FINAL ESIA AND ESMP

November 2016

SEYCHELLES FISHING AUTHORITY

Final ESIA and ESMP for the Proposed Implementation of the Seychelles Mariculture Masterplan (MMP)

Submitted to:
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Ministry of Environment, Energy and Climate Change
Environment Department
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SEYCHELLES FISHING AUTHORITY

Golder Associates

Executive Summary

Introduction

Golder Associates Africa (Pty) Ltd have been appointed by the Seychelles Fishing Authority (SFA) as independent environmental assessment practitioners (EAPs) for the purpose of conducting an Environmental and Social Impact Assessment (ESIA) for the proposed implementation of the Seychelles Mariculture Master Plan (MMP). This ESIA report has been compiled in line with the requirements of local Seychelles legislation and aligned with international best practice.

Description of the MMP and the proposed new Aquaculture Sector

As a core component of the Seychelles Blue Economy Strategy the development of an aquaculture sector has been prioritised by the Seychelles government. The process of developing the MMP commenced in 2007 with a Rapid Assessment Study to gauge public and private opinion as to the desirability of developing marine aquaculture in Seychelles. Based on the positive response a comprehensive Scoping Study followed in 2009, to assess the opportunities and constraints to developing an offshore mariculture industry and to assess the need for a Master Plan to drive the rational development of the sector. The Scoping Study revealed strong institutional support for the development of an environmentally responsible mariculture sector. This led to initiation of a process to develop a Mariculture Master Plan (MMP) in 2011. During the period from 2011 to 2015, a number of technical studies, reports and data was generated, as part of the MMP. The MMP was finalised at the end of 2015.

During the current ESIA the MMP studies have been reviewed, and supplemented where required, in order to assess the impacts and propose suitable mitigation measures to guide the Government of Seychelles and SFA.

The Mariculture Master Plan (MMP) describes the strategic development of an aquaculture industry which has been contemplated for development across four different zones, namely:

- Land-Based Zone;
- Inshore Zone;
- Aquaculture Development Zones (ADZs); and
- Offshore Zone.

Three different development scenarios have also been determined as part of the MMP and these represent a low, medium and high scale development scenario of the aquaculture sector, each with different potential aquaculture zones being development as part of the new sector.

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.

This ESIA focuses on finfish cage culture within the ADZs, which makes up a component of the mid-road scenario.

SFA have identified areas that could potentially be suitable for the initiation of marine aquaculture development. During the site selection and evaluation process of potential ADZs, a number of sites were identified and initially 16 were shortlisted. After a thorough analysis of the prevailing bio-physical and social

receptors at each site, the number was reduced to 12 ADZs which were taken forward for assessment as part of this ESIA.

Legal Context

This ESIA has taken into account the various legal, institutional and regulatory frameworks of the republic of Seychelles. Reference is specifically made to the following:

The Seychelles Constitution (1993)

The Seychelles Constitution (1993), Article 38 declares that:
"the State recognizes the right of every person to live in and enjoy a clean, healthy and ecologically balanced environment and with a view to ensuring the effective realization of this right the State undertakes ….to ensure a sustainable socio-economic development of Seychelles by a judicious use and management of the resources of the Seychelles"

The Environment Protection Act, No. 9 of 1994 (as consolidated to 2012)

The implementation of the Seychelles MMP requires administrative clearance from the Ministry of Environment, Energy and Climate Change, in conformity with the provisions of the Environment Protection Act (EPA), Act No. 9 of 1994. This ESIA for the Seychelles MMP is being carried out in accordance with the EPA and the EIA Regulations contained therein.

The Fisheries Act, No. 20 of 2014

Makes provision for the protection of several areas in Seychelles waters. Some of these areas are specifically designated to exclude certain types of fishing. Other areas are specifically designated to prevent damage to the benthos (i.e. Exclusion of certain gear types in specified areas). The Acts also provide for fishing agreements and licence conditions as well as management of fisheries stocks.

Other important regulations, standards and policies that find application to aquaculture and which have been aligned to the Fisheries Act, 2014 are the following:

- The Marine Aquaculture and Sea Ranching Regulations 2015*;
- Seychelles Aquaculture Standards (various)*; and
- Marine Aquaculture License: Special Conditions (various)*.

**These regulations have not been gazetted as of yet and will be amended based on the findings from this ESIA before submission to cabinet in 2017.*

Baseline Environmental Conditions

A detailed review of the biophysical and socio-cultural prevailing conditions of the Seychelles inner islands are presented in this report. It indicates that the general oceanographic conditions are well suited to aquaculture development. Sensitive receptors and users such as fisherman, tourism establishments and operators and the general public have also all been identified and consulted. The baseline and receiving environment is therefore well understood and forms the basis upon which the detailed impact assessment has been undertaken by our specialist team in determining impacts, both negative and positive and recommending appropriate mitigation or management measures that will need to be applied to reduce negative impacts to acceptable levels and enhance positive impacts linked to the proposed new aquaculture sector.

Site Selection and Suitability of Aquaculture in Seychelles

Cage aquaculture of finfish species is well-established in many countries with benchmarks for classifying site characteristics. Due to the location of the Seychelles ADZ sites, with their moderate wind and swell regimes, the most applicable category for Seychelles is the Food and Agriculture Organization (FAO) "Off the coast category". Based on wind speeds during the NW monsoon the sea state would be classified as 2-3 (smooth-

slight) and as 4-5 (moderate to rough) during the SE monsoon period. In respect of aquaculture operation feasibility, this is a favourable classification as the cages are accessible on at least once daily basis, with 'landing' (accessing cages) usually possible. These average and maximum oceanographic conditions and the FAO site classification guide indicate that finfish cage aquaculture is highly feasible around the inner islands of the Seychelles.

It was concluded that the present evaluation of the environmental sustainability of the Seychelles Mariculture Master Plan indicates that:

- Sufficient environmental information is available to assess the sustainability and operational viability of cage aquaculture at the 12 proposed ADZs;
- Similar environmental conditions prevail at the 12 sites due to their position on Mahé plateau, with its relatively homogenous oceanography, depth profile, sediment characteristics and well mixed water.
- The ADZ sites are highly suitable for cage aquaculture of tropical species due to:
  - The relatively low average swell and wind regime, allowing for almost daily operational access and the effective mooring of cages in open water.
  - The shallow Mahé Plateau (20-60m depth) which is ideal for mooring cages.
  - The well mixed water and consistent SE and NW monsoon current regimes which will effectively disperse organic nutrients from the sites. This is confirmed by the Norwegian MOM model (Modelling – Ongrowing – Monitoring) of cage culture carrying capacity (detailed further in the Technical Aquaculture Report (APPENDIX E) and elsewhere in this ESIA document).
  - The inner islands lie outside the tropical cyclone belt.
  - The narrow range of water temperature which coincides with the optimal temperatures for growth of tropical species.
  - The low exposure to pollution, freshwater and sediment run off from land.
- The site surveys undertaken for the 12 ADZs revealed no ecological reasons not to proceed with the Mariculture Master Plan. However, **site specific survey and monitoring should begin before cages are positioned on site to establish and verify the baseline conditions** which will be required to be monitored on an ongoing basis in order to proactively manage impacts from fish farming operations.

Public Participation Process

During the scoping phase an extensive public participation process was held whereby stakeholders and members of the public were informed of the MMP. A number of advertisements (television, newspaper, posters and radio) were used to announce the MMP and relevant information such as the Background Information Document (BID) for comment, as well as details regarding any of the four public meetings which the public could attend.

Meetings were held on Mahé (two meetings) on 25 June, and a meeting on Praslin and La Digue each on 2 July. A number of specific focus group meetings were held with target audiences such as fisherman groups, tourism and members of the scientific and NGO groupings. A number of informal key informant meetings were held with a representative cross-section of the local Seychellois population (women, men, youth and children) in order to get a broad understanding of issues and concerns from a diverse group of stakeholders.

The issues and concerns were discussed in public meetings and captured in the comment and response report, which was appended to the scoping report and terms of reference that was submitted to the Ministry of Environment, Energy and Climate Change (MEECC) on 15 September 2016. These issues and concerns were considered during by the various specialist teams in assessing impacts and devising appropriate mitigation measures.

The draft ESIA and ESMP report, was made available for public comment as part of the public participation process for the impact assessment phase. The public comment period ran for a period of **17 days** from **15 – 31 October 2016**. This enabled stakeholders to comment on the findings of the ESIA as well as verify that previous concerns and suggestions raised as part of the scoping phase stakeholder engagement exercise were taken into account during the impact assessment phase.

A public meeting was held on Saturday, 22 October 2016 on Mahé at the STC Conference Room, Bois de Rose Avenue from 2pm – 5pm.

In addition to the public meeting, focus group meetings (FGM's) were held on Praslin on 23 October 2016 at Baie St Anne Bahai Centre from 1pm – 4pm. Residents of Praslin and La Digue were welcome to attend this FGM, with SFA facilitating attendance of La Digue residents with the option to have their ferry tickets reimbursed. Focus Group Meetings were also held on Mahe on 24 & 25 October 2016 with key stakeholder groups including fisherman, tourism and NGO's.

The attendance registers of stakeholders who attended these meetings, as well as scoping (comment) forms and the comment and response report (CRR) can be found under APPENDIX J.

The various socio-economic impacts which have been identified include both positive and negative impacts. The new aquaculture sector will lead to the creation of various job opportunities, mostly highly skilled positions. Many of these required skills are currently not available in Seychelles, but will require implementation of a National skills development programme linked to schools and the university of Seychelles, as well as foreign educational and other institutions. The new sector may lead to some migrant labour requirements, although this will be limited in numbers, as local employment and upskilling will be promoted as far as possible, including attracting Seychellois currently residing elsewhere in the world to return home.

In order to ensure that farmed fish sold on the local market do not compete with wild fish caught by artisanal or semi-commercial fisherman, SFA will engage these groups further in order to ensure that their livelihoods are not negatively affected.

SFA and the artisanal fishermen will work together to ensure a constant supply of fish is available domestically that will improve the current offering available to tourists and Seychellois, especially during the SE monsoon season. A primary aim of the new aquaculture sector is diversification of the Seychelles economy and generating export earnings. This will potentially have a large positive impact on the National economy as well as direct and indirect impacts on downstream and upstream industries and sectors supporting the new aquaculture sector (logistics, warehousing, maintenance, financial, manufacturing services etc). It was found during the social impact assessment, that there will be very few negative impacts, and all of these can be suitably managed. SFA will need regular engagement with various government departments to ensure that the development and maintenance of key social infrastructure (roads, water, power, schools, hospitals, airport infrastructure etc) are able to keep pace with the development and expansion of the new aquaculture sector in order that it is able to reach its potential and contribute meaningfully to the economy of the Seychelles.

ESIA Specialist Studies

The following stand-alone specialist studies were developed and used to inform the compilation of this ESIA and ESMP report, which are appended to this document:

- Physical Oceanographic Modelling Study (APPENDIX B);
- Waste Study (APPENDIX C);
- Coral Reef and Benthic Study (APPENDIX D);
- Technical Aquaculture Aspects Study (APPENDIX E);
- Visual Impact Assessment (APPENDIX F);

- Noise Impact Assessment (APPENDIX G);
- Social Impact Assessment (APPENDIX H); and
- Cultural Heritage Impact Assessment (APPENDIX I).

The public participation documents are contained in APPENDIX J.

The terms of reference (ToR) and letter of transmission from the MEECC can be found under APPENDIX K.

Impacts and Mitigation

The impacts that have been assessed by each specialist are presented below under the relevant sections. The mitigation measures proposed are contained in the ESMP under section 8.0.

A summary of the impact defined and assessed for the construction phase are summarised below in Table ES 1, both before mitigation and after mitigation measures have been applied.

Table ES 1: Summary of Construction Phase Impacts

Potential Environmental Impact: Construction Phase	Before mitigation	After mitigation
Coral Reef and Benthos		
Importation of potentially genetically distinct fingerlings - Disease Impact	**High**	**Moderate**
Importation of potentially genetically distinct fingerlings -Genetic Impact	**High**	**Moderate**
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - Disease impact	**Moderate**	**Moderate**
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - genetic impact	**Moderate**	**Low**
Cage installation - ADZs	**Low**	**Low**
Pilot-project cage construction	**Low**	**Low**
Broodstock facility water intake pipeline construction	**Low**	**Low**
R & D facility water intake pipeline construction	**High**	**Low**
Technical Aquaculture Aspects		
Importation of potentially genetically distinct fingerlings - Disease Impact	**High**	**Moderate**
Importation of potentially genetically distinct fingerlings -Genetic Impact	**High**	**Moderate**
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - Disease impact	**Moderate**	**Moderate**
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - genetic impact	**Moderate**	**Low**
Cage installation	**Low**	**Low**
Visual		
Reduction in visual resource value due to increased shipping/boat traffic (construction, operational and decommissioning activities)	**Moderate**	**Low**
Light pollution at night	**Moderate**	**Moderate**
Noise		
Construction of the BQAF and R&D Facility: Site preparation, earthworks, clearing, transport, construction of the facilities and installation of the pumps, tanks etc.	**Moderate**	**Moderate**
Construction of the pilot project cage site and ADZ cages	**Low**	**Low**
Social		
Job Opportunities and Local Employment	**Low**	**Moderate**
Population Influx	**Low**	**Low**
Project-Induced In-Migration	**Low**	**Low**
Skills Requirement	**Low**	**Moderate**

Change in Employment Equity of Vulnerable Groups	Low	Low
Impacts on Daily Living and Movement Patterns	Moderate	Low
Introduction of New Social Classes and Related Socio-Cultural Impacts	Low	Low
Impacts on Quality of Life	Low	Low
Cultural Heritage		
Offshore impacts from excavations, pipe placement, and anchoring for Project construction and pilot project cage place placement.	Moderate	Moderate
Impacts from anchoring for Project construction/ placement of cages in ADZs.	Moderate	Low
Subsurface impacts in the close to the shore at the proposed R&D Facility	Moderate	Low

A summary of the impact defined and assessed for the operational phase are summarised below in Table ES 2, both before mitigation and after mitigation measures have been applied.

Table ES 2: Summary of Operational Phase Impacts

Potential Environmental Impact: Operational Phase	Before mitigation	After mitigation
Physical Oceanography		
Implementation of aquaculture cages in ADZs will generate solid organic waste releases in the marine environment that could adversely impact diverse physical and biological components of the marine ecosystem, both locally and remotely through advection.	Moderate	Low
Waste		
Undercage benthic effects from faeces and fish waste can impact seabed under cage and down-current	Moderate	Low
Waterborne nutrient loss can contribute to local and subb-regional nutrient concentrations in coastal waters with potential effects on phytoplankton growth	Low	Low
Sediment contaminant accumulation can occur through antifouling and from trace elements in feed	Moderate	Low
Sediment debris accumulation can occur from the loss of cage fouling during on site cleaning	Low	Low
Rubbish loss can occur through poor on-site management (introduction of recalcitrant rubbish, especially plastics)	Low	Low
Coral Reef and Benthos		
Genetic Contamination	Moderate	Low
Disease and parasite transmission to wild fish stocks	Moderate	Moderate
Degraded water quality as a result of organic wastes	Moderate	Low
Particulate organic build-up beneath cages	Moderate	Moderate
Chemical pollution arising from finfish cages	Moderate	Low
Entanglement of cetaceans	Low	Low
Entanglement of turtles and sharks	Low	Low
Interactions with piscivorous marine animals	Moderate	Low
Impacts on fishing, yachting and recreational vessels	Low	Low
Interactions with piscivores-pilot cages	Low	Low
Entanglement of turtles and sharks - pilot cages	Low	Low
R&D facility water intake pipeline maintenance	Low	Low
Technical Aquaculture Aspects		
Potential Genetic Contamination	Moderate	Low
Potential Disease and parasite transmission to wild fish stocks	Moderate	Moderate
Degraded water quality as a result of organic wastes	Low	Low
Chemical pollution arising from finfish cages	Moderate	Low

Entanglement of cetaceans	Low	Low
Interactions with piscivorous marine animals	Low	Low
Impacts on fishing, yachting, recreational and other vessels	Low	Low
Visual		
Reduction in visual resource value due to increased shipping/boat traffic (construction, operational and decommissioning activities)	Moderate	Low
Reduction in visual resource value due to presence of floating cages and associated infrastructure (feed barges and work/well boats)	Moderate	Low
Light pollution at night	Moderate	Moderate
Noise		
Stock transport vehicles /vessels servicing the pilot project and ADZ	Moderate	Low
Life support systems at the BQAF and Research & Development Facilities	Moderate	Low
Social		
Job Opportunities and Local Employment	Moderate	Moderate
Continued Population Influx	Low	Low
Project-Induced In-Migration	Low	Low
Skills Requirement	Moderate	Moderate
Change in Employment Equity of Vulnerable Groups	Low	Moderate
Impacts on Daily Living and Movement Patterns	Moderate	Low
Introduction of New Social Classes and Related Socio-Cultural Impacts	Low	Low
Impacts on Quality of Life	Moderate	Low
Conflict Potential	Moderate	Moderate
Impacts ion Social Infrastructure: ability to accommodate influx of skilled labour	Moderate	Moderate
Impacts on Social Infrastructure: pressure on existing social amenities	Low	Low
Cultural Heritage		
Impacts from anchoring of cages and service vessels.	Moderate	Low

A summary of the impact defined and assessed for the decommissioning phase are summarised below in Table ES 3, both before mitigation and after mitigation measures have been applied.

Table ES 3: Summary of Decommissioning Phase Impacts

Potential Environmental Impact: Decommissioning Phase	Before mitigation	After mitigation
Coral Reef and Benthos		
Farm operations cease	Moderate	Low
General decommissioning - ADZ cages	Moderate	Low
General decommissioning - pilot-project cages	Moderate	Low
Brood stock pipeline	Moderate	Low
R & D facility water intake pipeline	Moderate	Low
Technical Aquaculture Aspects		
Farm operations cease	Moderate	Low
Visual		
Reduction in visual resource value due to increased shipping/boat traffic (construction, operational and decommissioning activities)	Moderate	Low
Light pollution at night	Moderate	Moderate
Noise		
Decommissioning of the BQAF and R&D Facility: Demolition, clearing and transport of waste offsite	Moderate	Moderate

Disassembly of the pilot project and ADZ cages and transport back to the island	**Moderate**	**Low**
Social		
Loss of employment	**Moderate**	**Moderate**
Loss of economic benefits	**Moderate**	**Moderate**
Cultural Heritage		
Impacts from anchoring of cages and service vessels.	**Moderate**	**Low**

Environmental and Social Management Plan (ESMP)

The impacts that have been assessed will require an Environmental and Social Management Plan (ESMP) which contain mitigation measures designed to minimise or eliminate the significant adverse impacts and to enhance the positive impacts that may be caused as a result of the implementation of the proposed aquaculture sector.

The overall objective of the ESMP is to provide SFA, fish farm operators and its contractors with practical guidance for environmentally and socially responsible construction, operation and eventual closure and decommissioning of individual fish farms, and aquaculture related facilities.

The full ESMP can be found in section 8.0 of this report.

The final step was to integrate the comments from the public and key stakeholders and finalise the ESIA & ESMP for submission to MEECC for decision making purposes.

List of Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
ADZ	Aquaculture Development Zone
BOD	Biological Oxygen Demand
BQAF	Broodstock Quarantine and Acclimation Facility
CC	Carrying Capacity
cm	Centimetres (unit of measure)
COD	Chemical Oxygen Demand
EAP	Environmental Assessment Practitioner
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FADs	Fish Aggregating Devices
FAO	Food and Agriculture Organization
GPS	Global Positioning System
HAB	Harmful Algal Blooms
HAT	Highest Astronomical Tide
HDPE	High Density Poly-Ethylene
Hs	Significant wave height
km	Kilometres (unit of measure)
km^2	Square Kilometre (unit of area)
LAT	Lowest astronomical tide
m	Metres (unit of measure)
MHWN	Mean high water neap
MHWS	Mean high water spring
MHWS	Mean high water
MLWN	Mean Low water neap
MLWN	Mean Low water
MLWS	Mean Low water spring
MMP	Mariculture Master Plan
MOM	Modelling-Ongrowing fish farm -Monitoring
MPA	Marine Protected Area
NH_3	Ammonia
POC	Particulate organic carbon
PON	Particulate organic nitrogen
PSU	Practical Salinity Unit
R&D	Research and Development
ROV	Remote Operated Vehicle
SFA	Seychelles Fishing Authority
UNISEY	University of Seychelles

Terminology

Mariculture (or Aquaculture)	Is the farming of aquatic organisms, under controlled conditions, and entails the breeding, rearing, and harvesting of plants and animals in all types of water environments including ponds, rivers, lakes, and the ocean. When done in the ocean or in saltwater, aquaculture is often referred to as Mariculture.
Piscivores	A carnivorous animal which eats primarily fish.
Cetaceans	An order of aquatic, chiefly marine mammals, including whales and dolphins.
Broodstock	A group of mature individuals used in aquaculture for breeding purposes.
Finfish	A bony fish, such as a salmon, or a cartilaginous fish, such as a shark, especially in contrast to a shellfish or other aquatic animal.
Organic	Matter that has come from a once-living organism, is capable of decay or the product of decay, or is composed of organic compounds (Organic compound, a compound that contains carbon).
Indigenous	Originating or occurring naturally in a particular place; native.
Disinfectant	A chemical liquid that destroys bacteria.
Antifoulant	Materials and coatings to remove or prevent biofouling by any number of organisms on wetted surfaces.
Therapeutants	Medicine.
Fingerlings	Juvenile fish.

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APPENDICES

1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd have been appointed by the Seychelles Fishing Authority (SFA) as independent Environmental Assessment Practitioners (EAPs) for the purpose of conducting an Environmental and Social Impact Assessment (ESIA) for the proposed implementation of the Seychelles Mariculture Master Plan (MMP). This ESIA report has been compiled in line with the requirements of local Seychelles legislation and aligned with international best practice.

This ESIA report is structured into the following chapters:

- 1.0 – Introduction;
- 2.0 - Description of the Mariculture Master Plan;
- 3.0 - Alternatives Considered;
- 4.0 - Legal Framework;
- 5.0- The Receiving Environment;
- 6.0 - Public Participation Process;
- 7.0 – Environment and Social Impact Assessment;
- 8.0 - Environment and Social Management Plan;
- 9.0 – Conclusion;
- 10.0 – References.
- Appendices:
  - A – Document Limitations;
  - B – Physical Oceanographic Modelling Study;
  - C – Waste Study;
  - D – Coral Reef and Benthic Study;
  - E – Technical Aquaculture Study;
  - F – Visual Impact Assessment;
  - G – Noise Impact Assessment;
  - H – Social Impact Assessment;
  - I – Cultural Heritage Impact Assessment;
  - J – Public Participation Documents; and
  - K – Terms of Reference (ToR) from MEECC.

2.0 DESCRIPTION OF THE MARICULTURE MASTERPLAN

2.1 Background and Context

As a core component of the Blue Economy Strategy (broadly defined as a strategy aimed at the development of a sustainable ocean-based economy) the development of an aquaculture sector has been prioritised by the Seychelles government. The process commenced in 2007 with a Rapid Assessment Study to gauge public and private opinion as to the desirability of developing marine aquaculture in Seychelles. Based on the positive response a comprehensive Mariculture Scoping Study followed in 2009 to assess the

opportunities and constraints to developing an offshore mariculture industry and to assess the need for a Master Plan to drive the rational development of the sector. The Mariculture Scoping Study revealed strong institutional support for the development of an environmentally responsible mariculture sector. This lead to the development of a Mariculture Master Plan (MMP), which started in 2011 and was to be concluded at the end of 2015.

During the period from 2011 to 2015, a number of technical studies, reports and data were generated, as part of the MMP development process. During the ESIA these studies were reviewed, and supplemented where required, impacts associated with implementation of the proposed master plan. Where necessary the ESIA advises SFA and the Ministry of Environment, Energy and Climate Change (MECC) and/or the Ministry of Agriculture and Fisheries, on additional mitigation measures which are recommended to reduce the environmental and social risk, or enhance benefits, should the mariculture master plan be implemented in the Seychelles, and the development of a Marine aquaculture industry commence.

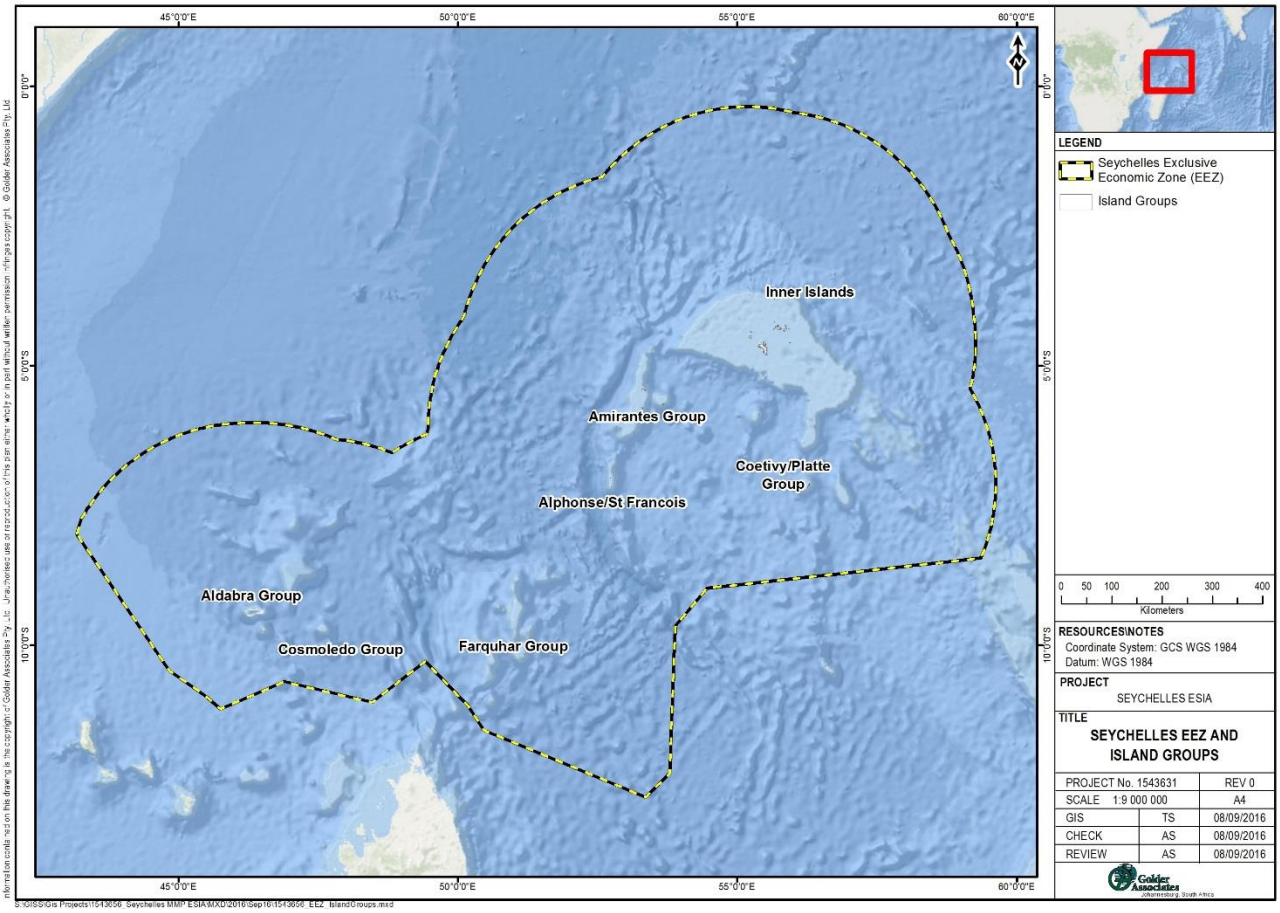

Figure 1: Location of the inner islands and ESIA study area within the Seychelles Exclusive Economic Zone (EEZ)

2.2 What is Aquaculture?

Aquaculture is the process of farming aquatic organisms such as fish, molluscs, crustaceans and aquatic plants (Fitzgerald, 2014; OGA, 2013). Mariculture is merely a branch of aquaculture that involves the farming of marine organisms in the open ocean, an enclosed section of the ocean or under controlled conditions (e.g. tanks and ponds), which are filled with seawater.

Aquaculture involves the cultivation of species under controlled conditions. Under these conditions there is some degree of intervention in the rearing process so that production may be enhanced. Such

enhancements include the breeding and stocking of organisms, the feeding, protection and manipulation of environmental conditions (such as temperature).

Using the Grouper (*Epinephelus sp*) as an example and the figure below (Figure 2), the production cycle and its main components for the production of grouper under controlled conditions, can be unpacked.

Typically, broodstock will be housed under controlled conditions where constant temperatures will enable natural spawning (release of eggs) to take place. In situations where brooders do not spawn naturally, hormones can be used to induce spawning. Post spawning, the eggs will be collected and placed in an incubation tank on land where eggs will be aerated until they hatch (FAO, 2010).

After hatching the larvae are reared with a diet typically made up of rotifers (*Brachionus plicatilis*) and Artemia (*A. nauplii*), which are often referred to as live feed. Larvae grow into juvenile fish and are thereafter transferred to nursery systems until they reach a certain size, and are ultimately transferred to floating cages for grow-out to full maturity (FAO, 2010).

Once fish reach the desired size/weight, they will be harvested and sold. The size that fish are grown to, is dependent on the desired market and generally fish grown for fillets need to be much larger than 1kg.

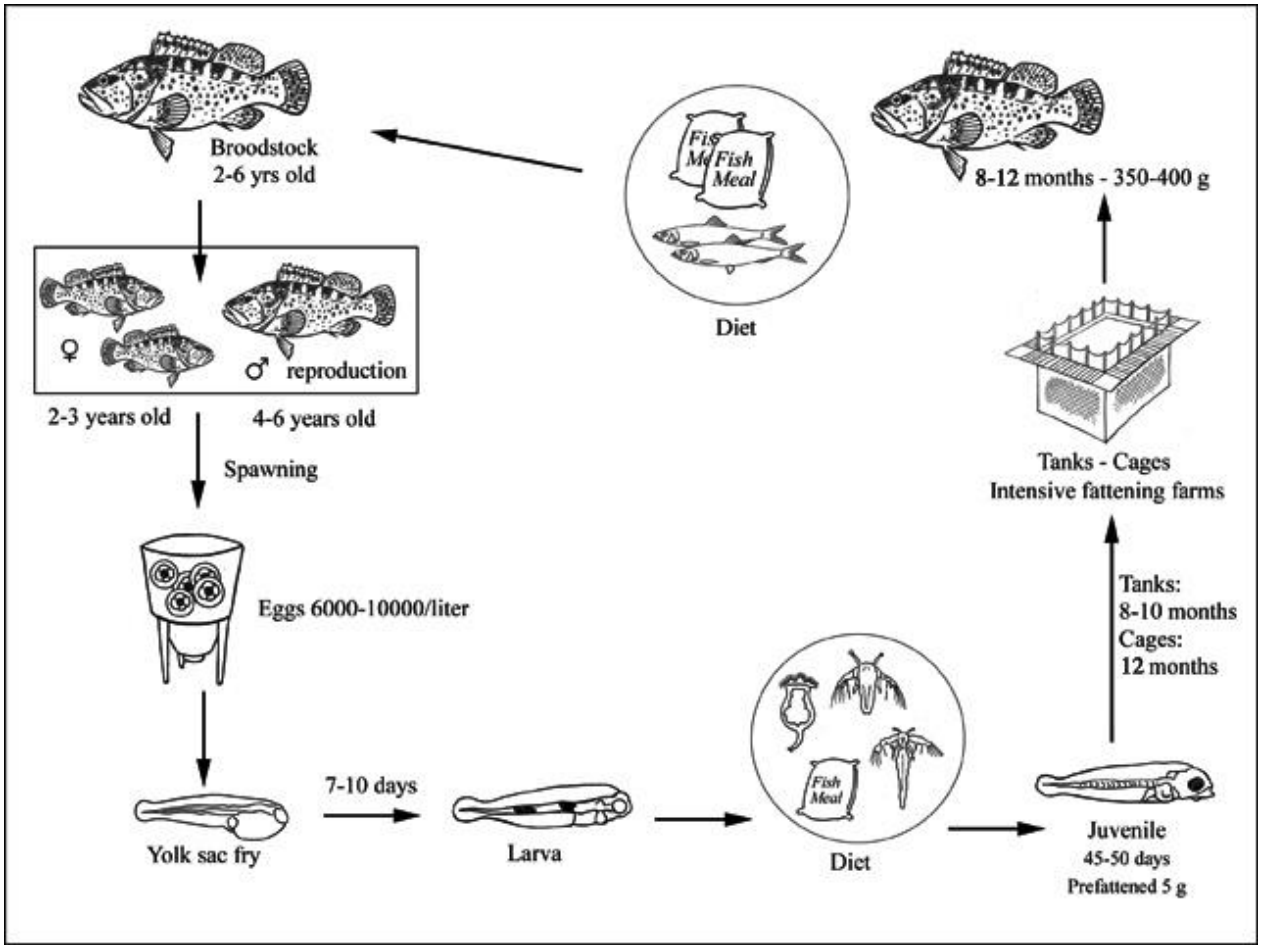

Figure 2: Production cycle of Grouper (Epinephelus sp.) (FAO, 2010)

2.3 The Proposed Aquaculture Sector

The Seychelles Mariculture Master Plan (MMP), which was initiated in 2011 aims to develop marine aquaculture in Seychelles. The Seychelles MMP proposes the development of cage aquaculture off the populated 'Inner Islands', namely; - Mahé, Praslin, La Dique, Silhouette and North Island. The Inner Islands are situated on the granitic Mahé Plateau (see Figure 1 above), which forms the northern crescent of the

Mascarene ridge. The MMP is intended to guide the development of a sustainable aquaculture sector in the Seychelles. The MMP has therefore included a number of potential zones in which various aquaculture activities may occur (section 2.3.1). Three different development scenarios have also been determined as part of the MMP and these represent a low, medium and high scale development scenario (section 2.3.2) of the aquaculture sector, each with different potential aquaculture zones being developed as part of the new sector. These aquaculture zones and development scenarios as part of the MMP are further described below.

2.3.1 Aquaculture Zones

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

The following section provides a summary of the aquaculture development scenarios and the production envisaged under each scenario and further outlines the expansion of the industry that may be realised under different constraints (e.g. physical, environmental, societal, and licensing).

In order to understand the three aquaculture development scenarios and corresponding modelling, each zonation around the inner islands is first briefly explained.

Following a comprehensive screening exercise by the SFA, which considered biological, environmental, and technological and market factors, the master plan recognises and describes four different zones which are listed and described below, namely:

- Land-Based Zone;
- Inshore Zone;
- Aquaculture Development Zone (ADZs); and
- Offshore Zone.

It should be noted that this ESIA focuses on the ADZ's and critical land based facilities (Research & Development (R&D) Facility and Broodstock Quarantine & Acclimation Facility (BQAF), as well as the pilot project cage site located near to the BQAF. The full MMP is described in more detail below to give the reader a broad understanding of what the aquaculture sector may consist of in future.

Figure 3 illustrates the various zones which comprise the proposed new aquaculture sector and which of these are assessed in this ESIA.

The land based aquaculture production (sea urchins, pearl oyster spat, ornamental finfish and finfish fingerlings), inshore aquaculture (oysters and finfish) and offshore aquaculture (finfish) components have not been assessed as these sites have not been identified and any developer coming into the aquaculture sector will be required to undertake an ESIA for developments in these areas where required.

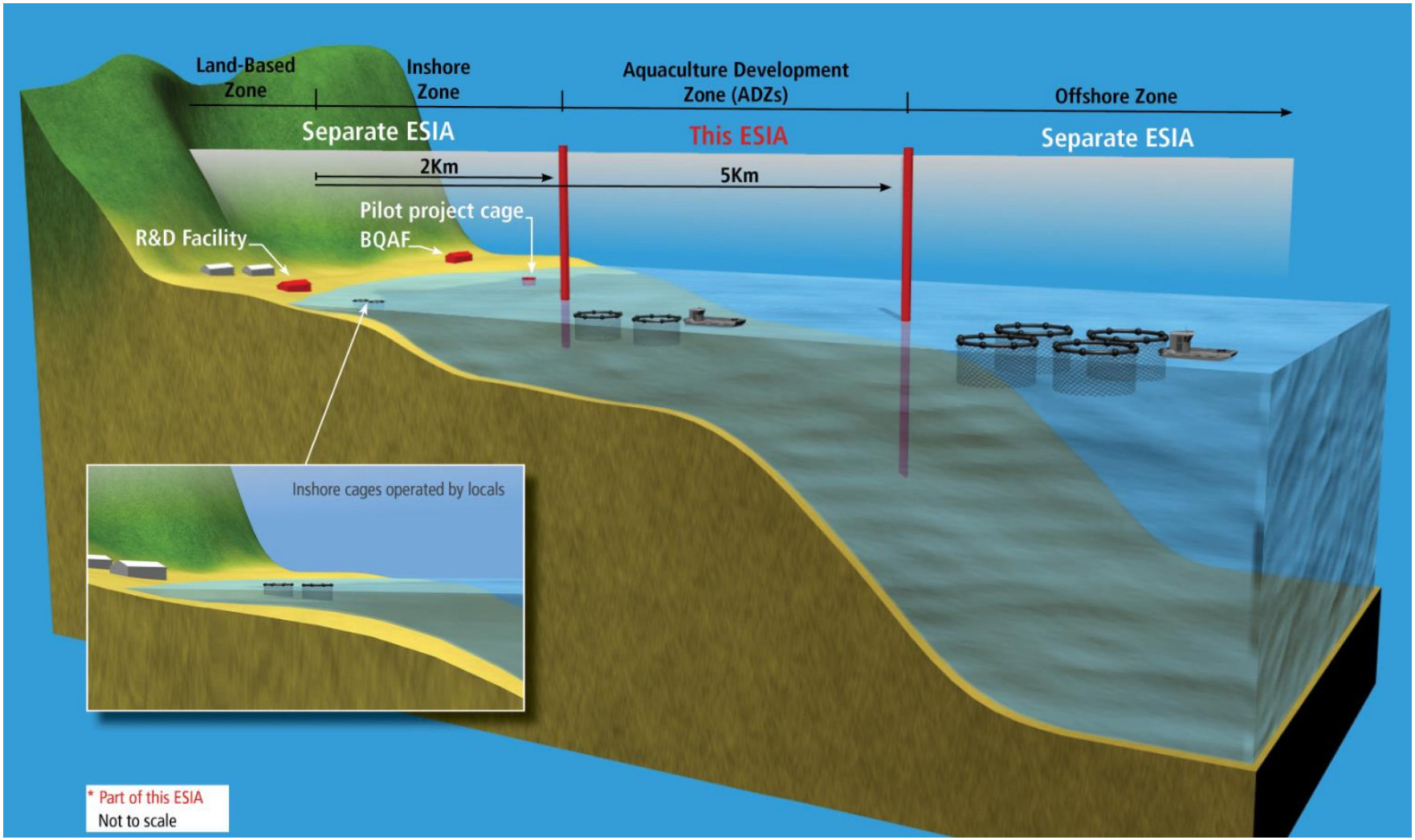

Figure 3: The various zones of the proposed new aquaculture sector. Note the components in red which are covered as part of this ESIA

2.3.1.1 Land-Based Zone Aquaculture

As part of land-based aquaculture, a Research & Development Facility and Broodstock Quarantine & Acclimation Facility (BQAF) will be built on Mahé. Both facilities will be multipurpose buildings and will be important support facilities for sustainable growth and development of the aquaculture sector. A pilot project cage site will be established just offshore from Providence harbour and will be linked to the BQAF facility situated there.

Seychelles Inner Islands offer a limited opportunity for the culture of various species in contained land-based systems. These production systems would typically involve pumping ocean water onshore for use in tanks in Recirculating Aquaculture Systems (RAS) and/or flow-through systems where land allows. These systems typically offer excellent biosecurity and husbandry controls, however they are often energy inefficient and currently expensive systems to operate and as such are limited to the culture of very high value species.

In addition, there is the possibility of other land based aquaculture facilities being established in future as part of the aquaculture sector, however these aspects are not considered as part of this ESIA study. The products that could be successfully cultivated in the Inner Islands using land-based production systems are: sea urchins, pearl oyster spat (oyster larvae which permanently attach to a surface), ornamental finfish and finfish fingerlings.

2.3.1.2 Inshore Zone Aquaculture

The inshore zone comprises sea-based areas within 2km of the islands of Mahé, Praslin, La Digue, potentially Silhouette and Romainville, which have been identified as suitable for small-scale aquaculture development.

Inshore finfish aquaculture is viable in the Seychelles Inner Islands on a small scale under specific conditions. The objective of establishing small-scale inshore projects is to accommodate an entry point into the aquaculture sector for local Seychellois investors who may not have access to the quantum of capital required to establish an offshore farm. The inshore projects will comprise primarily grow-out units and as such they will be reliant on commercial operators and government facilities for the supply of suitable stocking material as well as access to quality pelleted feed at competitive pricing. Small-scale operations will have exclusive access to the domestic market and as such direct competition with products from the commercial operations will be avoided. Products that could be successfully cultivated in the inshore zones are pearl oysters and finfish.

It should be noted that this zone has potentially the highest user conflict due to its proximity to the shore and sensitive receptors.

***Note*: This ESIA will not be assessing the inshore zone for environmental and social suitability (ESIA) for aquaculture production. Each potential inshore project will require a specific ESIA to determine impacts.**

2.3.1.3 Aquaculture Development Zones (ADZs)

This zone refers to finfish cage culture within identified Aquaculture Development Zones (ADZs) of the MMP. These cages will be serviced daily from land and occur at a distance greater than 2km from land (the 2km distance from shore criterion was applied only where the shore (in direct line of sight) was inhabited. The site selection criteria are discussed further in section 2.3.5. In-depth analysis and research has been undertaken in order to select each ADZ based on environmental and ecological criteria. Products that could be successfully cultivated in the ADZs using cage culture are high–value finfish.

2.3.1.4 Offshore Zone Aquaculture

Aquaculture established further than 5km from land is termed Offshore Zone Aquaculture. This form of production is characterised by a fully industrial approach to aquaculture within the Seychelles EEZ but beyond 5km from any of the islands. To accommodate the environmental and logistical requirements of this approach, leading technologies (such as feed barges utilised in Norway) are applied at an industrial scale. Products that could be successfully cultivated in the offshore zone using cage culture are high-value finfish.

***Note*: This ESIA will not be assessing the offshore zone (>5km offshore cage aquaculture) for environmental and social suitability (ESIA) for aquaculture production. Each potential offshore project will require a specific ESIA to determine impacts.**

A summary of the zones with further species details are captured in Figure 4 below.

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

Figure 4: Summary of the various zones

2.3.2 Development Scenarios of Aquaculture Sector

Various development scenarios were determined by SFA based on a high-level assessment of potential factors that would influence the potential expansion of the aquaculture sector. These included conflict with existing resource users, market demand and availability, infrastructure, and industrialized technology in other aquaculture industries e.g. the salmon industry in Norway.

Three possible scenarios with different aquaculture development opportunities have been identified:

4) The low-road scenario;

5) The mid-road scenario; and

6) The high-road scenario.

Each scenario will utilize different aquaculture zones, as depicted in Figure 5.

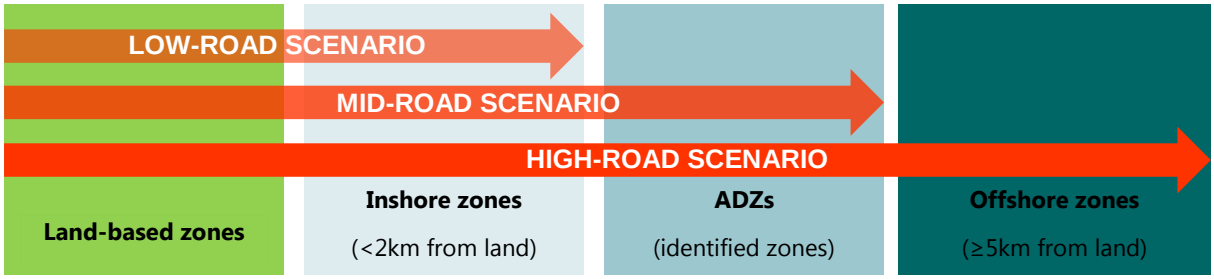

Figure 5: The various scenarios and their utilisation of each of the zones

2.3.2.1 The Low-Road Scenario

The low-road scenario considers the development scenario 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 (including, but not limited to Pomacentrids, Apogonids and Gobiids) 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 Quarantine & Acclimation Facility (BQAF). 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.

2.3.2.2 The 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 oysters, finfish fingerlings, and activities at the R&D Facility and BQAF. 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 particular scenario.

2.3.2.3 The 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.

This 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.

A summary of the various zones, species, systems and permitting approach for each aquaculture development scenario is presented in Figure 6.

2.3.3 Species Selection

In order to ensure that aquaculture contributes to the long-term sustainability of the Seychelles economy, in line with its Blue Economy strategy, emphasis was placed on high-value species with lower production volumes. The species to potentially be cultivated during the pilot project and the ADZs as part of this ESIA are the following:

- Brown-marbled grouper (*Epinephelus fuscoguttatus*);
- Mangrove river snapper (*Lutjanus argentimaculatus*);
- Snubnose pompano (*Trachinotus blochii*);
- Emperor snapper (*Lutjanus sebae*);
- Other target species identified as part of the MMP.

The species that will be cultivated are discussed further in Section 2.3.4.

AQUACULTURE ZONE	SPECIES	PRODUCTION SYSTEMS	ENVIRONMENTAL AUTHORISATION & DETAILS	CARRYING CAPACITY SCENARIOS
Land-based zone	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)	Each project will require its own ESIA; specific sites for hatcheries and production systems to be determined per project. Only the Research & Development facility, Broodstock Acclimation & Quarantine facility and pilot cage will be assessed as part of the Golder Associates ESIA (Feb-Oct 2016).	
Inshore zone	Pearl oysters (*Pinctada margaritifera*) Finfish (Grouper spp., Snapper spp.)	Oyster longlines Cages; serviced daily from land	Each project will require its own ESIA, sponsored by SFA. Cage culture of finfish reserved for local residents.	
ADZs	Finfish (Grouper spp., Snapper spp.)	Cages; serviced daily from land	Finfish cage culture within ADZs being assessed as part of Golder Associates ESIA (Feb-Sept 2016).	
Offshore zone	Finfish (Grouper spp., Snapper spp.) only	Cages; serviced by offshore-based automated feeding barges	Each project will require a site specific ESIA, which the project proponent will fund.	

Figure 6: Summary of the zones, species, systems and permitting approach for each carrying capacity scenario

As summarised above, only the finfish cage culture within ADZs and the Research & Development facility, Broodstock Quarantine & Acclimation Facility and pilot project cage site have been assessed as part of this ESIA. Therefore, the components and activities related to these two zones will be described further for purposes of this ESIA.

2.3.4 Land Based Zone

The land based zone for the phase 1 implementation includes the Broodstock Quarantine & Acclimation Facility (BQAF), the pilot project cage site, both located at Providence, and the Research and Development (R&D) Facility located at the University of Seychelles (UNISEY), Anse Royale as shown in Figure 7.

Broodstock Quarantine and Acclimation Facility

Commercial aquaculture operations need to be supplied with young fish (fingerlings) that will ultimately be placed out in cages to be reared for harvest. To ensure a reliable supply of young fish for aquaculture it is necessary to maintain mature breeding stock (called broodstock) of the desired fish species from which eggs can be harvested, fertilised and reared to fingerlings, ready for placement in grow out cages. The facility where this breeding stock is held is termed a broodstock facility. In addition, when an industry first starts, mature fish of breeding age must be caught in the wild and then held in a quarantine facility to ensure that they are healthy and disease-free. The proposed Mariculture master plan consequently includes a Broodstock Quarantine and Acclimation Facility, which is described further below (see Figure 8).

The Seychelles Broodstock Quarantine & Acclimation Facility (BQAF) will be a multi-species quarantine and acclimation facility that provides quarantine treatments for wild-caught broodstock, and prepares these fish for life and reproduction in captivity at the proposed Anse Royale Research & Development Facility, discussed further below. It should be noted however, that for the initial pilot project cycle, it is likely that fingerlings may need to be imported. Should this take place, these fingerlings would also be held in the quarantine facility for an appropriate period of time on arrival in the Seychelles.

These broodstock will form the basis of production at the hatchery. Broodstock selection, quarantine and acclimation are therefore of utmost importance in ensuring the successful production of juvenile fish at the R&D Facility. The BQAF is designed to ensure that broodstock are well cared for, readily adjust to captive conditions, spawn and produce good numbers of high quality eggs, have fewer disease problems and greater longevity. The broodstock will be sourced from Seychelles waters, mitigating any genetic or other environmental risks associated with the importation of exotic fishes.

In line with the production objectives for the R&D Facility and pilot project, the following species will initially undergo R&D and aquaculture production from Seychelles waters:

1. Brown-marbled grouper (*Epinephelus fuscoguttatus*);
2. Emperor snapper (*Lutjanus sebae*);
3. Mangrove river snapper (*Lutjanus argentimaculatus*);
4. Snubnose pompano (*Trachinotus blochii*);
5. Other grouper species;
6. Other target species identified as part of the MMP.

Broodstock will be collected using the Seychelles Fishing Authority vessel *R/V Amitie* (or any other suitable vessel which is available at the time) which has holding facilities capable of transporting live fish from the inner and outer islands back to these facilities.

Incoming broodstock will be placed in quarantine tanks and will undergo a series of treatments including freshwater baths and prophylaxis (treatment given or action taken to prevent disease). This will ensure that no pathogens and disease are introduced to the facility and readies the broodstock for captive breeding.

During acclimatization, which lasts for a period of up to two years, the broodstock will be adjusted to the environmental conditions of the BQAF and the types of feed that will be given. This is especially important where formulated diets will be used to supplement natural feeds.

After a period of one-two years (depending on the species), acclimated broodstock will be transferred to the R&D Facility at Anse Royale and stocked into the broodstock tanks for spawning and egg production.

Figure 7: Pilot project, BQAF and R&D Facilities located on Mahé

Figure 8: Broodstock Quarantine and Acclimation Facility, Providence

The proposed BQAF will be located in Providence, Mahé (Figure 8), at the Providence Harbour and adjacent to the shoreline thereby providing convenient and cost effective access to sea water supply. Bulk infrastructure including port infrastructure, road access, unused warehousing, and electrical power and fresh water is available at this site. Facilities including ablutions and offices are available on site. This site also has the added benefit of being located adjacent to the SFA Providence Office.

The BQAF has been designed in alignment with international best-practice standards in terms of engineering quality and safety and, as such, the required equipment will primarily be imported.

Aquaculture systems

The BQAF is comprised of a quarantine area and an acclimation area. Six quarantine tanks (7.6m^3) will be installed. These tanks will be located adjacent to the entrance of the BQAF to facilitate the rapid transfer of broodstock from the transport vehicle/vessel to the quarantine tanks. They will also be used to house batches of imported fingerlings, which will undergo strict quarantine measures prior to transfer to the pilot project cages. The quarantine area will be isolated to allow for sanitation once the pilot project fingerlings have been transferred to the cages. Two acclimation tanks (40m^3) for grouper and other large species, and four acclimation tanks (22m^3) for snapper and pompano will be installed. Water supply to the tanks will be on a flow-through basis.

The quarantine section will be isolated from the acclimation facility and will be a recirculating aquaculture system (RAS). Total biomass in the acclimation facility (167m^3) will be around 250 kg while the quarantine facility (44.5 m^3) will hold a maximum of around 60 kg biomass.

Services

The life support infrastructure will include; water treatment units, air blowers, and electrical works.

Seawater will be pumped ashore into a header tank before being gravity-fed through a drum filter into the aquaculture systems. Water supply to the tanks will be via suspended pipes (overhead) and drainage will be via an outlet into a central channel. Wastewater will be drum filtered before being discharged into a canal or existing stormwater drain. Wastewater from the quarantine section will flow through a chlorine contact tank before being discharged.

Air blowers and oxygen bottles will be housed within the services building. Air supply lines to the aquaculture systems will be suspended (overhead). Electrical supply will be obtained from the public service as well as a diesel generator.

Feed

Feed (fish and squid) will be stored within a dedicated feed storage freezer facility.

Veterinary medicines

Prophylactics and other drugs for quarantine and acclimation will be stored in a dedicated refrigerator within the services building.

Staff Facilities

Offices and ablutions for BQAF staff are located within the adjacent SFA existing building.

The proposed layout of the BQAF (approximately 400m^2), including the position of the abstraction point and the water supply line is provided in Figure 8. It should be noted that design and layout are not final and will be dependent on the final building configuration secured for the BQAF.

Figure 9 indicates the proposed internal layout of the BQAF Facility including water supply and drainage. The different components of the BQAF facility are labelled as follows:

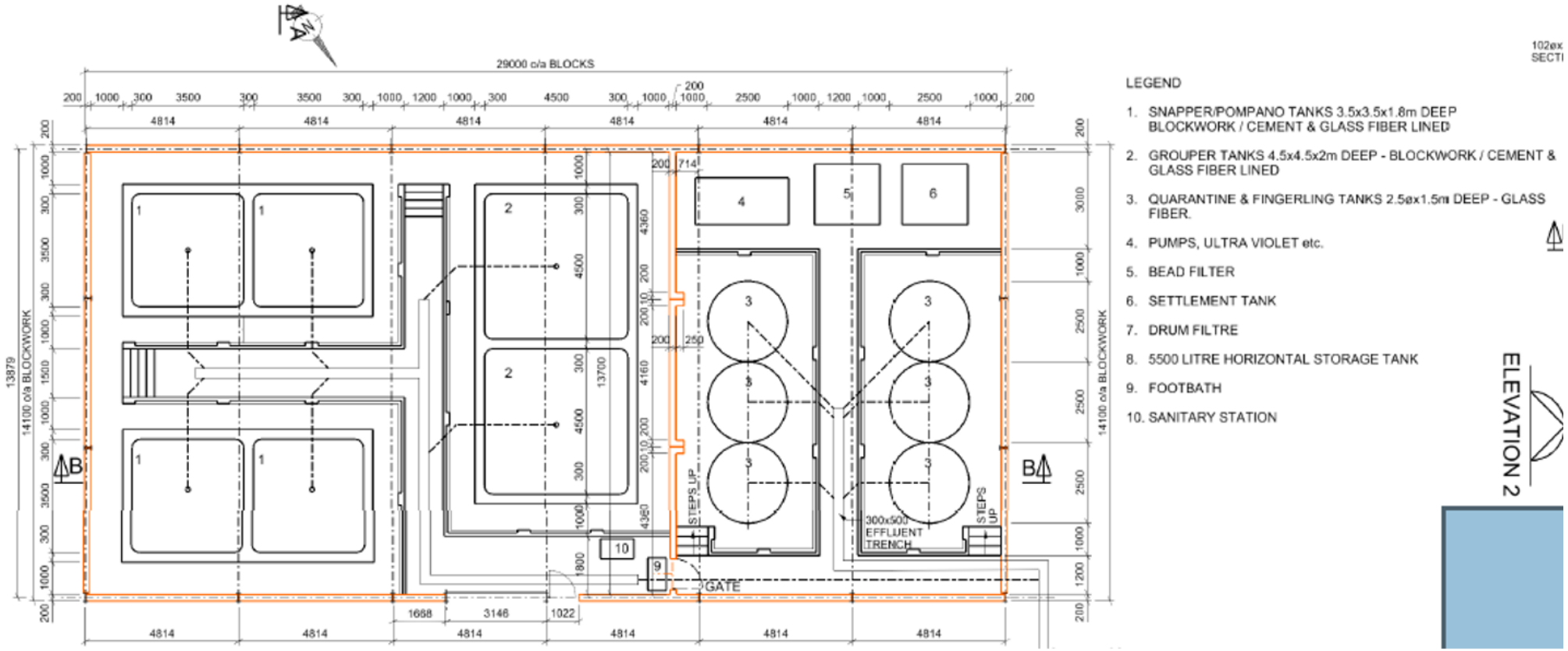

Figure 9: Proposed Layout of the Broodstock Acclimation Facility at Providence, Mahé

Pilot Project Cage Site

The planned pilot project forms a strategic link between the activities of the R&D Facility and the commercial scale projects. The pilot project is scaled at 200 tonnes per annum and aims to grow-out candidate species to a marketable size for sale in the domestic market and for shipment as product samples to target international markets.

