The Seychelles Mariculture Master Plan
A summary

Prepared by
Advance Africa Management Services CC and the
The Seychelles Fishing Authority

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Preamble

Recognising the need to diversify the national economy and on the basis of encouraging preliminary investigations, the President and the Cabinet of Ministers on 8 April 2009 sanctioned the proposal to establish a marine aquaculture sector in the country and mandated the Seychelles Fishing Authority to develop a Mariculture Master Plan (MMP). The overall goal of the MMP process was to *"enable Seychelles to establish and develop a sustainable aquaculture sector that is integrated into the country's social and economic vision, which respects the unique and sensitive nature of the marine environment and that contributes to food security and the creation of wealth"*.

The Seychelles Mariculture Master Plan designed and developed the strategic tools and processes for the creation of a developmental framework with which to guide the implementation and development of ecologically sustainable aquaculture as a new industrial sector. This was achieved through a structured and transparent approach of identifying, addressing and concluding on all institutional, scientific / environmental and socio-economic matters and challenges facing the development of the sector and balancing and harmonizing all constituent elements. Moreover, the MMP comprises an action agenda that outlines the necessary short and medium-term actions to achieve the goals of the plan. The MMP was developed within the boundaries of the Ecosystems Approach to Aquaculture, in accordance with the principles of sustainable development and is strongly aligned with all legal instruments as well as the Seychelles Sustainable Development Strategy 2012-2020 and other relevant national economic and social development agendas. The standards of the MMP will ensure ecologically sustainable use of natural resources in the coastal zone and waters of the inner and outer islands of the Seychelles and will contribute to national economic and social objectives.

Executive Summary

Recognising the need to diversify the Seychelles' economy and under pinned by earlier positive indicators of the potential for aquaculture, the President and the Cabinet of Ministers in April 2009 mandated the Seychelles Fishing Authority to develop a Mariculture Master Plan (MMP) for the country, in accordance with the Ecosystems Approach to Aquaculture development.

The vision of the MMP, as defined in the draft Seychelles National Aquaculture Policy, is to *"enable Seychelles to develop a sustainable aquaculture sector that is integrated into the country's social and economic vision, that respects the unique and sensitive nature of the marine environment and that contributes to food security and the creation of wealth"*.

The specific objectives of the Seychelles Mariculture Master Plan were to -

- Promote investment and sustainable growth in the aquaculture sector
- Realise the economic potential of the aquaculture sector
- Maximise the socio-economic benefits of the aquaculture sector for society
- Promote aquaculture at the large and SME scale
- Develop an enabling institutional environment for the development of the aquaculture sector
- Develop appropriate aquaculture technology through research and development
- Develop the necessary industry support services for the sector
- Build the necessary human capacity for development of the sector
- Enhance the perception of aquaculture in the country and its many benefits
- Promote aquaculture as an important component of integrated coastal management

- Establish aquaculture as a supplementary source of fish for domestic markets
- Promote aquaculture as a pivotal component of the Blue Economy
- Develop an aquaculture industry compatible with responsible stewardship of the marine environment and its resources

All MMP outputs are listed in Appendix 1.

A Master Plan is a process that establishes a platform or framework for development within the context of existing National policies and strategies. To establish an aquaculture industry, from a near zero basis, on the inner and outer islands of the Seychelles therefore required a suite of custom designed products, strategic tools and activities within the institutional, enviro-technical and the socio-economic frameworks of the country. Collectively these products were designed to guide the implementation and growth of a new aquaculture sector according to the principles of ecologically sustainable development. This was achieved through a structured approach of identifying, addressing and concluding on all institutional, scientific / environmental and socio-economic needs and challenges facing the proposed development of the sector and balancing and harmonizing all constituent elements. Moreover, the MMP provides an action agenda with which to "kick start" investor interest.

The MMP was specifically developed within the precincts of the Ecosystems Approach to Aquaculture, the FAO Code of Conduct for Responsible Fisheries (Aquaculture), Best Aquaculture Practices of the Global Aquaculture Alliance and in accordance with the principles of sustainable development and is aligned with all legal instruments as well as the Seychelles Sustainable Development Strategy 2012-2020 and other relevant national economic and social development agendas.

This MMP explains the background, the processes and the outputs that constitute the development frameworks. The MMP comprises several chapters. The first provides an overview of the Seychelles' geography, its people, the economy, the fisheries and the opportunities presented by the Blue Economy, the requirement for a Master Plan and the processes adopted in developing the MMP. This is followed by a chapter that traces the evolution of the MMP. The five principal products (development frameworks) of the MMP are then presented and these include;

1. The Strategic Framework (comprising the draft *Seychelles National Aquaculture Policy*, draft Policy Guidelines for Aquaculture on the outer Islands, the Aquaculture awareness programme and Capacity building needs and programmes).
2. The Legislative and Regulatory Framework (comprising the legal framework within which the MMP outputs were developed, the draft *Seychelles Aquaculture and Sea Ranching Regulations* and the draft *Seychelles Aquaculture Standards*).
3. The Administrative Framework (that focused on creating an enabling environment for investors at the large and SMME scales, including an application and evaluation procedure, guidelines for business plan development, a licensing process, the license conditions, fiscal incentives, ocean lease conditions and fees, and the role of the public and private sectors in developing the aquaculture sector).
4. The Biophysical and Oceanographic Framework (comprising background / baseline reports, an assessment of the impact of oceanographic conditions on the future development of the sector, open ocean and land based aquaculture site selection, an assessment of ecological carrying capacity, a benthic community survey of several outer islands, an assessment of opportunities for sea cucumber ranching, finfish and prawn farming on and around some outer islands)
5. The Bio-economic and Production Framework (comprising candidate species selection and assessment, assessing land and sea based farming opportunities on the inner and select outer

islands, estimates of the potential size of the industry, and marketing, economic feasibility modelling, assessing the social and economic impacts and spin-offs of an aquaculture industry, identifying appropriate training needs and opportunities).

These frameworks provide the basis upon which the aquaculture sector in the Seychelles can be developed in accordance with the Seychelles Sustainable Development Strategy 2012 – 2020 and the principles of sustainable development.

The transition to implementation of the MMP was preceded by a successful Environmental and Social Impact Assessment, including a rigorous public participation process. The documentation of the ESIA can be accessed at www.seyaquaculture.com . On the strength of the ESIA and PPP the Ministry of Environment, Energy and Climate Change in February 2017 provided environmental approval to proceed with the implementation of the MMP, subject to the conditions of the recommended Environmental and Social Management Plan.

Abbreviations

ADZ – Aquaculture Development Zone
AfDB – African Development Bank
BAQF – Broodstock acclimation and quarantine facility
BMP – Best Management Practices
CBD - The Convention of Biological Diversity
CITES - The Convention on International Trade in Endangered Species
CPUE – Catch per unit of Effort
DUEL - Direct uptake and elimination processes
EAA - Ecosystems Approach to Aquaculture
EEZ – Exclusive Economic Zone
EMP – Environmental Management Plan
EMPS - Environmental Management Plan of Seychelles
ESIA – Environmental and Social Impact assessment
ESMP – Environmental and Social Management Plan
EU – European Union
FAO – Food and Agriculture Organization of the United Nations (Rome)
GDP – Gross Domestic Product
GNI – Gross National Income
ha- Hectare
HR – Human Resources
ICRI - International Coral Reef Initiative
ICT - Information and communication technology
IDC – Islands Development Company Ltd
IRR – Internal Rate of return
MMP – Mariculture Master Plan
MOM - Modelling–Ongrowing fish farm–Monitoring system
MSC – Mariculture Steering Committee
MT – Metric tonne
NEPAD - The New Partnership for Africa's Development
NGO – Non-Governmental Organisation
NPV – Net present value
OFCF - Overseas Fishery Cooperation Foundation (Japan)
pa = per annum
PPP - Public participation process
R&D – Research and Development
ReCoMaP - Regional Coastal Management Programme of the Indian Ocean Commission
SFA – Seychelles Fishing Authority
SME – Small and medium scale enterprises
SMME – Small, medium and micro enterprises
SMPA - Seychelles Marine Parks Authority
SNAP - Seychelles National Aquaculture Policy
SNCRN - Seychelles National Coral Reef Network
SSDS - Seychelles Sustainable Development Strategy 2012-2020
USD – Unites States Dollar

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1. Introduction

A Master Plan is a process that establishes a platform or framework for the development and management of the sector[1]. To establish an aquaculture industry, from a near zero basis, on the inner and outer islands of the Seychelles therefore required a suite of custom designed products, strategic tools and activities within the institutional, enviro-technical and the socio-economic frameworks of the country. Collectively these products were designed to guide the implementation and growth of a new aquaculture sector according to the principles of ecologically sustainable development. This was achieved through a structured approach of identifying, addressing and concluding on all institutional, scientific / environmental and socio-economic needs and challenges facing the proposed development of the sector and balancing and harmonizing all constituent elements. Moreover, the MMP comprises an action agenda with which to "kick start" investor interest. The MMP was specifically developed within the precincts of the Ecosystems Approach to Aquaculture[2], the FAO Code of Conduct for Responsible Fisheries (Aquaculture)[3] and in accordance with the principles of sustainable development and is aligned with all legal instruments as well as the Seychelles Sustainable Development Strategy 2012-2020 and other relevant national economic and social development agendas. The *Seychelles Aquaculture and Sea Ranching Regulations* and the adjunct *Seychelles Aquaculture Standards* will ensure the ecologically sustainable practices in the coastal zone and waters of the inner and outer islands of the Seychelles.

The master planning process is an inclusive one that is dependent on stakeholder cooperation and collaboration. The final overall goal of this Master Plan as well as the objectives and strategies required to reach the goal was defined by the Mariculture Steering Committee (MSC). The MSC comprised all relevant stakeholder and was established at the start of the MMP process to ensure transparency and stakeholder participation. The following broad objectives formed the basis of the MMP workplan.

- Increasing the recognition and understanding of the benefits of aquaculture in the country.
- Developing the human resources to develop, manage, monitor and provide scientific and technical support to the industry.
- Understanding and defining demand and supply projections
- Providing an enabling legislative and investment environment for aquaculture development.
- Promoting aquaculture as a future supplementary source of fish on the domestic market
- Providing a roadmap to establish aquaculture as an export industry
- Developing an industry that will produce products of the highest international standards under conditions that will ensure the welfare of the animals and the environment and using indigenous species only, under conditions that will ensure the genetic diversity of the farmed species.
- Developing an aquaculture sector that is compatible with responsible stewardship of the coastal and offshore environment and resources.

As enshrined in the Constitution, the Seychelles is keenly aware of the importance of its beautiful yet fragile environment for the wellbeing of its people. Since 1989, the country has furthered this dedication by enacting several decadal policies to ensure sustainable development namely the EMP of Seychelles (EMPS) 1990-2000, followed by the EMPS 2000-2010. Both decade-long environmental management plans resulted in significant advances in environmental legislation, conservation and management actions by Government and NGOs, capacity building and outreach. Following closely on the heels of the EMPS 2000-2010, the Government published the Seychelles Sustainable Development Strategy (SSDS) 2012-2020, with a vision "**To contribute to the realisation of the nation's economic,**

[1] Nash. C. E. 1995. Aquaculture sector planning and management. Fishing News Books. Oxford. 310p.
[2] EAA
[3] FAO Code of Conduct

social and cultural potential through an innovative, knowledge-led approach, being mindful of the need to conserve the integrity of the Seychelles natural environment and heritage for present and future generations". It follows that an environmentally responsible aquaculture sector coupled to the vision statement of the SSDS provides natural strategic advantage for marketing farmed aquatic products from the Seychelles globally.

Based on rigorous bio-economic modelling several financially feasible aquaculture opportunities were identified for the inner and outer islands of the Seychelles. These include cage farming of several high value fish species supported by land-based hatcheries, production of ornamental fish and other aquarium species, expansion of black pearl farming, ranching of sea cucumbers in the lagoons of some outer islands and land-based farming of sea urchins. The economic modelling process has shown that the sector has the potential to contribute significantly to the country's GDP.

This document describes the background to and the processes employed during the MMP project and then presents the principal MMP products. As background the document provides an overview of the Seychelles' geography, its people, the economy, the fisheries, the contribution by a future aquaculture sector to the Blue Economy strategy, the requirement for a Master Plan and the processes adopted in developing the MMP. The next chapter traces the evolution of the MMP. The five principal development frameworks that constitute the MMP are then presented. These frameworks carefully considered all social, economic and environmental impacts as well as the requirements to ensure the development of an environmentally responsible industry. These measures are reflected in the regulatory framework and other outputs of the MMP, which will govern the development and operations of the future industry.

2. The geography, demography and economy of the Seychelles and the importance of its fisheries

2.1. Geography and demography

The Republic of Seychelles is a Small Island Developing State (SIDS) and comprises an archipelago of 115 islands located north east of Madagascar and around 1600 km east of Kenya, between 4° and 11° South and between 46° and 57° East. By the beginning of 2018 the country will have a population of around 98 200 people[4] of which approximately 90% live on Mahe and 9% on Praslin and Le Digue. The age distribution of the population shows that 22% of people are under 15 years old, 71% are between 15 and 71 and 7% are above 65 years old. The overall literacy rate is 95.2% and youth literacy rate is 99.05%. Life expectancy is also high at 73.5 years. The country is classified as a high income country and the total dependency ratio is relatively low at 40.9%. The current (2017) birth rate is below 1. In 2015 the Seychelles was reclassified by the World Bank as a 'High Income' country[5]. The high level of education of the population is a solid base upon which to build an aquaculture industry.

The archipelago comprises a total land area of 455.3 km^2, within an Exclusive Economic Zone of 1.44 million km^2. Mahe and Aldabra are the largest islands and each comprise around a third of the country's land area. The archipelago is divided into the inner and the outer island groups. There are 45 inner islands, of which 43 are granitic and 2 are coralline. The granitic islands are the world's oldest oceanic islands. Mahe, Praslin and Le Digue form the core of the Seychelles and Victoria, on Mahe, is the capital.

[4] www.countrymeters.info/en/Seychelles#population_2017
[5] https://blogs.worldbank.org/opendata/new-country-classifications

The outer islands are made up of 5 groups. These include the Southern Coral Group (Ile Platte and Coetivy Island), the Amirante Islands including Desroches, the Alphonse Group (Alphonse, St, Francois, Bijoutier and Poivre) the Aldabra Group (Aldabra atoll, Assumption Island, Cosmoledo atoll and Astove Island) and the Farquhar Group (Farquhar and Providence atolls and St. Pierre island). Most of the outer islands are small (except Aldabra), low-lying, flat coral atolls around a central lagoon. Most are uninhabited and all lack freshwater resources. The total population of the outer islands in 2016 was around 700 but this increases during the tourism season between October and April. The outer islands comprise around 217 km^2 or 46% of the total land area of the Seychelles and are located between 230 and 1 150 km from Mahe.

The climate of the Seychelles is humid tropical and dominated by alternating monsoons. Temperature in Seychelles remains fairly high with a mean of 26.9°C throughout the year (Figure 1). The South East Monsoon period occurs from May to October and is relatively dry and cool. The highest average wind speeds occur in July and August (11.7 knots / moderate breeze). Precipitation during this period is normally light and of a short duration. The North West Inter Monsoon period occurs in November and is characterised by a shift in the wind regime from South East to North West and this is associated with the onset of the rainy season (Figure 2). This period is usually relatively warm with very light winds (3.9 knots / light breeze). The North West Monsoon occurs from December to March. Winds are predominantly from the west to northwest but are generally light. This is also the Cyclone Season over the Southwest Indian Ocean region south of 6°S. In contrast to Reunion, Madagascar, Comoros, Mauritius and Rodrigues, the Seychelles inner islands lie outside of the tropical cyclone belt (Chang-Seng 2007, ASCLME 2012). The South East Inter Monsoon occurs in April. It is the calmest and warmest period of the year as the intensity of winds reduces significantly before reversing to the Southeast in late April / May.

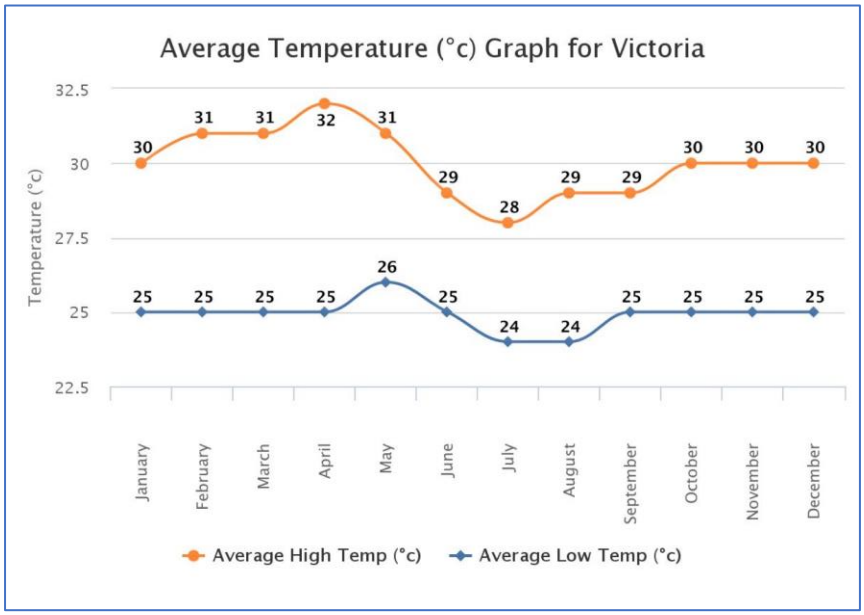


Figure 1: Average monthly high and low air temperatures (Source: www.worldweatheronline.com).

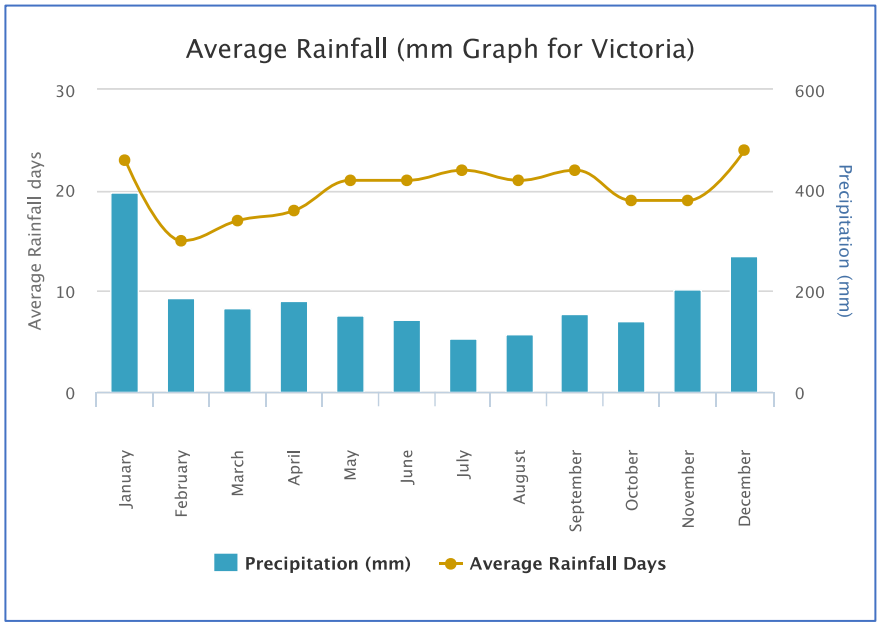


Figure 2: Monthly precipitation and average rainy days per month (Source: www.worldweatheronline.com).

2.2. The economy

The Seychelles economy is small and is predominantly service based. Juxtaposed with its geographic isolation makes the country particularly vulnerable to global environmental and economic shocks and climate change. The Government currently accounts for about 20% of Seychelles' GDP (2014), while the remainder (80%) is contributed by the private sector and State-Owned Enterprises. In 2016[6] the economy was based largely on the services sector, with a GDP share of 83.5%, of which tourism made up almost 30% and ICT 7.2%. The service sector is followed by the industrial sector (13.9%) and agriculture contributed around 3% to GDP. Tourism contributed around 35% to forex earnings and the industrial tuna fishery contributed 26%, while the. Collectively the fishing sector generates around 6,000 jobs, which is about 17% of total formal employment, and the contribution of the fisheries sector to GDP is estimated at 9%.

Despite its small economy the gross national income (GNI) has increased from US$ 2,080 in 1980 to US$ 13,900 in 2014 and in 2015, with a GNI of US$14,760, the country attained 'high-income' status. Continued political stability and good governance has been key to this success story[7]. Since the adoption of the macro-economic reforms in 2008 the country has made enormous economic progress[8]. On a comparative basis, the country's social indicators are strong: it has the 3rd highest Human Development Index ranking in Africa, 7 out of 8 Millennium Development Goals have been met, and poverty is virtually non-existent. Seychelles' medium-term growth outlook is positive, with GDP projected to grow at an average 3.5% from 2015 through 2020, with the traditional tourism and fisheries sectors expected to remain the main drivers of growth. The high level of education of the population is a solid basis upon which to construct an economy on the tenets of sustainable development[9].

Notwithstanding these advances and its current status, the country faces several challenges. Limited land, capital and human resources restrict its ability to benefit from economies of scale and the country relies on imports for almost all raw material, food, consumer products and specialized services. Above all, it is recognized that the lack of economic diversification makes the country

[6] CIA World Fact Book and Index Mundi
[7] www.data.worldbank.org/country/seychelles
[8] LaPorte 2013, Thornton 2013
[9] AfDB 2016, Republic of Seychelles, Country Strategy Paper 2016-2020. E Africa Resource Center. 36pp.

vulnerable to external shocks. In response, Government has prioritised the development of the private sector and is making concerted efforts to create an enabling business environment to fully exploit the country's potentials and to diversify the economy. Most importantly, Government recognises the potential and opportunities presented by the Blue Economy. These are defined in the 'National Development Strategy' 2015-19 and the 'Seychelles Sustainable Development Strategy' (SSDS) 2012-2020, both which have identified Fisheries and Marine Resources as key cross cutting issues.

Essentially the Blue Economy strategy underscores the economic potential of Seychelles' vast Exclusive Economic Zone of just under 1.4 million km^2. More specifically, the strategy integrates conservation and sustainable use of ocean resources, the development of aquaculture and sea ranching, oil and mineral wealth extraction, bio-prospecting, sustainable energy production and marine transport, as well as branding Seychelles as a 'Blue' tourism destination. Within the context of the Blue Economy aquaculture is viewed as having significant potential to contribute significantly towards economic growth in the country. The waters of the Seychelles are some of the cleanest in the world and ranks 7th out of 221 EEZ on the Ocean Health Index[10]. This provides the imminent aquaculture sector with significant natural strategic marketing advantage for of high value, niche products.

2.3. The fisheries of the Seychelles

Seychelles has a well-developed fishing sector that is a vital part of the social and economic fabric of the country and is pivotal for the nation's food security. The sector employs around 6000 people, including fishermen and people employed in fish processing, export activities, maintenance, ship chandelling, stevedoring, etc. This equates to 10% of total formal employment in the country. The number of full time and part-time fishers in 2013 was between 1300 and 1400[11].

The fisheries of the Seychelles comprise the industrial fisheries targeting skipjack tuna primarily and several other species such as yellowfin and bigeye tuna, the semi-industrial fishery targeting large pelagic species, mainly tuna and swordfish, the artisanal fisheries targeting demersal and semi-pelagic fish and invertebrate species and the recreational and sport fishery. In economic terms, the industrial fisheries are of greatest importance. However, from a food security perspective the artisanal fisheries are the most valuable to the nation. At around 61 kg per year, the per capita fish consumption in Seychelles is one of the highest in the world and the artisanal fisheries contribute significantly to the protein requirements of the country[12].

The industrial fishery has two components, namely the purse seine fishery (Spanish, French, Seychelles, Korean, Mayotte and Mauritian flagged vessels) and the longline fishery (comprising mainly Japanese, Chinese, Oman, Philippines, Tanzania, Taiwanese and Seychelles flagged vessels). Victoria is one of the major tuna landing sites globally and has one of the largest tuna canneries in the world. A total of 233,574 MT of purse seine catches were landed or transshipped in Port Victoria in 2013, compared to the 186,743 MT in 2012. In 2013, juvenile Yellowfin (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*) accounted for 49% and 42% of the total purse seine catch, respectively. Total reported catch by industrial longliners inside the Seychelles EEZ was 11,224 MT in 2013. Bigeye tuna was the dominant species in this fishery, accounting for 54% of the total catch. Yellowfin tuna and swordfish were the second and third most dominant species, comprising 11% and 9% of the total catch respectively. The remaining 27% of the catch in 2013 comprised of marlins, sailfish and sharks.

[10] http://www.oceanhealthindex.org/region-scores/scores/seychelles
[11] SFA Annual Report 2013
[12] Robinson and Shroft 2004, SFA Annual Report 2013

The semi-industrial longline fishery, all locally flagged and owned vessels, is small and lands approximately 300 MT of large pelagic species. In 2013 there were 6 vessels operating in this fishery and swordfish was the dominant species caught in this fishery, accounting for 62% of the total catch whilst tuna (yellowfin & bigeye) made up 30% of the total catch. The bulk of the catch from this fishery, except for a small proportion of linefish and tuna, is exported.

The artisanal fisheries (except for the rock lobster and sea cucumber fisheries) are largely open-access and diverse, comprising the hook and line fishery, a drop line fishery, the trap fishery, the SCUBA based sea cucumber fishery, the mackerel net fishery, the spanner crab, the octopus and the rock lobster fisheries. The catch has remained fairly stable since 1985 with landings typically ranging between 4,000 and 5,000 tonnes per year, except for the period 2009 to 2012 when catches declined to between 2,000 and 3,000 MT. In 2013, there were 456 boats consisting mainly of outboard engine boats (67%), followed by whalers (22.4%), schooners (6.4%) and pirogues (3.3%). Most of the fish in the handline fishery are caught by whalers and schooners. A large number of species are targeted in the offshore line fishery, predominately snappers, groupers and emperors. The main fishing grounds are the offshore banks and drop-offs of the Mahe Plateau. However, catches of semi-pelagic carangid species by the smaller outboard powered vessels are also significant.

The trap fishery is restricted to inshore areas around the main granitic islands. It is mostly a small outboard boat fishery. They are usually deployed on or near coral and granite reefs, mainly for *Siganus* spp., *Lethrinus* spp. and *Epinephelus* spp. Since 2004 catches have been fairly consistent and ranged between 300 and 400 MT per annum.

The sport and recreational fishery is also open access and a largely unknown quantum with respect to the species composition of the catch and the total annual catch, although the latter is regarded as substantial. A recent 100% vessel survey has revealed that the fishery has 376 vessels, including charter fishing vessels but excluding the smaller Mini-Mahe vessels. In other words the recreational fishery has about three times more vessels (excluding mini mahe's) than the commercial artisanal and semi-industrial fisheries.

2.3.1. Fish supply and demand

Fish for local consumption is obtained mainly from the artisanal fishery and to a lesser extent from the semi-industrial fishery. Prices vary seasonally and peak during the SE Monsoon season. During the SE Monsoon prices are on average 20% higher than during the NW Monsoon[13]. The demersal species in the semi-industrial fishery, and nearly all of the species in the artisanal fisheries, are either fully or over exploited[14] and overall CPUE is declining. This implies that, even if the stocks were managed sustainably, the artisanal fishery will be hard pressed to maintain the current per capita fish consumption rate of 61 kg/per person/annum.

On the assumption that the population of the Seychelles continues to grow at the current rate of 0.87% per annum (mean growth rate over last 10 years) for the next four decades and that the current per capita consumption of fish, which is variably reported as 57 or 65 kg/annum (average 61 kg/annum) remains constant shows that by 2026 the artisanal catch would have to increase from its current level of around 5,490 tonnes pa to 6,462 tonnes in 2026, to 7,685 tonnes in 2046 (see Table 1 below). A 30% increase in landings between now and 2046 by the artisanal fishery, in which most species are either fully or over-exploited[14], is a highly unlikely scenario. To maintain the high fish consumption rate the supply would have to be augmented by the semi-industrial fishery, or through imports or by way of aquaculture.

[13] SFA Statistics Department pers.comm. May 2017.

[14] FAO Fisheries and Aquaculture report 875. SFS/R875. Report of 2nd session of the Scientific Committee. 77p. ISSN 2070-6987.

Table 1. Fish demand projections 2016 to 2047.

Year	Population Size increase at constant 0.87% pa	Constant per capita consumption (kg/annum	Fish demand t/pa
Sep-16	97 150	61	5 926
Sep-26	105 941	61	6 462
Sep-36	115 527	61	7 047
Sep-46	125 981	61	7 685

Population Size Source: www.Countrymeters.info/en/Seychelles

3. Aquaculture in Seychelles and the world

3.1. Aquaculture in Seychelles and lessons learnt

The Seychelles has a relatively long history of marine farming. Black tiger prawn (*Penaeus monodon*) farming on Coëtivy was established in 1989 by the Island Development Company (IDC) and the Seychelles Marketing Board (SMB) and later taken over by SMB. At full production in 2004 the farm, comprising 96 ha of production ponds, produced 1 175 MT per annum and operated two hatcheries capable of producing 50 million post-larvae per year and employed 350 workers all of whom were housed on the island. Prawn production is shown in Figure 3 below. Broodstock was imported from Madagascar and Mozambique. The operation was serviced by air and by sea from Victoria and prawn feed was produced locally. Recognizing that aquaculture can contribute significantly to the socio-economic development of Coëtivy the IDC retained a portion of the farm after it was de-commissioned in 2008 for future re-development. The product was held in high esteem both locally and in Europe. The viability of reviving the Northern ponds to produce a smaller volume of prawns is being considered.

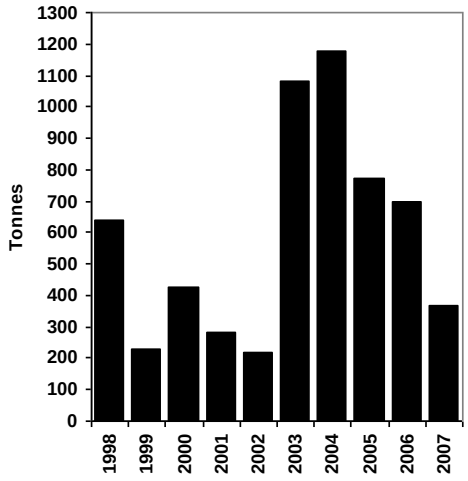


Figure 3 Seychelles Prawn production on Coëtivy (1997 to 2007)

Black-lipped pearl oyster (*Pinctada magaritifera*) farming on a commercial scale in Seychelles was started in 1995 and continues successfully on Praslin and the Curieuse Marine National Park. The farming concession covers an area of around 19 ha. Nuclii are imported from Japan and Australia and implanted by foreign specialists and harvesting occurs 2 years after implantation and the size of the round pearls vary from 8 to 12 mm. The nacre thickness is 1.2 ~ 1.5 mm and the colour varies from

black, greenish-black to grey. Spat collection occurs throughout the year, although October is most productive[15]. There is significant opportunity to expand pearl farming in the Seychelles[16].

