Seychelles Mariculture Master Plan

Aquaculture Fact Sheet

Mangrove snapper

Lutjanus argentimaculatus

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by Advance Africa Management Services

Table of contents

List of figures

1. Background

Common names

Mangrove snapper; mangrove jack; river snapper	*English*
Karp	*Seychelles Creole*

Biology and ecology

Mangrove snapper (*Lutjanus argentimaculatus*) is a euryhaline fish of the Lutjanidae (snapper) family. It has a wide distribution in warm waters of the Indo-Pacific from the east coast of Africa to the western Pacific Islands (Figure 1) (Allen, 1985; Russell *et al*., 2003), where it inhabits a diverse range of habitats. Juveniles and sub-adults inhabit water of lower salinities, including mangrove estuaries and lower reaches of freshwater streams (Sommer *et al*., 1996; Emata, 2003; Russell *et al*., 2003), while adults are reef-associated and tend to inhabit areas with abundant caves and overhangs, and older individuals may occur on reefs at depths exceeding 100m (Allen, 1985; Lieske and Myers, 1994; Leu *et al*., 2003; Russell *et al*., 2003).

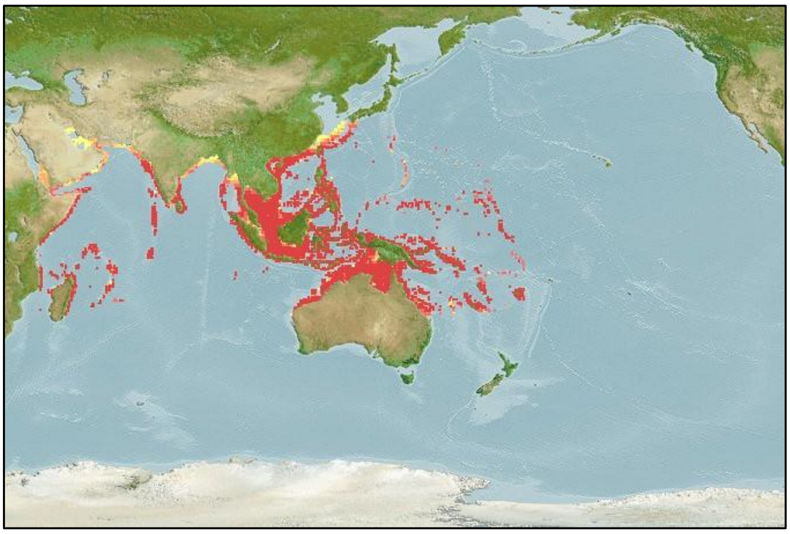

Figure 1: Natural distribution of Mangrove snapper (Source: Aquamaps, 2015).

Juvenile Mangrove snapper have a dark brown-red body with vertical pale stripes on their sides and one or two blue stripes across their cheeks (Figure 2A), while adults have a green-brown back and reddish sides lacking stripes (Figure 2B) (Myers, 1999; Allen and Erdmann, 2012). The species reaches a maximum length of over 120cm and an age of 39 years, with a maximum recorded weight of 14.5kg (Doi and Singhagraiwan, 1993; Russell *et al*., 2003; FAO, 2019; Grandcourt *et al*., 2013). It is carnivorous, feeding mainly on fish and crustaceans, and is mostly nocturnal (Russell *et al*., 2016).