The pilot project cage site will be located at Providence, Mahé as indicated in Figure 10 below.

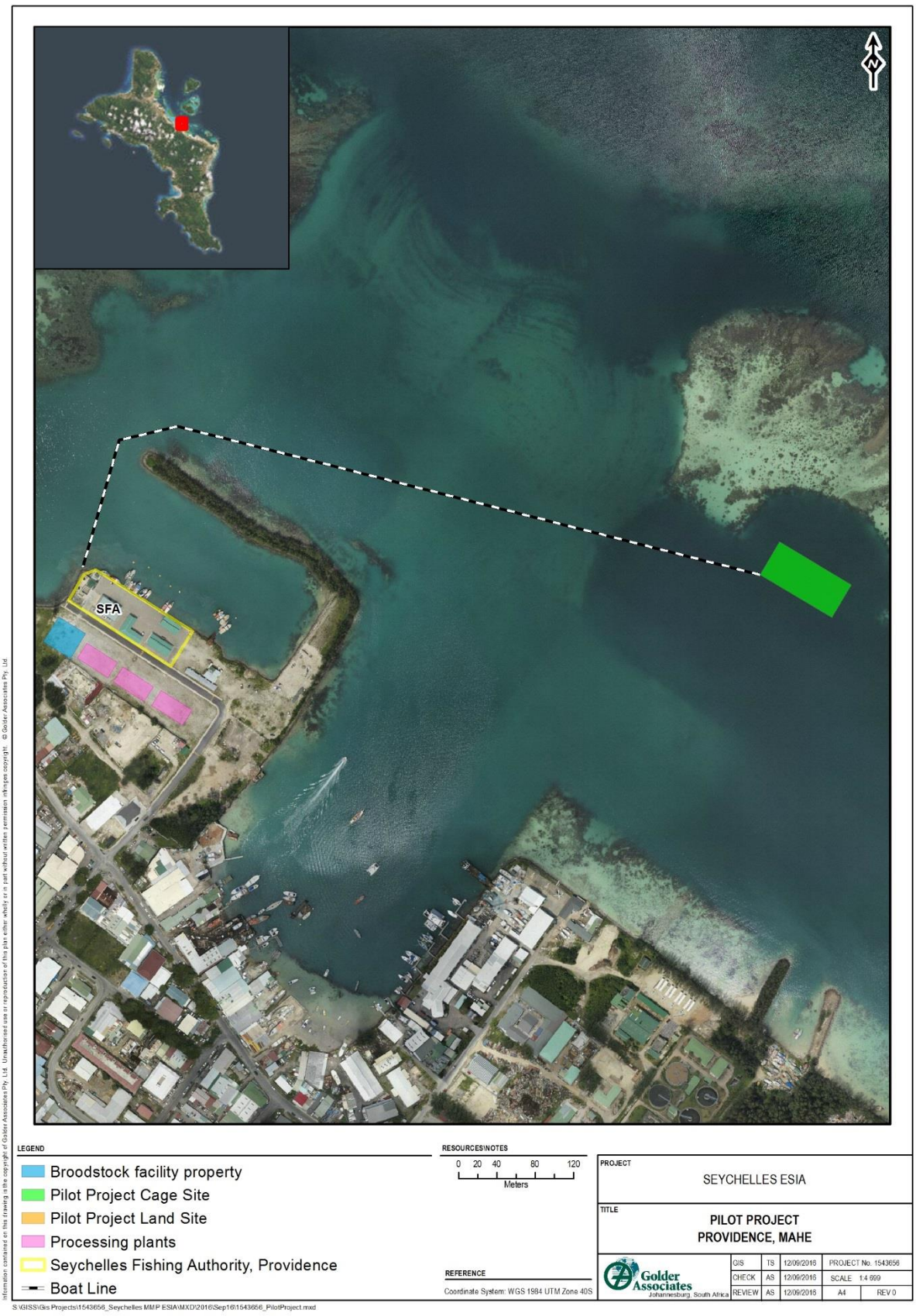

Figure 10: Pilot project Cage Site

Research and Development Facility

The Seychelles Aquaculture Research and Development (R&D) Facility at Anse Royale, Mahé will be a multi-species tropical fish hatchery, science hub and visitors centre. The facility aims to provide technical support, research, and training to develop and advance the Seychelles aquaculture sector while promoting public awareness and enthusiasm for this new sector.

The R&D Facility will recognise 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 will have an educational mandate with aquarium displays of a variety of broodstock species, information boards, and views of a working marine hatchery.

The proposed R&D Facility will be located 8km from the Mahé International Airport, and 18km from the capital Victoria. The proposed site is on the southern grounds of the University of Seychelles (UNISEY) and is easily accessible and well serviced by road networks. The area has a very gentle slope and is situated next to an artificial canal that leads under the East Coast Road into the sea, offering good access for water supply and waste discharge pipes from the facility into the sea without causing significant new disturbance (Figure 11).

The location has two distinct sites: the “inland” area (where two sites are being considered in close proximity to each other) adjacent to the University of Seychelles where the R&D facility is proposed to be situated, and the “beach” area 200m east, adjacent to the SFA ice plant. The beach area links the R&D facility to the sea and the pilot project cage operation at Providence. As part of the R&D Facility, the water storage reservoir and water abstraction and discharge pipe will be assessed for impact. The R&D Facility cannot function without a constant supply of water, hence the need for water storage and the water pipe.

For the purposes of this report, infrastructural requirements and sizing calculations are considered for the inland site, storage reservoir and water pipe only for the proposed R&D facility site and proposed layout. Requirements for the beach area will be considered at a later stage, however the preferred site is indicated for purposes of this ESIA. The R&D Facility will be developed and operated in parallel to the pilot project at Providence, Mahé. 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 sector and in particular:

- Production of brown-marbled grouper, emperor snapper, mangrove snapper and snub-nose pompano fingerlings;
- Technical support to the pilot project;
- Research into further aquaculture species; and
- Environmental research.

Figure 11: Location of the R&D Facility (land based and beach site and water abstraction pipe) at UNISEY, Anse Royale

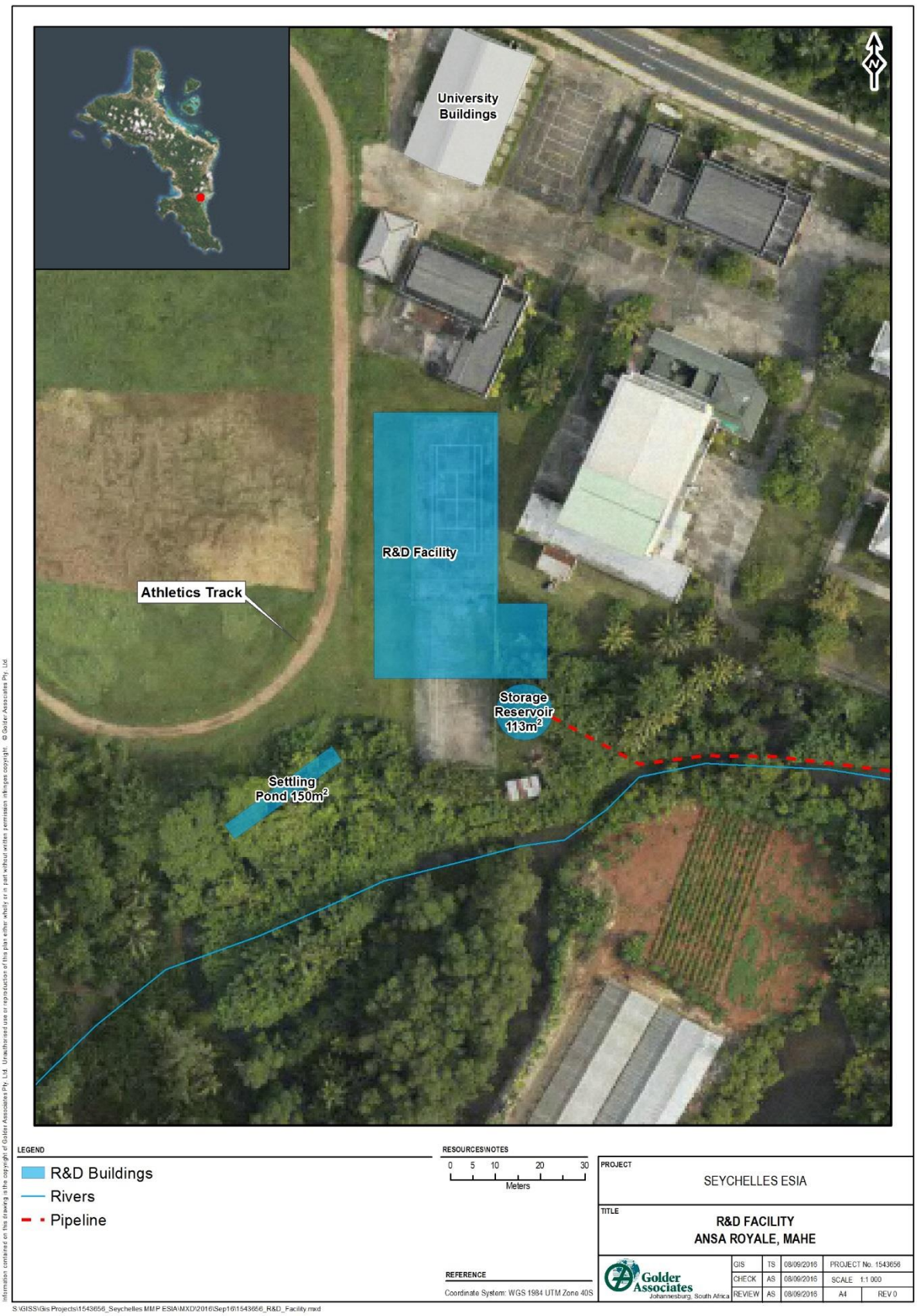

Figure 12: The land based components of the R&D Facility

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 monitoring and 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 sector and its needs.

The various operators within this new aquaculture sector will pay a levy to fund these research activities, which will benefit the sector as a whole. Furthermore, the R&D Facility will undertake environmental and scientific research programmes to ensure its credibility and aim to maintain good stakeholder and ensure public relations are maintained in terms of its environmental responsibilities and impacts.

Internally, the hatchery is compartmentalized into specific areas based on fish life cycle stages, the biosecurity requirements for each stage, potential for future expansion, and flexibility in terms of support services.

Aquaculture systems

The hatchery sector of the facility will comprise quarantine, broodstock, larval, nursery and experimental aquaculture tanks as well as a live feed area. The systems will operate on a flow-through basis with varying rates of water exchange depending on the different life-stages (the exception is the larviculture area which operates on a recirculating aquaculture system (RAS)). Highly sensitive areas, including the larviculture and quarantine areas, will be cordoned off and strict bio-security measures will be implemented to mitigate the risk of disease.

Services

The services building will contain essential life support infrastructure including water treatment units, air blowers, oxygen generators, and electrical works.

Seawater will be pumped ashore into a storage reservoir. It will then be pumped into a header tank before being gravity-fed through a drum filter into the aquaculture systems. Water supply to the tanks will be via suspended pipes (overhead) and drainage will be via an outlet into a central channel. Wastewater will be drum filtered and drained into a settling pond before being discharged into the canal (Figure 12). The exact routing of the water abstraction point and pipeline is still to be determined, however the most likely option is presented in Figure 11. A new jetty is being planned for fisherman and it is likely that the pipeline will follow this structure out to sea.

Air blowers and oxygen generators will be housed within the services building. Supply lines to the aquaculture systems will be suspended (overhead). Electrical supply will be obtained from the public service provider (Public Utilities Corporation) as well as a diesel generator, when needed.

Staff Facilities

The R&D Facility will install three laboratories – two wet laboratories and a dry laboratory. The laboratories will be fully equipped to enable researchers to conduct experiments and monitor aspects such as fish health, growth performance, and other contemporary tropical aquaculture topics.

An administration area will be provided for R&D Facility staff, including lockers, ablutions and a canteen.

Visitor Facilities

The reception area will welcome visitors and provide educational material and information boards relating to aquaculture in the Seychelles. Ablutions will be available for visitors in this area.

Visitors will be able to view the hatchery and a range of different tropical aquaculture species, including large grouper and snapper broodstock, along the hatchery viewing corridor.

Figure 13 indicates the proposed internal layout of the R&D Facility including water supply and drainage. The different components of the R&D facility are labelled as follows:

- 1 = Algal stock culture room;
- 2 = Algal duplication room;
- 3 = Glassware cleaning/sterilization room;
- 4 = Algal primary culture unit;
- 5 = Artemia/Rotifer enrichment area;
- 6 = Rotifer tanks;
- 7 = Artemia tanks;
- C = Chemical store;
- DF = Drum filter;
- Gen = Diesel generator;
- HT= Header tank;
- G BS = Grouper Broodstock;
- P BS = Pompano broodstock; and
- S BS = Snapper broodstock.

The development of the R&D Facility is aligned with the development of the pilot project grow-out operation located at Providence Harbour.

Species

The R&D Facility will first focus on producing brown-marbled grouper fingerlings, and a smaller proportion of snapper fingerlings. Once the production of fingerlings for these species has been achieved, in line with the goals of the pilot project, the focus will switch to producing pompano (*Trachinotus blochii*), and other target species identified in the MMP, such as sea urchins, sea cucumbers and ornamental finfish.

Stock and Genetics

All broodstock will be collected from the wild in Seychelles waters, mitigating any ecological or genetic risk associated with the introduction of broodstock from other regions. The broodstock will be quarantined and acclimated at the Broodstock Quarantine and Acclimation Facility before being transported to the R&D Facility for housing and reproduction. Broodstock will be housed in low densities (approximately 1kg/m^3) in large tanks (23 m^3 - 75$m^{3)}$ which will allow for voluntary spawning behaviour and freedom of movement. The broodstock tanks will operate on a flow-through system using drum-filtered and degassed seawater at a daily water exchange of 250% (i.e. the flow through volume will replace volume of water in each tank 2.5 times each day).

As grouper and snappers are serial spawners (spawning in multiple bursts over a specific period) the aim is to house four different groups of spawners under different light regimes using photoperiod control techniques and, therefore, to be able to produce eggs throughout the year.

Egg collection and incubation

Eggs will be collected from the broodstock tanks using overflow egg collectors. They will then be screened, treated with ozone, and placed in incubation tanks for a period of 18-20 hours before being stocked into the larval rearing tanks prior to hatching.

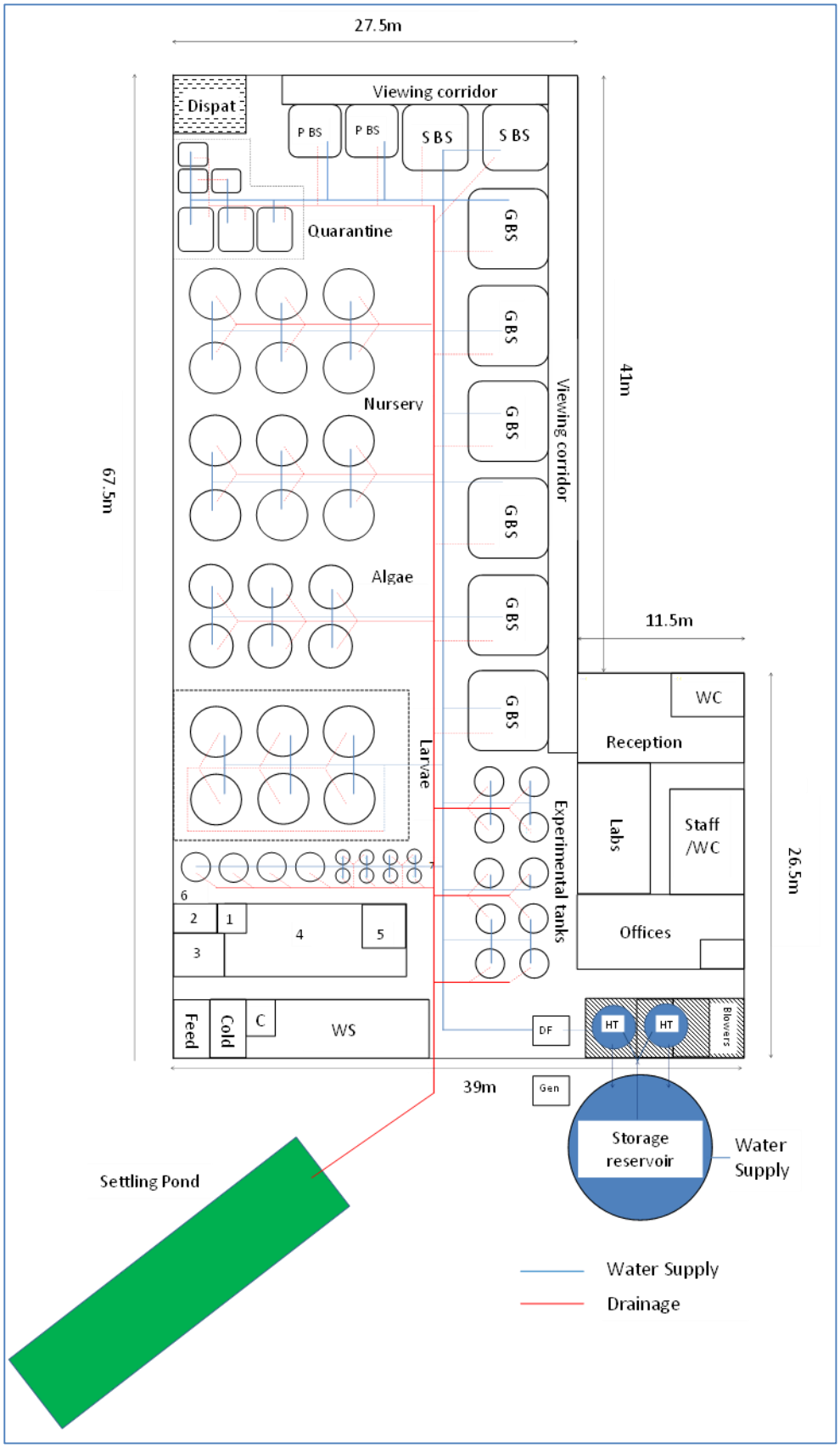

Figure 13: Proposed Layout of the R&D Facility at Anse Royale

Larval rearing and Bio-security

The larval rearing sector will operate on a recirculating aquaculture system (RAS) in order to provide the highest quality water at this sensitive life stage. Bio-security measures including footbaths and lockable doors will be installed in this sector. The larval stage of the life cycle is typically 45 days and will require stable environmental conditions and a good supply of quality live feed. Towards the end of the larval stage, larvae will slowly be weaned onto artificial feed. Once the larvae have undergone full metamorphosis into the juvenile stage, they will be stocked into the nursery tanks.

Nursery rearing

Post-larvae (juveniles) will be stocked into the nursery tanks and reared for approximately 45 days to a weight of 10g.

Transfer of fingerlings to cages

Fingerlings will then be stocked from the nursery tanks into containers which will be placed on the workboat and transferred to the pilot project grow-out cages at Providence.

2.3.5 Aquaculture Development Zone

This zone refers to finfish cage culture within identified Aquaculture Development Zones (ADZs) of the MMP (see Section 2.0 for prior discussion). These cages will be serviced daily from land and be moored at a distance greater than 2km from land (unless the coast is uninhabited then distances closer than 2km are allowable). In-depth analysis and research has been undertaken in order to select each ADZ based on environmental and ecological criteria. Products that could be successfully cultivated in the ADZs using cage culture have been identified as the following finfish species:

1) Brown-marbled grouper (*Epinephelus fuscoguttatus*);

2) Mangrove snapper (*Lutjanus argentimaculatus*);

3) Snubnose pompano (*Trachinotus blochii*); and

4) Emperor snapper (*Lutjanus sebae*).

The location of these ADZs are shown below in Figure 14 above.

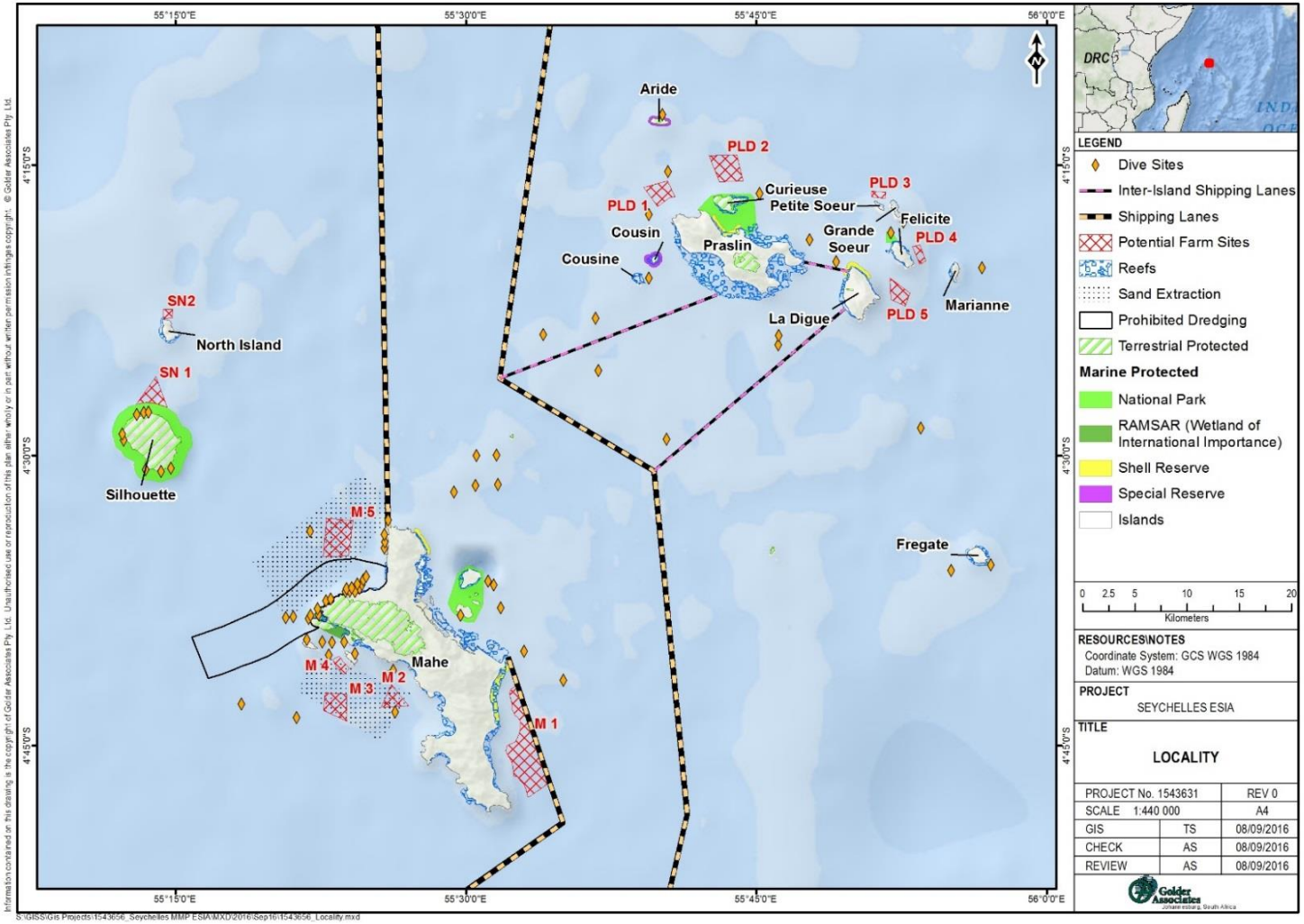

Figure 14: Locality of proposed ADZs

Site Selection and Ecological Carrying Capacity Modelling

As part of the development of the MMP, the SFA undertook a site selection exercise by gathering data in field, as well as from secondary sources.

The four primary goals of this study were to assess:

- the suitability of the Seychelles inner islands' offshore marine environment for finfish cage aquaculture;
- to select suitable areas for farming fish in cages around the inner islands;
- to provide a synthesis of the possible impacts of cage culture on the environment; and
- the mitigation thereof.

Furthermore, on the basis of the precautionary principle the final objective was to model the ecological carrying capacity of the ocean environment under different scenarios and to make appropriate recommendations for environmentally responsible cage aquaculture.

From an oceanographic perspective, the inner islands and the entire Mahé Plateau is data-poor and, hence, from a development perspective the precautionary approach was adopted and environmental best management benchmarks set by the global industry served as the foundations upon which suitable areas for large-scale cage farming in the ADZs were selected.

The SFA and the team developing the MMP analysed all available; physical and biological oceanographic, meteorological and hydrographic data. 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 collected and analysed in relation to international benchmarks of the physical suitability of the region for cage aquaculture. On the basis of this analysis, 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 possible and all oceanic conditions are within the physical stress levels of modern cage farming equipment and technologies.

Apart from analysing oceanographic processes and drivers, the selection of aquaculture development zones included social and economic considerations. The process took into account several limiting criteria, including a 2km exclusion zone around the coast of inhabited islands, a 1km exclusion zone around MPAs, mitigating visual conflict, avoiding conflict with the sport diving sector and artisanal fisheries, 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.

The criteria listed in Table 1 were used to broadly delineate the ADZ areas.

Table 1: Primary selection criteria for fish cage culture areas around the inner granitic Islands.

Item	Parameter	Criterion	Reason	Reference or source
1	Bathymetry	Flat or low profile areas	- Currents not deflected or slowed down. -Preferred for cage moorings	- Navigational Chart - Cruise 1 data.
2	Depth	Range = 25 – 65 m (Isobaths shown on GIS maps)	- Min. free water depth below cages > 10m - Impact on sediment is reduced with depth. - Avoids possible harmful feedback from wasted material accumulated on the seabed	- Hilke 2007 - Perez et al. 2003 -Cardia & Lovatelli 2015

Item	Parameter	Criterion	Reason	Reference or source
3	Distance from shore	> 2km from inhabited islands, where appropriate.	- Open Ocean cage culture minimizes impacts. - Mitigates visual impact	Proposed by Dept. of Environment and Tourism Bd.(2009)
4	Location	Reduced/little visibility from tourism infrastructure, if possible	- Mitigate visual impact.	Proposed by Env. Dept. Tourism Bd
5	Suitable seabed type	Sand, rubble dominated areas. Sandy areas with patches of macro-algae	- High assimilation capacity.	Price & Morris 2013
6	Unsuitable seabed type	All areas dominated by coral reefs and extensive seagrass meadows were excluded	- Ecologically sensitive area	Price & Morris 2013
8	Shipping lanes	All shipping lanes excluded (shown on GIS maps)	- Marine safety.	Seychelles Maritime Safety Administration
9	Sport and recreation	All sport diving spots excluded (shown on GIS maps)	- Mitigate conflict.	GPS locations obtained from private operators
10	Fishing grounds	All artisanal fishing areas excluded (shown on GIS maps)	- Mitigate conflict.	Christophe 2006
11	Restricted areas	- Marine protected areas (MPAs) and restricted zones excluded - Fibre optic cable area excluded (shown on GIS maps)	- High conservation value - Security / Safety	-Seychelles National Parks Authority - Seychelles Maritime Safety Administration

The following notes on the selection criteria are applicable:

- The 2km distance from shore criterion was applied only where the shore (in direct line of sight) was inhabited;
- Locations not in the direct line of sight of tourism infrastructure were few and far between and this was the reason why the sector suggested a 2 km buffer zone;
- All coral reef areas were excluded but isolated corals were not;
- Shipping lanes included the southern and northern approaches to Mahé and the southern approach to Praslin; and
- Restricted areas included the 1 000 m buffer zones around MPAs as well as the “Dredging Prohibited” zone around the fibre optic cable that lands on Beau Vallon beach, Mahé. It was excluded for cage culture because of the possible damage that cage moorings could cause.

Four ‘aquaculture zone selection’ cruises were undertaken by SFA and the MMP development team with the SFAs “R/V Amitie” vessel. The first cruise was of an exploratory nature while each of the subsequent cruises were used to increase the data and knowledge base upon which the final sites were selected. The two final cruises used a ROV to assess the nature of the seabed.

Of the original 16 aquaculture development zones proposed, 25% were ultimately 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 25-62 m). 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 (or 5,320 hectares) for the initial development of the sector. Eight of the 12 sites are relatively well sheltered from the SE monsoon, one is partly sheltered and three are not protected.

Tier 1 Sites

For purposes of the ESIA, the following sites were selected as Tier 1 sites:

- Site M 2;
- Site M 3;
- Site M 5; and
- Site PLD 2.

These sites are supported by the fact that extensive areas which have already been approved or granted environmental authorisation for sand extraction, occur over Sites M2, M3 and M5. Site PLD 2 was selected as it is sufficiently screened by Curieuse Island and offers developers who wish to base themselves at Praslin and/or La Digue, the opportunity to access an ADZ which is nearby and therefore logistically viable as these farms will be serviced from land. Tier 1 sites should ideally be developed over the first 10 years of the new aquaculture sector, where after monitoring and an increased understanding of the potential environmental impacts, operators may access Tier 2 sites.

Furthermore, due to the existence of the vast sand extraction areas, which are already pre-approved for this activity, the ADZs that occur over this area have some flexibility with regards to size and location within the sand abstraction area owing to the fact that the substrate within these areas has already been disturbed. Based on this historical disturbance, it is recommended Tier 1 sites should be prioritized in terms of pre-approval for development by the Ministry of Environment, Energy and Climate Change as detailed above.

By having sand extraction activities occur together with aquaculture operations, an ongoing environmental monitoring programme should be implemented over these areas.

Tier 2 sites

The remainder of the 12 ADZs will therefore be classed as Tier 2 sites for the purpose of the ESIA:

- Site M 1;
- Site M 4;
- Site PLD 1;
- Site PLD 3;
- Site PLD 4;
- Site PLD 5;
- Site SN 1; and
- Site SN 2.

Table 2: For purposes of the ESIA, the following sites were classed as Tier 1 and Tier 2 sites respectively

Tier 1 Sites	Tier 2 Sites
Site M 2; Site M 3; Site M 5; and Site PLD 2.	Site M 1; Site M 4; Site PLD 1; Site PLD 3; Site PLD 4; Site PLD 5; Site SN 1; and Site SN 2.

A proposed precautionary limit of 1 000 tpa/km^2 will be the benchmark upon which to start the sector in the Seychelles. This means that operators will apply for licenses to operate farms at 1 000 tpa/km^2 and each ADZ may have one operator with a number of 1000 tpa licenses or multiple operators with 1000 tpa licenses each. Therefore, each ADZ may have a number of different operators, each with sufficient buffer zones between them. These and other conditions are stipulated in the EMP. This conservative start (tiered approach) will mitigate uncertainty until such time as there is empirical data available from monitoring programmes upon which to go forward with greater certitude.

It should be noted that the ADZs are not fixed in space and could be shifted within a 1 nautical mile zone around their current proposed locations to find sandy seabed on sites with unsuitable substrate (such as isolated coral, seagrass or macro-algae patches), should this occur. This is important from a sector development perspective.

In the case of the ADZs located within the pre-approved sand extraction areas, it is recommended that these ADZ sites be able to move within these areas or expand in size owing to the disturbance caused by the sand extraction activities. Even so, other sensitive receptors will still be taken into account and assessed for impact (i.e. conflict with tourism and fisheries should these occur in the area).

Table 3: Summary features of ADZs.

ID No.	ADZ	ADZ name	Max Depth (m)	Area (ha)	Ave Temp (°C)	Ave Salinity (psu)	Seabed Echo	Seabed (ROV survey)	Seabed (grab samples)	>2km offshore	Depth (m)	Benthos	Sheltered from SE monsoon
1	PLD1	Baie Chevalier	40.1	390.42	27.96	33	Soft	Sand	Medium sand	Yes	25-40	No macrobenthos	Yes
2	PLD2	Curieuse North	44.5	614.45	28.03	33	Soft	Sand	Medium sand	No - uninhabited	30-45	Bivalves, small polychaetes	Yes
3	PLD3	Petite Soeur	47.7	75.23	28.00	33	Soft	Sand	Medium sand	No - uninhabited	46-48	No macrobenthos	Yes
4	PLD4	Felicite East	--	116.31	--	--	Mainly soft	tbd	Fine sand	Yes	36-42	Polychaetes	Partly
5	PLD5	La Digue East	--	292.52	--	--	Soft and hard	tbd	Fine / medium sand	Yes	41-43	Shrimp, polychaete.	No
6	M1	Mahé South East	53	1872.77	27.63	33.4	Mainly soft	tbd	Medium sand / shell grit	Yes	32-52	Sponge, Brittle star, gastropod, bivalve, sand anemone	No
7	M2	Trois Banc	41.4	284.56	26.95	34	Soft	Sand	Coarse sand Shell grit	Yes	29-41	Crab, bivalve, polychaete	Yes
8	M3	Stork patch	48.3	346.04	26.88	34	Mainly soft	Sand/ Macro algae	Fine sand / shell grit	4,6 km offshore	42-48	Sea urchin remains, crab, bivalves, brittle star	Yes
9	M4	Ile Therese	40	106.02	27.09	34	Mainly soft	Sand/ Macro algae	Medium / coarse sand	No - uninhabited	25-40	No macrobenthos	No
10	M5	Beau Vallon	43.1	858.51	27.40	33.7	Soft	Sand	Medium & fine sand and silt	3,5 km offshore	40-43	Anemone, bivalves, crabs, polychaete	Yes
11	SN1	Silhouette North	62.2	305.27	27.7	32.7	Mainly soft	Sand	Coarse sand / shell grit	No, 1km MPA zone	32-62	No macrobenthos	Yes
12	SN2	North Is. North	48.5	50.71	28.13	32.9	Mainly soft	Sand	Shell grit	No (to hide from hotel beach)	35-48	Bivalves	Yes

Proposed Cages and Technology

Due to the fact that the MMP is guiding the development of a new aquaculture sector, where individual investors and farm operators are yet unknown, it should be kept in mind that their preferred cages, technology and other support infrastructure are not yet known at this time. The below section therefore attempts to give the reader more insight into what typical cages, technology are expected to be used by such investors and operators of individual farms. Images and descriptions have been taken from the AKVA Group website, and more information can be accessed directly from their website (http://www.akvagroup.com/home).

Background

Despite the fact that large-scale offshore aquaculture production only began globally in the early 1970's, there has been a rapid development of the technological solutions required to support farming in remote areas and under a wide range of environmental conditions. Across a range of factors, the Seychelles is characterised by moderate sea conditions and adequate technology exists to efficiently support the envisaged operations. Key to correctly specifying the various equipment components for the MMP is ensuring that a 'technological fit' is achieved where site conditions, species, scale, skill-sets, market requirements and investment capital are effectively aligned to create an efficient production unit.

Cage Site Characterisation

In the ADZsthe nominated grow-out sites are characterised as 'moderate' by international standards (per the table below) allowing a wide range of technological solutions that can be successfully applied.

Table 4: Parameters influencing cage selection

ENVIRONMENTAL FACTOR	UNIT	TYPCIAL SITE VALUE	COMMENT
Significant wave height	Meters (m)	1.6	Small in comparison to other offshore cage sites
Maximum wave height	Meters (m)	2.33	Small in comparison to other offshore cage sites
Current speed	Meters per second (m/s)	Min=0.19,Max = 0.32, Mean = 0.19	Ideal
Wind speed	Meters per second (m/s)	SE monsoon (Mean= 7.33) NW monsoon = 3.18	Wind is consistent and only increases to above gale force for short periods normally less than 1 hour
Depth	Meters (m)	25-40m	Ideal
Seabed		Course sand	Ideal for waste assimilation
Water temperature	° C	5m (24.8, Max = 30.5, Mean = 27.7)	
Oxygen	mg/L	5m(Min=4.42, Max = 5, Mean = 4.73	Typical values for tropical waters

Cages

Aquaculture cages offer numerous designs and configurations that can be applied to the wide range of environmental conditions associated with sites around the world. Based on the 'moderate' site characterisation a number of different cage types could be successfully selected for application in the

Seychelles ADZs; in particular, either square steel cages or circular High-Density Polyethylene (HDPE) cages could be used. Steel cages provide easy access, a stable and safe working platform and are well suited to hand-feeding operations. Circular HDPE cages are best suited for rough sea conditions and are the most adaptable cage solution. For the purposes of the economic model Circular HDPE cages with 100m circumference have been assumed as detailed in the table below. Since individual licenses will be allocated on a 1,000tpa basis, the typical specifications for a 1,000tpa production unit is presented below.

Table 5: Typical cage specifications

Cage Specification per 1,000tpa unit		
Component	**Detail**	
Cage number	Cages per unit	12
Cage type	Polarcirkel	High-density polyethylene (HDPE)
Cage size	Circumference	100m
Cage size	Diameter	32m
Floating pipes	Pipe diameter	315mm
Net depth	Depth of net in water	>5m (+1.3)
Cage volume	Volume in water	>4,019m³
Mooring system	Anchors	-

Figure 15: Typical Cage Structure (not to specifications in Table 5)

Nets

The Seychelles sites experience minimal seasonal bio-fouling and therefore regular nylon nets can be used, impregnated with standard anti-fouling coatings. Net depth is important and will be determined by both the site and species – for the grouper species model an effective depth of 5m has been used i.e. 5m underwater and 1m above water.

Table 6: Typical net configuration

Net Specification per 1,000tpa unit		
Component	**Detail**	
Net number	Nets per unit	14
Net size		100mC x 5m Depth (+1.3m)
Net material		Nylon
Net aperture	Full mesh size	(2x) 12mm (12x) 28mm

Feeding Systems

An assortment of technologies can be applied to feeding fish in offshore cages. In the simplest form feeding is done by hand using scoops that are used to manually distribute feed pellets over the cage surface. Various types of equipment are available as a means of mechanising feeding operations and ultimately even a fully automated system could be used. Such as represented in Figure 16.

Figure 16: Example of an automated AKVA Feeding System

Boats and Barges

Feed Barge

The use of feed barges combining feed silos, feeding equipment, monitoring systems and living facilities are the commonly used approach for off-shore aquaculture. Barges are scalable with production requirements and it is possible that a 100 tonne unit would be used per 1,000tpa site, however this is more likely to occur for offshore sites as described in section 2.3.1.4 (not covered under this ESIA).

Figure 17: Example of an AKVA Feed Barge

Well-boat

The transport of harvest size fish (harvest weight is species dependent) from the grow-out sites to the onshore processing facility is done by the use of a well-boat. In mature industries it is common that this service can be outsourced to a third party operator but based on the early stage nature of the industry in the Seychelles it is assumed that a well-boat would not be purchased by individual operators, however they may choose to combine and purchase one that services multiple operators and sites.

Figure 18: Example of a typical 220m^3 Well-boat

Workboats

A large workboat will typically be required for the delivery of feed to the cage sites and general operations. A second boat may be required for the transport of employees. It is anticipated that cage sites may have a workboat permanently moored to the cages for emergencies.

Figure 19: Example of a smaller workboat

Hatchery and Nursery

As already described in Section 2.3.4, the hatchery, nursery and broodstock holding facility (or BQAF) will all be housed on Mahe. The R&D hatchery will use a partial Recirculating Aquaculture System (RAS), while the nursery and broodstock holding facilities will use a flow-through system similar to the one depicted below. Operators may in future wish to set up their facilities which may also follow the same configuration.

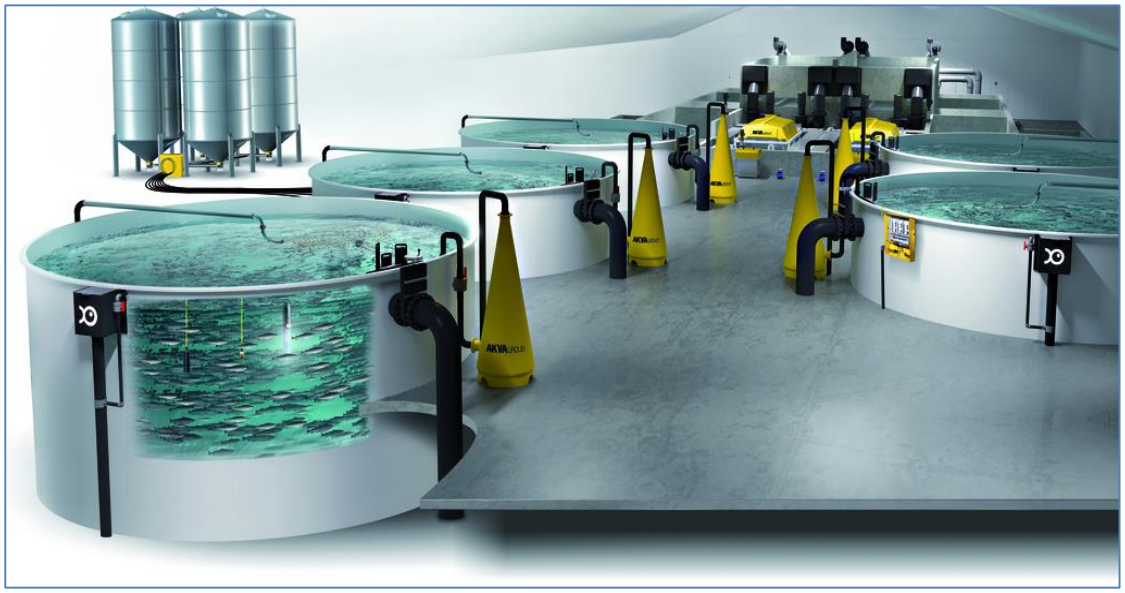

Figure 20: Example of an AKVA RAS System

Building design limitations and standards

Building design limitations such as the location, development rights and access have been detailed within this ESIA.

Building quality standards to be adhered to Seychelles national building regulations and standards.

Architectural criteria

The professional team consisting of experts in various engineering disciplines have designed the facilities such that the operational requirements of the aquaculture systems are met. The design takes into consideration the topography, soil type, available building materials, weather conditions, site orientation and building lines amongst other criteria

Plant and equipment

The use of mobile cranes, will be required for erecting the steel structures.. Certificates of competence will need to accompany all major plant and equipment to be used to ensure that all major plant and equipment are in good working condition to ensure safety on building sites. Excavators, compactors, tractors & trailers, and forklifts will also be in use during the construction phase of the projects.

Further details on mitigation measures during construction, operation and decommissioning of the infrastructure, is detailed in section 7.4.

Processing Facility

For the first few years of the new aquaculture sector, it is assumed that the existing tuna (and other) processing plants have adequate capacity to handle the processing and waste volumes associated with the ADZs. In future, new fish processing plants will need to be established to support the sector.

A product mix of live fish, fresh and frozen HOGG (head-on, gilled and gutted) and filleted product has been assumed for a typical new onshore processing facility. Fish are likely be transferred from the grow-out cages to the well-boat using a fish pump and then delivered to the processing facility and off-loaded into holding tanks in the same manner. In future, new processing plants may be owned by operators of fish farms or processing may be out-sourced to a third party or alternatively, existing facilities could be rented and/or refitted for this purpose.

Support Services

In support of the proposed aquaculture sector, there would be a number of services and suppliers all contributing to the support and functioning of this new sector. It is anticipated that there would be a range of services and suppliers, mostly operating out of established ports such as those at Victoria, Providence, Praslin and La Digue. Air freight would also enter and depart the Seychelles through the International airport at Mahé. The following services and suppliers would typically support the new sector:

- Feed suppliers and distributors;
- Warehousing (feed, equipment, supplies etc);
- Manufacturers and suppliers of equipment (tanks, filters, plumbing);
- Outboard and boat/vessel maintenance;
- Logistics operators;
- Processing;
- Cold chain storage and transport;
- Office and administration; and
- Financial and Banking.

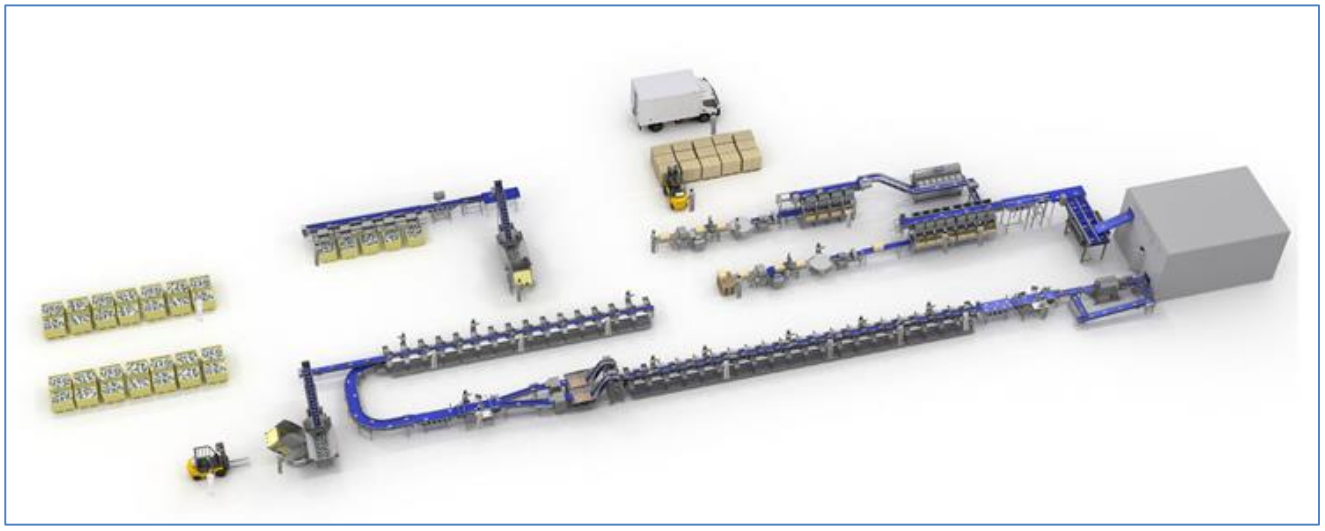

Figure 21: Example of a typical Marel Fish Processing Line

2.3.6 Project Phasing for this ESIA

It is anticipated that the following timeframes apply to each of the project phases:

- **Construction Phase**: The BQAF and R&D facilities are likely to be constructed and ready for hand-over to the operational teams after a period of approximately 12-24 months. This includes the installation of the pilot project cages and grow-out cages associated with individual fish farm operators. It should be noted that floating cages can be assembled and commissioned in a very short period of time (a couple of days to weeks), and as such may occur at different stages when needed as more operators enter the aquaculture sector. A project implementation plan, including key milestones, assigned responsibilities and other relevant construction activity information will need to be submitted to MEECC prior to the commencement of construction works.
- **Operational Phase**: The operational phase of the aquaculture industry for purposes of this ESIA has been set at 25 years, however, it is very possible that the sector develops into a stable sector that continues for many more years.
- **Decommissioning Phase**: This phase is not described in detail in this ESIA, as imminent closure and decommissioning of the aquaculture sector is not anticipated. However, this phase would involve the removal of infrastructure such as the cages, moorings and boats from the waters, with the land based facilities being utilised for alternative purposes. This would require removal of aquaculture equipment and infrastructure activities.

This ESIA has assessed impacts linked to the above phasing of the aquaculture sector for the land based components described as well as the establishment of fish farms in ADZs. The inshore and offshore aquaculture zones (described in sections 2.3.1.2 and 2.3.1.4) of the MMP and the larger potential aquaculture sector, is subject to separate ESIA's that will address each of these project specific components.

3.0 ALTERNATIVES CONSIDERED

Seychelles' economy is based on tourism and fisheries both of which are subject to fluctuation. The government of Seychelles has made a concerted effort to diversify the economy. Aligned to this objective, the 'Blue Economy' strategy has been developed focussing on several important spheres including the marine environment; fisheries and aquaculture; tourism; ocean-based renewable sources of energy; transportation; marine mineral resources and maritime security.

As a core component of the Blue Economy the development of an aquaculture industry has been prioritised by the Seychelles government.

3.1 Alternative ADZ Sites

Owing to the fact that the MMP is developing a **sector** and not a finite project, a number of site alternatives have been identified and assessed. The original 20 ADZs identified, were taken forward for further assessment. This led to 4 sites being eliminated, as a result of unsatisfactory substrate conditions. There are many other alternative sites which exist located between the 16 ADZs. They do however, require further investigation if they are to be developed in future.

Bird and Fregate Islands are too remote for economical, feed-based aquaculture operations and were excluded from this study.

3.2 Alternative Species

The start of the MMP Implementation Phase, required a market assessment study to determine the most suitable species for aquaculture development in the Seychelles. The MMP development team, conducted the market assessment to focus on areas and species based on pre-determined selection criteria. A combination of these criteria is critical in selecting the most suitable species for aquaculture. Species selection is fundamental to the success of the MMP, which dictates the foundations required for infrastructure, human resources, marketing and supporting industries.

The aim of the desktop study was to take a high-level approach and narrow the range of potential species according to key selection criteria. The starting point focussed on species for which aquaculture production techniques are well established, and are naturally occurring in Seychelles waters. Geographically, Seychelles shares the Indian Ocean with (among others) Australia and South East Asia, and these regions have developed aquaculture production techniques for a variety of Indian Ocean species. Those species non-native to Seychelles were eliminated from the selection process. After natural distribution in Seychelles waters was determined, selected species were assessed according the following selection criteria:

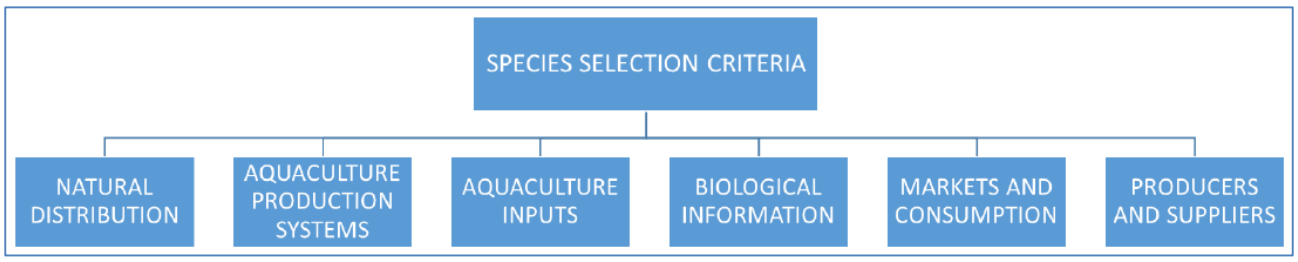

Figure 22: Species Selection Criteria

The second objective then assessed the selected species' market availability and price. This allowed for an intensified focus on those species with market potential. Further refinement of these species using the following inputs:

- Regulatory factors;
- Environmental factors;
- Technical factors; and
- Combined market and economic factors.

Search results were refined to produce a list of 30 species, comprised of twenty-two finfish species, three species of sea cucumber, two species of oysters, one species of urchin, one species of crab and one species of prawn.

This process generated four candidate aquaculture species, which have: natural distributions in Seychelles, a market exists, and are currently being cultivated in a number of regions at various scales (small-scale and commercial production) (more details in section 2.3.3). There are an additional twenty-seven species to be explored in aquaculture research and development. It should be noted that species are continually being

researched globally and once the aquaculture lifecycle is closed for additional species, they may be explored for aquaculture potential in the Seychelles.

The outputs of this MMP research include species data sheets which contain detailed information based on the selection criteria. In addition to this, basic economic models were created for selected species to determine if they were economically suitable for development in the Seychelles and a contact list of producers, suppliers and markets, was created for future utilisation.

3.3 Alternative Aquaculture Cages and Technologies

A number of different aquaculture cages and technologies exist. A number of these are described under section 2.3.5. Since the proposed aquaculture sector would have a variety of operators enter the Seychelles with different preferences for cages, configuration and level of automation.

4.0 LEGAL FRAMEWORK

4.1 National Legislation, Policies and Standards

This ESIA has taken into account the various legal, institutional and regulatory frameworks of the republic of Seychelles. Reference is specifically made to the following:

The Seychelles Constitution (1993)

The Seychelles Constitution (1993), Article 38 declares that:

"the State recognizes the right of every person to live in and enjoy a clean, healthy and ecologically balanced environment and with a view to ensuring the effective realization of this right the State undertakes ….to ensure a sustainable socio-economic development of Seychelles by a judicious use and management of the resources of the Seychelles"

The Environment Protection Act, No. 9 of 1994 (as consolidated to 2012)

The implementation of the Seychelles MMP requires administrative clearance from the Ministry of Environment, Energy and Climate Change, in conformity with the provisions of the Environment Protection Act (EPA), Act No. 9 of 1994.

The EPA 1994 provides for the protection, preservation and improvement of the environment and for the control of hazards to human beings, other living creatures, plants and property. The Act also provides for the coordination, implementation and enforcement of policies pursuant to the national objectives on environment protection.

This Act is administered by the Department of Environment in the Ministry of Environment, Energy and Climate Change, which has been designated as the Authority under the Act. The Act makes provisions for the Authority to co-ordinate the activities of other agencies concerned with the protection of the Environment. The Act provides for the prevention, control and abatement of environmental pollution.

The Environment Protection Act 9 of 1994. The aim of the EPA is stated as follows:

"… *to provide for the protection, improvement and preservation of the environment and for the prevention, control and abatement of environmental pollution*."