Seychelles has been affected by several coral bleaching events, which have had a devastating effect on reefs around the inner and outer islands. There are several initiatives that aim to conserve and restore coral reef ecosystems. These include the Seychelles National Biodiversity Strategy and Action Plan 2015-2020 (NBSAP), the Seychelles Marine Spatial Planning Initiative, the Seychelles National Coral Reef Network (SNCRN), the Demersal Fishery Management plan for Mahé plateau 2015, the International Coral Reef Initiative (ICRI) and perhaps most importantly the coral restoration projects by several NGOs and the Seychelles Marine Parks Authority (SMPA).

Despite these initiatives there is a lack of cooperation and coordination[17]. Seychelles is a small country which should allow for high levels of cooperation between stakeholders, leading to effective management and protection of its reefs. Bijoux (2016) argues strongly for a national policy for the conservation of coral reefs.

Seychelles has established itself, with support from Reef Care International, as one of the global leaders in restorative coral farming. Principal actors include Nature Seychelles, Marine Conservation Society and Cerf Island Conservation Programme, Four Seasons resort and WiseOceans, and the Seychelles Marine Park Authority and more recently the Anse Forbans Community Conservation Programme[18].

The Seychelles Fishing Authority (SFA) played a pivotal R&D role in establishing prawn farming on Coetivy and undertook baseline studies on pearl oyster growth and spat settlement in the early 1990s, which provided the impetus for the establishment of pearl farming in Seychelles.

Several reasons have been advocated why aquaculture in the Seychelles has not progressed beyond commercial prawn farming on Coëtivy, pearl and Giant Clam farming on Praslin / Curieuse. These were principally associated with prawn market conditions, a poor understanding of the sector by the business community, the absence of a sector "champion", an uncompetitive investment environment, lack of scientific and technical capacity and the absence of a properly defined legislative and regulatory framework within which the industry could develop in a structured manner.

Lessons learnt from past and present aquaculture activities[19] are summarised in the following bullet points;

- Seychelles has the fortunate opportunity to develop a Master Plan prior to the development of small, medium and large-scale commercial aquaculture. This has several advantages. Most importantly, it provides the responsible authority with the prospect to think carefully how the sector should look like in future, how to get there and how to attract sustainable investments. This process, as opposed to *post hoc* sector development planning, also allows the responsible authority to reflect on the mistakes made by other countries and to conceive mitigating strategies to avoid similar mistakes happening in its own back yard. Moreover, the ability to plan prior to large-scale investment means that there is no pressure from an existing sector.

[15] (ITTAS 2004
[16] MMP Report 29 (Outer Island Opportunities)
[17] Bijoux 2016
[18] MMP Report 87 Badenhorst, M. 2017. Seychelles Coral reefs: Threats and restoration, Advance Africa Management Services report, 21p.
[19] Hecht, T. 2013. Aquaculture in Seychelles: History, current state of play and lessons learnt. Eds. M. Seisay and S. Nouala. **African Union - Interafrican Bureau for Animal Resources.** 18p. Downloadable at http://www.au-ibar.org/2012-10-01-13-08-42/news/171-au-ibar/664-special-edition-of-the-bahpa-fisheries-and-aquaculture-resources

Small Island Developing States are, by the very nature of their size and the need to provide for growing populations, fragile ecosystems. Seychelles is no different and this juxtaposed with the economic importance of the tourism industry means that any new industrial sector must be planned and ultimately developed in an environmentally responsible manner and that it is harmonised with other economic sectors. This can only be achieved if planning precedes development.

- In drafting the Aquaculture and Sea Ranching Regulations the Seychelles has learnt from the mistakes made by others and the shortcomings of regulations elsewhere in the world. Examination of such shortcomings has revealed that in most instances planning was done in a top-down manner. It was for this reason that Seychelles decided to make the Aquaculture Master Planning process as participatory and transparent as possible. The benefits of this approach have been substantial and the public as well as the private sector and civil society have made significant contributions to developing the Regulations.
- In developing the regulatory framework Seychelles has drawn heavily from the frameworks developed in other countries in Europe, North America, Africa as well as Australasia and New Zealand. This allowed for the extraction of "the good" and the rejection of the "not so good" and the drafting of a custom designed regulatory framework that falls within the desired environmental guidelines of society.
- Operating any commercial venture in common public space without clearly defined rules must lead to discord. The case in point from Seychelles is the Pearl Farm on Praslin. The proposed regulatory framework will resolve the issue. The lesson learnt is that - to allow an industry to develop in a space where planning is inadequate and in the absence of a regulatory framework must "end in tears". This in turn illustrates the importance of participatory and transparent planning.
- Finally, there is perhaps a lesson to be learnt from the prawn farm. Seychelles was one of the pioneering countries to produce top quality tiger prawns in full strength seawater ponds. This happened at a time when the price of prawns was favourable. Change occurred in about 2004 when India was able to outcompete any other prawn producing country on price and this had a major impact on the Coetivy prawn farm. There are other contributing reasons why the farm was closed but the low price of Indian prawns took its toll on tiger prawn farms globally and Seychelles was no exception. The principal lesson to be learnt here is the need for management to plan and adapt to predictable realities and to undertake rigorous sensitivity analyses in the development of business plans.

3.2. Global aquaculture and world fish supply

World capture fishery production has remained relatively static since the late 1980s and it has been the aquaculture sector that has been responsible for the impressive growth in the supply of fish (Figure 4) for human consumption[20].

[20] FAO 2016 State of World Fisheries

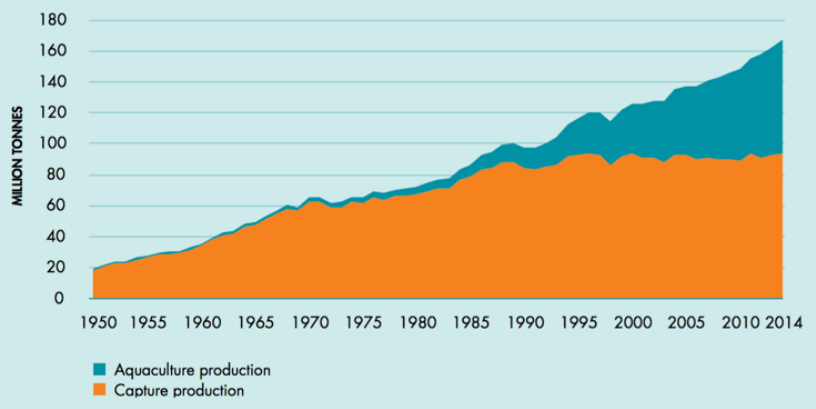


Figure 4 World capture fisheries and aquaculture production (source: FAO 2016)

A milestone was reached in 2014 when the aquaculture sector's contribution to the supply of fish for human consumption overtook that of wild-caught fish for the first time. In 2014, global aquaculture contributed 73.8 million tonnes (50.4%) of total fish production for human consumption and the worlds per capita global food fish supply increased to 20.1 kg. Total aquaculture production comprised 49.8 million tonnes of finfish (first sale value US$99.2 billion), 16.1 million tonnes of molluscs (US$19 billion), 6.9 million tonnes of crustaceans (US$36.2 billion) and 7.3 million tonnes of other aquatic animals including amphibians (US$3.7 billion) (Figure 5). China accounted for 45.5 million tonnes in 2014, or more than 60 percent of global fish production from aquaculture. However, the rest of the world (excluding China) has also benefited with its share of aquaculture in the overall supply of fish for human consumption more than doubling since 1995. Other major producers in particular, were India, Viet Nam, Bangladesh and Egypt. Africa has made remarkable progress in developing its aquaculture sectors (Figure 6). Nigeria, Zambia, Uganda, Ghana and South Africa have made significant strides with respect to volume and value of aquaculture products.

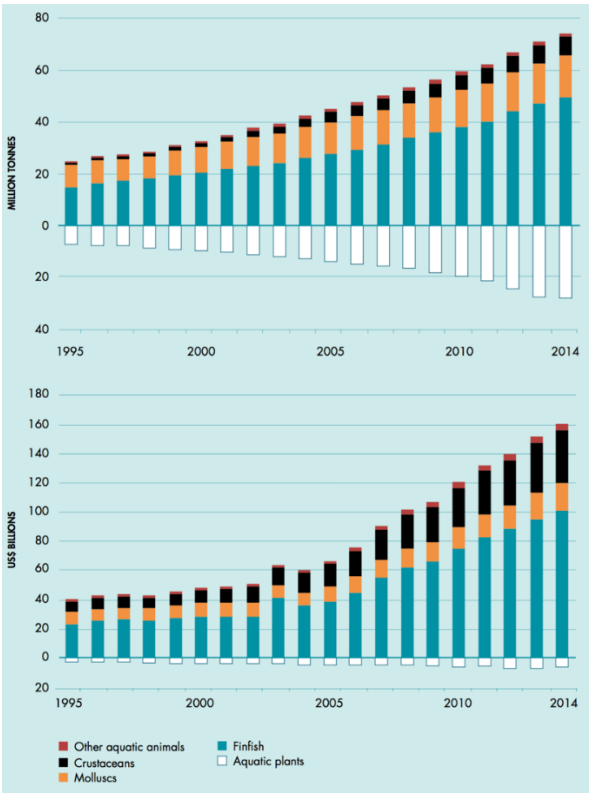


Figure 5 World aquaculture production volume and value of aquatic animals and plants (1995-2014)

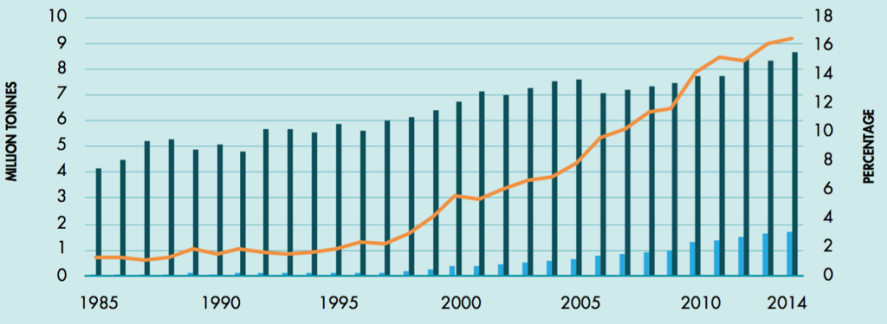


Figure 6 Share of aquaculture in total production of aquatic animals in Africa.

4. The evolution of the Aquaculture Master Plan and the development process

The MMP evolved in three steps; an IOC supported rapid assessment, followed by a Scoping Study, which triggered the launch of the MMP process.

4.1. The Rapid Assessment

In 2007, the Regional Coastal Management Programme (ReCoMaP) of the Indian Ocean Commission commissioned a "rapid assessment" of the potential for aquaculture and to gauge public and private opinion on the desirability of developing aquaculture in several countries in the Western Indian Ocean region. Seychelles was one of the target countries. The others were Kenya, Tanzania, Mauritius (plus Rodriguez), Comoros and Madagascar.

The "rapid assessment" identified significant opportunities for aquaculture and also defined the constraining factors, which were mainly of an institutional nature[21]. It was recommended that a more comprehensive scoping mission be undertaken to define these opportunities in greater detail and to assess the prerequisites for the development of an aquaculture sector in the country.

4.2. The Scoping Study

In 2009, based on the findings of the "rapid assessment" the Seychelles Fishing Authority (SFA) with the support of ReCoMaP commissioned a more comprehensive Scoping Study to assess the potential in greater detail. The Scoping Study was undertaken in January / February 2009[22].

The objectives of the Scoping Study were to;

- define in the opportunities provided by aquaculture in Seychelles
- describe the constraints facing a aquaculture sector in Seychelles
- assess the prerequisites for developing aquaculture in the Seychelles

The scope of work to achieve the objectives included

- A synoptic review of the legislation and investment incentives that may constrain the sector and the requirements for legislative amendments and harmonization.
- A review of previous aquaculture assessment studies in the Seychelles.
- Scoping institutional opinion on national socio-economic objectives, food security, perceived opportunities and threats and constraints facing the development of an aquaculture sector.
- A rapid assessment of input costs and possible levels of production and revenues that could be expected from the sector.
- A pilot bio-physical assessment of the suitability of the offshore environment for cage aquaculture and an appraisal of possible land-based sites for fish hatcheries.

[21] (Shipton and Hecht 2007) ReCoMaP Report
[22] Hecht 2009 2nd ReCoMap report

Institutional opinion was acquired by engaging with all key stakeholders individually and publicly, including the Principal Secretaries of all strategically relevant government departments (Environment, Education, Natural Resources, Employment, Land Use, National Development), the Principal State Council, parastatals and authorities (Seychelles Fishing Authority, OFCF (Japan), Seychelles Centre for Marine Research and Technology, Seychelles Maritime Academy, Marine Parks Authority, Islands Development Company, Seychelles Tourism Board, Seychelles Investment Bureau), NGO's (Seychelles Island Foundation, Island Conservation Foundation, Marine Conservation Society) and the private sector (Seychelles Chamber of Commerce and Industry, Indian Ocean Tuna, the Morin Group, Oceana, Sea Harvest and the Seychelles Farmers Marketing Cooperation).

The principal findings and outputs of the Scoping Study indicated that;

- There was strong institutional support for the development of an aquaculture sector in Seychelles and that synergies exist for cooperation between aquaculture and other sectors of the economy.
- The support for a new industrial sector was driven largely by socio-economic needs, declining fisheries output and the vulnerability of the tourism industry.
- There is substantial potential for medium and large scale, feed based aquaculture around the inner, granitic islands of Seychelles, while the outer Islands lend themselves to extensive sea ranching practices.
- All the support for aquaculture in Seychelles was conditional on the precondition that the sector be developed orderly and in an environmentally responsible manner and according to international best management practices.
- It was recognised that the development was principally constrained by human capacity and the absence of an appropriate legislative and regulatory framework.
- The most important perquisite for developing aquaculture in Seychelles was the need for a sector development plan (Aquaculture Master Plan) that would provide the framework, which would ensure that the sector develops in an environmentally responsible and orderly manner.
- The final output was the formulation of a draft process to develop an MMP.

The basic site selection exercise found that there are suitable cage culture sites around the inner islands. It was, however, recognised that a more comprehensive site selection study would have to be undertaken if the industry were to be developed. Based on two conservative production estimation methods it was calculated that if 10% of the available area is used then this could potentially yield between 13,338 and 15,043 tonnes of fish per annum, with gross revenues between $95 and US$105 million. It was concluded that the contribution to GDP could be significant even if only half of the theoretical production levels were reached in 10% of the identified areas. Ranching of sea cucumbers in the lagoons of some of the outer islands was also identified as possibly having potential. However, this would have to be examined more carefully by way of a bio-physical feasibility study and the preparation of a ranching policy and guidelines.

A SWOT analysis revealed that the identified strengths and opportunities outweighed the internal weaknesses and external threats. The pivotal development issues that were identified were building the necessary human capacity, preparing an appropriate regulatory framework, raising public awareness of the benefits of responsible aquaculture and the wise promotion of the sector to national and international investors.

The Scoping Study concluded that Seychelles has the potential to develop a substantial aquaculture industry, but that the development must be guided by a sector development plan.

The findings of the Scoping Study were presented to the President and the Cabinet at a meeting on 8 April 2009. Recognising the fundamental need to diversify the national economy, which is largely based on tourism and fishing, the President mandated the Seychelles Fishing Authority (SFA) to develop a Mariculture Master Plan in accordance with the principles of sustainable development and the three principles of the Ecosystems Approach to Aquaculture (EAA), which state;

i. Aquaculture should be developed in the context of ecosystem functions and services (including biodiversity) with no degradation of these beyond their resilience capacity.
ii. Aquaculture should improve human well-being and equity for all relevant stakeholders.
iii. Aquaculture should be developed in the context of (and integrated with) other relevant sectors.

The Scoping Study identified 39 primary actions to develop an MMP. These actions are listed in the following three tables (2, 3 and 4);

Table 2

Institutional / governance actions

1. Orientation and preparatory work.
2. Complete stocktaking and diagnostic survey.
3. Establish Mariculture Steering Committee (MSC) comprising all stakeholders in government agencies, parastatals that have responsibilities or an interest within the framework of a mariculture sector.
4. Undertake capacity needs assessment and make necessary arrangements for training.
5. Review past aquaculture initiatives (lessons learnt)
6. Review all legislation and amend where necessary.
7. Review and revise investment incentives to promote investment in the sector.
8. Develop concept of Aquaculture Park to establish hatcheries.
9. Review, revise and streamline application, licensing procedures and guidelines to investors.
10. Establish "one stop shop" for applications and harmonize institutional links.
11. Develop equitable "user pays" lease policy for open ocean mariculture and ranching.
12. Assess and adapt fish quality standards procedures to accommodate farmed products.
13. Review and improve Government support services for the industry.
14. Promote and establish collaborative research programmes with partner country institutions.
15. Develop aquaculture curriculum for post-secondary vocational education.
16. Expand services of the Fish Inspection Unit to include appropriate services for mariculture.
17. Facilitate technology transfer between Seychelles and other countries.
18. Formulate policy on mariculture practices in and close to Marine Protected Areas.
19. Develop National Aquaculture Policy

Table 3

Socio-Economic actions

1. Conduct preliminary economic feasibility studies, indicative investment levels and costs and identify specific business opportunities.
2. Undertake bio-economic assessment of sea cucumber ranching.
3. Assess interest and opportunities for small and medium scale farmers and identify suitable sites
4. Assess perceived threats of mariculture to marine environment and develop mitigation measures.
5. Identify possible user conflict and engage with relevant associations and develop mitigating measures and promote sectoral integration.
6. Develop and implement action plan to promote mariculture as environmentally responsible activity.

Table 4

Scientific / Environmental / Technical actions

1. Undertake ecological assessment of ranching and farming opportunities around the inner islands and selected outer Islands.

2. Assess locations for support infrastructure on Silhouette, Praslin, and La Digue islands.
3. Undertake environmental and economic risk analysis of various culture systems.
4. Establish procedures for regular water quality monitoring.
5. Assess ecological carrying capacity for cage aquaculture.
6. Develop appropriate mariculture guidelines (Aquaculture Standards).
7. Assess inshore cage farming sites and an alternative site for prawn farming.
8. Assess risks (bio/physical) to fish cage farms and conceptualize mitigating measures.
9. SFA to begin R&D programmes for decision support to investors (e.g. rate of bio-fouling, appropriate use of fresh tuna waste as feed, predators, fish growth).
10. Assess potential hatchery sites on Mahe, LaDigue, Praslin and Silhouette.
11. Assess optimum cage size under local oceanographic conditions
12. Refine zoning of open ocean sea cage sites by inclusion of other limiting factors (e.g. artisanal fishing activity, sport diving locations) and get final government approval.
13. Develop criteria for water quality and effluent standards and monitoring protocols for sea and land-based operations and undertake baseline studies (bio-chemical, micro-biological) on selected cage culture sites
14. Develop specific EISA procedures for mariculture operations (offshore and onshore) to ensure adherence to EAA.

4.3. The Aquaculture Master Plan process and programme of work

4.3.1. A participatory process

Establishing a new industrial sector, particularly in a small Island developing state, must be approached with due consideration of stakeholder opinion. Moreover, the FAO Ecosystems Approach to Aquaculture stresses the importance of comprehensive stakeholder involvement. For these reasons the project team established the Mariculture Steering Committee at the very beginning of the project, as a mechanism to develop the MMP in a participatory manner. Representatives from ALL possible stakeholders in the public sector, in parastatals, from the private sector and civil society were invited to become members of the MSC.

The purpose of establishing the MSC was to provide a platform for stakeholders to meet and discuss, share and provide ideas about aquaculture *per se* and the development of a MMP. The MSC provided constructive comment towards most of the outputs of the MMP and also provided excellent input and strong arguments during the Policy drafting workshop. The MSC also scrutinized and provided comment on the objectives, the workplan and the products of the various phases and likewise provided valuable commentary on the draft Seychelles Aquaculture and Ranching Regulations and the draft Seychelles National Aquaculture Policy.

The MSC met at the beginning and at the end of the each MMP phase and its services have been retained for the Implementation Phase.

4.3.2. The MMP phases and programme of work

Because of funding constraints, the MMP project was split into six, non-continuous, phases and was developed during 32-month over a 5 ¾ year period. The phases and their timelines are described below. Funding for the various phases was provided by AfDB, SFA, NEPAD, EU and the Government of Seychelles.

Phase 1 (May 2011 to August 2011). Comprised a stocktaking and diagnostic survey and the preparation of an inception report. This survey focused on analyzing past and present aquaculture initiatives in the Seychelles, the institutional framework with respect to the application and licensing procedures, the relevant legislation and regulatory instruments, institutional opinion, bio-physical farming opportunities, investment incentives for FDI and available human capacity in the Seychelles. The survey provided the necessary background information upon which to define he objectives of the MMP and to develop the workplan to achieve the defined objectives.

Phase 2 (July 2013 to October 2013). Focused on developing the key pillars upon which to build an aquaculture industry. These were:

- Developing and drafting the *Seychelles Aquaculture Regulations* to support the development of the sector in the Seychelles. The Regulations define how the sector will be managed and by whom, the conditions under which an aquaculture license is issued and the associated fees, the environmental, genetic, disease and animal welfare operating rules and biosecurity requirements, and the general operating standards including monitoring protocols and compliance with quality standards and international best management practices.
- Drafting the *Seychelles Aquaculture Standards*. These are adjunct legal instruments and stipulate compulsory best management operational practices.
- Developing user friendly *application and evaluation procedures* with a single entry and exit point
- Developing the license conditions for various forms of aquaculture (commercial large scale, SME commercial aquaculture, ornamental aquaculture, restorative) aquaculture, bioprospecting aquaculture and experimental aquaculture).
- Undertaking a first-round *capacity needs assessment* to build the scientific, administrative, managerial and bio-technical capacity in the country.

Phase 3 (December 2013 to June 2014). Focused mainly on assessing the aquaculture potential of several outer islands, judged to have aquaculture potential by the IDC. These islands comprised Coetivy, Alphonse, St Francois, Bijoutier, Poivre and Desroches.
The scope of work of Phase 3 included the following;

- Developing a Ranching and Aquaculture Policy for the outer islands
- Developing environmental and operational guidelines for sustainable and ecologically responsible sea cucumber ranching in environmentally sensitive areas
- Developing guidelines for sustainable and ecologically responsible fish, crustacean and shellfish farming in environmentally sensitive areas
- Undertaking a baseline ecological and bio-physical assessment of ranching and farming opportunities of the outer islands of Seychelles
- Undertaking a bio-economic assessment of sea cucumber ranching
- Undertaking an environmental and economic risk analysis of various culture systems and species on outer Islands
- Reviewing the economic feasibility of prawn farming on outer islands.
- Undertaking baseline study of benthic community structure at cage and ranching sites

Phase 4 (September 2014 to January 2015). The scope of this phase was mixed and included the following activities;

- Formulation and drafting of Seychelles National Aquaculture Policy
- Policy on aquaculture in and adjacent to Marine Protected Areas.
- Action plan to promote aquaculture as environmentally responsible activity
- Harmonized and integrated legislation
- Local training opportunities and international short training courses
- Donor support for R&D. Promote and establish collaborative research programmes with overseas institutions, particularly for key research and development projects identified by the industry, and for potential small and medium pilot-scale projects
- Locations for infra-structure support on Silhouette, Praslin and La Digue
- Baseline studies of benthic community structure at cage sites and at proposed hatchery water discharge site
- Identification of alternative prawn farming site
- Conduct preliminary economic feasibility studies, indicative investment levels and costs and identify specific small and medium business opportunities.

- Develop and implement action plan to promote aquaculture as environmentally responsible activity
- Preparation of educational awareness and training needs.

Phase 5A (January 2015 to July 2015). Addressed outstanding tasks including;

- International peer review workshop.
- Continue with preparatory work on scientific support with potential partner countries (Japan, Norway) for R&D facilities.
- Establish appropriate procedures for water quality monitoring
- Develop strategy to enhance capacity of veterinary services for appropriate fish health management
- Identify suitable sites around inner Islands for small and medium scale aquaculture.
- Finalization of sea-based site selection process,
- Impact of cage aquaculture and carrying capacity modelling.
- Finalization of land-based sites for hatchery clusters (Providence, Ile Romainville, BBC Grand Anse, Bel Ombre, La Digue and Praslin)
- Assess fish quality standards procedures and adapt to accommodate farmed products.

Phase B (September 2015 to Feb 2017 – deferred by funding delays). Focused on all outstanding tasks and preparation for and management of the Environmental and Social Impact Assessment and the Public Participation Process. Also included proposed 2nd outer island trip but this was terminated by the cyclone.

Phase 6 (Implementation Phase). Overlapped with Phase 5B and comprised preparation of presentation to Cabinet for approval to proceed with implementation of the MMP. Approval to proceed granted by President and Cabinet on 22 Feb 2017. Presidential High Level Aquaculture Committee and sub-committees established to drive the implementation process, subject to the conditions stipulated by the ESMP and the Ministry. Planning and implementation of pilot projects, including; Broodstock acclimation and quarantine facility, pilot cage farm and R&D Centre, marketing and scientific cooperation missions. The role and function of the various sub-committees of the High-Level Aquaculture Committee are summarised in Section 7 of this document.

5. The Seychelles Mariculture Master Plan frameworks

The products of the Mariculture Master Plan comprise of a suite of five development frameworks. These frameworks provide the structures within which the aquaculture sector in the country can develop in an orderly manner, subject to the Fisheries Act 2014 and according to the principles of the Ecosystems Approach to Aquaculture, the FAO Code of Conduct for Responsible Fisheries (Aquaculture) and the Seychelles Sustainable Development Strategy 2012 – 2020.

The five MMP development frameworks are;

1. The Strategic Framework comprises the draft *Seychelles National Aquaculture Policy*, draft Policy Guidelines for Aquaculture on the outer Islands, Aquaculture Awareness Programme and Human Capacity needs and training programmes.
2. The Legislative and Regulatory Framework provides the legal context within which the MMP frameworks were developed, the draft *Seychelles Aquaculture and Sea Ranching Regulations* and the draft *Seychelles Aquaculture Standards*.
3. The Administrative Framework creates an enabling environment for investors at the large and SMME scale, including a license application and evaluation procedure, guidelines for business plan development, the licensing process, the license conditions, fiscal incentives, ocean lease conditions and fees.

4. The Biophysical and Oceanographic Framework defines the proposed land and sea-based Aquaculture Development Zones and sites, and based on the precautionary principle and modelling of ecological carrying capacity and monitoring obligations provides the foundations upon which to start an aquaculture industry in the country.
5. The Bio-economic and Production Framework defines land and sea-based farming opportunities on the inner and specific outer islands and profiles the most promising candidate species for farming in the Seychelles and presents comprehensive economic feasibility studies for the flagship candidate species.

5.1. The strategic framework

Seychelles faces several challenges. Limited land space, capital and human resources restrict the country's ability to benefit from economies of scale and the country relies on imports for almost all raw material, food, consumer products and specialized services. Above all, it is recognized that the geographic isolation, the small size of the Seychelles and lack of economic diversification makes the country vulnerable to external shocks. In response, Government has prioritised the development of the private sector and is making concerted efforts to create an enabling business environment to fully exploit the country's potentials and to diversify the economy. Most importantly, Government recognises the potential and opportunities offered by the Blue Economy. These are defined in the 'National Development Strategy' 2015-19 and the 'Seychelles Sustainable Development Strategy' (SSDS) 2012-2020, both which have identified Fisheries and Marine Resources as key cross cutting issues.

The strategic framework for aquaculture comprises the draft *Seychelles National Aquaculture Policy* and the draft *Policy Guidelines for Aquaculture on the outer Islands*. These frameworks are fundamental and express the Governments' commitment to the development of the sector. The strategic framework for aquaculture is strongly aligned with the objectives of the 'National Development Strategy' 2015-19 and the 'Seychelles Sustainable Development Strategy' (SSDS) 2012-2020. The framework further incorporates an *Aquaculture Awareness Programme* and a *Human Capacity Building Programme*. Both the latter initiatives are of strategic importance for the successful development of the sector.

5.1.1. Seychelles National Aquaculture Policy (SNAP)

The *Seychelles National Aquaculture Policy* (SNAP) was developed on the back of two policy workshops in August 2014 and further discussions with all relevant stakeholders. The process was driven by the members of an Aquaculture Policy Working Group. Appendix 2 lists the stakeholders that were represented at the policy workshops in August 2014 or interviewed during subsequent meetings.

The vision of the policy is to create:
"A responsible, internationally competitive, knowledge based industry, contributing to local food security and supplying international niche markets for high value fish products, which is guided by international best management practices in accordance with the principles of the Ecosystems Approach to Aquaculture and ecological sustainability", while the overall goal of the policy is: "*To guide an effectively managed and environmentally responsible aquaculture industry that contributes towards food security and the creation of wealth in the Seychelles".*

The SNAP is fully aligned with the Fisheries Act 2014 and all other primary legislation that pertains to aquaculture, the SSDS and the National Food Security and Nutrition Policy. The SSDS is one of the cornerstones of the SNAP, which aims to guide the development of the sector in a manner congruent

with the 'triple bottom line' objectives of ecologically sustainable development (economic prosperity, environmental quality and social justice).

Because aquaculture in the Seychelles is nascent, the policy is broad and developmental in nature and addresses matters of a general as well as of a specific nature. General policy matters are those that address governance, ecological sustainability and responsible aquaculture practices. The more specific matters address farming of fish that are fed, the farming of filter feeding (non-fed) organisms and for sea-ranching and land-based aquaculture activities.

The policy document comprises a background sketch, highlighting the state of fisheries, focusing on food security and the need for national economic development, followed by a portrayal of the legal and administrative framework in which it was developed. This is followed by identifying the challenges facing Government in developing a new industrial sector. The principal challenge for Government is to ensure that the development, operation and management of aquaculture in the Seychelles is ecologically sustainable and that the new sector generates economic and social benefits for the people of the Seychelles, under the provisions, where appropriate, of the Fisheries Act 2014 and the *Seychelles Aquaculture and Sea-Ranching Regulations* and the *Seychelles Aquaculture Standards*.

The policy contains 11 general policy statements and these bear relevance to;

- Good governance and ecologically sustainable aquaculture practices
- Sector development
- Research and development
- Human capacity building
- Food security
- Animal welfare and fish health management
- Quality control and certification
- Fish marketing, trade and value addition
- Monitoring and evaluation
- Financial resources and support
- Policy review process

The general commitments are supplemented with four activity specific policy statements, focusing on finfish net pen culture, pearling, sea ranching and land-based aquaculture activities.

The remainder of the policy centres on the how and by whom the policy commitments will be implemented and for each commitment provides measurable indicators and proposes a timeline.
To remain relevant the policy guideline will be reviewed from time to time and revised to consider changing circumstances and new/emerging economic opportunities and pressures on the natural resource base of the inner Islands to ensure the future sustainability of the sector.

The policy is currently in draft form and will be finalized by the Ministerial Aquaculture sub-Committee for Legislative, Policy and Regulatory matters.

5.1.2. Policy Guidelines for Aquaculture and Sea Ranching on the outer Islands of the Seychelles

The Policy Guidelines for Aquaculture and Sea Ranching on the outer Islands was developed on the back of the SNAP but with a focus on the outer Islands and with the IDC as the competent management agency.

The Islands Development Company is entrusted with the management and development of 14 islands of the Republic of the Seychelles. These are Alphonse, Astove, Assumption, Coëtivy, Cosmoledo, Desroches, Desnoeuf, Farquhar, Marie-Louise, Platte, Poivre, Providence, Remire and Silhouette. All

are coralline outer islands except Silhouette, which is a granitic island that falls within the inner island group.

