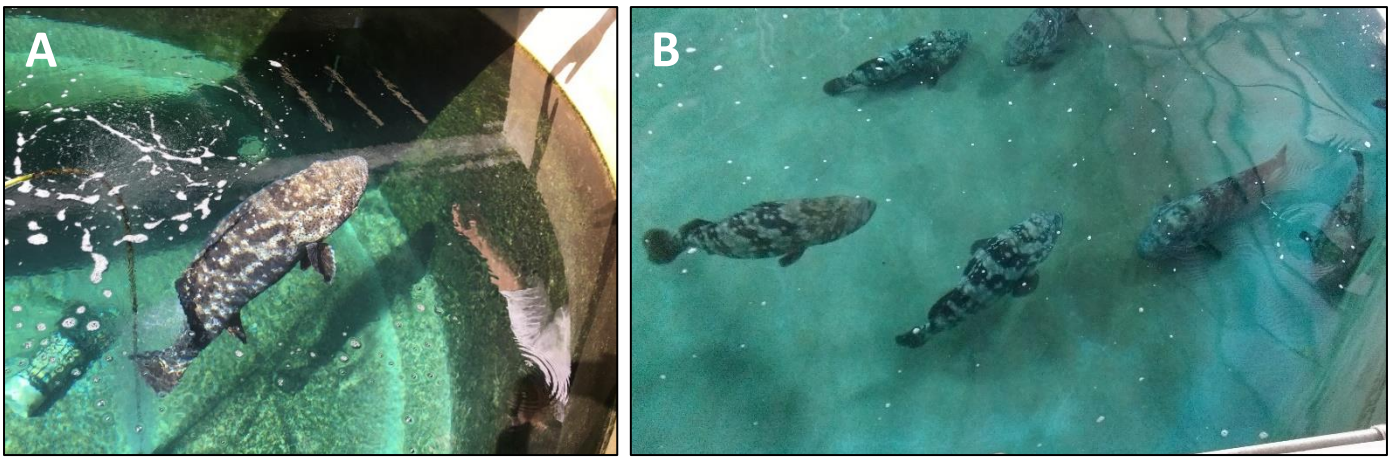

Figure 8: A) Broodstock acclimation tank; and B) Broodstock spawning tank in land-based facility

Larviculture and nursery phase

The larval rearing period lasts approximately 45 days (Sugama *et al*., 2012). Eggs are placed into indoor tanks (Figure 9A) where they hatch into larvae 15-19 hours after fertilisation (Sugama *et al*., 2012). The mouth of larval groupers generally opens 2–3 days after hatching and the larvae begin feeding soon thereafter (Doi *et al*., 1997; Rimmer, 2000; Sugama *et al*., 2012). A diversity of live feed is provided during the larval stage to simulate the diversity of phytoplankton species found in the natural environment. The live feed organisms are introduced in overlapping phases to meet nutritional requirements as larvae develop and grow. Live feeds include microalgae, rotifers, copepods, and Artemia (Figure 11). Towards the end of the larval phase, formulated feeds are introduced to begin weaning the juveniles onto this diet.

After 45 days, larvae have metamorphosed into 2 to 3cm juveniles. The juveniles are moved from the larval rearing tanks into nursery tanks (Figure 9B), where they receive formulated feeds. During the nursery phase, the juveniles are reared to between 5 and 10 cm (Figure 10) and at this stage they ready to be transferred to grow-out facilities (Sugama *et al*., 2012).

Figure 9: A) Larval rearing; and B) Nursery tanks in a land-based facility.

Figure 10: Grouper fingerlings (Photo: Muhmad Ismail).