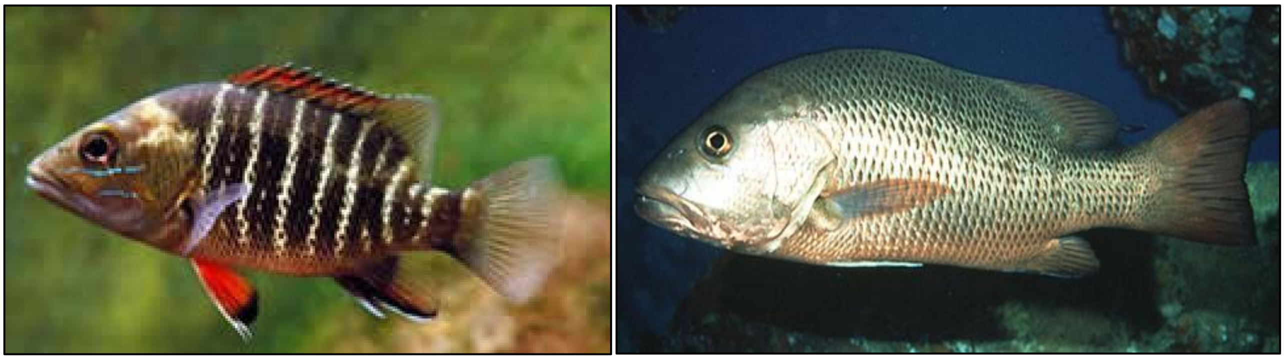

Figure 2: A) Juvenile; and B) Adult Mangrove snapper (Source: Department of Agriculture and Fisheries, Queensland).

The Mangrove snapper is a gonochoristic species; each individual matures as either male or female and remains as such throughout its life without any sex change occurring (Grimes, 1987; Russell *et al*., 2003). It is a late-maturing species, reaching sexual maturity at around 56cm, which is equivalent to ages of 14 and 13 years for females and males, respectively (Grandcourt *et al*., 2013). The species spawns between January and November, with peak spawning months varying across its distribution (Singhagraiwan and Doi, 1993; Emata et al., 1994; Leu *et al*., 2003; Russell and McDougall, 2008), and may spawn throughout the year closer to the equator (Anderson and Allen, 2001; Russell and McDougall, 2008). Spawning takes place at night, and is based on the lunar cycle, generally occurring during spring tides (Grimes, 1987; Russell and McDougall, 2008). They are broadcast spawners, and form spawning aggregations releasing eggs and sperm into the water column where eggs are fertilised. Spawning generally occurs in offshore areas (Russell *et al*., 2003; Russell and McDougall, 2008).

Fisheries

Mangrove snapper is known for its superior eating quality, and is an important artisanal and recreational angling species throughout its distribution (Anderson and Allen, 2001; Russell and McDougall, 2008; Sustainable Fisheries Partnership, 2019). The main fishing methods include gillnets, handlines, bottom longlines, traps and trawling (Anderson and Allen, 2001; Ovenden *et al*., 2003). A small component of the production of this species supplies the Live Reef Food Fish Trade (LRFFT) in southeast Asia. However, its value in the LRFFT is relatively low, with an average wholesale value of USD 13.95/kg, compared to an average of 60.20 USD/kg for grouper species in 2016 (HK Fish Net, 2017). The majority of processed Mangrove snapper products are fresh or frozen. These products are highly valued and are consumed by domestic markets, as well as by US and European export markets (Ovenden *et al*., 2003; Sustainable Fisheries Partnership, 2019).

Global snapper catch is increasing, with a catch of 229 170 tonnes in 2016 (Figure 6Figure 3) (FAO, 2018). Indonesia accounts for the largest portion of Indo-Pacific snapper catches (55% in 2016), followed by Mexico, the Philippines, Malaysia and Thailand (Sustainable Fisheries Partnership, 2009; FAO, 2018). An average of 11 520 tonnes per annum (tpa) of Mangrove snapper were caught between 2010 and 2014 (Figure 5) (FAO, 2019).

In 2015 the Mangrove snapper is listed as 'Least Concern' on the IUCN Red List of Threatened Species (Russell *et al*., 2016). Declines in population numbers from overfishing have, however, been observed in certain regions e.g. the Persian Gulf where it is classified as overfished (Grandcourt *et al*., 2013; Russell *et al*., 2016). As demand for snappers increases, the species is likely to experience increasing fishing pressure which may lead to it becoming threatened.

Aquaculture

Snappers are highly valued food fishes and, as such, attempts have been made to establish aquaculture technologies for a number of species since the mid-1980s including:

1. John's snapper (*L. johnii)*
2. Common bluestripe snapper (*L. kasmira)*

3. Star snapper (*L. stellatus)*
4. Northern red snapper (*L. campechanus)*
5. Grey snapper (*L. griseus)*
6. Mutton snapper (*L. analis)*
7. Mangrove snapper (*L. argentimaculatus)*
8. Emperor red snapper (*L. sebae)*

Currently, snapper aquaculture production contributes a small percentage (5.5%) to total snapper production. However, aquaculture production has increased in recent years (Figure 3).