The principal goal of the IDC is to develop the Islands in a manner congruent with the 'triple bottom line' objectives of ecologically sustainable development (economic prosperity, environmental quality and social justice).

The IDC has identified aquaculture and sea-ranching as economic diversification opportunities for several of the islands under its management. To date, these include but are not limited to Alphonse, St Francois and Bijoutier, Coëtivy, Desroches, Poivre and Silhouette.

The Mariculture Master Plan process advocated the development of broad policy guidelines for the development of aquaculture and sea-ranching on the outer Islands, the purpose of which will be to guide the launch and progression of aquaculture activities in pristine ecosystems in a responsible manner. This is aligned with the IDCs mission, which states, *"To ensure that the outer islands actively contribute in the socio-economic development of the Seychelles, while adhering to the highest environmental standards"*.

Several significant aquaculture opportunities have been identified on the outer Islands and include opportunities for finfish net pen culture, sea cucumber and tiger prawn farming in ponds, black pearl oyster farming, land-based farming of ornamental fish, hard and soft corals and live rock, and ranching of sea cucumber and other suitable species. The outer Islands, unlike the inner islands, also offer abundant land for the development of hatcheries and nursery facilities.

The vision for aquaculture and sea-ranching on the outer Islands of the Seychelles is:

An aquaculture industry that is managed on the basis of international best management practices, in accordance with the principles of the ecosystems approach to aquaculture and ecological sustainability, and the goals of the policy guidelines are;

a) To seek environmentally responsible investors to develop the industry on the outer islands.
b) To create conditions that facilitate investment in aquaculture on the outer islands
c) To facilitate the development of an environmentally responsible aquaculture industry on the outer islands
d) To design and implement an effective human capacity building programme for the development of the sector on the outer islands
e) To encourage future operators to co-manage the sector with the IDC and the SFA.

The *Policy Guidelines* have been formulated for general cross-cutting issues as well as for the more activity specific matters to guide the development of the sector on the outer islands. Cross cutting policy guidelines are those dealing with institutional matters and governance, ecological sustainability as well as economic and social development, while the specific guidelines are focused on particular forms of aquaculture. These policy guidelines shall serve as the foundation upon which the IDC the SFA as well as prospective investors shall manage and develop aquaculture and sea-ranching on the outer Islands.

As with the SNAP the *Outer Islands Policy Guidelines* focus on the following proposed commitments;

- Good governance and ecologically sustainable aquaculture practices
- Sector development
- Research and development
- Human capacity building
- Quality control and certification

- Monitoring and evaluation
- Financial resources and support
- Policy review process

The activity specific commitments include, orderly sector development, sea cucumber ranching, finfish cage culture, pearling and land-based aquaculture activities.

The remainder of the policy guidelines centre on the how and by whom the policy commitments will be implemented and for each commitment provides measurable indicators and proposes a timeline. Noteworthy is the proposed formation of a joint "Outer Island Aquaculture Management Committee" by the IDC and the SFA. The function of this committee would be to oversee the implementation of the activity specific commitments, to monitor development and compliance and to take the lead in creating strong linkages and cooperation between the future industry, the Regulator, and the IDC and to prepare an annual report on the development of the sector.

To remain relevant the policy guideline will be reviewed from time to time and revised to consider changing circumstances and new/emerging economic opportunities and pressures on the natural resource base of the inner Islands to ensure the future sustainability of the sector.

5.1.3. Aquaculture Education and Awareness Programme

In developing any new sector, the competent authority must be mindful of public perceptions and how this might impact on the proposed development. An important set of activities to maintain stakeholder support and reduce the potential for conflict will be sensitisation and raising awareness among other food producers (e.g. fishers, farmers) and users of the maritime and coastal environments (e.g. dive tourism operators, fishermen) as well as society at large. Equally important is the raising of awareness among the youth of the potential employment opportunities offered by a new aquaculture sector.

It was for these reasons that an Aquaculture Education and Awareness Programme was developed for implementation by the SFA. The development of the awareness and education plan was preceded by a national survey that was used to assess the views and perceptions and current understanding of aquaculture by all sectors of society.

The education and awareness programme was developed for direct contact, social media and the worldwide web.

Direct contact programme

The direct contact programme consists of a series of six modules. The modules and the detail contained therein are shown in the following table. It should be noted that the modules are tailored in their level of complexity for specific target audiences. For example, the presentation to junior school pupils is no longer than 35 minutes, to secondary and post-secondary learners it is 1 hour and at the institutional level it is 2 hours. The modules are amply illustrated with photographs and other graphics and much time is given for Q & A sessions.

Table 5. Detailed content of the aquaculture awareness presentations

Presentation / Session	Details of Presentation
1. What is aquaculture?	Background about aquaculture in general is covered, including; explaining the different types of farming, and the countries who are the biggest producers. A simple fish and pearl oyster production process is explained and the species to be grown in Seychelles are shown.
2. Why is the Seychelles suitable for aquaculture?	The various aspects which make Seychelles suitable for aquaculture are explained, including; its strategic location in the Western Indian Ocean, pristine and ideal marine environment, and species diversity. The Mahe plateau and cyclone belt is also shown on pictures to explain them as further reasons for Seychelles being suitable for aquaculture.
3. What has been done to date?	Details of the in-depth research and planning process is explained from 2009-2016. The process began with a rapid assessment study, followed by scoping study and MMP inception report. All the studies undertaken, Ecosystems Approach to Aquaculture and the regulatory framework policies are stated in order to reiterate the long, thorough planning process which the MMP incorporated.
4. What will the sector look like for Seychelles?	The industry modelling which has been done is graphically represented and explained in the module. Production forecasts, labour and land requirements are explained for 3 different development scenarios.
5. What still needs to be done?	This session explains the 'short-term' actions, which need to be fulfilled in the next 2-3 years. These actions include; refining the regulatory framework and associated legislation, procurement & construction of the broodstock facility, securing funding for pilot project and R&D facility with hatchery, finalizing designs and commence with procurement for pilot project and R&D facility, continue the education programme, conclude the human capital development plan, undertake marketing and promote foreign investment to the Seychelles.
6. Entrepreneurship & career opportunities	Various entrepreneurial opportunities and needs for the sector are presented. The objective of the presentation is to get the youth to think about potential career opportunities and what studies to pursue once they graduate from school.

Post-secondary schools are prioritized as these learners need to be informed of potential employment opportunities, which will arise as part of the sector development, which may influence their study choices.

Picture 1: Aquaculture banner and scholars of A- level School

To date, the sessions have been presented at 4 schools and 6 institutions. Awareness building is ongoing and will continue indefinitely. Based on the feedback from sessions to date, it was found that scholars were shy to answer questions but by handing out prizes and SFA keyrings, the attendees became more responsive and interactive with the presenter. The post-secondary institutes were best engaged in Creole, and were interested in potential apprenticeship roles as plumbers and electricians. There was an interested response from the staff and teachers at every education session. Intelligent and challenging questions were asked, further indicating how all ages of the public should be targeted for the education programme. It is a new sector for all.

Some target audiences request to hear more detail than others. For this reason, the duration of the presentation was tailored according to needs, as shown in the table below.

Table 6. Content and duration of aquaculture awareness presentations for various Target Audiences

Audience	Sessions	Time required
Institutions/ Government/ NGOs	1. What is aquaculture? 2. Why is the Seychelles suitable? 3. What has been done to date? 4. What needs to still be done? 5. What does the sector look like for Seychelles?	2 hours (with long Q&A period)
Parents/general public	1. What is aquaculture? 2. Why is the Seychelles suitable? 5. What does the sector look like for Seychelles? 6. Entrepreneurship & career opportunities / Is aquaculture for you?	1 hour
A level graduates/ Post-secondary school	1. Introduction to aquaculture 2. Why is the Seychelles suitable? / Why aquaculture in the Seychelles? 6. Entrepreneurship & career opportunities / Is aquaculture for you?	1 hour
Secondary-school	1. Introduction to aquaculture 2. Why is the Seychelles suitable? / Why aquaculture in the Seychelles?	1 hour
Primary school	1.Introduction to aquaculture	30-45 minutes. Very interactive. Q&A session with prizes.

Social media

Facebook is the most popular means of communication in Seychelles. For this reason, a Facebook page was developed (www.facebook.com/SeychellesAquaculture/). The page has been a useful platform to share information, to provide contact information and access to the MMP website (www.seyaquaculture.com) which contains more detailed information.

Picture 2: Banners at Independence Day Stand of SFA

The Facebook page was launched on 26 January 2017 to sensitize the public about aquaculture. To date, 271 people have liked the page, 276 people follow the page and 11 894 Seychellois have been reached by the page (as at 14:51 on 18 July 2017). The Facebook page is managed by the aquaculture staff at SFA and Advance Africa. Interesting articles, images or information are posted once a month.

A video was produced in 2016 (by Radius Studios) during the ESIA process to create further public awareness of the sector. On 13 March 2017, the video was published to Facebook and received 10 000 views and the post reached 20 008 people. The video received 183 likes and was shared 45 times. The video is also available online (https://www.youtube.com/watch?v=yLuES6C9HLA) and will also be aired on television once approval from SFA management is granted.

The website provides background information on why aquaculture is being developed in Seychelles, defines of what aquaculture is all about (including descriptions and informative videos), progress in the development of the sector, links to documents and interesting reading, services offered and contact information. The objective of the website is to serve as a platform for information sharing and eventually to serve as an investment portal for foreign investors to access application paperwork and the *Aquaculture and Sea Ranching Regulations*.

Television and printed media

Television media is also being targeted. A full feature interview took place on Bonzour Sesel (21 October 2016), and another is being planned. The MMP has also featured in the printed media.

5.1.4. Human capacity building programme

Technical and scientific support staff needs.

There are no trained marine aquaculture technicians in Seychelles and the country only has two graduates in aquaculture (both of whom are engaged in aquaculture development administration). To develop an aquaculture industry in the Seychelles requires the fast tracking of technicians and research scientists.

To attract investors and to kickstart aquaculture in Seychelles it has been agreed by the Seychelles Fishing Authority and the Government to establish a

1. Broodstock holding facility near Providence Harbour
2. Research and Development Centre at Anse Royale campus of the University of Seychelles
3. and a Pilot cage farming project

These facilities and initiatives cannot be successful and cannot achieve their objectives unless they are managed by technicians and scientists. A two-pronged approach has been proposed to achieve this goal, viz. by way of mentoring and formal training. Mentoring will be achieved by inviting / seconding foreign expert technician and scientists to Seychelles for a number of months per year and secondly that appropriately qualified young Seychellois receive on the job training as technicians and research scientists in certain partner countries.

To fast track the development of the sector it is necessary to also train young Seychellois formally as technicians and research scientists in disciplines that have a bearing on marine aquaculture.

The Government of Seychelles has prioritized the development of aquaculture as the third pillar of the national economy. The number of technicians and scientist that would be required by the industry for the next 10 years has been identified and Government has made the training of aquaculture technicians and scientists a top priority for the next 10 years. Table 7 summarises the short to medium term training needs (2-6 years).

Table 7. Summary of the short to medium term training needs (2-6 years).

Operational Unit	Qualification	Number
Environment / Compliance officer	BSc Environmental Science	3
Microbiologist	BSc Microbiology	4
Laboratory personnel	Laboratory diploma	4
Health and Safety officer	Occupational Health and Safety Diploma / Degree	2
Maintenance Manager	Aquaculture systems Engineer BSc degree / Diploma	2
Maintenance Superintendent	Mechanical / Electrical Diploma	3
Hatchery / Nursery Manager	BSc / MSc / Aquaculture	5
Hatchery / Nursery Superintendent	BSc / MSc / Diploma Aquaculture	5
Hatchery Scientist/Biologist	PhD / MSc / BSc / Aquaculture	2
Grow-out Manager	BSc / MSc Aquaculture	2
Food Scientist	BSc / MSc Food Science	3
Fish veterinarians	Veterinarian degree - PhD Science	3
TOTAL		**33**

5.2. The Legislative and Regulatory Framework

5.2.1. Primary legislation and international agreements

Several Acts and international agreements bear relevance for the orderly development of aquaculture in the Seychelles. These Acts and Conventions served as the cornerstone for the finalisation of the Seychelles Aquaculture and Sea Ranching Regulations. The Regulations as well as the Seychelles Aquaculture Standards are therefore fully harmonised with all relevant legal instruments.

The Fisheries Act 2014

The new Fisheries Act of 2014 provides the framework for the development and management of aquaculture and sea-ranching in the exclusive economic zone (EEZ) of the Republic of Seychelles.

According to the Act “aquaculture" –
(a) means the cultivation, propagation or farming at sea or on land of fish from eggs, spawn, spat, fingerling or seed; and
(b) includes the rearing and ranching of fish taken locally or imported into Seychelles.

Part III, Sub-part 7, Section 34 (1) of the Fisheries Act of 2014 delegates the competent Authority (the SFA) to manage the development of aquaculture and sea-ranching in the Seychelles in accordance with an Aquaculture Sector Plan (the MMP).

The Act authorises the Authority to issue licenses that are subject to compliance with the regulations. In summary, the Act as it stands:

- Delegates the management of the development process to the Seychelles Fishing Authority;
- Requires that the Aquaculture Sector Plan is used to manage the development of the Sector;
- Ensures that no aquaculture may be undertaken without a license granted by the Seychelles Fishing Authority;
- Requires that license holders operate according to the Regulations;
- Indicates conditions associated with licenses.

The *Seychelles Aquaculture and Sea Ranching Regulations*, and the adjunct *Seychelles Aquaculture Standards*, which form part of the Sector Plan, were developed in accordance with the Act and these provide the rules for issuing licenses and the conditions of such licenses and are the legal instruments that guide and control the development of the sector in an environmentally responsible and sustainable manner. Licenses granted under authority of the Act are subject to all provision of the Act, where appropriate.

The Fisheries Act 2014 adequately allows for the commencement of aquaculture. However, should the sector develop to a level of critical mass it is likely that a comprehensive Aquaculture Act may become necessary.

The Export of Fisheries Products Act 2010

The Export of Fisheries Products Act 2010 details regulations pertaining to the quality and food safety of aquaculture products. The Act nominates the Fish Inspection and Quality Control Unit of the Seychelles Bureau of Standards as the competent authority responsible for the monitoring and enforcement of the regulations that pertain to quality and food safety. The Act provides that exports may be undertaken only from aquaculture processing establishments that operate under a permit granted by the CEO of the Seychelles Bureau of Standards. The Act details banned substances, permitted veterinary medicines, unfit products, monitoring and reporting.

This Act serves the important role of ensuring that export aquaculture products produced in the Seychelles are of a standard that will uphold the Seychelles reputation for quality in external markets.

Other relevant Acts and associated regulations.

Several other Acts are relevant to the development and control of aquaculture in the Seychelles. Cooperative governance between ministries and competent authorities is both necessary and essential for the efficient development of the sector. The relevant Acts include;

- Environment Protection Act 2016
- The Animal and Plant Biosecurity Act 2014
- The Seychelles Bureau of Standards Act
- The Food Act 2014
- The Animal (Diseases and Imports) Act 1975
- Export of Fishery Products Act 1996 and amendments
- Agriculture and Fisheries (Incentives) Act 2005
- National Parks and Nature Conservancy Act 1969 consolidated to 2012
- Protected Areas Act 1967 consolidated to 2012
- Right of Access to Islands Act 1967
- Town and Country Planning Act 1970
- International Business Companies Act 2016
- Companies (Special Licences) Act 2003
- Employment Act 1995 and amendments

International conventions and agreements

The Seychelles is signatory to a number of relevant international agreements. Those having a bearing on aquaculture operations include:

- The Nairobi Convention
- B (CBD)
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- The *Codex Alimentarius*
- SADC Regional Aquaculture Strategy and Action Plan (2016-2026)

5.2.2. The Seychelles Aquaculture and Sea Ranching Regulations

It should be noted that the Seychelles Aquaculture and Sea Ranching Regulations as well as the Seychelles Aquaculture Standards are still in draft form and will only be finalized once the Ministry of Finance has reviewed and approved the proposed financing mechanisms.

The Seychelles Aquaculture and Sea Ranching Regulations as well as the Seychelles Aquaculture Standards were developed on the back of a comprehensive, global, review of aquaculture regulations (or absence thereof) in countries with established and emerging industries. The review also had a special focus on aquaculture in the tropics and on understanding environmental consequences of regulatory shortcomings. The final text was prepared to ensure strict adherence to international codes of best practice, including EAA, the FAO Code of Conduct for Responsible Fisheries and the SSDS 2012-2020, while simultaneously providing an enabling environment for investors.

The *Regulations* also serve to underpin the principal objectives of the MMP, which are to

- Stimulate growth in the sector,
- Realise the economic potential of the aquaculture sector,
- Maximise the socio-economic benefits of the aquaculture sector for society,
- Promote aquaculture at the large and SME scale,
- Develop an enabling institutional environment for development of the aquaculture sector,

- Develop appropriate aquaculture technology through research and development,
- Develop the necessary industry support services for the aquaculture sector,
- Build the necessary human capacity for development of the aquaculture sector,
- Enhance the perception of aquaculture in the country and its many benefits,
- Promote aquaculture as an important component of integrated coastal management,
- Establish aquaculture as a supplementary source of fish for domestic markets,
- Promote aquaculture as a pivotal component of the Blue Economy,
- Develop a aquaculture industry compatible with responsible stewardship of the marine environment and its resources.

The *Regulations* are comprised of six parts, as shown below.

Part 1. Introduction
a) Title and commencement
b) Interpretation
c) Scope of Application
d) Objectives of the regualtions

Part 2. Establishment of the Aquaculture Regulator
a) Establishment of the Regulator
b) The composition of the Regulator
c) Establishment and composition of the Aquaculture Steering Committee
d) Functions of the Aquaculture Steering Committee
e) Reporting

Part 3. License, leases and fees
a) Aquaculture is not permitted without a license
b) Types of aquaculture licenses and leases
c) Application for an aquaculture license and a lease
d) Ownership / Foreign equity
e) Issuing of a license and a lease
f) Validity and renewal of an aquaculture license
g) Validity and renewal of a lease
h) Transferability of licenses and leases
i) Notice to halt aquaculture, refusal to grant a license and appeal
j) Fees and levies

Part 4. Sustainability and Ecosystem Integrity
a) Sustainable aquaculture
b) Seychelles Aquaculture Standards
c) Land based and Offshore Aquaculture Development Zones
d) Aquaculture sites not in an ADZ
e) Fallowing
f) Maintenance of genetic diversity and protection of biodiversity
g) Pollution and waste management
h) Environmental Impact Assessment

Part 5. Animal Welfare
a) Health of aquatic organisms, environmental monitoring and stocking densities
b) Food safety and food quality

Part 6. Monitoring, Reporting and Enforcement

a) Monitoring and reporting
b) Enforcement of the Regulations
c) Offences and penalties

The *Seychelles Aquaculture and Sea Ranching Regulations* are aligned strongly with all relevant Acts, International Conventions as well as with the Fisheries Policy 2007/2011, the Nutrition and Food Security Policy 2013, the Seychelles Protected Areas Policy 2013 and with the SSDS 2012-2020.

There are several administrative issues that still have to be resolved by the *Aquaculture sub-Committee for Legislative, Policy and Regulatory matters*. Once these have been resolved then the regulations will undergo a legal review, where after they will be published in the Government Gazette and come into law.

5.2.3. The Seychelles Aquaculture Standards.

The Government of Seychelles has adopted the "Ecosystems Approach to Aquaculture, through which the new aquaculture sector will be developed in a manner that is aligned with the wider ecosystem and its socio-ecological interactions with other sectors. The three principles of "Ecosystems Approach to Aquaculture" are:

- Aquaculture should be developed in the context of ecosystem functions and services with no degradation of these beyond their resilience.
- Aquaculture should improve human well-being and equity for all relevant stakeholders.
- Aquaculture should be developed in the context of other sectors, policies and goals

Therefore, the purpose of the *Aquaculture Standards* is to provide guidance for responsible operations and procedures. The *Aquaculture Standards* serve as an adjunct to the *Regulations* and provide additional regulatory detail that must be observed by farmers. Hence, the *Standards* must be read in combination with the Fisheries Act (2014), the *Aquaculture and Sea Ranching Regulations* and other relevant Acts and Regulations pertaining to the specific focus of the particular *Standard*. Each specific Standard lists the relevant Acts and regulations that have relevance. Overall, the *Standards* strive to enshrine environmentally and socially responsible aquaculture practices in the Seychelles.

It should be noted that the *Seychelles Aquaculture Standards* are not definitive and may be amended by the Regulator from time to time. This provision was made so that the *Standards* can be kept up to date with modern thinking and aquaculture practices.

The following *Aquaculture Standards* have been developed and form an integral part of the regulatory framework.

1) SEYCHELLES AQUACULTURE STANDARD: Responsible effluent and waste management
2) SEYCHELLES AQUACULTURE STANDARD: Aquaculture in Sustainable Use Areas
3) SEYCHELLES AQUACULTURE STANDARD: Responsible Finfish Cage Culture
4) SEYCHELLES AQUACULTURE STANDARD: Biosecurity protocols for hatcheries
5) SEYCHELLES AQUACULTURE STANDARD: Responsible pearl farming
6) SEYCHELLES AQUACULTURE STANDARD: Responsible Sea Cucumber Farming, Ranching and Stock Enhancement on the Outer Islands
7) SEYCHELLES AQUACULTURE STANDARD: Responsible prawn farming in ponds
8) SEYCHELLES AQUACULTURE STANDARD: Fish health management
9) SEYCHELLES AQUACULTURE STANDARD: Monitoring and reporting

The *Seychelles Aquaculture Standards* are also aligned with all relevant Acts, International Conventions as well as with the Fisheries Policy 2007/2011, the Nutrition and Food Security Policy 2013, the Seychelles Protected Areas Policy 2013 and with the SSDS 2012-2020.

The *Standards* still have to undergoing legal revue, where after they will also be published in the Government Gazette and come into law.

5.2.4. Governance Structure

A proposed Legislative and Regulatory Governance Structure for aquaculture in Seychelles has been developed during the MMP and is shown in the following Figure. The figure shows the relation between Policy, the relevant legislation that governs Aquaculture and future self-regulation.

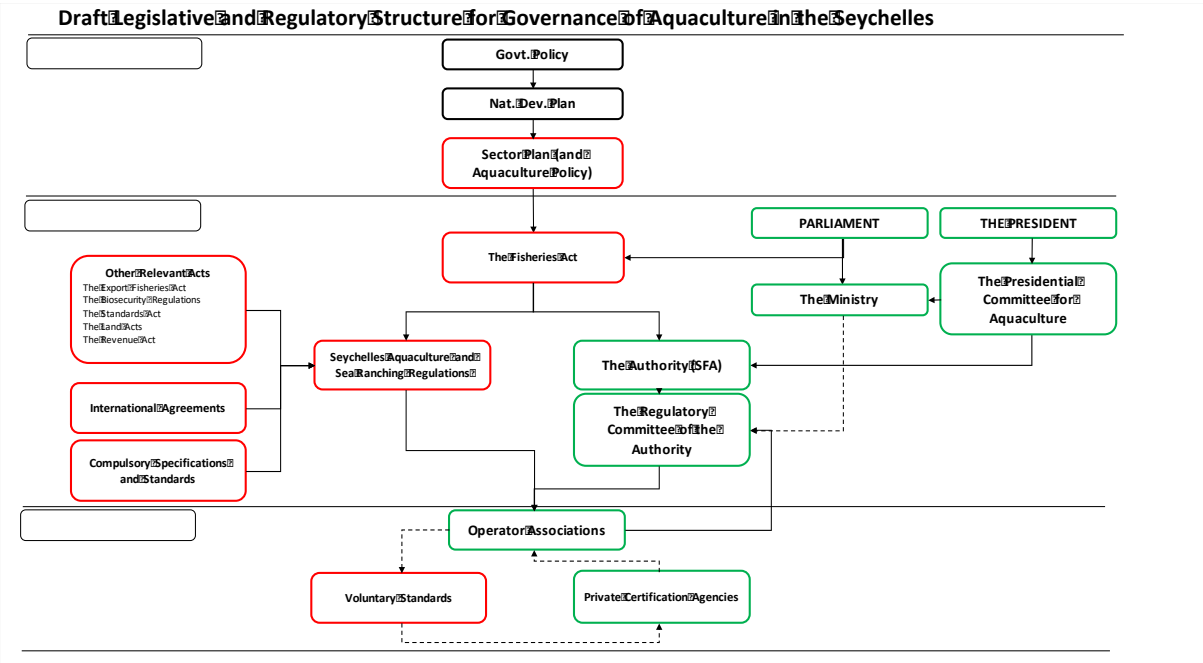


Figure 7 Draft legislative and regulatory structure for governance of aquaculture in the Seychelles

5.3. The administrative framework

The Administrative Framework was focused on creating an enabling environment for investors at the large and SMME scales and includes the new draft application and evaluation procedure, guidelines for business plan development, aquaculture licenses and license conditions, fiscal incentives, ocean lease conditions and fees.

The necessity for this framework was identified by a review of the administrative structure of aquaculture in many other countries. Common to many if not most countries are the complaints by investors that the systems are restrictive and not enabling. It was the express purpose of the MMP process to make the administrative structure as enabling as possible, without compromising on the environmental responsibility of producers. Moreover, the application and evaluation procedures were developed in a manner that does not prejudice big or small investors.

5.3.1. Seychelles Aquaculture License Application Package

The draft package provides all the wherewithal required by a potential investor to apply for an aquaculture license. When a potential investor applies for a license to undertake aquaculture in Seychelles s/he is presented with the *Seychelles Aquaculture License Application Package*. This package comprises the following;

1. The application form for an Aquaculture License and Lease,
2. A checklist of documents required for the completion of the application form for an Aquaculture License and Lease
3. The application form for a Seychelles Business License,
4. The application form for a SITZ Special Business License,
5. The guidelines for the preparation of the Aquaculture Business Plan,
6. The schedule of fees and levies,
7. The *Seychelles Aquaculture and Sea Ranching Regulations*.
8. An outline of the application and evaluation process

The "Aquaculture License Application Package" can be obtained from the SFA and the SIB, in hard and soft copy. A system has been developed and tested whereby SFA acts as a "one-stop" clearinghouse for all applications for the inner as well as the outer islands and manages the application and decision-making process for all aquaculture and sea ranching licenses and lease agreements.

5.3.2. Aquaculture Business Plan

The preparation of a detailed Aquaculture Business Plan is the fundamental cornerstone for a successful application for an aquaculture license. It is for this reason that *"The guidelines for the preparation of an Aquaculture Business Plan"* have been developed. It provides the applicant with precise instructions of what must be addressed in the business plan and how. The guidelines also serve to standardise the business plans as a means to prevent bias. The Guidelines have also been developed such that they are suitable to instruct the development of business plans for small, medium and large enterprises. The business plan must be submitted together with the license and lease application form and is the foundation upon which a decision is based to grant an aquaculture license. The business plan comprises a technical and a financial component.

The technical component of the business plan must give consideration to;

A. The species, the technologies, bio-planning, processing and personnel requirements.

- An explanation why a particular species has been chosen as the candidate species, a description of the species and a precise, verifiable summary of what is known about the farming technology of this / these species.
- The intended scale of production per annum
- A description of the farming / ranching techniques to be employed.
- A description of all sea based and land-based infrastructure and equipment requirements
- Planned broodstock holding facility and its reticulation
- Description of hatchery operation (including production targets and forecasts)
- Description of the transport of seed stock from hatchery to cages, other grow out facilities or to the seabed for ranching purposes.
- Type and source of feed for various life history stages as well as FCR forecasts for each stage of the farming operation.
- A bioplan that provides monthly forecasts of fish production in tonnes, mortality, FCR, fish growth, stocking densities etc. for the first 10 years of operation.
- Description of the required processing procedures and facilities.
- Description of staff requirements for the operation (detail the number of staff the operation will employ at senior and middle management level, scientific staff, operational staff and general workers and distinguish between local and foreign employees and indicate their respective skills requirements.

B. Animal health, food safety and public health

- The technical component of the business plan must demonstrate that the design of the aquaculture facility is such that it will accommodate the environmental requirements of the species to be farmed and that there is a low risk of unforeseen incidents resulting in damage or distress of the farmed animals.
- The technical component of the business plan must describe operational control routines, setting out how operational responsibilities and key parameters will be monitored, logged, documented and archived, including–
- Ensuring that regulations pertaining to aquaculture are easily available to and understood by all staff.
- Ensuring that all staff is adequately trained in and familiar with the internal operational control system.
- Ensuring that all staff members are familiar with the organizational structure of the operation and with their respective roles and responsibilities therein.
- The technical component of the business plan must describe an emergency plan specifying preventative or mitigating measures and their practical implementation to deal with critical events *e.g.* outbreak/spreading of infectious decease, mass mortality, breakdown of moorings, cages, nets or other operational infrastructure, or other critical situations.

C. Environmental integrity and user conflict

The technical component of the business plan must;

- Demonstrate how the fish farming operation will result in minimal or least possible user conflict with other legitimate users or interest groups
- Describe mitigating measures such that the farm does not significantly compromise the integrity of the water column or the seabed.
- If a farm is located outside of a designated ADZ then the applicant must provide primary data on current speed, bathymetry, seabed composition and condition, planned monthly harvesting plan, type and amount of feed used per month.

The financial component of the business plan must give consideration to;

- Detailed cost per component, land, buildings, land based and sea-based equipment,
- Cashflow projections for the first 10 years and financial indicators (IRR and NPV).
- All spreadsheets must be submitted in soft copy and must be active
- Investment, equity and loan/ financing plan for the first five years of operation.
- Financial and other guarantees for the development of the operation.
- Description of proposed markets, detailed information on product price and verifiable offtake agreements.

5.3.3. Schedule of fees and levies

- The draft schedule of fees and levies for aquaculture and sea ranching activities were developed on the basis of a 15-year projected cash flow of aquaculture revenue streams, according to the three development scenarios (low medium and high road scenarios)[23]. It should be noted that the draft fee proposals require review and approval of the Ministerial Aquaculture sub-Committee for Funding and Investment.

[23] Advance Africa Management Services 2016. Seychelles aquaculture industry – revenue streams and costs for the public sector. MMP Discussion document. 24 Nov 2016. 5p.