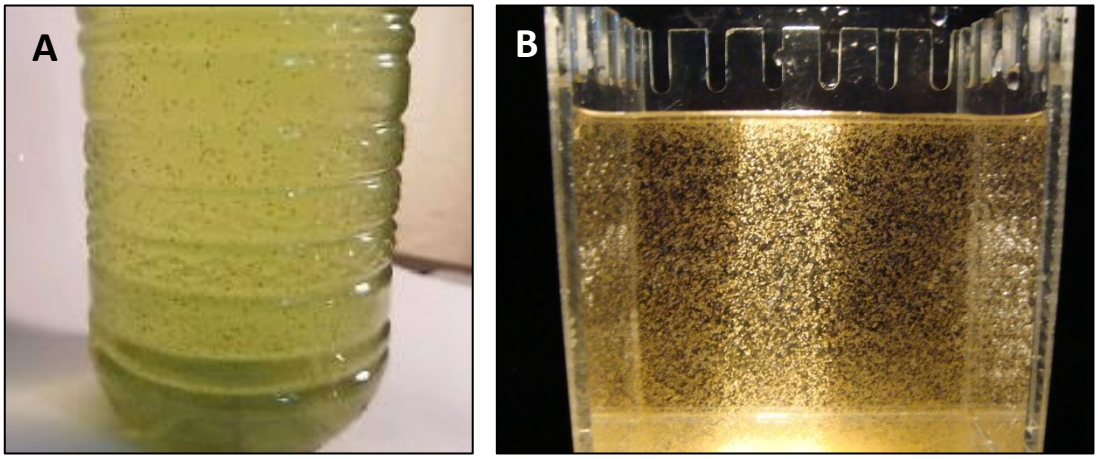

Figure 11: Live feed for larviculture rearing phase: A) Rotifers; and B) Artemia nauplii (Source: Aquaculture Nursey Farms).

Grow-out and harvesting

The grow-out phase generally ranges from 10 to 18 months during which the fish reach a market size of 1 to 2kg. Grow-out systems are typically sea-based cages or earthen ponds. The size of cages can vary widely; small 5x5x5m cages are used widely in Asia, although those used in large-scale commercial farms are circular, 12 to 16m diameter structures with depths ranging from 5 to 8m (Figure 12). The mesh size of the cages ranges from 5mm to 40mm depending on the size of the fish during the production cycle. Continuous monitoring, cleaning and maintenance of the cages is undertaken to maintain their safety and functionality (Cardia and Lovatelli, 2015).

Stocking densities in grow-out net cage systems can range from 10 fingerlings per m^3 for small-scale farms, to 20 fingerlings per m^3 for large-scale farms.

Figure 12: Sea-based cages for grow-out phase (Source: Bigstock).

Formulated pellets (Figure 13A) are the preferred feed for groupers in sea-based cages. Fish are fed once every second day (Talbot *et al*., 1999; Al Zahrani *et al*., 2016), either by hand (Figure 13B) or using automated devices (Baliao *et al*., 2000). Feeding is done in such a way as to allow all individuals to reach the food; additionally, commercial pellets are formulated to sink slowly, allowing all fish to reach food and reduce the amount of uneaten feed. Feeding is stopped when all fish are satiated and no longer feeding. Pellets are formulated to meet the nutritional requirements of the species, and the nutritional value of pellets can be enhanced with additions of vitamins and minerals to maintain fish health. By using pellets instead of fish, the possibility of transfer of disease is also greatly reduced (Ismi *et al*., 2012). Pellets also have a long shelf-life, reducing food waste.

Figure 13: A) Artificial pellet feed for grow-out phase; and B) Hand-feeding of cage fish.

Fish are graded throughout the grow-out phase. Once fish are ready for market, they are harvested from cages (Cardia and Lovatelli, 2015).

Fish health

At all stages of the production cycle, care is taken to ensure fish health and welfare. Minimising stress is key to reducing susceptibility to disease and infections, and is done by maintaining optimal production and environmental parameters including stocking densities, feeding regimens, water quality and temperatures among others (Nagasawa and Cruz-Lacierda, 2004; Sugama *et al*., 2012). A very high level of biosecurity and cleanliness is also maintained to reduce the likelihood of disease outbreaks (Sugama *et al*., 2012).

Fish can be vaccinated against a number of viral and bacterial diseases and infections, including Viral Nervous Necrosis (VNN), the most common disease affecting brown-marbled grouper in culture environments (Lio-Po and de la Peña, 2004; Harikrishnan *et al*., 2011; Manin and Ransangan, 2011; Sugama *et al*., 2012). These vaccines are highly effective and preclude the use of antibiotics.