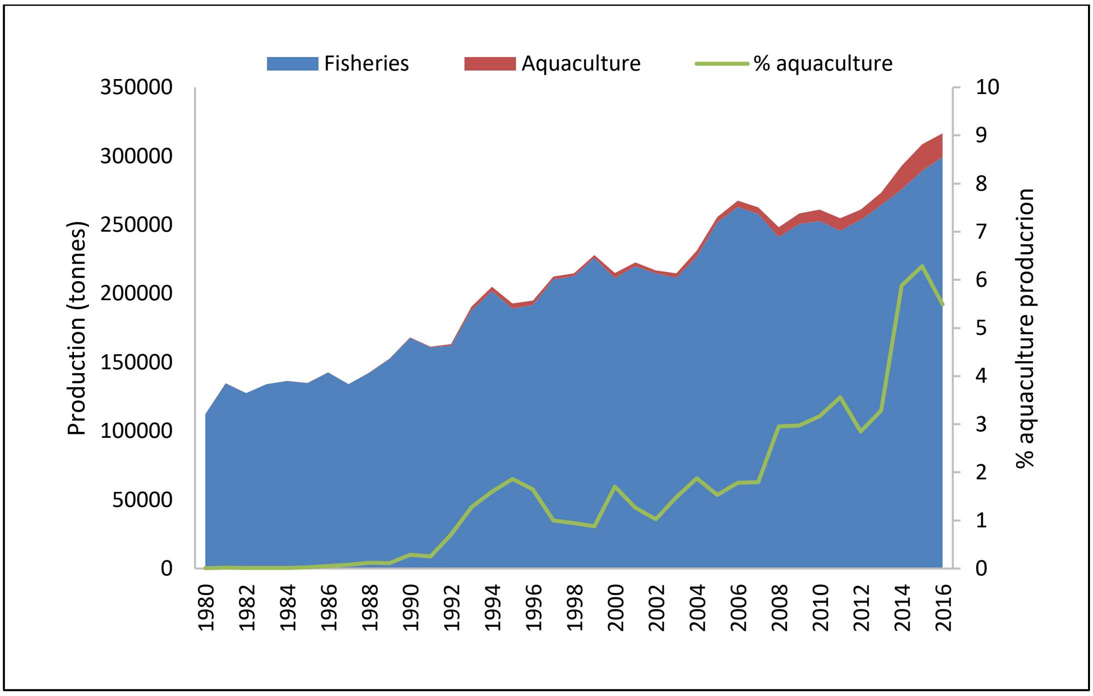

Figure 3: Global snapper production, 1980-2016 (Source: FAO, 2018).

Snappers are currently farmed in Southeast Asia and Australia. Malaysia is the dominant producer of cultured snappers followed by Indonesia (Figure 4) (however data reporting to the FAO may contain some inaccuracies; Kongkeo *et al*., 2010) (Emata and Borlongan, 2003; Sanil *et al.*, 2011; FAO, 2018). Snapper production in southeast Asia is generally small-scale; many grouper-producing farms in southeast Asia have a small component of snapper production, and grow-out of snapper to market size is mostly in wooden marine cages and brackish water ponds (Sanil et al., 2011). Aquaculture in these regions relies largely on the grow-out of wild-caught fingerlings; this is a constraint to successful and stable aquaculture ventures, and places further fishing pressure on wild stocks (Emata *et al*., 2003; Chi and True, 2017). Mangrove snapper farming is now also happening in the Middle East, particularly Bahrain (Shams, 2005).