License application, transfer and renewal fees

- Commercial aquaculture application fee — SR 10 000
- Commercial ranching application fee — SR 10 000
- Experimental license application fee — SR 4 500
- Restorative license application fee — SR 1 500
- Transfer of aquaculture license fee — SR 3 500
- Renewal of aquaculture license fee — SR 3 500

Cost of license

- Finfish aquaculture license — US$10 000 per 1000 MT pa
- Sea cucumber and Sea urchin license — US$10 000 per 50 MT pa
- Ornamental fish license — US$5 000 per 0.5 MT pa
- Pearl oysters — US$5 000 per 12.5 MT shells pa
- Restorative aquaculture license — US$250
- All other aquaculture licenses — US$ 500

Annual license fees

- Finfish aquaculture license fee — US$ 1 000 per 1000 MT pa
- Sea cucumber and Sea urchin license fee — US$ 2 000 per 50 MT pa
- Ornamental fish license fee — US$ 2 000 per 10 MT pa
- Pearl oysters — US$ 2 000 per 12.5 MT shells pa
- Restorative aquaculture license fee — US$ 250 pa
- All other aquaculture license fees — US$ 500 pa

Annual lease fees

- An annual lease fee is payable for the use or intended use of a land-based and or sea-based ADZ or a sea-based site that is not in a designated ADZ.
- An aquaculture lease fee is payable for the use of any sea surface, seabed or land-based area within or outside of sea or land based ADZs.
- The lease fee for sea-based sites is calculated on the basis of the total area allocated as stipulated in the lease but excluding the farm exclusion zone.
- The lease fee for land-based sites is calculated on the basis of the size of the area allocated and as stipulated in the lease.
- The lease fee is payable in March of each year and the Regulator will send out timely reminders to farmers.
- The annual lease fees for sites on land based ADZs on the inner islands and for sea-based sites around the inner and outer islands are payable to the SFA.
- The annual lease fee for land-based sites on the outer islands is payable to the IDC.
- The annual lease fees are as follows;
    - Land based sites on inner Islands -- US$ 1 / m^2
    - Land based sites on outer Islands – US$ 1 / m^2
    - Sea based sites around the inner and outer Islands -- US$ 0.10 / m^2.
- The Regulator and the IDC will revise the annual lease fees every three (3) years.

Fish Production levy

Levies were calculated on the basis of full cost recovery of initial development spend by the State. The levies will be used for monitoring, control and surveillance of the aquaculture industry on and around the inner and outer islands and enforcement of the Regulations and providing feedback to license holders and the Minister. A fixed component of resources and cost will be necessary to regulate the industry diligently and this fixed value will be increased variably with the ramp-up of production through the associated costs of monitoring, auditing, sampling etc.

It is not possible that full cost recovery on an annual basis can be achieved from the outset during the period that producers are building up production and harvest capacity. The target would be to achieve full annual cost recovery within 5 to 10 years under all modelled industry growth scenarios. To achieve this outcome the following production levies would be applied;

- Finfish LFE = USD 25.00/MT harvest.
- Ornamentals LFE = USD 50/MT harvest
- Sea cucumbers, sea urchins, ornamentals and Pearl oysters LFE = USD 50/MT

At USD 25.00/MT for finfish the proposed levy is closely correlated to levies in Scotland (USD28/T), Norway (0.3% which equals ±USD25/T for salmon) and Lesotho (USD25/T).

These values would be sustainable under the low-road scenario and would lead to substantial excesses under the high-road scenario, which could either be returned to license holders as rebates or utilised for the further development of the industry, for example, into the outer islands or through value-chain investments into infrastructure etc. It is further proposed that levies would contribute to provisional funds to be set aside for any adverse environmental issues arising.
The annual production levy is payable to the SFA and the Regulator will revise the production levy fees every five (5) years.

5.3.4. The license application and evaluation process

The evaluation process has been developed as a “one stop shop”, meaning an application process with a single entry and exit point. This circumvents the need by the applicant to personally approach multiple institutions during the process.

The following table provides the structure of the application and evaluation process that will implemented on the Seychelles (Table 8).

Table 8. The structure of the application and evaluation process that will implemented on the Seychelles.

AQUACULTURE APPLICATION and EVALUATION PROCESS							
	PROCEDURE A			PROCEDURE B			NOTES
	Action by whom	Timeframe (work days)	Cummulative timeframe (work days)	Action by whom	Timeframe (work days)	Cummulative timeframe (work days)	
Application package obtained from SAQA	INVESTOR						
Application by investor delivered to SAQA (standard form application document together with list of required supporting documents)							1
Assign unique number, enter into register. Assign SAQA lead assessor. Lead assessor is appointed by the Head of the SAQA Investment and Promotion	SAQA App Centre	2 days	2 days				
Distribute to assessment units: Economic Feasibility, Finance, Biological and technical /Environment, Labour and Employment	SAQA lead assessor	2 days	4 days				2
Assesment period	Assessment units	10 days	14 days				
Submit assessment reports to SAQA lead assessor	Assessment units	1 day	15 days				
Review assessment reports	SAQA lead	2 days	17 days				
Proceed with procedure A or B. If no clarifications are required from the Investor, proceed with Procedure A. If clarification is required from the Investor, proceed with procedure B. SAQA lead assessor to make this decision.	SAQA lead assessor	0 days	17 days				
Compile clarification request (standard form document)	N/A	N/A	N/A	SAQA lead	1 day	18 days	
Send clarification request to Investor	N/A	N/A	N/A	SAQA lead	1 day	19 days	
Clarification period. Investor to respond to clarification document comprehensively within given period, or else the investor must re-submit a completely new investment application and start the process from the beginning.	N/A	N/A	N/A	Investor	20 days	39 days	
Clarification response received from investor and re-distributed to affected Assessment unit(s)	N/A	N/A	N/A	SAQA lead assessor	2 days	41 days	3
Evaluation of clarification response by Assessment Unit(s)	N/A	N/A	N/A	Assessment units	5 days	46 days	
Submit assessment reports to SAQA lead assessor	N/A	N/A	N/A	Assessment units	1 day	47 days	
Review assessment report(s)	N/A	N/A	N/A	SAQA lead	2 days	49 days	
Compile executive summary assessment report. This report will provide the SAQA lead assessor's recommendation to the SAQA Investment Adjudication Committee whether or not granting of an Aquaculture License is recommended.	SAQA lead assessor	2 days	19 days	SAQA lead assessor	2 days	51 days	
Submit to SAQA Investment Adjudication Committee	SAQA lead	1 day	20 days	SAQA lead	1 day	52 days	
SAQA Investment Adjudication Committee sits for **1 day each month**. It makes a final binding decision in the meeting. It immediately advises the SAQA lead assessor of its decision.	SAQA Investment Adjudication Committee	1 day	42 days (max, depends on when committee sits)	SAQA Investment Adjudication Committee	1 day	74 days (max, depends on when committee sits)	
Inform the investor of the Committee decision.	SAQA App Centre	1 day	43 days (max, depends on when committee sits)	SAQA App Centre	1 day	75 days (max, depends on when committee sits)	
			Process complete within 2 months			Process complete within 4 months	
Conclusion: If the Investor completes all documentation required for the Investment Application comprehensively, the decision to grant an aquaculture license can be taken within a 2 month period. If clarifications are required and it is necessary for the Investor to provide more information subsequent to its application, the process could take 4 months. This is based on the Investment Adjudication Committee only sitting once a month to review applications.							

NOTES

1. Secretariat checks whether all documents as stipulated in application package are completed and submitted. If not then package is returned to applicant to fix.
2. If application is for outer islands or in MPA then application goes to IDC of SNPA for "no objection"
3. For functional one stop shop several regulatory authoritirs also need to provide license (with conditions) or permit (with conditions).

These include where appropriate SNPA (permit and conditions), Environment (Environmental approval EIA), IDC (permit and conditions), LUH (Land lease where appropriate), SBS PUC (Provison of bulk services), SVS (approval of biossecurity plan), FSA (SITZ business license, SIBA (Seyhelles business license).

5.3.5. Application for a lease for an offshore, nearshore or land-based aquaculture site in Seychelles

Approval is required from the Aquaculture Regulator and the responsible Ministry (currently 2017 the Ministry of Habitat, Infrastructure and Land Transport) to undertake aquaculture operations in the sea and from the responsible Ministry for land-based aquaculture operations on state land in the Seychelles. If approval is granted, then the operator must enter into a lease agreement with the responsible Ministry.

The application for an aquaculture lease is made and lodged with SFA together with the application for an aquaculture license. No fee is required to make an application for a lease. Potential operators should acquaint themselves with the locations and availability of sea or land-based sites. This information is available from the Regulator.

To apply for an aquaculture, lease an application form (available in the *Aquaculture License Application Package*) must be completed and lodged together with the aquaculture license application and all necessary plans and documents with SFA.

Consideration of the application for a lease for any area intended for aquaculture purposes, whether on land or at sea, is subject to the applicant being granted an aquaculture license.

In the event of an applicant for a lease being a holder of an existing aquaculture lease/s then a record of full compliance with the terms and conditions of those lease/s must be presented with the new application. If it transpires during the process of an application that any information supplied by the applicant is false or misleading or that material information has been withheld, then the Regulator may reject the application.

It is a condition of any lease granted by the Regulator for aquaculture purposes that all deployed equipment, including moorings and any ancillary equipment, is removed from the leased area(s) when the lease is terminated, by either party. The Regulator will reserve the right to request a survey of the leased area, at the lessee's expense, to confirm complete removal where this is considered necessary.

On approval of the license and subsequent lease application the Regulator will draw up a lease agreement to be signed by all relevant parties. In the draft lease agreement, the lease is valid for a period of 15 years and is renewable. It should be noted that the duration of the lease as well as the license is not finalized and will be considered and may be changed by the Ministerial Legal Sub-Committee.

5.3.6. The Aquaculture license and license conditions

As stipulated in the Aquaculture Regulations aquaculture in Seychelles may not be practiced by anyone except under authority of a valid license issued by the competent authority.

The Seychelles aquaculture license comprises details of the license holder and specifies the duration of the license, the species that the operator may farm, the type of farming infrastructure / facility, the maximum production limit of the license and the conditions of the license. All licenses are subject to the *Standard Aquaculture License Conditions*.

Special License Conditions

All license holders are also subject Special License Conditions have been developed specifically for various types of farming operations. These include Special License Conditions for;

- Finfish hatchery and nursery
- Finfish grow out in cages
- Ornamental fish and coral
- Sea cucumber farming
- Sea urchin farming
- Crustaceans
- Bivalve and pearl farming
- Crab fattening
- Restorative aquaculture
- Bio-prospecting aquaculture
- Sponge farming.

5.3.7. Fiscal incentives

Investment incentives are common in emerging aquaculture sectors. Seychelles has agreed to maintain the 0% duty on feed importation and exportation of fish. Moreover, all imported aquaculture equipment will carry a 0% import duty for the first 10 years of implementation and the income tax rate for all aquaculture businesses (throughout the value chain) shall be fixed at 15% (at least for the first 10 years).

Given the attractive investment destination that the Seychelles offers through existing instruments, combined with the unique aquaculture opportunity, no further incentives should be necessary to

attract private-sector investors. Generic investment incentives can be obtained on the website of the Seychelles Investment Bureau at www.sib.gov.sc/

5.4. The biophysical framework

The bio-physical framework which provides the geographic locations of sea based ADZs is based on a comprehensive study on the environmental suitability of the Seychelles inner island maritime zone for cage culture and the identification of certain areas for cage culture. The framework also describes the process that was used to identify these areas as potential Aquaculture Development Zones (ADZ)[24]. Moreover, based on an assessment of ecological carrying capacity, the framework provides a precautionary production limitation and based on a synthesis of the possible impacts of cage culture on the marine environment the framework provides guidelines for responsible cage aquaculture.

5.4.1. Background to site selection

To locate farms such that they are socially acceptable, and commercially and ecologically viable and sustainable, is complex and requires high-resolution biological and environmental / oceanographic data, good information on societal perceptions, marine spatial planning data as well as detailed information of contiguous multi-sectoral planning information and activities (Benetti *et al*. 2010). Moreover, the development of any new industry in Seychelles must be harmonized with tourism and fisheries, which currently are the two primary pillars of the country's economy (SSDS 2012-2020).
The suitability of the open ocean area for cage culture was based on an analysis of the oceanic conditions around the inner islands and considered in relation to benchmarks as outlined in Cardia and Lovatelli (2015).

Because of the oceanographically data-poor nature of the region, the zone selection process was undertaken on the basis of the precautionary principle, the EAA (Soto *et al*. 2008) and global best management benchmarks. Following the primary identification of aquaculture opportunities and the selection of areas in which the activity could take place it was necessary to determine the ecological- and social carrying capacity of the environment and of the country as a whole (Ross *et al*. 2013). The social implications of creating an aquaculture industry in the Seychelles have been assessed and the outputs are incorporated in the economic modelling component of the MMP implementation programme and the associated narrative. Cage culture in Seychelles is being promoted as a new economic sector and hence the selection of zones within which the industry can develop becomes pivotal to ensure the social acceptance of aquaculture as an industrial activity and, secondly, to warrant its expansion in the future.

The selection of ADZs was therefore undertaken to (1) minimise ecological impacts, (2) select the most suitable sites for cage culture, (3) moderate possible conflicts with affected parties and (4) address objections and concerns from affected parties. It was mainly because of these objectives that the focus was on open ocean areas from the beginning of the site selection process. Because of their greater depth, stronger currents, and distance from shore the environmental impacts potentially associated with aquaculture in the open ocean are considerably lower than in inshore, coastal areas, bays and or fjords (Benetti *et al*. 2010, Price and Morris 2013).

Land-based ADZs will be developed on State land and this will largely mitigate ownership conflicts. Selection of specific sites for the establishment of land based ADZs in Seychelles is principally dictated by the availability of land rather than defining the most suitable areas from environmental and social perspectives.

[24] Advance Africa Management Services 2016. Selection of Aquaculture Development Zones around the inner islands of the Seychelles and their ecological carrying capacity. Aquaculture Master Plan Report, 105p.

The development of any new sector unquestionably leads to some measure of user conflict and concern, which commonly arises out of ignorance. Therefore, it was decided to undertake all investigations in a transparent manner and to engage with stakeholders from the beginning. As a starting point, it was decided in 2009 to consult with stakeholders to develop a common vision for aquaculture in the country. This was achieved through a series of consultations with key stakeholders in all sectors of society. The list of stakeholders consulted, and a summary of the outcomes are provided. Many of the comments and suggestions were incorporated into the MMP process and into the Regulatory Framework. With respect to site selection, the key take-home messages from these consultations were:

- All stakeholders recognised the need for a new industrial sector to contribute towards the economic growth of the country and supported the development of the sector on the back of a comprehensive and diligent Master Planning process.
- Concern was expressed about the possible environmental impact of aquaculture.
- The possibility of user conflict was raised, particularly with tourism, sport diving and the artisanal trap fishery, and suggestions were made as to how such possible conflict could be mitigated.
- The Environment Department and the Tourism Board accepted that large scale cage culture farms could have a visual impact but acknowledged that there is a need for compromise to develop and accommodate a new industrial sector. They suggested that large-scale cage culture farms should perhaps be located 2km from the shoreline to mitigate visual and environmental impacts.

5.4.2. Location of sea based ADZs

It should be noted that the inner Islands and the entire Mahe Plateau from a scientific perspective is data poor. In the absence of high-resolution oceanographic data, the precautionary principle was adopted, and environmental best management benchmarks set by the global industry (particularly in Europe, Canada, the USA, Australia and New Zealand) were considered. Moreover, the SSDS 2012-2020 and the EAA served as additional foundations upon which suitable areas for large-scale cage farming in the offshore zone were identified.

It should further be noted that this investigation on the feasibility of large-scale cage aquaculture was focused in the maritime zone > 2km from the shore. This spatial constraint was based on recommendations from wide ranging stakeholder consultations in 2009 as referred to above.

The inshore zone (< 2 km from the shore) has been reserved for local investors and any potential site will be subject to an independent EIA and hence did not form part of the offshore site selection study.

A thorough analysis of all available physical, chemical and biological oceanographic, meteorological and hydrographic data was undertaken. The data that were used to determine the suitability of Seychelles' maritime zone for cage culture, and the selection of suitable areas, included primary scientific data, satellite imagery, hydrographic and nautical charts, proxy data, photographs, underwater video-footage, all available oceanographic and meteorological data and data from the literature and international oceanographic databases.

Data on climate, wind and wave fields, sea state, currents, dissolved oxygen, temperature, primary production, spatial distribution of coral and seagrass meadows and the structure and composition of the seabed around the inner islands were analysed in relation to international benchmarks of the physical suitability for cage aquaculture. The oceanographic data used in this study is mostly generic for the inner island area and the surrounding shelf area and is not zone-specific. Due to equipment constraints, it was not possible to collect zone-specific oceanographic data. This is not unusual in many countries and, hence, it is normally recommended that any new aquaculture license holder starts an

environmental monitoring programme at least six months before fish are brought on site. It should also be noted that the open ocean nature of the zones provides a cage culture environment that allows for greater efficiency with respect to dispersal of wastes than sites in protected bays[25]. For this reason, the generic nature of the data was considered adequate upon which to decide on the suitability of the sea around the inner islands for cage culture and to select specific ADZs.

From the analysis of the data in relation to the FAO cage site classification guide[26], and the fact that the inner islands lie to the north of the cyclone belt, it was concluded from a physical and biological perspective that fish cage aquaculture around the inner Islands is eminently possible. Moreover, all oceanic conditions are within the stress levels of modern cage farming equipment and technologies.

Apart from analysing the oceanographic processes the selection of locations for ADZs included social and economic dimensions. The process took several limiting criteria into account, including a 2km exclusion zone around the coast of inhabited islands, a 1km exclusion zone around MPAs, mitigating visual impact, avoiding conflict with the sport diving sector and artisanal fisheries (particularly the trap fishery), avoiding restricted areas such as shipping lanes and fibre optic cables, selection of areas with a suitable sand dominated seabed, avoiding coral reefs and seagrass meadows and other sensitive areas, choosing areas with a suitable depth and bathymetry and seeking partial protection from the SE Monsoon winds.

Four 'ADZ selection' cruises were undertaken. The first cruise was exploratory while each of the subsequence cruises were used to increase the data and knowledgebase upon which the final locations were selected. During the two last cruises a total of 58 ROV transects were undertaken in 12 of the 16 zones. Based on the ROV data 25% of the original 16 ADZs were rejected, mainly because of the presence of coral. The other 12 zones have a sand dominated seabed and were not affected by the exclusionary criteria. Average depth of the sites is 40 m (range 25-62m). Prevailing current profiles are more than adequate to ensure dispersal of dissolved and solid wastes from the fish cages. The 12 zones provide a total of 53.2 km^2 for the initial development of the industry. Eight of the 12 sites are relatively well sheltered from the SE Monsoon, one is partly sheltered and three are not protected.

The selection of suitable zones for cage culture was carried out with due appreciation that the process is a compromise of eliminations that seeks to minimise user conflict but having to remain within acceptable bio-physical limits for economically sustainable cage culture (Table 9). It is also important to note that the selection of ADZs in the Seychelles was approached from an industry development perspective and was not undertaken at the farm-scale level. Hence, it may be possible to have 2 or more farms in any ADZ.

Table 9. Summary of oceanographic conditions in the Seychelles and comparative suitability for cage culture.

Environmental variable	Unit	Typical zone value	Comment /Reference
Significant wave height	m	1.1 to 2.4 depending on season with mean Hs = 1.6	Small in comparison to other offshore cage sites (Cardia and Lovatelli 2015)
Max wave height	m	5m, but % frequency occurrence of 0.5% over 35 months	Small in comparison to other offshore cage sites with waves of 6 to 8 m (Cardia and Lovatelli 2015)

[25] (Benetti *et al*. 2010)
[26] Cardia and Lovatelli 2015

Current speed	cm/sec	Min=2, Max=35, Mean=18	Ideal (Price and Beck- Simpert 2014)
Wind speed	m/sec	SE Monsoon = 7.3 NW Monsoon = 3.2	Wind is consistent and only increases to gale force for short periods normally <1.5 hour (Source: Seychelles Meteorological Services). Max wind speeds and wave heights result in moderate to rough seas. Wind speeds, Hs and wave period are all within very acceptable limits (Cardia and Lovatelli 2015, Benetti et al. 2010)
Depth	m	25 to 57	Ideal, > 15 m free depth below bottom of cage (Beveridge 2004, Cardia and Lovatelli 2015, Price & Morris 2013)
Substrate		Sand and rubble (fine to course & shell grit)	Optimal for waste assimilation and cage moorings (Cardia and Lovatelli 2015, Price & Morris 2013)
Water temperature	^{o}C at 5m	Min=24.8, Max=30.5 Mean=27.7	Typical value for tropical waters
Dissolved oxygen	mg/L at 5m	Max=5.1, Min=4.5, Mean=4.8	Typical value for tropical waters (eg. Glude 1982)

Finally, it should be noted that the 12 identified zones are most likely not the only possible areas that conform to international standards suitable for cage culture around the inner Islands and further offshore (figures 8, 9, 10 & 11).

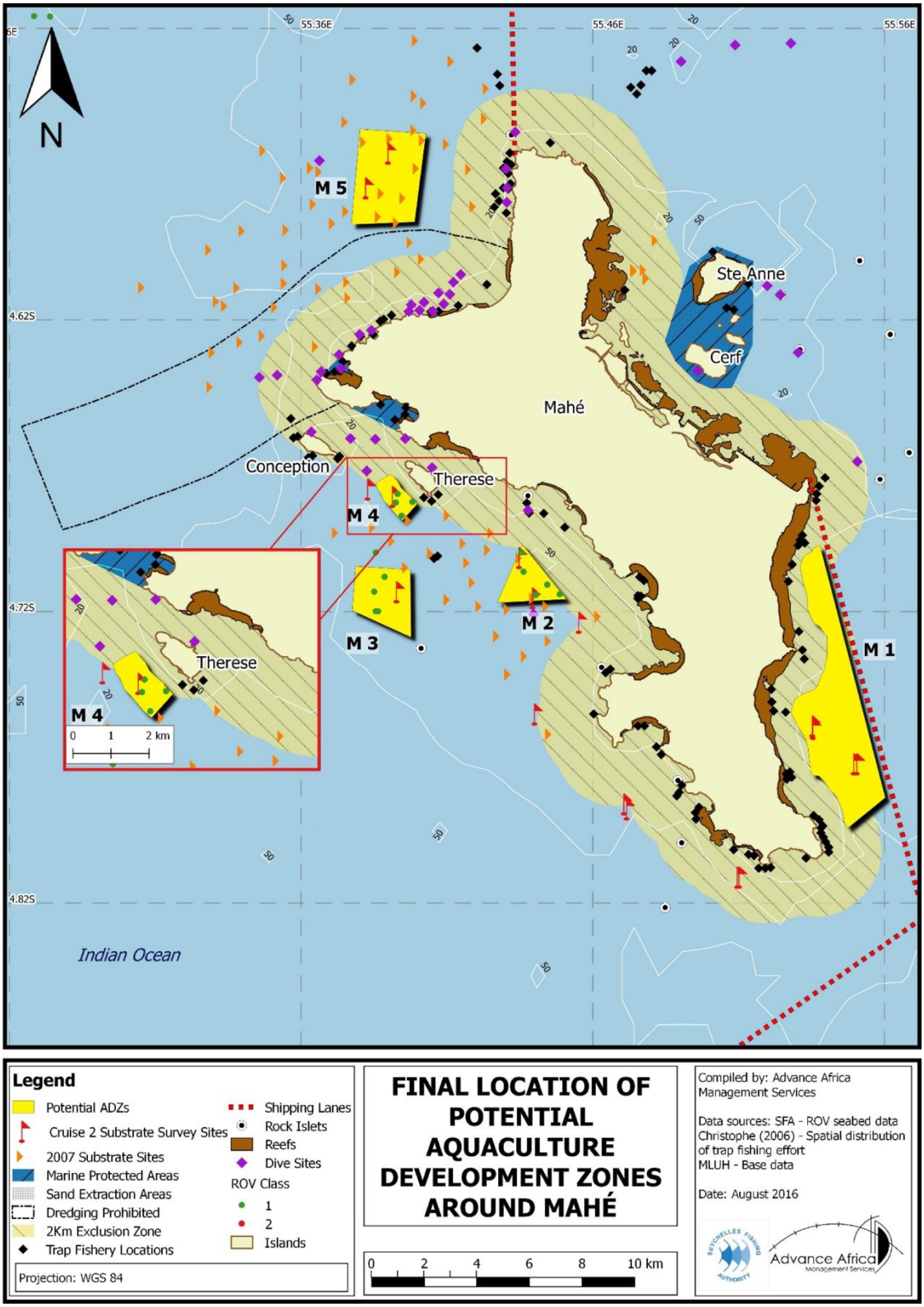


Figure 8 Final location of ADZs around Mahé

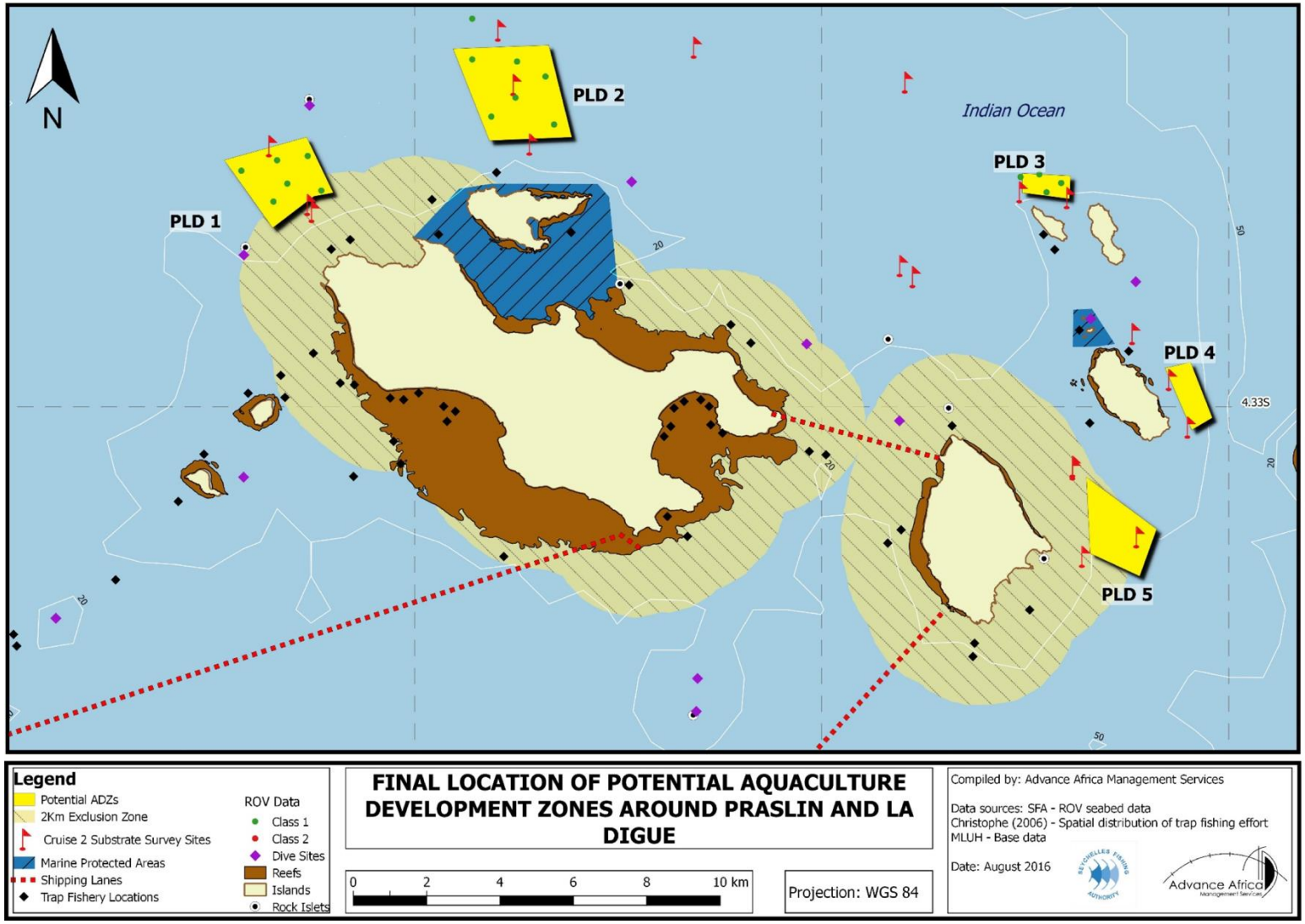


Figure 9 Final location of ADZs around Praslin and La Digue

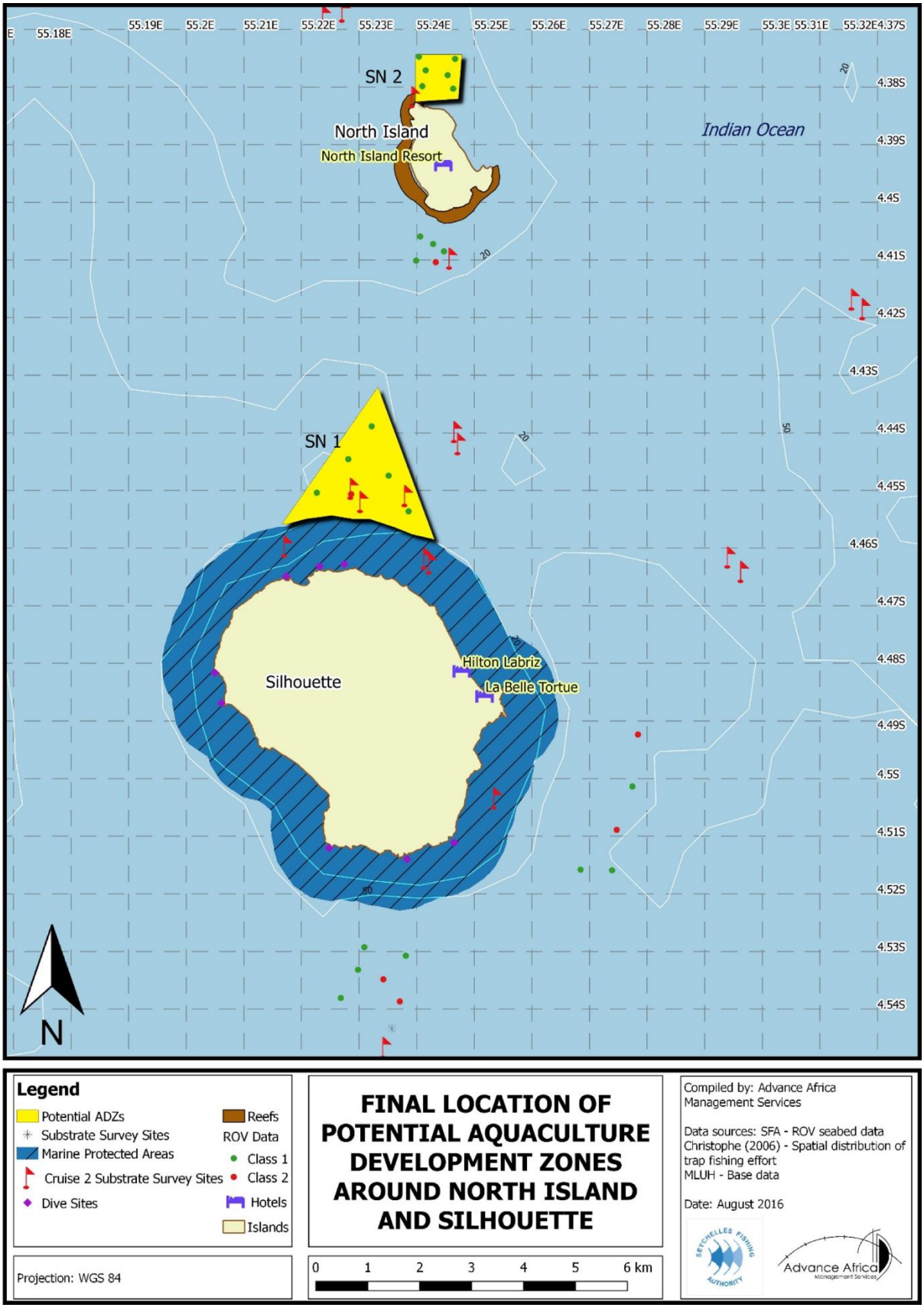


Figure 10 Final location of ADZs around Silhouette and North island

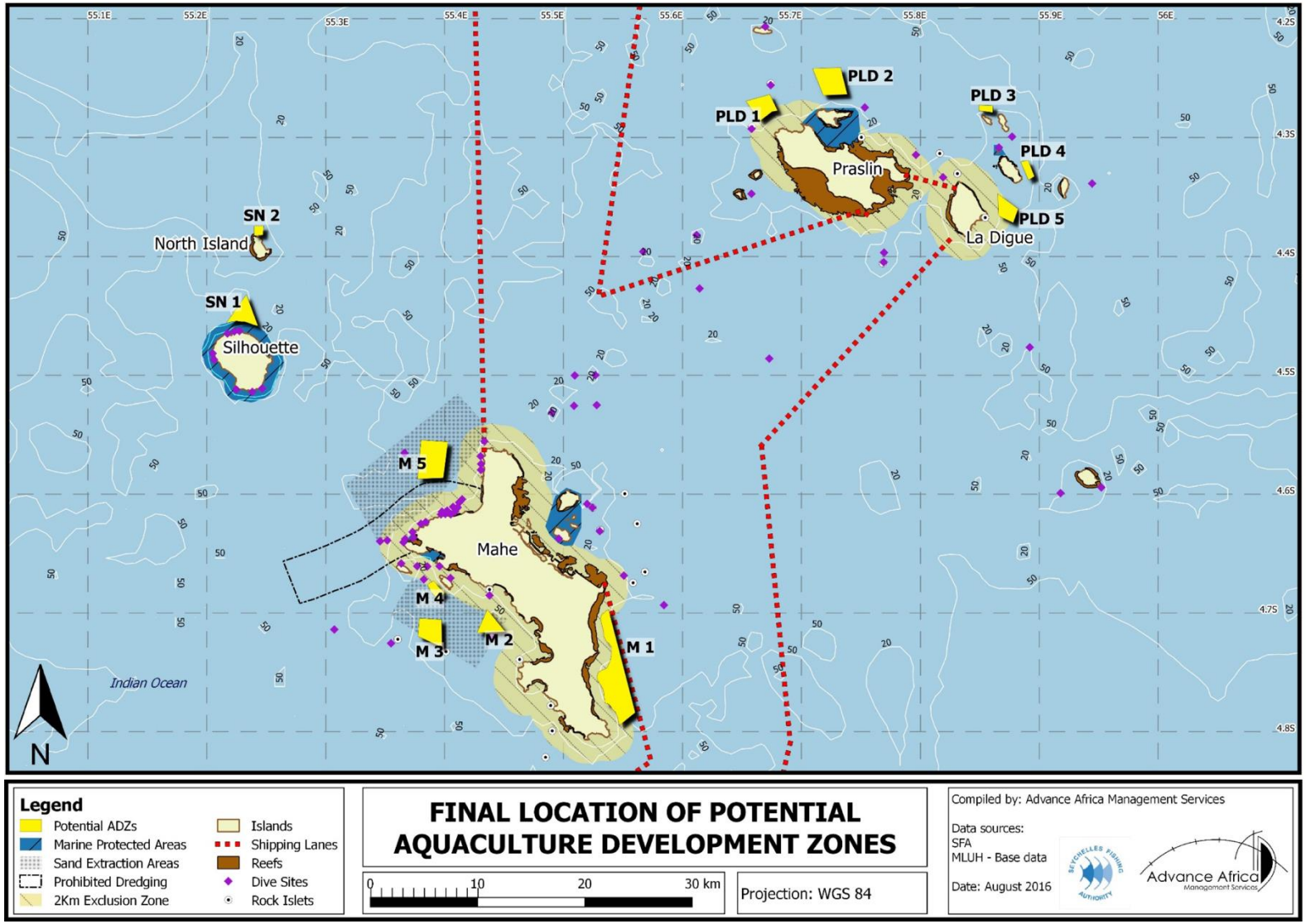


Figure 11 Composite overview of final ADZ locations around the inner Islands of the Seychelles.