3. Market for brown-marbled grouper products

In Asia a significant proportion of farmed groupers are sold into live reef fish market. Processed groupers are also highly sought after in markets in Asia, the USA and Europe. Historically, farmed grouper has largely supplied the live reef markets, while wild caught grouper has supplied the processed market.

Globally, there is a growing market for high-quality processed grouper products, including whole gutted and gilled fish, and chilled and frozen fillets (Figure 14) (SeafoodSource, 2014). In 2012, for example, the largest portion of Indonesia's grouper production was in the form of frozen product (approximately 6 800 tonnes), most of which was exported to Thailand followed by China (Fishery Statistics Indonesia, 2012).

Figure 14: Processed grouper fillets.

Figure 15 shows the position of grouper products in global markets, relative to other popular food species, in terms of market value (US dollars per kilogram) and relative market perception, or desirability amongst consumers. Grouper ranks high on this scale in in terms of both value and perception in comparison to other valuable, popular food fish species, for example Atlantic salmon.

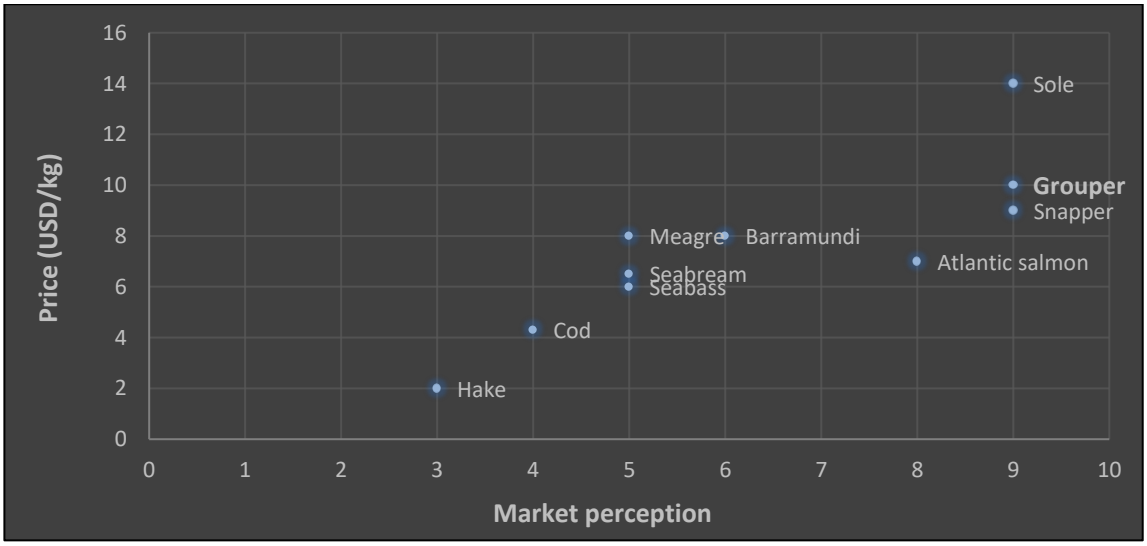

Figure 15: Market price and perception of grouper in relation to other marine finfish products.

With increasing access to global markets, it is expected that there will be a shift from live to processed fresh and frozen products. Increasing demand for these products is expected to come from markets in the USA, Japan and Europe. Imports of fresh and frozen grouper products by the USA have increased in recent years (Figure 16), with the average cost of USD 8.37/kg from 2014 to 2017 (NOAA, 2018). Grouper are already a popular species in these countries but, due to limited wild caught supply, total consumption is low and aquaculture has the potential to fill this gap. The USA currently imports farmed grouper in the form of fresh and frozen processed products from a number of producing nations, including Indonesia, Mexico, Costa Rica, Brazil, India, Panama and China (NOAA, 2018).