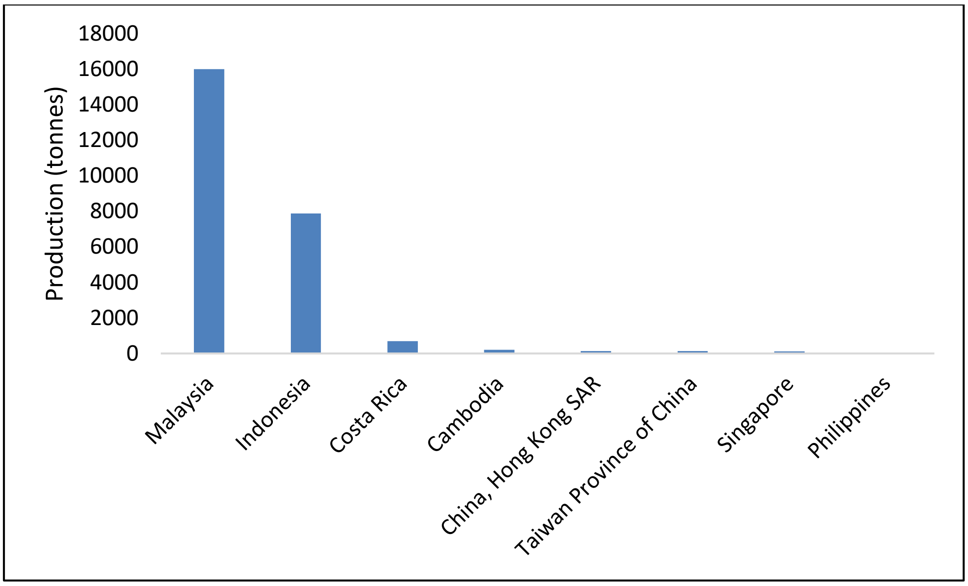

Figure 4: Snapper aquaculture per country in 2016 (Indonesian Fisheries Statistics, 2017; FAO, 2018).

Mangrove snapper

As with all snappers, the majority of Mangrove snapper is obtained from wild fisheries. However, aquaculture production is increasing, with 10 390 tonnes produced in 2014, which equates to 46% of total production (Figure 5) (FAO, 2018). The increase can be attributed to improvements in culture technologies and significant demand for this species in Asian markets.

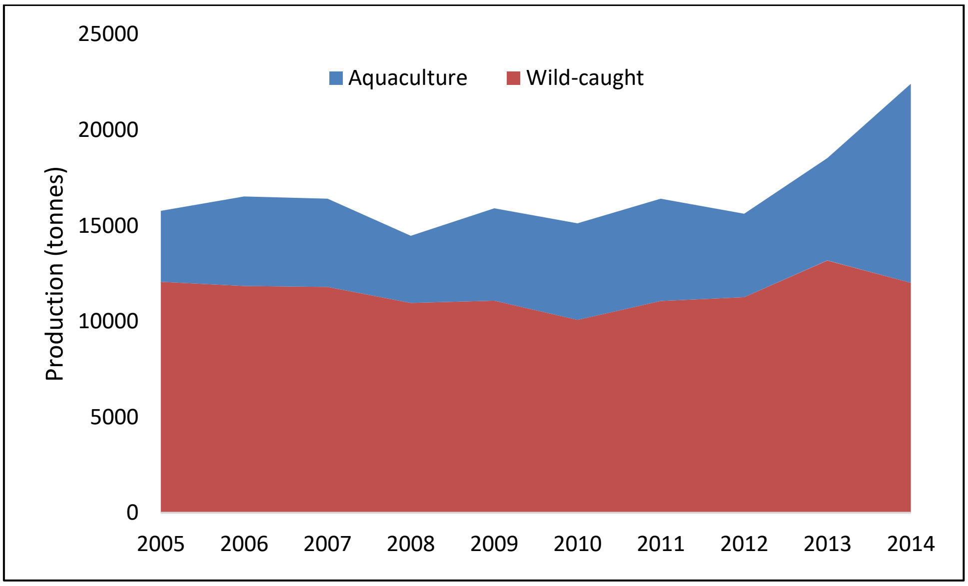

Figure 5: Mangrove snapper production (Source: FAO, 2019).

2. Technical approach to aquaculture production

Production cycle

Mangrove snapper can be farmed entirely on land or, as will be the case in Seychelles, through a combination of land- and sea-based phases (Figure 6). 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 6).

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.