Section 15, under Part IV of the EPA deals with Environment Impact Assessment (EIA). Where a project is deemed to have a potentially significant impact on the environment, a Class 1 EIA will be required and the Ministry of Environment will provide the Terms of Reference for the EIA.

The Seychelles MMP is deemed to be a Class 1 EIA and the legislation requires that an EIA study be carried out and that an environmental authorisation is obtained before any prescribed project or activity occurs in a protected or ecologically sensitive area. The criteria, which establishes the necessity of an EIA is found in the EIA Regulations which lists categories of projects or activities requiring environmental authorisation. Schedule 1 of the EIA mariculture or aquaculture related activities are listed:

"*4. Fish and associated products farming:*

4-1 Fish farming works and extension, aquaculture.

4-2 Fish processing plants and equipment."

This ESIA for the Seychelles MMP is being carried out in accordance with the EPA and the EIA Regulations contained therein. The ESIA will include the Terms of Reference as provided by the Ministry as well inclusion of an Environmental Management Plan (EMP).

The Fisheries Act, No. 20 of 2014

Makes provision for the protection of several areas in Seychelles waters. Some of these areas are specifically designated to exclude certain types of fishing. Other areas are specifically designated to prevent damage to the benthos (i.e. Exclusion of certain gear types in specified areas). The Acts also provide for fishing agreements and licence conditions as well as management of fisheries stocks.

Other important regulations, standards and policies that find application to aquaculture and which have been aligned to the Fisheries Act, 2014 are the following:

- The Marine Aquaculture and Sea Ranching Regulations 2015*;
- Seychelles Aquaculture Standards (various)*; and
- Marine Aquaculture License: Special Conditions (various)*.

**These regulations are not gazetted as of yet, and will be amended after the ESIA Record of Decision, to align with EMP findings, prior to cabinet submission.*

Other Relevant Legislation, Policy and Standards

Other regulatory requirements that may be relevant to the MMP are:

- Environmental Impacts Assessment Regulations of 1996;
- Environment Protection (Standards) Regulations, SI No. 84 of 1995;
- Environment Protection (Noise Emission Standards) Regulations, SI No. 49 of 1999;
- Agricultural and Fisheries (Incentives) Act, 2005 (No. 3 of 2005);
- Environmental Management Plan for Seychelles (EMPS 2000 – 2010);
- Final Draft of the National Biosafety Framework (2005);
- National Parks and Nature Conservancy Act (1969, as amended);
- National Parks and Nature Conservancy Act (Subsidiary legislation) Revised edition 1991;
- Protected Areas Act (1967);
- Protected Areas Policy 2013;
- Wild Animals and Birds Protection Act (and associated regulations) (1966);
- Town and Country Planning Act (1972);
- Food Act, 1987;
- Export of Fishery Products Act of 1996;
- Export of Fishery Products (Aquaculture) Regulations, 2010;
- Export of Fishery Products (Aquaculture Feed) Regulations, 2010;

- Export of Fishery Products (Sanitary) Regulations, 2010;
- Animal and Plant Biosecurity Act of 2012;
- Solid Waste Management Policy 2014-2018;
- Animal (Diseases & Import) Act 1981(revised in 1991);
- Merchant Shipping Act of 1995;
- Maritime Zones (Maritime Pollution) regulation (1981);
- Merchant shipping (Oil Pollution) Seychelles Order (1975);
- Beach Control Act (1978);
- Harbour Act & Regulation 1933), Harbour (inner harbour) (control of traffic), regulation Harbour (fishing port) Regulation 1988,Ports (interim Provisions) Declaration Order 1975; and
- Seychelles Bureau of Standards Act (1987).

4.2 International Policies, Guidelines and Standards

A summary of international treaties and conventions that could potentially be applicable to the Seychelles MMP are presented below:

- Basel Convention 1992;
- Geneva Convention on the High Seas (1958);
- United Nations Convention on the Law of the Sea (UNCLOS) (1982);
- International Convention for the Prevention of Pollution from Ships (MARPOL) London, 1973;
- MARPOL 73/78 Annex I/II;
- MARPOL 73/78 Annex III;
- MARPOL 73/78 Annex IV;
- MARPOL 73/78 Annex V;
- MARPOL 73/78 Annex VI;
- International Convention on Standards of Training Certification and Watchkeeping for Seafarers (STEW)London, 1978;
- International Convention on Civil Liability for Oil Pollution Damage Brussels, 1969;
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990 (guidance) Oil Company International Marine Forum (OCIMF) Guidelines 1975;
- International Convention on the Control of Harmful Anti-fouling Systems on Ships, October 2001;
- The International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004;
- Convention on the International Regulations for Preventing Collisions at Sea, (COLREGs)1972;
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972;
- Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal;
- Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971;

- Convention on Biological Diversity (CBD), 1996;
- South Indian Ocean Fisheries Agreement, 2006;
- Protocol on Fisheries of the Southern African Development Community;
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- African Convention on the Conservation of Nature and Natural Resources (Revised version, 2003);
- Secretariat for Eastern African Coastal Area Management (SEACAM);
- Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (the Nairobi Convention) 1996;
- Convention concerning the Protection of the World Cultural and Natural Heritage Paris, 1972;
- Convention on the Conservation of Migratory Species of Wild Animals (CMS) (The Bonn Convention 1979) and agreement (Birds mammals and their habitats, 1994);
- ILO Freedom of Association and Protection of the Right to Organise Convention. No. 87. 1948;
- UN Convention on the Rights of the Child 1989;
- ILO Worst forms of Child Labour Convention, No. 182 1999;
- ILO Discrimination (Employment and Occupation) Convention, No. 111 1958;
- ILO Equal Remuneration Convention. No. 100 1951; and
- International Labour Organisation (ILO) Forced Labour Convention, No 29 1930.

5.0 THE RECEIVING ENVIRONMENT

The broad regional study area centres on the granitic Inner Islands of Mahé, Praslin, La Digue, Silhouette and North Islands. The terrestrial and marine receiving environments are discussed below.

5.1 The Bio-Physical Environment

5.1.1 Geology, Soils and Topography

The Seychelles are made up of 115 granite and coral islands which extend from between 4 and 10 degrees south of the equator and lie between 480km and 1,600km from the east coast of Africa in the western Indian Ocean.

The inner islands of the Seychelles comprise some of the oldest mid-oceanic granite islands on earth while the outer islands consist primarily of low-lying coral atolls and reef islets. The inner Islands which are mostly granitic, cluster mainly around the largest islands of Mahé, Silhouette, Praslin and La Digue. There are 43 inner islands in total – 41 granitic and 2 coralline islands. Mahé is the largest island of the Seychelles archipelago (Figure 23). The outer islands are those situated beyond the Seychelles plateau. The outer islands owe their existence to continental drift, upliftment and subsequent volcanic activity which ultimately led to the formation of island land masses.

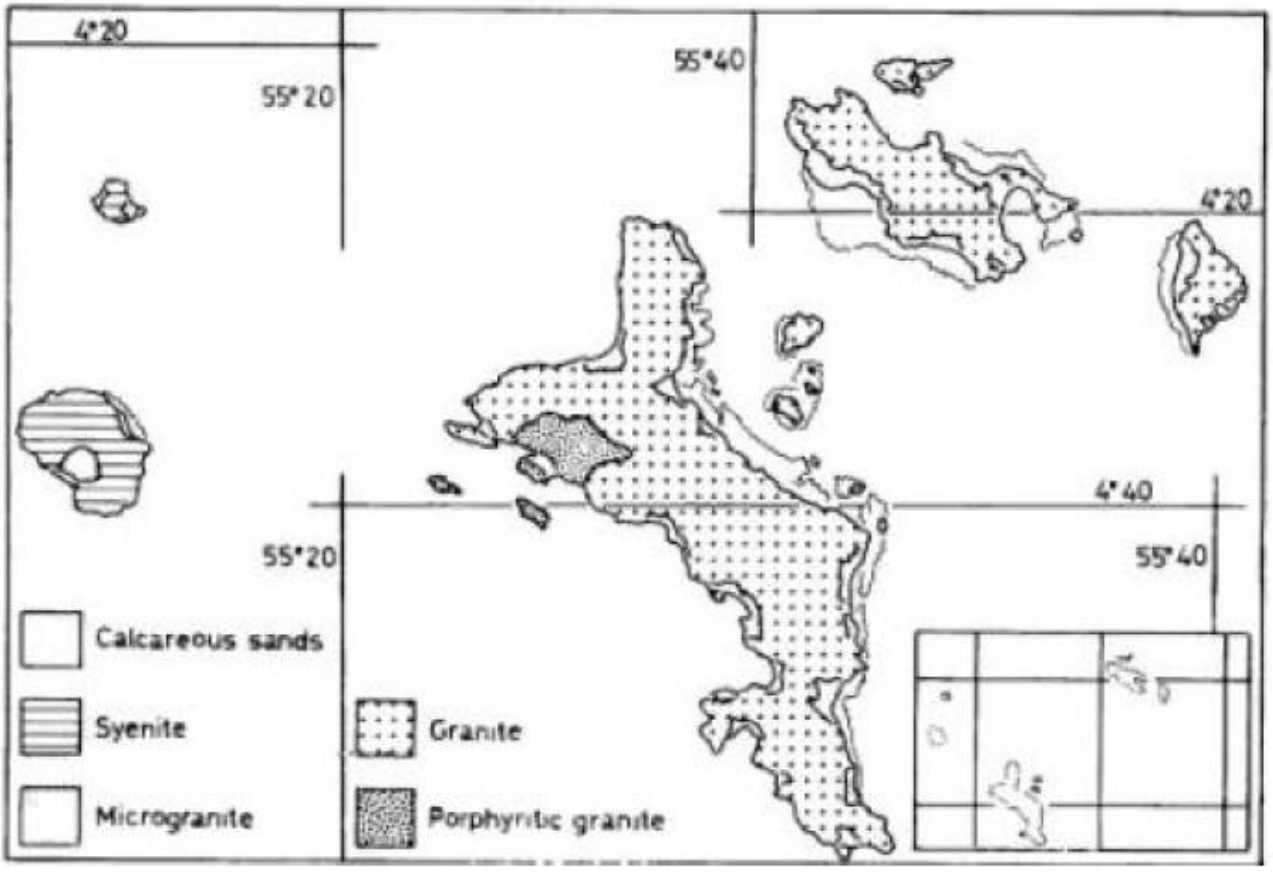

Figure 23: Geology of the granitic Seychelles after Baker (1963)

The soils of the granitic islands are generally very poor and slightly acidic. This is due to the geologically very old granitic base rock, which is inherently poor in nutrients. The shallow, leached soils are typically short of organic matter.

The topography of the inner islands is fairly consistent.

5.1.2 Climate

The climate of the Seychelles inner islands is warm (monthly mean temperature of 26-28°C) and can be classified as “humid tropical”. No distinct dry season occurs throughout the year and even during the driest and coolest month in July the mean rainfall exceeds 70 mm (Chang-Seng 2007). The average annual rainfall of the Seychelles is 2,200 mm. The highest parts of Mahé receive the highest rainfall, of around 3,000 mm. The lower elevations, and particularly the southern parts of Mahé receive considerably less, which is on average 2,000 mm. Praslin (1,600 mm), La Digue (2,000 mm) and all the outer islands receive even less rain.

Humidity is uniformly high at an average 80% throughout the inner islands. Mean wind speed during the SE and NW monsoons are 7.3 and 3.2 knots, respectively. During the NW Monsoon the wind blows predominantly from the NW but is very variable, while during the SE Monsoon the wind blows almost consistently, with little variation, from the SE.

Data for the period 1972-2001 shows that the mean evaporation is 5.2 mm (Table 7). The maximum evaporation of 6.1mm occurs in September and the lowest evaporation of 4.3mm occurs in December and January.

Table 7: Monthly averages for the Seychelles International Airport from 1972 to 2001.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)	26,9	27,4	27,8	28,1	27,8	26,7	26,0	26,5	26,5	26,9	26,9	26,9
Rainfall (mm)	402,6	283,2	194,9	186,7	151,6	105,1	76,6	119,3	154,0	189,7	206,3	302,8
Relative humidity (%)	82	80	80	80	79	79	80	80	79	79	80	82
Predominant wind direction	NW	NW	NW	SW-NW	SE	SE	SE	SE	SE	SE	SW-NW	NW
Wind speed (Knots)	6,3	6,3	5,2	4,9	7,8	10,4	11,4	12,1	11,3	7,9	5,4	5,4

Alternating monsoons generated by changes in the air pressure over the Indian sub-continent (Thurman and Trujillo, 2004) dominate the seasonality. These changes in atmospheric pressure are driven by the lower heat capacity of rocks and soil compared with water. During northern hemisphere's summer, the Asian mainland warms faster than the adjacent water, creating low pressure over the continent and forcing air to move from the Indian Ocean onto the Asian landmass. During winter, the pattern is reversed and air over the Asian mainland rapidly cools, creating high pressure and the movement of atmospheric masses off the continent and out over the ocean. The general monsoon patterns are as follows:

- **South east monsoon**: relatively dry and cool season from May to October. Wind is dominated by persistent southeast trade winds which attain maximum speeds in the month of July and August (average of 5-10 m/s). Precipitation during this period is normally light (70-190 mm/month) and rather short-lived.
- **Pre-north west monsoon**: shift in wind from southeast to northwest that occurs in November and is associated with the onset of the rainy season (>200 mm) and very light winds (~3 m/s).
- **North west monsoon**: rainy season from December to March with relatively elevated precipitations in December and January (~300-400 mm/month). Winds are generally light (~3 m/s) and predominantly from the west and north west during this period. However, the northwest monsoon also corresponds to the cyclone season in the southwest Indian Ocean and storm surges and strong swells can hit the Seychelles during these months. For example, the large tropical storm named *Felleng* on January 27–

28, 2013 resulted in heavy rains (up to 184 mmm within 24 hrs), which caused severe flooding and numerous landslides across the country (World Bank 2013).

- **Pre-south east monsoon**: calmest and warmest period of the year during the month of April. This is the transition period when the intensity of winds reduces significantly (~2.5 m/s) before reversing to the southeast.

In contrast to many other inhabited South West Indian Ocean Islands such as Reunion, Madagascar, Comoros, Mauritius and Rodrigues, it should be noted that the Seychelles inner islands fall outside of the tropical cyclone belt (Chang-Seng 2007, ASCLME 2012). The cyclone paths for the period 1945-2003 (Figure 24) clearly show that most of the activity is to the south of the inner islands.

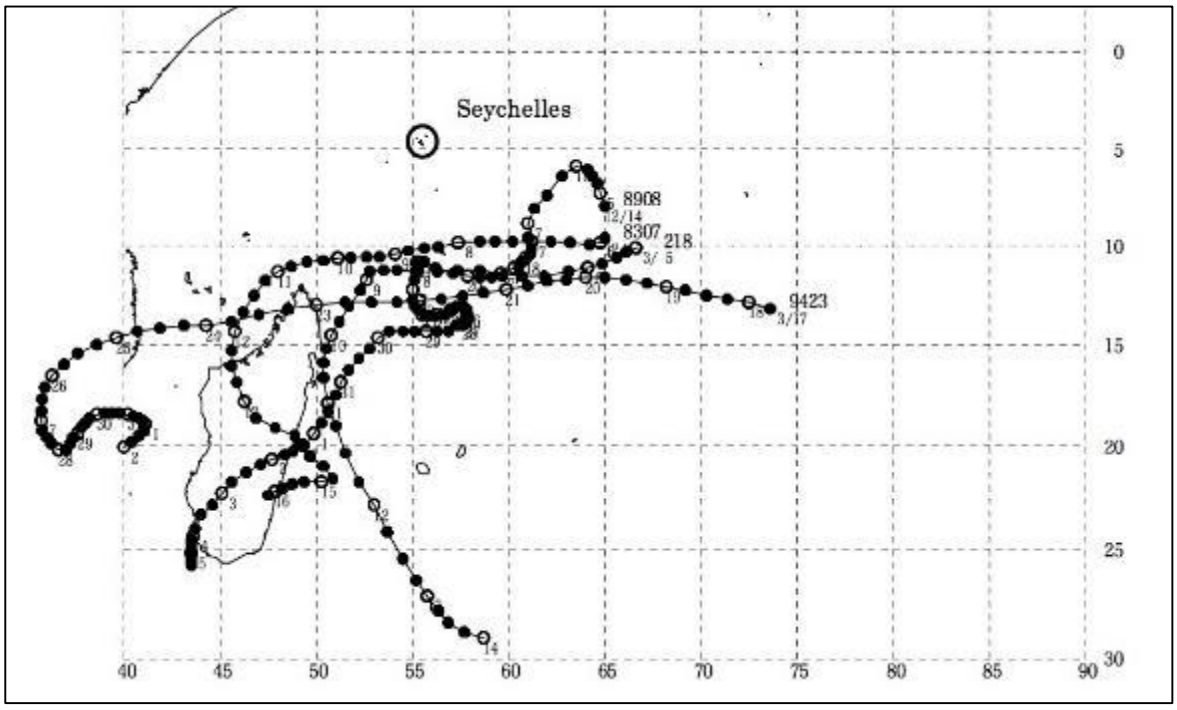

Figure 24: Cyclone routes 1945 – 2003 (JICA 2006, data source: Seychelles Meteorological Services).

The 2013 assessment conducted by the Government of Seychelles (World Bank 2013) also concluded that during the majority of the El Niño/La Niña years, an extreme weather event typically occurred over the Seychelles. Severe drought during the La Niña phenomenon of 1998-1999 caused acute shortage of freshwater resulting in the shutdown of public establishments (ASCLME 2012). In 1997-1998, the strongest El Niño ever recorded caused a 40% loss of revenue from the tuna fisheries sector (Robinson *et al*. 2010) and generated massive coral bleaching in the shallow reefs of the Seychelles granitic islands (Spencer et al., 2000). With global warming, other tropical oscillations could be altered, such as modifications in the Indian Ocean Dipole that is expected to lead to stronger easterly winds south of the equator during the austral spring, faster warming of sea surface temperatures in the western Indian Ocean compared with the eastern basin (Cai *et al*. 2013).

5.1.3 Wind

The Seychelles Meteorological Services (SMS) is responsible for monitoring wind and waves. Daily marine forecasts issued by SMS include forecasts on wind speed, significant wave height and wave period.

Figure 25 shows mean, minimum and maximum monthly wind speeds. Figure 26 and Figure 27 show wind strength and direction and the annual fractions of time of wind from various directions, respectively. Mean wind speed during the SE and NW monsoons are 7.3 and 3.2 m/s, respectively. During the NW Monsoon the wind blows predominantly from the NW but is very variable, while during the SE Monsoon the wind blows almost consistently, with little variation, from the SE.

In contrast to many other inhabited south west Indian Ocean Islands such as Reunion, Madagascar, Comoros, Mauritius and Rodrigues, it should be noted that the Seychelles inner islands fall outside of the tropical cyclone belt (Chang-Seng 2007, ASCLME 2012). The cyclone paths for the period 1945-2003 clearly show that most of the activity is to the south of the inner islands.

Month	Mean	SD	Min	Max
Jan	3.2	1.7	0.0	10.0
Feb	3.7	1.7	0.0	11.1
Mar	2.9	1.6	0.0	9.7
Apr	2.8	1.7	0.0	12.5
May	5.1	2.4	0.6	15.2
Jun	7.5	2.3	0.0	14.5
July	8.2	2.7	0.0	19.5
Aug	9.2	2.6	1.1	22.6
Sep	8.4	2.2	1.3	15.8
Oct	5.6	2.4	0.1	11.7
Nov	3.5	1.7	0.0	8.8
Dec	3.0	1.6	0.0	8.8

Figure 25: Average monthly wind speed (kts) at Seychelles International Airport (2000 to 2007) (Source: Seychelles Meteorological Services).

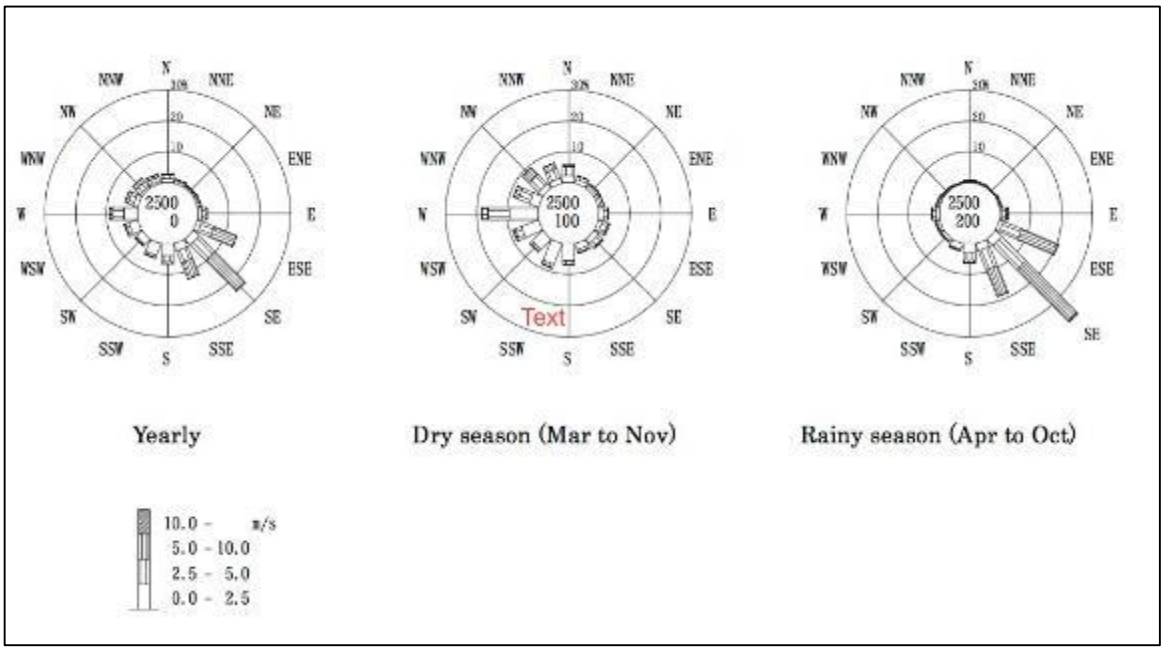

Figure 26: Wind rose for Seychelles International Airport (1996 – 2005 at 24 observations per day) (Data Source: JICA 2006 and Seychelles Meteorological Services).

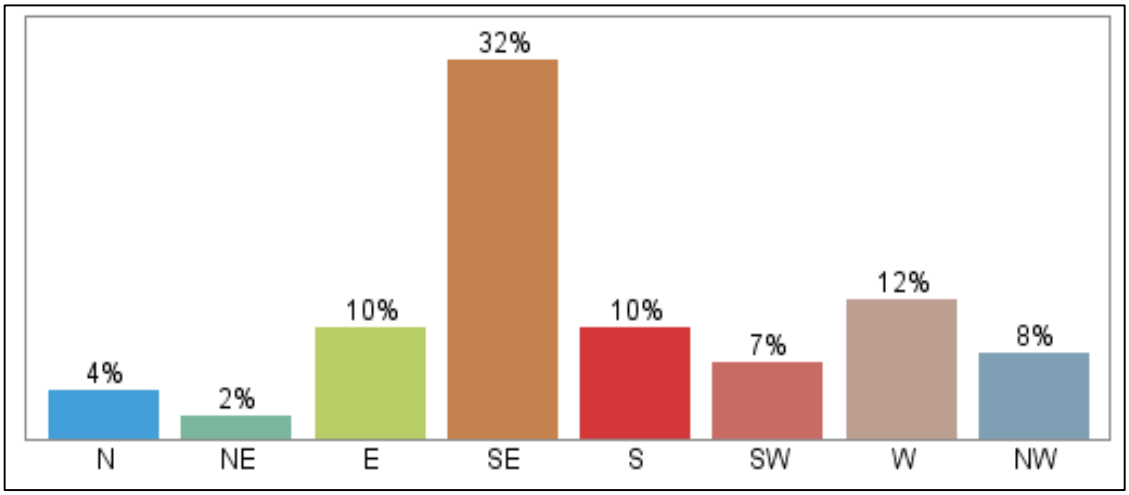

Figure 27: The fraction of time with the wind blowing from the various directions over the entire year. Values do not sum to 100% because the wind direction is undefined when the wind speed is zero. (Source: https://weatherspark.com/averages/29137/Mahé-).

5.1.4 Water Temperature

The sea surface temperature (SST) in Seychelles waters is characterised by two maxima and two minima, which are linked to the transition period associated with the monsoon and Indian Ocean Equatorial currents. The primary maxima occur in April, which is the Inter-Tropical monsoon phase, when SSTs can reach 30.7°C. The primary minima occur in July-August, when the Southeast monsoon is at its peak and the sun is in the northern hemisphere. In July-August, SSTs may be as low as 24.0°C. From November to February, secondary maxima occur and this is followed by secondary minima. The SST difference between secondary maxima and minima has a range of about 1°C. Overall, Seychelles has a mean sea surface temperature of 27.96°C with a standard deviation of 1.5°C (ASCLME 2012).

Minimum, maximum and mean temperatures at 5 and 15m depths (SFA data) are shown in Table 8 and Figure 28 shows monthly average SSTs. Data for SST recorded at Point La Rue during 2000 to 2006 is shown in Figure 30. The sampling locations for temperature and dissolved oxygen (DO) are shown in Figure 29.

Table 8: Minimum, maximum and mean temperature at 5 and 15 m around Mahé and Praslin/La Digue (Source: SFA Oceanographic database from World Ocean Database (NOAA/USAODC))

Location	Min (°C)	Max (°C)	Mean (°C)
Mahé (5m)	24.73	30.52	27.65
Mahé (15m)	23.55	30.17	27.51
Praslin/LaDigue (5m)	25.26	30.25	27.82
Praslin/LaDigue (15m)	24.94	30.42	27.77

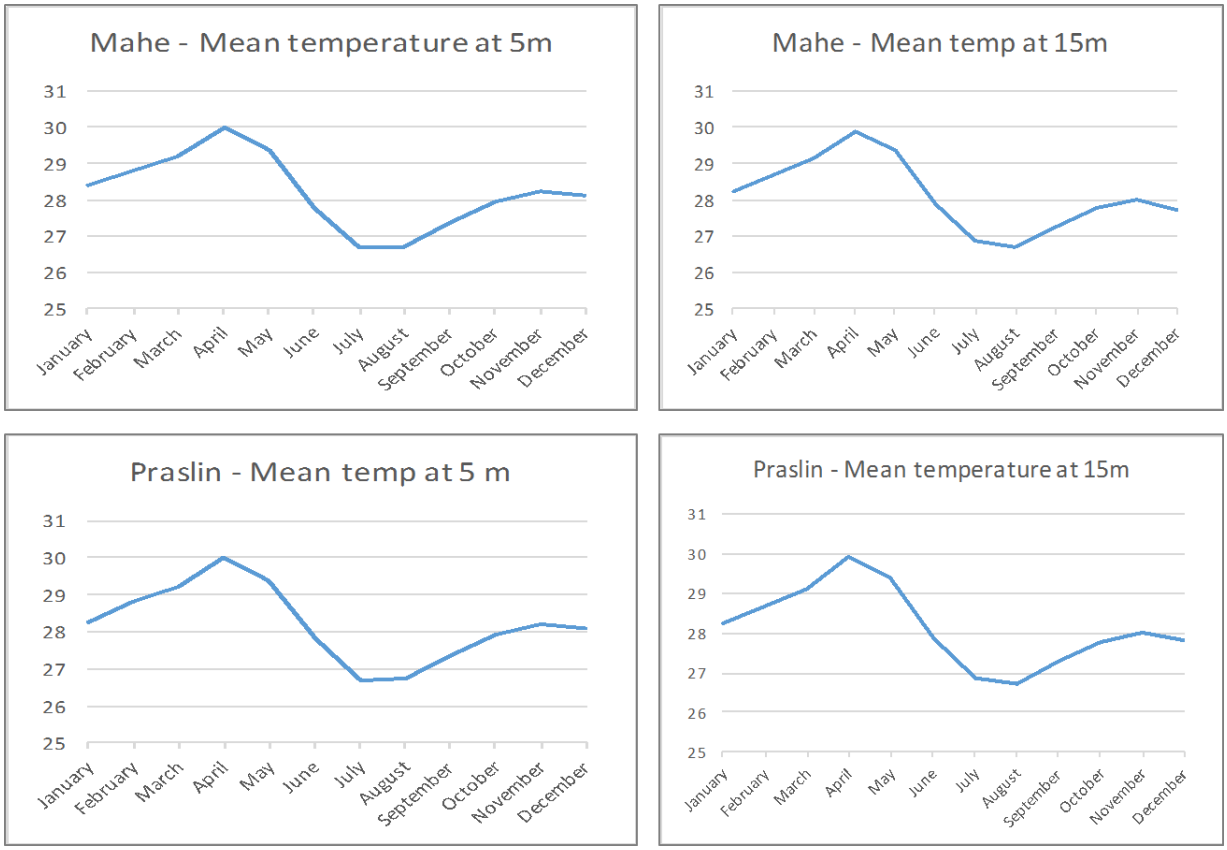

Figure 28: Mean monthly temperatures (°C) at 5 and 15m – Mahé and Praslin / La Digue (Source: SFA Oceanographic database from World Ocean Database (NOAA/USAODC))

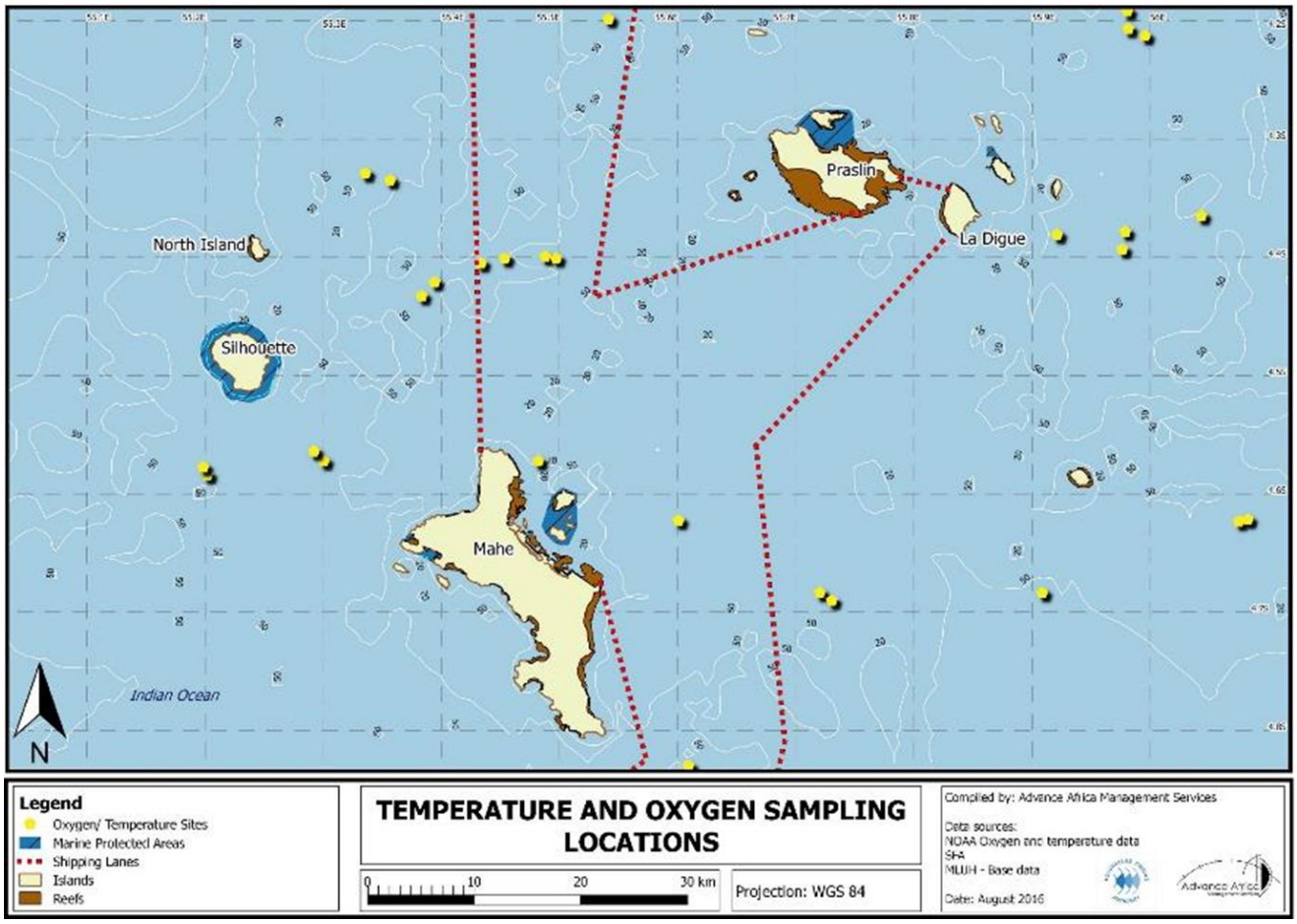

Figure 29: Temperature and oxygen sampling locations (Source: SFA Oceanographic database)

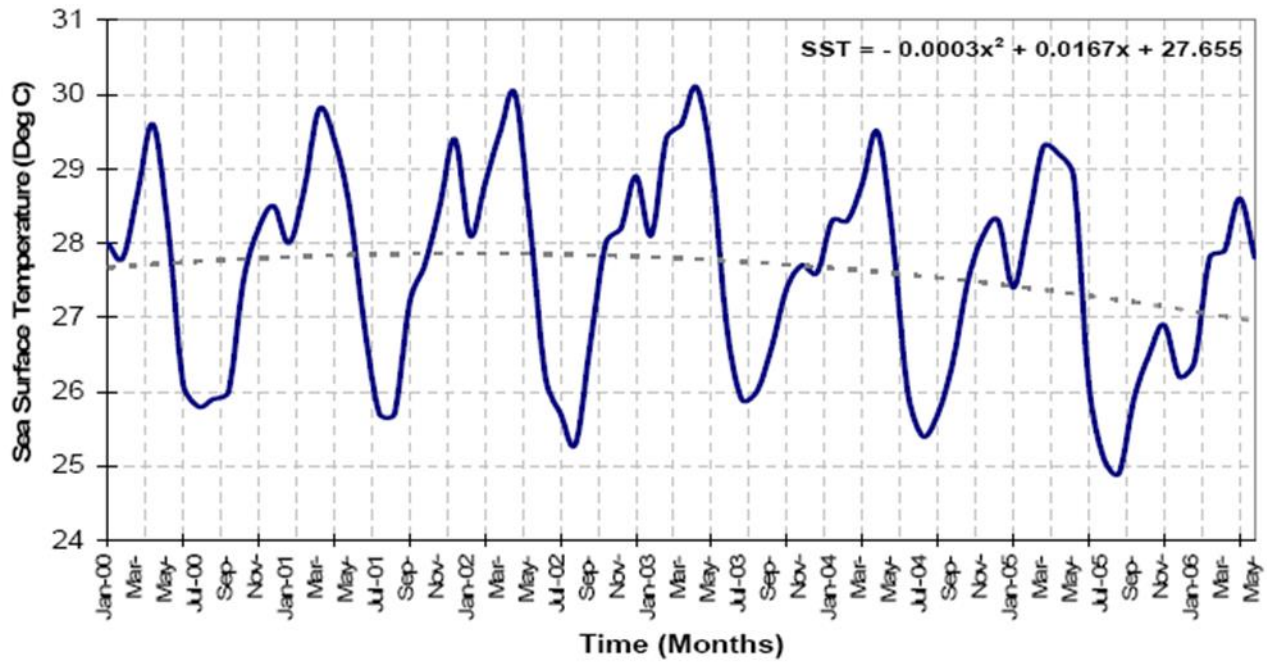

Figure 30: SST at Point La Rue 2000 to May 2006. (Source: Seychelles National Climate Change Strategy 2009, and Seychelles Meteorological Services)

Temperature / depth data from the YSI Sonde deployment during Cruise 3 show that there is very little difference in temperature with depth, decreasing by only 0.02°C from 0 to 45m. The data shown in Figure 31 were recorded at -4.67965, 55.39308333 near Isle Therese. All other Sonde temperature data, which show identical patterns, are stored in the SFA database and are available on request.

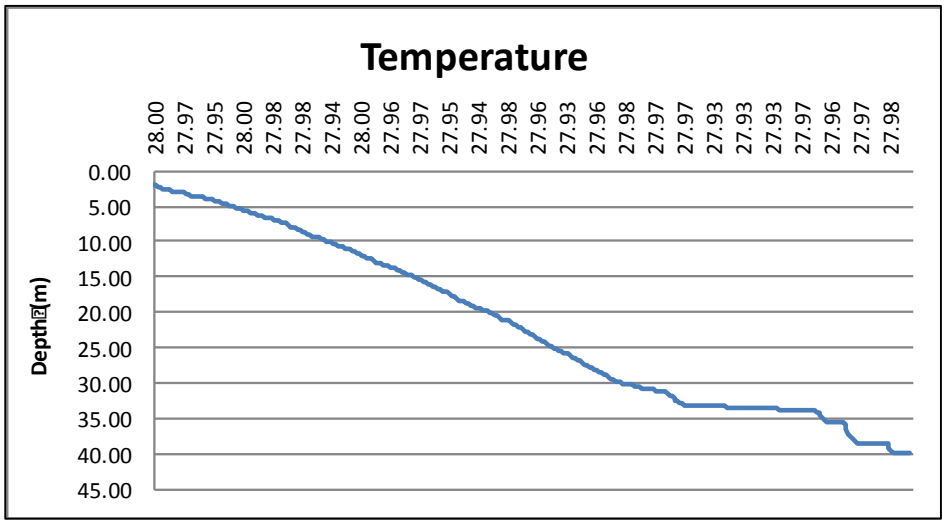

Figure 31: Change in temperature with depth off Isle Therese in October 2013

5.1.5 Salinity

Salinity patterns and variability are poorly understood in Seychelles, particularly during the rainy season. Taylor (1968) measured values around 35 ppt in “open circulation” areas beyond the fringing reef on the east coast. However, values as low as 5.6 ppt have been recorded in the inter-tidal zone after heavy runoff at Le Cap. On the reef flats, between Anse Etoile and Cascade salinities of 28 to 33 ppt have been recorded during the rainy season. The high runoff during the peak rainy season resulting in reduced salinities and increased turbidity were further reason to locate cage culture operations in the open ocean zone and not in the more protected inshore areas or bays.

Salinity measurements have been undertaken in Seychelles waters by various research programmes. In 1992, salinity measurements were taken at Beau Vallon (Mahé), Port Victoria (Mahé) and along the East Coast of Mahé. The average salinity for Beau Vallon and East Coast was 32.72 PSU, whereas for Port Victoria it was 33.14 PSU. There are some historical salinity profiles from Seychelles waters and these are available in the NOAA World Ocean Database. These data show a mean surface salinity of 35.13 PSU with a standard deviation of 0.7079.

During the October 2013 cruise, CTD readings were taken on the SW coast at -4.67965, 55.39308333 near Isle Therese. Salinity ranged from 32.7 to 34 PSU and did not vary much with depth (Figure 32). All other salinity Sonde data, and which show identical patterns, are stored in the SFA database and are available on request

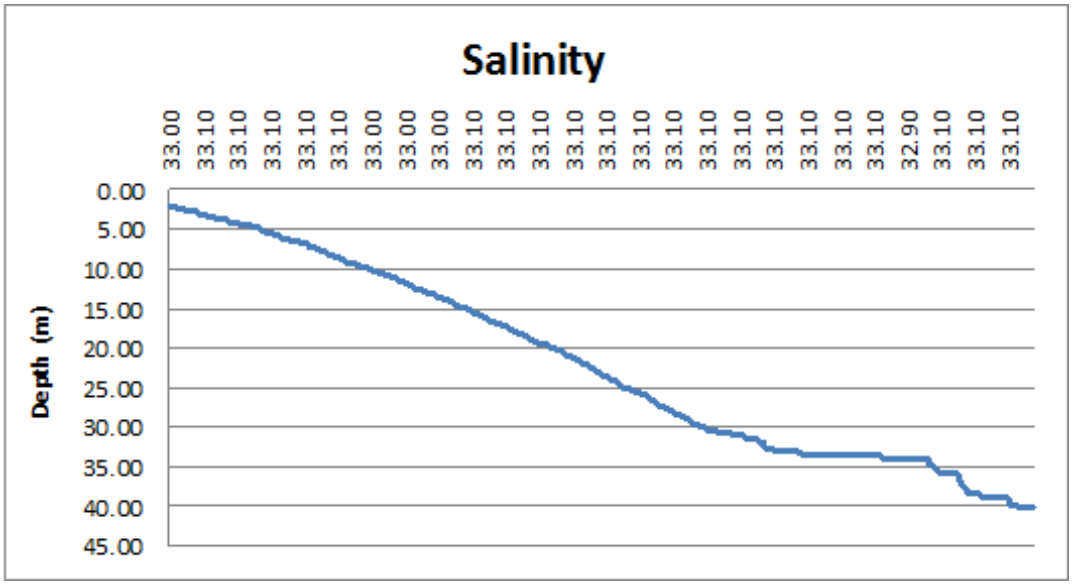

Figure 32: Change in salinity with depth off Isle Therese in October 2013 (Data Source: SFA Oceanographic Database).

5.1.6 Dissolved oxygen

There is very little data on dissolved oxygen (DO) levels for the inner islands and for the Mahé Plateau. The only available data (1980 to 1995 summarised in Figure 33), show DO levels ranging from 5.03 mg/L at 5 m to 3.98 mg/L at 50m. Similar DO levels at comparable temperatures have been recorded at Riau Archipelago in Indonesia and are considered satisfactory for the farming of a similar suite of species as those proposed for cage aquaculture in the Seychelles (Glude 1982). In fact, Indonesia is now one of the leading Grouper farming countries (FAO Fishtat 2014).

Depth	5m	25m	50m
Mean	4.78	4.67	3.98
Min	4.46	3.92	2.56
Max	5.08	4.92	4.75
SD	0.13	0.18	0.60

Figure 33: Dissolved oxygen levels (mg/L) at 5, 25 and 50m depth (Data source: SFA Oceanographic database from World Ocean Database (NOAA/USAODC))

5.1.7 Nutrients and pollutants

The coastal waters of Seychelles are generally low in nutrients with the exception of areas which receive significant inflow from rivers and food processing factories. High nutrient inputs in areas such as Port Victoria have led to eutrophication and formation of algal blooms in certain periods of the year when hydrodynamic and climatic conditions are favourable. However, in the absence of a monitoring programme, the risks associated with harmful algal blooms are yet to be fully established (ASCLME 2012). The main sources of Persistent Organic Pollutants (POPs) in the marine environment are agricultural activities. However, the use of POPs such as dichlorodiphenyltrichloroethane (DDT) and Aldrin has been banned in Seychelles. Agricultural activities in Seychelles are primarily small-scale and pollution from pesticides and fertilizers is minimal. In addition, concentrations of heavy metals are quite low, with the exception of chromium, copper, lead and zinc in Port Victoria (Radegonde 2008 in ASCLME 2012).

Unfortunately, the Seychelles does not yet have a regular ocean water quality monitoring programme for coliform bacteria (*E.coli*) or hydrocarbons. JICA (2006) engineers undertook basic water quality tests from 4 stations at ebb and flood tide in and around the Providence (Mahé) harbour site for chemical oxygen demand (COD), suspended solids, *E. coli* and n-hexane extracts. The results are shown in Table 9. All are

within Japanese standard values (JICA 2006) except for n-hexane extracts that indicate the presence of hydrocarbons. Coliform bacteria at this site were well within limits as was COD.

Table 9: Water quality test results at 4 stations around Providence harbour site. (Source: JICA 2006).

Test	Std. value	S1		S2		S3		S4	
		ebb	flood	ebb	flood	ebb	flood	ebb	flood
COD	< 2mg/L	2	1.4	1.4	1.2	1.2	1.2	1.8	1.6
Suspended solids		15	22	22	17	12	10	<3	5
n-hexane extracts	Not detectable	8	4	5	6	<4	<4	<4	-
Coliform bacteria (CFU/100ml)	<1000	50	80	150	250	98	300	65	72

5.1.8 Primary production

The oceanic waters surrounding Seychelles are characterized by low and variable rates of primary production. Primary productivity varies with changes in the monsoon season. In general, the SE monsoon period is relatively more productive than the NW monsoon period (Cuching 1973 cited in UNEP Seas and Reports and Studies No.13). There have only been a few studies focusing on primary production. Most data is captured through satellite imagery and model outputs. This data has, for example, been used to examine the effects of primary production on breeding success of several bird species in Seychelles (Monticelli *et al.* 2007).

Harmful algal blooms (HABs) have been recorded on three occasions in Seychelles. HABs are concentrated densities of phytoplankton that produce compounds harmful to humans or marine life. Because of the potential harm to public health and fisheries, the possibility that marine fish farm effluent could induce HABs in coastal waters has been raised. When HABs occur near fish farms, fish may die of direct poisoning, incur gill damage or show decreased growth and vigor (Beveridge 2004).

A significant phytoplankton bloom was recorded in August 2003 resulting in extensive macro-benthos and fish mortalities (Bijoux *et al*. 2003). Another harmful algal bloom (HAB) comprising the dinoflagellate *Cochlodinium polykrikoides* was recorded in October 2015 resulting in significant shallow reef fish mortalities. A further, smaller bloom (unknown species) occurred in December 2015 (SFA, 2015).

It has often been suggested that nutrient effluents from cage culture operations have led to localised eutrophication that could trigger algal events. However, there is little research to date supporting a link between nutrient discharge from fish farms and the occurrence of HABs (Huntington et al. 2006, Halwart *et al*. 2007). Moreover, in their very extensive and critical review of the impacts of cage culture on the environment, Price and Morris (2013) suggest that algal blooms in the vicinity of cage culture operations are consequences of larger oceanographic events. Moreover, the dispersal of nutrients from a point source such as a cage farm in the open ocean would be too rapid to lead to an algal event.

5.1.9 Currents, Tides and Waves

From a broad ocean circulation perspective, the Seychelles Bank is in the centre of the northern Indian Ocean Gyre, a large-scale circulation pattern that changes with the seasonal monsoon (Novzhilov *et al.* 1992; Spencer et al. 2000). During the northwest monsoon from November to March, the Seychelles are influenced by the eastward-flowing Equatorial Counter Current (ECC) which is flanked to the north and to the south by the westward-flowing North Equatorial Currents (NEC) and South Equatorial Current (SEC) (Figure 34). The ECC flows between 2 and 8°S contrary to similar equatorial counter currents of the Pacific and Atlantic oceans which flow north of the equator. During the north hemisphere's summer (southeast monsoon from April to October), the winds reverse with southeast trade winds becoming dominant. As a result, the ECC disappears and is replaced by the Southwest Monsoon Current (Figure 34), which flows from west to east centred on 6-10°N and is fed by the northward Somali Current that flows along the coast of Africa with velocities approaching 1-2 m/s (Thurman and Trujillo 2004). The SEC remains present in both seasonal monsoon contexts.

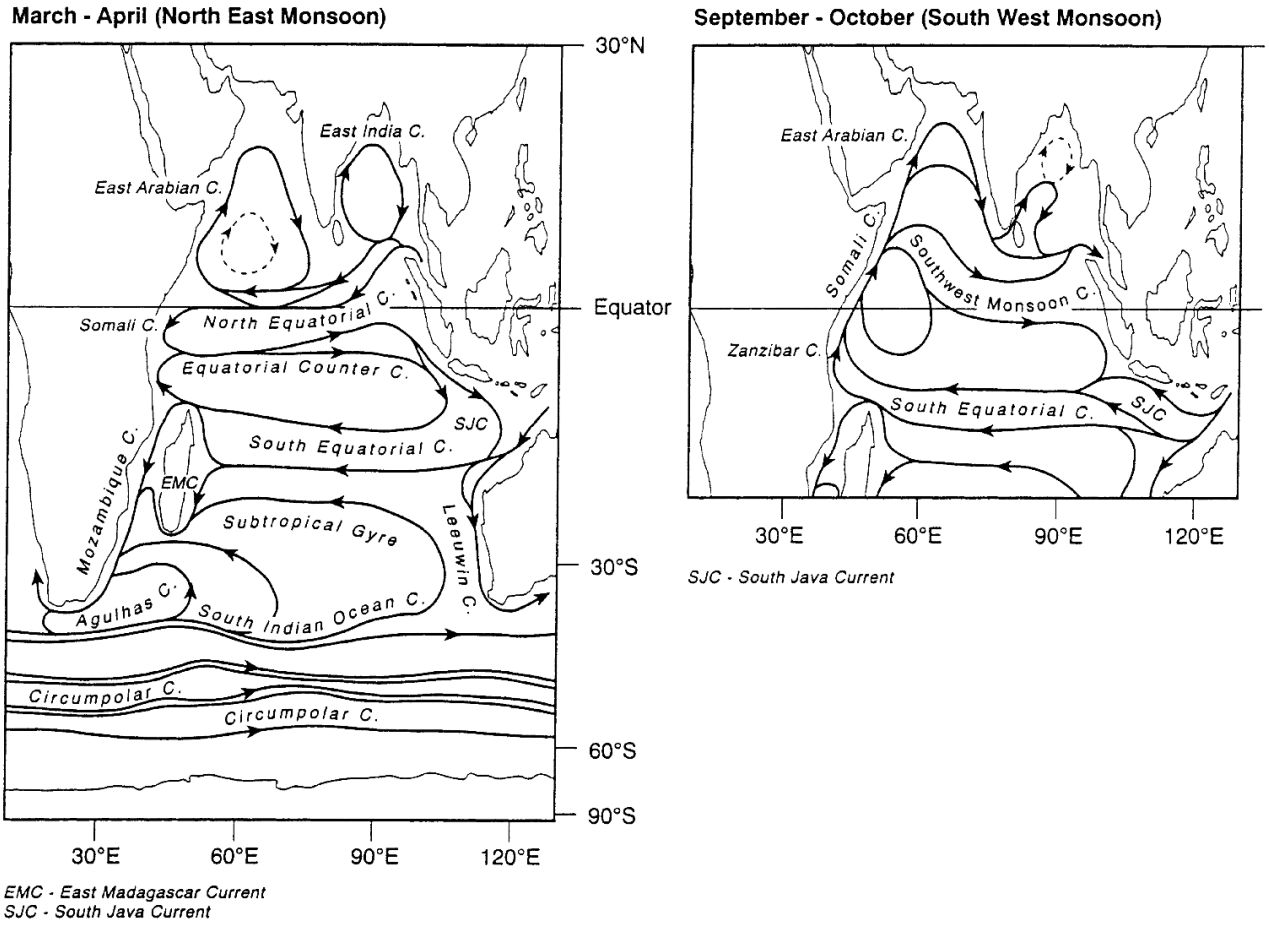

Figure 34: Surface currents in the Indian Ocean in March to April (late northeast monsoon) and September-October (late southwest monsoon). Adapted from Spencer et al. (2000)

Vasco Consulting (2008) have done extensive research on the two sand burrows (sand extraction areas) off the NW and the SW coast of Mahé. In general, however, very little work has been done on coastal currents in Seychelles waters.

Most studies have been done on a project basis and, usually, current data have constituted only a small component of the projects. The Beau Vallon Sewerage Plant feasibility study by SETOI 1990 (in Grandcourt 1995) investigated the currents in the bay. They recorded that the direction of the current depends on the prevailing wind direction. During the SE Monsoon the current veered anti-clockwise in the bay and during the NW Monsoon the current direction was clockwise. Current speeds ranged between 5 and 10 cm/sec during the SE Monsoon and between 10 and 26 cm/sec during the NW monsoon. Data extracted from the NOAA database by the ASCLME (2012) project for current speeds in the offshore area at Beau Vallon, Mahé, are shown in Figure 41. The data closely match the monthly current speeds at Lat-4.5°: Lon 55.5° data, shown in Figure 42.

Vasco Consulting (2008) deployed two acoustic Doppler current profilers in the sand burrows for a three week period from the last week of March until the second week of April 2009. The results are presented below (Figure 35 to Figure 38).