5.4.2. The environmental impact of fish cage aquaculture

Scientific background

The inner islands, all of which are within a 56 km radius of Mahe, have a total land area of approximately 247 km^2, which is 0.6 % of the Seychelles Bank area. While there may be site-specific hydrographic and oceanographic differences, it is reasonable to assume that the oceanography in the offshore zones of the islands in which it is proposed to develop cage aquaculture would be fairly homogenous. It is within this context that the impact of fish cage aquaculture was considered. This differs radically from protected bays, fjords and lochs in which most studies on the environmental impact of cage aquaculture have been undertaken.

Intensive fish cage culture generates organic and inorganic wastes that are released into the marine environment. In general, the recipient for the soluble waste is the water column and the recipient for the particulate organic waste is the seabed or benthic environment[27] [28]. The environmental impacts of cage culture on the water column and the substratum below the cages have been studied extensively and are well known (Danovaro *et al*., 2003, Aguado-Giménez & García-García 2004). The impacts can be particularly significant under poor management conditions, particularly in shallow bays with poor water exchange rates. In extreme cases, waste accumulation (uneaten food, faeces and metabolic wastes) below the cages can change the aerobic waste assimilation processes in the sediment to anaerobic fermentation and a completely altered benthic community structure (Danavaro *et al*. 2003, Hargrave 2003).

Price and Morris (2013) reviewed the large body of work published since 2000 on the environmental impacts of marine finfish aquaculture around the world. Their paper reviews the results, finding and conclusions of over 420 papers, primarily in peer reviewed journals.

Except in areas with poor circulation, the impact of poor management practices has limited impact on the water column and phytoplankton growth (Beveridge 2004, O'Donohue *et al*. 2000). In fact, several studies have failed to establish a relationship between farm waste and phytoplankton growth in offshore areas, even when large inorganic nutrient inputs were observed (Beveridge 2004). The primary potential effects to water quality associated with marine cage culture include dissolved nitrogen and phosphorus, turbidity, lipids and dissolved oxygen fluxes. Usually there are no measurable effects 30 meters beyond the cages when farms are sited in well- flushed waters. Nutrient spikes and declines in dissolved oxygen sometimes are seen following feeding events, but there are few reports of long-term risk to water quality from marine aquaculture (Price and Morris 2013).

There is a great deal of information about the biogeochemical processes in sediments near fish farms and how those processes may be driven under nutrient enrichment from fish cages. Excess feed and fish waste are discharged from the farms and, if they accumulate, may alter the chemical processes of decomposition and nutrient assimilation. Well-managed farms may exhibit little perturbation and, where chemical changes are measured, impacts are typically confined to within 100 meters of the cages. Benthic chemical recovery is often rapid following harvest (Price and Morris 2013). The Seychelles Marine Aquaculture and Sea Ranching Regulations stipulate that all fish farming sites in the Seychelles must be fallowed for a period equal to at least one production cycle. This provides further time for recovery of the seafloor, if it were to be impacted. Fallowing is the practice of relocating or not re-stocking marine cages to allow the sediment below to undergo natural recovery, both geochemically and ecologically, from the impacts of nutrient loading. Under ideal conditions, farms should not require a fallowing period for the purpose of sediment recovery. However, this practice is

[27] Willoughby 1999
[28] O'Donohoe *et al*. 2000

widely and successfully implemented around the world as a method for preventing long- lasting damage to the benthic environment (Price and Morris 2013). In contrast to fish cage aquaculture in the nearshore environment and in bays or Fjords the impacts of offshore cage culture on the seafloor are negligible (Grizzle et al. 2014). Their study was based on a 9-year sampling programme at sites inside a predicted impact area, modelled by oceanographic conditions and faecal and food settling characteristics, and nearby reference sites. Analyses of benthic community measures from box core samples indicated minimal or no significant differences between impact and reference areas.

The degree of exposure is a major factor influencing background ecological responses to fish cage wastes. For example, finfish farming operations in temperate waters in Tasmania are located in a range of environments. In a study examining indicators of farm effects at 20 separate farm lease locations, Edgar *et al*. (2005) showed that there were marked differences in environmental conditions and that exposure level may be a major determinant of regional variability in background ecology.

Wild fish and other marine life often aggregate around fish cages and this may be considered a beneficial impact to marine life at some locations (Price and Morris 2013). Vita *et al*. (2004) illustrated the important function of wild fish associated with cage culture operations and concluded that wild fish play an important role in recycling the organic matter of the sediment and regulating benthic community structure below sea cages. The authors showed that 80% of the particulate organic matter leaving the rearing cages may be consumed by wild fish before it settles on the sediment and that significant changes in the nutrient quality of the organic matter exported are also due to consumption by wild fishes. Similarly, in inland waters, Beveridge (2004) estimated that the effects of fish farm emissions on total phosphorous were approximately 45–55% lower than the values predicted by mass-balance models such as the Dillon and Rigler model. Earlier work by Hakanson *et al*. (1998) focused on modelling and quantifying direct uptake and elimination processes (DUEL) by in-lake biota and found that less than 10% of the projected phosphorous loading from fish farms is actually released into the environment while the remainder is eliminated by other processes. Hakanson *et al* (1998) concluded that the classical models vastly overestimate farm emissions and hence significantly underestimate the biological carrying capacity of freshwater lakes.

The negative impacts of cage culture on the water column and the substratum can be mitigated by best management practices (BMPs) and working in water with a depth of at least twice the depth of the net pen and average current speeds > 7cm/sec (Bell and Nash 2008, Price and Beck-Simpert 2014). Under such conditions, nutrients will likely be diluted within a few hundred meters and dispersed for natural assimilation (Price *et al*. 2014).

Most importantly, BMPs include optimal feed and feeding practices, species-specific optimal stocking densities, farm site fallowing and an approved monitoring programme. It should be noted, however, that the sediments in certain marine areas, depending on the background organic content, have greater resilience to organic inputs than others (Macleod *et al*. 2007). In tropical regions, the assimilative capacity of the sediments has been found to be 3 to 4 times greater than in temperate zones (Angel *et al*. 1997). Moreover, BMPs also imply that fish welfare is optimised, which manifests in optimal feeding efficiency. Under such conditions and within the prevailing physical oceanographic parameters in the offshore environments around the inner islands, it is unlikely that sea cage farming would have a significant impact on the water column and the seabed.

The overall question of environmental impacts of any farm should be considered within a holistic context taking into account variable oceanographic, hydrological and ecological characteristics of the site and the structural, technological and production aspects of the farm. Price and Morris (2013) pointed out that decreasing environmental risk from aquaculture appears to be driven by prudent siting of operations outside of shallow, enclosed, coastal and nearshore waters lacking dispersive

current regimes, coupled with modern feed, aquatic health and farm management. This observation is important as it suggests that farming with minimal or acceptable environmental effects is possible in many ecosystems if proper safeguards are in place to minimize nutrient and chemical discharge and to manage its immediate and cumulative impacts. Such safeguards are best achieved in the form of regulatory oversight coupled with industry-developed best management practices.

This background underpinned the development of The Seychelles Aquaculture and Sea Ranching Regulations as well as the appropriate Seychelles Aquaculture Standards. The proposed monitoring programmes and international BMPs as outlined in the Regulations and Standards, such as obligatory fallowing and the distance between farms will ensure the ecological sustainability of fish cage culture around the inner islands.

5.4.4. Ecological carrying capacity

The importance of carrying capacity

Ecological carrying capacity is defined as the magnitude of aquaculture production that can be supported without leading to significant changes to ecological processes, services, species, populations or communities in the environment. Carrying capacity is an important concept for ecosystem-based management of fish cage culture, which given the environmental limits and social acceptability of aquaculture helps set the upper limits of aquaculture production, thus avoiding "unacceptable change" to both the natural ecosystem and the social functions and structures. In general terms, carrying capacity can be defined as the level of resource use both by humans and animals that can be sustained over the long term by the natural regenerative power of the environment (Ross et al. 2013).

Throughout the Mariculture Master Planning process, the focus has been to develop the sector in accordance with the ecosystems approach to aquaculture, which incorporates and considers the physical and ecological carrying capacities, aquaculture production potential and the social ramifications of sector development (Mc Kindsey et al. 2006, Soto et al. 2008, FAO 2010). The mandatory monitoring programmes of all farms prior to and during operations, as outlined in the draft "Marine Aquaculture and Sea Ranching Regulations" and the relevant Seychelles Aquaculture Standard, will ensure that the assimilative capacity of the sediments and the water column are not exceeded. The particular importance of this regulatory requirement is the implementation of a monitoring programme prior to the start of farming operations to develop a database of background levels upon which possible impacts can be assessed. Moreover, based on the precautionary principle an initial production limit of 10 MT / ha has been be imposed on all cage farms.

Scientific background and data inputs

Assessing the carrying capacity for aquaculture is challenging because of the number and nature of interactions, processes and scenarios involved. As mentioned elsewhere, the oceanographically data-poor situation in the Seychelles made the exercise even more challenging. Over the past decade, numerous simulation models have been developed to predict environmental changes with different nutrient loadings from dissolved and particulate inputs from fish cage aquaculture (Byron and Costa-Pierce, 2013). Models such as DEPOMOD and others can be used in local-scale assessment of the effects of fish cages on the environment (Byron and Costa-Pierce 2013, Ross et al. 2013). These models use information on depth, current velocity, current direction, feed input, and farm management practices to predict the deposition of wastes from the cages. Other models such as MOM (Modelling–On-growing fish farm–Monitoring system) (Ervik et al. 1997, Hansen et al. 2001, Stigebrandt et al. 2004) are used to predict carrying capacity. An overview of MOM is provided by Stigebrandt (2011). Based on a review of carrying capacity models, Byron and Costa-Pierce (2013) concluded that MOM

ver. 3.2 was the most appropriate and most widely used carrying capacity model for marine aquaculture.

It is now generally accepted that before aquaculture is established in a certain area, the carrying capacity should be estimated using appropriate models together with representative observational data from the area and the local environmental quality standards in force and appropriate farm water quality standards (Stigebrandt 2011). The Norwegian MOM system has two components: monitoring and modelling. Modelling is used before a farm is established to estimate the theoretical carrying capacity. Monitoring is used to ensure that the environmental impact does not violate any Environmental Quality Standards in force. The monitoring programme is flexible and its contents depend on how close the farm is to carrying capacity. If the set biomass is much less than the carrying capacity, then a farm does not require a hugely comprehensive monitoring programme (Stigebrandt 2011).

The MOM model has been adapted for a range of species, including two grouper species, viz. *Epinephelus malabaricus* and *E. tauvina*. Both species occur in the Seychelles and reach a large size. This is similar to the brown marbled grouper *E. fuscuguttatus,* which is one of the primary candidate aquaculture species. Growth performance indices (Φ) for the three species are similar, *E.malabaricus* = 3.72, *E.tauvina* = 3.31 and *E. fuscoguttatus* = 3.21 (www.Fishbase.org, Kirubasankar et al. 2013). For these reasons we were comfortable to use the MOM 3.2 model for *E.malabaricus* and *E. tauvina* as a proxy for *E. fuscoguttatus*.

As mentioned above, the MOM version 3.2 model computes individual carrying capacities for 1) A certain minimum oxygen concentration in the cages and 2) a certain maximum ammonium concentration in the cages securing good conditions for the fish in the cages and 3) a certain minimum oxygen concentration at the bottom securing reasonably good oxygen conditions for benthic animals beneath the cages. The smallest of these carrying capacity values represents the theoretical carrying capacity for the area.

The Model was run using the generic oceanographic data for the inner islands and the Mahe plateau as well as the more detailed current data provided by (Vacso Consulting 2009) for the NW and the SW coast of Mahe. The model was run for three depths (25, 35 and 55 m), each with a best, mid and worst-case scenario. For this purpose, the following parameters were varied accordingly, viz. Current standard deviation, Dissolved O_2 in bottom layer, Dimensioning current surface layer, Dimensioning current bottom layer, Lowest acceptable DO in cages, Lowest acceptable DO at the bottom and food conversion ratio. For the "Reduction factor for through flow" we used the recommended default value of 0.7. The reduction factor is a value for the reduction of the current speed as it passes through the cage and the fish in the cage. The necessary "Food data" and part of the "Fish Data" were obtained from the literature and we worked on the basis of the proposed precautionary production limit of 1000 tonnes per annum per square kilometer, which at any one time would have a maximum biomass of 650 tonnes.

Carrying capacity outputs

The model predicts that the maximum annual production of fish that can be sustained under all model scenarios was 4292 tonnes / km^2 (42.9 tpa/ha). The only predicted differences were the magnitudes of dissolved and particulate wastes that are released into the water column or to the sediment. As mentioned above, the MOM model uses four sub-models, viz. the Fish model, the Dispersion Model, the Benthic Model and the Fish Cage Water Quality Model (Stigebrandt (2011) to calculate several carrying capacities. These are Carrying $Capacity_{benthos}$, Carrying $Capacity_{DO}$ and Carrying $Capacity_{UIA}$ and the smallest of these three determines the final sustainable carrying capacity of the location. In all cases the production level was limited by the CC_{DO} sub-model. In other words, the "oxygen supply to

the cages" was too low to allow for higher production levels. This implies that the 42.92 tpa/ha production level is below a threshold level that would have an impact on the benthos or unfavourable NH_3 levels in the cages. Given the low DO levels in the waters of the Mahe plateau the result was not altogether unexpected.

The limiting production value of 42.92 tpa/ha is 4.3 times higher than the chosen precautionary production limit of 10 tpa / ha. The significantly higher production capacity than the precautionary limit adds a great deal of confidence that the proposed production limit is adequately conservative to cover for any of the possible data short comings.

It was recommended that the precautionary principle prevail and that the 10 tpa/ha limit is not exceeded until actual farm monitoring data become available that may support an increase in the rate of production per unit area.

Monitoring requirements

The MOM modelling system has two components: monitoring and modelling. Modelling is used before a farm is established to estimate the theoretical carrying capacity and monitoring is undertaken to ensure that the environmental impact does not violate any Environmental Quality Standards that have been set by the Regulator. Despite the ability to model and set production limits, responsible cage aquaculture also depends on the implementation of Best Management Practices, the Regulating Authority and its ability to manage appropriate monitoring systems.

The Seychelles monitoring programme is based on those developed for the US Virgin Islands and Puerto Rico, which have similar pristine marine environments as the Seychelles. In other words, monitoring must be conducted on approved farm sites during all phases of development, including prior to operations (the baseline assessment), despite any work on the suitability of the sites that might have been done previously. The baseline assessment must include the same sampling parameters as the long-term monitoring program. Both the baseline assessment and long-term monitoring must include video-recorded observations of benthic substrates, hydrographic information, water quality measurements, sediment analysis, and benthic community assessment. Sampling and data collection must occur at a pre-determined frequency that capture seasonal variation in circulation, water quality, and other environmental characteristics.

A similar monitoring system is recommended for cage aquaculture in Seychelles. This is outlined in "Seychelles Aquaculture Standards – Responsible finfish cage culture". Obligatory monitoring programmes are recommended in the relevant Standards for all types of aquaculture practices in the Seychelles.

5.5. The Biological Production Framework

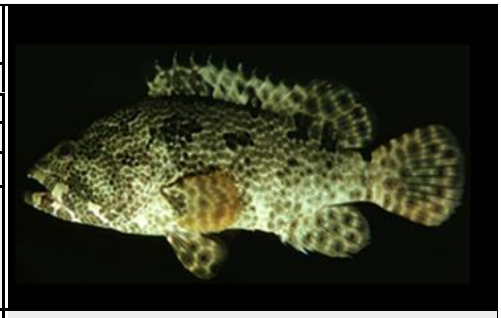
5.5.1. Background

The Biological Production Framework defines land and sea-based farming opportunities on the inner and certain outer islands and profiles the most promising candidate species for farming in the Seychelles.

Comprehensive biological and aquaculture profiles (fact sheet) as well as a detailed bio-economic model was developed for each of the Flagship priority candidate species. The candidate species identified for aquaculture in the Seychelles are listed in the following tables. The first lists the flagship priority species and the second table includes the high potential species, for which further R&D is required.

Table 10. Flagship candidate species

Epinephelus fuscoguttatus



Family	Serranidae
French name	Vieille machatta
Common name	Brown-marbled grouper
Status	**Indigenous** to Seychelles
Aquaculture countries	*E. fuscoguttatus* is farmed extensively throughout South East Asia (China; Taiwan; Indonesia; Malaysia; Thailand; Vietnam; Philippines)

Lutjanus argentimaculatus

Family	Lutjanidae
Seychellois name	Karp
Common name	Mangrove snapper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Lutjanus argentimaculatus* is farmed extensively throughout South East Asia (China; Japan; Cambodia; Philippines; Indonesia; Malaysia)

Trachinotus blochii

Family	Carangidae
Seychellois name	Lune; Pampe
Common name	Snubnose pompano
Status	**Indigenous** to Seychelles
Aquaculture countries	*Trachinotus blochii* is farmed in China, Indonesia, Hong Kong and Singapore

Siganus sutor

Family	Siganidae
Seychellois name	Kordonnyen Blan
Common name	Shoemaker spinefoot
Status	**Indigenous** to Seychelles
Aquaculture countries	Siganus spp. are farmed in India, Malaysia, Philippines, Indonesia, African east coast, the Middle East and the Mediterranean region

Aquarium finfish species

Family	Various
Seychellois name	-
Common name	-
Status	Spp. **indigenous** to Seychelles
Aquaculture countries	*Aquarium finfish species are farmed extensively worldwide; Major producing countries include Philippines and Indonesia*

Pinctada Margaritifera

Family	Pteriidae
Seychellois name	Zwit
Common name	Black-lip pearl oyster
Status	**Indigenous** to Seychelles
Aquaculture countries	*Pinctada Margaritifera* producer countries include Japan; China; India; French Polynesia and the USA

Holothuria scabra

Family	Holothuriidae
French name	Kokonm
Common name	Sandfish
Status	**Indigenous** to Seychelles
Aquaculture countries	*Holothuria scabra* is produced in Indonesia, South Korea, Madagascar, Russia and China

Tripneustes gratilla

Family	Toxopneustidae
Seychellois name	Zoursen
Common name	Collector urchin
Status	**Indigenous** to Seychelles
Aquaculture countries	*Tripneustes gratilla* is farmed in Japan, the Philippines, Russia, China and Ireland

Scylla serrata

Family	Portunidae
Seychellois name	Krab Mangliye
Common name	Mudcrab
Status	**Indigenous** to Seychelles
Aquaculture countries	*Scylla serrata* is farmed extensively in China, Bangladesh, India, Myanmar, Vietnam, Thailand and Philippines

Penaeus monodon

Family	Penaeidae
Seychellois name	Kanmaron
Common name	Giant tiger prawn
Status	**Indigenous** to Seychelles
Aquaculture countries	Main producers of *Penaeus monodon* include Thailand, Vietnam, Indonesia, India, the Philippines, Malaysia and Myanmar

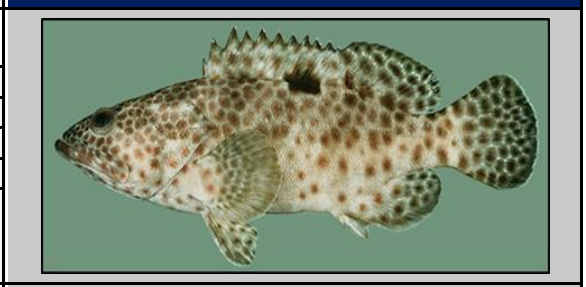
Table 11. High priority candidate species

Epinephelus tukula	
Family	Serranidae
Seychellois name	Vyey tukula
Common name	Potato bass; Potato grouper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Ephinephelus tukula* is farmed extensively throughout South East Asia (China; Japan; Indonesia; Malaysia)

Epinephelus malabaricus	
Family	Serranidae
Seychellois name	-
Common name	Malabar grouper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Ephinephelus malabaricus* is farmed extensively throughout South East Asia (China; Japan; Singapore; Indonesia and Malaysia)

Epinephelus lanceolatus	
Family	Serranidae
Seychellois name	Vyey krab
Common name	Giant grouper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Ephinephelus lanceolatus* is farmed extensively throughout South East Asia (China; Japan; Singapore; Indonesia and Malaysia)

Epinephelus tauvina	
Family	Serranidae
Seychellois name	-
Common name	Greasy grouper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Ephinephelus tauvina* is farmed in China, Malaysia and the UAE



Epinephelus polyphekadion	
Family	Serranidae
Seychellois name	Vyey goni
Common name	Camouflage grouper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Ephinephelus polyphekadion* is farmed extensively throughout South East Asia (China; Japan; Indonesia; Malaysia)

Epinephelus multinotatus	
Family	Serranidae
Seychellois name	Vyey plat
Common name	Whiteblotched grouper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Ephinephelus multinotatus* is farmed in China and other areas of South East Asia

Lutjanus sebae

Family	Lutjanidae
Seychellois name	Bourzwa
Common name	Emperor snapper
Status	**Indigenous** to Seychelles
Aquaculture countries	*Lutjanus sebae* is farmed in China, Malaysia, Singapore, Philippines and Cambodia

Rhabdosargus sarba

Family	Sparidae
Seychellois name	-
Common name	Goldlined sea bream; Natal stumpnose
Status	**Indigenous** to Seychelles
Aquaculture countries	*Rhabdosargus sarba* is farmed in China, Mauritius, Mayotte, Saudi Arabia and the UAE

Seriola rivoliana

Family	Carangidae
Seychellois name	Somon
Common name	Longfin yellowtail
Status	**Indigenous** to Seychelles
Aquaculture countries	Seriola species are farmed in Japan, Korea, New Zealand, Australia and in the Americas

Thunnus albacares

Family	Scombridae
Seychellois name	Ton Zonn
Common name	Yellowfin tuna
Status	**Indigenous** to Seychelles
Aquaculture countries	*Thunnus albacares* is farmed in Oman and Mexico

Holothuria fuscogilva

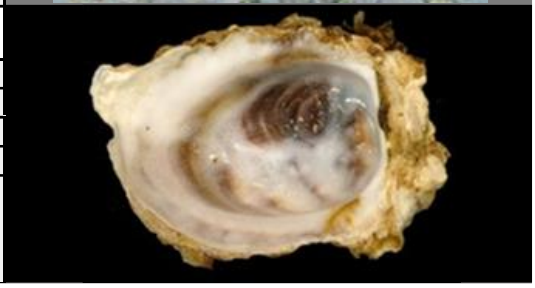
Family	Holothuriidae
Seychellois name	Kokosye Blan
Common name	White teatfish
Status	**Indigenous** to Seychelles
Aquaculture countries	Holothuria species are produced in Indonesia, South Korea, Madagascar, Russia and China

Holothuria lessoni

Family	Holothuriidae
Seychellois name	Lakol
Common name	Golden sandfish
Status	**Indigenous** to Seychelles
Aquaculture countries	Holothuria species are produced in Indonesia, South Korea, Madagascar, Russia and China

Saccostrea cucullata

Family	Ostreidae
Seychellois name	Zwit
Common name	Hooded oyster
Status	**Indigenous** to Seychelles
Aquaculture countries	*Saccostrea cucullata* is farmed in India and Mauritius



5.5.2. Bio-economic modelling

The key objective of the bio-economic models was to determine whether the species meets the minimum performance requirements across a range of variables that support production at scale in the Seychelles environment and whether the associated costs of production and sales price result in a viable economic business case. Models for Brown marbled grouper (2), Mangrove snapper, Snubnose pompano and Sandfish (sea cucumber) are illustrated below [29,30,31,32,33] Models for the remainder of the flagship species as well as the most important high priority species will be developed during the implementation phase and as more data becomes available.

In constructing the bio-economic models for each of the species the following key variables were considered. It should be noted that certain variable vary with scale of operation.

- **Regulatory and legislative requirements:** will the species receive the necessary permissions to be farmed commercially in the Seychelles waters along with the other legislative requirements that are applicable to the operation
- **Biological performance under local environmental conditions:** do the conditions for the spawning and growth of Sandfish *(Holothuria scabra)* match the environmental conditions present in the Seychelles conferring a natural strategic advantage
- **Established farming technology:** is there adequate farming technology available globally that could be utilised and adapted to support the commercial farming of sandfish in the Seychelles
- **Access to skilled personnel:** does the Seychelles have skilled personnel that could manage a large-scale sandfish operation and can expatriate skills be contracted in for the purposes of addressing skills gaps during the early stage of business development
- **Availability of land and water-based infrastructural requirements:** does the existing infrastructure in the Seychelles support operations and can it be successfully extended to match the predicted growth of the industry specifically on the outer islands
- **Competitive costs of production:** can a scale sandfish farm achieve the operational efficiencies required to return a competitive production cost
- **Access to market:** can a product be developed that will meet market demands and the legislative, logistical and certification requirements required for export to international markets
- **Sales price:** can the product achieve a sales price that supports a profitable result for the commercial farming of the species

To model realistic economic results certain macro-economic, biological, market and operational assumptions had to be made. Apart from the above considerations and assumptions the models incorporate a business strategy, a comprehensive assessment of the biological performance of the species, a technical approach section (including hatchery, nursery, grow-out, harvesting and processing), a development plan, capital budget, an operational plan (including starting stock, feed, supply, harvest and export logistics, HR, processing, certification, sales and marketing), management and strategic alliances, project location and facilities, market analysis, financial projections, a risk analysis and a section on funding.

[29] Brown marbled grouper 200 MT pa
[30] Brown marbled grouper 3000 MT pa
[31] Mangrove snapper 3000 MT pa
[32] Sandfish (sea cucumber) Model
[33] Bluntnose pompano model 3000 MT pa

The base bioplan upon which the economic model was constructed, the basic economic indicators, the key cashflow results and key risks for farming each of the species for three flagship candidate species are summarised below:

Brown marbled grouper (Epinephelus fuscoguttatus).