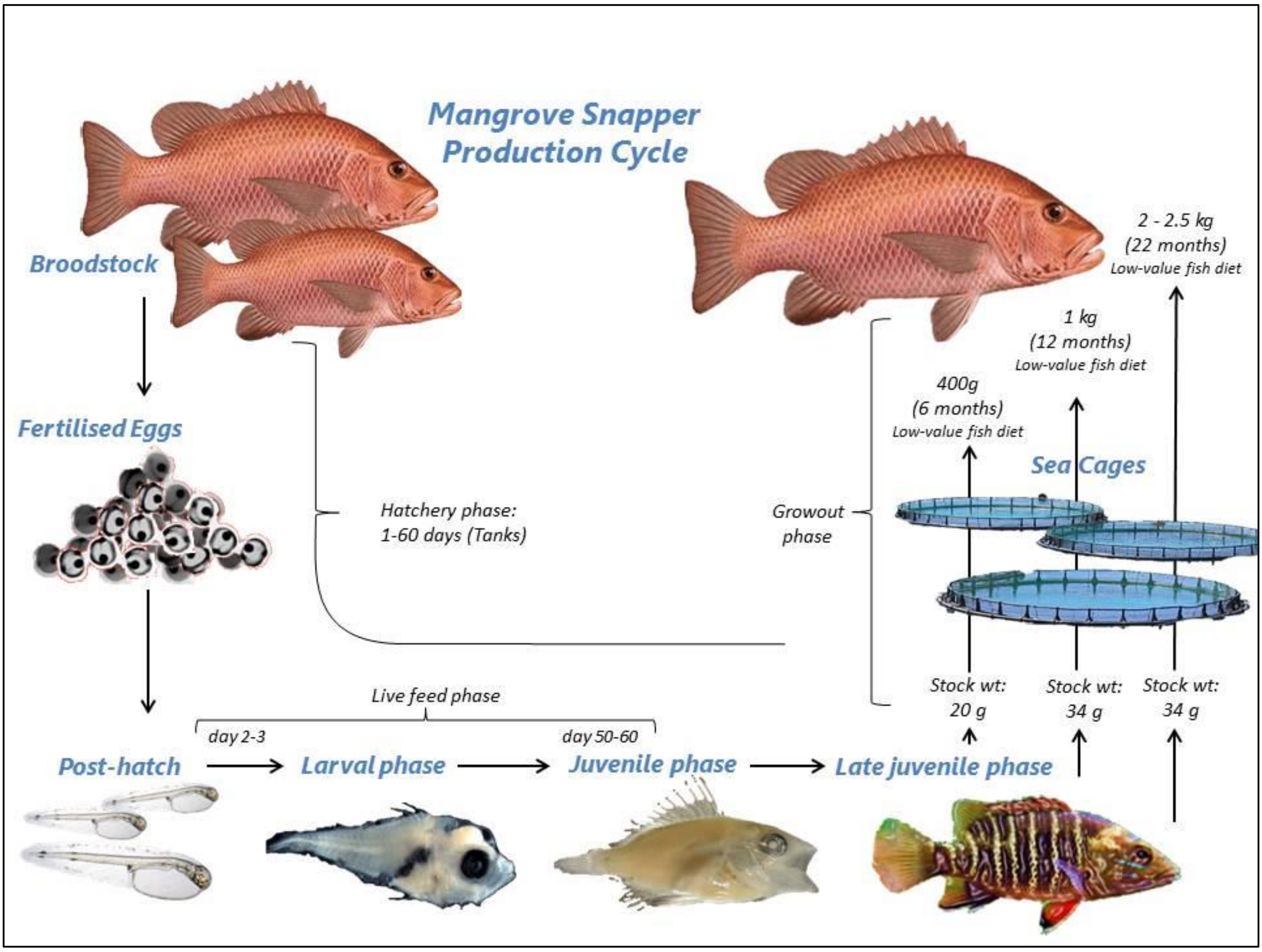

Figure 6: Production cycle of Mangrove snapper.

Broodstock and spawning

Mangrove snapper 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 or spawning tanks. These fish are fed a nutritious diet for successful production of high-quality eggs and healthy larvae, which can consist of a combination of artificial pellets and fish and squid, which can be enriched with vitamins to maintain their health (Emata and Borlongan, 2003).

Once broodstock have acclimated to captivity, they are transferred to spawning tanks, with a sex ratio of one female to one or two males. Spawning can occur naturally within spawning tanks based on lunar cycles, or can be artificially induced, by using human chorionic gonadotropin (hCG) (Chi and True, 2017). During spawning, eggs and sperm from mature fish are released into the water where eggs become fertilised and float to the surface. Fertilised eggs are collected from the surface using fine-meshed skimming nets, and transferred to larval rearing tanks for hatching (Emata, 2003). Mature female Mangrove snapper have a high fecundity; one female is able to produce more than one million eggs per spawning event, requiring relatively few broodstock for successful culture (Ostrowski, 1995; Emata, 2003; Russell *et al*., 2003).

Broodstock 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).