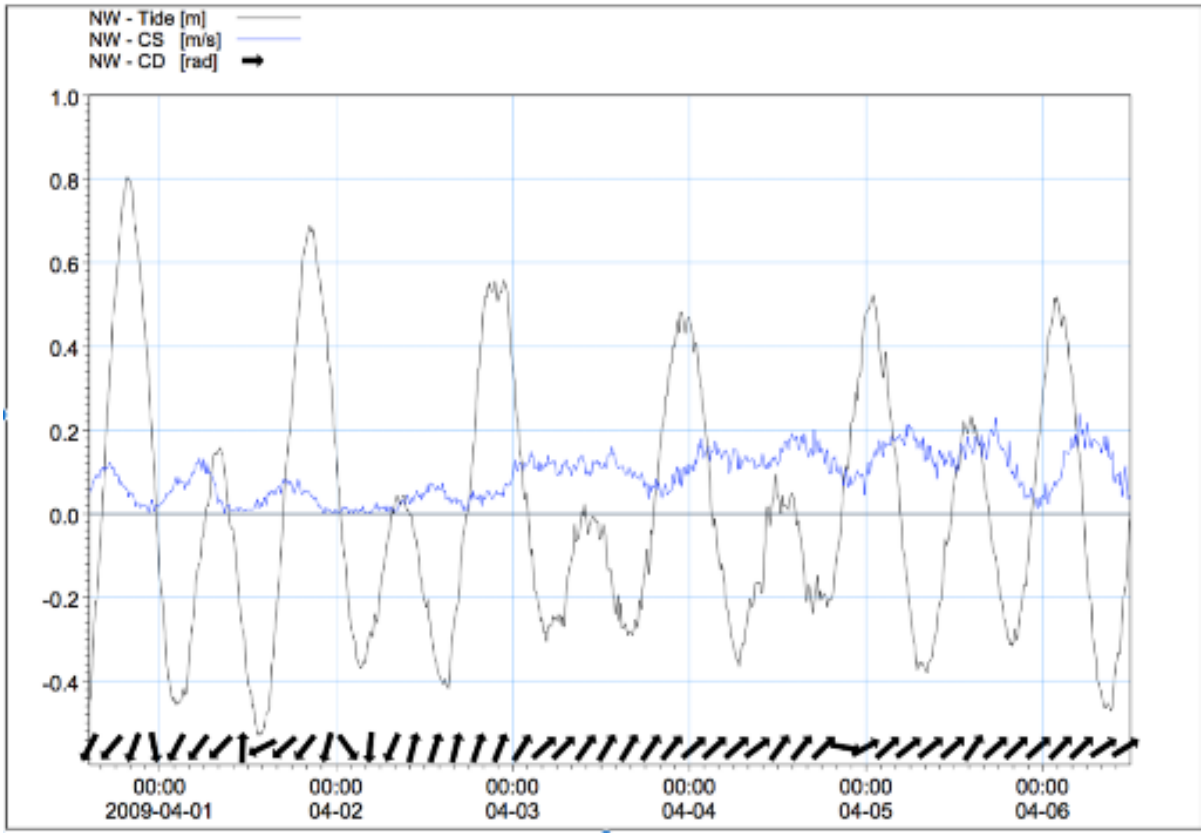

Figure 35: NW Burrow tide and currents April 2009. (measured ADCP data)

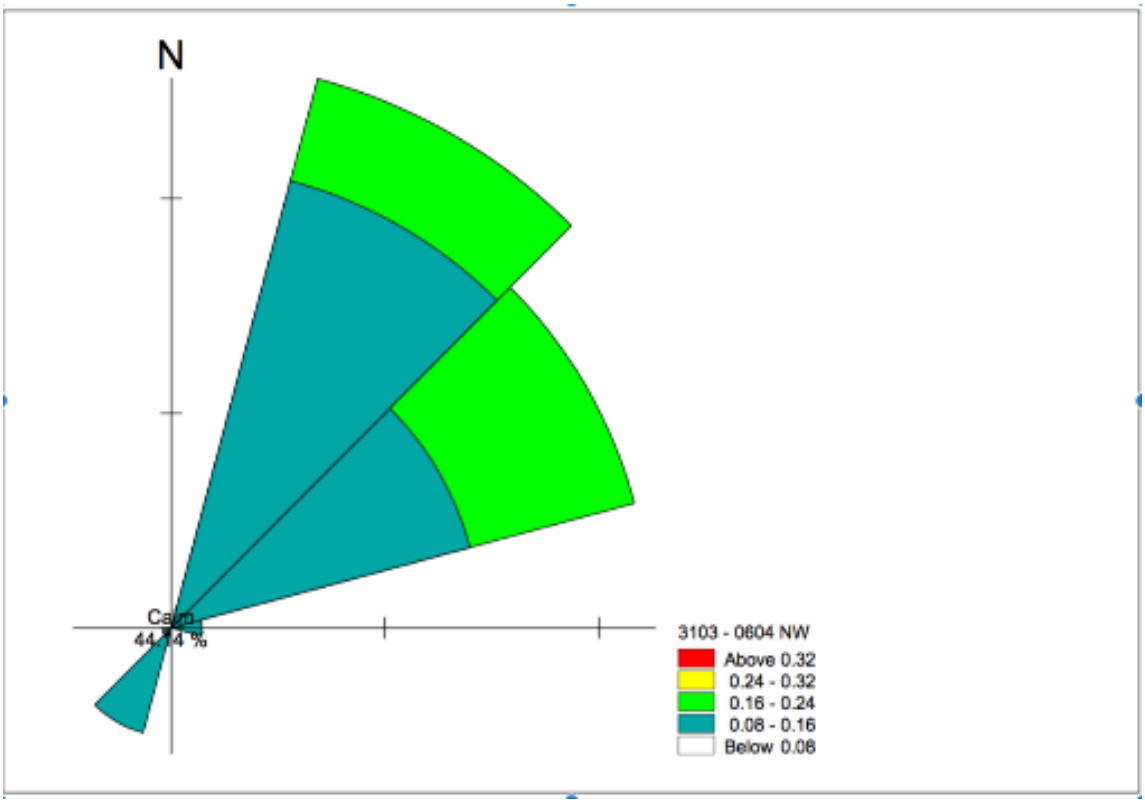

Figure 36: NW Burrow – Current rose April 2009 (measured ADCP data)

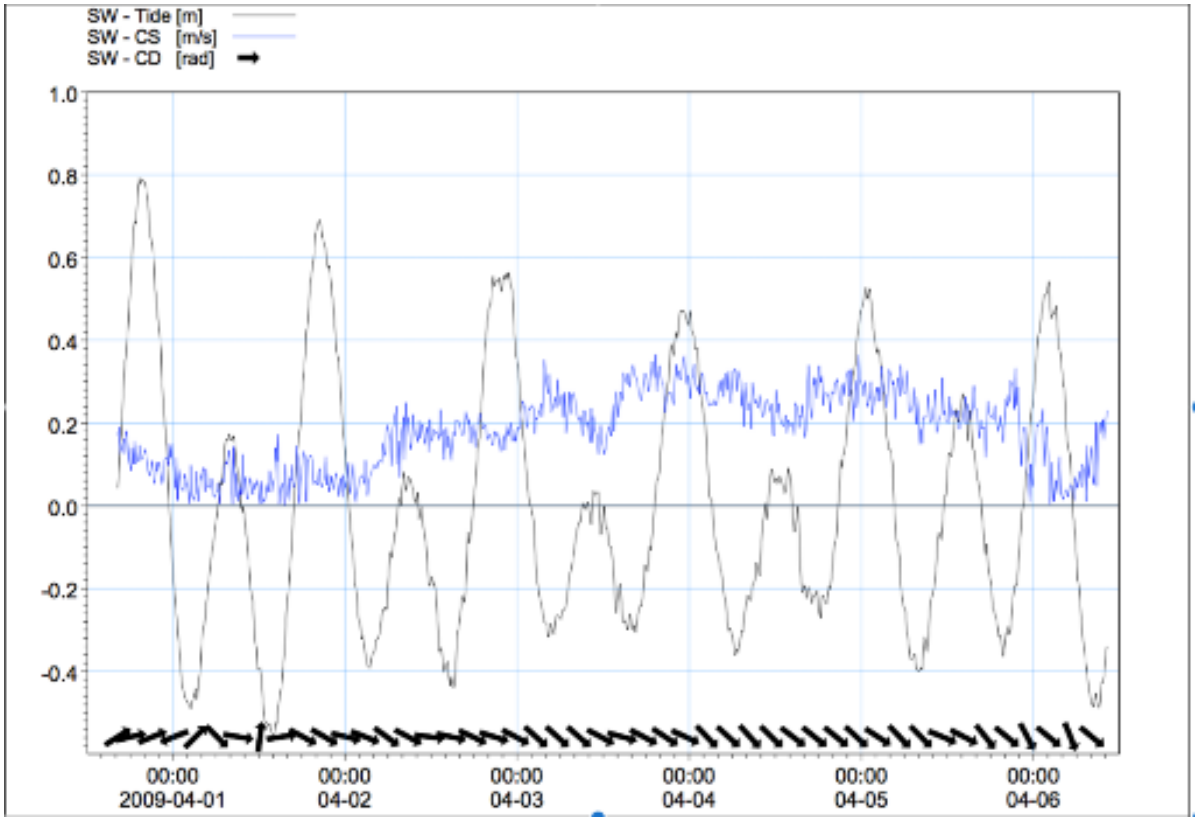

Figure 37: SW Burrow tide and currents April 2009 (measured ADCP data)

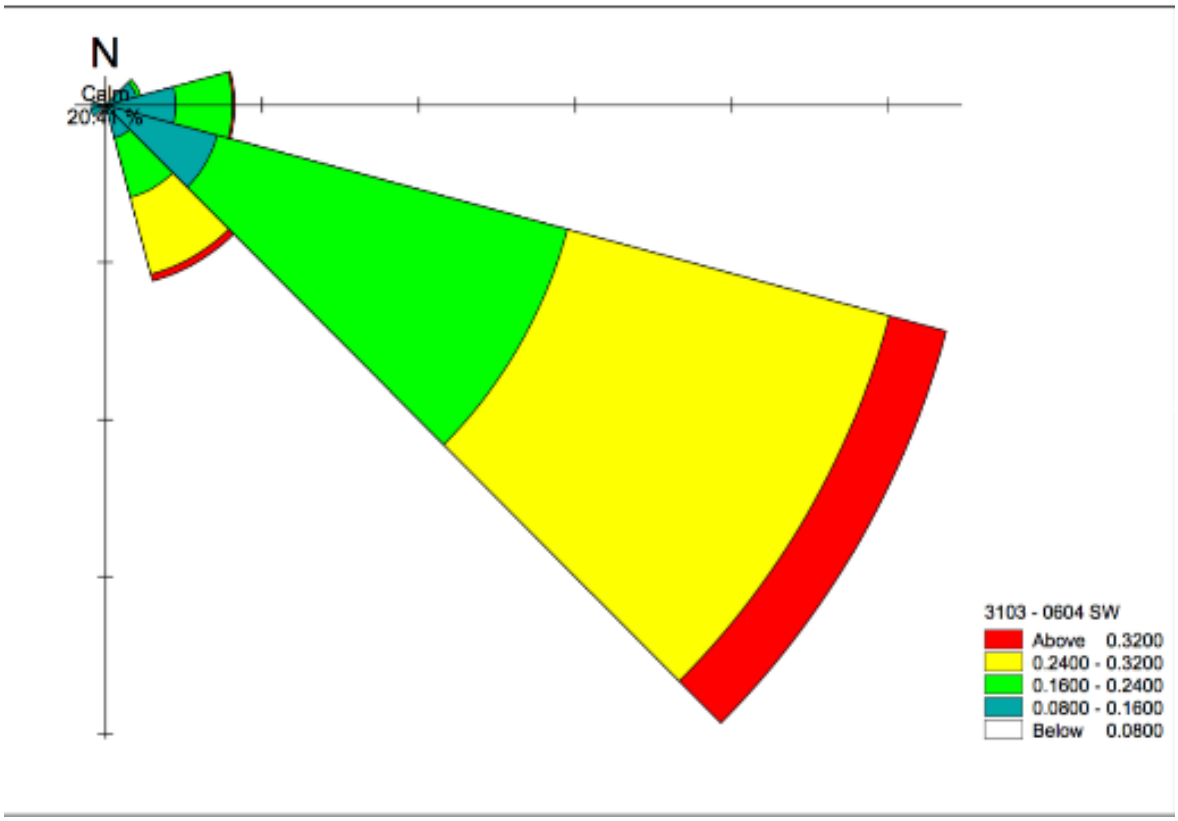

Figure 38: SW Burrow area – Current rose April 2009 (measured ADCP data)

Vasco Consulting (2008) concluded that the measurements and the predictive modelling thereof indicated the presence of the eastward flowing Southern Equatorial Counter Current (SECC), forcing the dominating current in the NW borrow area to the North-East and in the SW borrow area to the South-East. Current speeds varied between 0.02 to 0.36 m/sec. They also found that large amplitude tides are driving forces of the current. At tidal conditions with small amplitude however, the SECC is the driving force for the local current. After calibrating the model they simulated the hydrodynamic conditions that can be expected in August, during the SE Monsoon. Wind data for the SE Monsoon data were used as input data for the model. The predicted currents in the two burrows (Figure 39 and Figure 40) during the SE Monsoon were weak (ca. 0 - 0.16 m/sec and 0 – 0.11 m/sec, respectively) in comparison to the NW Monsoon period, suggesting that the SE wind dampens the current.

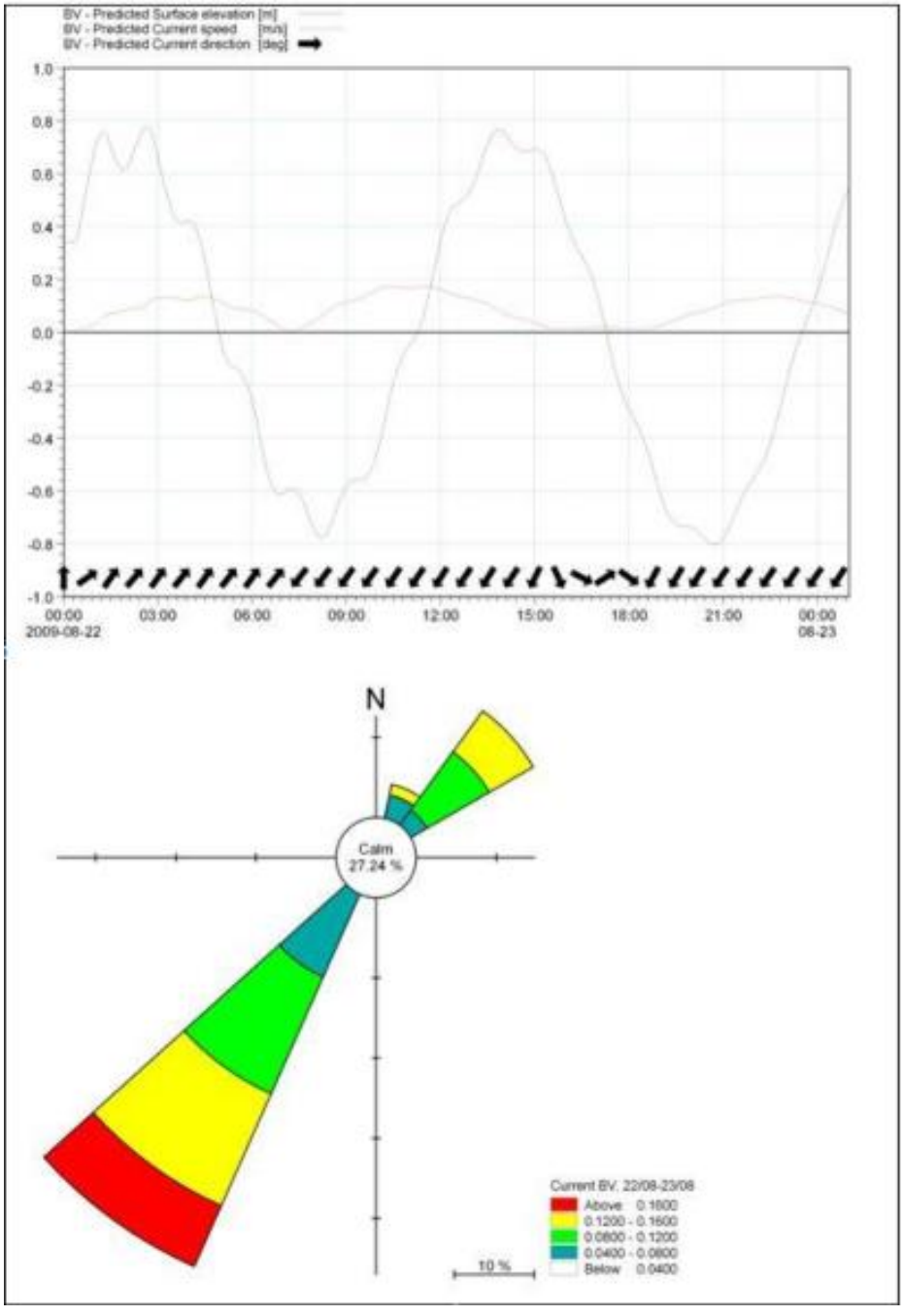

Figure 39: NW Burrow area – tide and predicted current for August 2009

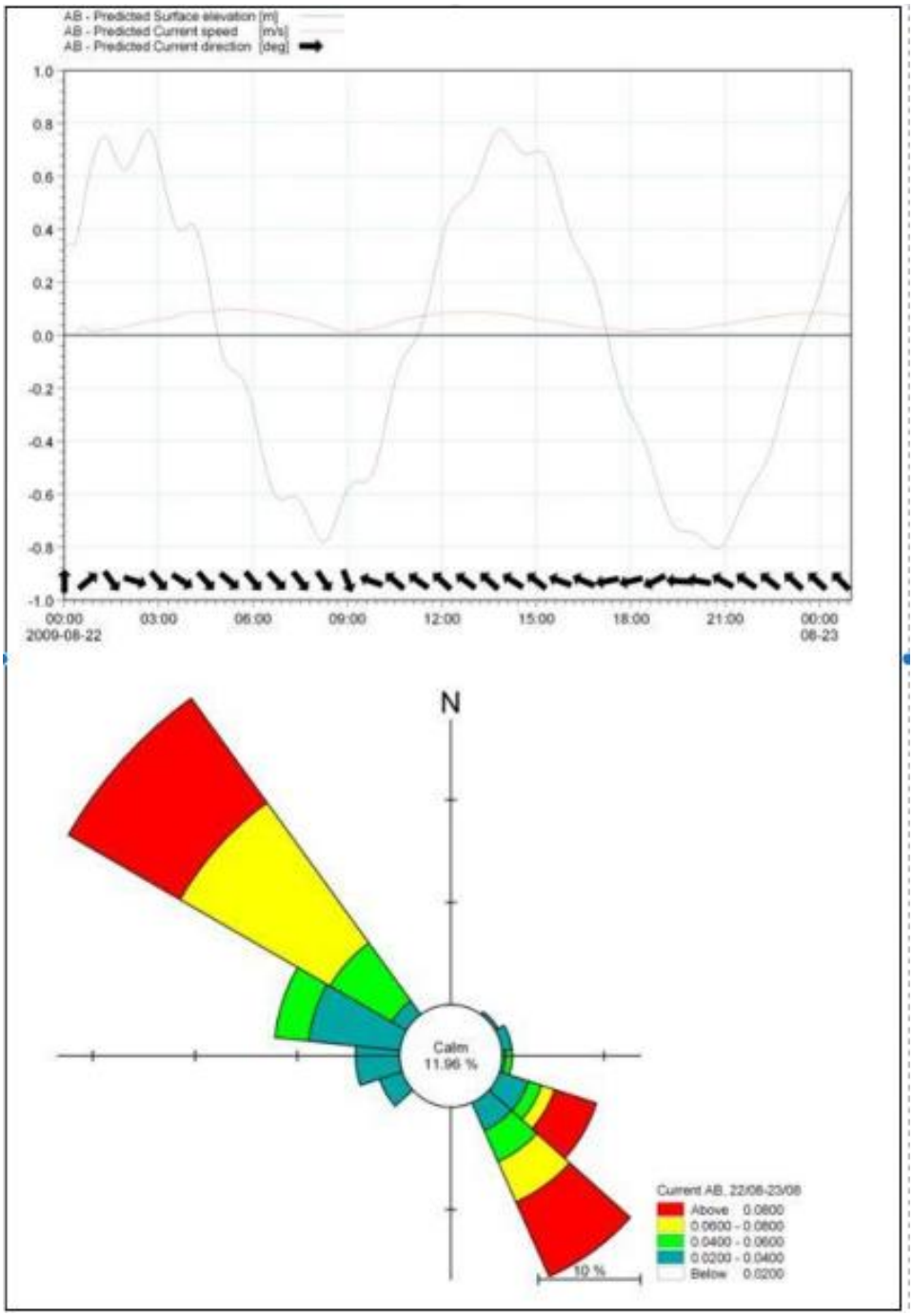

Figure 40: SW Burrow area – tide and predicted current for August 2009

Other current velocity data include monthly current speeds measured by remote sensing at Lat -4.5°. Long 55.5° (Figure 42) (data from C. Gerry, SFA Oceanography Division), which show a very similar pattern to those in the offshore region of Beau Vallon Bay (see below). The recorded minimum (5cm/sec), maximum (29 cm/sec) and mean (18 cm/sec) **current speeds fall within the optimal range for the dispersal of particulate matter from below sea cages** (Cardio & Lovatelli 2015).

During Cruise 2 SFA used vessel drift speed as a proxy for current speed. These data are shown in (Figure 43). Only those drift speeds were used to estimate current speed when there was no wind and the sea was glassy. The mean current speed was 0.26 m/sec and falls well within the ranges shown in Figure 42 and Figure 43).

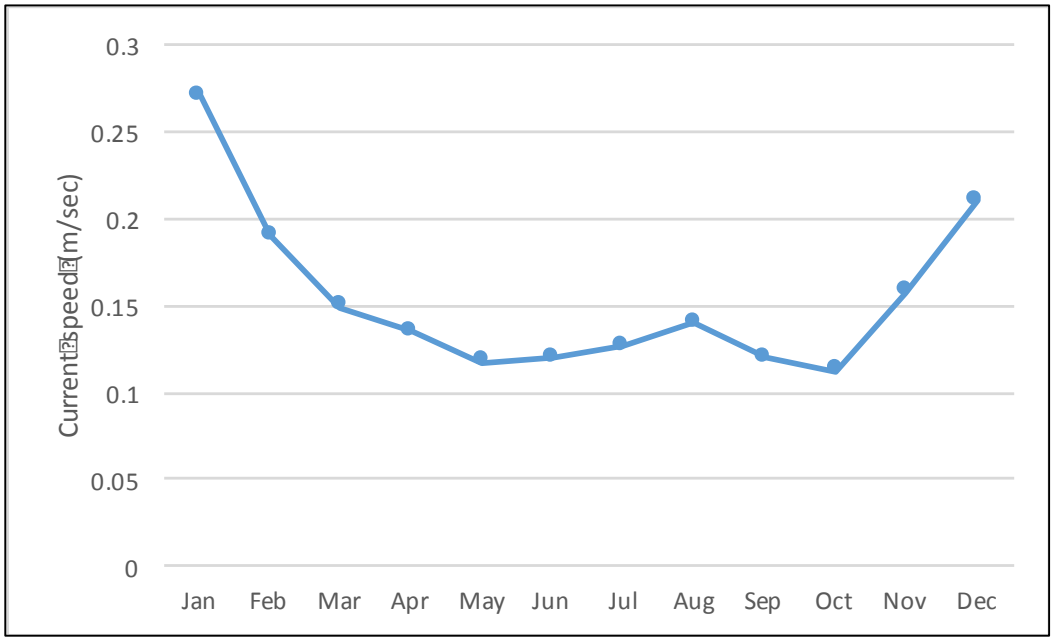

Figure 41: Mean monthly surface current speed offshore from Beau Vallon on Mahé (Source: ASCLME 2012 / NOAA)

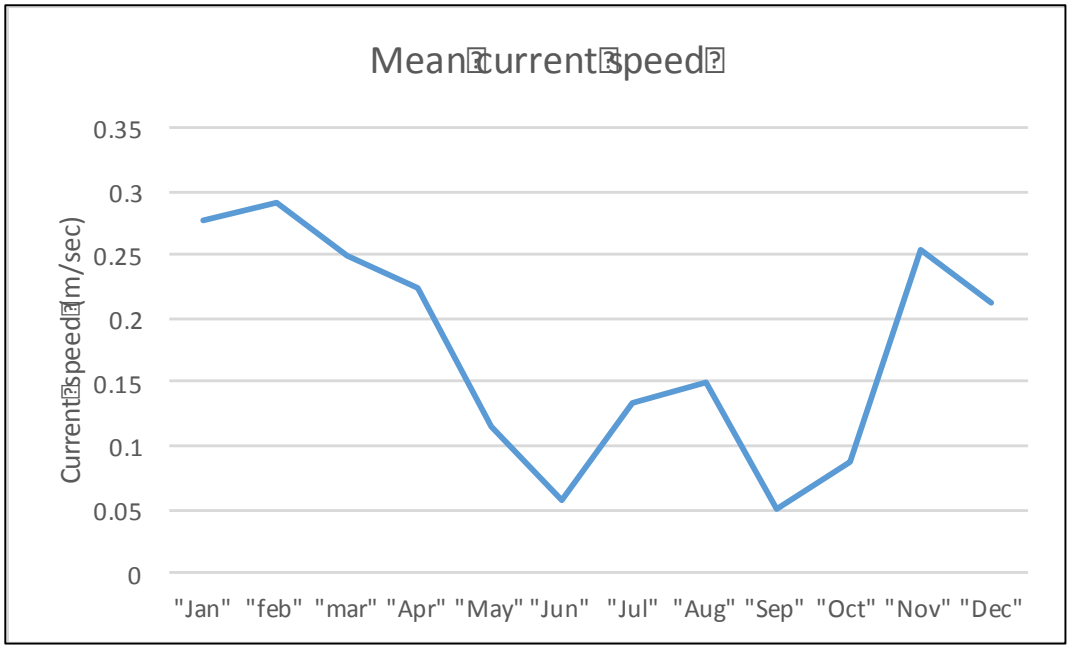

Figure 42: Monthly current speed (m/sec) at Lat-4.5°: Lon 55.5° (Mean=0.18, Max = 0.29, Min = 0.05) (Data Source: World Ocean Database (NOAA/USAODC). The datasets are of a continuous series).

During the planning phase of the fisheries facilities on Providence Island, Mahé, and the JICA engineers measured current speeds at 0.5m depth in the vicinity of Providence harbour and recorded current speeds of 10cm/sec (JICA 2006).

Transect	Date	Wind	Sea condition	Time start	Time end	Seconds	Waypt start	Waypt end	Distance (m)	Drift m/sec	Depth m	Current speed
1	27-Jan-09	Light air	Rippled	9.1	9.25	900	10	11			43-46	m/s
2	27-Jan-09	Light air	Rippled	9.53	10.12	3540	12	13			42-43	
3	27-Jan-09	Light breeze	Wavelets	11.25	11.4	900	14	15	1050	1.17	42-48	
4	27-Jan-09	Light air	Rippled	13.2	13.25	300	16	17	500	1.67	38-44	
5	28-Jan-09	Calm	Glassy	17.15	17.22	420	20	21				
6	28-Jan-09	Calm	Glassy	8.3	8.35	300	22	23			45-50	
7	28-Jan-09	Calm	Glassy	9.04	9.18	840	24	25	205	0.24	39-43	0.24
8	28-Jan-09	Calm	Glassy	10.38	10.5	720	26	27	520	0.72	35-37	0.72
9	28-Jan-09	Calm	Glassy	11.56	12.11	3300	28	29	426	0.13	35-37	0.13
10	28-Jan-09	Calm	Glassy	13.2	13.32	720	30	31	245	0.34		0.34
11	28-Jan-09	Light air	Rippled	15.08	15.24	960	32	33	660	0.69	41-43	
12	29-Jan-09	Light air	Rippled	10.3	10.37	420	36	37	224	0.53	43-46	
13	29-Jan-09	Calm	Glassy	11.3	11.37	420	38	39	124	0.30	45-50	0.30
14	29-Jan-09	Calm	Glassy	12.05	12.18	780	40	41	180	0.23	46-47.5	0.23
15	29-Jan-09	Light air	Rippled	13.38	13.47	540	42	43	266	0.49	46-49	
16	30-Jan-09	Calm	Glassy	7.5	8	3000	50	52	45	0.02	34-35	0.02
17	30-Jan-09	Calm	Glassy	8.53	9	2820	53	54	245	0.09	36-40	0.09
18	30-Jan-09	Calm	Glassy	9.35	9.5	900	55	56	243	0.27	43-46	0.27
19	30-Jan-09	Calm	Glassy	10.37	10.5	780	57	58	345	0.44	36-37	0.44
20	30-Jan-09	Calm	Glassy	11.5	12.04	3240	59	60	184	0.06	44-46	0.06
21	30-Jan-09	Light air	Rippled	12.35	12.46	660	61	62	319	0.48	44-47	
22	30-Jan-09	Light breeze	Wavelets	13.4	13.55	900	63	64	484	0.54	36-38	
											Mean	0.26
											SD	0.20

Figure 43: Vessel drift speed used as a proxy for current speed (SFA, 2016c)

Considering all these data sources the current speeds during SE monsoon ranged from 0.05 to 0.11m/sec and during the NW monsoon from 0.5 to 0.36m/sec. These ranges are well within international benchmarks for cage aquaculture (Cardia and Lovatelli 2015).

Tidal range data from the automatic tide gauge at the Seychelles International Airport at Pointe Larue is shown below in Table 10. The work by Vasco Consulting (2008) clearly show that the tides have a marked influence on current velocity and direction.

Table 10: Seychelles mean tide levels (1993-2010) at Point La Rue, charted against a fixed Admiral Chart Datum (Data source: Seychelles Meteorological Authority).

Tide	Height (m) above chart Datum
Highest Astronomical tide (HAT)	2.10
Mean high water spring (MHWS)	1.63
Mean high water (MHW)	1.45
Mean high water neap (MHWN)	1.27
Mean Level	1.10
Mean Low water neap (MLWN)	0.81
Mean Low water (MLW)	0.63
Mean Low water Spring (MLWS)	0.45
Lowest astronomical tide (LAT)	0.20

Waves are either swells (all year-round dominated by SE-swells) or wind-waves (Vasco Consulting 2008). Maximum wave heights at various storm return periods are shown in Table 11.

Table 11: Offshore maximum wave height at variable storm return periods.

Storm return period (Years)	Wave height (1994-2004 data)
1	3.46
10	4.02
50	4.41
100	4.58

Data source: Vasco (2008), OCEANOR Wave Data 1994-2004 at LAT 4°23' S & LON 55° 28' E

During the NW monsoon offshore waves generally approach the coast from a N-NE direction and remain relatively moderate in height, with a significant wave height (H_s) of 1.2 m and only 9.5% of the waves greater than 2 m high. During the SE Monsoon, waves are higher and approach the coast from a S-SE direction. During the SE monsoon, H_s = 2.16 m and peaks at 2.4 m (Figure 44).

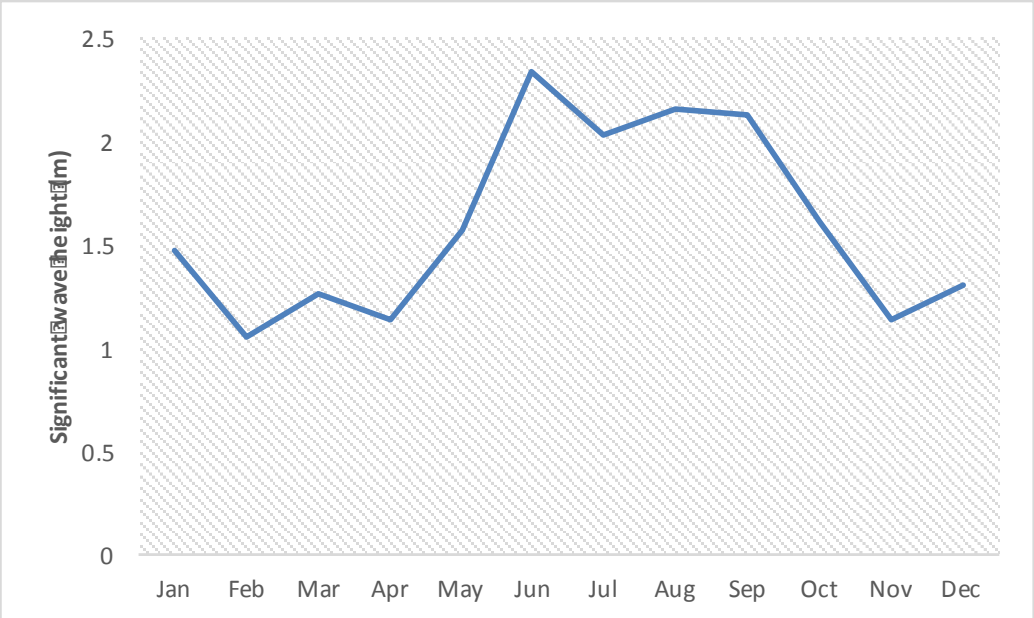

Figure 44: Significant wave height at Lat -4°: Lon 55° (Data source: Seychelles Meteorological Authority)

Calculations by JICA (2006) engineers that served as background data for the design and construction of the fisheries facilities at Providence Harbour, Mahé, present frequency of wave height, direction and period of offshore wave patterns in Seychelles. The data show that wave direction is influenced by wind direction and waves from E to S account for approximately 80% of the frequency. Maximum recorded wave height is around 5 m, which is approximately the same as the calculated maximum wave height during the SE Monsoon (calculated by multiplying Hs by 1.9). Wave period distribution ranges widely from 3 to 10 sec, although the predominant period is 6 to 8 sec (Figure 45 below).

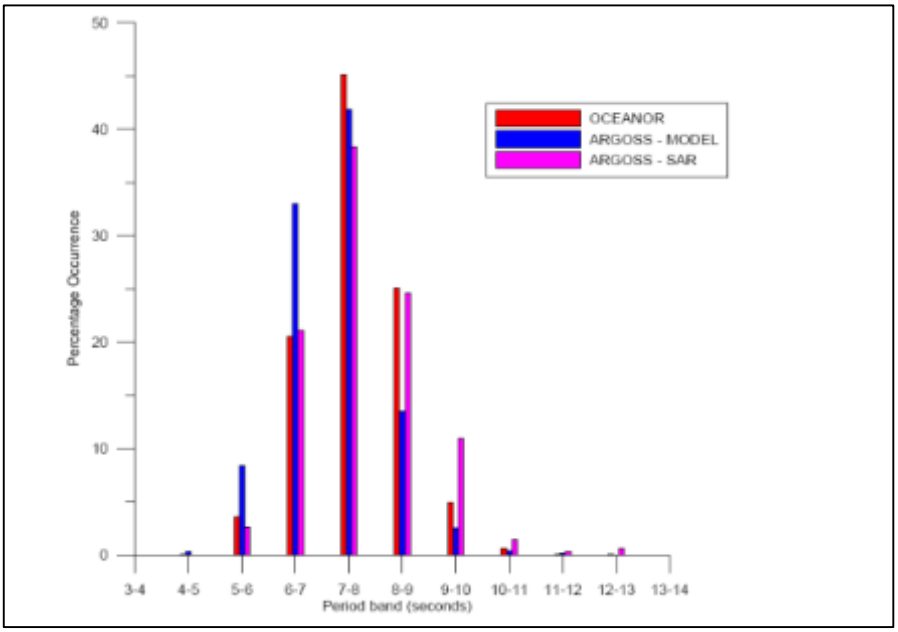

Figure 45: Satellite deduced offshore wave periods (Source: Vasco Consulting, 2008)

Significant and maximum wave heights, wave periods (Figure 44, Figure 46 and Figure 47) and wind speeds (Figure 25) recorded for Seychelles are well within the stress thresholds of present day off-shore, HDPE cage systems (Jørn Vad, AkvaPlan Niva, Norway, pers.comm.). Modern HDPE cage systems can deal with significant wave heights of over 6m (Cardia and Lovatelli 2015). Submerged cages, such as the Aquapod and SeaStation, would also be very suitable (L.Gace. President, Innovasea, Panama, personal communication with proponent team).

5.1.10 Hydrology

The inland waters or hydrology in Seychelles can be divided into three categories:

5) Rivers and streams;

6) Highland wetlands; and

7) Lowland wetlands.

There are 146 water courses on the three main islands of Mahé, Praslin and La Digue and these are listed for protection under the State Lands and River Reserves Act (1976) in recognition of their importance for socioeconomic development. The lower reaches of watercourses in many regions have been affected by human activity including enrichment and chemical pollution, canalisation and reclamation of flood plains. (GoS, 2014).

Lowland wetlands were a characteristic feature of many of the original coastal plains of the granitic inner islands. The coastal dune formations naturally created a simple basin-like structure to the landward that prevented free drainage resulting in the formation of extensive inland wetlands. These habitats were historically used for agricultural purposes such as rice production. However as agricultural patterns and development pressures changed these areas were increasingly drained to meet the demand for flat land and this trend has continued into the 21st century, such that lowland wetlands can be considered the most severely threatened habitat type in Seychelles. It is estimated that some 90% of lowland wetlands have been lost to reclamation since the colonisation of the islands in 1770 (GoS, 2014).

WAVE DIRECTION	U.K.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
WAVE HEIGHT(M)																		
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 - 0.50	0 .0	676 2.6	450 1.7	48 .2	45 .2	65 .2	330 1.3	1090 4.1	638 2.4	68 .3	9 .0	0 .0	0 .0	0 .0	0 .0	0 .0	22 .1	3441 13.1
0.50 - 1.00	0 .0	1004 3.8	728 2.8	40 .2	85 .3	16 .1	1088 4.1	2080 7.9	699 2.7	354 1.3	35 .1	0 .0	0 .0	27 .1	107 .4	91 .3	92 .3	6446 24.5
1.00 - 1.50	0 .0	774 2.9	254 1.0	14 .1	0 .0	1 .0	635 2.4	1771 6.7	719 2.7	320 1.2	25 .1	0 .0	17 .1	0 .0	75 .3	52 .2	85 .3	4742 18.0
1.50 - 2.00	0 .0	127 .5	3 .0	0 .0	0 .0	0 .0	799 3.0	2000 7.6	584 2.2	282 1.1	2 .0	0 .0	0 .0	17 .1	6 .0	42 .2	43 .2	3905 14.8
2.00 - 2.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	669 2.5	1583 6.0	661 2.5	237 .9	15 .1	0 .0	0 .0	5 .0	0 .0	3 .0	27 .1	3200 12.2
2.50 - 3.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	328 1.2	1363 5.2	647 2.5	213 .8	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	2551 9.7
3.00 - 3.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	90 .3	822 3.1	321 1.2	127 .5	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	1360 5.2
3.50 - 4.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	5 .0	253 1.0	183 .7	91 .3	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	532 2.0
4.00 - 5.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	27 .1	48 .2	45 .2	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	120 .5
5.00 - 6.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
6.00 - 7.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
7.00 -	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
TOTAL	0 .0	2581 9.8	1435 5.5	102 .4	130 .5	82 .3	3944 15.0	10989 41.8	4500 17.1	1737 6.6	86 .3	0 .0	17 .1	49 .2	188 .7	188 .7	269 1.0	26297 100.0

Figure 46: Frequency of wave height and direction (Mar 2001 to Feb 2004) (Source of data: JICA 2006)

YEAR 2500	MONTH	0	KESOK	7													
WAVE PERIOD(S)	CALM	0- 1	1- 2	2- 3	3- 4	4- 5	5- 6	6- 7	7- 8	8- 9	9-10	10-11	11-12	12-13	13-14	14-15	15-	TOTAL
WAVE HEIGHT(M)																		
CALM	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
0.00 - 0.50	0 .0	0 .0	16 .1	151 .6	783 3.0	517 2.0	569 2.2	431 1.6	417 1.6	437 1.7	115 .4	5 .0	0 .0	0 .0	0 .0	0 .0	0 .0	3441 13.1
0.50 - 1.00	0 .0	0 .0	0 .0	0 .0	962 3.7	1725 6.6	1147 4.4	906 3.4	629 2.4	765 2.9	219 .8	80 .3	13 .0	0 .0	0 .0	0 .0	0 .0	6446 24.5
1.00 - 1.50	0 .0	0 .0	0 .0	0 .0	0 .0	461 1.8	1872 7.1	999 3.8	649 2.5	458 1.7	261 1.0	40 .2	2 .0	0 .0	0 .0	0 .0	0 .0	4742 18.0
1.50 - 2.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	977 3.7	1804 6.9	683 2.6	215 .8	145 .6	60 .2	20 .1	1 .0	0 .0	0 .0	0 .0	3905 14.8
2.00 - 2.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	6 .0	1550 5.9	1326 5.0	234 .9	68 .3	16 .1	0 .0	0 .0	0 .0	0 .0	0 .0	3200 12.2
2.50 - 3.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	181 .7	1780 6.8	543 2.1	33 .1	14 .1	0 .0	0 .0	0 .0	0 .0	0 .0	2551 9.7
3.00 - 3.50	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	557 2.1	782 3.0	21 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	1360 5.2
3.50 - 4.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	15 .1	416 1.6	101 .4	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	532 2.0
4.00 - 5.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	96 .4	24 .1	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	120 .5
5.00 - 6.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
6.00 - 7.00	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
7.00 -	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0	0 .0
TOTAL	0 .0	0 .0	16 .1	151 .6	1745 6.6	2703 10.3	4571 17.4	5871 22.3	6056 23.0	3946 15.0	987 3.8	215 .8	35 .1	1 .0	0 .0	0 .0	0 .0	26297 100.0

Figure 47: Frequency of wave height and wave period (Mar 2001 to Feb 2004) (Source of data: JICA 2006)

5.1.11 Coastal terrestrial habitats

The coastal plateau is made up of calcareous sand derived from adjacent fringing reefs which have accumulated over the last 6,000 years. These coastal plateau have been colonised by coastal plants such as coconut (*Cocos nucifera*), takamaka (*Calophyllum inophyllum*) and badamier (*Terminalia catappa*). According to the National Biodiversity Action Plan (GoS, 2014), the mountainsides of Mahé and Silhouette from approximately 200 metres above sea level, harbour the bulk of Seychelles known endemic biodiversity whilst Praslin island supports unique stands of Coco-de-mer palm (*Lodoicea maldivica)* dominated forest and associated species.

Coastal brackish water marshes (wetlands) are also present and play an important role in settling out sediments from freshwater systems before entering the sea, especially after rainfall events. The islands have extensive white sandy beaches which are used primarily by the tourism industry and the locals. Many of these beaches are also used for nesting by marine turtles. The terrestrial coastal habitats of many of the inhabited inner islands have been heavily modified for human settlement, industries, public infrastructure and tourism (UNEP, 2008).

5.1.12 Mangrove forests and coastal wetlands

Mangrove forest and coastal wetlands are found within the inner granitic islands. There are 8 species of mangrove described in the the Seychelles, occupying a total area of 29 km^2 (Spalding et al., 2001). The 8 species are *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Sonneratia alba*, *Lumnitzera racemosa*, *Avicennia marina*, *Xylocarpus granatum* and *Xylocarpus moluccensis*.

At Port Launay in Mahé, all eight species of mangroves are found in an area that has been designated a RAMSAR site.

Mangroves once covered many shores of the granitic inner islands, especially close to river mouths and marshland (Shah *et al*., 1997). Since men first settled in the Seychelles in the late 1700s mangrove forests have been cleared to make way for coastal construction. There is presently a proliferation of mangrove in the Seychelles. This is clearly visible on the east coast of Mahé, from Victoria to Pointe Larue, in the lagoons created by coastal reclamation and in places such as Anse Soulliac in the Port Launay Marine National Park, where the mangrove forest is slowly extending seawards.

The mangroves and coastal wetlands carry out important ecosystem functions related to the regulation of fresh water, nutrients and sediment inputs into marine waters. They play an important role in pollution control through their absorptive and assimilative capacity of organic pollutants and nutrients. They also trap and settle-out fine suspended sediments which help in controlling the quality of marine coastal waters. They are also exceptionally important in maintaining coastal ecosystems and populations of various species that inhabit areas such as mangroves at different stages of their life cycle, such as birds, fish and crustaceans.

Pulfrich *et al.* (2006) describes the mangrove faunal assemblage in the inner islands which are characterized by low species diversity and high abundance, dominated by herbivorous gastropods and suspension feeding bivalves. The mangrove whelks (*Terebralia palustris*) are found in extremely high densities in the inner islands, especially at sites with limited circulation. In channels closer to the shore, the Cerith gastropod *Cerithium (Pithocerithium) morum* are extremely abundant, and numerous bivalves (*Quidnipagus palatam, Gafrarium tumidum, G. pectinatum, Anadara antiqyata* and *Ctena divergens*) are also found in the sediment (Pulfrich *et al.,* 2006).

Various mangrove crabs in the genera *Scylla*, *Metapograpsus*, *Sesarma*, *Macrophthalmus* and *Uca* inhabits the emergent mangrove mudflats at low tide (Pulfrich *et al*., 2006). The edible mangrove crab *Scylla serrata* can be found but in most mangrove areas but are in low numbers. The other large mangrove crab *Cardisoma carnifex* is common.

The typical flora of freshwater wetlands consists of reeds, sedges, grasses and herbs, including *Typha javanica* (Zon), *Eleocharis dulcis*, *Cyperus articulatus, Mariscus pennatus, Pycreus polystachyos, Paspalidum geminatum, Ludwigia octovalvis* (Lerb Lanmar) and *Polygonum senegalense* (Persiker). The water fern *Ceratopteris cornuta* (Kreson Lanmar) occurs in some wetlands.

The fauna of freshwater wetlands includes pan-tropical indigenous species as well as introduced ones. Endemic insects from the family *Rhagovelia, Nepidae* and *Notonectidae* still occur in healthy marshes. Caecilians have also been observed in freshwater wetlands, with the most commonly observed species being *Hypogeophis rostratus.* Freshwater wetlands and rivers are also habitat for the 2 endemic sub species of terrapins, *Pelusios castanoides intergularis* and *Pelusios subniger parietalis.* The tilapia, *Orechromis mossambicus,* has been introduced to the Seychelles and is now described as an invasive species affecting freshwater wetlands and rivers. Traditionally, Moorhens (*Gallinula chloropus)* were abundant but restricted to these habitats in the granitic islands; populations have been reduced in recent times, although now humans no longer eat them. An endemic bird the Black Paradise Flycatcher, *Terpsiphone corvina*, is sometimes associated with La Mare Soupape on la Digue. This marsh is important in the ecology of this bird because it is the breeding ground of insects, which the bird captures on the wing (Pulfrich *et al*., 2006).

The large fern *Acrostichum aureum* (Fouzer Lanmar) is common around the edges of lowland marshes. Common coastal trees such as *Calophyllum inophyllum* (Takamaka), *Terminalia catappa* (Bodanmyen) and *Hibiscus tiliaceus* (Var) often establish themselves near the edges. Introduced weed species, in particular *Eichornia crassipes* (Water Hyacinth) and *Pistia stratiotes* (Water Lettuce), now dominate many wetlands on Mahé, Praslin and La Digue (Pulfrich *et al*., 2006).

5.1.13 Marine ecosystems

The coastal-marine environment of Seychelles is complex and includes a series of habitats and biogeochemical processes that influence the dynamics and functionality of the ecosystem. These habitats include coral reefs, seagrass beds, rocky shores, intertidal areas, and mangrove forests as well as coastal plains. These ecosystems are interconnected to form a complex coastal-marine ecosystem. They provide important nesting and foraging grounds for numerous micro and macro-organisms (nesting grounds for micro-organisms as well as larger species), assist in nutrient and hydrological cycles, larval and sediment transport and provide important protein sources for the coastal communities (ASCLME, 2012).

5.1.13.1 Sediment/Soft bottom habitats

The Seychelles Bank (4-5°S, 54-57°E) is a shallow (<100 m water depth) and low-lying plateau (2-6 m above sea level on average) of approximatively 320 km by 150 km representing the northernmost part of the Mascarene Plateau (Fisher et al. 1967). The bank is relatively isolated and is surrounded by the deep Indian Ocean reaching depths of thousands of meters. The sea floor of the Seychelles Bank (or Mahé Plateau; UNEP 2008) has been mapped to some degree and hard substrate is known to make up to ~45% of the plateau (UNEP 2008; IXSURVEY 2010). The rest of the plateau is made up of soft sediments of different categories of which muddy sand and mud are the most common (Figure 48). The main islands of Mahé and Praslin are apparently both located in a zone dominated by consolidated mud sediments, while the island of Silhouette is located in the muddy-sand zone.

The two extensive sand burrow areas off Beau Vallon Bay and the NW coast of Mahé are shown in Figure 14 and Figure 51, are highly disturbed areas. In 2011 a total of 600,000m^3 of quartz sand was extracted and it is estimated that a further 50 million m^3 of quartz sand remain at a depth of ca. 50m. A proposal is being prepared to extract a further 4-6 million m^3 for land reclamation and stockpiling for the building industry (P. Lablache, MLUH, pers.comm. September 2016). To date, Seychelles has reclaimed over 750 ha of land on the east coast of Mahé, mainly between 1973 and 1999 (Vuksanovic 2008). Precisely because of the disturbed seabed, the sand burrow areas are considered as prime zones for cage culture.

In 2007, as part of the sand burrowing EIA, SFA technicians undertook a survey of sediment types off Beau Vallon and on the SW coast of Mahé. More specifically, Grandcourt (1995) analysed panchromatic aerial photographs in black and white of the seabed off Beau Vallon beach. Within the limits of the sensitivity of the photographic film, the analysis showed that the seabed in and on either side of the bay is sandy to at least 5.6 km out to sea.

In addition, data from Cruise 1 also revealed extensive areas of soft sediment in the survey areas as described.

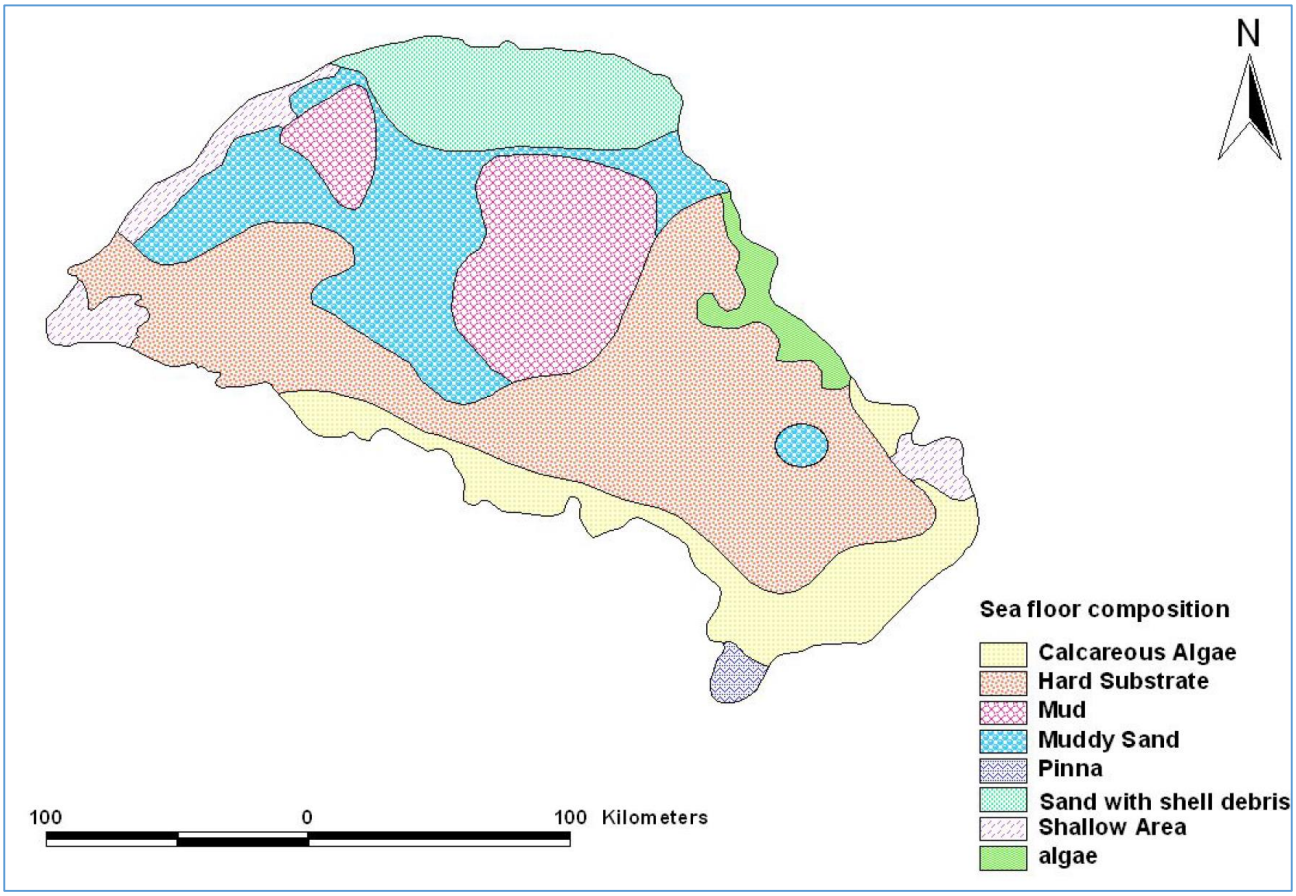

Figure 48: General Sea floor composition of the Seychelles Bank (source: UNEP 2008)

5.1.13.2 Coral reef

The coral reefs of the Seychelles cover an estimated area of 1,690 km^2 (Spalding et al., 2001). Most of these coral reef areas are found in the South East of the Seychelles Archipelago, around the outer coralline islands, with fewer reefs being found in the inner granitic islands (Jennings et al., 2000).

There are 2 main types of reefs: granite reefs, which are made up of corals growing over large granite boulders, and carbonate reefs which are further divided into fringing reefs, atolls and platform reefs (Stoddart, 1984). Fringing reefs are characteristic of the granitic inner islands. They vary greatly in extent and development both within and between islands (Stoddart, 1984). The fringing reefs are most extensive on the islands of Mahé and Praslin where they occupy large areas around these islands.

Along the east coast of Mahé the reef is continuous and unbroken (width: 500 – 750 m), apart from places where they have been dredged or reclaimed. Conversely, on the west coast of Mahé they are mostly small and discontinuous and are mainly found in bays (Stoddart, 1984) and are generally narrower than those found on the east coast. The situation reverses for Praslin where the coral reefs are widest on the east coast with width up to 2850 metres. Reef type, area and width for islands with extensive coral reefs are provided in the Table below. More than 300 species of *Scleractinian* corals are known from the Seychelles (Veron & Stafford- Smith, 2000) however so far there are no identified Seychelles endemics.

Table 12: Reef characteristics around some of the main islands of Seychelles. Source: Payet et al. (2005).

Island	Reef Type	Total Area (Km^2)	Total area of island (km^2)	Area of reef (km^2)	Reef Width (m)
Mahé	Fringing	173.91	156.88	17.03	75-1400

Island	Reef Type	Total Area (Km^2)	Total area of island (km^2)	Area of reef (km^2)	Reef Width (m)
Praslin	Fringing	66.02	37.85	28.17	135-3100
La Digue	Fringing	12.75	9.82	2.93	50-630
Curieuse	Fringing	3.47	2.74	0.73	40-275
St. Anne	Fringing	2.85	2.19	0.66	45-440
Cousine	Fringing	0.74	0.24	0.50	70-440
Cousin	Fringing	0.78	0.29	0.49	110-305

The back reef environment is mostly covered by macro-algae of the genus Sargassum and Turbinaria (Stoddart, 1984) or seagrass comprising mostly of *Thalassodendron ciliatum* and *Thalassia hemprichii* (Kalugina-Gutnik et al., 1992). Other reef associated animals groups have also been described to varying extents and they include: corals, crustaceans, echinoderms, fish, macroalgae, mollusc, and sponges. There are however gaps in the diversity of other reef associated phyla.

Before the 1998 coral bleaching event the coral reefs of the Seychelles were considered as healthy and were characterised in 3 different assemblages (Pocillopora assemblages: associated with rough water, especially in or near the surf zone, Acropora assemblages: found along open water reef fronts, Porites assemblages: reef flat environments) (Rosen, 1971) distinguished by the main coral species they host, which is in-turn brought about by the physical environment of the area.

The coral bleaching event of 1998 was brought about by high sea temperature which prompted the corals to bleach and die after a few weeks (Wilkinson et al., 1999). This bleaching event was in fact the first case of wide scale coral bleaching event which has been recorded in the Seychelles. Early Assessments in 1999 by Engelhardt (2000) and Turner et al. (2000) found that the fast growing *Acroporas* and *Pocilloporas* had suffered the most. At the time of these assessments the most dominant genus were the *Porites*, thus suggesting that they were better able to withstand the high sea temperature that caused widespread bleaching in 1998 (Payet *et al*., 2005). The 1998 bleaching was followed by 2 smaller scale events in 2002 and 2003.