Feasibility of a 200 MT pa operation

Table 12: Bioplan for 200 tpa operation

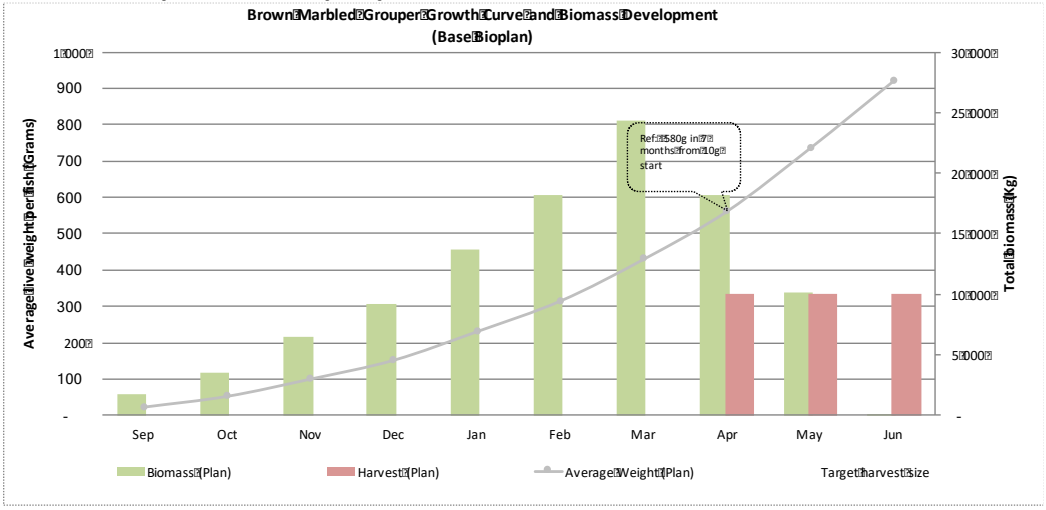


Table 13: Key economic indicators for 3000 tpa operation

Key economic indicators for 3000 tpa operation	
Timeframe	15 yrs
Discount rate	24%
NPV	(322)
IRR	14%
Max cash required (USD)	2 170 000
Payback	Yr 7. Month 9

Feasibility of a 3000 MT pa operation

Table 14: Bioplan for 3000 tpa operation

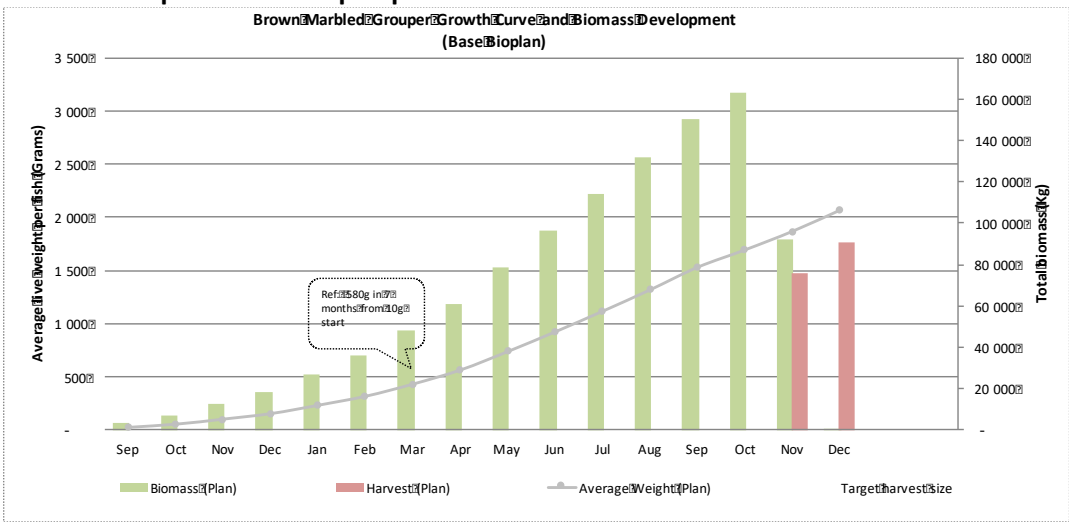


Table 15: Key economic indicators for 3000 tpa operation

Key economic indicators for 3000 tpa operation	
Timeframe	15 yrs
Discount rate	8%
NPV	24 241
IRR	24%
Max cash required (USD)	19 141 378

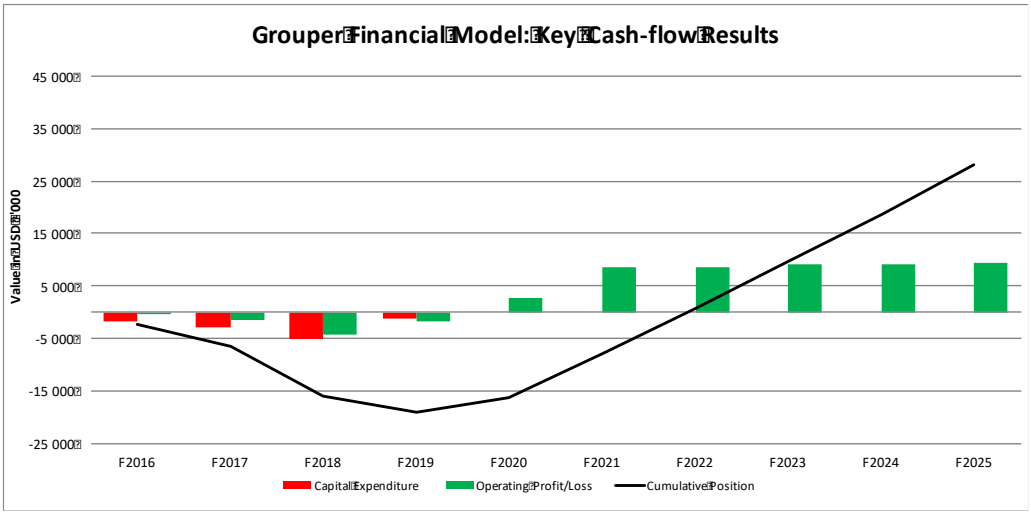


Figure 12 Grouper Financial Model: Key Cash-flow Results

Project risks for Brown marbled grouper have been identified and plotted against the likelihood of them happening (% probability) and the impact they would have on the business should they occur (financial/reputational/ health and safety/market/legislative etc.) Table 16.

Table 16a: Risk matrix for brown marbled grouper.

RISK MATRIX

LIKELIHOOD							
	F 99% Probability	Medium	Medium	High	Very High	Very High	Very High
	E >50% Probability	Low	Medium	High	High	Very High	Very High
	D >20% Probability	Low	Medium	Medium	High	Very High	Very High
	C >10% Probability	Low	Low	Medium	High	High	Very High
	B >1% Probability	Low	Low	Medium	Medium	High	Very High
	A <1% Probability	Low	Low	Low	Medium	High	High
		1	2	3	4	5	6
		IMPACT					

Table 16b: Risk category, description, factor and mitigation for brown marbled grouper.

Risk Category	Description	Factor	Mitigation
Financial			
Exchange Rate	Exchange rates move in a direction that is negative to the project	Medium	A natural hedge is created with the primary income and costs (feed) being denominated in hard currency
Rate of Inflation	Inflation erodes the profitability of the project	Low	Export products are denominated in hard currency
Corporate Tax Rate	Project does not qualify for reduced tax rates through incentives	Low	15% used in budgets
Capitalisation	The total investment capital required exceeds budget	Medium	A conservative approach has been taken to project capitalisation
Biological			
Growth-rate/period	More than 18months is required to grow to market size	Medium	The impact will only be on cage space required (small increase in CAPEX) and delay to first sales
EFCR	The achieved EFCR of 1.8 is not achieved	Medium	A conservative approach has been taken
Monthly mortality rate	Mortality rates exceed the budgeted 2% per month	Medium	Quality starting stock and feed and conservative stocking densities make this an achievable target
Product Yields	The budgeted processing yields are not achieved	Low	These yields have been proven in Grouper aquaculture already
Market			
Market access	Access to the planned markets is not achieved	High	Certification as required must be prioritised
Product quality	The end products do not meet customers quality requirements	High	A diversified product and market mix is required
Price	The end products do not achieve the budgeted price	Medium	Global prices for grouper products are known
Cost			
Feed price	The price of feed exceeds budget	Medium	Historical information shows a strong correlation between feed prices and fish sales prices
Cost of Sales	The costs associated with sales exceed budget	High	Based on planned volumes a direct to retailer sale will be possible
Logistical costs	Logistical costs exceed budget	Low	Logistical costs are based on current standard rates – these are likely to improve with volume
Human Resources			
Management	The ability to attract suitable management is not achieved	Medium	There are qualified Seychellois graduates working in various parts of the world that have indicated an interest in returning to practice aquaculture

Skills transfer	Skills transfer is not achieved and permanent expat resources are required	High	The approach to industry should be to encourage domestic involvement through appropriate technology and the associated use of skilled personnel
Stakeholders			
Local community	The local communities oppose aquaculture development	Medium	A well-considered stakeholder program will be essential to gaining local support
Fishermen	The fishing industry opposes aquaculture development	High	Ensuring that fisheries and aquaculture are aligned is important and can be achieved through consultations

Mangrove snapper (Lutjanus argentimaculatus)

Table 17: Base bioplan for 3000 tpa operation

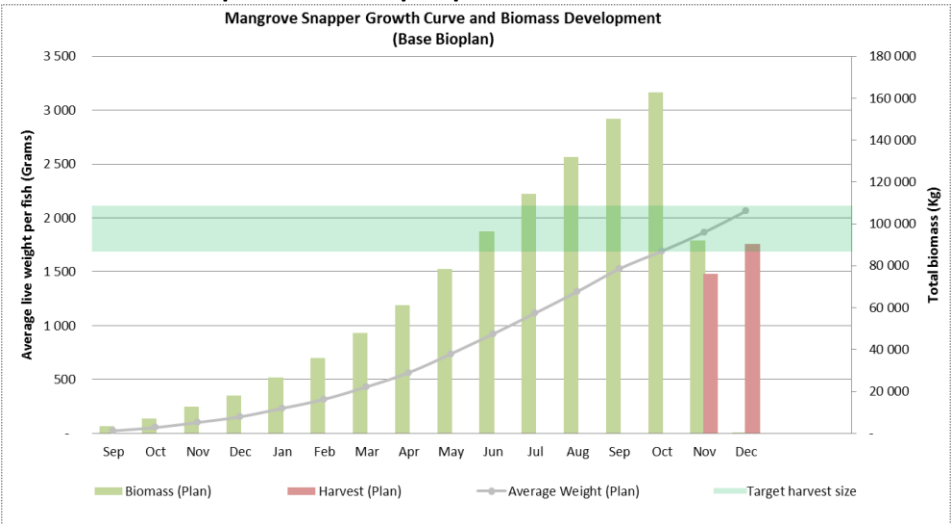


Table 18: Key economic indicators

Key economic indicators	
Timeframe	15 yrs
Discount rate	8%
NPV	7136
IRR	13%
Max cash required (USD)	24 206 889

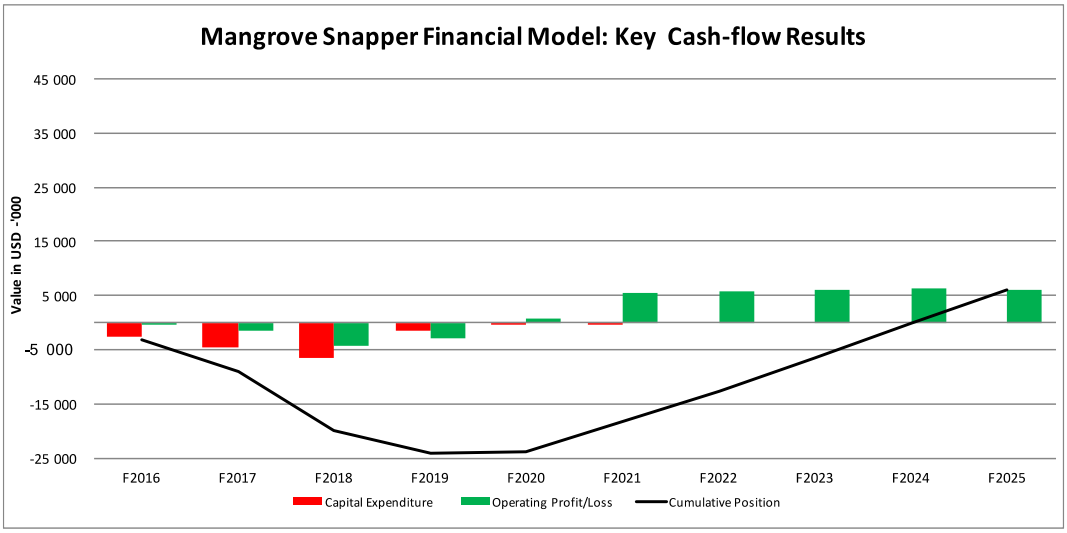


Figure 13 Mangrove Snapper Financial Model: Key Cash-flow Results

Project risks for Mangrove snapper have been identified and plotted against the likelihood of them happening (% probability) and the impact they would have on the business should they occur (financial/reputational/ health and safety/market/legislative etc.).

Table 19a: Risk matrix for Mangrove snapper.

RISK MATRIX

LIKELIHOOD							
	F 99% Probability	Medium	Medium	High	Very High	Very High	Very High
	E >50% Probability	Low	Medium	High	High	Very High	Very High
	D >20% Probability	Low	Medium	Medium	High	Very High	Very High
	C >10% Probability	Low	Low	Medium	High	High	Very High
	B >1% Probability	Low	Low	Medium	Medium	High	Very High
	A <1% Probability	Low	Low	Low	Medium	High	High
		1	2	3	4	5	6
		IMPACT					

Table 19b: Risk category, description, factor and mitigation for Mangrove snapper.

Risk Category	Description	Factor	Mitigation
Financial			
Exchange Rate	Exchange rates move in a direction that is negative to the project	Medium	A natural hedge is created with the primary income and costs (feed) being denominated in hard currency

Rate of Inflation	Inflation erodes the profitability of the project	Low	Export products are denominated in hard currency
Corporate Tax Rate	Project does not qualify for reduced tax rates through incentives	Low	15% used in budgets
Capitalisation	The total investment capital required exceeds budget	Medium	A conservative approach has been taken to project capitalisation
Biological			
Growth-rate/period	More than 18months is required to grow to market size	Medium	The impact will only be on cage space required (small increase in CAPEX) and delay to first sales
EFCR	The achieved EFCR of 1.8 is not achieved	Medium	A conservative approach has been taken
Monthly mortality rate	Mortality rates exceed the budgeted 2% per month	Medium	Quality starting stock and feed and conservative stocking densities make this an achievable target
Product Yields	The budgeted processing yields are not achieved	Low	These yields have been proven in wild-harvest snapper
Market access	Access to the planned markets is not achieved	High	Certification as required must be prioritised
Product quality	The end products do not meet customers quality requirements	High	A diversified product and market mix is required
Price	The end products do not achieve the budgeted price	Medium	Prices have been conservatively set at similar to seabass and seabream
Cost			
Feed price	The price of feed exceeds budget	Medium	Historical information shows a strong correlation between feed prices and fish sales prices
Cost of Sales	The costs associated with sales exceed budget	High	Based on planned volumes a direct to retailer sale will be possible
Logistical costs	Logistical costs exceed budget	Low	Logistical costs are based on current standard rates – these are likely to improve with volume
Human Resources			
Management	The ability to attract suitable management is not achieved	Medium	There are qualified Seychellois graduates working in various parts of the world that have indicated an interest in returning to practice aquaculture
Skills transfer	Skills transfer is not achieved and permanent expat resources are required	High	The approach to industry should be to encourage domestic involvement through appropriate technology and the associated use of skilled personnel
Stakeholders			
Local community	The local communities oppose aquaculture development	Medium	A well-considered stakeholder program will be essential to gaining local support
Fishermen	The fishing industry opposes aquaculture development	High	Ensuring that fisheries and aquaculture are aligned is important and can be achieved through consultations

Snubnose Pompano (Trachinotus blochii)

Table 20: Base bioplan for 3000 MT pa operation

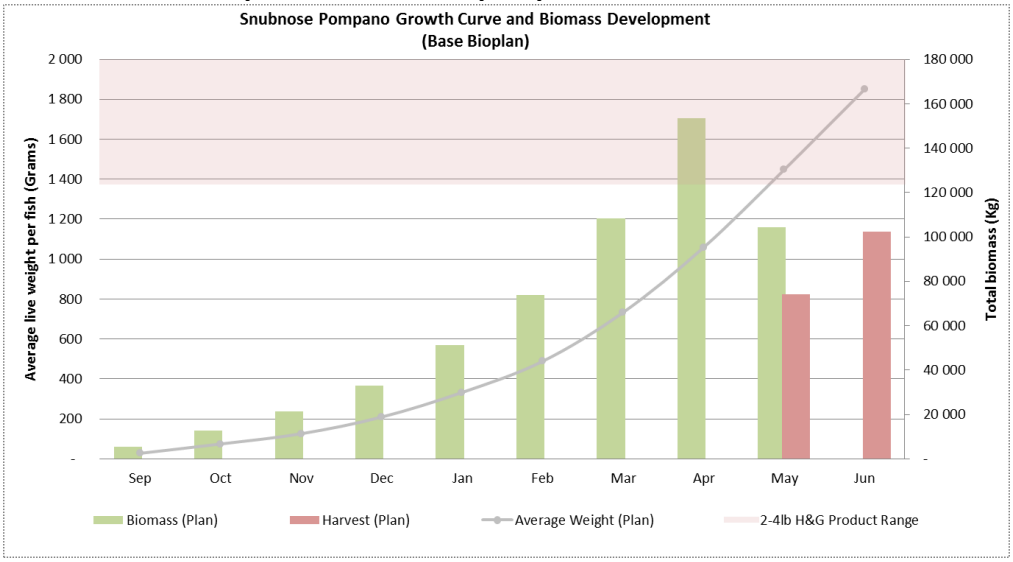


Table 21: Key economic indicators

Key economic indicators	
Timeframe	15 yrs
Discount rate	8%
NPV	15 174
IRR	21%
Max cash required (USD)	15 708 910

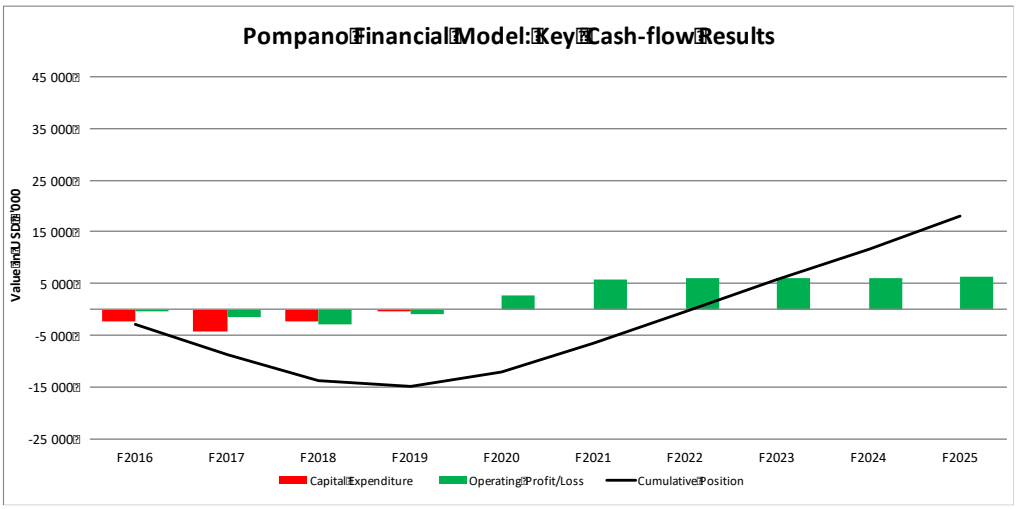


Figure 14 Pompano Financial Model: Key Cash-flow results

Project risks have been identified and plotted against the likelihood of them happening (% probability) and the impact they would have on the business should they occur (financial/reputational/ health and safety/market/legislative etc.).

Table 22a: Risk matrix for Snubnose Pompano.

RISK MATRIX

LIKELIHOOD							
	F 99% Probability	Medium	Medium	High	Very High	Very High	Very High
	E >50% Probability	Low	Medium	High	High	Very High	Very High
	D >20% Probability	Low	Medium	Medium	High	Very High	Very High
	C >10% Probability	Low	Low	Medium	High	High	Very High
	B >1% Probability	Low	Low	Medium	Medium	High	Very High
	A <1% Probability	Low	Low	Low	Medium	High	High
		1	2	3	4	5	6
		IMPACT					

Table 22b: Risk category, description, factor and mitigation for Snubnose Pompano.

Risk Category	Description	Factor	Mitigation
Financial			
Exchange Rate	Exchange rates move in a direction that is negative to the project	Medium	A natural hedge is created with the primary income and costs (feed) being denominated in hard currency
Rate of Inflation	Inflation erodes the profitability of the project	Low	Export products are denominated in hard currency
Corporate Tax Rate	Project does not qualify for reduced tax rates through incentives	Low	15% used in budgets
Capitalisation	The total investment capital required exceeds budget	Medium	A conservative approach has been taken to project capitalisation
Biological			
Growth-rate/period	More than 8months is required to grow to market size	Medium	The impact will only be on cage space required (small increase in CAPEX) and delay to first sales
EFCR	The achieved EFCR of 1.4 is not achieved	Medium	A conservative approach has been taken
Monthly mortality rate	Mortality rates exceed the budgeted 2% per month	Medium	Quality starting stock and feed and conservative stocking densities make this an achievable target
Product Yields	The budgeted processing yields are not achieved	Low	Whole round frozen product assumed only
Market access	Access to the planned markets is not achieved	High	Certification as required must be prioritised

Product quality	The end products do not meet customers quality requirements	Low	Simple base product specified
Price	The end products do not achieve the budgeted price	High	A new higher priced niche in the pompano market is assumed for a larger, quality product
Cost			
Feed price	The price of feed exceeds budget	Medium	Historical information shows a strong correlation between feed prices and fish sales prices
Cost of Sales	The costs associated with sales exceed budget	Low	A simple frozen product is assumed and reefer container logistics are well known
Logistical costs	Logistical costs exceed budget	Low	Logistical costs are based on current standard rates – these are likely to improve with volume
Human Resources			
Management	The ability to attract suitable management is not achieved	Medium	There are qualified Seychellois graduates working in various parts of the world that have indicated an interest in returning to practice aquaculture
Skills transfer	Skills transfer is not achieved and permanent expat resources are required	High	The approach to industry should be to encourage domestic involvement through appropriate technology and the associated use of skilled personnel
Stakeholders			
Local community	The local communities oppose aquaculture development	Medium	A well-considered stakeholder program will be essential to gaining local support
Fishermen	The fishing industry opposes aquaculture development	High	Ensuring that fisheries and aquaculture are aligned is important and can be achieved through consultations

Sandfish (sea cucumber)

Table 23: Base bioplan for Sandfish

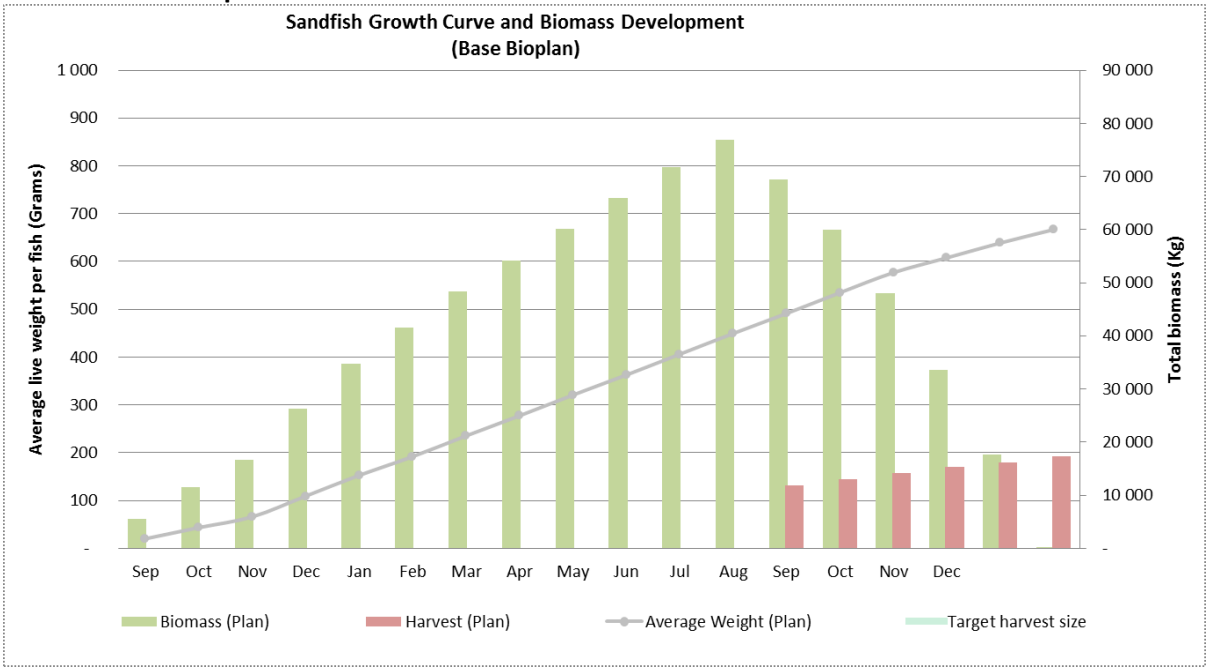


Table 24: Key economic indicators

Key economic indicators	
Timeframe	15 yrs
Discount rate	8%
NPV	1631
IRR	23%
Max cash required (USD)	1 750 522

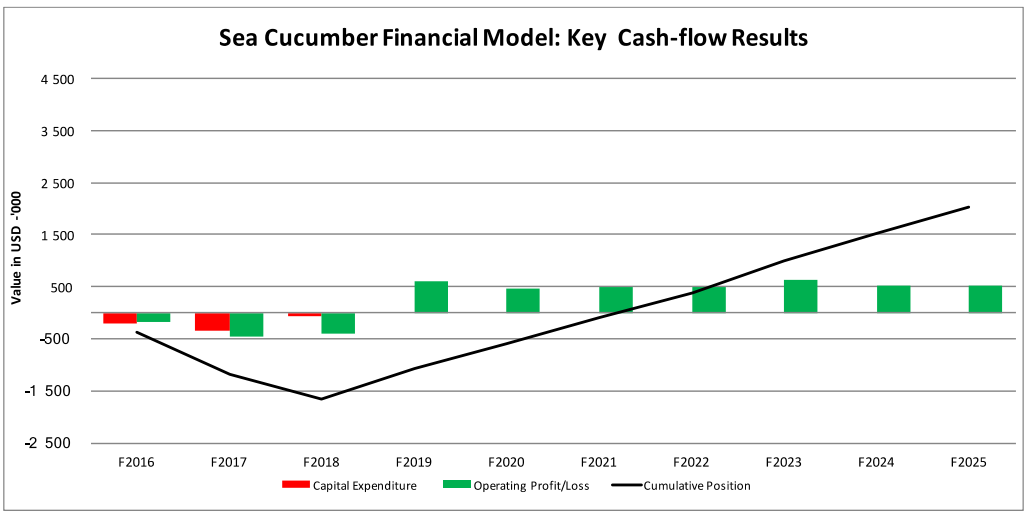


Figure 15 Sea Cucumber Financial Model: Key Cash-flow Results

Project risks for Sandfish have been identified and plotted against the likelihood of them happening (% probability) and the impact they would have on the business should they occur (financial/reputational/ health and safety/market/legislative etc.).

Table 25a: Risk matrix for Sandfish.

RISK MATRIX

LIKELIHOOD							
	F 99% Probability	Medium	Medium	High	Very High	Very High	Very High
	E >50% Probability	Low	Medium	High	High	Very High	Very High
	D >20% Probability	Low	Medium	Medium	High	Very High	Very High
	C >10% Probability	Low	Low	Medium	High	High	Very High
	B >1% Probability	Low	Low	Medium	Medium	High	Very High
	A <1% Probability	Low	Low	Low	Medium	High	High
		1	2	3	4	5	6
		IMPACT					

Table 25b: Risk category, description, factor and mitigation for Sandfish.

Risk Category	Description	Factor	Mitigation
Financial			
Exchange Rate	Exchange rates move in a direction that is negative to the project	Medium	Sales price is USD based and most production costs are equally based in USD
Rate of Inflation	Inflation erodes the profitability of the project	Low	Only a substantial valuation of the SCR versus the USD would impact profitability
Corporate Tax Rate	Project does not qualify for reduced tax rates through incentives	Low	15% used in budgets
Capitalisation	The total investment capital required exceeds budget	Medium	A conservative approach has been taken to project capitalisation
Biological			
Growth-rate/period	More than 11months is required to grow to market size	Medium	The impact will delay first sales and negatively impact cash-flow and capitalisation
Monthly mortality rate	Mortality rates exceed the budgeted 2% per month	Medium	The cumulative mortality rate of 60% is highly conservative.
Product Yields	The budgeted processing yields are not achieved	Low	Yield is set at 7% which is viewed as conservative. Processing techniques can be adjusted if this result are not achieved
Market			
Market access	Access to the planned markets is not achieved	Low	Current exports of the product are successful

Product quality	The end products do not meet customers quality requirements	Low	Established acceptance of Seychelles product
Price	The end products do not achieve the budgeted price	Medium	Global prices for sea cucumber products are well known
Cost			
Cost of Sales	The costs associated with sales exceed budget	Low	Based on planned volumes a direct sale will be possible
Logistical costs	Logistical costs exceed budget	Low	Logistical costs are based on current standard rates
Human Resources			
Management	The ability to attract suitable management is not achieved	Low	There are qualified Seychellois graduates working in various parts of the world that have indicated an interest in returning to practice aquaculture
General skills	General skills cannot be adequately developed	Low	The industry has been operational for many years and adequate skills have already been developed
Stakeholders			
Local community	The local communities oppose aquaculture development	Medium	A well-considered stakeholder program will be essential to gaining local support
Fishermen	The existing wild harvest industry opposes aquaculture development	High	Existing industry players must be incorporated into the ranching sector

5.5.3. Commercial aquaculture opportunities - Inner Islands

Based on first hand market research in Belgium, Japan, Hong Kong, Taiwan and Thailand and rigorous bio-economic modelling, the MMP has identified several commercially feasible aquaculture opportunities for the inner islands of the Seychelles. These include cage culture of several fish species supported by land-based hatcheries, production of ornamental fish and other aquarium species, expansion of black pearl farming and land-based farming of sea urchins. These opportunities will be supported by a proposed National Aquaculture Research and Development Facility, located at the Anse Royale campus of the University of Seychelles (see Section 7).

A comprehensive site selection study was undertaken, which identified certain ADZs around the inner islands that are suitable for finfish cage farming (see Section 5.4)[34]. These ADZs are all more than 2 km from the shore except in areas where they are not visible. The inshore zone (< 2km from the shore) has been reserved for local entrepreneurs. Suitable sites have been identified[35] but these were not considered in the ESIA. This means that if an application for a license is provisionally approved then local entrepreneur will have to undertake a separate EIA for the activities to be undertaken on that site. The cost of the EIA will be borne by SFA and recouped through future production levies[36].

[34] Site selection Report

[35] Badenhorst and Lesperance July 2016. Report on the inshore sites for small-scale farming in the Inner Islands of the Seychelles

[36] MMP Report 2016. Seychelles Aquaculture Industry – Revenue streams and costs for the public sector

Several fish and invertebrate species have been identified as top priority candidate species[37] (see above). However, the specific choice to farm a particular species is left to the investor so as not to interfere with private enterprise.

Ranching of sea cucumbers was not recommended for the inner Islands. This decision is based on the high likelihood of poaching and the inability to control it. For this reason, sea cucumber ranching is only recommended for the outer islands, where stocked animals can be better controlled by the investors.

Land-based aquaculture on the inner island is limited by available space and will largely be restricted to hatchery and nursery activities in a clustered fashion to maximize land use. Several areas have been identified[38] and will be ring fenced for aquaculture development by the "Aquaculture Sub-Committee for Land" (see Section 6 of this report).

Silhouette and La Digue islands offer significant opportunities for land-based hatchery activities and for the intensive farming of short spine (collector) sea urchin (*Tripneustes gratilla*).

Production potential for finfish has been modelled according to three scenarios (low, mid and high road) and these findings are presented in Section 5.5.4.

5.5.4. Commercial aquaculture opportunities - Outer Islands

General background

A qualitative and quantitative analysis was undertaken to assess opportunities for sea cucumber ranching and farming, fin fish cage culture, pond farming of tiger prawns and black pearl oyster farming on Coetivy, Alphonse, St Francois, Bijoutier, Poivre and Desroches islands[39].