Larviculture and nursery phase

Fertilised eggs are stocked into larval rearing tanks (Figure 7A) at a density of 5 to 30 eggs per litre of water (Duray *et al*., 1996). Larvae hatch from eggs approximately 16 hours after fertilisation (Emata *et al.*, 1994), and are smaller than 2mm at hatching.

The mouths of larvae open after 2 to 5 days, at which stage they begin to feed. It is important that the correct nutritional food source is available in their rearing tanks, and a diversity of live feed is provided from the beginning of the larviculture stage (Emata *et al*., 2003). 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 (**Error! Reference source not found.**) (Leu *et al*., 2003). Formulated pellet feeds are introduced together with the live feed towards the end of the nursery phase at day 30, as fish are fed only pellets during the grow-out phase, and by day 40 fish have typically been weaned onto a diet of only pellets (Leu *et al*., 2003). Metamorphosis occurs from day 18 after hatching, and by day 35 larvae have metamorphosed into juveniles of 17 to 18mm in length, and are transferred to nursery tanks (Figure 7B) (Emata, 2003).

Figure 7: A) Larval rearing; and B) Nursery tanks in a land-based facility.

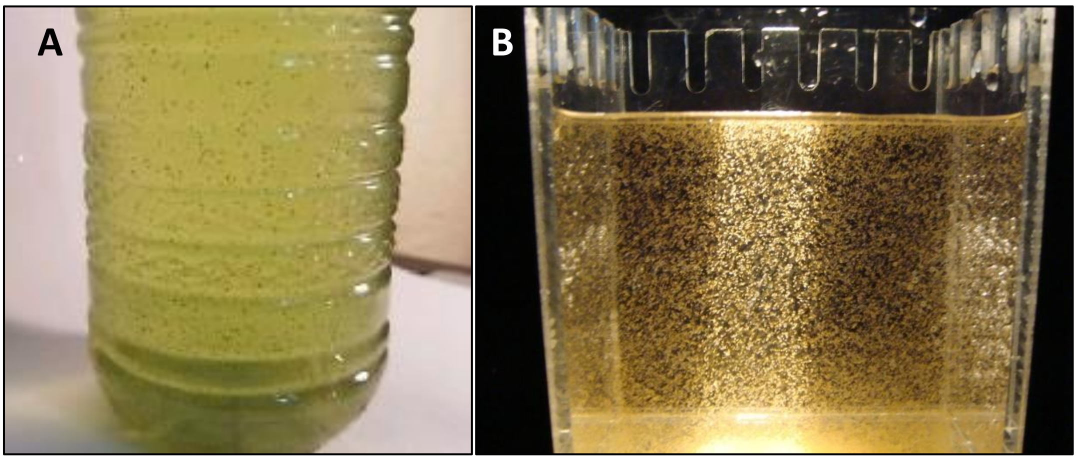

Figure 8: Live feed for larviculture rearing phase: A) Rotifers; and B) Artemia.

Grow-out and harvesting

The total grow-out phase generally ranges from 6 to 22 months, for fish to reach a market size of 400g to 2.5kg. Grow-out systems are typically sea-based cages or earthen ponds. The size of snapper grow-out cages can vary widely; small 3 to 5m diameter cages are used in smaller operations (Chaitanawisuti and Piyatiratitivorakul, 1994; Castillo-Vargasmachuca *et al*., 2007) although those used in large-scale commercial farms are circular, 15 to 30m diameter structures with depths ranging from 5 to 20m (Figure 9). The net mesh size of the cages ranges from 5 to 40mm depending on the size of the fish during the production cycle. Continuous monitoring, cleaning and maintenance of the cages is performed to maintain their safety and functionality (Cardia and Lovatelli, 2015).

Snapper stocking densities in grow-out net cage systems can range from 5 to 12 fingerlings per m^3 for small-scale farms (Guerrero-Tortolero *et al*., 1999; Kongkeo *et al*., 2010), to 20 to 50 fingerlings per m^3 for large-scale farms (Chen *et al*., 2007; Kongkeo *et al*., 2010; Castillo-Vargasmachuca *et al*., 2007).