Although mortality among corals was extensive and the diversity at most sites surveyed was low following the 1998 mass bleaching event, no extinctions have been reported, rather the abundance and distribution of species have reduced. Since then management focus had to change from managing healthy and diverse coral reefs to promoting the recovery of coral reefs (Payet *et a*l., 2005). Recent reports (Payet *et al.,* 2005; Graham et al., 2006) indicate that today the situation on the reefs of the inner islands is drastically different from its pre-bleaching level. Since the bleaching event, the coral reef system of the inner Seychelles has undergone a widespread phase shift from a coral-dominated state to a rubble and algal-dominated state (Graham *et al*., 2006). Before the 1998 bleaching event the reefs were characterized by high cover of live branching and massive coral, soft coral, and high structural complexity, whereas today the reefs are of low complexity comprising mostly of rubble, standing dead coral and algal fields. Average coral cover is presently low with few of the benthos consisting of fast growing, habitat forming branching and plating functional groups of corals (Graham *et al*., 2006). Recovery of corals reefs from the bleaching events have been relatively slow and it is highly apparent that the carbonate based reefs are not doing as well as the granitic based reefs.

5.1.13.3 Reef flats

This mixed habitat complex has been subject to intensive disturbance around populated islands. In the central archipelago reef flats are utilised extensively for gleaning fisheries (e.g. octopus and shell fish) and

shell collecting activities. In the last 25 years significant areas of this habitat have been lost to major land reclamations. Sedimentation and in some areas pollution are also factors of concern.

Most reef flats consist of a complex patchwork of habitats: areas of sand and gravel interspersed between areas of coral rubble, coral outcrops, sea grass and algal growth. In their natural state these habitats are rich in life and commodity species such as octopus, lobster and sea cucumber. Mollusc fauna can be very rich with Cowries (*Cypraea moneta, C. annulus, C. Lynx, C. caurca and C. helvola* being common), Cones (*Conus leopardus, C. litteratus, C. virgo, C. maldivus, C. betulinus* and *C. quercinus*) readily found in the seagrass; whilst species such as *Bittium zebrum* and *Smaragdia rangiana* can be found in algal mats. Four Shell Reserves were declared in the 1960s and were subsequently incorporated under the 1986 Fisheries Act (1987 Shell Reserve Regulations) but the areas are not managed or enforced (GoS, 2014).

5.1.13.4 Seagrass bed

According to the National Biodiversity Plan (GoS, 2014), the extensive shallow submarine banks of Seychelles support significant sea grass areas. A particularly large sea grass bed (estimated at 45km long and 15km at its widest) lies on the Providence-Cerf bank. Many of the outer islands, such as the lagoons of Aldabra, Cosmoledo and Astove, support large sea grass communities. Sea grass habitats are also common around the granitic inner islands, notably in the St Anne Marine National Park and off Grand Anse-Amities coast of Praslin. A brief survey of inshore sea grass bed substrate around the island of Mahé recorded 58 species of infaunae invertebrates. Sea grass beds are also essential for many marine herbivore species including megafauna such as the green turtle and the Dugong.

There is evidence that sea grass beds around the main populated islands are in decline due to a combination of anthropogenic factors – pollution, reclamation, coastal development and climate change. It also likely that the historical exploitation of the main sea grass grazers, green turtles, and ongoing fishery activities mean that the natural grazer/growth balance in sea grass beds has been lost potentially leading to changes in community structure and health (GoS, 2014).

To date 8 species of seagrass have been described from the Seychelles (Spalding et al., 2001): *Cymodocea rotundata, Cymodocea serrulata, Enhalus acocroides, Halodule uninervis, Halophila ovalis, Syringodium isoetifolium Thalassia hemprichii* and *Thalassodendron ciliatum* with 6 of them present around Mahé. The sea grasses of Seychelles remain poorly studies with only a few studies having being undertaken of various locations over the years (UNEP, 2008).

5.1.13.5 Rocky shores

Rocky Shore is the most common shore habitat in the granitic islands and is typified by a limited vegetation structure consisting of species such as *Hibiscus tiliaceus,* occasional stands of the endemic Balfour's pandanus (*Pandanus balfouri*), *Scaevola sericea*, creepers (e.g. *Ipomea pescaprae*) and grasses. In their natural state and particularly on promontories and rocky islets, rocky shores historically supported important seabird populations and and/or roosts (e.g. *Sterna anaethetus, Phaethon lepturus, Puffinus pacificus)* such as can still be found on reserve islands like Cousin and Aride.

The intertidal zone is rich in gastropods some of which are commonly exploited for food (e.g. *Patella exusta* and *Cellana radiata*). The *trochus Monodonta australis* and the majority of Seychelles *Nerites* (*Nerita albicilla, N. plicata, N. polita, N. textilis*) are common in this zone; as are various species of *Littorinid* (*Littorina kraussi. L. scabra, L. undulata* and *Peasiella roepstorffiana*). *Planaxis sulcatus* occurs in large colonies in this zone, the Morulas, *Morula granulata* and *M. uva* are also common and the cowrie *Cypraea caputserpentis* is common in rocks clefts typified by strong wave action.

Rocky shores also harbour large crab populations (*Grapsus* and *Geograpsus* spp) and occasionally the distinctive *chiton*, *Acanthopleura brevispinosa.* Accessible rocky shores are quite intensively harvested for shell fish for both domestic and commercial use and increasingly physical development is encroaching in these areas to meet the demand for seaside properties (GoS, 2014).

5.1.14 Marine Fauna

5.1.14.1 Marine mammals

According to UNEP report 2008, two orders of marine mammals (*Sirenia* and *Cetacea*) occur in Seychelles waters. In 1963, the humpback whale was officially protected in the southern hemisphere but captures continued up to 1974. In 1979, the Indian Ocean Whale Sanctuary was created prohibiting the further capture of whales.

Today, both baleen (*Mysticetes*) and toothed (*Ondoctocetes*: dolphins, beaked whales and sperm whales) whales are still found in the Seychelles. Over 26 species have been observed, comprising 7 dolphin species of which 4 are common and 19 whale species. Some of these species such as the Bottlenose dolphin (*Tursiops truncatus*) and sperm whale (*Physeter macrocephalus*) are regularly sighted whereas others such as the Blue whale (*Balaenoptera musculus*) are rare.

The most important areas for *cetaceans* in the Seychelles include the area north and south of the Mahé Plateau, the Amirantes and the area around the Aldabra atoll. There have been no specific studies to investigate whether these areas are important breeding, foraging or resting grounds. The Marine Conservation Society of Seychelles (MCSS) is the only NGO that works with marine mammals in the Seychelles.

In 2002, the Zoological Society of Paris (ZSP) and the Paris Natural History Museum, the Seychelles Ministry of the Environment and Natural Resources (MENR) and the Marine Conservation Society Seychelles (MCSS) joined to develop a Volunteer Observer Network for *Cetaceans* in the Seychelles. In 2005 an informal Marine Mammal Observatory was set up to provide a central collection point for opportunistic as well as formal marine mammal sighting data.

Table 13: Known species of cetaceans found in the Seychelles (Wendling et al. 2003).

Scientific names	Vernacular names
Dolphins	
Stenella longirostris	Spinner dolphin
Stenella attenuata	Spotted dolphin
Stenella coeruleoalba	Striped dolphin
Tursiops truncatus	Bottlenose dolphin
Lagenodelphis hosei	Fraser's dolphin
Steno bredanensis	Rough toothed dolphin
Grampus griseus	Risso's dolphin
Toothed Whales	
Globicephala sp.	Pilot whale
Peponocephala electra	Melon-headed whale
Orcinus orca	Killer whale
Feresa attenuata	Pygmy killer whale
Pseudorca crassidens	false killer whale
Ziphiidae	Beaked whales
Mesoplodon grayi	Gray's beaked whale
Mesoplodon pacificus	
Mesoplodon densirostris	Dense beaked whale
Ziphius cavirostris	Goose beaked whale
Baleen Whales	
Kogia simus	Dwarf sperm whale
Physeter macrocephalus	Sperm whale

Megaptera novaeangliae	Humpback whale
Eubalaena glacialis	Right whale
Balaenoptera physalus	Fin whale
Balaenoptera borealis	Sei whale
Balaenoptera acurostrata	Minke whale
Balaenoptera edeni	Bryde's whale
Balaenoptera musculus	Blue wale

5.1.14.2 Fish Resources

The vast majority of fish found in Seychelles are wide ranging species that extend across the Indian Ocean to the western or mid Pacific Ocean (Smith and Smith 1969). In addition to open ocean pelagic waters, which constitute the bulk of the EEZ, Seychelles is characterized by a series of continental shelves with a total surface area of almost 50,000 km^2 (Sweenarain and Cayré 1988). Therefore, there are a wide range of marine habitats for fishes, including shallow water fringing reefs, granitic reefs, banks, plateaux, shelves and drop-offs, atolls, lagoons, seamounts, abyssal and pelagic habitats (Jennings *et al*. 1999). The Seychelles waters are therefore relatively rich in fishing resources (Sweenarain and Cayré 1988). A total of 1196 marine species belonging to 140 families have been recorded in the Seychelles. However, a relatively low percentage of these species are targeted by the fishery sectors (industrial, semi-industrial or artisanal).

It has become increasingly apparent since the mid-1980s that the demersal fishery resources of the Mahé plateau are being overexploited. Initially it was considered a concern of the inner reefs but Vessel Monitoring System data coupled with steadily declining catches since 1991, indicate that the entire plateau is overexploited. This is particularly apparent in the decline of the occurrence, diversity and abundance of *Serranidae* on the plateau with several species now very scarce or absent from the Mahé plateau catch. Declines are also apparent in key commercials species most notably the Emperor red snapper (*Lutjanus sebae*) and the Brownspotted grouper (*Epinephelus chlorostigma*).

Figure 49: Example of the artisanal catch (Emperor Snapper and Grouper)

Taxa	No. of Species	Notes
Macroalgae	approx. 330	Rich species composition at most islands. Occurs in high density in nutrient rich waters off Port Victoria and certain seabird colony islands.
Alismatales (Sea grasses)	8 species	
Porifera (Sponges)	>350	351 species recorded. 135 sp exclusive to the granitics, 95 exclusive to the Amirantes and 121 sp shared. 14 species to date have been confirmed as endemic:
Anthozoa		
Sea Anemones	55 species	
Scleratinian corals	>200	Diversity greater around coral islands. At least 34 species are classified as Vulnerable or Endangered by the IUCN.
Octocorallian corals	>70	
Molluscs		
Gastropods	500	
Bivalves	>100	
Crustacea		
Shrimps	>165	At least 5 endemic species:
Macrura	7	Lobster fishery managed by periodic closures.
Echinoderms		
Crinoids	10	
Asteroidea	32	
Ophiuroidea	44	
Echinoidea	33	
Holothuroidea	43	43 species recorded including more than 20 commercial species. 6 species constituting the vast bulk of the catch.
Osteichthyes	>1,150	Endemism is low considered to be at about 1%. More than 400 coral reef associated species. Some 150 species (several of which are threatened) make up the artisanal fishery.
Chondrichthyes	79	79 confirmed species of Chondrichthyan: 60 shark, 16 ray and 3 guitarfish species. Of the 71 identified to species level 30 are threatened (i.e. Vulnerable or Endangered) and 15 are Data Deficient.
Chelonii	5	Hawksbill (*E. imbricata*) and Green (*C. mydas*) turtles nest in Seychelles though much reduced from historical numbers. The Leatherback (*D. coriacea*), Loggerhead (*C. caretta*) and Olive Ridley (*L. olivacea*) turtles occur in Seychelles waters.
Mammals Cetaceans Sirenia	 27 1	Including the Endangered Sei, Blue and Fin Whales (*Balaenoptera borealis*, *B. musculus* & *B.physalus*), and eight species of dolphin. There is a small but apparently increasing population (approx. 20-25) of the Dugong (*D. dugong*) at Aldabra atoll.

Figure 50: Summary of Marine Biodiversity in Seychelles (GoS, 2014)

5.1.14.3 Birds

According to the National Marine Ecosystem Diagnostic Analysis (ASCLME, 2012), the Seychelles' high ornithological profile is partly due to the vast amount of breading seabirds that occur within its EEZ (Bijoux *et al.* 2003). Despite the fact that the archipelago is not situated along any important migratory routes, some colonies of *Frigate* spp. regularly consist of more than 1 million birds and hence, are amongst the largest colonies in the world (Bijoux *et al.* 2003). Hence, seabird conservation is of great importance in maintaining both national and international bird biodiversity. To date, 18 species of seabirds are known to breed in the Seychelles (Burger and Lawrence 2003). The most comprehensive document on seabirds of the Seychelles is the Important Bird Areas (IBAs) of the Seychelles inventory by Rocamora and Skerrett (2001). This report encompasses the seabirds and water birds of Seychelles.

Within the Seychelles, the inner granitic and outer coralline islands can be considered as two distinct bio-geographical regions. In this biogeographical region, Aride, Cousin, Cousine and Bird Island host seabird colonies of regional and global importance (Rocamora and Skerrett 2001). Seabirds found in large numbers on these four islands include: *Puffinus pacificus* (wedge-tailed shearwater), *Puffinus Iherminieri* (Audubon's shearwater), *Anous tenuirostris* (lesser noddy), *Anous stolidus* (brown noddy), *Gygis alba* (white tern), *Phaeton lepturus* (white-tailed tropicbird), *Sterna fuscata* (sooty tern), *Sterna anaethetus* (bridled terns) and *Sterna dougallii* (Roseate terns). The presence of the Yellow bittern, *Ixobrychus sinensis*, on Mahé, Praslin, La Digue and Curieuse is of particular interest as the Seychelles in the only location within the Western Indian Ocean and African regions where this Asian species occurs (Bijoux *et al.* 2003). Two other species of waterbirds that have been described in the granitics include *Bubulcus ibis sechellarum* (cattle egret) and *Butorides striatus degens* (green-backed heron) (Bijoux *et al*. 2003).

Seabird colonies of regional or global importance which are found in the granitic islands on Aride, Cousin, Cousine and Bird Island (UNEP, 2008):

- *Puffinus pacificus* (Wedge-tailed shearwater) c. 60,000 pairs between Cousin, Aride, and Cousine which holds the largest colony ;
- *Puffinus lherminieri nicolae* (Audubon's shearwater) c. 60,000 pairs, mainly on Aride;
- *Anous tenuirostris* (Lesser noddy) 300,000 pairs in total on Aride, Cousin and Cousine, *Anous stolidus* (Brown noddy) > 15 000 pairs between the four islands, mainly Bird;
- *Gygis alba monte* (White tern) 11,000-15,000 pairs mainly in the four islands but also at low densities in the other granitics;
- *Phaethon lepturus* (White-tailed tropicbird) minimum 2,500 pairs between Cousin, Cousine and Aride, but also at low density in other granitics;
- *Sterna fuscata* (Sooty tern) c.700,000 pairs on Bird, and c. 300,000 pairs on Aride;
- *Sterna anaethetus* (Bridled terns) 4,000 pairs, mainly on Recif; and
- *Sterna dougallii* (Roseate terns) 1,255 pairs on Aride.

5.1.14.4 Sea turtles

Four species of sea turtles are found in Seychelles waters. However, only the Green turtle (*Cheloniamydas*) and the Hawksbill turtles (*Erethmochelys imbticata*) nests in the Seychelles. Hawksbill turtles nest mainly in the granitic islands whereas Green turtles nest mainly in the outer islands. The other 2 species found in Seychelles waters are the Leatherback turtle (*Dermochelys coriacea*) and the Loggerhead turtle (*Caretta caretta*). The Seychelles hosts 1 of the 5 most significant populations of hawksbill turtle, which is listed as critically endangered. There has been a decline in the number of female nesting hawksbill turtles over the past few decades. Fortunately, some of the most important nesting sites have protected status either as special reserves or as marine national parks. For green turtles, the numbers of nesting females appear to have increased significantly during the past few decades.

The Marine National Parks of Ste. Anne and Curieuse and the two Special Reserves of Cousin and Aride and the island of Cousine remain some of the most important hawksbill nesting sites in Seychelles. Aldabra atoll, in the outer islands, is both a Special Reserve and a UNESCO World Heritage site and has one of the largest populations of nesting green turtles in the Seychelles.

5.1.14.5 Species of special importance

5.1.14.5.1 Sharks

According to UNEP report 2008, there are 18 toothed sharks known to the Seychelles and it is estimated that there is between 50,000 and 56,000 Mt of shark biomass on the Mahé Plateau with an additional 34,000 Mt on the other banks (Shah *et al.,* 1997).

The whale shark is also common in Seychelles waters. The earliest report of whale sharks, *Rhincodon typus*, in Seychelles dates back to 1868, some 40 years after the species was first described by Dr Andrew Smith from a specimen caught in Table Bay, Cape of Good Hope, South Africa. The presence of whale sharks, known locally as '*Sagren*', in the coastal waters of Seychelles was therefore well known but little research has been done on their population dynamics or life history. In view of this, a pilot project was set up by MCSS in November 1996 to tag and monitor whale sharks in Seychelles. To date more than 100 whale sharks have been tagged.

5.1.14.5.2 Sea Cucumber

The sea cucumber fishery in the Seychelles has seen a rapid development during the past decade or more. By 1999 there were already signs of population depletion, including lower volumes of high value species and fishers having to travel further and dive deeper to maintain catch rates, and concerns were raised regarding the sustainability of the fishery (Aumeeruddy et al., 2005). As a result a survey of sea cucumber density at 246 sites throughout the Amirantes and Mahé Plateau was undertaken by SFA in 2004. Two species were considered as over-exploited, 3 as fully-exploited, and the remainder as either under-exploited or at virgin levels (Aumeeruddy *et al.,* 2005). After this survey that Total Allowable Catch (TAC) was calculated at 1707t. However, 68% of the TAC is made up of lower value species such as *Holothuria atra.* Shallow water high value species are overexploited or showing signs of significant local depletion. About 2 dozen sea cucumber species are exploited in the Seychelles and are sold mostly to Hong Kong and Singapore, with smaller markets in Korea, Taiwan and Malaysia.

5.1.15 Protected Areas

The Seychelles terrestrial Protected Area Network (PAN) constitutes 46.6% of Seychelles' total landmass, an enormous commitment to biodiversity conservation. Furthermore, the President has stated the political objective of incorporating more than 50% of Seychelles landmass in the PAN and indeed preliminary approval has been given for the declaration of additional areas to take the total over 50%. These percentages are very impressive but perhaps more important than the quantity is the quality of protected areas in question. The vast majority of Seychelles endemic biodiversity is to be found in the ancient granitic inner islands. Within the granitic islands however, "only" 22.3% of the landmass or significantly less than the national average is currently protected.

Marine Protected Areas (MPAs) in Seychelles present a very different scenario (Table 14). Seychelles was the first country in east Africa to establish a network of MPAs but at the time of their selection (Procter 1971), they were primarily chosen for touristic utility, as opposed to biodiversity criteria, as at that time the marine environment was still of a relatively homogenous high quality. Subsequent human development activities and impacts, and notably the 1998 ENSO-related coral bleaching event have changed that scenario. Furthermore, unlike the terrestrial scenario where nearly 50% of the landmass lies within the PAN, the existing MPAs in Seychelles constitute less than 1% of the country's EEZ.

In Seychelles there are at least five different types of MPAs:

- Marine National Park (National Parks and Nature Conservancy Act 1969 (Cap 141)) Marine Protected Areas in the Republic of Seychelles;
- Shell (Mollusc) Reserve (Fisheries Act (Cap 82));
- Special Reserve (National Parks and Nature Conservancy Act 1969(Cap 141));
- Protected Areas (Protected Areas Act (Cap 185); and
- Strict Natural Reserve (National Parks and Nature Conservancy Act (Cap 141)).

Table 14: MPA's of the Inner Island Group

Name	Designating Regulation	Date Designated	Land Area (ha)	Marine Area (ha)	Total Area (ha)
Ste. Anne Marine National Park	National Park (Ste. Anne Marine)(Designation) Order. Cap. 141, Sub. Leg. pg. 1-2	19/03/1973	388	996	1,384
Baie Ternay Marine National Park	National Park (Baie Ternay Marine) (Designation) Order. Cap. 141, Sub. Leg. pg 5-6	11/06/1979	1	86	87
Curieuse Marine National Park	National Park (Curieuse Marine) (Designation) Order. Cap. 141, Sub. Leg. pg. 6-7	11/06/1979	286	1,370	1,656
Port Launay Marine National Park	National Park (Port Launay Marine) (Designation) Order. Cap. 141, Sub. Leg. pg. 7	11/06/1979	4	154	158
Silhouette Marine National Park	National Park (Silhouette Marine) (Designation) Order. Cap. 141, Sub. Leg. pg 9.	26/10/1987	1,860	1,000	2,860
Ile Coco, Ile La Fouche, Ilot Platte National Park	S.I. 20 of 1997 (National Parks and Nature Conservancy (Ile Coco, Ile La Fouche, Ilot Platte) Order 1997	19/02/1997	5	165	170
Cousin Special Reserve		1966	-	27	27

See Figure 51, Figure 52 and Figure 53 for these Marine and Terrestrial Protected Areas.

The Seychelles Government has recognised this short fall in the marine domain and, mindful of its international commitments, has initiated a marine spatial planning process with the ultimate objective of designating 30% of the EEZ as protected. Half of that area, or 15% of the EEZ, is to be designated as strict no take zones. The marine spatial planning is being facilitated by The Nature Conservancy and began in early 2014.

This marine spatial planning process is already well underway and there have been engagements with SFA regarding the MMP and how this will integrate with marine spatial plans or marine user classes.

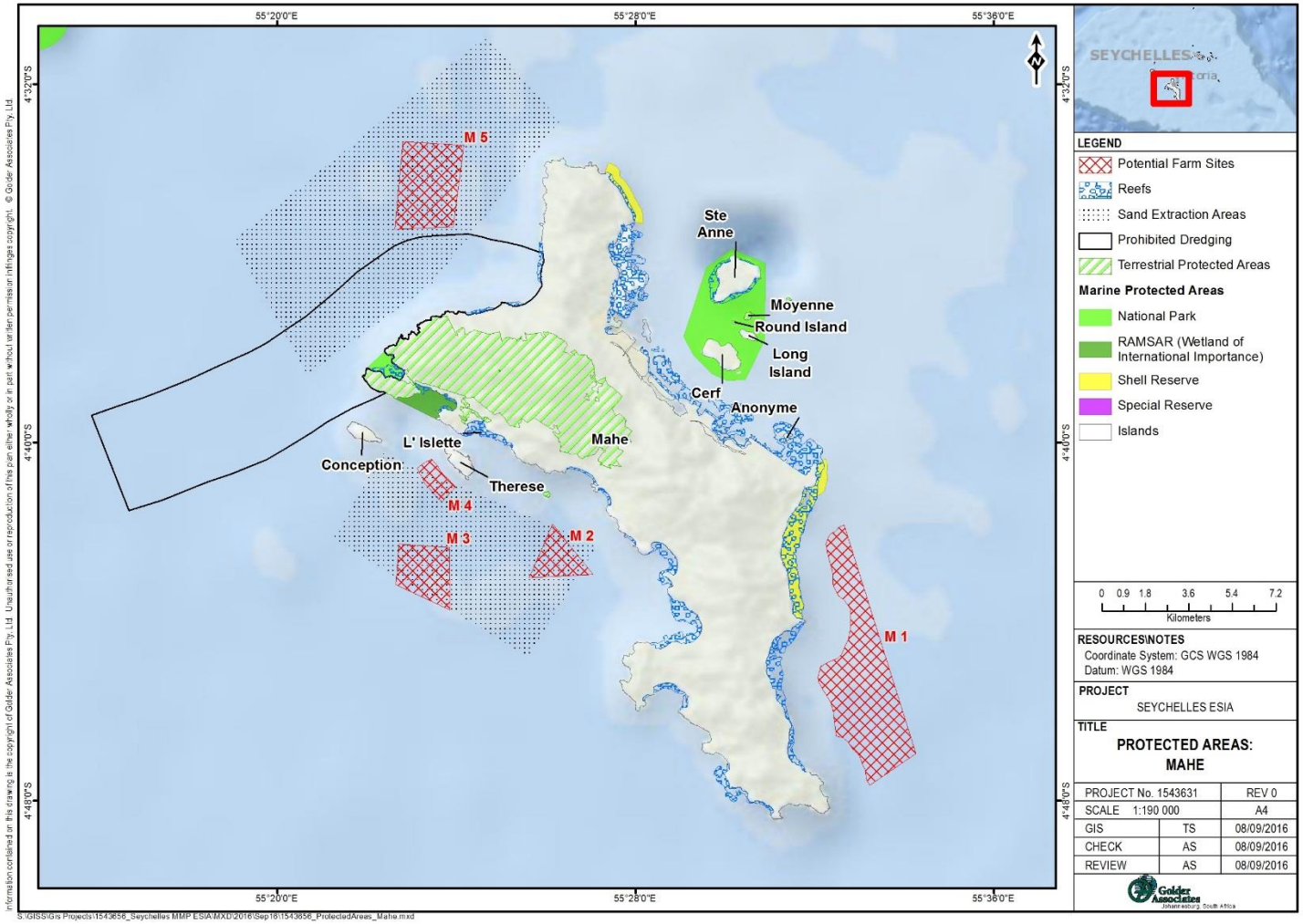

Figure 51: Mahé Island and surrounding Marine and Terrestrial Protected Areas

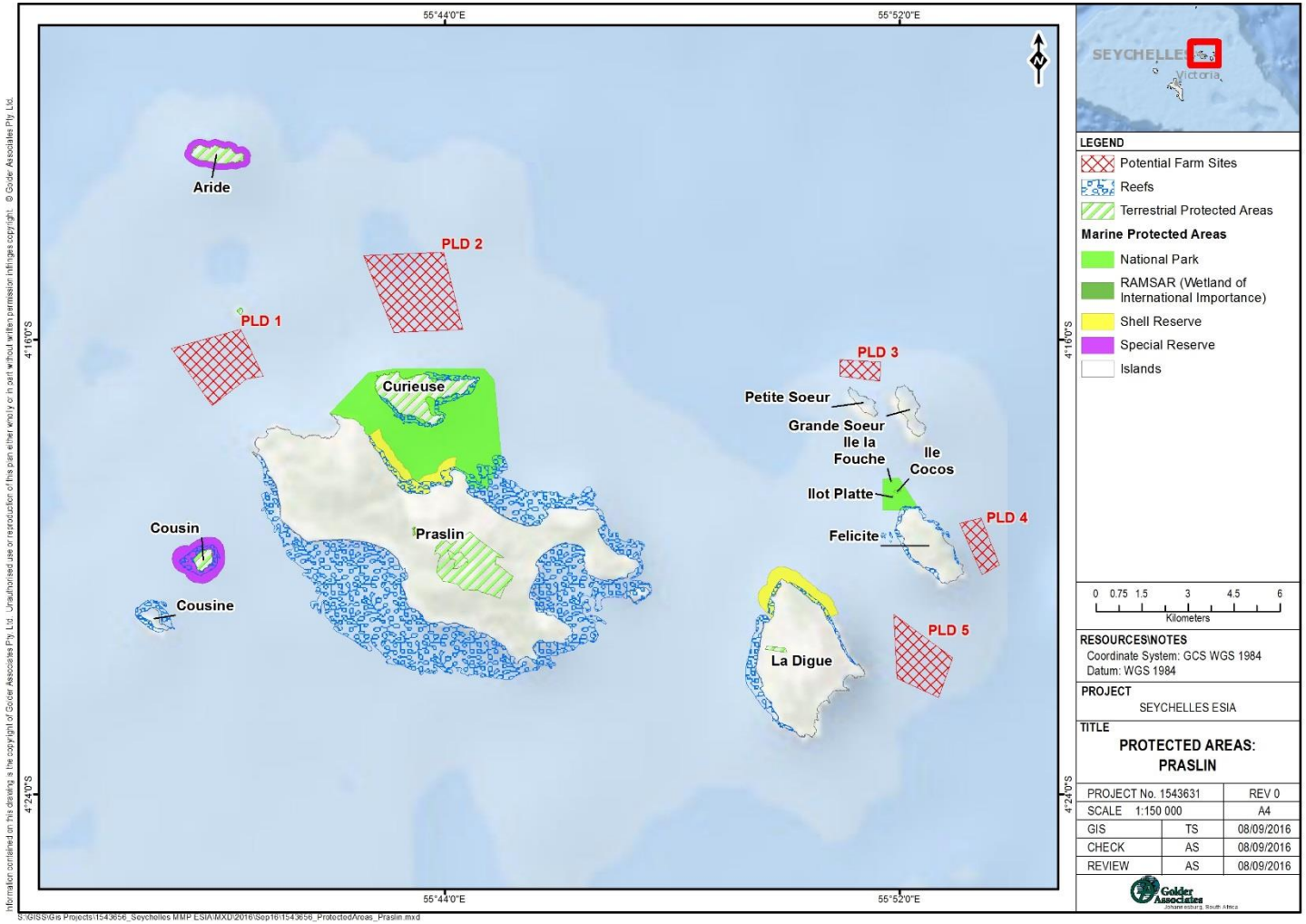

Figure 52: Praslin and La Digue Islands and surrounding Marine and Terrestrial Protected Areas

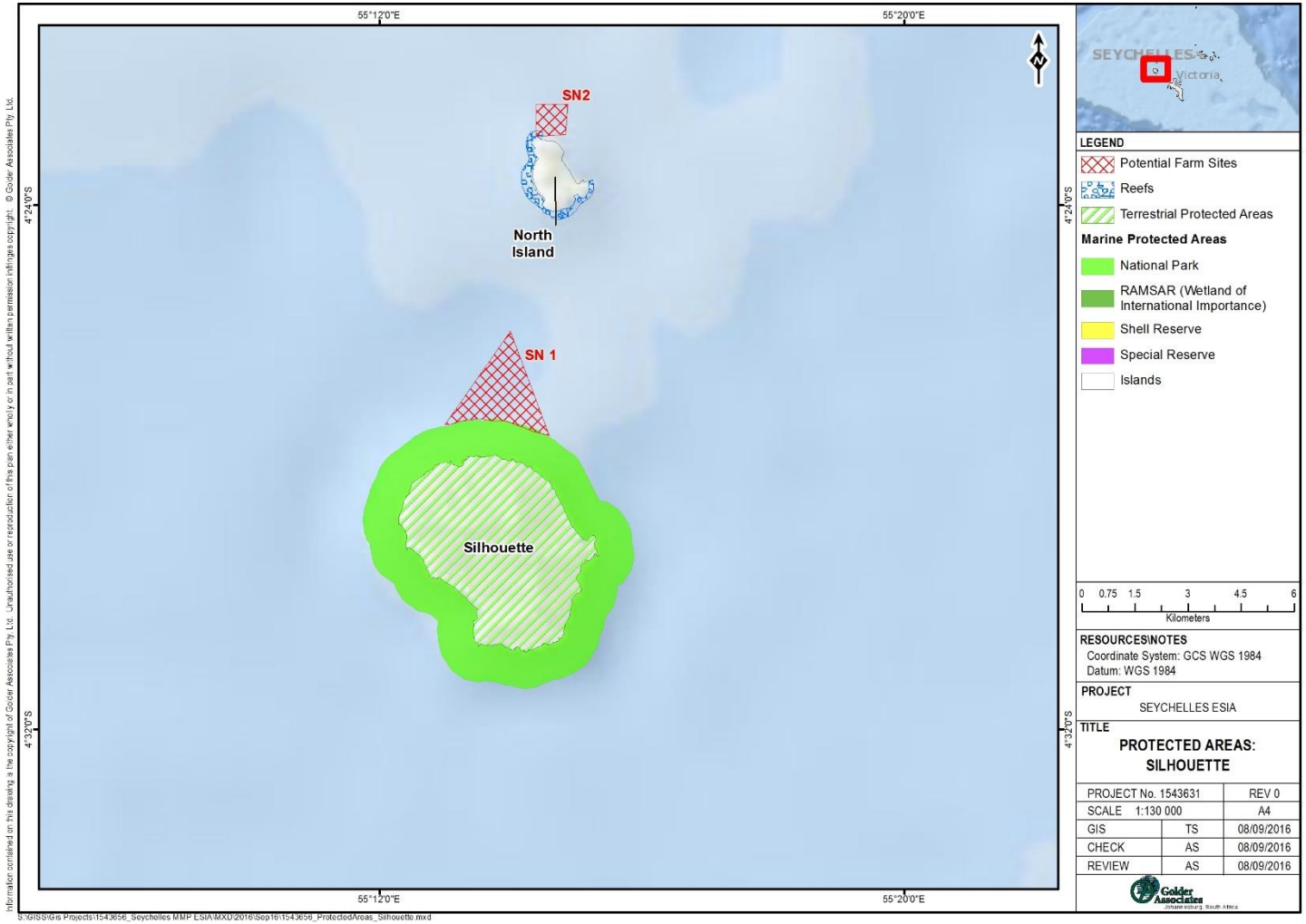

Figure 53: Silhouette and North Island Marine and Terrestrial Protected Areas

5.2 Socio-economic

The socio-economic environment refers to a wide range of interrelated and diverse aspects and variables relating to or involving a combination of social and economic factors. These aspects and variables could, in general, be categorised into several categories including, economic, demographic, public services, fiscal and social. The full social baseline is available in APPENDIX H.

5.2.1 Population Demographics

5.2.1.1 Population Numbers

The Seychelles population stood at 94 677 at in mid-June 2016. In mid-2016 there were 47,343 males and 47,334 females. These population figures reflect a growth rate of 1.3% since 2015. Of interest, is that the ratio of men to women is practically 1:1. From July 2015 to June 2016 the Seychelles received 297 in-migrants (Seychelles National Bureau of Statistics 2016a).

The Seychelles population is projected to grow to some 100,000 in mid-2020, reaching 108,000 in mid-2045. More details are provided Table 15 (Seychelles National Bureau of Statistics 2014a).

Table 15: Projected resident population ('000)

Population	Mid-2020	Mid-2025	Mid-2030	Mid-2035	Mid-2040	Mid-2045
Total Population	100,009	102,917	104,289	106,308	107,481	108,034
Male	51.6	51.4	51.1	50.5	49.7	53.4
Female	48.4	48.6	48.9	49.5	50.3	46.6[1]
% Growth Rate over 5 year period	0.9	0.6	0.3	0.3	0.3	0.1
Median Age	34	35	37	39	40	41

In reference to Table 15, indications are that the Seychellois population is slowly growing older. The % growth rate is projected to decrease steadily to as low as 0.1% from 2042 to 2045. Any significant influx of migrants may skew these figures, due to the low baseline population numbers.

5.2.1.2 Geographical Distribution

The Seychellois population are mainly located on the three main islands of Mahé, Praslin and La Digue. Indications are that 78.9% of the population are located on Mahé Island, some 8.7 % on Praslin and the rest (3.7%) on La Digue and the Outer Islands (Seychelles National Bureau of Statistics 2015a).

5.2.1.3 Household Characteristics

The average household size in 2013 was 3.4 persons, down from 3.7 persons in 2010. In 2013, the number of households were 28 367 (Seychelles National Bureau of Statistics 2014b).

The household head distribution by sex and marital status is depicted in Table 16:

Table 16: Percentage distribution of households by sex and marital status of head of household

Marital status	sex		Both sexes
	Male	Female	
Single/ never married	26.7	38.5	33.5
Married / co-habiting	65.4	40.8	51.2

[1] The source document indicates a female percentage of 54.6. This is assumed to be an error and has been corrected to 100%.

Separated / divorced / widowed	7.9	20.7	15.3
Total	100.0	100.0	100.0

Source: Seychelles National Bureau of Statistics (2014b)

5.2.2 Ethnicity, Religion and Languages

The Seychelles Constitution states that English, French and Creole are the official languages in the Seychelles (Seychelles Parliament 2010). Creole is the most common language spoken within the inner islands.

The ethnic groups in the Seychelles consist of primarily the Seychellois Creole at 89%, with Indian (5%), Malagasy (3%) and Chinese (1%) making up the rest. Most citizens consider themselves as Seychellois. There constant flux of immigrants to Seychelles, initially from continental Africa, Europe and the Indian sub-continent, and later from China, have created an ethnically diverse, harmonious people, accustomed to meeting and working alongside people from places and backgrounds vastly different to their own (COMESA 2012).

The Roman Catholic religion is dominant (close to 90%) The other Christian affiliations (some 8%), Hindu (less than 1%) and other religions make up the rest (COMESA 2012; Bovet *et al.* 2013).

Figure 54: Catholic shrine- South Mahé (left), Catholic Church -La Digue (right)

Figure 55: Catholic churches (South Mahé)

5.2.3 Social Services and Facilities

5.2.3.1 Education

In 2015 the national literacy rate was 95.32% (The World Bank: 2015). According to the 2012 figures, the literacy rate is almost even for both genders, with male at 91.4% and female at 92.3%). These figures are noteworthy, when considering that the 2004 literacy rate was 88% (Seychelle Republic 2004).

The total number of private and public education facilities is depicted in Table 17. Pre-primary and primary schools have the most establishments available in Seychelles. There is only one special needs school. Private educational facilities are limited with public educational facilities outweighing the number of private establishments. (Seychelles National Bureau of Statistics 2015a).

Table 17: Education facilities

Facility	Total No. of Institutions	No. of Private	No. of Public
Pre-Primary School	33	4	29
Primary School	28	4	24
Secondary School	14	-	-
Tertiary Institutions	14	3	10
Special Schools	1	0	1
Grand Total	90	11	64

Source: Seychelles National Bureau of Statistics (2015a)

In 2014 there was a total of 662 primary school teaching staff with a pupil/teacher ratio of 13:1 and 550 secondary teaching staff with a pupil/teacher ratio of 12:1. Public tertiary education and training (non-university) facilities have a teaching staff of 180 with a pupil/teacher ratio of 13:1. Private tertiary education and training (non-university) facilities have a teaching staff of 37 with a pupil/teacher ratio of 3:1 (Seychelles National Bureau of Statistics 2015a).

Respondents from social focus group meetings from all three large islands (Mahé, Praslin and La Digue) indicated that the access to primary schools adequate. Access to tertiary institutions, however, is problematical as most tertiary institutions are located on Mahé, necessitating that people who want to further their education have to relocate to the main island to do so.

Figure 56: Schools, Anse Royale (left), La Digue Island (right)

Tertiary non-university education and training (public) institutions consist of the following:

- Seychelles Institute of Technology.
- Maritime Training Centre.
- School of Advanced Level Studies.
- School of Visual Arts.
- School of Business Studies and Accounting.
- National Institute of Health and Social Studies.
- Seychelles Agricultural and Horticultural Training Centre.
- Seychelles Tourism Academy.
- Seychelles Police Academy.
- Seychelles Institute of Teacher Education.

Private tertiary institutions in the Seychelles include the following:

- Seychelles Polytechnic.

The Seychelles Polytechnic was established in 1983. The Polytechnic offers post secondary education and training in three main programme areas. These programme areas are Business & Secretarial Studies, Visual Arts and the Manchester Twinning Programme (a first year degree programme in partnership with the University of Manchester in UK) (Seychelles Polytechnic 2016).

- University of the Seychelles (UniSey).

There is only one university in the Seychelles The young University of Seychelles had its first student intake in September 2009 (Africa Universities, 2016). The University of Seychelles, popularly known as UniSey, has three campuses, two of which are close to Victoria and the third located south of the capital, in Anse Royale. The university had 1,330 students enrolled in 2015, offering a number of undergraduate and postgraduate courses, many in cooperation with leading international universities (University of Seychelles 2015).

5.2.3.2 Health Care

According to the Seychelles Constitution, access to health care is free for all Seychellois. The Seychelles operates a three tier health delivery system (primary, secondary and tertiary). This system comprises of a central referral hospital, a cottage hospital and district health centres. A number of special clinics, including

rehabilitative hospitals, wellness centres, youth health centres, and prison health centres provide services to vulnerable groups (Bovet *et al.* 2013; World Health Organization 2014).

The Seychelles National Care is centralised in Victoria (Mahé). Residents in Praslin and La Digue who are in need of free health care can travel for free by ferry to Victoria to obtain free health care. Residents that are pregnant in Praslin and La Digue are encouraged to travel to the main island (Mahé) to give birth to their children.

In 2014, the private healthcare included 22 general practitioners, four dentists and nine pharmacists. In addition, there are 26 private medical, dental and optometry clinics that offer primary healthcare, referring patients the government healthcare system when necessary. At the same time, the government healthcare system had available 153 medical practitioners, including 13 consultants in 2014. There were 20 dentists, including two consultants. There were seven government pharmacist (World Health Organization 2014; Seychelles National Bureau of Statistics 2015a).

The ratio of population per doctor was 522 in 2014. The ratio per dentist was 3807. Although these ratios are considered to be high for the WHO African Region, it must be considered that the Seychelles is deeply dependent on expatriate medical practitioners, who account for just more than 60% of all medical doctors (World Health Organization 2014; Seychelles National Bureau of Statistics 2015a).

The following healthcare facilities are available in the Seychelles.

Table 18: Health facilities (number)

Government Establishments	**2014**
Hospitals	6
Hospital Beds	302
Health centres	18
Private Clinics	
General Practitioners	22
Dentists	4
Pharmacists	9

*Source:*Seychelles National Bureau of Statistics (2015a)

5.2.4 Health

From 2005 to 2008, the five leading causes of hospitalisation in the Seychelles were: obstetrics and gynaecology (20.2%), infectious diseases (9.6%), respiratory ailments (9.4%), digestive problems (8.4 %) and cardiovascular disease (8.3%). There has been an increase in non-communicable diseases which is linked to the ageing population and behavioural factors such as smoking, excessive alcohol intake, physical inactivity and unhealthy diet. The decrease in the consumption of traditional foods based on fish, rice, and tea in favour of fatty and sugary foods also partly explains the increase in non-communicable diseases. The main risk factors are cardiovascular diseases, hypertension, obesity, smoking and diseases related to alcoholism (see Table 19). According to the Seychelles National Cancer Registry in 2010, 131 new cases of cancer were reported and 93 people died (Bovet, 2012). In the risk factors highlighted by the WHO, 36.7% of adult females suffer from obesity and 17.6% of adult men. Weight related illnesses are more prevalent in females than males (World Health Organization, 2016).

Table 19: Prevalence of diabetes and related risk factors (WHO, 2016)

	Males	Females	Total
Diabetes	9.6%	10.5%	10.1%
Overweight	48.3%	64.5%	56.3%
Obesity	17.6%	36.7%	26.9%
Physical inactivity	18.2%	23%	20.6%

Source: World Health Organization (2016)

Along with favourable socio-economic development that contributes to public health successes, the Seychelles are actively fighting infectious diseases and NCDs, producing significant achievements, including high life expectancy (Bovet, 2012). The life expectancy at birth for Seychelles is reported to have decreased from 62·0 years to 61·3 years for men, and from 72·4 years to 71·8 years for women between 1990 and 2010 (Wang, Salomon and Murray 2013).

5.2.4.1 Household Amenities

The Seychelles Ministry of Land Use and Housing (MLUH) are aware of the predicted increase in pressure on various social infrastructure. The MLUH have planned to develop additional housing, hospitality, office, retail and industrial units over the next 30 years as depicted in the Seychelles Strategic Land Use and Development Plan 2015 (Seychelles Ministry of Land Use and Housing and Abu Dhabi Urban Planning Council, 2015).

5.2.4.2 Social Security

A telephonic interview with the Seychelles Police Headquarters revealed that there are 17 police stations throughout the Seychelles with a ratio of 1:1000 police to civilians. Respondents from a focus group meeting with key community members from Praslin stated that the island needed to have their policing services upgraded and that there is a lack of experienced policemen and women.

5.2.5 Housing

The most recently published Population and Housing Census of the Seychelles (2010), reported 23 770 housing units in the Seychelles. There are in the order of 4.9 rooms per household (Seychelles National Bureau of Statistics 2014b).

The Seychelles MLUH spokesperson, the Principal Secretary, stated that the ministry has planned for future population growth and influx. Residential development will be supported within existing settlements through new development and redevelopment. The MLUH has planned to develop additional housing units as shown in Table 20.

Table 20: Seychelles strategic development plan prediction for housing units

	2020	2025	2030	2035	2040
Housing Units	5815	8960	11290	13570	15830

Source: Seychelles Ministry of Land Use and Housing and Abu Dhabi Urban Planning Council (2015)

The tenancy figures for housing in 2013 are depicted in Table 21. The majority of homes in the Seychelles are owned followed by 11% of the population renting accommodation.

Table 21: Tenancy (owned, rented, supplied free)

Tenure	%
Owner Occupied	82.0
Rent free	6.9
Renting	11.1
Total	100.0

Source: (Seychelles National Bureau of Statistics 2014b)

5.2.6 Employment and Economy

The national unemployment rate in 2014 was 3%, decreasing from 3.3% in 2013. The unemployment rate for youths (between ages of 15-24) was 11% (male: 8.4% and female: 14.2%) (NBS, 13 September 2014).

In comparison, the national unemployment rate decreased to 4.2% during the second quarter of 2016. The unemployment rate among the youth was 10%[2]. The female unemployment rate (4.6%) was higher than that of the males at 3.9% (Seychelles National Bureau of Statistics 2016b).

The employment by sector (Government, Parastatal and Private) is shown below Table 22.

Table 22: Formal employment by sector

Sector	2012 Annual Average	2013 Annual Average	2014 Annual Average
Private	29 999	31 769	33 370
Parastatal	5 092	5 173	5 432
Government	9 024	8 876	9 150
All Sectors	**44 115**	**45 818**	**47 952**

Source: Seychelles National Bureau of Statistics (2015a)

From Table 22, it follows that the private sector provides the majority of employment and that employment within this sector is steadily growing. In contrast, the employment by the government sector shows a relative stability while employment within the parastatal sector showed slight but constant growth.

The average monthly earnings for each of these sectors are indicated in Table 23.The most earnings are accumulated within the parastatal sector.

Table 23: Average monthly earnings per sector (Rupees)

Sector	2012 Annual Average	2013 Annual Average	2014 Annual Average
Private	7 942	8 187	9 052
Parastatal	10 518	11 519	13 112
Government	8 830	9 826	11 648
All Sectors	**27290**	**29532**	**33812**

Source: Seychelles National Bureau of Statistics (2015a)

[2] When contemplating the significance of the high unemployment among the youth, considered that the youngest members in this category, would not typically be in the job market.

The average monthly employment by industry and sector is shown in Table 24 below. The highest concentration of employment occurs in the accommodation and food service activities (19%) which are tourism related activities. The second largest employment industry is that of construction (12%) which is evident by all the new developments taking place in and around the inner islands.

Table 24: Average Monthly Employment by Industry and Sector - 2015 Q1

Industry	Numbers	%
Agriculture, forestry and fishing	516	1
Manufacturing	4 439	9
Electricity, gas, steam and air conditioning supply	504	1
Water supply; sewerage, waste management and remediation activities	651	1
Construction	5 655	12
Wholesale and retail trade; repair of motor vehicles and motorcycles	4 100	8
Transportation and storage	3 464	7
Accommodation and food service activities	9 115	19
Information and communication	1 020	2
Financial and insurance activities	1 708	4
Real estate activities	1 076	2
Professional, scientific and technical activities	1 517	3
Administrative and support services activities	2 889	6
Public Administration and defence; compulsory social security	4 562	9
Education	3 110	6
Human health and social work activities	1 934	4
Arts, entertainment and recreation	1 065	2
Other service activities	637	1
Activities of households as employers of domestic personnel	191	0
Activities of extraterritorial organisations and bodies	49	0
Unclassified	45	0
Total	**48 247**	100

Source: Seychelles National Bureau of Statistics (2015b)

The estimated poverty threshold in the Seychelles for 2013 was SCR 3,945 per adult equivalent per month. An estimated 39.3% of the population live below the poverty line (see Table 25). The Poverty Gap Index[3] was estimated at 12.6%, which reflects the mean shortfall of gross income from the poverty line as a percentage of the poverty line. The Gini Index[4] was estimated at 45.9%, which measures the disparity in income distribution (National Bureau of Statistics Seychelles and The World Bank 2016).

[3] The poverty gap index is a measure of the intensity of poverty. It is defined as the average poverty gap in the population as a proportion of the poverty line.

[4] The Gini index is a measurement of the income distribution of a country's residents. Tis number helps define the gap between the rich and the poor, with 0 representing perfect equality and 1 representing perfect inequality.

Table 25: Poverty and inequality based on estimated gross income, 2013

Indicator	
Poverty line (SCR/adult equivalent /month)	3,945
Poverty headcount ratio (%)	39.3[19]
Poverty gap index (%)	12.6
Poverty gap squared index (%)	6.6
Gini index (%)	45.9

Source:(Seychelles National Bureau of Statistics 2015c).

Seychelles' relatively high poverty rate may appear to be the result of a poverty line which is unusually high. For a high income country, this falls within the general range, which plots the relationship between per capita income and national poverty lines (National Bureau of Statistics Seychelles and The World Bank 2016).

5.2.7 Transport

Thoroughfares in the Seychelles consist of a total of 998 km of roadway. Of this, 508 km is tarred and 490 km is paved roadway. The traffic density is four vehicles per kilometre of road. There are an estimated number of 615 private cars per 1000 households. More than a quarter of households have motorised transport. On the islands of Mahé and Praslin, there are independently operated taxis and there are a few operating on La Digue. The local population of La Digue predominantly uses bicycles as their means of transport. Cars are not commonly used on the island.

The city of Victoria on Mahé Island houses the main seaport. Small harbours are located at Praslin and La Digue. These small harbours service local fishing boats, tourist charters and general boat traffic between the islands. Transport between the islands relies on a network of regular air and sea transport that operates for the most part out of Mahé (Seychelles National Bureau of Statistics 2015a).

Respondents from social focus group meetings stated that all local roads require upgrading as they are too narrow and it is becoming a safety and security risk.

Figure 57: Bicycle rental, La Digue (left), Inter-Island Ferry's (right)

5.2.8 Land Use

Almost half of the ground comprising the Seychelles (about 47%) is protected by a number of conservation areas. Arable land includes approximately 10,000 ha, of which about 60% consists of coconut and other tree-crop plantations. A large amount of arable land has been used for other purposes, especially for housing (King and Walmsley 2013).

On the major granitic islands, 42% of the land is covered by forests. Forest cover consists of unprotected natural forest (41%), national park forests (48%) and plantations (11%). Forested areas do not lend themselves to other uses due to the topography of the land. However, as land availability decreases, housing developments are rapidly encroaching into the higher forested areas.

There is an economic desire to endorse local products which translates into the need for industrial land. Industrial developments include coconut oil and soap manufacturing factories, a tuna-canning operation and various related operations. Land is also needed for public utilities such as sewage works and desalination operations. On Mahé, the airport, the Victoria Sewage Works and the desalination plant are all located on reclaimed land. Other industries and some housing are also located on reclaimed land (King and Walmsley, 2013).

5.2.9 Economic Activity

5.2.9.1 Fisheries

Seychelles has a well-developed fishing sector that is a vital part of the social and economic development of the country. Three main types of fisheries are recognised: artisanal fisheries targeting demersal and semi-pelagic species, semi-industrial fisheries targeting pelagic species, and industrial fisheries targeting species of tuna. In economic terms, the industrial fisheries are of greatest importance. The per capita consumption of fish in Seychelles is one of the highest in the world at around 54-65 kg/person/year and the artisanal fisheries contribute significantly to the protein requirements of the country. Artisanal fisheries catches have remained fairly stable since comprehensive monitoring began in 1985, averaging around 4000 MT per annum but with some inter-annual variation. A wide range of fish and invertebrate species are targeted and the general catch composition has remained stable. The demersal stocks targeted by the artisanal fisheries are known to be over- or optimally exploited close to centres of population, and lightly exploited elsewhere, while the industrialised fisheries for pelagic species require a precautionary approach to management as some stocks are being exploited close to maximum sustainable yield levels (Robinson 2004).

The submarine banks of the Seychelles form the basis of the artisanal fisheries providing vital food security, employment and high value trade commodities. The Mahé Plateau is of particular importance. This shallow bank of some 39,000 km^2 supports important demersal fisheries such as: *Lethrinidae, Lutjanidae, Scaridae, Serranidiae, Siganidae* some 100 species of demersal fish are commonly caught in the fishery. Also important are the sea cucumber, lobster and octopus fisheries.

As with many small island nations, Seychelles has a high reliance on marine resources. Fisheries and ancillary services also account for 15 percent formal employment. Seychelles is characterised by a wide range of marine habitats: shallow water fringing reefs, granitic reefs, banks and plateau shelves, drop-offs, lagoons, seamounts and pelagic habitats.

The only fisheries that could potentially be impacted by aquaculture are the near-shore artisanal fisheries, which are characterised by a multispecies resource base, encompassing a diverse assemblage of demersal, reef-associated and pelagic fish species, plus a range of invertebrate groups such as lobsters, sea cucumbers and octopus.

The artisanal fisheries, practised solely by Seychellois fishers, comprise a variety of vessel and gear types. Although still used in a few near-shore areas, the traditional wooden canoes (‘pirogues’) have largely been replaced by more powerful craft. The fleet is now dominated by small fibreglass boats (‘Mini-Mahé’) powered by outboard motors (> 15 hp) and partially decked whaler vessels (‘Lekonomi’ and ‘Lavenir’) powered by inboard motors. Until the introduction of the schooner fishery in 1974, the fleet was largely restricted to near-shore fishing grounds on the Mahé Plateau but now have moved further offshore. The outlying coralline islands and atolls are less exploited. The main gear type employed is hook and line, with bamboo traps (‘kazye’), beach seines, droplines, and longlines of lesser importance. Spear guns and shark gill nets are prohibited in Seychelles, as is the use of trawl nets to target demersal resources. Figure 58 illustrates examples of a typical tuna vessel and artisanal fishing vessels.

There are two fisheries that could be impacted upon by cage aquaculture and these are the trap fishery and the near-shore dropline fishery. The spatial distribution of the trap fishery around the inhabited inner islands

and its operational detail were examined in detail by Christophe (2006). The spatial data was transferred to the GIS maps of Mahé, Praslin and La Digue. The data show that the fishery is largely restricted to less than 2 km offshore and where it occurs further offshore, particularly off Praslin, it takes place in shallow waters and far away from any of the proposed aquaculture development. The dropline fishery (mainly targeting large sharks) is generally restricted to hard ground and is also restricted by the depth to around 25 m. Other artisanal fisheries such as the inshore octopus and the beach seine fishery also occur in areas far removed from the proposed aquaculture zones.

The main commercial fishing products produced in the Seychelles is depicted in Table 26.

Table 26: Fishery Products

Fishery Products	Tonnes
Fish Landed	3 468
Canned Tuna	32 219
Smoked Fish	41

Source: Seychelles National Bureau of Statistics (2015a)

5.2.9.2 Small-Scale Fisheries

Subsistence and semi-industrial small-scale fishing contribute between 1% and 2% to the Seychelles GDP annually. As a whole, the fisheries sector contributed 7.7% to the GDP in 2008. Land-based economic opportunities are very limited in the Seychelles. Fishing is, therefore, an integral source of income, employment, food security and foreign exchange in the country. The fishing industry accounts for 17% of employment in the Seychelles, indicating the importance of this industry. Some 30% of this employment is in the small-scale sector, and 10% of the population is reliant on income from the small-scale fishing sector (Hilmi, N., Allemand 2015).