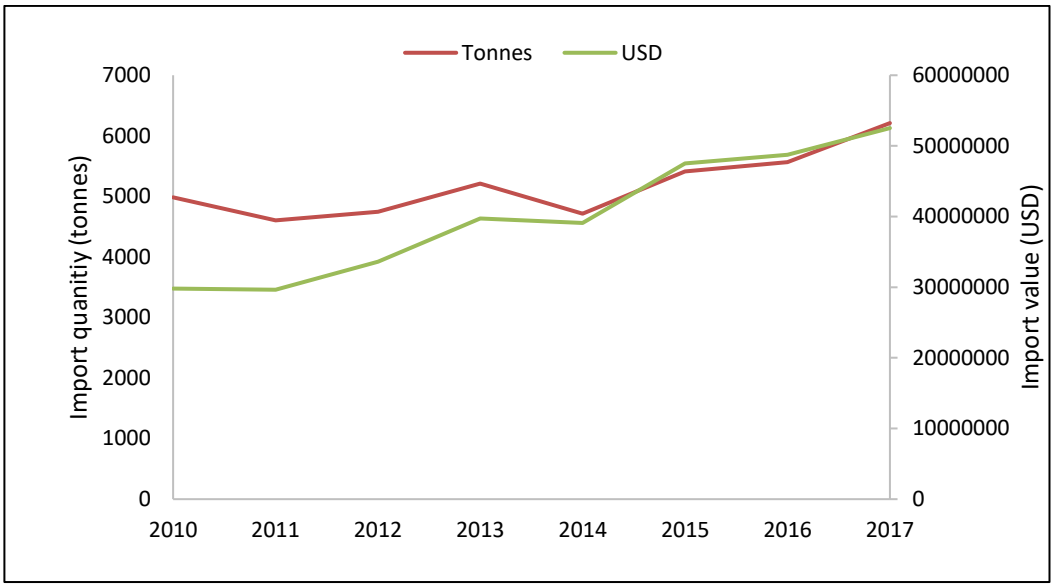

Figure 16: Quantity and value of US imports of fresh and frozen grouper products, 2010 to 2017 (NOAA, 2018).

4. Suitability for aquaculture in Seychelles

The species

The brown-marbled grouper is indigenous to Seychelles waters and is therefore permitted for aquaculture production. Broodstock can be obtained from local waters for use in aquaculture facilities. Brown-marbled grouper has proven to be a successful candidate species for aquaculture as they spawn naturally in captivity (Chao *et al*., 1993; Sudaryanto *et al*., 1994; Sugama *et al*., 2012), have demonstrated high survival rates in hatcheries and have a relatively fast growth rate under farming conditions (de Silva, 2012).

Environmental and oceanographic conditions for cage culture

The environmental conditions of Seychelles waters, such as temperature and salinity, are optimal for the survival and growth of brown-marbled grouper (Hecht, 2016).

A number of factors have to be considered when selecting an area and sites for cage culture (Cardia and Lovatelli, 2015). The shelf area of the Seychelles inner islands in particular provide a suitable environment for cage culture. This region falls outside of the cyclone belt, and is less affected by the strong seasonal south east monsoon than the outer islands (Chang-Seng, 2007; ASCLME, 2012; UNEP, 2004). The oceanographic conditions are well within the optimum range for successful cage culture. Wave height, including during the SE and NE monsoons, is below the maximum swell height of 6m that such cages can withstand. Average current speeds are high enough to ensure water circulation within cages and dissolving of particles, without being too strong for the cage structure. Dissolved oxygen levels are above the threshold required for cage culture (Hecht, 2016).

Within this region a number of specific sites have been identified which will provide the conditions for optimal fish growth and minimal environmental and social impact. These zones are located such that they do not interfere with other activities such as tourism, artisanal fisheries and transport routes, and are far enough offshore to allow optimum water quality for fish health and to further ensure they do no conflict with land-based activities. These sites are characterised by ideal depth and sea-floor structure (relatively flat and soft or sandy) for cage culture, and a lack of coral reef or seagrass below cages to minimise the impact on marine ecosystems (Hecht, 2016).

Access to markets

Seychelles' level of transport infrastructure and its location in the middle of the western Indian Ocean makes it well-suited to aquaculture production for global markets. Seychelles has access to markets in Europe, the USA and Asia, via air and sea transport, and is able to receive imports of supplies, such 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.

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