The qualitative analysis was based on information and data obtained from the ICS, the IDC and the Seychelles Protected Areas Policy (2013), UNDP GEF PIMS Project 4529 (*Expansion and Strengthening of the Protected Area subsystem of the Outer Islands of Seychelles and its integration into the broader land and sea scape*) experience as well as observations made on the islands during March / April 2014. The findings are presented by way of the following four tables.

Table 26. Aquaculture potential based on bio-physical parameters (seafloor cover, sediment type, depth, suitable area and species compatibility.

Island	Finfish	Sea Cucumbers	Prawns	Black pearls	Ornamental fish	Corals
Coetivy	Low	Low *	High**	Medium	High	High
Alphonse	NO	Medium	NO	NO	Medium	Medium
SaintFrancois	NO	Medium	NO	NO	NO	NO
Bijoutier	NO	High	NO	NO	NO	NO
Poivre	NO	High	NO	NO	Low	NO
Desroche	High	High	Very limited	High	High	High

* But Coetivy presents excellent pond farming conditions for sea cucumbers

** Approx. 200 tpa could be produced in the northern ponds.

[37] Species selection report

[38] Land-based Aquaculture Sites

[39] Robinson, G., Hecht, T. and Lesperance, A. 2014. Aquaculture and sea-ranching potential of Coetivy, Alphonse, St. Francois, Bijoutier and Desroches Islands. Advance Africa Management Services Report. 27p.

Table 27. Potential for user conflict (this may change with time and sensitive development)

Island	Finfish	Sea Cucumbers	Prawns	Black pearls	Ornamental fish	Corals
Coetivy	Low	Low	Low	Low	Low	Low
Alphonse	–	Medium	–	–	Low	Low
SaintFrancois	–	Medium	–	–	–	–
Bijoutier	–	Medium	–	–	–	–
Poivre	–	Low	–	–	Low	–
Desroche	Medium	Low	High	Low	Low	Low

Table 28. Terrestrial sensitivity

Island	High	Medium	Low
Coetivy			X
Alphonse		X	X
SaintFrancoise	X		
Bijoutier	X		
Poivre NORTH		X	X
Poivre SOUTH	X		
Desroche	X	X	

If the potential for user conflict and / or terrestrial sensitivity in Tables 27 AND 28 is medium or high, then potential for land-based aquaculture was nil.

Table 29. Suitability for land-based and sea-based aquaculture activities.

Island	Land-based	Sea-based
Coetivy	YES	YES
Alphonse	YES	YES
SaintFrancoise	NO	YES
Bijoutier	NO	YES
Poivre NORTH	YES	YES
Poivre SOUTH	NO	YES
Desroche	YES	YES

The overall conclusions from the qualitative analysis is that certain types of sea-based aquaculture / ranching can be undertaken at all of the Islands, while only some of the Islands are suited for land based aquaculture activities. The islands not suitable for land-based activities were classified as such because of their conservation status and the potential for user conflict.

Sea cucumber ranching opportunities

The assessment of sea cucumber ranching opportunities was based on the results of a comprehensive benthic community structure assessment and identification of aquaculture zones around several outer islands[40]. This study in the lagoons of the atolls (except Coetivy) provided the base information upon which to conclude on the feasibility for responsible sea cucumber ranching and fish cage aquaculture.

In assessing the suitability of sites for sea cucumber ranching the following parameters were considered:

- Surface area of suitable habitat (assessed by physical diving surveys, GPS coordinates and GIS mapping.
- Water depth in suitable areas
- The depth of the soft substratum
- The type of substratum (classified according to the Wentworth Scale and the percentage coverage was estimated using 50 cm x 50 cm quadrat analysis).
- Organic matter content by analysis

[40] Richard, C. 2015. Benthic community assessments in the outer islands of Seychelles. (Coëtivy, Alphonse, Bijoutier, Saint François, Poivre and Desroches). Report to Advance Africa Management. 94p.

- Abundance and diversity of sea cucumbers (at each candidate site a semi-quantitative estimate of sea cucumber abundance and diversity was made, by way of 50 m diving transects, manta tows, and timed searches using SCUBA).
- Carrying capacity assessment to assess the maximum sea cucumber biomass a site could support, quantitative methods employing 50 m x 2m transects and timed searches were used to assess the densities of sea cucumbers present. *H. atra* is an excellent indicator of site suitability given its high natural abundance and occurrence in the wild and low commercial value which means that it remains relatively unexploited in the Seychelles. Importantly, densities of *H. atra* can be used to indicate the carrying capacity of the site since a relationship exists between the trophic status (level of organic enrichment) of a site and the population densities of *H. atra* . To provide an approximate estimate of the carrying capacity of *H. scabra,* which generally requires a higher level of organic enrichment than *H. atra,* an index based on the mean density and size of *H. atra* was developed. The mean density of *H. atra* was multiplied by the average weight of the *H. atra* individuals in the fissiparous population (30g) and then divided by two to give a carrying capacity in grams per square meter for *Holothuria scabra.* At deeper lagoon sites, the presence of other deposit feeders such as polychaete worms that employ a similar mode of nutrition to sea cucumbers were used as indicators of site productivity.
- Presence of predators
- Direct observations or indicators of presence of the main predators of juvenile sea cucumbers, which include carnivorous fish, birds, turtles, sea stars, crabs, gastropods and other invertebrates were made.

There are six high value sea cucumber species that occur on the outer islands, of which only two were recommended for farming (*Holothuria scabra* and *H. lessoni*) and two for further research and development (*H. fuscogilva* and the Pentard). A summary of the advantages of the two main ranching species is provided below.

***The Golden Sandfish (Holothuria lessoni*)**

Figure 16 Colour morphs of Golden sandfish

- One of the highest commercially valued species ranking probably number one on the world Beche-de-mer market alongside *Holothuria scabra* (Conand, 2008)
- It is rarer than *H. scabra* therefore offers a competitive edge
- The species is well regarded for its taste
- This species is not currently the focus of any aquaculture projects in the Indo-Pacific region and therefore it has great potential for market penetration
- Broodstock populations were recorded on Poivre (south Island) and Desroches in the Amirantes group.

***The sand fish (Holothuria scabra*)**

Figure 17 The sand fish (Holothuria scabra)

- The highest commercially valued species on the world bêche-de-mer market (Conand, 2008)
- Over-exploited status in Seychelles provides opportunities for re-stocking
- Hatchery and nursery technologies are well developed
- Suited to culture in a wide range of grow-out systems including ranching, sea pen farming and pond culture
- Broodstock populations were recorded on Poivre South Island in the Amirantes group.

The potential.

Collectively the five Islands provide over 5089 ha of suitable area for sea cucumber ranching, of which 1600 ha can be used immediately using *Holothuria scabra* and *Holothuria lessoni*, two of the very high value species.

Coetivy

Ranching: Coetivy does not have a natural enclosed lagoon, but around 47 ha of suitable substrate is found on the SE Monsoon lee. Hence, there is little scope for large scale sea cucumber ranching. Substrate and sea grass beds on the reef flats are not suitable for ranching. Small area on West coast fulfils bio-physical conditions for *Holothuria scabra* ranching. Substrate soft sandy. Calculated carrying capacity = 350 g/m^2.

Pond farming:

The 84 Northern prawn ponds provide ca. 40 ha pond floor area, highly suitable for farming of *H.scabra* or *H.lessoni.* There are three options for using these ponds for the farming of sea cucumbers.

Option 1: Extensive (unfed) = 112 tonnes per annum (tpa)

Option 2: Intensive monoculture and fed 16% protein formulated feed = 480 tpa

Option 3: Integrated Multi-trophic Aquaculture: Semi intensive alternating with prawns = 320 tpa. This is preferred option (using sea cucumbers to bio-remediate prawn sludge thereby reducing nitrogenous waste to environment).

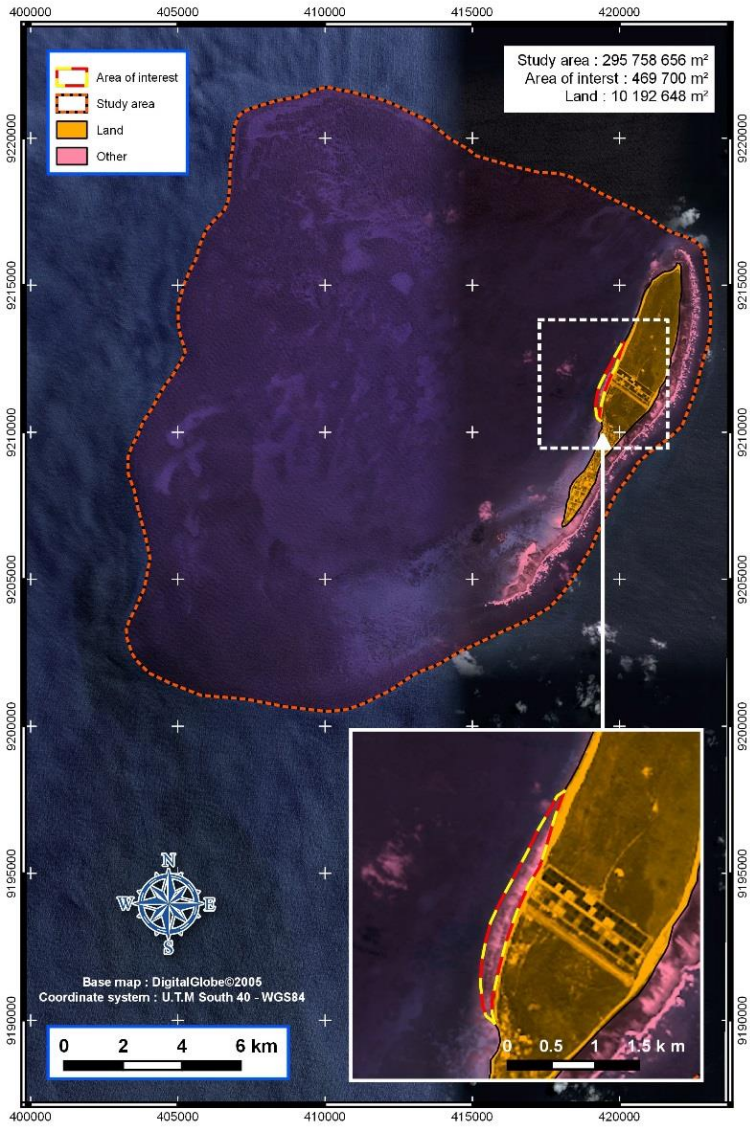


Figure 18 Sea cucumber ranching area on Coetivy

Figure 19 Abandoned northern prawn ponds on Coetivy

Poivre Flats

Flats between north and south Poivre ideally suited for commercial ranching.
Suitable species for ranching on Poivre: *H.scabra*
Suitable area for ranching 28 (highly suitable) + 86(suitable) =114 ha
Substrate is fine with sparse *Thalassia hemprichii*
Calculated carrying capacity between 420 and 42 g/m^2.

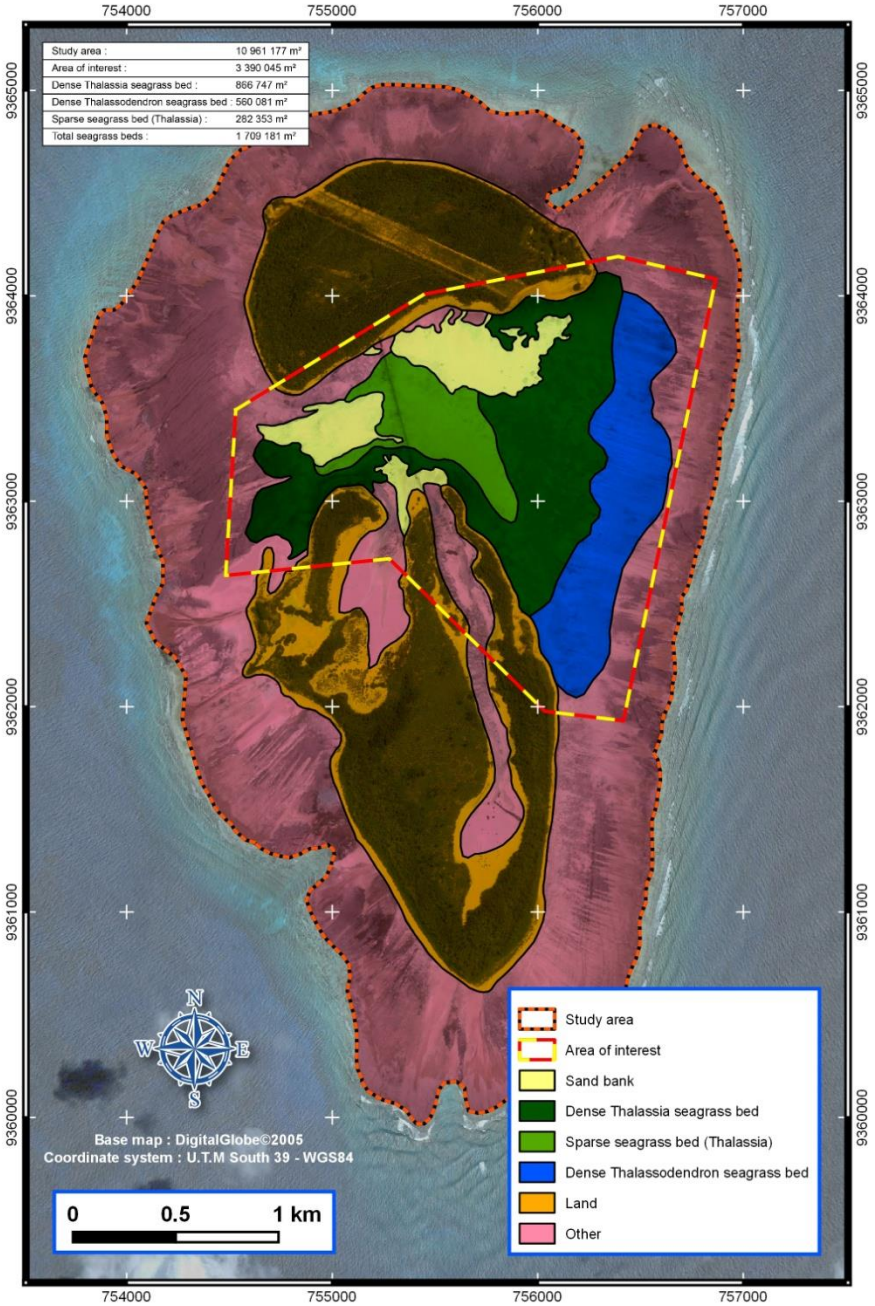


Figure 20 Area of interest for sea cucumber ranching around Poivre Island

Desroches lagoon

Very suitable on North coast beyond *Thallasodendron ciliatum* beds.
Suitable species for ranching: Golden sandfish (*H.lessoni*)
Suitable area for ranching = 332 ha (initial area of interest) but can expand to 1440 ha
Substrate: lagoon floor is muddy – sandy fine
Calculated carrying capacity = 150g/m^2

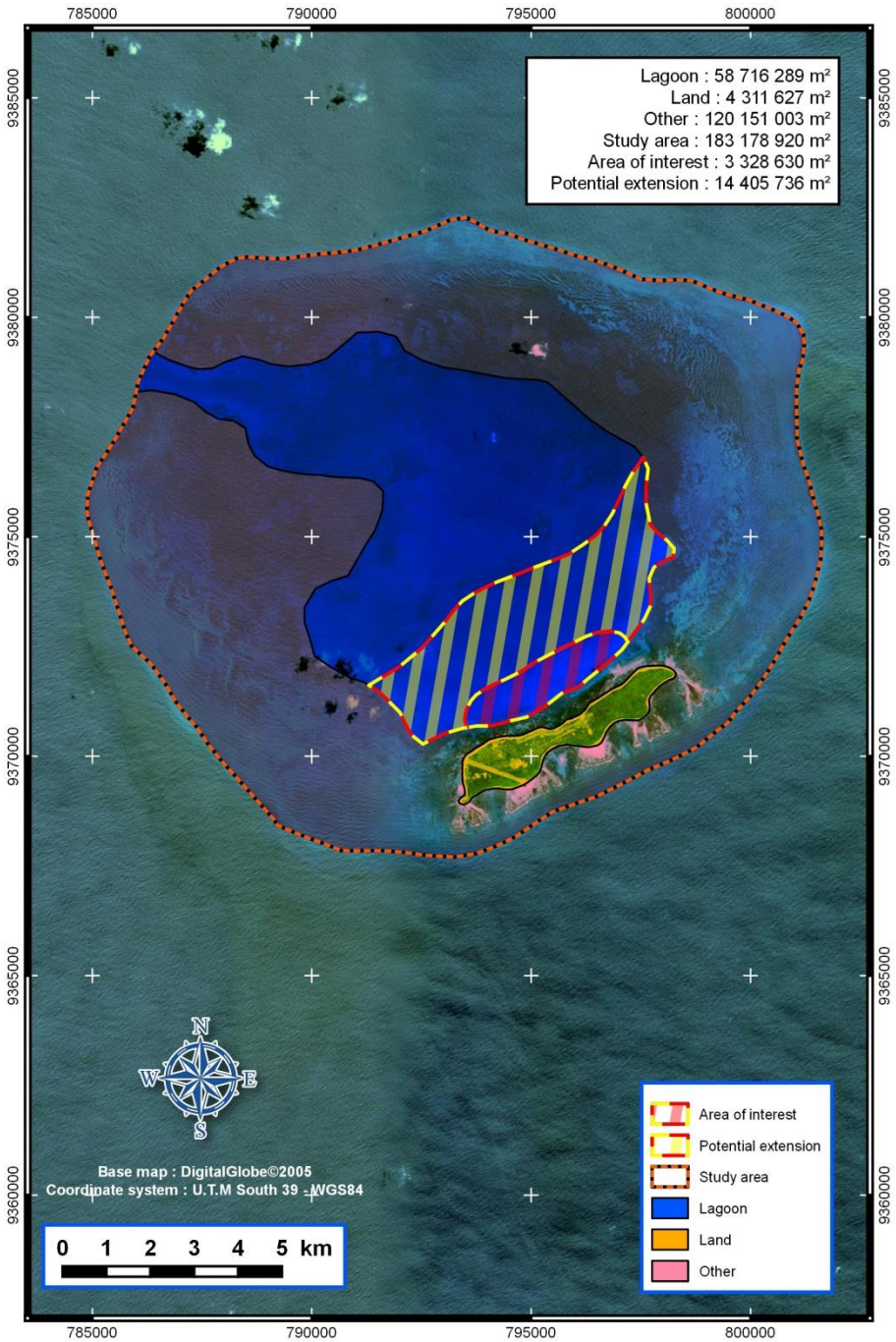


Figure 21 Area of interest for sea cucumber ranching in the Desroches Lagoon

There are additional suitable areas for cucumber ranching on Alphonse, St. Francois and Bijoutier. However, these areas are only suitable for White teat fish and Pentard for which the hatchery technology is not yet available. The lagoons of all three islands are, however, earmarked as Marine Protected Areas. This may result in user conflict and for this reason they have been excluded.

The bio-economic model for sea cucumber ranching predicts that the activity would be commercially viable.

Prawn farming on Coetivy

It has been calculated that just over 200 tonnes of tiger prawns can be produced annually in the 84 x 0.05ha Northern ponds on Coetivy. Two crops of prawns could be grown to 24-26 ind/kg in 5 ½ months each. The Northern ponds would need to be renovated. A comprehensive business plan to assess the economic viability would have to be developed and compared to the integrated farming of prawns and sea cucumbers.

Finfish farming in Desroches lagoon

A model for finfish farming in the Desroches lagoon was developed with the following assumptions.

- Percent of Desroches lagoon used = 17% (10 sq km of 58 sq km)
- 50% of suitable area to always lie fallow
- Maximum production limit = 9 kg/m^3
- Average farm size = 1000 tpa
- Sales price $7.5/kg
- Cage diameter and depth = 20m and 10m
- Exclusion zone = 500m in all directions
- Distance between cages = 20m
- Average harvest weigh to fish = 2 kg
- Average growth period = 2 yrs (excl. hatchery/nursery phase)

Based on this scenario the Desroches lagoon would be able to support a total production of around 2 486 MT pa with a gross value based only on sales of $ 18.6 million. The most suitable species for farming would be the Brown Marbled Grouper (*Epinephelus fuscoguttatus*).

Pearl oyster farming

For pearl oysters we developed a model with the following restrictions.

- Max allowable farm block size – 50 ha
- Max length of long lines = 110m
- Min distance between long lines = 25m
- Min spacing of chaplets = 1m
- Min number of oyster per chaplet = 10 shells
- Min spacing between kangaroo nets = 1.5m
- Max number shells per net = 12

The Desroches lagoon is over 50 square kilometres, of which 332 ha have been identified as being highly suited for sea cucumber ranching. A total of 4 x 50 ha pearl oyster farm blocks with a minimum exclusion zone of 500 m between blocks could be placed into this area. This would provide the infrastructure to hold 400 000 seeded pearl oysters. Four farm blocks in the Desroches lagoon would increase pearl production in Seychelles 20-fold.

Collecting wild spat for an operation of this size is not possible and a hatchery would have to be built on Desroches, most likely using Australian technology.

The integrated farming of pearl oysters and sea cucumbers makes good sense as the faeces and pseudofaeces of the pearl oyster would be utilized by the sea cucumbers. It has also been shown that sea cucumbers tend to remain in areas of high food availability, and this would increase the percent of returns at harvest.

6. Potential size of the aquaculture industry in the Seychelles and contribution to GDP[41]

To assess the environmental and social impacts associated with aquaculture development in Seychelles, potential industry scenarios (herein referred to as "carrying capacity scenarios") reflecting the possible direction and expansion of the industry were modelled using constraints identified in line with the FAO Ecosystems Approach to Aquaculture.

Following a comprehensive screening exercise which considered biological, environmental, technological and market factors, four zones have been identified for differing aquaculture operations around the inner islands of Seychelles (see Table 30 below).

Table 30. Seychelles aquaculture zones and farming opportunities.

AQUACULTURE ZONE	DEFINITION	REQUIRED SUPPORTING INFRASTRUCTURE	SPECIES TO BE PRODUCED	PRODUCTION SYSTEMS
Land-based zone	Aquaculture taking place on land	□ Research & Development Facility □ Broodstock Acclimation & Quarantine Facility □ Sea urchin hatchery/nursery □ Pearl oyster hatchery/nursery □ Finfish hatcheries □ Processing & waste management factories □ Transport/logistic capacity □ Feed storage	Ornamental finfish (Pomacentridae spp., Pomacanthidae spp., Acanthuridae spp., Chaetodontidae spp.) Sea urchins (*Tripneustes gratilla*) Finfish fingerlings (Grouper spp., Snapper spp.) Pearl oyster spat	Pump-ashore flow-through systems Recirculating aquaculture systems (RAS)
Inshore zone	Aquaculture within 2km of the land (shoreline) of the inner islands		Pearl oysters (*Pinctada margaritifera*) Finfish (Grouper spp, Snapper spp.)	Oyster longlines Cages; serviced daily from land
ADZs	Cage culture within promulgated Aquaculture Development Zones (ADZs)/MMP		Finfish (Grouper spp., Snapper spp.)	Cages; serviced daily from land
Offshore zone	Cage culture beyond 5 km of the land of the inner islands		Finfish (Grouper spp., Snapper spp.) only	Cages; serviced by offshore-based automated feeding barges

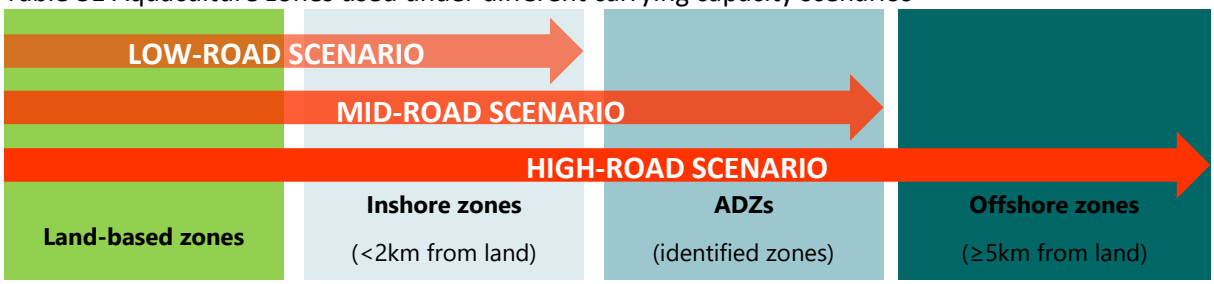
[41] MMP Document 2016. Seychelles Industry Capacity Projections. 31p.

Carrying capacity scenarios were created based on a high-level assessment of potential factors that would determine the potential expansion of the industry. These included: conflict with existing resource users, market demand and availability, infrastructure, and industrialized technology in other aquaculture industries.
Three possible carrying-capacity scenarios with different aquaculture development opportunities have been identified:

1. The low-road scenario;
2. The mid-road scenario; and
3. The high-road scenario.

Each scenario utilizes different aquaculture zones, as depicted in Table 31 (Aquaculture zones used under different carrying capacity scenarios) below:

Table 31 Aquaculture zones used under different carrying capacity scenarios



Each carrying capacity scenario is briefly explored in the sections which follow.

6.1. Low-road Scenario

The low-road scenario considers the carrying capacity for aquaculture where social constraints dictate that finfish cage culture is not possible. One example of such limits would be determined during the Environmental and Social Impact Assessment (ESIA) and may be resistance from society or other industries. In this instance, aquaculture would be limited to:

1. The land-based zone; and
2. The inshore zone (pearl oysters only).

Land-based zone aquaculture activities would focus on production of ornamental finfish and sea urchins, as well as hatchery production of pearl oyster spat. Industry-focused research into these species and other potential species suitable for land-based and inshore zone aquaculture would be conducted at the Research and Development (R&D) Facility. Any incoming broodstock would be quarantined and acclimated at the Broodstock Acclimation and Quarantine Facility (BAQF). As cage culture is not a possibility, there would be no land-based production of finfish fingerlings for grow-out. Inshore zone aquaculture would be restricted to longline culture of pearl oysters.

Under the low road scenario production of various organisms and labour requirements are shown in Figure 22 below.

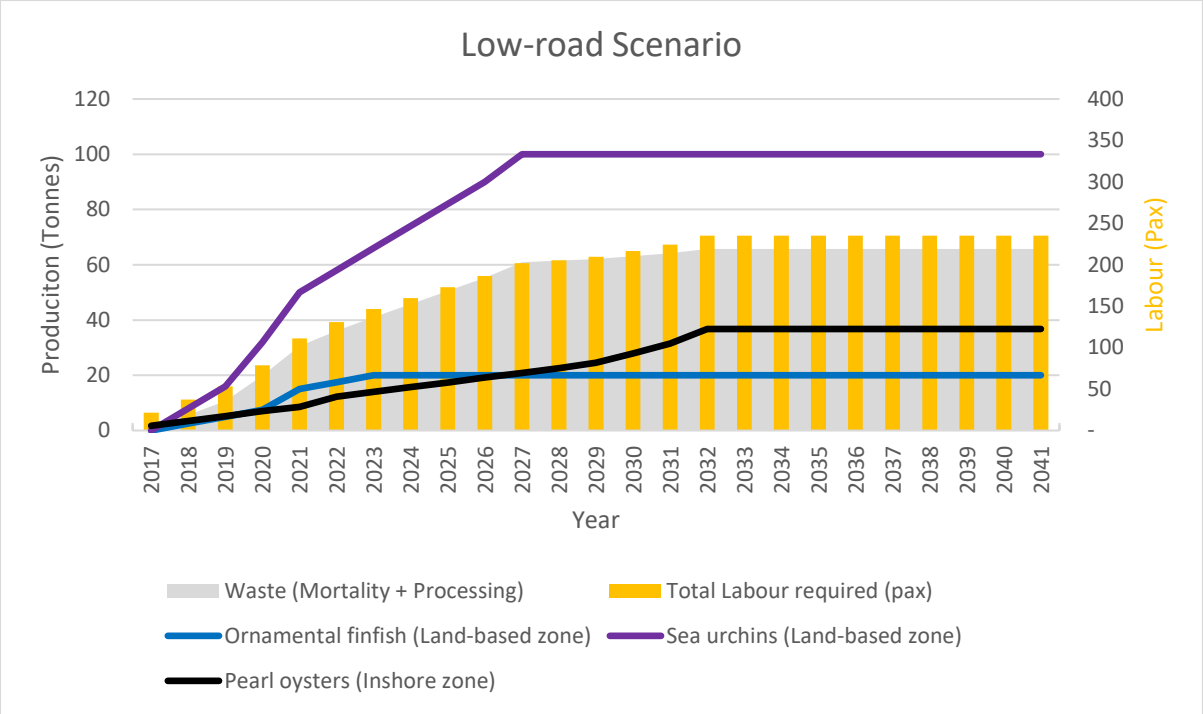


Figure 22: Low-road scenario indicating production volumes, waste/byproduct and labour requirements

6.2. Mid-road Scenario

The mid-road scenario assumes that aquaculture development occurs in:

1. The land-based zone;
2. The inshore zone; and
3. Aquaculture Development Zones (ADZs).

Cage culture is permissible in both the inshore zone and ADZs. As a result, land-based zone aquaculture includes the production of ornamental finfish, sea urchins, pearl oyster spat and juveniles, finfish fingerlings, and activities at the R&D Facility and BAQF. Pearl oysters and cage culture of finfish occurs in the inshore zone. In the ADZs, cage culture of finfish will take place. The offshore zone is not utilised under this scenario.

Under the mid- road scenario production of various organisms and labour requirements are shown in Figure 23 below.

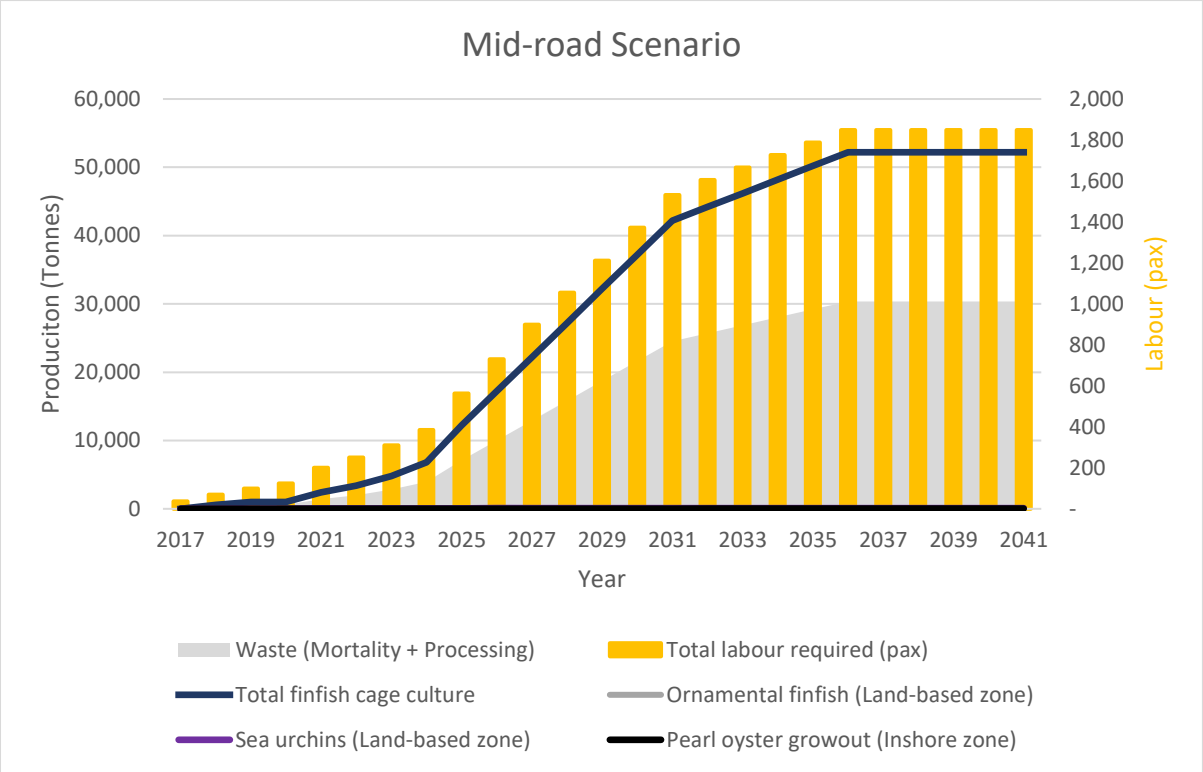


Figure 23: Mid-road scenario indicating production volumes, waste/byproduct and labour requirements

6.3. High-road Scenario

The high-road scenario assumes that aquaculture develops under the same conditions as the mid-road scenario with the exception that cage culture of finfish is also developed in the offshore zone. Therefore, under the high-road, aquaculture development would occur in:

1. The land-based zone;
2. The inshore zone;
3. ADZs; and
4. The offshore zone.

The high road scenario will require substantial land areas for hatchery and processing facility development. Therefore, the Seychelles Government will have to make the required land available for sector development if they wish to reach the high-road scenario production opportunities.