The small-scale fishing industry is challenged by numerous constraints, in spite of its economic importance in coastal regions. One of these constraints is the high operating and investment costs which have made it problematic for the sector to conform to quality standards set by the EU. This has both blocked access to the European market and also reduced competitiveness in the global market. Other constraints comprise little development in value-added products, inadequate marketing, as well as insufficient processing companies (Hilmi, N., Allemand 2015).

Figure 58: Commercial tuna vessel (left) and artisanal fishing vessel (right)

5.2.9.3 Tourism

A major contributor to the GDP of the Seychelles is tourism, amounting to 25.6% in 2010, which is an increase of 2.2% from 2007. The tourism industry directly employs 25% of the labour force and generated in the order of $270 million per year (2012). The Seychelles economy is tourism dependent, reflecting almost a quarter of the GDP. Only Macau and Maldives have economies more reliant upon tourism, according to 2012 figures. Tourism generates $270 million per year. In 2012, Seychelles received 208,034 tourists (King and Walmsley, 2013).

Although the expected increases in the tourism industry have been realised, there are some constraints to the growth of this sector. For example, various environmental factors associated with tourism impact negatively on this sector. These factors include climate change, conflict over land use between agriculture and tourism, as well as water shortages. The capacity of local communities to handle increases in tourism activity, as well as the ability of government to monitor development in tourism, has also been indicated as a threat to the sector (Hilmi, N., Allemand 2015).

Figure 59: Department of tourism promoting tourism in the Seychelles (left), key tourist node on the Anse Royale beach front (right)

Figure 60: Luxury boats and super yachts at Eden Island Marina (left), Mahé New beach villa developments, Beau Vallon (right)

5.2.9.4 Mariculture

Mariculture has not been well developed in the Seychelles. While there is a small number of pearl oysters being produced by a small-scale farming operation, the industriy does not require much labour and as such generates very few employment opportunities.

Mariculture opportunities have not been comprehensively assessed. Few policies are in place and little planning has been conducted for the sector as yet. Recommendations for the development of this sector are dependent on the building of bio-technical mariculture capacity which is still being developed in the country. A development plan funded by the African Development Bank has been commissioned by the government to investigate bio-technical and economic prospects in the sector. The SFA also has numerous international links, specifically in research, which should be beneficial in the planning process (Hilmi, N., Allemand 2015).

5.2.9.5 Agriculture and Forestry

Due to a paucity of land-based opportunities in the Seychelles, agriculture and forestry contribute considerably less to the GDP than the more lucrative tourism sector. However, by 1995 subsistence agriculture, forestry and fishing contributed 6% to the GDP and the agricultural industry provided employment for nearly 6% of the labour force in 1995. There has recently been a revival in the traditional exports of cinnamon and copra as the government provides incentives to the sector to increase productivity. The heavy reliance on the importation of staple foods means that food security remains an issue. This is in spite of the country becoming mostly self-sufficient in eggs, poultry and pork during the late 1990's (Hilmi, N., Allemand 2015).

Most agricultural practices are focused in the South of Mahé. This consists mainly of small-scale commercial farming that is conducted in small open fields and greenhouse tunnels. The mountainous terrain and low soil fertility of the Seychelles greatly reduce productivity in the agricultural sector (Hilmi, N., Allemand 2015).

Table 27: Agricultural Production (2014)

Cash Crops	Tonnes
Copra	2
Cinnamon bark	8
Tea (green leaf)	27

Source: Seychelles National Bureau of Statistics (2015a)

Figure 61: Agricultural Greenhouses, Mahé South (left), Palm oil planation, La Digue (right)

5.3 Cultural Heritage

The following sections summarize some of the historical developments, activities and industries of the Seychelles beginning with the archipelago's exploration and colonization by humans. Emphasis is placed on the developments, activities and industries that contain maritime elements that may manifest themselves in the archaeological record pertinent to the sector.

5.3.1 Exploration and Colonization

Due to its isolation, the history of human occupation in the Seychelles is tied to the history of seafaring in the Indian Ocean. While evidence exists that points towards human awareness of the Seychelles during the 10th Century by Arab seafarers (Benedict 1984), it is possible that humans visited the archipelago much earlier. It is known that Phoenician sailors circled the continent of Africa in the middle of the first millennium BC and palaeontological, linguistic, genetic research points toward a peopling of Madagascar by Austronesian migrants from Indonesia approximately two thousand years ago (Dahl 1951; Burney et al. 2004; Kusuma *et al*. 2015). These migrants could have sailed either a coastal route along the shores of Asia, India and Africa or along an equatorial route, taking advantage of favourable winds and currents to traverse the width of the Indian Ocean in what were likely extended logboats with double outriggers. If taking this dangerous and long (up to six weeks) voyage, the possibility exists that Austronesian migrants sailing an equatorial route could have encountered, and taken advantage of the abundant resources present on the Seychelles to replenish supplies in much the same way that the English East India Trading Company vessel *Ascension* did in 1609 before being lost on the Malacca Banks off the coast of western India (McGrail 2004; Wrecksite.eu 2016a).

European exploration of the Seychelles began in 1502 when the Portuguese explorer Vasco da Gama charted the Amirantes group during a voyage from India to East Africa (see Figure 1) (Galvano 1862; Stoddart 1984). The Portuguese established an early a pattern of preying on Arab and other non-European trading vessels, particularly in the Red Sea and the Malabar Coast of India. Rulers of other European nations, for instance James I (England) in the 1630s, sent ships to capture rich cargos from local vessels as it was not considered piracy if the vessel's owners and occupants were not Christian (Biddulph 1907). Around 1685, buccaneers or freebooters, from countless nations but with perhaps the largest number from New England, expanded their operations into the Indian Ocean and targeted both local vessels and various East India company ships. Pirate "settlements" were established, including at Sainte Marie (off Madagascar) and "Johanna" in the Comoros Islands, both located about 1500 km south of Mahé (Richie 1986). It is perhaps surprizing that the Seychelles Islands were not used more frequently as a source of supplies and shelter by pirates given their central location in an otherwise largely open ocean along the route of European vessels travelling to and from the East Indies, and located about 1300 km southeast of Mogadishu (the Somali Coast), 2300 km southeast of Babs-al-Mandab Strait (the entrance to the Red Sea), and 2800 km southwest of the Malabar Coast (Biddulph 1907). The Seychelles were certainly used to some degree in the 17th and early 18th centuries (Benedict 1984) and legend has it that the pirate Olivier Levasseur ("The Buzzard") buried his treasure on Mahé (Behar 2004).

In 1742, French explorer Lazare Picault arrived in the Seychelles. During the course of two expeditions between 1742 and 1744, Picault mapped and named many of the granitic islands however; the Seychelles remained unclaimed until 1756 when France formally took possession. They remained uninhabited until French settlers from Mauritius arrived on Ste. Anne Island in 1770. The French continued to colonize the inner islands throughout the latter part of the 18th Century and early 19th Century. As on Mauritius, the plantations on the Seychelles thrived until infested by non-native rat populations. The islands were surrendered to the British in 1810 during the Napoleonic Wars and under the terms of the Treaty of Paris (1814), the British were formally given the Seychelles. In 1903, the Seychelles became a colony of the British Empire of which it remained until 1976 when the British granted the Seychelles independence within the Commonwealth of Nations and the Seychelles formed a republic (Sparks 2016).

5.3.2 The Battle of Mahé (1801)

Near the end of the French Revolutionary War, a naval battle between the British Empire and the Republic of France was fought in Victoria Harbour. The battle commenced on August 19, 1801 as the frigate HMS *Sibylle*, which had been captured by the British in 1794 during the Battle of Mykonos, and her 38 guns opened fire on the 36-gun French frigate *Chiffonne* while the *Chiffonne* was at anchor near Pointe Conan undergoing repairs and replacement of the foremast (Maurel 2016).

The *Chiffonne* had been sent to the western Indian Ocean to engage British ships that were in the process of supplying the British forces in the Red Sea (James 2002). During her voyage from Nantes, the *Chiffonne* captured the Portuguese schooner *Parachi Pachia* off the coast of Brazil on May 15, 1801 and defeated the Portuguese frigate *Andorinha* on May 18, 1801. On June 16, 1801, *Chiffonne* captured the East India

Company ship *Bellona*, crewed her and sent her to Mauritius while the *Chiffonne* and the captured *Parachi Pachia* continued to Mahé.

The battle between *Sibylle*, captained by Charles Adam, and *Chiffonne*, captained by Pierre Guiyesse, lasted less than half an hour and resulted in *Sibylle* sinking *Parachi Pachia* and Guiyesse striking the colors and cutting anchor to ground *Chiffonne* on a reef. The fate of *Parachi Pachia* is uncertain. Maurel (2016) states that the vessel could not be refloated while Pollock (1841) states that following the battle, the *Parachi Pachia* was sold to merchants for cattle while it was still sitting on the bottom. The *Chiffonne* was dragged off the reef, repaired and sailed to India.

Less than a month later, a second naval battle took place in Victoria Harbour on September 6 and September 7, 1801. This battle pitted the 18-gun French brig *La Flèche*, which had sailed from Nantes and was captained by Lieutenant Jean-Baptiste Bonami against the 18-gun British sloop *Victor* which was captained by George Ralph Collier and had been dispatched from the Red Sea fleet in search of the raiding *La Flèche*. An initial engagement between the two vessels began at sea a few days previous on September 2, 1801 which resulted in damage to the rigging of the *Victor* and provided *La Flèche* with the opportunity evade *Victor* and sail to Mahé (James 2002).

On September 6, 1801, *Victor* re-engaged *La Flèche* in Victoria Harbour. Following an exchange of cannon fire that lasted over two hours, the *La Flèche* began to sink and in response, Bonami sailed the ship onto a reef and set it ablaze. Despite a boarding party from the *Victor* extinguishing the blaze, *La Flèche* rolled off the reef and sank (*London Gazette* 1802). *La Flèche* was salvaged shortly after sinking (Mathiot 2016) and was purchased by a Portuguese merchant from East Africa (Maurel 2016).

5.3.3 World War 1

In 1914, the outbreak of World War 1 resulted in a call to arms across the British Empire, including the Seychelles. During the war, German warships were responsible for the sinking of several vessels in the western Indian Ocean (Northern Maritime Research 2002), none were very near to the Seychelles. While geographically isolated from conflict, the Seychelles were not isolated from the consequences of the war and 347 Seychellois lost their lives (Pillay and Uranie 2014).

5.3.4 World War 2

Following the outbreak of World War 2, the Imperial Japanese Navy (IJN) advanced into the Indian Ocean on its quest to expand the Japanese Empire. To combat this advancement, the British Royal Air Force (RAF) and the Royal Navy (RN) established bases throughout the Indian Ocean. These bases, constructed on strategically located British colonies and protectorates such as Diego Garcia in the Chagos Archipelago, Addu Atoll in the Maldives, and Ste. Anne Island in the Seychelles, provided safe harbour for the refueling and refitting of the naval vessels and aircraft operating in the region.

In the Seychelles, Victoria Harbour on the island of Mahé was fortified by the placement of a six-inch artillery battery manned by the Ceylon Garrison Artillery on Pointe Conan and, in April 1941, the RAF established a seaplane base on the island of Ste. Anne. This base, known as RAF Seychelles would remain in operation until May 1945 by which time, the IJN had pulled back from the Indian Ocean to combat advancing American forces in the Battle of Okinawa.

While in operation, RAF Seychelles was manned by detached elements of RAF squadrons No. 205, 209, 259, 265 and Royal Canadian Air Force (RCAF) squadron No. 413 flying Consolidated Aircraft PBY Catalina's with missions primarily related to anti-submarine warfare, air to sea rescue, and transport (Halley 1988). These detachments were supported by HMS *Manela*, a passenger cargo vessel which the RN requisitioned in 1939 and converted into a seaplane depot (Clydebuilt Database 2016).

Although the aircraft stationed at RAF Seychelles saw little in the way of enemy action, they were not immune to losses. On July 8, 1944, Flight Sergeant William Hatton of RAF Squadron No. 209 (Commonwealth War Graves Commission 2016) perished and four other crew members were listed as missing and presumed dead following the crash landing at RAF Seychelles of Catalina 1B FP107. FP107 was not the only loss that Squadron No. 209 would experience at RAF Seychelles as records indicate that, in 1945, FP247 was able to be salvaged following its crash landing into the Indian Ocean, with no resultant loss

of life, during takeoff. Further, a number of aircraft attached to RAF Seychelles, including W8415, W8427 and Z2142, were struck off charge during the war. Records relating to the circumstances surrounding the events necessitating these aircraft being struck off were not available for this review therefore it is unknown if these aircraft may represent wrecks present due to accident or abandonment within Seychellois waters.

5.3.5 Mining and Resource Exploration

Over millennia, the excrement of seabirds (guano) accumulated on the surfaces of the coralline and granitic islands of the Seychelles. Beginning in 1891, commercial mining of that guano, which has a high nitrogen content and is thus prized for use in fertilizer, commenced and continued into the late 1970's. During this time, over 700,000 tons of guano was exported via ship from the Seychelles to markets around the world. The mining process was destructive and required the removal of large quantities of vegetation from the islands. It led to the extinction of four bird species on the island of Assumption and resulted in a significant reduction in the population of the Assumption green turtle (Stoddart 1984c).

In recent decades, offshore exploration for oil and natural gas deposits has occurred within the Seychelles EEZ that has resulted in the completion of 2D and 3D seismic surveys and the drilling of four exploratory wells. Three of the exploratory wells were drilled by Amoco in 1980 and 1981 and while they encountered oil and gas, they were not commercially viable. In 1995, an exploratory well was drilled by Enterprise Oil Plc, however, this well did not reach its target depth prior to being discontinued (Petroseychelles 2016). A 2012 United States Geological Survey (USGS) study suggests that the Seychelles contain hydrocarbon reserves of approximately 2,394 million barrels of oil, 20,736 billion cubic feet of gas and 739 million barrels of natural gas liquids. At present, Afren Plc has a petroleum agreement for the Seychelles EEZ and Japan Oil Gas and Metals National Corporation has an exploration license (Petroseychelles 2016).

5.3.6 Agriculture

Agricultural activity in the Seychelles began with the arrival of the first colonists in the 18th century and resulted in the widespread clearing of native forest. The harvesting of maize, rice and root crops were primarily for local subsistence with cotton subsequently being introduced as a cash crop. A shift in agricultural practice in the middle and late 19th century began with the creation of large scale coconut plantations that required even greater amounts of forest to be cleared. During this time, coconut oil was locally manufactured and exported. In the early 20th century, copra (dried coconut kernel) supplanted coconut oil as the primary export resulting from the coconut and by the 1950's, over 7,000 tons of copra was exported annually. During the early 20th century, vanilla and cinnamon joined the coconut as major agricultural crops in the Seychelles while small quantities of cloves, cacao, patchouli, coffee and tea were also produced and exported (Stoddart 1984c). All exports are carried by ships with the exception of light and valuable produce taken by air. Inter-island trade in produce is of necessity by boat or ship.

In addition to farming, seabird eggs were exploited for local subsistence and the export of yolk for pharmaceutical production. Giant tortoises were also locally consumed and used to replenish food stocks on passing ships while sea turtles were exploited for food and their shells (Stoddart 1984c).

5.3.7 Fishing

The absence of large indigenous mammals in the Seychelles necessitated that the Seychellois colonists become dependent on fish for their primary source of animal protein. To that end, an artisanal fishing industry developed that was conducted from locally produced pirogues (canoes) made from almond trees as well as whalers (an open canoe with sail) made from the takamaka tree, which is resistant to rot (Estridge 1885; Lagarde and Pommeret 2010).

Locally produced vessels that were primarily constructed in shipyards on Mahé, Praslin and La Digue were not restricted to just small fishing boats. The *Arpenteur*, a two masted 95 ton brig which foundered off on Cheynes Beach, Western Australia in 1849 was constructed in 1839 on Mahé (de L. Marshall 2001).

Many of the local shipyards ceased operations following the arrival of fiberglass vessels, ranging in length from 6 to 16 meters, manufactured in Sri Lanka (Lagarde and Pommeret 2010). Industrial fishing undertaken by primarily foreign-owned vessels commenced in 1983 (Lagarde and Pommeret 2010).

5.3.7.1 Whaling

During the 19th century, the northern regions of the Seychelles territory was subject to whaling by vessels from the United States and England (Stoddart 1984c). On December 17, 1828, the United States registered *Asp*, a 345 ton three-masted whaler sunk of Madge Rocks between Praslin and Mahé (Mathiot 2016). A whaling station operated on the island of Sainte Anne until 1915 (Stoddart 1984c).

5.3.7.2 Artisanal Fishery

Traditionally, artisanal fishing was confined to nearshore areas (Payet 1996). Artisanal fishermen are now able to take advantage of the availability of larger vessels with fish storage facilities and living quarters to venture, if they so choose to the edge of the continental shelf or further on excursions lasting up to twelve days (Lagarde and Pommeret 2010). The area within the continental shelf and areas with depths shallower than 200 m is reserved for the use of the artisanal fleet (Mees 1990).

In addition to the pirogue, artisanal fishing vessel categories tracked by the SFA for statistical use include Outboard, Inboard, Whaler and Schooner. An example of an Outboard vessel is the mini-Mahé; an approximately 5 m long fiberglass hull boat that is powered by a small outboard motor whereas an example of an Inboard vessel would be the Lekonomi; a simulated clinker fiberglass hulled vessel approximately 6.5 m in length that is equipped with a sloop rig and a small engine. Whalers, not be confused with the traditional whaler described above, are of wood clinker construction and are approximately 8 to 12 metres in length. They can be decked or open, possess an inboard motor and may be equipped for overnight trips. A Schooner is a 10 to 13 metres long wooden hulled vessel that is equipped with a diesel engine and is capable of extended trips (Seychelles Fishing Authority 2015a; Payet 1996). Payet (1996) describes another type of vessel, the Lavenir and Nouvo Lavenir which are constructed of fiberglass. The Lavenir is approximately 8.5 m in length and is equipped with an ice chest, small cabin and inboard motor while the Nouvo Lavenir is an extended version that has greater fish carrying capacity. The Whaler and Lavenir are similar in size and function therefore it is considered likely that the SFA considers the Lavenir and Nouvo Lavenir as a Whaler for statistical analysis.

Although artisanal fishermen practice a number of techniques including diving, net and trap, the most common practice is hook and line fishing (Payet 1996; Lagarde and Pommeret 2010) which provides for control of the size and type of fish caught (Payet 1996) and allows for sustainability of the resource (Lagarde and Pommeret 2010). Set bottom fishing, ball bottom fishing and bottom fishing adrift are the three main types of hook and line fishing (Lagarde and Pommeret 2010) and has centered on the capture of species such as red snapper, emperor, jobfish, groupers, mackerel, jack fish, tuna, sharks and octopus (Grandcourt 1993; Payet 1996; Lagarde and Pommeret 2010). On an annual basis, artisanal fishing lands over 4,000 tons of fish from the territorial waters of the Seychelles (Mees 1989; Grandcourt 1993; Seychelles Fishing Authority 2015b).

5.3.7.3 Semi-industrial and Industrial Fishery

Within the Seychelles EEZ, semi-industrial and industrial fishing is practiced by a combination of a fleet of local and foreign owned vessels primarily capturing Bluefin and Bigeye tuna. Semi-industrial fishing comprises locally owned longliners plying techniques such as longlining, handlining and droplining to land swordfish and tuna (Payet 1996) whereas industrial fishing is comprised of foreign owned long-liners and purse seiners. Over 110,000 tons of fish were landed by semi-industrial and industrial fishing within the Seychelles EEZ in 2013, the last year that the Seychelles Fishing Authority has published statistics (Seychelles Fishing Authority 2015b).

As a result of the semi-industrial and industrial fishery within the Seychelles EEZ, the second largest cannery in the world, Indian Ocean Tuna (Lagarde and Pommeret 2010), is the leading employer in the Seychelles with a workforce of over 2,500 (Seychelles Fishing Authority 2015b).

5.3.8 Sea Travel

Throughout its history, the sea has connected the Seychelles to the rest of the world. Prior to the twentieth century and the advent of the airplane, access to the Seychelles was restricted to boats and ships that could navigate the immense distances between the mainlands (e.g., Africa, India) and the Seychelles Archipelago.

While evidence indicates that the islands among the Seychelles were known to seafarers in the 9th Century AD, and possibly earlier, confirmed widespread sea travel to the islands throughout the Seychelles archipelago did not begin until the arrival of European explorers (Stoddart 1984a). With the arrival of colonists, via ship, the Seychelles was able to begin producing exports, primarily agricultural, which were required to travel over the sea to reach markets around the world. Section 5.3.4 described the importance the importance of the Seychelles to sea travel during World War 2 as a safe harbour for refueling and maintenance activities.

The sea continues to be an important aspect of life in the Seychelles. The ability to use the sea to move people and goods on vessels such as pirogues, whalers, schooners, interisland ferries, cruise ships and cargo ships is vital to the continued day to day operations of the country while, the sea provides further natural benefits to the country through tourism, food procurement and access to recreational activities such as sailing and diving. Shipwrecks are also beneficial to dive tourism, and multiple wrecks have been intentionally sunk in the Seychelles for that purpose (wrecksite.eu 2016b-f; Elizabeth Fideria, personal communication, September 20, 2016).

5.3.9 Air Travel

Prior to the opening of Seychelles International Airport in 1972 in Victoria, international air travel to the Seychelles was restricted to flying boats. There are only two documented instances of aircraft in the Seychelles prior to World War 2. The first documented aircraft to arrive in the Seychelles was in 1935 when a Royal Navy amphibious plane that had been launched from a passing cruiser landed in Victoria Harbour. The second documented instance occurred in 1939 when a Consolidated Model 28, the civilian version of a PBY, known as *Guba II* landed in Victoria Harbour while transiting the globe (Guttery 1998).

As discussed in Section 5.3.4, the commencement of World War 2 saw the arrival of RAF with Consolidated PBY Catalina's and between 1944 and 1946, the British Overseas Airways Corporation (BOAC) provided mail service to the Seychelles using a Short Brothers S.26 (G-class) flying boat. Following World War II, air travel to the Seychelles remained restricted to flying boats and was poorly developed, with East African Airways briefly providing service between Victoria and Mombasa in 1953 and Trans Oceanic Lines providing service between Nairobi and Mahé during the 1960's using surplus Consolidated PBY Catalinas. Between 1963 and 1970, Pan American World Airways provided support for a United States satellite tracking station as well as mail and medical evacuation service between Victoria and Mombasa with a Grumman Albatross flying boat (Guttery 1998).

With the opening of the Seychelles International Airport in 1972, flying boats were no longer required and commercial air traffic to and among the Seychelles archipelago increased as conventional long distance aircraft were able to land in Victoria. During the 1970's, interisland air travel throughout the Seychelles Archipelago was provided by Air Mahé and Inter-Island Airways until their merger in 1979 to form Air Seychelles (Guttery 1998). Air Seychelles continues to provide interisland and international flights.

During the 21st Century, the United States has been operating unmanned aerial vehicles (UAVs) from Seychelles International Airport in an effort to combat piracy in the Indian Ocean off the east coast of Africa. Since their deployment, there have been two recorded instances involving UAVs crashing into the ocean adjacent to the Seychelles International Airport (Gambino 2012).

Background review did not identify any instances of civilian aircraft losses in the seas among the islands of the Seychelles.

5.3.10 Archaeological Setting

In his seminal publication, maritime archaeology was defined by Muckelroy (1978:4) as the "scientific study of the material remains of man and his activities on the sea." This definition is limiting however and subsequently; broader more holistic definitions have been developed describing a discipline that encompasses the entire maritime cultural landscape. Delgado (1997:259) defined maritime archaeology as "the study of human interaction with the sea, lakes, and rivers through the archaeological study of material manifestations of maritime culture, including vessels, shore-side facilities, cargoes, and even human

remains." In the sections which follow, the term maritime archaeology used to represent those aspects of maritime archaeology not represented by the archaeology of ship and aircraft wrecks.

5.3.10.1 Maritime and Shipwreck Archaeology in the Western Indian Ocean Region

The western Indian Ocean region boasts an extensive bibliography related to coastal "Swahili" maritime archaeology (Kusimba 1999; Horton and Middleton 2000). The cultural area includes the African coast adjacent to the Seychelles from Somalia to Mozambique and including the Mafia archipelago as well as the Comoro Islands and the islands of Pemba, Zanzibar. Breen and Lane (2003) describe the dynamic relationship that the inhabitants of the East African coast have had with the sea over the last 2500 years, while the presence of more than four hundred sites comprising of stone built architecture along the coastline of East Africa from Mogadishu, Somalia to Nova Sofala, Mozambique (Breen and Lane 2003) can be construed to indicate that the utilization of marine resources as well as trans-Indian Ocean trade were significant aspects of Swahili culture (Prins 1965; Allen 1993; Pearson 1998; Horton and Middleton 2000).

Over the last decade, an increasing number of maritime cultural landscape studies have been conducted along the East African coast (Christie 2007; 2011, Pollard 2007, 2008; Rhodes 2010). These studies have generally centered on the exploitation of marine resources and the development of coastal facilities (Lane 2012). Perhaps the most comprehensive maritime cultural landscape study conducted along the East African coast was completed by Pollard during his doctoral research. Pollard (2007) examined the maritime cultural landscape around the communities of Bagamoyo, Kaole and Kilwa in Tanzania during the Iron Age with a focus on the maritime features of the society including nautical infrastructure (lighthouses, wharves), marine resources and the technology developed to exploit those resources (fish, shell fish, fish traps), transportation (shipwrecks and shipping routes), and features of maritime culture with social and religious contexts such as shrines.

Pollard's research combined inter-tidal and coastal survey with test-excavations and ethnoarchaeological studies. The results of which included new understandings of the maritime landscape of southern Tanzania and the identification of coral causeways and platforms likely dating to the thirteenth-sixteenth century AD and have been postulated to be have been used to access marine resources or ships at low water. They may also have been used as navigational aids and breakwaters (Lane 2012; Pollard 2008).

There has not yet been any archaeological evidence of Swahili presence on any islands of the Seychelles.

Shipwreck archaeology predated the emergence of maritime archaeology in the western Indian Ocean by about a decade. Regional marine archaeological expertise is now being developed in Egypt, India and South Africa. Unfortunately, this increase in maritime and shipwreck archaeology has coincided with increased activity of treasure hunters (Lane 2012). Three examples of underwater archaeological excavations in the region and located closest to the Seychelles follow.

Perhaps the first instance of shipwreck archaeology in the western Indian Ocean was the underwater archaeological excavation of the Portuguese frigate *Santo António de Tanná* which had sailed from Mozambique to assist with the defence of Fort Jesus on Mombasa Island, Kenya from Omani forces (located about 1500 km south of Mahé). The *Santo António de Tanná* (also known as the Mombasa Wreck) sunk in Mombasa Harbour in 1697 after coming free of mooring lines and drifting onto a reef where it lost its rudder and took on water. The remains of the *Santo António de Tanná* were located during the 1960s by recreational divers (Lane 2012). Divers returned to the wreck in 1970 and during the dive collected artifacts including a bronze swivel gun which assisted in the positive identification of the wreck. In 1976, archaeologists from the Institute of Nautical Archaeology conducted an initial survey of the wreck and an underwater excavation and recording of the wreck was conducted between 1977 and 1980 and resulted in the recovery of over 6000 artifacts (Bass 1997; Green 1978; Piercy 1978, 1979, 1981, 1982, 1983, 1992, 2005; Sassoon 1978, 1979). Since the conclusion of the underwater excavation, two additional surveys have been conducted in the area of the Mombasa Wreck. In 2001, a marine geophysical survey comprising of magnetometry, side-scan sonar and bathymetric profiling identified targets of interest in the vicinity of the *Santo António de Tanná* which may represent additional wreckage (Quinn et al. 2007). Between 2005 and 2007, a maritime archaeologist from the National Museums of Kenya located and recorded timbers

approximately 25 m from the Mombasa Wreck. These timbers have not been subject to further investigation though it is thought that they may represent a separate wreck (Sommer 2007; Lane 2012).

In 1999, the wreck of a wooden vessel believed to be HMS *Serapis*, a British warship captured by American naval commander John Paul Jones in 1779 during the American Revolution, was located following a magnetometry survey at Île Sainte Marie (located about 1500 km south south-west of Mahé). The ship had been lost 1781 as a result of an onboard fire. A team comprising American maritime archaeologists and researchers at the University of Madagascar conducted an excavation at the site in 2004 which resulted in the mapping of copper hull sheathing and a ballast pile. Material culture recovered during these investigations was analyzed and conserved at the University of Antananarivo's Museum of Art and Civilization (Lane 2012; Van den Boogaerde 2009).

Between 2006 and 2008, researchers affiliated with the French not-for-profit organization *Groupe de Recherche en Archéologie Navale* located and investigated *L'Utile*, a ship owned by France's *Compagnies des Indes Orientales* that wrecked near Tromelin Island (located about 1250 km south of Mahé) in 1761 while enroute from Madagascar to Mauritius. The project was part of a broader UNESCO initiative to research the history of slavery in the Western Indian Ocean. Remnants of the wreck site comprised a widely scattered artifact assemblage, including iron cannons and anchors. In conjunction with the shipwreck survey, excavations were conducted on Tromelin Island which resulted in the identification of the location of the L'Utile's survivors' camp. Analysis of artifacts recovered during the terrestrial excavations indicate that the survivors scavenged the remains of the wreck for materials that would be useful in ensuring their survival (Lane 2012; Marriner *et al*. 2010; Hunter 2014) while researchers have been able to examine the survivors diet through the analysis of faunal remains recovered from the terrestrial excavation. Faunal remains include almost 18,000 avian bones, primarily belonging to the sooty tern, as well as far lesser quantities of turtle and fish (Laroulandie and Lefevre 2014).

5.3.10.2 Maritime Archaeology and Recorded Shipwreck Sites in Seychelles

No records or publications of terrestrial or maritime archaeological work conducted in the Seychelles were located as part of this study, and no systematic study of the maritime cultural landscape of the Seychelles has been undertaken.

Across the Seychelles, shipwrecks have been recorded on many of the islands (Burridge 2016), however, there has been no comprehensive shipwreck survey completed. What is known regarding early shipwrecks within the territorial waters of the Seychelles is from historic charts and accounts from survivors. If accessible, fishermen are also good sources for the location of potential wrecks as they often encounter objects in their nets or lose nets after being snagged on undersea obstructions. More recent shipwrecks may be identified on charts, especially if they pose a hazard to shipping.

Within the Seychelles territorial waters, wrecks are primarily associated with early European activities in the region and include among many, a Portuguese wreck along the shore of Boudeuse Cay, the French frigate *L'Heureux* (1769) along the shore of Providence Island, the Portuguese frigate *Don Royal* (1760) along the shore of Astove, and the British sloop *Spitfire* (1801) along the shore of Remire Island (Burridge 2016). More recent wrecks (< 100 years old) are few and are primarily associated with the fishing industry or have been sunk on purpose as artificial reefs and SCUBA diving sites (Wrecksites.eu 2016b-f) with the British tanker *RFA Ennerdale* (1970) being perhaps the most conspicuous due to its size (216.4 m and 29,189 gross tons) and its location between Mahé and Praslin (Figure 63).

Only the Boudeuse Cay wreck in the Seychelles has been subject to archaeological investigations. It was first located by fishermen in 1970 on the southwest side of the island that is located approximately 180 nautical miles (335 km) southwest of Mahé in the Amirantes Group (Figure 1). Following the discovery, fishermen and SCUBA divers removed many artifacts including cannon and copper ingots from the wreck (Hunter 2014).

Archaeological investigations were conducted at the Boudeuse Cay wreck in 1976 that included surveying and excavating with the objective of identifying the vessel (Blake and Green 1986). During the archaeological investigation, a sample of hull planking was taken for wood species identification. The sample was identified as larch, which leads Blake and Green (1986) to conclude that the vessel was built in Europe

and to which they comment “presumably Portugal” based on the artifact assemblage which suggests wreck occurred in the mid- to late 16th century. Measurements of the thickness of the hull planking and attached frames point toward the vessel being a *nau* or *caravela* of the period. Approximately 30 cannon were removed from the wreck site prior to the archaeological survey by fishermen and SCUBA divers, some of which are present at the Carnegie Museum in Victoria, Mahé. The Boudeuse Cay shipwreck is commonly cited as representing the *Santo António* which was lost in 1589 (Lane 2012; Viera de Castro 2005), however, a diver who participated in salvage of the wreck believes it to be the *Nossa Sehora Da Conceicoa* lost in 1555 (Peter Sachs, personal communication, September 28, 2016).

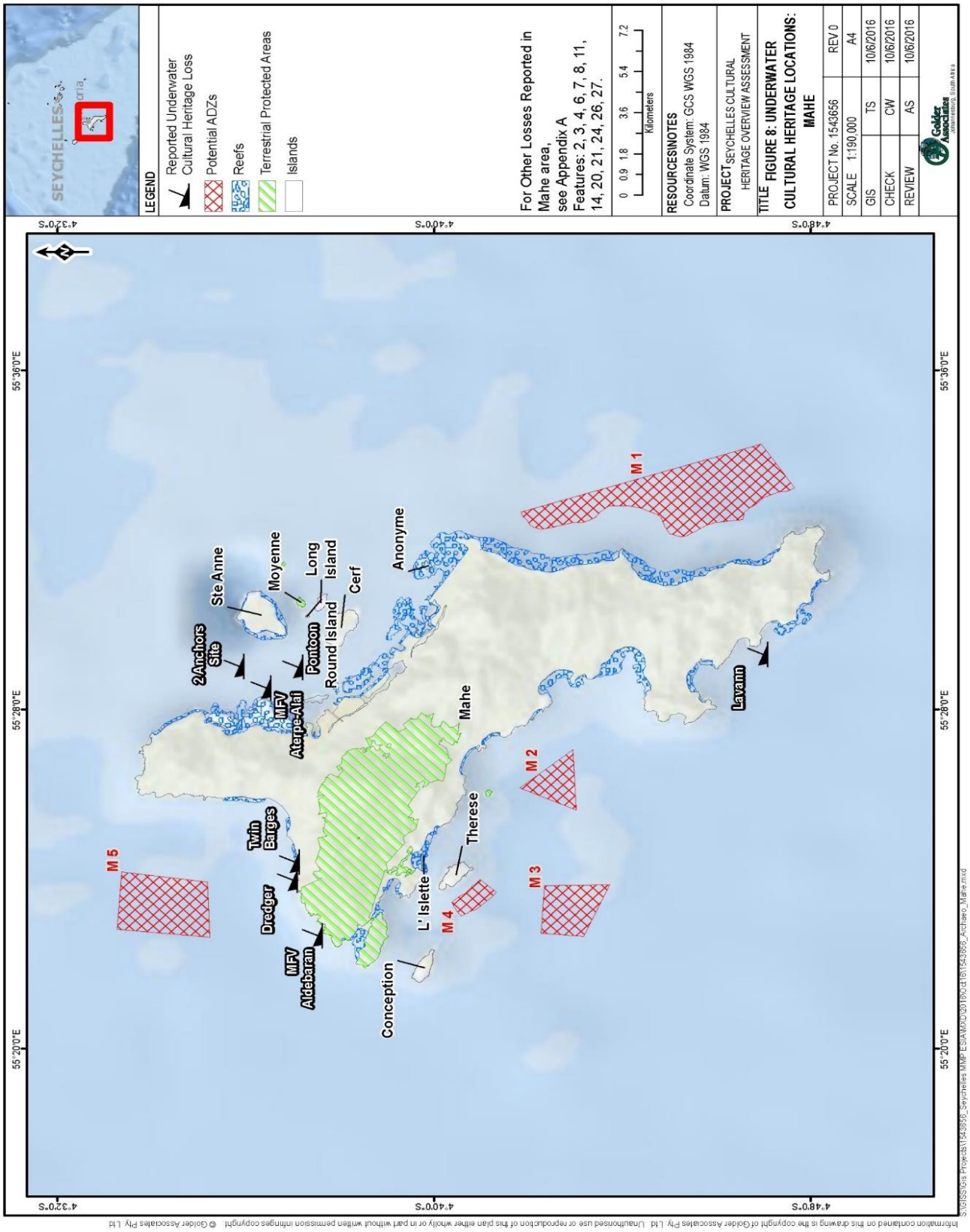

Figure 62: Underwater cultural heritage locations: Mahé

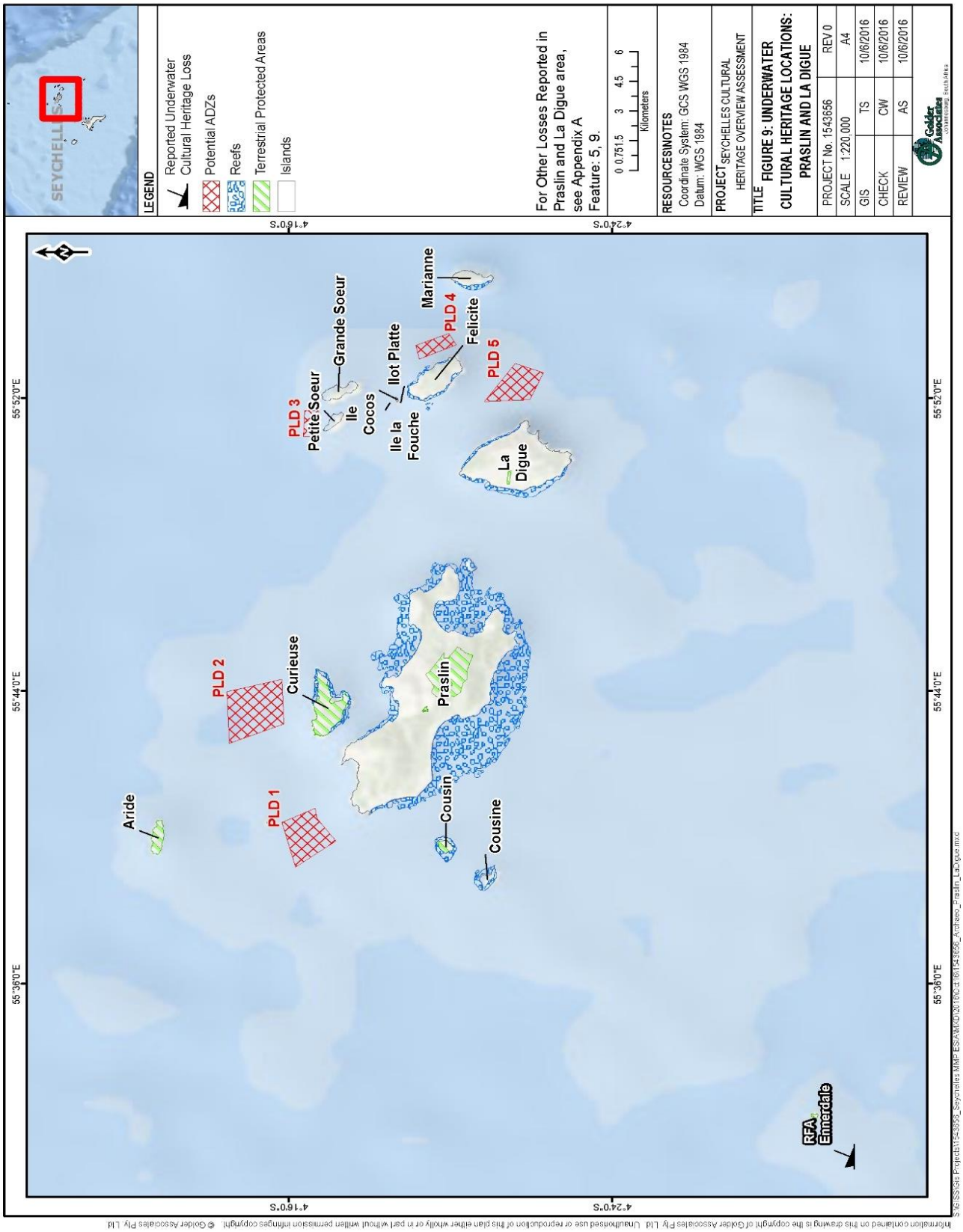

Figure 63: Underwater cultural heritage locations: Praslin and La Digue

5.3.11 Review of Reported Wrecks in the Vicinity of the Project

No wrecking events are known to have been reported in the Project area. Background review has identified ship (20) and aircraft (2) wrecking events that occurred in the vicinity of various locations in the Project area. A summary of the ship and aircraft wrecking events in the vicinity of the Land based zones and to the various ADZs associated with specific islands is presented in **Table 28**. These reported wrecks would be in addition to what is likely numerous losses of smaller watercraft that have been used for artisanal fishing and short distance transportation during precolonial and colonial times that have gone unrecorded.

This total also does not include instances where underwater cultural heritage has been observed absent of vessel wreckage (see Section 7.2.2 of the Cultural Heritage Overview Assessment under APPENDIX I). A summary of all identified underwater cultural heritage within the vicinity of the Project area is presented as an appendix of the Cultural Heritage Overview Assessment.

Table 28: Summary of ship and aircraft wrecking events reported in the vicinity of the Project

Project Component	Location	Number of Ships Wrecked	Number of Aircraft Wrecked
Land-based Zone	Research & Development Site	0	0
	Broodstock Quarantine & Acclimation Facility and Pilot Project Cage Site	8	2
Aquaculture Development Zone	Mahé	8	0
	Silhouette & North Island	2	0
	Praslin & La Digue	2	0

5.3.12 Cultural Heritage Sites within the Project Area

The background review did not result in the identification of any cultural heritage sites within either the terrestrial or underwater components of the Project study area.

6.0 PUBLIC PARTICIPATION PROCESS

6.1 Objectives of Public Participation

Public participation is an essential regulatory requirement for an environmental authorisation process, such as an ESIA. The public participation process is designed to provide sufficient and accessible information to Interested and Affected Parties (I&APs) in an objective manner to assist them to:

During the Scoping Phase:

- Raise issues of concern and offer suggestions for alternatives and enhanced benefits;
- Contribute local knowledge;
- Verify that their issues have been captured; and
- Verify that their issues have been considered by the technical investigations.

During the Impact Assessment Phase:

- Verify that their issues have been considered in the environmental investigations;
- Contribute relevant local knowledge and information towards the environmental assessments, and
- Comment on the findings of the impact assessments.

During the last phase of the ESIA process, i.e. the Decision-making Phase, when the lead authority has made a decision stating whether or not the project may proceed, registered stakeholders are informed of that

decision. Stakeholders are also provided with information regarding the appeal process, should they wish to appeal the decision of the authorities.

6.2 Identification of Interested and Affected Parties

In terms of the ESIA process, stakeholders are required to formally register as stakeholders/Interested and Affected Parties (I&APs) for the ESIA. The Public Participation Office (Valsen Consulting) started this process by building on an initial stakeholder list of I&APs which have been identified and engaged throughout the MMP process to date.

Key I&APs were further identified through a process of networking and referral; obtaining information from existing stakeholders; liaison with potentially affected parties in the study area; newspaper advertisements; and a registration process involving completion of a registration and comment sheet.

The stakeholder database represents a broad spectrum of sectors of society, including fisherman (artisanal to commercial), and their associations, tourism (owners, operators and employees), NGO's (including scientific community), government officials, business owners, and members of the public. The initial stakeholder database was used to formally announce the project.

6.3 Public Participation during Announcement and Scoping Phase

All stakeholders on the initial database received a background information document (BID) as well as a registration and comment sheet aligned with the requirements of the Ministry of Environment, Energy and Climate Change. Stakeholders were asked to submit comments either by completing the comment sheet attached to the BID and submitting these to the Public Participation Office, or alternatively to make verbal or written submissions directly to the Public Participation Office. Stakeholders were also notified of Public Meetings which were held on Mahé (north), Mahé (south), Praslin and La Digue and that by attending they could obtain more information about the MMP and ESIA, as well as ask questions or share concerns with the panel.

The Public Meetings were announced through the following media outlets:

- Television advert on SBC channels;
- Radio adverts on SBC radio;
- Newspaper adverts in Seychelles Nation; and
- Posters located outside the venues on the day of the meeting.

The advertisements were all broadcast or published in Creole, French and English.

The public participation process followed during the Announcement and Scoping Phase of the EIA is summarised in **Table 29**.

Table 29: Summary of Public Participation process during the Announcement and Scoping Phase

Date	Description
Project Announcement and Scoping Phase	
June 2016 – July 2016	**The commencement of the EIA process and the opportunity to participate was announced by way of:** A public participation information pack, distributed to I&APs on the database. The information pack consisted of: ■ Background Information Document (BID) including a map of the proposed project area and a description and visual illustrations of the project components; ■ Registration and Comment Sheet.

Date	Description
	The information was distributed to existing I&APs as well as new stakeholders who registered during the process. Existing stakeholders and potential I&APs, as well members of the public were invited to attend any of the 4 public meetings listed below. **Meetings on 25 June 2016 at 2-5pm:** ■ Mahé (north), STC conference room; and ■ Mahé (south), UNISEY small auditorium. **Meetings on 2 July 2016 at 2-5pm:** ■ Praslin, Baie St Anne Bahai Centre; and ■ La Digue, Community Centre. On the morning of 25 June 2016 at 10:30, two community facilitation meetings were held with the Bel Ombre and Roche Caiman fishers groups. The purpose of these engagements was to mobilise these members ahead of the Public Meetings that afternoon and FGDs later in the week. The project was discussed and the opportunity to comment and share concerns was afforded to these members who actively participated in discussions. In addition to the public meetings, a series of Focus Group Discussions (FGD) were held. These FGDs were aimed at key stakeholder groups, which allowed them more time engage with the ESIA team and SFA regarding the proposed activities. These FGDs were held as follows: **FGD meeting on 28 June 2016 at 9-11am:** ■ Fishing industry stakeholders, SFA conference room. **FGD meeting on 28 June 2016 at 1:30-3:30pm:** ■ NGOs/civil society organisations, SFA conference room. **FGD meeting on 30 June 2016 at 9-11am:** ■ Fishing industry stakeholders, SFA conference room. **FGD meeting on 30 June 2016 at 1:30-3:30pm:** ■ Marine tourism (diving, boat charters, yachting, sports fishing), SFA conference room. As part of the Social Impact Assessment (SIA), the ESIA team also engaged with various members of society from members fishing associations and tourism organisations through a series of informal key informant interviews. These informal meetings also took place during the PP consultation period 25 June – 2 July 2016. **Stakeholders were invited to attend any of the 4 public meetings by way of:** ■ Background Information Document (BID); ■ SBC television advertisement ■ SBC Radio advertisement; ■ Newspaper advertisement; and ■ Posters located outside select venues. The public meetings were opened by a representative from the MEECC who provided an overview of the ESIA process and the role of the Ministry. This was followed by a presentation by a member of SFA on the MMP and project details, followed by a representative from Golder who presented on the ESIA process and specialist studies that will be conducted during the impact assessment phase.

Date	Description
	Information was displayed visually through photographic examples and on detailed maps during the presentations. The meetings were held in Creole, with some parts in English which were then translated into Creole if requested by the stakeholders. Comment sheets (scoping forms) aligned with the MEECC template were made available at all meetings for stakeholders to complete should they wish to submit comments. Comments and suggestions made verbally during the public meetings were recorded and captured in the Comment and Response Report. Attendance registers for the various meetings were also kept and submitted to MEECC as proof of attendance by stakeholders.
Impact Assessment Phase	
15 – 31 October 2016	The next round of PPP engagements will comprise of sharing the results and findings of the impact assessment compiled by the specialist team. The draft ESIA report will be made available to stakeholders for comment and a series of public meetings will again be held to discuss these findings and obtain comments and suggestions from stakeholders. The ESIA report will thereafter be updated and finalised before being submitted to the MEECC for decision-making.

6.4 Public Participation during Impact Assessment Phase

The following section describes the public participation activities for the impact assessment phase.

The availability of the draft ESIA and ESMP report and invitation for stakeholders to attend public meetings and provide comments was advertised through the following:

- SBC television advertisement;
- SBC Radio advertisement; and
- Newspaper advertisement.

The draft ESIA and ESMP report was made available at designated public places, as well as being available to download at Golders website: **http://www.golder.com/public,** where stakeholders would able to click on the project tab entitled: "***SFA: draft ESIA and ESMP for the Proposed Implementation of the Seychelles Mariculture Masterplan***", in order to access the relevant documentation. Stakeholders were advised to provide comments during the public comment period which ran for 17 consecutive days from **15 - 31 October 2016**. Stakeholders were able to submit comments by completing a comment sheet (scoping form), or alternatively by providing written comments via electronic mail or verbal comments by telephoning the public participation office (Valsen Consulting) directly.

The schedule of public meetings for the impact assessment phase are detailed in Table 30 below.

Table 30: Schedule of public meeting for impact assessment phase

REGION	VENUE	TIME & DATE
Mahé	STC Conference Room, Bois de Rose Avenue	Saturday, 22 October 2016 at 2pm-5pm

REGION	VENUE	TIME & DATE
■ Free bus service provided from UNISEY (Anse Royale) to STC, Victoria ■ Bus departed from UNISEY, Anse Royale at 1pm.		

In addition, specific focus group meetings were held with various stakeholders on Sunday 23rd, Monday 24th and Tuesday 25th October 2016, as shown below:

Table 31: Schedule of focus group meetings

GROUP	DATE	VENUE	TIME
Fishing & tourism industry stakeholders and members of the public (Praslin & La Digue)	Sunday, 23 October 2016	Bahai Centre, Baie Ste Anne Praslin	13:00 - 16:00
NGOs/civil society organisations	Monday, 24 October 2016	SFA, Victoria	9:00 -11:00
Fishing industry stakeholders	Monday, 24 October 2016	SFA, Victoria	13:30 -15:30
Fishing industry stakeholders & Tourism industry stakeholders	Tuesday, 25 October 2016	Ex Assembly Hall, National House, Mont Fleuri, Victoria	9:00 -11:00
Tourism including Marine tourism (diving, boat charters, yachting, sports fishing) as well as other NGO's	Tuesday, 25 October 2016	Ex Assembly Hall, National House, Mont Fleuri, Victoria	13:30 -15:30

Stakeholder comments were captured during the public meetings as well as the focus group meetings and compiled in a comment and response report (along with other comments received during the comment period), which can be found under APPENDIX J. These comments are submitted along with this final ESIA and ESMP report to the MEECC for decision-making. Proof of attendance by stakeholders, in the form of competed attendance registers for all meetings, can also found under APPENDIX J.

7.0 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

7.1 Approach to Impact Assessment

This ESIA endeavours to comply with the requirements of the Seychelles as well as align with best practice such as FAO ecosystem approach to aquaculture.

Key principles contained in the ESIA methodology include:

- Sustainability – development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs;
- Mitigation hierarchy – The mitigation hierarchy describes a step-wise approach (BBOP, 2009) that illustrates the preferred approach to mitigating adverse impacts as follows (the governing principle is to achieve no net loss and preferably a net positive impact on people and the environment as a result of the project):
  1) The preferred mitigation measure is **avoidance;**
  2) Then **minimisation;**

3) Then **rehabilitation** or **restoration**; and

4) Finally **offsetting** residual, unavoidable impacts.

- Developers have a duty of care towards the environment.

The assessment of the impacts of the proposed activities has been conducted within the context provided by these principles and objectives.

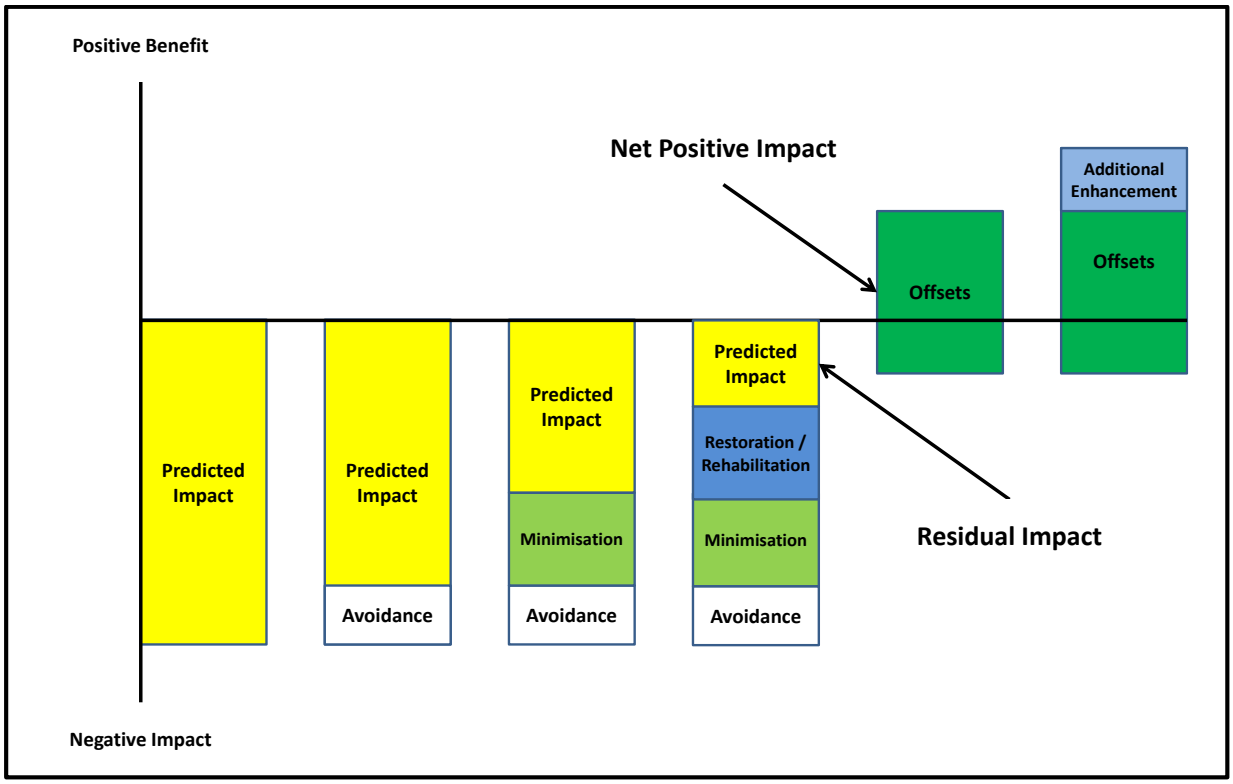

Figure 64: Mitigation Hierarchy Adapted from (BBOP, 2009)

7.2 Methodology for Assessing Impacts

The significance of the identified impacts have been determined using the approach outlined below (terminology from the South African Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998). This approach incorporates two aspects for assessing the potential significance of impacts, namely occurrence and severity, which are further sub-divided as follows:

Occurrence		**Severity**	
Probability of occurrence	Duration of occurrence	Scale / extent of impact	Magnitude (severity) of impact

To assess each of these factors for each impact, the following four ranking scales are used:

Probability	Duration
5 - Definite/don't know	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8-15 years)
2 - Low probability	2 - Short-term (0-7 years) (impact ceases after the operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	
Scale	**Magnitude**
5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 - Local	4 - Low
1 - Site only	2 - Minor
0 - None	

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

SP (significance points) = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). The impact significance will then be rated as follows:

SP >75	Indicates **high** environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates **moderate** environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates **low** environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that constitutes an improvement over pre-project conditions

For the methodology outlined above, the following definitions were used:

- **Magnitude** is a measure of the degree of change in a measurement or analysis (e.g., the area of pasture, or the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none/negligible, low, moderate or high. The categorization of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment) pertinent to each of the discipline areas and key questions analysed. The specialist study must attempt to quantify the magnitude and outline the rationale used. Appropriate, widely-recognised standards are to be used as a measure of the level of impact.
- **Scale/Geographic extent** refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international.