Figure 9: Sea-based cages for grow-out phase (Source: Bigstock)

During the grow-out phase, artificial pellets (Figure 10Figure 10A) are the preferred feed for snapper in sea-based cages to ensure optimal egg quality and larval growth and survival (Catacutan *et al*., 2001; Emata and Borlongan, 2003; Emata *et al*., 2003). Fish are generally fed twice daily, either by hand (Figure 10B) or using automated devices (Castillo-Vargasmachuca *et al*., 2007). 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 Mangrove snapper, which requires a diet relatively high in protein and fatty acids for high growth rates and reproductive success (Catacutan *et al*., 2001; Bell and Sargent, 2003; Emata *et al*., 2003; Abbas *et al*., 2012), and the nutritional value of pellets can be enhanced with additions of vitamins and minerals to maintain fish health (Emata *et al*., 2003; Ghulam *et al*., 2005). 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 10: A) Artificial pellet feed for grow-out phase; and B) Hand-feeding of cage fish.

Fish are graded throughout the grow-out phase to determine their size. 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 in land-based systems 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 alleviate the likelihood of disease outbreaks (Sugama *et al*., 2012).

Vaccines and treatments are available for common diseases and parasites affecting farmed snapper. Snapper can be infected with viral diseases, such as Indoviral GIV, bacterial diseases (such as those caused by *Vibrio*, *Aeromonas* and *Streptococcus* spp.), and various parasites (such as *Tenuiproboscis* and *Haliotrema* spp.) (Seng and Seng, 1992; Seng, 1997; Liang *et al*., 2011; Sanil *et al*., 2011). Prophylaxis treatments can be administered to prevent viral diseases (Seng, 1997). Fish can be vaccinated against bacterial diseases affecting snapper in culture environments (Liang *et al*., 2011). These vaccines are highly effective and preclude the use of antibiotics. Quarantine of infected fish and water treatments can be used to treat parasitic infections, such as freshwater baths and formalin baths (Seng, 1997).

3. Market for Mangrove snapper products

The majority of snapper is processed into products such as fresh, chilled or frozen whole fish and fillets (Figure 11). Snapper products are consumed locally in producing countries, such as Malaysia, and exported to foreign markets in the USA, Europe and Asia. This market is supplied by both wild-caught and aquaculture products, with the global wild-caught production currently exceeding aquaculture production. The demand for snapper is increasing, creating an opportunity for aquaculture production without putting greater pressure on wild populations.

Figure 11: A) Whole chilled Mangrove snapper; and B): Fresh fillet of Mangrove snapper.

There is a high global demand for snapper products due to their high perceived value, and as a result it fetches a high retail price. In relation to other popular finfish species, snapper ranks highly in terms of both retail value and market demand (Figure 12).

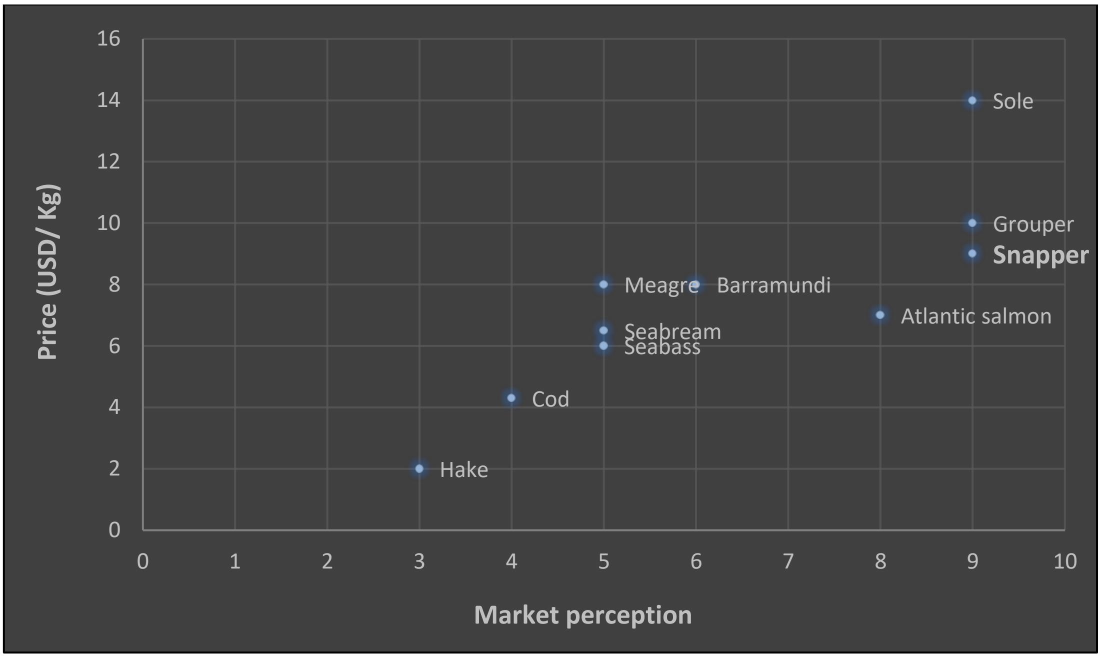

Figure 12: Market price and perception of snapper in relation to other marine finfish products.