Under the high-road scenario production of various organisms and labour requirements are shown in Figure 24 below.

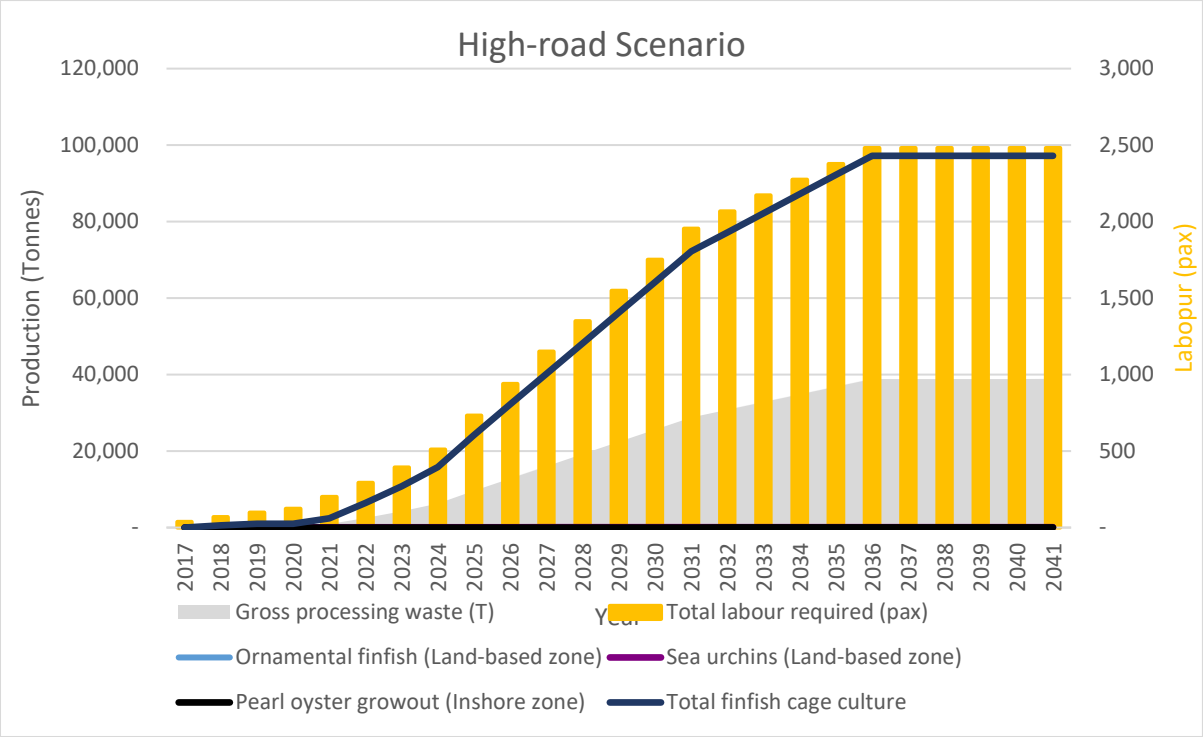


Figure 24: High-road scenario indicating production volumes, waste/byproduct and labour requirements

6.4. Revenue Generation Forecast for the three scenarios

All three scenarios are vastly different and will result in different impacts in the Seychelles. By modelling the three scenarios, the various labour and land requirements and waste and revenue generation is depicted. All three scenarios were modelled under the assumptions that all licences were taken up by investors and that the government developed the necessary supportive services and infrastructure for the creation of a mariculture industry. Government will need to ensure necessary infrastructure such as power, housing, licencing, law enforcement, regulatory frameworks, freight, logistic services and waste processing is upgraded and developed to match the development of the corresponding scenario.

Inshore finfish cage culture has been included as an opportunity for local Seychellois investors but it must be stressed how a project-specific ESIA must be completed for each proposed project. There are many sensitivities that exist within the inshore zone and the potential conflicts with tourism are substantially higher than the ADZ and offshore zone.

The current GDP growth is estimated to be 3,6% per annum which is wholly dependent on tourism and commercial fisheries. Even though commercial fisheries face challenges such as depleting fish stocks, it is modelled as a consistent contributor to the Seychelles economy in Figure 9 below. The three scenarios' impact on the GDP is depicted in Figure 25 assuming that the GDP maintains a 3,6% growth rate.

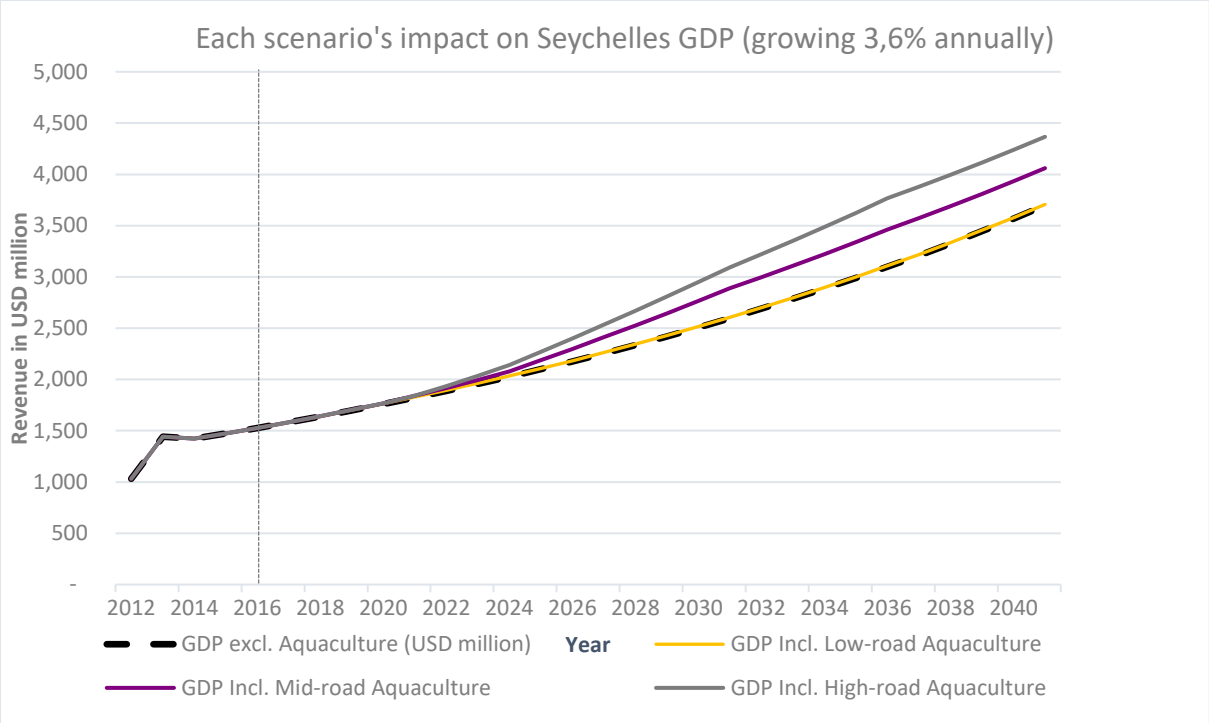


Figure 25:Revenue generation for the three scenarios

Full calculation detail of the figures are available as a supporting excel spreadsheet. The industry models are live and evolve as more information becomes available. The model summaries depicted here are valid up to date 25 July 2016.

7. The Transition to Implementation

7.1. Implementation structure - Governance

On 22 February 2017, SFA and its consultants presented the MMP results to the President, the Vice President and the Cabinet of Ministers of the Seychelles. At that meeting, it was decided that a High Level Aquaculture Committee should be established consisting of:

- The Vice President (Chairman)
- The Minister for Education and Human Resource Development
- The Minister for Environment, Energy and Climate Change
- The Minister for Employment, Entrepreneurship Development and Business Innovation
- The Minister for Agriculture and Fisheries
- The Minister for Finance, Trade and Economic Planning
- The Minister for Habitat, Infrastructure and Land Transport

The Committee was to hold their first meeting as soon as possible. On 04 April 2017, the High-Level Aquaculture Committee held its first meeting. It was decided that the following sub-Committees should be formed. The key objectives of the sub-Committees are listed below:

- <u>Aquaculture sub-Committee for Markets, Products and Sector Promotion</u>
  - ✓ The ongoing development of the international market for Seychelles aquaculture products and the Seychelles brand;
  - ✓ Supporting access to, and the development of, the domestic fish market;
  - ✓ Progressing initiatives to further product development in the sector through processing, beneficiation and product development;
  - ✓ The development of a comprehensive sector value-chain;
  - ✓ To optimize logistical solutions with particular focus on the cost-effective export of aquaculture products into the international market place;
  - ✓ To promote innovation in the Fisheries and Aquaculture sectors.

- <u>Aquaculture sub-Committee for Legislative, Policy and Regulatory matters</u>
  - ✓ The finalization of a legislative framework to ensure robust governance of the sector;
  - ✓ The structuring of institutional roles and responsibilities;
  - ✓ To finalize the Sector Plan for Aquaculture;
  - ✓ To progress necessary amendments to the Fisheries Act;
  - ✓ To complete, review and gazette the Regulatory Framework for Aquaculture;
  - ✓ To establish the Aquaculture Authority and Regulatory Committee;
  - ✓ To progress the drafting of sector specific compulsory specifications and standards for aquaculture;
  - ✓ To assist in the formation of Associations of Aquaculture Operators.

- <u>Aquaculture sub-Committee for Land</u>
  - ✓ To identify and reserve 30ha of land for future private sector aquaculture requirements;
  - ✓ To consider priority geographic locations and the establishment of land-based ADZ's;
  - ✓ To resolve land availability for future aquaculture sector requirements including accommodation, schools and medical facilities.

- <u>Aquaculture sub-Committee for Human Capital Development</u>
  - ✓ To establish the future HR requirements of the aquaculture sector;

- ✓ To conduct gap-analysis between HR requirements and existing resources;
- ✓ To conclude a National Human Capital Development Plan (Aquaculture);
- ✓ To establish training and mentoring programmes;
- ✓ To oversee the continued function of the domestic education and awareness programme;
- ✓ To establish an entrepreneurship programme.

- Aquaculture sub-Committee for Funding and Investment
  - ✓ To define the funding strategy for short, medium and long-term aquaculture sector development requirements;
  - ✓ To secure funding for the development and operations of the R&D Facility and Pilot Project;
  - ✓ To explore opportunities to promote local ownership in the aquaculture value-chain and to define and establish the Local Ownership Support Programme and funding thereof;
  - ✓ To finalize the parameters of an Incentive Scheme for aquaculture sector specific investors;
  - ✓ To co-ordinate and support foreign and local investment programmes;
  - ✓ To progress strategic international co-operation initiatives.

7.2. Implementation structure – International Partnerships

International partnerships are being actively pursued in the following areas:

6.2.1 Markets and products development: Partners are being pursued in Norway, Japan, France, Hong Kong and Singapore.

6.2.2 Science and Technology: Partners are being pursued in Norway, Germany, France, Japan, Thailand and Australia.

6.2.3 Investment and Funding: Partners are being pursued in Norway, France, Japan, Hong Kong and Singapore.

7.3. Primary infrastructure and operations

To attract investment the Government of Seychelles, as a further contribution towards the MMP, has committed resources for the development of primary development facilities. The purpose of these key facilities is to provide the basic foundations upon which to demonstrate the viability of the sector and to promote the development of the industry in the Seychelles. The proposed facilities comprise a Broodstock Quarantine and Acclimation Facility, a Research and Development Facility, and a pilot scale finfish cage culture operation. The latter provides a grow-out facility for the fingerlings of different species produced at the R&D Facility. The R&D Centre and the Pilot cage culture project will be developed in tandem. Land for the developments has been approved and allocated and construction of the Broodstock Facility commenced in July 2017. The Broodstock Facility will be located on land near the Providence Fishing Harbour (figure 26) and the R&D Facility will be located adjacent to the University of Seychelles campus in Anse Royale. The pilot scale cage culture operation will be located to the south east of the Providence harbour (figure 27). The map below shows the location of these two facilities.

Figure 26 Location of Broodstock Acclimation and Quarantine Facility – Providence Fishing Harbour

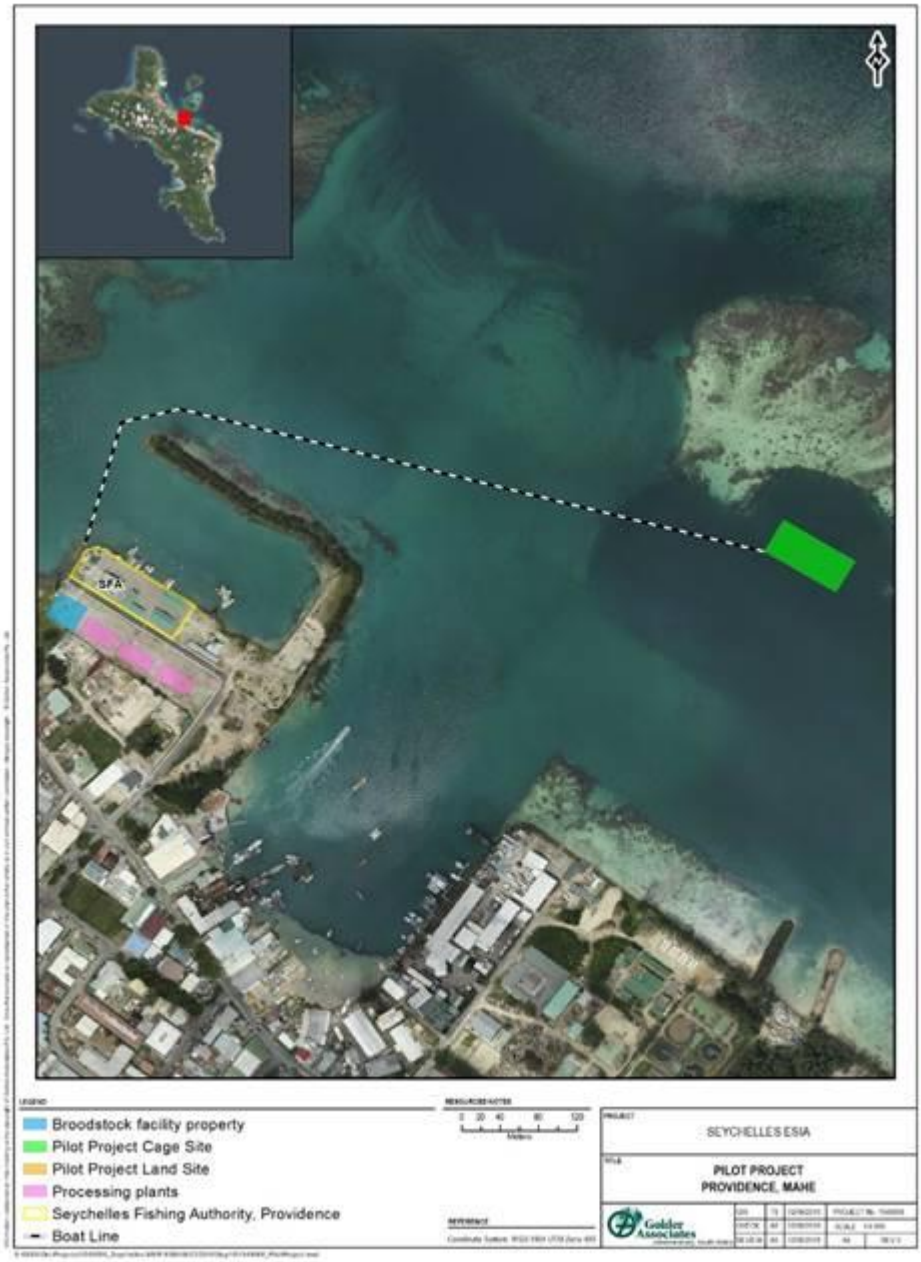


Figure 27 Location of pilot scale fish cage operation near Providence Fishing Harbour.

7.3.1. Strategic objectives of the primary development facilities

The plan for the Seychelles Aquaculture Research and Development (R&D) Facility at Anse Royale, Mahe is to become a multi-species tropical finfish hatchery, regional aquaculture science hub and visitors centre. The facility aims to provide technical support, research, and training to develop and advance the Seychelles aquaculture industry while promoting public awareness and enthusiasm for this new sector. The R&D Facility recognises the importance of providing support to both small- and large-scale aquaculture operators while ensuring the sustainable development of the sector. This will be achieved through contemporary and relevant research programmes aimed at investigating the aquaculture potential of different species, improving fish health and production, empowering small-scale operators with research into diverse aquaculture strategies, training and capacity building of Seychellois in aquaculture, and ongoing environmental monitoring. In addition to technical support, the R&D Facility has an educational mandate with aquarium displays of a variety of broodstock species, information boards, and views of a working marine hatchery.

The Broodstock facility will be used to quarantine and acclimate broodstock fish brought in from the wild and therefore will be developed first, followed by parallel development of the R&D Facility and the Pilot Project at Providence. The Pilot Project cages provide a grow-out facility for the fingerlings of different species produced at the R&D Facility.

The key short, medium and long-term objectives of the R&D Facility can be summarised as follows:

Short-term objectives of the R&D Facility are centred on support to the emergent aquaculture industry and in particular:

- Production of brown-marbled grouper (*Epinephelus fuscoguttatus*), mangrove snapper (*Lutjanus argentimaculatus*) and snubnose pompano (*Trachinotus blochii*) fingerlings
- Technical support to the Pilot project
- Research into additional candidate aquaculture species
- Environmental research

Medium and long-term objectives of the R&D Facility will, to a large extent, be determined by the established aquaculture industry. It is planned that the R&D Facility will focus on conducting industry-driven research into improving production and performing diagnostic services for disease and other issues. The aquaculture potential of "attractive" species (relative to biological performance and economic potential) will also be investigated at the behest of the industry and its needs. The industry will pay a levy to fund these activities. Furthermore, the R&D Facility will undertake environmental research programmes to ensure the credibility and positive public perception of the aquaculture industry is maintained in terms of its environmental responsibilities and impacts.

<u>Objective 1 – Establishment of a hatchery and live-feed facility for Pilot Project production of 200 t.p.a of brown-marbled grouper and 3 t.p.a of mangrove snapper</u>
The first objective of the R&D Facility is the production of brown-marbled grouper and mangrove snapper fingerlings as required to support the Pilot Project grow-out operations. The quantity of fingerlings to be produced in the R&D Facility, based on the Pilot Project production capacity of 203t.p.a is ±125000 10g fingerlings in 4 cohort batches per annum (500 000 fingerlings/annum). The R&D Facility aims to adapt established husbandry techniques practised by other countries to local conditions, such that fingerling imports of fingerlings are fully substituted with local production.

<u>Objective 2 – Diversification of cultured species</u>
Once the techniques for producing brown-marbled grouper and mangrove snapper fingerlings at the R&D Facility hatchery have been successfully developed, the focus will shift to include hatchery production of a range of different species with aquaculture potential. These will include:

Snubnose pompano (*T. blochii*)
Emperor snapper (*Lutjanus sebae*)
Sea urchins (*Tripneustes gratilla*)
Sea cucumbers (*Holothuria scabra, H. fuscogilva*, *H. lessoni*)
Grouper species: Potato (*E. tukula*), giant (*E. lanceolatus*), greasy (*E. tauvina*), malabar (*E. malabaricus*), camouflage (*E. polyphekadion*), and lyretail (*Variola lauti*) groupers
Yellowtail (*Seriola rivoliana*)
Cobia (*Rachycentron canadum*)
Yellowfin tuna (*Thunnus albacares*)
Ornamental fishes: (Several spp. of gobies, damsel, anemone and cardinal fish)
Mudcrab (*Scylla serrata*)
Oysters (*Saccostrea cucculata* and *Pinctada margaritifera*)
Giant tiger prawn (*Penaeus monodon*)

And in collaboration with NGOs to develop technologies to enhance restorative coral aquaculture.

Production of finfish species will be commensurate with the R&D Facility's production capacity and that of the Pilot Project grow-out cages.

Objective 3 – Supply of surplus fingerlings and eggs to the industry

Surplus production of eggs and fingerlings that are not required for the 200 t.p.a. grow-out facility will be made available to the local small-scale aquaculture industry. The R&D Facility will, however, not become a constant supplier of fingerlings of a certain species for the industry ad infinitum. This is outside of the scope of the R&D Facility and should be fulfilled by large-scale commercial operators in dedicated hatchery and nursery facilities located elsewhere (e.g. Romainville Island).

Objective 4 – Environmental Research

The R&D Facility will conduct research into the environmental impacts of aquaculture in the Seychelles. This research will ensure that the credibility of the industry is maintained and that the current status of the Seychelles as an environmentally responsible nation is not altered or damaged.

Objective 5 – Live Feed Research and Larval Nutrition Programme

Research into alternative live feed strategies for improving larval survival will be conducted at the R&D Facility. The focus will initially be on production of copepods for grouper and other finfish larvae.

Objective 6 – Fish Health Programme

A fish health laboratory will be incorporated into the R&D Facility. The lab will serve the basic veterinary needs of the industry.

Objective 7 – Potential for environmental remediation

The potential for the R&D Facility to participate in coral reef rehabilitation will be investigated in collaboration with several NGOs who are involved with coral rehabilitation. It will be a positive environmental contribution especially given the Seychelles' emphasis on a "Blue Economy". This, however, will be on a scale commensurate with the size of the R&D Facility.

Objective 7 – Potential for interface with fisheries research

The potential to interface the research activities at the R&D facility with fisheries research will be investigated. Increasing the environmental responsibility mandate of the R&D Facility will be achieved through the development of additional research programmes focussed on the collection of fisheries-independent data and other contemporary research areas such as climate change.

8. Conclusion

The Seychelles MMP was developed in 32 months in several phases over a period of 5 ¾ years. From the outset, the process was developed and managed in a fully participatory and transparent manner, with regular feedback to all stakeholders via the Mariculture Steering Committee. The process has culminated in a suite of products that were rigorously benchmarked against international standards to ensure the development of an environmentally responsible aquaculture industry. The outputs were subjected to rigorous international peer review, and where necessary corrective action was taken.

Based on thorough investigations of the market and the current state of aquaculture technologies several indigenous finfish and invertebrate species were identified as having excellent attributes and potential for small, medium and large-scale aquaculture in the Seychelles.

Similarly, based on the nearshore and offshore physical and chemical oceanography, the characteristics of the seabed and mindful of other users of the inshore and offshore maritime zones a set of suitable sea areas around Mahe, Praslin, Silhouette and La Digue where identified. These areas will be declared as Aquaculture Development Zones. Based on the ESIA, which was undertaken during the period June to December 2016 and which incorporated an inclusive PPP, environmental approval was granted by the Department of the Environment in early February 2017.

The outer Islands were assessed with respect to their potential for land and sea-based aquaculture. The outer islands differ from the inner islands in that there is more land for commercial activities. After a detailed benthic community structure survey of several outer islands suitable marine sites around Coetivy, Poivre and Desroches were identified for integrated fish cage aquaculture, pearl oyster farming and sea cucumber ranching, while land based opportunities exist for the intensive farming of sea urchins on Coetivy and Desroches.

The draft Aquaculture Policy was developed in partnership with all interested stakeholders and serves as a foundation for the future development of the industry. It was recommended that the policy be reviewed every five years to stay abreast of developments and to cater for the orderly development and governance of the industry.

A Regulatory Framework has been developed to manage the development of the industry and future aquaculture operations. The Framework consists of the draft Aquaculture and Sea Ranching Regulations and a suite of adjunct draft Seychelles Aquaculture Standards. These products were developed in harmony with all current legislation and in line with modern thinking on mitigating the environmental impacts of aquaculture, including the EAA, the FAO Code of Conduct and in accordance with BAP of the Global Aquaculture Alliance.

A user friendly “one stop shop” has been developed and tested for the license application and evaluation process. On condition that the application form has been completed correctly and all application requirements have been met, as outlined in the Guidelines for Applications, the process should take a maximum of 43 working days.

While every effort has been made to deal with the complexities of establishing a new economic activity in the Seychelles and to prepare the development platforms for orderly and environmentally responsible development it is inevitable that certain elements may have been overlooked. These will no doubt be identified as the industry develops. We are however confident that the developmental and governance platforms are sufficiently robust to cope with any eventualities that may occur.

Appendix 1. Outputs of the Mariculture Mariculture Master Plan Process

1. Stock taking and diagnostic survey report
2. Seychelles National Aquaculture Policy
3. "Marine Aquaculture and Sea-Ranching Regulations" (The Regulations are currently under legal review, where after they will be corrected and Gazetted under the new Fisheries Act 2014)
4. Aquaculture license and lease application form
5. Guidelines for development of aquaculture business plan
6. Application process
7. Fees and levies
8. Monitoring and reporting requirements
9. EIA Requirements
10. Marine Aquaculture License (template)
11. Standard license conditions
12. Aquaculture License Special Conditions: Bi-valve hatchery and grow-out
13. Aquaculture License Special conditions: crab fattening
14. Aquaculture License Special conditions: Finfish hatchery
15. Aquaculture License Special conditions: Finfish grow-out in cages
16. Aquaculture License Special conditions: Ornamental fish and coral
17. Aquaculture License Special conditions: Pearl farming
18. Aquaculture License Special conditions: Sea cucumbers
19. Proposal to Cabinet to declare certain offshore areas as designated Aquaculture Development Zones (on completion of ESIA)
20. Guidelines for lease applications for an offshore, nearshore or intertidal aquaculture site in Seychelles.
21. Draft lease agreement for land-based aquaculture site
22. SEYCHELLES AQUACULTURE STANDARD: Fish health management
23. SEYCHELLES AQUACULTURE STANDARD: Biosecurity protocols for hatcheries
24. SEYCHELLES AQUACULTURE STANDARD: Effluent water quality parameters
25. SEYCHELLES AQUACULTURE STANDARD: Responsible finfish cage culture
26. SEYCHELLES AQUACULTURE STANDARD: Responsible pearl oyster farming.
27. SEYCHELLES AQUACULTURE STANDARD: Responsible Sea Cucumber Farming, Ranching and Stock Enhancement on the outer Islands.
28. SEYCHELLES AQUACULTURE STANDARD: Health and fitness protocol for sandfish, *Holothuria scabra*.
29. SEYCHELLES AQUACULTURE STANDARDS: Responsible prawn farming in ponds.
30. SEYCHELLES AQUACULTURE STANDARDS: Marine protected areas.
31. SEYCHELLES AQUACULTURE STANDARDS: Effluent and solid waste management.
32. (The Seychelles Aquaculture Standards are legal adjuncts to the Regulations)
33. Aquaculture awareness / education plan (to be implemented with GEF small projects funding in May 2015)
34. Socio-economic survey report
35. REPORT: Fiscal and other investment incentives for aquaculture development.
36. REPORT: Bio-physical oceanography of sea based Aquaculture Development Zones.
37. REPORT: Seychelles Aquaculture Hatcheries: Potential sites, Size, production capacity and the way forward.
38. REPORT: Synoptic overview of the aquaculture and sea-ranching potential of some outer islands
39. REPORT: Opportunities for ecologically sustainable sea cucumber ranching and farming in the outer Islands of the Seychelles.

40. REPORT: Benthic community assessments to identify aquaculture zones around Coetivy, Alphonse, St Francois Bijoutier, Poivre and Desroches)
41. Policy Guidelines for Aquaculture and Sea-Ranching on the Outer Islands of the Seychelles.
42. Proposal for training to develop the aquaculture industry in Seychelles
43. Opportunities for small-scale aquaculture around inner islands of the Seychelles.
44. Curriculum for Diploma in Aquaculture at the Seychelles maritime Academy
45. Report on suitable sites for land-based hatchery clusters
46. REPORT: Marine Assessment Report on the location of water intake pipe for the Aquaculture Development Zone (ADZ) on Ile de Romainville.
47. Brown-marbled Grouper fact sheet
48. Economic feasibility model: Brown-marbled Grouper (industrial scale)
49. Economic feasibility model: Brown-marbled Grouper (small scale)
50. Sea cucumber (H. scabra) fact sheet
51. Economic feasibility model: Sea cucumber
52. Economic feasibility model: Prawns
53. Economic feasibility model: Snubnose pompano
54. Snubnose pompano fact sheet
55. Economic feasibility model: Mangrove snapper
56. Mangrove snapper fact sheet
57. Established training courses (fish health management, hatchery management, spawning and larval rearing techniques, commercial diving)

Appendix 2. Organisations represented at the Aquaculture Policy Workshops

on 9 & 10 August 2014 or interviewed for their inputs into the policy.

Agency for National Human Resource Development
Financial Services Seychelles
Fishermen and Boat Owners Association
GEF/SGP Coordination Unit (Seychelles)
Island Conservation Society
Island Development Company
Marine Conservation Society of Seychelles
Maritime Training Centre
Ministry of Environment and Energy (Dept. Of Environment)
Ministry of Finance, Trade and Investment
Ministry of Fisheries and Agriculture
Ministry of Fisheries and Agriculture
Ministry of Foreign Affairs
Ministry of Health
Ministry of Labour and Human Resources Development
Ministry of Land Use and Housing
National Bureau of Statistics
National Institute for Science, Technology and Innovation
Ocean Products Seychelles Ltd.
Oceana Fisheries Ltd.
Petro Seychelles
Sea Harvest Ltd.
Seychelles Bureau of Standards (Fish Inspection Unit and Quality Control Unit)
Seychelles Chamber of Commerce and Industry
Seychelles Civil Aviation Authority
Seychelles Coast Guards

Seychelles Energy Commission
Seychelles Investment Board
Seychelles Maritime Safety Administration
Seychelles National Parks Authority
Seychelles Port Authority
Seychelles Sports Fishing Club
Seychelles Tourism Board
Seychelles Veterinary Services
University of Seychelles