- **Duration** refers to the length of time over which an environmental impact may occur: i.e. immediate/transient, short-term (0 to 7 years), medium term (8 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project), or permanent.
- **Probability of occurrence** is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40% to 60% chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

7.3 Project Phases and Activities

The environmental impacts of the project were assessed for the:

- Construction phase;
- Operational phase; and
- Decommissioning phase.

Potential cumulative impacts will also be identified and assessed for each component, where applicable. However, due to the fact that this ESIA is assessing a Masterplan (and development of a sector) with a number of potential farms that could operate collectively in the near future, the assessment does inherently consider cumulative impacts.

It is anticipated that there will be no Transboundary impacts emanating from this project since the activities will occur well within the Seychelles EEZ and territorial waters.

The following main activities are likely to occur during each phase.

7.3.1 Construction

The following activities were considered during the construction phase:

- Construction activities associated with the building of the R&D facility and BQAF;
- Increased construction vehicle movements in the vicinity of the BQAF and R&D facility;
- Construction of the associated water intake pipelines extending offshore;
- Construction and assembly of the pilot project cages, including deployment of mooring blocks and chains;
- Construction and assembly of the cages within ADZs, including deployment of mooring blocks and chains;
- Increased boat traffic associated with transporting cage components and work crews to farm sites within ADZs; and
- Increased boat traffic associated with construction of water intake pipelines.

7.3.2 Operational

The following activities were considered during the operational phase:

- Increased boat traffic associated with servicing fish farms and transporting crews, feed, supplies and harvested fish to shore;
- Operational activities at fish farms: fingerling stocking, feeding, grading, monitoring, harvesting, maintenance, cleaning and waste management etc.; and
- Maintenance of BQAF, R&D facilities as well as maintenance of water intake pipelines.

7.3.3 Decommissioning

- Decommissioning activities related to stripping and closing of BQAF and R&D facilities (unlikely that the buildings will be demolished);
- Increased vehicular traffic associated with decommissioning activities at BQAF and R&D facility;
- Decommissioning activities related to removal of the water intake pipelines;
- Decommissioning activities related to the disassembly and removal of the pilot project and fish farm cages in ADZs; and
- Increased boat traffic associated with the decommissioning and transport of cages and related infrastructure back to shore.

7.4 Impact Assessment and Mitigation Measures

The following stand-alone specialist studies were developed and used to inform the compilation of this ESIA and ESMP report, which are appended to this document:

- Physical Oceanographic Modelling Study (APPENDIX B);
- Waste Study (APPENDIX C);
- Coral Reef and Benthic Study (APPENDIX D);
- Technical Aquaculture Aspects Study (APPENDIX E);
- Visual Impact Assessment (APPENDIX F);
- Noise Impact Assessment (APPENDIX G);
- Social Impact Assessment (APPENDIX H); and
- Cultural Heritage Impact Assessment (APPENDIX I).

The impacts that have been assessed by each specialist and the corresponding mitigation measures for each, are presented below under the relevant sections. The scope of these specialist studies were informed by the terms of reference provided by the MEECC, which is attached under APPENDIX K.

7.4.1 Physical Oceanographic Modelling

7.4.1.1 Construction

There are no impacts during the construction phase.

7.4.1.2 Operation

Impacts

Aquaculture cages are expected to produce particulate wastes comprised of faeces and uneaten food pellets. An idealized modelling exercise was set up to evaluate the trajectory and accumulation of these wastes in the water column and on the seabed. The impact assessment was conducted using a theoretical fish production of 42.1 tons of fish per cage per year. Our estimates are based on fully-operational cages and can be considered as representative of the upper limit of the MMP carrying capacity scenarios.

A conservative flux to the seabed of approximatively 25 mg C m^{-2} d^{-1} (or 9.1 g C m^{-2} yr^{-1}) was estimated based on idealized modelling runs. This would generate moderate impact on the environment as detailed below (*SP = 32*). The degree of confidence in prediction on the results is however low given that the actual fish production per individual cage is unknown at this stage and that biological processes were not constrained as part of the purely physical Flow-3D hydrodynamic and particle tracking model. Given the lack of bio-uptake and elimination processes in the model, the annual estimate of 9.1 g C m^{-2} yr^{-1} computed here would be expected to translate into a near-zero deposition rate. More complex simulations would be needed to increase the level of confidence on the prediction.

The impact on the marine environment of solid waste dispersion during the operational phase was assessed as being of ***moderate (SP = 32)*** significance in the context of the conservative simulation provided here. The following mitigation measures are recommended to reduce the impact to one of ***low (SP = 24)*** significance:

Degree of confidence in prediction of impact: Low.

Mitigation Measures

- Restrict cage operations to open water conditions depths >25 m; typical minimum current speeds >0.1 m/s; no coastal restrictions on circulation;
- Locate cage sites downdrift from sensitive habitats (corals, seagrass); and
- Rotate cage use and implement fallow intervals as part of production cycle (as per Aquaculture regulations and/or standards).

The Marine Aquaculture and Sea Ranching Regulations (2015) (regulation that is still to be gazetted) in the Seychelles are very clear with respect to effluent and solid waste generation and disposal. License holders of aquaculture facilities, including processing facilities, shall ensure that solid waste from such facilities are disposed adequately. In addition, the Aquaculture Standards serve as an adjunct to the Marine Aquaculture and Sea Ranching Regulations (2015) and provide further regulatory detail that must be adhered to by farmers. Suspended solids from uneaten food and metabolic products from faeces comprises the greater proportion of any kind of aquaculture wastes. Accumulation of solids on the seafloor below the cages or elsewhere as a result of advection/diffusion should thus be prevented. The effluent quality standards for aquaculture facilities in the Seychelles is provided in **Table 32**. The standard that relates to maximum solid waste concentration is highlighted.

Table 32: Effluent Quality Standards for aquaculture facilities

Parameter	Maximum concentration in milligrams per litre (mg/L), unless otherwise stated (except pH)
Temperature	30°C measured at the point of discharge
pH	5.5 – 8.5
Suspended Solids	30
Biological Oxygen Demand at 20°C	30
Chemical Oxygen Demand	80
Free Chlorine (as Cl_2)	0.5
Phosphorus (as $PO4_3$)	5
Nitrate (as NO_3)	15
Nitrite (As NO_2)	1
Phenols	0.1
Chromium (total)	1.0
Arsenic (total)	0.1
Mercury (total)	0.05
Cadmium (total)	0.2
Lead (total)	0.9
Copper (total)	1
Zinc (total)	2
Iron (total)	5
Nickel (total)	1

Parameter	Maximum concentration in milligrams per litre (mg/L), unless otherwise stated (except pH)
Aluminum (total)	1
Tin (total)	0.1
Manganese (total)	2.0
Oil and grease	10
Total coliforms	500/100ml
Faecal coliforms	100/100 ml
Faecal streptococcus	100/100 ml
Salmonella	Must not be detectable in any 100 ml sample
Pesticides	In accordance with the law relating to

7.4.1.3 Decommissioning

There are no impacts during the decommissioning phase.

7.4.2 Waste

7.4.2.1 Construction

There are no impacts during the construction phase.

7.4.2.2 Operation

Impacts

Undercage benthic effects from faeces and fish waste

The formulated diets provided to sustain increased production are the ultimate sources of the loadings of organic material. Some loss due to uneaten food is inevitable and difficult to quantify; some loss is due to the breakdown of pelleted feed to particles too small for the fish to consume. Fish meal contains fines but these are likely to be a small component of the total feed.

As the unconsumed part of the feed is organic matter, it has a relatively high biological oxygen demand. As such, loss to water and incorporation into sediment (following deposition) has potential to result in oxygen consumption.

The amount of uneaten fish food varies considerably between studies. The feed losses are a function of the nature of the feed, application method, cage fish density etc. As an example, Penczak *et a*l. (1982) observed loss estimates of 27 % and 31 % for dry and moist feeds respectively, for trout cultured in net cages. Not all of the lost feed reaches the seabed. Vita et al. (2004) concluded that the natural fish population under fish cages have a role in recycling the organic matter lost from 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 seabed.

Low level fluxes of organic material can have both positive and negative impacts on the biodiversity of fish habitat, depending on habitat type and the resident species. However, at high rates, it is generally accepted that the flux of organic material to the seafloor is likely to cause a harmful alteration in fish habitat, a reduction in biodiversity, and changes in benthic species composition.

The most commonly used model of processes leading to the deposition of particulate wastes from marine finfish aquaculture is “DEPOMOD” (Cromey *et al*. 2002; Chamberlain *et al*. 2005). DEPOMOD is used to predict organic carbon deposition rates resulting from feed wastage and fish faeces production. Although the relationship between carbon flux and the level of total dissolved sulfides in marine sediments is complex there is a relationship between these parameters (DFO 2012).

Figure 65 illustrates the relationship between carbon deposition rates and the probability of anoxic conditions occurring under fish cages. The DFO (2012) DEPOMOD data indicates that at low carbon deposition rates (<5 gC/m^2/d), aerobic conditions prevail and the probability of anoxic conditions occurring is low. Under higher carbon deposition rates, there is a much higher probability of anoxic conditions occurring. As such, the DEPOMOD settlement rates provide useful broad scale indications of the potential for negative environmental effects to arise from carbon deposition. Carbon deposition rates can subsequently be related to fish stocking rates (also called fish stocking densities).

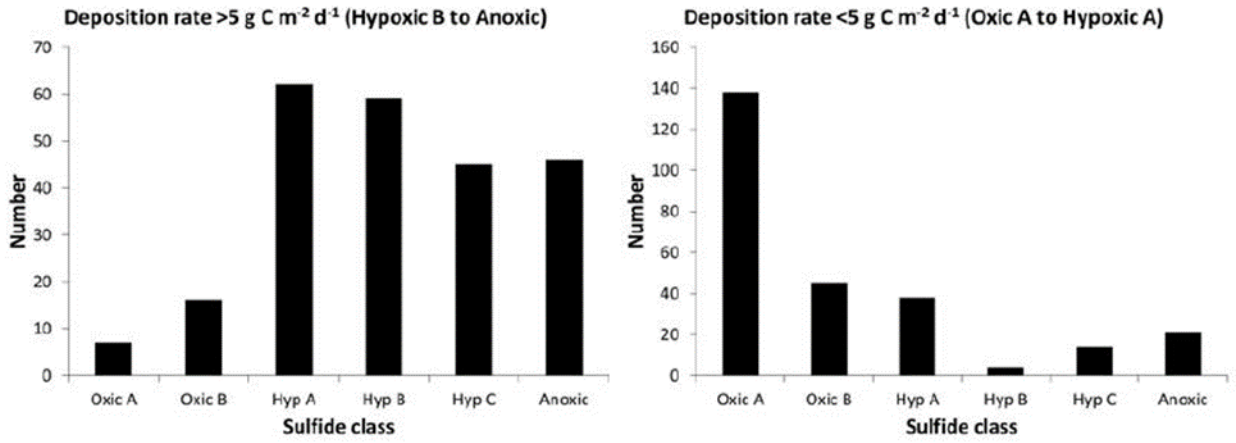

Figure 65: Left: Sulfide concentrations for DEPOMOD predictions >5 gC/m2/d. Right: Sulfide concentrations for DEPOMOD predictions <5 gC/m2/d (hyp = hypoxic) (Figure from DFO 2012)

Waterborne nutrient loss and nutrient concentrations in coastal waters with potential effects on phytoplankton growth

Nitrogen

There are a number of studies that have not identified increases in dissolved inorganic nitrogen (DIN) concentrations (refer Price *et al*. 2015). These studies have included a range of fish species in locations from Hawaii, Bahama and India. However, with increased biomass of fish within cages (increased fish stocking densities), normal metabolic processes in the fish and the loss of even a minor portion of feed must result in a flux of nitrogen from the cage to the surrounding water. There are a wide range of factors that determine the flux and whether the flux (or dispersed concentration) will be measurable compared to the local flux.

Nitrogen flux from fish farms (and other sources) can be traced using stable nitrogen isotopes. Garcia-Sanz (2011) examined nitrogen isotopes to assess the spatial pattern and scales of nitrogen dispersal of from two fish farms in the Mediterranean Sea and one in the Atlantic. The Canary Island farm stocked sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) and the others Atlantic bluefin tuna (*Thunnus thynnus*) and sea bream. In the Canary Islands, the maximum distance obtained for detection of fish farm wastes was between 450 m and 700 m and at one of the Mediterranean locations (Murcia) fish farm waste influence was detectable between 1,550 m and 2,450 m. At the other Mediterranean farm (Catalonia) the distance was less than 120 m. The short distance was considered to be due to other sources making the trend undetectable.

Also shown by Perez (2008), fish farm activities were closely reflected in the biochemistry of epiphytes and tissues of the seagrass *Posidonia oceanica* including total nitrogen content and ∂15N along with the total phosphorus concentration in rhizomes and epiphytes. Elevated ∂15N signatures were measured 2.8 km SW of the fish farm.

Effects of nitrogen loss from marine fish farms is dependent on the nature of the local/regional nitrogen fluxes. Marine sources, terrestrial sources including wastewater discharges, and current contributions from the fishing industry (waste disposal at sea etc.) all influence the regional nitrogen flux of a location.

The most significant time for nitrogen and phosphorus losses are during the spring and summer when natural marine phytoplankton will be utilising nitrogen and phosphorus for growth. Increases to the nitrogen and phosphorus pool will reduce the potential local pool in the photic zone from being depleted.

Phosphorus

Price *et al*. (2013) summarised studies that reported on phosphorus in the discharge from cage fish farms. Ten studies reported no significant changes (even though a measureable increase may have been detected), seven reported minimal change and seven more reported significant increases. Increased concentrations of dissolved reactive phosphorus (DRP) have been reported in studies of barramundi farming (McKinnon et al. 2008), sea bream and sea bass (Matijevic *et al*. 2009, Tsagaraki *et al*. 2011) but in all cases detected changes (typically within a few hundred metres) were not considered to result in environmentally significant increases in concentration.

There are a range of studies that have identified significant changes in DRP (or other forms of P) concentrations that depended on farm location, species farmed and feed (refer review by Price *et al.* 2013).

Overall, changes in down current DRP concentrations will be site specific and the extent of effect on phytoplankton or benthic algal growth and production will depend on season, water temperature and the nutrient status of local waters (i.e., whether nitrogen is limiting etc.) as to whether phosphorus release to the water column has identifiable effects.

Algal blooms

Algal blooms (including harmful algal blooms) have been identified around the Seychelles. A range of studies (field measurements (at a diverse range of cage fish sites) and a range of modelling) have not demonstrated impacts (as measured by chlorophyll-a increases) from the additional nutrients from caged fish farms on adjacent environments. As described by Price *et al*. (2015) a number of studies have shown that the nutrients contributed by cage farms can contribute to the flux of both N and P and that the flux can be manifest in growth of alga (phytoplankton, alga on fixed plates, macro-algae).

Several studies have identified increased phytoplankton biomass (as chlorophyll-a) at distances of 1,000 m (Modica et al. 2006) and further (Pitta *et al*. 2005). Sara *et al*. (2011) reported that expansion of cage farming (sea bream, sea bass and tuna) in the Sicilian Gulf contributed N and P amounting to 17 % of the N and 34 % of the P inputs per year. This was reflected in an increase in chlorophyll-a concentrations. As Price *et a*l. (2015) point out this study is relatively unique in detecting changes at a regional scale.

Harmful algal blooms (which generate cytotoxins) have the potential to adversely affect or kill fish in aquaculture cages or biota in natural habitats. Harmful algal blooms occur in response to a complex number of factors. The cause of the harmful bloom that occurred around the Seychelles in 2015 is not known with certainty. That bloom (identified as *Cochlodinium polykrikoides*) affected wider areas of the Indian Ocean archipelago. Overall, there is little, if any, direct evidence in the literature that directly links nutrient releases from offshore cage farms to harmful algal blooms.

Sediment contaminant accumulation from antifouling and from trace elements in feed

Copper is the most common element used in antifoulants which may be applied to cage nets. Antifoulants are used on fish cages in a range of countries. Clement *et al*. (2010) determined that 21 % of the copper agent from the original coating of a net entered the marine environment (with an annual usage per farm in the range 230 kg to 700 kg). Elevated copper concentrations have been found in sediment under fish cages using copper antifoulants and at concentrations higher than the ANZECC (2000) ISQG-High trigger value of 110 mg/kg.

Zinc is present in feed as a nutritional additive with concentrations of up to 100 mg/kg reported. Any zinc not utilised by the fish or lost in fed is excreted and enters the environment under and downstream of the cage. Elevated concentrations of zinc in sediments under and adjacent to cage sites have been reported (e.g., Keely & Morrisey 2013). The concentrations in those situations exceed the ANZECC (2000) ISQG-High sediment quality trigger values for zinc of 410 mg/kg, indicating that there is a high probability of zinc potentially resulting in adverse effects on infaunal biota at those sites.

Sediment debris accumulation from the loss of cage fouling during on site cleaning

SFA (2012) reported that biofouling rates in the Seychelles is considered low. The loss of biofouling from cage cleaning however has the potential to:

- Alter habitat under cages (through the deposition of shell material).
- Add organic matter to sediment affecting basic sediment biogeochemical properties (especially reduction-oxidation (redox) conditions).

Rubbish loss due to poor on-site management (introduction of recalcitrant rubbish, especially plastics)

The loss of rubbish from cage farming operations has a range of potential effects. Debris and rubbish may include:

- Paper and plastic waste from workers at cages.
- Discarded equipment.
- Organic fish waste, dead fish and cage biofouling (refer above).

Loss of plastics, in particular, can have a multitude of effects including negative effects on marine biota due to ingestion, entanglement (if plastic net or rope etc.) and the addition of organic compounds as the plastic degrades. The latter may contribute compounds such as phthalates and bisphenol and to sediment and water.

7.4.2.3 Decommissioning

There are no impacts during the decommissioning phase.

7.4.3 Coral Reef and Benthos

7.4.3.1 Construction

ADZs

Construction phase impacts on the benthic environment in the vicinity of the ADZs are limited to those resulting from the placement of anchoring and mooring infrastructure. These are likely to cause mortality and disturbance to benthic communities directly within the footprint of each anchor or mooring block and any movements of mooring cables or chains will result in disturbance. Surveys of the seafloor indicate that the benthic habitats within proposed ADZs largely comprise sandy substratum. M3 and M5 are already zoned in a previously disturbed and transformed part of the seafloor due to dredging operations. Areas of consolidated substratum with reef have been excluded, although some consolidated habitat has been detected within M1 (SFA, 2016c). It is also obvious that parts of SN2 overlay reef. It is an essential mitigation measure that consolidated reef habitat is excised from M1 & SN2. The impact is likely to be localised, of low intensity and assessed has having low overall significance for each of the proposed ADZs.

Pilot Phase Cages

During construction and assembly of the pilot phase cages, mooring blocks and anchors will be placed on the seafloor. This is likely to be of very low overall significance as the area has been previously disturbed and mooring blocks are only likely to affect the benthic habitat within their footprints. The cage will be located near reef (~50 m) to the north-east and it is essential that this area is designated a “no-go” area for construction vessels and workmen. Furthermore, no mooring blocks/anchors should be positioned on any reef.

Mitigation measures:

- Nearby reef to the north-east must be a designated “no-go” area to construction vessels, workmen and mooring blocks/anchors.

BQAF

A broodstock facility is proposed at Providence, Mahe which will have a submarine pipeline into the coastal zone providing it with fresh seawater (Section 1.2 of APPENDIX D). The proposed pipeline will be positioned over soft unconsolidated sediments which have previously undergone disturbance due to historical construction of the Providence harbour. The pipeline will thus cover an already disturbed area of low biodiversity value. Minimal impacts are expected during construction, operational and maintenance phases which are likely to be due to smothering and disturbance of the benthos in the footprint and close proximity of the pipeline.

R&D Facility

A research and development facility (R&D) is proposed at Anse Royale, Mahe which will have a pipeline running below the high water mark into the coastal zone providing it with fresh seawater (Section 1.2 of APPENDIX D). The proposed pipeline will be positioned across the fringing reef. Impacts are expected during the construction and maintenance phases. During construction, mortality of coral reef organisms, caused by trampling by construction workers, is likely to occur during the construction and lying down of the pipeline.

The pipeline is to be constructed over existing reef with high biodiversity value directly adjacent to the R&D facility. The pipeline will cover more than 700 m^2 of reef. This will lead to mortality of all coral reef organisms beneath the pipeline with limited or no mobility. Essential mitigation measures are detailed in the ESMP. This entails rerouting the pipeline which will reduce the amount of coral reef affected by approximately 85% (see Figure 66 below).

Figure 66: The proposed re-routing of the pipeline indicated by the solid red line

The pipeline may need to undergo inspections and maintenance from time to time and the impacts of this are likely to be further trampling and disturbance albeit to a lesser intensity.

7.4.3.2 Operation

Impacts associated with the operation of finfish cage culture include:

- Eutrophication and pollution of water and benthic habitats due to increased amounts of organic waste associated with faeces and uneaten food;
- Chemical pollution of marine food webs and mortality of sensitive organisms as a result of using certain chemical therapeutics on stock, antifouling treatments on cages and heavy metals in feed;
- Transmission of fish diseases and parasites from cultured fish to wild populations;
- Escape of genetically different cultured fish which may interbreed and compete with wild stocks that are depleted;
- Physical hazards to marine life which may become entangled in moorings and nets; and
- Piscivores such as sharks and other apex predators are attracted to cages and may damage nets leading to escapees. Conflicts are likely to arise between these animals and farmers who are likely to kill problem animals.

Each of these potential impacts is assessed in the following sections and mitigation measures provided where possible.

Eutrophication and organic pollution of water and benthic habitats (ADZs)

The extent of contamination of the sediments under fish cages is obviously highly site and project specific. Inshore marine environments with low flushing rates or with substrata susceptible to organic loading should be avoided when selecting sites for finfish culture. Fallowing is the standard mitigation practice used to allow recovery of sediments beneath cages, but recovery may take up to fifteen months as was observed in a Scottish fish farm (Black *et al*. 2004). Fallowing is not a viable option for consolidated habitats comprising long-lived organisms as this merely increases the impact footprint (Hall-Spencer and Bamber 2007). Feeding by wild fish on waste and uneaten food beneath cages has been shown to mitigate the impacts on the benthic environment. As much as 40-80% of the uneaten food and waste falling from cages may be eaten by wild fish (Vita et al. 2004; Felsing *et a*l. 2005). This however, may increase the risk of parasite and disease transmission to wild fish and may also attract piscivores to cages resulting in several problems.

In a meta-analysis of 41 studies from locations around the world focused on the effects of fish farms on sediments, the horizontal distance affected by fish farm wastes was found to decrease with high depth, low latitude and fine sediment (Kalantzi and Karakassis 2006). **These findings therefore contribute favourably to the locations of the proposed ADZs which are in relatively deep water, are located at low latitude and positioned over sandy unconsolidated sediments for the most part**. It was however, noted by SFA (2016) that benthic macro-algal patches were prevalent in some of the proposed ADZs. The ecological roles that these algae may play in the Seychelles are unclear but it is likely that they could be very important in assimilating and recycling organic waste produced by farms. It is therefore recommended that these areas are avoided as an important mitigation measure.

The impacts of particulate wastes are assessed for all proposed ADZs together as the scale of the impacts are considered to be confined to within several hundred metres around each cage and therefore limited to within an ADZ (i.e. limits of the concession area) regardless of its size. They are expected to have **moderate** overall significance (**moderate** with effective mitigation).

The sizes of each proposed ADZ differ and they are each located in different oceanographic settings. The potential impact of waste disposal on water quality and sensitive habitats is nonetheless assessed as similar for the proposed ADZs based on available data but both general and specific mitigation measures are indicated per ADZ. The impact of dissolved nutrients is assessed as having a **moderate** overall significance (**low** with effective mitigation).

It is recommended that an extensive hydrodynamic modelling study (extending the modelling undertaken as part of this ESIA) using detailed, site-specific current modelling data for each ADZ be conducted prior to any development, where possible. The results of this study with respect to the potential impacts on sensitive habitats (coral reefs, seagrass beds) should be used to *assess the cumulative impacts of dissolved nutrients and toxic chemicals* and to guide the scale of developments on the ADZs (i.e. if the waste plume is modelled to reach sensitive habitats that carrying capacity of the ADZ should be reduced) or to shift them further offshore. It is proposed that this monitoring and modelling exercise is undertaken by the SFA/regulator of the aquaculture sector, and be re-run on a regular basis as more data is acquired from various ADZs. It should be noted that the initial development (Tier 1 sites) are sited over the areas designated for sand mining and subsequent loss of substrate habitat has already or will occur over these areas. Fish farm operators will be required to conduct confirmatory 6 months monitoring of their chosen farm site(s) in order to confirm the presence of suitable substrate such as sand and if any sensitive habitat is encountered, the the farm site be moved with sufficient buffer (500m) employed around such a sensitive receptor. The 6 months of monitoring should also include monitoring of the water coloumn, substrate and currents in the vicinity of their preferred farm site. Fish farm operators will be required to undertake monitoring and modelling of their operations on an ongoing basis during their operational phase in order to determine the impact on the environment and to manage these impacts proactively.

The results of the idealized hydrodynamic modelling and waste study conducted have revealed a similar level of impact that can be expected (see section 7.4.1 and 7.4.2).

It is likely that several proposed ADZs may potentially need to be shifted further offshore to limit the impact of their dissolved nutrients on sensitive habitats, which should be considered before time and effort is invested in collecting site-specific data within the current locations of proposed tier 2 ADZs. Proposed ADZs that would qualify for this include SN1, SN2, M1, PLD4 and PLD5. By collecting current data and undertaking faar-field hydrodynamic modelling, the SFA/regulator will be able to further refine the siting of ADZs and fish farms proactively ahead of development at subsequent ADZs (Tier 2 sites). The monitoring of currents and hydrodynamic modelling will alos be used in identifying areas of low current flow or areas which may exhibit circular flow, which are not suitable for fish farming.

Mitigation measures:

- Prior to developing any ADZ, an operator will be required to collect 6 months data on the substrate and water coloumn surrounding their preferred farm site. In parallel, the SFA/regulator should start the collection of current data at various ADZs. Where possible, this should entail 12 months of data collection prior to development at ADZs, The initial development sites have been selected over areas identified for sand mining and where sufficient current data existis. ADZs occurring elsewhere and where later development is expected, should include a far-field hydrodynamic modelling exercise of dissolved nutrient dispersal for each ADZ and for all farms at one time (cumulative impact) using detailed current profiling data (and other relevant data i.e. bathymetry, wind, cage drag, Coriolis Force) collected over a period of at least a year. Model different intensities of ADZ development and predict dissolved nutrient diffusion (nitrate and phosphate) from each ADZ and ensure that waste plumes have dissipated sufficiently before coming into contact with sensitive habitats such as coral reefs and seagrass beds;
- Use species specific dietary formulations designed to enhance nitrogen and phosphorus retention efficiency, and reduce metabolic waste output;
- Monitor feeding behaviour and adapt feeding strategy to ensure minimal wastage (excess) of feed; and
- Undertake monitoring of water quality and adjacent coral reef and seagrass habitats, including baseline surveys at control and ADZs sites to determine scale of impacts and decrease ADZ carrying capacity should the impact start effecting sensitive habitats.

Chemical pollution arising from cages (ADZs)

Therapeutic chemicals (medicines), disinfectants and antifoulants are usually used in caged finfish culture (Weston 2000; Boyd and McNevin 2015). Many of these chemicals are highly toxic to non-target organisms even at low concentrations and may persist in the environment for significant periods of time (Kerry et al. 1995; Costello *et al.* 2001). Some of the chemicals used historically on fish farms to combat sea lice infestations were carcinogenic, whilst others are known to adversely affect reproduction in salmonids (Staniford 2002, More & Waring 2001).

Corals in particular, but also other primitive life forms, are especially sensitive to copper which is often the active ingredient in antifoulants (Reichelt-Brushett and Harrison 1999, 2000; Negri and Heyward 2001; Webster *et al*. 2001; Yanong 2010). Corals pre-exposed to high temperatures (such as is often the case in the Seychelles) followed by exposure to copper may be particularly sensitive and negatively affected (Nyström et al. 2001). Elevated levels of copper are also toxic to seagrass (Zhao *et al.* 2016). Global bodies, (e.g. the World Health Organisation and GESAMP), have highlighted the environmental and public health threats of chemical use on fish farms (GESAMP: 1997, WHO: 1999 cited in Staniford 2002).

Due to these concerns, the salmon farming industry is no longer using antibiotics and organophosphates, but numerous other potentially hazardous chemicals such as synthetic pyrethroids, artificial colorants, antifoulants, and antiparasitics are still a serious concern (Staniford 2002). According to the Seychelles Fishing Authority: Responsible Finfish Cage Culture (yet to be gazetted by Government), the use of biocidal chemicals for cleaning nets on site is prohibited (SFA 2015). However, the use of a copper-based alloy material for the cage nets seems likely.

Sediments below sea farms can accumulate elevated copper levels (Loucks *et al.* 2012, Nikolaou et al. 2014), but the toxicity of the deposited copper is difficult to assess as it depends on the interaction with the

environment where organic carbons and sulfides are able to reduce the reactivity (Burridge et al. 2010). Of 279 farms whose sediment below the cages were monitored between 2011 and 2015, ~20% had copper concentrations considered toxic to marine life even during short term exposure (>84 mg Cu kg−1 dry weight sediment) (Svåsand *et al*. 2016). Similar to the effects of dissolved nutrients assessed above, it is difficult to confidently assess the impact of dissolved chemical pollutants without hydrodynamic modelling being conducted first.

Farm operators will be required to undertake monitoring of the water column and substarte, particularly in order to confirm the presence of a suitable sandy substrate. Should sensitive receptros be located such as coral outcrops or seagrass, then a suitable buffer of 500m would be employed around such sensitive receptor and the fish farm would need to maintain that minimum distance from the receptor. The farm operators would also employ a rigourous monitoring programme during operations in order to ensure safe operating limits (as defined in the ESMP) are maintained. Ongoing biological modelling (MOM) will also be conducted annually, with the collected monitoring data as input. If any thresholds are exceeded during monitoring, the SFA will be notified and it will be determined in consultation with the regualator if it is a once off occurrence or if it is a trend that needs to be addressed, either by changing operational practices, or else by increasing the buffer and re-locatign the farm site.

7.4.3.3 Mitigation measures:

- Prior to developing any ADZ, an operator will be required to collect 6 months data on the substrate and water coloumn surrounding their preferred farm site. In parallel, the SFA/regulator should start the collection of current data at various ADZs. Where possible, this should entail 12 months of data collection prior to development at ADZs, The initial development sites have been selected over areas identified for sand mining and where sufficient current data existis. ADZs occurring elsewhere and where later development is expected, should include a far-field hydrodynamic modelling exercise of dissolved nutrient dispersal for each ADZ and for all farms at one time (cumulative impact) using detailed current profiling data (and other relevant data i.e. bathymetry, wind, cage drag, Coriolis Force) collected over a period of at least a year. Model different intensities of ADZ development and predict dissolved nutrient diffusion (nitrate and phosphate) from each ADZ and ensure that waste plumes have dissipated sufficiently before coming into contact with sensitive habitats such as coral reefs and seagrass beds;
- Use only approved veterinary chemicals and antifoulants;
- Where possible use environmentally friendly alternatives;
- Use the lowest effective dose of therapeutics;
- Clean cage nets regularly in order to prevent large accumulations of fouling organisms; and
- Conduct ongoing monitoring prior to site establishment.

Disease and parasites (ADZs)

High stocking density of fish in cages promotes disease and parasitic infections (Lafferty et al 2015). Furthermore, cultured stock is often prevented from exercising natural parasite shedding behaviours and the high number of concentrated hosts facilitates parasite and disease reproduction and transmission. Parasites and infectious diseases are regarded as the most significant threat to aquaculture, with the estimated losses from sea lice (genus *Caligus)* infections, of salmon stock, alone amounting to hundreds of millions of dollars annually (Staniford 2002; Heuch *et al*. 2005). This threat is not only limited to cultured fish, but also poses a significant threat to wild stocks due to increased transmission of parasites and diseases from cultured stock to wild populations of fish (Olivier 2002; Ford and Myers 2008; Johansen *et al.* 2011). Transmission to wild stock may simply occur via direct contact with cultured fish as wild fish are attracted to cages, or simply as a result of the higher concentration of pelagic parasite life history stages arising from fish farms that would enhance transmission indirectly without physical contact.

Wild salmon for example have suffered from significant increases in parasitic infection rates due to contact with caged stock (Heuch *et al.* 2005). The increased load of parasites on wild salmon have increased

mortality rates, reduced fecundity and delayed maturity which has synergistically reduced the productivity of wild stocks (Bjorn et al. 2002; Ford and Myers 2008). Similarly, in the Mediterranean, intensive culture of seabass and seabream have resulted in severe disease problems caused by *Nodavirosis* and *Pasteurellosis* and parasitic infections from *Ichtyobodo* sp., *Ceratomyxa* sp., *Amyloodinium ocellatum*, *Trichodina* sp., *Myxidium leei*, and *Diplectanum aequans* (Agius and Tanti 1997). In Australia, yellowtail were infected by Monogenean parasites up to 18 km downstream from cages (Chambers and Ernst 2005).

Parasites are also known to affect some of the proposed culture species. In Indonesia, wild and cultured brown-marbled grouper *Epinephelus fuscoguttatus* had a species-rich parasite fauna, and most abundant parasites were monogeans on both cultured and wild stocks (Rüeckert et al. 2010) Twenty-five and 30 parasite species/taxa were identified on cultured and wild grouper respectively. It was concluded that the high levels of infestation of potentially pathogenic monogeneans throughout the year could result in significant parasite outbreaks at the locality studied (Rüeckert et al. 2010). Several disease problems including vibriosis caused by *Vibrio alginolyticus* and *Vibrio carchariae*, viral diseases caused by nervous necrosis virus and iridovirus, and protozoan parasite like *Crytocaryon irritans* have threatened commercial grouper farming in southeast Asia, including brown marbled grouper (Yii *et al.,* 1997; Fukuda *et al*., 1999; Yambot and Song, 2006). Diseases of cultured grouper are described by Seng (1998), Nagasawa and Cruz-Lacierda (2004) and Harikrishnan *et al*. (2011). Snappers are also susceptible to parasites (Kritsky and Diggles 2014), and disease outbreaks caused by *Caligus* sp. in cultured snubnose pompano have been recorded (Johnson *et al.* 2004).

Diseases and parasites of the cultured species could therefore easily spread to wild stocks. This is of particular concern as snappers and groupers comprise a large proportion of demersal and commercial catches (ACLME 2012). Furthermore, diseases at lower tropical latitudes, such as the Seychelles, progress more rapidly and result in higher cumulative mortality, in particular at early stages of development and tropical countries suffer proportionally greater losses in aquaculture during disease outbreaks and have less time to mitigate losses (Leung and Bates 2013). Although treatment of cultured stock to control disease and parasite outbreaks is possible (unlike wild stocks), chemical treatment is not without further environmental impacts, whilst build-up of antibiotic and chemical resistance is becoming increasingly problematic (Staniford 2002).

Potential disease and parasite transmission to wild stocks could have negative impacts throughout the Seychelles inner island group and the natural distributional range of the species, the magnitude of the potential impact will be high as it could alter wider natural (ecosystem impacts) and social functions (fisheries), and the impact will be enduring. Mitigation measures are not completely effective, and the overall significance of the impact is estimated as **high** for the start-up phase of the hatchery since fingerlings will be imported (these impacts apply to construction phase as well as operation phase) and after mitigation as **moderate**.

During the operational phase and once indigenous fish are used the impact will be **moderate** without mitigation and this will reduce to a **moderate** impact with mitigation measures being applied. These impacts are also addressed in the Aquaculture Study (APPENDIX E).

It should be noted that the stocking density proposed for the new aquaculture sector in Seychelles has adopted the precautionary principle and is limited to 12 kg /m^3 which is 4 to 5 times lower than elsewhere in the world.

Mitigation measures:

- Maintain strict bio-security measures within hatchery, holding tanks and sea cages;
- Ensure all fry undergo a health examination before stocking in cages;
- Regularly inspect stock for disease and parasites as part of a formalised stock health monitoring programme and take necessary actions to eliminate pathogens through the use of therapeutic chemicals or improved farm management. This will require focused research effort into the identification, pathology and treatment of diseases and parasites infecting farmed species, both in culture and in wild stocks;

- Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the efficacy of treatments applied. These records should be made publically available to facilitate rapid responses by other operators to future outbreaks;
- Locate cages stocked with different cohorts of the same species as far apart as possible, if possible stock different species in cages successively; and
- Treat adjacent cages simultaneously even if infections have not yet been detected.
- Keep nets clean and allow sufficient fallowing time on sites to ensure low environmental levels of intermediate hosts and or pathogens.

Genetic impacts on wild stocks (ADZs)

Escapees from sea cages are a reality and will be inevitable in the Seychelles given that this is a global occurrence. Even in countries with advanced sea cage farming industries and calm sheltered waters such as in some seas in Norway, is it a regular occurrence. For example, an estimated 1.5 million escaped salmon are present in Norwegian fjords at any given time (Heuch *et a*l. 2005) and from 2001 to 2009, 3.93 million Atlantic salmon, 0.98 million rainbow trout and 1.05 million Atlantic cod escaped (Jensen *et al*. 2010).

It is unlikely to be any different in the Seychelles, especially due to the exposed nature of the region and the abundance of large piscivores such as sharks; escapes of cultured stock as a result of cage failure is possible.

As the proposed culture species are indigenous to the region, there is risk that escapees will breed with wild stocks. Cultured stocks are invariably genetically distinct from wild stocks as they are typically spawned from a reduced number of brood stock, have reduced genetic diversity compared to wild stocks and have undergone different selective pressures, often to artificially select for traits such as rapid growth for example. Thus genetically distinct escaped stock may interbreed or possibly out compete wild stocks, resulting in an overall reduction of genetic diversity leading to reduced fitness of wild populations (Hershberger 2002; Naylor *et al*. 2005; Ford and Myers 2008).

The significance of genetic impacts on wild stocks is largely determined by the extent of genetic differentiation between farmed and wild stocks, the quantity of escapees compared to the size of the wild stock, and the survival and reproductive success of eggs and escaped fish (Falconer and Mackay 1996).

Where genetic effects on performance traits have been documented, they always appear to be negative in comparison with the unaffected native populations (Hindar *et al*. 1991). Improved containment is recommended as the key mitigation measure to minimizing the numbers and therefore the effects of escaped fish (Youngson *et al*. 2001). Reproductive sterility is recommended as a future key to eliminating the genetic potential of escaped fish (Cotter et al. 2000; Youngson *et al*. 2001). The maintenance of robust populations of wild fish is recommended as a key to minimizing the effects of escaped fish on wild populations. Without such measures the significance of genetic impacts on wild stock is likely to be **high** for the start-up phase of the hatchery since fingerlings will be imported (these impacts apply to construction phase as well as operation phase) and after mitigation as **moderate**. During the operational phase and once indigenous fish are used the impact will be **moderate** without mitigation and this will reduce to a **low** impact with mitigation measures being applied. These impacts are also addressed in the Aquaculture Study (APPENDIX E).

The confidence of this aspect of the assessment is low as negative impacts on genetic diversity of wild stocks will only be reflected should the populations of wild stocks face a threat and present signs of reduced environmental fitness.

Furthermore, monitoring would be required to determine any changes in genetic diversity in wild stocks due to cultured escapees.

Mitigation measures:

- Maintain genetic compatibility between cultured and wild stocks by developing a genetic best-practice management guideline for finfish mariculture and ensure adequate genetic monitoring is undertaken routinely;
- Minimise the number of escapes by maintaining cage integrity through regular maintenance inspections and replacement of compromised or old infrastructure;
- Cages should have jump nets installed;
- Develop and implement stock recovery procedures should escapes happen;
- During fish transfers or harvest, operations must be conducted in appropriate weather conditions and under constant visual supervision. Equipment appropriate to the weather and cage design must be used. Where necessary or appropriate, additional netting must be used to prevent escapes during transfer; and
- Maintain robust and healthy populations of wild stocks;
- The use of anti-predator netting should be investigated; and
- Develop the technology to mass produce sterile fry for cage culture.

Interactions with piscivorous fishes (ADZs)

The activity of numerous fish within sea cages, the routine feeding of cultured fish, any dead cultured fish that may sink to the bottom of cages and the physical structure of the cages themselves all attract piscivorous predators, in particular sharks and barracuda (Bevan et al. 2002; Vita et al. 2004; Papastimatiou et al. 2010; Sclodnick et al. 2011; Roberson 2012). These predators may become entangled in nets and cause damage to nets allowing stock to escape. This invariably creates conflict between animals and farmers, with farmers often shooting problem animals. Sharks are common in the waters of the Seychelles, and silvertip shark *Carcharhinus albimarginatus* are abundant around oceanic islands and are particularly inquisitive (van der Elst 1993). Bull sharks are another large shark also known from the Seychelles and are listed as Near Threatened by the IUCN red list of threatened species (IUCN 2016).

There are however several measures that can be put in place to reduce the impact of interactions with piscivorous fish from having a **moderate** level of significance to a **low** level of significance. The effectiveness of these measures remains uncertain in the local context and therefore requires monitoring.

Mitigation measures:

- Develop a protocol to deal with problematic piscivores with experts and officials (Independent scientists and SFA);
- Maintain a record of all interactions with piscivores as per EMP;
- Remove any injured or dead fish from cages promptly;
- Install and maintain suitable anti-predator nets; and
- During harvesting ensure that minimal blood enters the water.

Entanglement of marine animals (benthic associated) - ADZs

Entanglement of marine animals, especially cetaceans but also turtles and birds, in cage infrastructure has been noted internationally (Wuersig & Gailey 2002; James *et al*. 2005; Watson-Capp and Mann 2005). Due to the mooring of cages with cables and chains and even the cages themselves the risk of entanglements is a possibility. Five species of turtle have been recorded in the Seychelles; the Hawksbill, Green, Loggerhead, Leatherback and Olive Ridley turtles. The Loggerhead, Leatherback and especially the Olive Ridley are however rarely reported. Both the Hawksbill and Green turtle are widespread and common in the Seychelles.

Hawksbill turtle also nest on Saint Anne Island and are closely associated with benthic habitats, particularly coral reefs.

The Hawksbill and Green turtle are of particular concern as they are listed by the IUCN as being CriticallyEndangered and Endangered respectively (IUCN 2016). However, it is likely that in most cases turtles will avoid any lethal effects associated with entanglement in cage infrastructure. Sharks are also at risk of entanglement. As such the overall significance of these impacts is assessed as **low**; however certain mitigation measures must be in place to reduce the risk of entanglements as far as possible in order that it remains **low**.

Mitigation measures:

- Ensure all mooring lines and nets are highly visible. Use thick visible lines.
- Keep all lines and nets as tight as possible and conduct regular inspections to ensure this.
- Do not have any hanging lines or unnecessary lines from cages.
- Maintain adequate separation between primary and secondary nets even during strong currents and rough seas.
- Use square mesh and ensure that net mesh-size does not exceed 16 cm whilst stretched.

Particulate organic build-up beneath cages (pilot project cages)

Impacts associated with the operational phase of the development are the same as those described above for construction phase, but which may have different levels of significance due to the scale and location of the proposed development, and include eutrophication and pollution of water and benthic habitats, chemical pollution, transmission of diseases and parasites to wild stocks, genetic impacts to wild stocks, physical entanglement to marine life and piscivore behavioural changes and associated human-animal conflicts.

Assessment of the impact of particulate organic build-up beneath cages is assessed as having **moderate** negative status without mitigation and **moderate** negative significance with mitigation.

Mitigation measures:

- Sensible site selection. This has been achieved by zoning the cages over previously disturbed unconsolidated habitat;
- Rotate cages (fallowing) to allow for recovery of soft sediment benthos;
- Use species and system-specific feed to maximise food conversion ratios and minimise waste;
- Monitor feeding behaviour and particulate deposition beneath cages and adapt feeding strategy to maximise feeding efficiency and minimise particulate matter fallout; and
- Undertake benthic monitoring, including baseline surveys to determine scale of impacts and decrease stocking densities should the impact exceed the accepted sacrificial footprint; and
- Move pilot cages offshore and in deeper water.

Eutrophication and organic pollution of water and benthic habitats (pilot project cages)

The impacts of dissolved nutrients emanating from the pilot cages on sensitive habitats such as coral reefs and seagrass beds is considered to have **moderate** negative significance without mitigation and **low** negative significance with mitigation.

Mitigation measures:

- Use species specific formulations designed to enhance nitrogen and phosphorus retention efficiency, and reduce metabolic waste output.
- Monitor feeding behaviour and adapt feeding strategy to ensure minimal wastage (excess) of feed.

- Undertake monitoring of water quality and adjacent coral reef and seagrass habitats, including baseline surveys at control and cage sites to determine scale of impacts and decrease stocking density should the impact start effecting sensitive habitats.

Chemical pollution arising from cages (pilot project cages)

The impact of chemicals such as copper based antifoulants and therapeutics is assessed as having **moderate** negative significance with mitigation and **low** negative significance with mitigation.

Mitigation measures:

- Use only approved veterinary chemicals and antifoulants;
- Where possible use environmentally friendly alternatives;
- Use the lowest effective dose of therapeutics;
- Clean cage nets on a regular basis before accumulatrio of significant levels of biofouling organisms;
- Monitoring: Total dissolved water column copper over reefs and seagrass beds **not to exceed 1.3 ppb / 1.3 µg L^{-1}**; and
- If required, shift pilot cages further offshore.

Disease and parasites (pilot project cages)

The impact from the transfer of diseases and parasites from cultured stock to wild stocks is assessed as having moderate negative significance without mitigation and moderate negative significance with mitigation.

Mitigation measures:

- Maintain strict bio-security measures within hatchery, holding tanks and sea cages;
- Ensure all fry undergo a health examination before stocking in cages;
- Regularly inspect stock for disease and parasites as part of a formalised stock health monitoring programme and take necessary actions to eliminate pathogens through the use of therapeutic chemicals or improved management. This will require focused research effort into the identification, pathology and treatment of diseases and parasites infecting farmed species, both in culture and in wild stocks;
- Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the effectiveness of treatments applied. These records should be made publically available to facilitate rapid responses by other operators to future outbreaks;
- If possible stock different species in cages successively;
- Treat adjacent cages simultaneously even if infections have not yet been detected;
- Keep nets clean and allow sufficient fallowing time on site to ensure low environmental levels of intermediate hosts and or pathogens.

Genetic impacts on wild stocks (pilot project cages)

The significance of genetic impacts on wild stocks as a result of escapees is assessed as having **moderate** negative significance without mitigation and **low** negative significance with mitigation.

Mitigation measures:

- Maintain genetic compatibility between cultured and wild stocks by developing a genetic best-practice management guideline for finfish mariculture and ensure adequate genetic monitoring is undertaken routinely;

- Minimise the number of escapes by maintaining cage integrity through regular maintenance inspections and replacement of compromised or old infrastructure;
- Cages should have jump nets installed;
- Develop and implement stock recovery procedures should escapes happen;
- During fish transfers, operations must be conducted in appropriate weather conditions and under constant visual supervision.
  - Equipment appropriate to the weather and cage design must be used.
  - Where necessary or appropriate, additional netting must be used to prevent escapes during transfer;
- Maintain robust and healthy populations of wild stocks;
- The use of anti-predator netting should be investigated; and
- Develop the technology to mass produce sterile fry for cage culture.

Interactions with piscivorous fishes (pilot project cages)

The impact of the pilot cages on piscivorous predators is assessed as having **low** negative significance, however, several essential mitigation measures are required to reduce this to **low** significance.

Mitigation measures:

- Develop a protocol to deal with problematic piscivores with experts and officials (Independent scientists and SFA);
- Maintain a record of all interactions with piscivores as per EMP;
- Remove any injured or dead fish from cages promptly; and
- Install and maintain suitable anti-predator nets.

Entanglement of marine animals (benthic associated)

The impact of entanglement of benthic associated marine life with pilot project cages and mooring ropes is assessed as having **low** negative significance without mitigation, however, several mitigation measures are required to reduce the probability of entanglements.

Mitigation measures:

- Ensure all mooring lines and nets are highly visible. Use thick visible lines.
- Keep all lines and nets as tight as possible and conduct regular inspections to ensure this
- Do not have any hanging lines or unnecessary lines from cages
- Use square mesh and ensure that net mesh-size does not exceed 16 cm whilst stretched

7.4.3.4 Decommissioning

Particulate pollution and entanglement hazards of cage infrastructure (ADZs)

Impacts associated with the decommissioning of ADZs are largely from particulate forms of pollution such as cage infrastructure and mooring equipment if left in the sea which would also persist as entanglement hazards for marine life. These impacts will be limited to the proposed development footprints, of medium intensity, long-term and ongoing. However, they can be easily mitigated by ensuring that all infrastructure associated with the development of cages and the ADZ projects are removed.

Mitigation measures:

- Ensure that all infrastructure associated with the development of aquaculture in the ADZs are removed from the sea and seafloor within 3 months of decommissioning a farm.

Particulate pollution and entanglement hazards of cage infrastructure (pilot project cages)

Impacts associated with the decommissioning of the pilot-project cages are largely associated with particulate forms of pollution such as cage infrastructure and mooring equipment if left in the sea. These impacts will be limited to the proposed development footprint, of relatively low intensity but nevertheless long-term and ongoing. However, this can be mitigated by ensuring that all infrastructure associated with the pilot project cages are removed.

Mitigation measures:

- Ensure that all infrastructure associated with the development of the pilot-project cages are removed from the sea and seafloor.

BQAF

When the broodstock facility is decommissioned, all associated pipeline infrastructure must be removed from the seafloor as this constitutes a source of pollution and could eventually breakup and physically damage adjacent reef and infrastructure. This must be carefully done so that adjacent coral reefs are not impacted. This impact is assessed as having medium significance but can be mitigated to have a low significance.

Mitigation measures:

- Remove all pipeline infrastructure.

Sensitive coral reef habitat exists in close proximity (<50 m) to the north-west of the proposed pipeline. This area must be a designated “no-go” area during the removal of all infrastructure.

R&D Facility

When the research and development facility is decommissioned the pipeline should be removed. Ageing infrastructure that is no longer maintained such as the pipeline after it has been decommissioned is likely to eventually break up and cause pollution and physical damage to the adjacent reef at it moves about with wave action. This impact is assessed as having medium significance but can be mitigated to have a low significance.

Essential mitigation measures:

- Remove all pipeline infrastructure within a year of it being decommissioned.
- Work only within a 2-m swath to reduce damage to adjacent reef.

7.4.4 Technical Aquaculture Aspects

7.4.4.1 Construction

Impacts

The construction phase impacts as a result of the industry establishment are limited to those caused by the placement of cages and mooring infrastructure on the sites, as well as the construction activities of land based facilities (i.e. the BQAF, the R&D facility as well as their associated abstraction and discharge infrastructure). The establishment of cages may have a negative impact (mortalities, loss of habitat) on benthic communities, but this is covered under the benthic assessment report (ORI Report No. 332, 2016 - APPENDIX D).

Importation of genetically distinct fingerlings that are not from the Seychelles inner islands populations

During the Pilot Project phase, SFA proposes that Grouper fingerlings be sourced from reputable, certified disease free hatcheries in Australasia for the first season or until such a point that the broodstock facility and

hatchery is up and running. This may potentially have disease and genetic impacts on the local fish populations.

The disease risk is potentially high as 1) alien species pathogens not present in the Seychelles ecosystem might be introduced and 2) pathogens with acquired drug resistance due to repeated exposure under aquaculture conditions may be introduced.

The fish would also originate from a related but genetically distinct regional population and escapees could have an impact on wild fish genetics if they successfully breed.

In general, the aquaculture industry is moving away from translocations for biosecurity reasons. However, should a transfer be done strict biosecurity and quarantine protocols will minimise the risk of disease introduction. Mitigation measures include risk assessment, authorisation of conditions by the regulator, a health certificate from exporting country, prophylactic treatment of imported fish for parasites, quarantine and monitoring for parasites and diseases, and application of ICES Code of Practise on the Transfer and Introduction of Marine Species (ICES, 2005). The Seychelles Aquaculture Standard: '*Hatchery Biosecurity Protocol*' and '*Responsible Finfish Cage Aquaculture*' provide protocols for biosecurity measures to minimise disease transfer to wild populations.

The potential disease impact is assessed **high** without mitigation and **moderate** with mitigation.

It should be noted that the importation of any biological matter, such as ova, fingerlings or broodstock at a later stage during the development of the sector, would carry with it the same risks and hence the same impact rating. Thus the importation of any biological matter at any time would constitute a "high" impact without mitigation.

The potential genetic impact of farmed fish on wild populations is dealt with below. The potential disease impact is assessed **high** without mitigation and **moderate** with mitigation.

Importation of genetically distinct broodstock fish that are not sourced from the Seychelles Inner Islands

The pilot project will be required to bring in Grouper broodstock from the outer island populations. This may have disease and genetic impacts on the local fish populations. The disease and genetic risk is not considered as high as the importation of cultured fingerlings form Australasia because the fish are part of the Seychelles Indian Ocean ecosystem. Therefore 1) the parasite and potential disease vectors are likely to present in inner island wild populations and 2) the farmed and wild fish are likely to be more similar genetically. As the wild brood fish have not been subject to husbandry conditions they are less likely to carry parasites and disease vectors that are drug resistant. The impacts and risks associated with genetic contamination and disease transfer to wild stocks are discussed more fully below.