Demand for snapper products is expected to increase in domestic and export markets. The USA has imported an increasing amount of snapper products in recent years (Figure 13), with an average cost of USD 6.36/kg from 2014 to 2017 (NOAA, 2018). The main countries supplying this market include Mexico, Nicaragua, Panama and Brazil (NOAA, 2018).

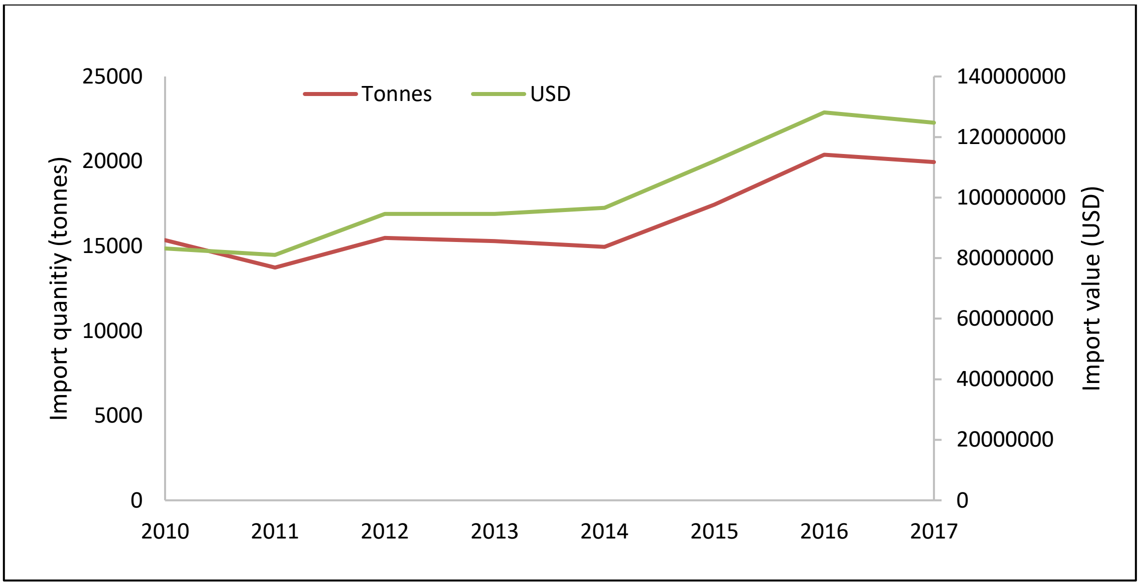

Figure 13: USA imports of snapper products over time (NOAA, 2018).

4. Suitability for aquaculture in Seychelles

The species

Mangrove snapper is indigenous to Seychelles and is therefore permitted for aquaculture production. Broodstock can be obtained from local waters for use in aquaculture facilities. Technologies and feeds for snapper production have been developed, and it has proven to be a successful candidate for land- and sea-based aquaculture due to a number of factors (Catacuan *et al*., 2001). It is euryhaline, and can tolerate a wide range of salinities, and is fast-growing, highly fecund, robust and tolerant of cage culture conditions (Chaitanawisuti and Piyatiratitivorakul, 1994; Estudillo *et al*., 2000; Leu *et al*., 2003; Abbas and Siddiqui, 2009, 2012; Sanil *et al.*, 2011). It additionally has a high market value and demand (Leu *et al*., 2003).

Environmental and oceanographic conditions

The environmental conditions of Seychelles waters, such as temperature and salinity, are optimal for the survival and growth of Mangrove snapper.

A number of factors have to be considered when selecting an area and sites for cage culture (Cardia and Lovatelli, 2015). The Seychelles inner islands, in particular, provide a suitable marine environment for cage culture of naturally occurring species. 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 interfering 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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