Mitigation measures include disease risk assessment, authorisation with conditions by the regulator, prophylactic treatment of imported fish for parasites, quarantine and monitoring for parasites and diseases, and application of ICES Code of Practise on the Transfer and Introduction of Marine Species (ICES, 2005). The Seychelles Aquaculture Standard: '*Hatchery Biosecurity Protocol*' and '*Responsible Finfish Cage Aquaculture*' provide protocols for biosecurity measures to minimise disease transfer to wild populations.

The potential disease impact is assessed as '**moderate'** both before and after mitigation.

The potential genetic impact is assessed as **moderate** without mitigation, and **low** with mitigation

Impact on sensitive benthic habitats with cage installation

Placing cages in areas that are near to sensitive receptors, such as coral reefs or in shallow waters could pose a risk to the sustainability of the operation and receiving environment.

The ADZ site selection protocol however anticipated these issues and areas with coral reefs were deemed unsuitable as ADZ sites. Furthermore, as demonstrated by the MOM model all ADZ sites selected have current speeds that will disperse organic wastes and not result in a build-up of organic waste in the sediments.

The ADZ site survey indicated that all have sandy/silty sediments. However, due to the lack of detailed data on the ADZ sites, it is possible that some sensitive habitats may be present. To mitigate the possibility of cage placement over sensitive habitats, any potential developer will be **required to undertake a site survey and monitoring at least six months prior to cage installation**. Proposed ADZ's may be moved by up to one nautical mile, should sensitive habitats be found.

With these mitigation measures in place, the likelihood of cages being situated over sensitive benthic habitats during the construction phase is minimal and the impact is ranked as **low** with mitigation.

Mitigation Measures

Importation of genetically distinct fingerlings that are not from the Seychelles inner islands populations

- Prior to the commencement of any aquaculture activities, use of the target species must be authorised by the regulator (currently SFA);
- Health certificate from exporting country;
- Prophylactic treatment of imported fish for parasites;
- Quarantine and monitoring for parasites and diseases;
- Follow ICES Code of Practise on the Transfer and Introduction of Marine Species; and
- Operational measures to minimise escapement according to Seychelles Aquaculture Standard for Responsible Finfish Cage Aquaculture.

Importation of genetically distinct broodstock fish that are not sourced from the Seychelles Inner Islands

- Prior to the commencement of any aquaculture activities, use of the target species must be authorised by the regulator (currently SFA);
- Native species should not be introduced to an area where they do not already occur;
- Prophylactic treatment of imported fish for parasites;
- Quarantine and monitoring for parasites and diseases;
- Adequate steps must be taken to prevent the escape of production organisms, especially from the hatchery environment where individual organisms may be very small; and
- Escape barriers may include netting, grids, sand and other filters, predator ponds, chemical treatment areas, soak away systems, etc.

Impact on sensitive benthic habitats with cage installation

- Pre-installation site survey to verify benthic habitat type and select sandy/muddy bottom.

7.4.4.2 Operation

Impacts

Genetic contamination of wild stocks

Farmed fish spawned from a small number of brood stock tend to have reduced genetic diversity compared to wild stocks. Furthermore, farmed fish are genetically selected for and typically preferred traits such as fast growth and high meat yield. Farmed is are thus genetically distinct and their breeding with wild stocks may have a negative effect on the fitness of the population (Hershberger, 2002; Naylor *et al*., 2005; Ford and Myers 2008).

Despite being confined to sea cages, it is inevitable that at some fish will escape from the farms and possible breed with wild populations. Even in countries with advanced sea cage farming industries such as Norway,

fish escapes are a regular occurrence with an estimated 1.5 million escaped salmon present in Norwegian fjords at any one time (Heuch, *et al*., 2005).

It should be noted that the significance of the impact of genetic contamination of escaped farm fish on wild stocks is largely determined by the extent of genetic differentiation between farmed and wild stocks, as well as the survival and reproductive success of escaped fish (Falconer and Mackay, 1996). If the farm broodstock population is made of a genetically representative selection of wild caught fish, and a 'no selection' policy is adopted in order to maintain the wild genetic profile, the effects of escapees interbreeding with the wild population will be low. If farmed fish are subject to a high level of genetic selection and inbreeding for production traits (e.g. fast growth rate), they will be genetically more differentiated from the wild population. Farm escapees could have a greater genetic impact on the wild population – depending on the scale of escape and their proportional contribution to the wild spawner stock.

The impact of farmed fish on the population genetics of one of the preferred aquaculture species, the Brown-marbled grouper (*Epinephelus fuscoguttatus*) is a potential issue as it is listed as 'Near Threatened' due to the over utilization and targeting of adults at spawning aggregations (IUCN, 2016-2). Large numbers of escaped wild fish could thus make a significant contribution to spawning and recruitment. There is however insufficient information available to assess the magnitude of this risk. The size of the Brown-marbled grouper population within the Seychelles inner and outer islands would need to be determined to fully understand the risk of possible genetic alteration at population level. There have been studies on the spawning aggregations of grouper within Seychelles (Robinson *et al.*, 2008), but these studies provide a high level of detail within a very small area.

Precautionary mitigation measures to reduce the risk of genetic alteration of wild populations through breeding with escapees could include a 'no selection policy', use of wild brood stock only and brood stock rotation. Once a better understanding of *E. fuscoguttatus* population genetics is obtained, and the risk of escaped fish affecting their genetics understood and minimised, it may be possible to selectively breed for traits that enhance stock productivity (stock improvement).

The Seychelles Aquaculture Standard for Responsible Finfish Cage Culture deals with "Escape Management', whereby it details proactively reducing the potential causes of escape and recommended escape response actions.

The impact of genetic contamination is ranked as **moderate** without mitigation and l**ow** with mitigation.

Disease and parasite transmission to wild fish stocks

Intensive fish farming involves high density stocking of fish per unit area which increases stress and the incidence and prevalence of infectious diseases and parasites (Lipton, 1994). Farmed fish are therefore inherently more prone to these disease vectors inducing pathogenic symptoms. Infectious diseases and parasites are regarded as the single biggest threat to aquaculture, for example, the estimated losses from sea lice (genus *Caligus*) infections of salmon stock alone amounting to hundreds of millions of dollars annually (Staniford, 2002; Heuch, *et al*., 2005).

Maintaining proper environmental conditions, selecting healthy fish, quarantining new broodstock, providing a nutritious diet, minimising stress, vaccinating fish, and rapidly diagnosing, isolating, and treating disease outbreaks are important aspects of good husbandry.

Under natural conditions, potential disease causing organisms are not normally pathogenic as they have co-evolved with the host fish species and are less concentrated than those confined to cages. Furthermore, wild fish exercise natural parasite shedding behaviours. The transmission of diseases from farmed fish to wild stocks may take place when wild fish are in close proximity to cages (fish may be attracted to the cages as a result of excess food), or simply as a result of the much higher concentration of pelagic parasite life history stages arising from intensive fish farming.

In cases where farmed fish species are not indigenous, the risk of wild fish becoming infected with new disease causing organisms to which they have no natural resistance is indeed high. One of the key criteria in species selection for the Seychelles MMP was "*Species that are naturally distributed in the Seychelles waters*". Thus as only indigenous fish species form part of the MMP (notwithstanding the potential for

bringing in an initial batch of fingerlings for the pilot project) and the associated disease causing organisms and parasites will originate from the wild fish populations and pose a lower risk due to the natural resistance of the wild fish.

Although treatment of cultured stock to control disease and parasite outbreaks is possible (unlike wild stocks), chemical treatment is not without further environmental impacts, whilst build-up of antibiotic and chemical resistance is becoming increasingly problematic (Staniford, 2002).

Modern best management practise is to reduce stress through good husbandry practise and to implement an on-farm preventative fish health management programme under supervision of a veterinarian. This involves ongoing baseline monitoring of fish health status including:

- Nutritional status;
- Parasite load;
- General conditions;
- Growth performance; and
- Pathogenic symptoms.

The Seychelles Aquaculture Standards for '*Fish Health Management*', '*Biosecurity Protocols for Hatcheries*' and '*Responsible Finfish Cage Culture*' provide regulations for biosecurity and fish health management based on internationally accepted best management practise. From the training of staff, identification of risks, through to the daily management, monitoring, contingency plans and treatment, these documents cover the detail required to compile a standard operating procedure (SOP) for Biosecurity and Fish Health Management.

Biosecurity in aquaculture is of critical importance. The control of pathogen entry and proliferation is an essential aspect of any intensive animal production unit and is one of the most difficult challenges facing the industry worldwide. As a result, strict biosecurity measures should be adhered to in hatcheries, including restricted access, hand washing and foot baths. Should new broodstock be introduced then these should be appropriately quarantined to ensure disease free status. The Seychelles Aquaculture Standard for Responsible Cage Aquaculture provides for the following biosecurity measures:

- Cage farms must maintain documentation identifying the source of all eggs, fry, fingerlings or adult fish in each cage.
- All purchases of live fish, regardless of life stage, must be accompanied by an accredited veterinarian signed "Certificate of Veterinary Inspection" attesting to the good health of the fish.
- Limit contact among groups of animals, workers, and equipment through disinfection/decontamination procedures.
- Facilities that use different life stages in the production process must, where necessary, implement quarantine or disinfection procedures to reduce the risk of pathogen transfer.
- The veterinarians approved by the Regulator must be informed of diseases or pathogens observed in cultured stocks, and before disposing of fish that manifest disease symptoms.
- Health management records must be archived for at least two years to document behavioural changes, clinical signs of disease, treatment procedures, or unusual mortality rates. These records will be made available for inspection by the Regulator.

The impact of disease transfer to wild fish is ranked as **moderate** without mitigation and **moderate** with mitigation.

Organic waste pollution from finfish cages

The potential for the deterioration of water quality in the receiving ecosystem as a result of fish farm intensification is potentially high if no mitigation and monitoring is implemented.

This potential deterioration of water quality as a result of organic fish farm effluents include eutrophication, sedimentation, increased Biological Oxygen Demarnd (BOD) and Chemical Oxygen Demarnd (COD) (Staniford, 2002). These effects are most severe in sheltered waters with low exchange rates (e.g. Norwegian/European fjords), and become less intense in open waters where currents and winds disperse the organic waste. As the waste is organic, the fish faeces and food waste compounds will assimilate into the ecosystem food chain, provided that the assimilation capacity of the local environment is not exceeded.

Aquaculture organic waste originates from the metabolism and excrement of the fish, as well as from waste feed. The particulate and dissolved waste is rich in carbon, nitrogen and phosphorous. Studies have documented increased dissolved nutrients and particular components (POC and PON) both below, and in plumes downstream, of fish cages (Pitta *et al*. 2005). These wastes impact both on the benthic environment and on the water column.

Sediments and benthic invertebrate communities under fish farms usually show chemical, physical and biological changes attributable to nutrient loading. Elevations in carbon, ammonia and hydrogen sulphide concentrations are frequently observed (Carroll, *et al.* 2003; Heggoey, *et al.,* 2005). Nutrient enrichment and resulting eutrophication of sediments under fish cages is regarded as a serious issue in area with low water exchange rates (Staniford, 2002). Impacts on benthic habitats below fish cages do, however, tend to be localized. Most studies indicate that the effect is contained within a few hundred meters (Porrello, *et al.* 2005; Merceron, 2002 and Kempf *et al.,* 2002), but one Mediterranean study was able to detect changes up to 1000 m away (Sara, *et al.* 2004).

It is thus important to determine the fish biomass carrying capacity of farm sites to ensure that the organic waste produced is assimilated by the local ecosystem without negative ecological impacts (Ross, *et al,* 2013). The MOM model described in section 6.0 of APPENDIX E is a modelling tool that determines safe production volumes based on three key indicators (i) benthic fauna at a farm site does not disappear due to organic sediment accumulation, (ii) the water quality in the net pens must be kept high, and (iii) the water quality in the areas surrounding the farm must not deteriorate (Stigebrand*t et al*, 2004).

Due rapid dispersal of wastes predicted by the MOM model and the precautionary production limit of 10t/ha year, the impact of organic waste pollution is ranked as **low** without mitigation and l**ow** with mitigation.

Chemical pollution arising from finfish cages

Disinfectants, antifoulants and therapeutic chemicals (medicines) are typically used in sea cage fish culture. Some of these chemicals may be toxic to non-target organisms and may remain active in the environment for extended periods. For this reason, the Seychelles Aquaculture Standard for '*Responsible Effluent and Waste Management*' stipulate that the use of hormones and anti-biotics in the Seychelles will be restricted to land based facilities under supervision of a state veterinarian.

Biofouling of cage nets in the Seychelles is considered low due to the oligothrophic nature of the tropical waters (SFA, 2012). The Seychelles MMP provides strict control of antifoulants to minimise their potential toxic effects on the receiving environment. The Special Conditions for the Seychelles Marine Aquaculture Licence for Finfish Grow-out in Cages, Section 8 (a) states, "*The License Holder shall ensure that the Regulator approves any anti-fouling product used on the net pen material"*.

Chemical use at sea is thus expected to be minimal in the Seychelles ADZs. The impact of chemical pollution is ranked as **low** with appropriate mitigation measures.

Accidental entanglement of cetaceans in finfish cage culture infrastructure

They Seychelles is home to resident and migratory populations of dolphins and whales. Southern right whales, humpbacks and short-finned pilot whales occur common in the Seychelles with a number of other species having been recorded. There is thus a small risk of entanglement in cage moorings.

Entanglement of marine mammals in fish cage infrastructure has been reported internationally but are rare events (Kemper & Gibbs 2001; Wuersig & Gailey 2002). Cetaceans and other marine animals may be able to avoid lethal effects associated with entanglement in fish cage infrastructure, but the mere presence of sea cages may well adversely affect habitat use and may have chronic negative effects on populations (as well as ecotourism activities) (Wuersig & Gailey 2002).

Cetaceans may be able to avoid lethal effects associated with entanglement in fish cage infrastructure, but the presence of sea cages may adversely affect habitat use and ecotourism activities (Wuersig & Gailey 2002).

Given the rarity of reported cetacean entanglement events, the impact is considered **low** with mitigation for the Seychelles ADZs.

Piscivorous marine animals interacting with finfish cage culture operations

Piscivorous (fish eating) marine animals including mammals, sharks, bony fish and birds are naturally attracted to the fish cages (Wuersig & Gailey 2002, Vita, *et al.* 2004). The cages act as natural Fish Aggregating Devices (FADs) and it is common to have a community of small fish associated with the cages for purposes of shelter and food. Both the fish in the cages and associated small fish community tend to attract larger, predatory marine animals. Their attempts to get at the stock may induce a stress response with consequent decreased growth rates and resistance to disease. Furthermore, predators can damage the cage nets, allowing fish to escape.

While a certain level of interaction between the farmed fish and wild fauna is unavoidable, such as the small fish seeking shelter and feeding on waste feed and faeces, the interaction with larger marine piscivores should be minimised through appropriate mitigation measures. For example, mortalities should be removed daily as they may attract wild fish and birds which may become tangled in nets. Apart from harm or death to the predator, this may result in damaged nets leading to escapes and stress or harm the cultured stock. The attraction of piscivorous marine animals may alter natural foraging behaviours. Farmers tend to kill problem predators or use acoustic deterrents.

There are various measures to mitigate the effect of fish cages on piscivorous marine animals. Bird netting over fish cages is standard to prevent entry, and the above water ‘jump nets’ around the circumference of the cage prevent the caged fish from escaping as well as wild fish and seals from jumping into the cage.

The impact on marine piscivores is ranked as **low** with appropriate mitigation.

Impacts on fishing, yachting and recreational vessels

The establishment of fish farms with the proposed ADZs will exclude other vessels from the fish cage area. This is essential for personal and navigational safety and farm security. The ADZ sites have been selected to avoid shipping lanes, diving reefs and fishing grounds and so are thus not expected to conflict with these activities. The main impact is will on the movement of fishing, yachting and recreational vessels.

The main effects will be on vessels 1) having to detour around the fish farm sites and 2) a potential open water navigational hazard.

Mitigation measures would include navigational lights on the cages, buoys delineating the fish farm boundaries, listing the fish farm sites on navigational charts and educating vessel operators about the fish farm presence. It should be possible to traverse the ADZ sites between the demarcated fish farms.

The impact on fishing, yachting and recreational vessels is ranked as **low** with appropriate mitigation.

Mitigation Measures

Genetic contamination of wild stocks

- Adequate steps must be taken to prevent the escape of aquaculture species, especially from the hatchery environment where individual organisms may be very small;
- Escape barriers may include netting, grids, sand and other filters, predator ponds, chemical treatment areas, soak away systems, etc; and

- Barriers should be adequate to prevent escape during flooding, overflows and during other unforeseen circumstances.

Disease and parasite transmission to wild fish stocks

- Staff trained in fish health management and disease recognition;
- Implement a Fish Health Management Programme;
- Apply aquaculture best management practices;
- Maintain strict bio-security measures within hatchery, holding tanks and sea cages;
- Ensure all fry undergo a health examination prior to stocking in sea cages;
- Regularly inspect stock for disease and/parasites as part of a formalised stock health monitoring programme;
- Take necessary action to eliminate pathogens through the use of therapeutic chemicals or improved farm management;
- Research into the identification, pathology and treatment of diseases and parasites infecting farmed species; and
- Treat adjacent cages simultaneously even if infections have not yet been detected in these cages.

Organic waste pollution from finfish cages

- Bio filtration of shore based hatchery effluent;
- Set production carrying capacity limits for cage sites;
- Cage location in areas with current >0.2m/s; and
- Ongoing MOM modelling and feedback into management measures.

Chemical pollution arising from finfish cages

- Utilise professional fish health services/veterinary expertise to diagnose disease prior to initiating any disease treatment;
- No veterinary therapeutic-products and medicinal premixes for inclusion in fish feeds may be applied to fish unless they are approved for use;
- Follow manufacturer's/veterinarian's instructions regarding dosage, frequency and duration;
- Keep a current copy of the veterinarian's written recommendation;
- Use environmentally-friendly detergents;
- Ensure all chemicals and drugs are secured to prevent unauthorised use; and
- Dispose of unutilised therapeutic agents and medicines according to conventional hazardous waste disposal practices.

Accidental entanglement of cetaceans in finfish cage culture infrastructure

- Do not locate ADZs in important cetacean habitats and migration routes;
- Ensure all mooring lines and nets are highly visual;
- Keep all lines and nets tight through regular inspections and maintenance; and
- Ensure that mesh size on primary and secondary nets does not exceed 16 cm stretched mesh.

Piscivorous marine animals interacting with finfish cage culture operations

- Install and maintain suitable predator nets (sufficient strength, visibility and mesh size, above and below water line);
- Install visual deterrents (e.g. tori line type deterrents for birds);
- Store feed so piscivores cannot access it, and implement efficient feeding strategy;
- Remove any injured or dead fish from cages promptly;
- During harvesting of stock, ensure that minimal blood or offal enters the water;
- Implement mitigation measures as for entanglement impacts (see above); and
- Develop a protocol for dealing with problem piscivores in conjunction with experts and officials (SFA)

Impacts on fishing, yachting and recreational vessels

- Install navigational markers and lights as required by SAMSA regulations;
- Include position of ADZs on navigational charts; and
- Ongoing consultation with user groups to keep them informed of the ADZ developments.

7.4.4.3 Decommissioning

Impacts

Farm operations cease

All businesses have a life cycle and closure is a normal phase of operation. Aquaculture businesses tend to have a high failure rate because the technology is new, markets are rapidly changing and environmental factors introduce a high element of unpredictability into performance.

Farm closure and decommissioning should thus be planned for. The environmental impacts of decommissioning can range from severe – if the farm infrastructure is abandoned, to negligible if all equipment is removed and responsibly disposed of.

If the cage culture operation is abandoned as a result of business failure, a number of harmful environmental effects are possible. These could include:

- Entanglement of marine animals such as turtles, birds, cetaceans and large fish in the netting; and
- A navigational hazard to vessels.

The impact rating of ceasing farm operations is rated as '**moderate**' without mitigation and as '**low**' with mitigation.

Mitigation measures could include a public liability insurance policy or an investment fund to provide for site rehabilitation should an operation be abandoned.

7.4.4.4 Cumulative Impacts

The cumulative impacts of an aquaculture industry will be similar to those listed, but may be exacerbated as a result of more operators farming within a certain area. Potential impacts include:

- Genetic Contamination.
  - A larger industry with more players, will likely attract new species, sources of seed and competition to produce artificially selected species.
- Disease and parasite transmission to wild fish stocks.

  - With more fish being farmed the potential for disease breakout is increased, furthermore the implications of such a breakout would likely be more significant and harder to manage across farms and operators.

- Degraded water quality as a result of organic wastes (see APPENDIX B and APPENDIX C).
  - More intensive farming has the potential to degrade water quality as a result of higher nutrient inputs.
- Chemical pollution arising from finfish cages.
  - Higher volumes of fish produced as a result of multiple farms within a unit area, will result in more stringent treatments to avoid disease and as a result more intensive farming has the potential for chemicals to accumulate.

The Seychelles Mariculture Master Plan is however designed to space marine cages and farms so that they operate within the carrying capacity of the environment. If the prescribed Aquaculture Standards and Regulations are adhered to, with effective monitoring and feedback into the management and regulatory processes, there should not be adverse cumulative impacts.

7.4.5 Visual

7.4.5.1 Construction

Impacts

- Reduction in visual resource value due to increased shipping/boat traffic (construction material and operational activities). The impact was assessed as being **moderate** before mitigation was applied and **low** after mitigation had been applied.
- Light pollution at night. The impact was assessed as being **moderate** before mitigation was applied and **moderate** after mitigation had been applied.

7.4.5.2 Operation

Impacts

- Reduction in visual resource value due to increased shipping/boat traffic (construction material and operational activities). The impact was assessed as being **moderate** before mitigation was applied and **low** after mitigation had been applied.
- Reduction in visual resource value due to presence of floating cages and associated infrastructure (feed barges and work/well boats). The impact was assessed as being **moderate** before mitigation was applied and **low** after mitigation had been applied.
- Light pollution at night. The impact was assessed as being **moderate** before mitigation was applied and **moderate** after mitigation had been applied.

7.4.5.3 Decommissioning

Impacts

- Reduction in visual resource value due to increased shipping/boat traffic (construction material and operational activities). The impact was assessed as being **moderate** before mitigation was applied and **low** after mitigation had been applied.
- Light pollution at night. The impact was assessed as being **moderate** before mitigation was applied and **moderate** after mitigation had been applied.

Mitigation Measures

Visual mitigation of fish farms from sensitive receptors can be approached by the appropriate siting of fish farms within ADZs. If there are sensitive receptors which may have views to a portion of the ADZ at a short distance, e.g. less than 2 km's which may lead to a degradation of the visual resource, then measures can

be implemented by the controlling authority, in this case SFA, which stipulate where fish farms should be sited in the ADZ. They may also reduce the size of ADZs accordingly in order to exclude sensitive receptors direct line of sight of a portion of the ADZs and therefore fish farms within it.

Sites PLD4 and SN2 may require being reduced in order to limit sensitive receptors direct line of sight into these ADZs. Furthermore, consideration can be given to moving these ADZs slightly in order to limit the visual intrusion towards sensitive receptors, which in these two instances are high value tourism establishments.

In addition, management measures at individual fish farms can be implemented that limit the amount of lighting / illumination and/or the intensity of such lighting on board of the floating cages. For safety reasons, navigational lighting has specific standards that need to be implemented, however lighting for on-board crew can be adjusted to an absolute minimum required in order reduce any excess light pollution that may be visible form shore. Utilise security lighting (if feasible) that is movement activated rather than permanently switched on, to prevent unnecessary constant illumination. Avoid up-lighting of structures by rather directing lighting downwards and focused on the area to be illuminated.

Lastly, in order to reduce the visual intrusion that may be experienced by additional boat/shipping traffic, it is recommended that operators of fish farms try and schedule trips from main port to the fish farms at times of the day when receptors are least active. This may be during first light (early morning) or late afternoon before sunset. By scheduling boat and ship traffic, it may have the effect of reducing visual degradation experienced by sensitive receptors with views towards ADZs.

7.4.5.4 Cumulative Impacts

The cumulative impact assessment case considers this project within the context of other similar fish farms being established within a particular ADZ or in an adjacent ADZ should there be one nearby. As previously stated, the below cumulative impacts are considered:

- Cumulative degradation of visual resource value as a result of multiple fish farms starting operations within the same ADZ; and
- Cumulative regional light pollution associated with multiple fish farms within an ADZ.

With multiple fish farms setting up operations within the same ADZ, there will be an enhanced degradation of the visual resource. By employing modern fish farming techniques that employ best practice guidelines, there should be adequate buffers in pace between each individual fish farm, including having a fallowing site for each active farming site. This should ensure that each ADZ is used efficiently, but also within the carrying capacity limits. By having adequate buffers between fish farms, this should have the effect of limiting the number of fish farms in a particular ADZ and therefore limiting the degradation of the visual resource.

The first fish farm sites within an ADZ should be utilised **at the furthest point away from the coastline**, which should have the added effect of further limiting the degradation of the visual resource and overall impact. However, with subsequent fish farms being set-up, these later farms will naturally take up sites which are closer to the shoreline (still within the ADZ), thereby increasing the cumulative impact and degradation of the visual resource.

The impacts assessed above, have however, taken the closest point of the ADZ to the shoreline and assessed this as the ‘worst-case’ scenario for purposes of this impact assessment.

7.4.6 Noise

7.4.6.1 Construction

Impacts

The noise levels created by construction equipment will vary greatly depending on factors such as the type of equipment, the specific model, the operation being performed and the condition of the equipment. The equivalent sound level (L_{eq}) of the construction activity also depends on the fraction of time that the equipment is operated over the time period of construction.

It is envisaged that noise sources associated with the construction of the BQAF and R&D Facility will include trucks transporting equipment, waste and project components, welders, diesel generators, pile drivers, air compressors, diggers, cutting and drilling equipment and mobile cranes.

It is anticipated that the construction of the BQAF and R&D Facility will generate noise in excess of the ambient noise standards[5] and pose a significant annoyance to those in close proximity to the activity particularly with regards to impact noise which is considered more intrusive than continuous noise.

Receptors at the University (in the vicinity of the R&D Facility) are likely to be more sensitive to elevated noise levels compared to receptors at the Providence Industrial Estate (BQAF). At both sites however, noise impacts will be short lived and limited to the duration of the construction phase.

The potential impact of construction noise at the proposed BQAF and R&D Facility sites was assessed as being of ***moderate (SP = 48)*** significance without mitigation measures and as ***moderate (SP = 40)*** significance after mitigation measures were applied.

Degree of confidence in prediction of impact: **high**. Noise associated with construction is well documented and understood.

It is assumed that the cage components for the pilot project and ADZ will be prefabricated and assembled on site. It is therefore anticipated that the noise sources will be limited to the work boats transporting the prefabricated components to the various sites.

The potential impact of the work boats was assessed as being of ***low (SP = 27)*** significance without mitigation measures and as ***lower (SP = 24)*** significance after mitigation measures were applied.

Degree of confidence in prediction of impact: **moderate**. The noise levels may differ from those anticipated as the technology selection has not yet been finalised.

Mitigation Measures

The following mitigation measures[6] are recommended to reduce the **construction** noise at the BQAF and R&D facility:

- Schedule noisy construction activities to periods when University lectures are not in session such as during breaks or after classes, or during University holidays where practical;
- Notify neighbours prior to commencing activities that will generate significant noise. Good communication can prevent complaints from arising, and resolve concerns before there is a problem. A phone number where the foreman can be reached should be provided prior to the work commencing;
- A complaints reporting procedure should be established and all complaints logged. Investigations into the cause of the complaints should be initiated and appropriate mitigation measures applied timeously;
- Construct noise barriers, such as temporary walls or piles of excavated material between noisy activities and noise-sensitive receptors (in extreme cases where a sensitive receptor is located close by);
- Re-route truck traffic away from residential streets where possible;
- Position noise generating equipment such as generators and air compressors on the construction lot as far away from noise sensitive receptors as possible;
- Shut down or throttle down equipment (such as backhoes, cranes, bobcats, loaders and generators) whenever they are not in actual use;

[5] Residential: 60 Leq (day) and 55 Leq (night); Industrial: 75 (At all times, measured at the boundary of the site)

[6] Mitigation measures sourced from: Work Safe New Zealand (2015); U.S. Department of Transportation, (2006); South Australian Environmental Protection Agency (2014); British Standard (1997).

- Combine noisy operations to occur in the same time period. The total noise level produced will not be significantly greater than the level produced if the operations were performed separately;
- Avoid night-time construction activities. Sensitivity to noise increases during the night-time hours and should be avoided;
- Select quieter equipment where possible. For example, while most compressors are powered by diesel or gasoline engines, many are contained or have baffles to help abate noise levels. Electric compressors are significantly quieter than diesel or gasoline engine powered compressors.
- Use newer equipment where possible as it is generally quieter than old equipment for many reasons, including technological advancements and the lack of worn, loose, or damaged components. Some equipment manufacturers have designed their equipment to function quieter in recent years and have achieved significant reductions over older equipment. In some cases, the use of over- or under-powered equipment may be an unexpected source of excessive noise. The types of engines and power transfer methods also plays a significant roll in achieving lowered equipment noise. The use of electric powered equipment is typically quieter than diesel, and hydraulic powered equipment is quieter than pneumatic power;
- Ensure equipment is well maintained. Poor maintenance of equipment typically causes excessive noise levels. Faulty or damaged mufflers and loose engine parts such as screws, bolts, or metal plates contribute to increased noise levels. Removal of noise-reducing attachments and devices such as mufflers, silencers, covers, guards, vibration isolators, etc., will, to varying degrees, increase noise emission levels. Old equipment may be made quieter by simple modifications, such as adding new mufflers or sound absorbing materials. Loose and worn parts should be fixed as soon as possible;
- Construct temporary walled enclosures around especially noisy activities or clusters of noisy equipment where required. These techniques can significantly reduce noise levels and, in many cases, are relatively inexpensive. These barriers can typically be constructed on the work site from common construction building material (plywood, block, stacks, or spoils). To be effective, the length of a barrier should be greater than its height, the noise source should not be visible, and any barrier should be located as close as possible to either the noise source or the receiver. In addition, providing increased distance between a noise source and a noise receiver can also be considered a form of abatement; and
- Ensure personnel are trained to carry out their respective tasks. Careless or improper operation or inappropriate use of equipment can increase noise levels. Poor loading, unloading, excavation, and hauling techniques are examples of how lack of adequate guidance and training may lead to increased noise levels.

The following mitigation measures[7] are recommended to reduce the impact of construction noise at the pilot project cages site and ADZs:

- Plan routes to avoid known dive sites and/ or tourism routes;
- Ensure boats and engines are well maintained; and
- Avoid night-time activities. Sensitivity to noise is increased during the night-time hours.

7.4.6.2 Operation

Impacts

The MMP will have a lifespan of 25 years at the least, possibly much longer. The following sources are likely to generate noise during the operation of the MMP:

- Work boats servicing the pilot project and ADZ; and

[7] Mitigation measures sourced from: Work Safe New Zealand (2015); U.S. Department of Transportation, (2006); South Australian Environmental Protection Agency (2014); British Standard (1997).

- Life support systems at the BQAF and Research & Development Facilities, including:
  - Water treatment units;
  - Air blowers;
  - Oxygen generators;
  - Seawater pumps; and
  - Diesel generators (it is assumed this will only be used when electrical supply is interrupted).

Noise emanating from the workboats transporting staff, feedstock and harvested fish to and from the pilot project and ADZs are likely to be in similar frequency and intensity ranges as those of existing commercial fishing and transport operations. For marine mammals, the effects of the sounds from these sources are usually transitory, or the animals can habituate to such sounds with regular exposure. However, the range of effects can be large, and cumulative effects cannot be ruled out for the louder vessels (Olesiuk, Lawson and Trippel, 2010). The noise study, however, does not consider the potential effects in marine life or any other underwater acoustic effects.

The potential impact of the work boats was assessed as being of ***moderate (SP = 30)*** significance without mitigation measures and as ***low (SP = 24)*** significance with mitigation measures.

Degree of confidence in prediction of impact: **moderate**. The noise levels may differ from those anticipated depending on the size and type of vessel/ work boat used.

Noise levels generated by the life support systems at the BQAF and Research & Development Facilities are anticipated to be low and continuous and have little/no impact on the baseline noise levels beyond the site boundary. Elevated noise levels may however result from the use of the diesel generators, although it is assumed the generators will only be used when electrical supply is interrupted (i.e. infrequently).

The potential impact was therefore assessed as being of ***moderate (SP = 36)*** significance without mitigation measures and one of ***low (SP = 27)*** significance with mitigation measures.

Degree of confidence in prediction of impact: **moderate**. The noise levels may differ from those anticipated based on the technology selected.

Mitigation Measures

The following mitigation measures are recommended to reduce the impact of noise from work boats travelling to and from the ADZs and pilot project cage site:

- Plan routes to avoid known dive sites and/ or tourism routes and use existing transport routes where possible; and
- Ensure boats and engines are well maintained.

The following mitigation measures are recommended to reduce the impact of noise generated by life support systems at the BQAF and R&D facilities:

- Noise mitigation measures should be implemented at all noise sources radiating noise in excess of 85.0 dB(A). Such measures may include:
  - Installing suitable mufflers on engine exhausts and compressor components;
  - Installing acoustic enclosures for equipment such as pumps and generators causing radiating noise;
  - Installing vibration isolation for mechanical equipment;
- Equipment/ technology with lower sound power levels should be prioritised in the procurement process;
- All equipment should be well maintained and frequently inspected to ensure optimum operation;

- The use of the generators should be limited to when electrical supply is interrupted; and
- A complaints reporting procedure should be established and all complaints logged. Investigations into the cause of the complaints should be initiated and appropriate mitigation measures applied timeously.

7.4.6.3 Decommissioning

Impacts

Noise impacts similar to those of the construction phase are likely to occur during the decommissioning of the MMP, but over a shorter period of time and restricted to the demolition and transport of waste material to a waste management facility.

It is anticipated that the decommissioning of the BQAF and R&D Facility will generate noise in excess of the ambient noise standards[8] and pose a significant annoyance to those in close proximity to the activity particularly with regards to impact noise which is considered more intrusive than continuous noise, however this will occur over relatively short periods. It is possible that the facilities are not entirely dismantled and that alternate uses can be made and that only removal of equipment and minor stripping of the interior takes place which will have relatively limited noise associated with these activities compared to fully decommissioning the facilities.

It is assumed that the cage components for the pilot project and ADZ will disassembled on site and transported. It is therefore anticipated that the noise sources will be limited to the work boats transporting the components back to the island.

The potential impact of decommissioning noise at the proposed BQAF and R&D Facility sites was assessed as being of ***moderate (SP = 40)*** significance without mitigation measures and of ***moderate (SP = 32)*** significance with mitigation measures.

Degree of confidence in prediction of impact: **high**. Noise associated with construction is well documented and understood.

The potential impact of the work boats was assessed as being of ***moderate (SP = 30)*** significance without mitigation measures and of ***low (SP = 24)*** significance with mitigation measures.

Degree of confidence in prediction of impact: **moderate**. The noise levels may differ from those anticipated as the technology selection has not yet been finalised.

Mitigation Measures

The following mitigation measures[9] are recommended to reduce the impact of decommissioning activities at the BQAF and R&D facilities:

- Schedule noisy construction activities to periods when University lectures are not in session such as during breaks or after classes, or during University holidays where practical;
- Notify neighbours prior to commencing activities that will generate significant noise. A phone number where the foreman can be reached should be provided prior to the work commencing;
- A complaints reporting procedure should be established and all complaints logged. Investigations into the cause of the complaints should be initiated and appropriate mitigation measures applied timeously;
- Mitigate noise from power equipment or other noise producing activities with sound barriers, muffling devices, lower settings on power equipment and limit ‘noisy’ work periods;
- Construct noise barriers, such as temporary walls or piles of excavated material between noisy activities and noise-sensitive receptors (where necessary or appropriate);

[8] Residential: 60 Leq (day) and 55 Leq (night); Industrial: 75 (At all times, measured at the boundary of the site)

[9] Mitigation measures sourced from: Work Safe New Zealand (2015); U.S. Department of Transportation, (2006); South Australian Environmental Protection Agency (2014); British Standard (1997).

- Reroute truck traffic away from residential streets where possible;
- Position noise generating equipment such as generators and air compressors on the construction lot as far away from noise sensitive receptors as possible;
- Shut down or throttle down equipment (such as backhoes, cranes, bobcats, loaders and generators) whenever they are not in actual use;
- Combine noisy operations to occur in the same time period. The total noise level produced will not be significantly greater than the level produced if the operations were performed separately;
- Avoid night-time activities. Sensitivity to noise increased during the night-time hours;
- Prioritise the procurement and use of equipment with lower noise levels;
- Ensure the equipment is well maintained;
- Construct temporary walled enclosures around especially noisy activities or clusters of noisy equipment; and
- Ensure personel are trained to carry out their respective tasks. Careless or improper operation or inappropriate use of equipment can increase noise levels. Poor loading, unloading, excavation, and hauling techniques are examples of how lack of adequate guidance and training may lead to increased noise levels.

The following mitigation measures[10] are recommended to reduce the impact of work boats:

- Plan routes to avoid known dive sites and/ or tourism routes;
- Ensure boats and engines are well maintained; and
- Avoid night-time activities. Sensitivity to noise increased during the night-time hours.

7.4.7 Social

7.4.7.1 Construction

The construction impact relates to the building of the BQAF and R&D facilities. This section considers the social impacts that may occur as a result, or in anticipation of the construction process.

Job Opportunities and Local Employment

Impacts

The land-based component, includes the construction of the BQAF and R&D facilities. Indications are that, to a large extent, conventional construction techniques will be used. Over and above the construction of the infrastructure, installation of specialised equipment and related structures will be required.

The Seychelles has a vibrant construction sector. The construction sector is the second or third largest[11] employment sector in the Seychelles (King and Walmsley 2013; Seychelles National Bureau of Statistics 2015a). The skills and capacity that would be required are available in the Seychelles. They may be a requirement for specific skills to install the specialised equipment and related structures. Depending on the nature of this equipment, the capacity could be found in the Seychelles. If this is not the case, it could be important. The number of people required for this specialised function with very low and will have an insignificant impact on local employment and population structure.

It is unclear at this stage how many construction workers would be required, but indications are that it will be a small number. These construction jobs will be of a temporary nature. It follows that the land-based

[10] Mitigation measures sourced from: Work Safe New Zealand (2015); U.S. Department of Transportation, (2006); South Australian Environmental Protection Agency (2014); British Standard (1997).

[11] This variance depends on the source as well as the sectoral breakdown.

construction related impacts will be very limited and should to a very large extent, be fulfilled from the Seychelles labour market. Very little if any importation of labour is anticipated.

When considering that, in 2016, the national unemployment rate was just above 4%, with the youth (10%) and woman (4.6%) the largest component thereof, an opportunity arises (Seychelles National Bureau of Statistics 2016b). Recruitment of labour for the land-based construction activities, should therefore target the youth and women, as part of the process to address the mentioned unemployment disparity.

This impact is perceived to be **positive**, even if of **low** significance. Any new construction activity and the associated creation of job opportunities will, *per se,* make a positive socio-economic contribution to some extent. This viewpoint is supported by the fact that the bulk of the construction skills are available locally. The positive impact can be enhanced to a **positive moderate** impact by focusing on the employment of the youth and women. This conclusion is based on the viewpoint that the construction activities will not cause any significant influx of foreigners and importation of labour into the Seychelles.

This aspect is considered in the following section.

Mitigation Measures

- Ensure adherence to the approach that local labour is used as far as possible with an emphasis on employing youth and women.
- Introduce contractual obligations for contractors to use local labour as far as possible.
- If specific skilled positions cannot be sourced within the local districts, they should be sourced at the national level first before looking at international workers.
- Establish community liaison officers to manage the local MMP public interface, specifically during the construction phase.
- Maximise the usage of local service providers, including contractors.

Population Influx

Impact

This variable refers to the moving into the area of temporary workers during the construction phase of a project. Typically, the skills levels required, which varies between highly skilled (e.g. professional engineers), technical staff (e.g. surveyors) to skilled machine operators to general unskilled/semi-skilled labourers, could influence this variable. An influx of a large number imported labour could result in social conflict and pressure on social services and facilities impacts.

When considering the low number of employment opportunities during the construction phase, linked to the fact that the bulk of the construction skills will be available locally, a population influx is not anticipated and the impact is likely to be **low** both before and after mitigation.

Mitigation Measures

Over and above the mitigation measures provided for “Job Opportunities and Local Employment”, the following measures are recommended:

- The use of Seychelles labour should be specified in the tender documentation.
- Before construction commences, representatives from the district and community-based organisations, as well as neighbouring residents should be informed of the details of the construction company, the size of the workforce and construction schedules.
- Construction workers should be easily identified as part of the construction team by e.g. wearing specific clothing and name tags.
- Criminal incidents should be communicated to the workforce and employees to ensure a general awareness of the safety situation in the area.

Project-Induced In-Migration

Impact

Project-induced in-migration associated with economic opportunity is a common phenomenon. Project-induced in-migration, in the context of this report, is seen as the large scale movement of people into an area in expectation of, or response to, economic opportunities associated with a new project (IFC 2011). In-migration is sometimes related to expectations rather than an ensured advantage.

Migrant groups will often vary according to the unique demographic, social or economic circumstances. Categories of migrant groups typically include labourers and their families, entrepreneurs, sex workers, and opportunistic seekers of prospects (IFC 2011).

In this regard, it is important to consider that jobs form part of a basic need. The introduction of job opportunities is likely to create competition among jobless people, be that local or migrants from other regions or even countries. Largescale in-migration may also have impacts on the cultural-social fabric of the recipient society. In this regard, some focus group respondents have stated that an influx of foreign cultures could have a negative impact on the Seychellois culture, as some foreign workers are believed to have made a nuisance of themselves on beaches popular with tourists and locals.

According to the Seychelles National Bureau of Statistics, there has been a net loss of 3,815 long-term migrants and a net gain of 1,420 in short-term migrants (Seychelles National Bureau of Statistics 2015d). They are little indication that this level of in and out migration had a significant impact on the social and cultural activities of the Seychellois (Personal observations and numerous discussions with Seychellois people).

Project-induced in-migration is not anticipated to realise during the construction of the BQAF and R&D facilities. This conclusion is underpinned by the following factors:

- The extraordinarily high employment levels in the Seychelles, will preclude any in-migration to a specific area due to the availability of jobs.
- As indicated, the number of temporary jobs created during the construction period is anticipated to be very limited.
- It is unlikely that significant labour imports will be required.
- Being an island, a large movement of unofficial in-migration will be difficult.

In a similar vein it is unlikely that any of the side effects of large-scale immigration would realise. It is also not anticipated that there would be any additional housing requirements, due to the small number of jobs and the proximity to the residential areas. The impact is rated as **low** before and **low** after mitigation measures have been applied.

Mitigation Measures

No further mitigation or management measures are proposed, over and above the ones made previously. In this regard the two following measures are reiterated:

- Implement an effective stakeholder engagement and awareness process regarding the construction process in particular, and the larger Seychelles MMP as well.
- Before construction commences, representatives from the District Authority, the District Social Committee and the District Team, and community-based organisations, as well as neighbouring residents should be informed of the details of the construction process, contractor (if any), the size of the workforce and construction schedules.

Skills Requirements

Impact

This aspect relates to the skills gap, if any, that may exist between the project requirements and the local labour offering. If the skills required by a construction process, or a project, are of a higher level and complexity than those on offer by the local inhabitants, it can have a number of diverse consequences. Among these are the need to import labour, competition for scarce resources in the local economy, as well as capital flowing out of the local economy. Extensive capacity building and training will be required if sustainable social and economic growth is to be attained over the longer term.

As indicated before, the skills required for the construction of the BQAF and R&D facilities are, to a large extent, locally available. If however, the recommended measure to focus on the employment of the youth and women is considered, it may require some focused capacity building and training. For such an approach to be successful, participants would have to be selected and empowered in a transparent manner. To this extent, the following recommendations are made.

The impact is rated as a negative **low** impact before and **positive moderate** impact after mitigation measures have been applied.

Mitigation Measures

- Finalise the details of the construction activities, specific job requirements and associated skills as well as the schedules. This should take place before the construction starts, to enable the process of capacity building if required.
- Develop the capacity requirements and associated budgets.
- Develop a list of potential candidates, focusing firstly on the unemployed youth and women before construction commences. Representatives from the District Authority, the District Social Committee and the District Team, as well as neighbouring residents should be consulted should be consulted in this regard.
- Appoint a training coordinator to manage and coordinate this process. This function can be combined not only why with those of the proposed community liaison officers.

Change in Employment Equity of Vulnerable Groups

Change in employment equity of vulnerable groups is interpreted as the degree to which job opportunities generated by the construction match, or stimulate the employment of vulnerable groupings living at or close to the development, including women and the youth.

As indicated before, the 2016 mid-year unemployment level in the Seychelles is just more than 4%. Of significance is that the youth[12] makes up 10% of this total, and women almost 5% (Seychelles National Bureau of Statistics 2016b). There is therefore an opportunity to target unemployed women and the youth to participate in the construction process. As disused before, this also opens up the prospect to build the skills and capacity of these people as required. This process may provide them with an opportunity to participate in the construction labour market over the longer term.

Due to the small number of people involved in the construction process, the impact will only affect a few people. Even though the numbers are small, the potential benefit is assessed as a potential low positive impact. The impact is rated as a negative **low** impact before and **positive low** impact after mitigation measures have been applied.

Mitigation Measures

- Implement the recommendations made to focus on involving women and the youth in the construction process.

[12] Of the unemployed youth, some 8% are men and 14% female (Seychelles National Bureau of Statistics 2016b).

- Implement the skills training and capacity building focus as indicated in previous sections.

Impacts on Daily Living and Movement Patterns

Impacts on daily living and movement patterns relate to the project-related traffic impacts of construction activities on residents and road users. The impacts on daily living and movement patterns relate to increases in levels of traffic and movement of vehicles, including heavy construction vehicles, in and out of the area as a result of building and infrastructure related activities. These project related vehicular movements may interfere adversely with current traffic patterns and negatively impact on public safety and access.

Heavy construction vehicles have the potential to damage roads, create noise, dust, visual intrusions and cause risk impacts for other road users and residents in the area. Care must be taken that any increases in traffic will not have a negative effect on pedestrians, in particular, children who may not, as yet, be well versed in road use and traffic rules. The impact is rated as a negative **moderate** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

Communicate information regarding the construction routes, peak operational times, hazards associated and precautionary measures to the local district as well as the relevant community representatives.

Notify the public of construction progress, when and where new construction will start and what routes will be affected. The proposed liaison officers could fulfil this function.

- Construction traffic past community infrastructures such as schools, crèches, sporting facilities, etc. must be strictly managed.
- Ensure construction activities avoid peak traffic hours and particular social usage requirements.
- General road rules should be enforced, and specific provision should be made for management of construction-related complaints.
- Ensure safe and secure public transport access points.
- Develop and implement a formal grievance mechanism.

Introduction of New Social Classes and Related Socio-Cultural Impacts

If a large number of outsiders with different values, beliefs and practices migrate to a project area during the construction phase, the presence of the outsiders may result in the disruption of the existing social-cultural networks. The intensity of such an impact would be more prominent if these outsiders are mostly single males and if no adequate housing facilities are created. The conduct of these groups (if outsiders) could lead to social tension and conflict between the locals and the construction workers.

Typically, any large influx of labourers from outside the area would include many foreigners or even specialists with different values, beliefs and practices. Such an event could result in the significant disruption of the existing social networks.

Respondents in focus group consultations in Mahé and Praslin stated that some foreign cultures could have a negative impact on Seychellois culture. It was also stated that the ways and norms of these foreign workers are very different to the way of the Seychellois and there is a fear the Seychellois culture will deteriorate and eventually disappear due to the foreign influence in the Seychelles.

While recognising the viewpoints expressed in some of the focus group consultations, it is not predicted that new social classes will be introduced during the construction process. It is therefore unlikely that the adverse socio-cultural impacts will realise. This viewpoint is based on the small number of construction workers, the anticipated high level of local employment and the employment focus on women and the youth.

The impact is rated as a negative **low** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

- Implement a comprehensive stakeholder engagement process.
- Maximise the use of local service providers, including contractors.
- The use of local labour should be a key requirement in the tender documentation.
- Provide skills related capacity building and support, particularly aimed at women and the youth.
- An appropriate exit strategy should be developed for the temporary construction related employees.

Quality of life Impacts

Impact

The quality of life can be defined as the general well-being of a person or society. It is defined by the English Dictionary in terms of health and happiness as well as a subjective measure of a person's satisfaction/dissatisfaction with the cultural or intellectual conditions under which they live[13]. This is a concept based on people's perceptions, but it has the potential to disrupt projects depending on how well it is addressed and mitigated.

The impact is rated as a negative **low** impact before and negative **low** impact after mitigation measures have been applied.

The quality of life has many factors and is difficult to measure quantitatively. The WHO has defined and developed a system to measure quality of life, which considers among others:

- Physical health.
- Psychological health.
- The level of independence.
- Social relationships.
- Environment.
- Spirituality/religion/personal beliefs.

In this case, the quality of life impacts refers to the potential for noise, dust, bad odours or adverse air quality intrusions as experienced by the respective affected residents. Such intrusions may influence physical and psychological health as well as the experienced environment. It follows from the above that quality of life is an interrelated experiential impact that may influence the lives of those people affected. Although most of these aspects (e.g. noise, air quality, visual intrusions and so forth) are the subject of specialist reports, it is the intrusion impacts (if any) on specific social receptors that may be experienced that is of relevance in this regard. The distance from the potentially intrusive aspect is a key consideration.

The construction process may cause increases in noise levels, graphic impacts, potentially some photo conclusion and some dusting intrusion. Due to the limited nature of the construction activities and the relatively short construction period, limited quality of life impacts is anticipated, if any.

Mitigation Measures

- Manage construction times to minimise noise intrusion during night time.
- Ensure effective dust management.
- Minimise on site lighting during the night times.

[13] http://www.thefreedictionary.com/quality+of+life

- It is recommended that the measures identified in the EMP be followed to reduce the occurrence of any intrusion impacts.
- Operating contractors/investors must comply with all MMP rules and regulations.
- Address issues and aspects identified using the proposed grievance mechanism in a timely and thorough fashion. Records of any such incidents should be kept and prompt feedback provided to the relevant stakeholders.

7.4.7.2 Operation

The operational phase of the aquaculture industry for purposes of this ESIA has been set at 25 years, however, it is possible that the sector develops into a stable scenario that continues for many more years.

Job Opportunities and Local Employment

Impact

It is anticipated that the operational phase is expected to result in 200 additional job opportunities within 5 years of the implementation of the MMP ADZs and escalating to approximately 730 job opportunities after 10 years (see Table 33). By the 25th year of operations it is estimated that the required number of aquaculture sector employees will be approximately 1850.

Table 33: Labour estimate (ten year middle-of-the-road projection

10 year projection	1	2	3	4	5	6	7	8	9	10
Estimated Operational Job Opportunities	**37**	**70**	**99**	**124**	**200**	**251**	**310**	**384**	**563**	**730**

If the operational labour requirements largely outstripped the availability of labour in the Seychelles, large numbers of employees would have to be imported. However, due to the phased growth in employment opportunities and the relatively small annual increments, little labour importation is anticipated.

It would be important that a robust awareness, capacity building and skill development process be implemented and maintained along the life the project. They may initially, be some importation of employees with specialised skills. This importation is, again, not anticipated to be of any significance due to the limited number of such people required. It is anticipated that as local skills capacity develop, the need to import specialised skills would diminish over time.

The national unemployment rate in 2016 was just above 4%. As indicated earlier, the youth (10%) and woman (4.6%) make up the largest component of the unemployed (Seychelles National Bureau of Statistics 2016b). In 2016 terms, this equates to a shortage of some 1800 job opportunities per year. In reference to Table 33, it is clear that the anticipated growth in job opportunities is far below the unemployment levels. The implication is that the job opportunities required will not outstrip the available resources in the Seychelles labour pool.

There should be a concerted effort to employ local people as far as possible. Recruitment of labour for the operational phase of the ADZ should, as in the case of the construction phase, therefore target the youth and women, as part of the process to address the mentioned unemployment disparity.

Implications of the operational phase of this component of the MMP, is anticipated to be positive and should not exceed the pool of available employees in the Seychelles. The absorption of more local employees due to the operational phase will have a positive socio-economic impact, which will escalate as the project grows over time.

The impact is rated as a **positive moderate** impact before and **positive moderate** impact after mitigation measures have been applied.

Mitigation Measures

The proposed measures to enhance the positive impacts are largely the same as during the construction phase, but repeated here for continuity.

- Recruit locally as a priority (from among those that are unemployed, poor or under income stress).
- Contractors (if any) must be contractually obliged to use local labour as far as possible.
- There should be an emphasis on employing the youth and women.
- If specific skilled positions cannot be sourced within the local districts, they should be sourced at the national level first before looking at international workers.
- Continue using the proposed community liaison officers to manage the local MMP public interface, specifically during the construction phase.
- Maximise the usage of local service providers, including contractors.
- A multi-level governance approach should be adopted to ensure all those with interest in mariculture is given the opportunity to learn more about this sector and be involved in decision-making on its future development (Stead 2016).

Population Influx

Impact

In reference to Table 15, the Seychelles population is projected to grow to some 103 000 by mid-2020. This reflects an average growth rate of some 7.5% over a ten year period (Seychelles National Bureau of Statistics 2014a). The anticipated growth in job opportunities over a similar operation period will be less than the number of unemployed or underemployed people[14]. There may be an initial importation of specialised skills but this will decrease over time as local capacity is developed. Indications are that there will not be a significant influx due to the ADZ linked operations of the Seychelles MMP.

The impact is rated as a negative **low** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

- The use of local labour should be a key requirement in the tender documentation.
- The operators must maximise the usage of local service providers. These requirements should be captured in a contractual agreement.
- The SFA must ensure that all operators source the bulk of their employees from the local labour market. The focus on creating employment opportunities for the youth and women should continue.
- The operators/investors should implement formal mentorship and skills development programmes to build the capacity of local candidates to fill the required skilled positions.
- There should be a concerted effort, monitored by the SFA, by operators/investors to make provision to replace expatriates with local people over time. A twinning programme[15] could be a mechanism to achieve this.

[14] This conclusion is based on the unemployment ratios in 2016, with an average projection for the next 10 years.

[15] A twinning programme is one where the expat specialist works with a local understudy for a set number of years, after which the understudy becomes the lead. The expat will then continue for another year to provide advice and support to the local specialist.

Project-Induced In-Migration

Impact

As mentioned before, project-induced in-migration, in the context of this report, is seen as the large scale movement of people into an area in expectation of, or response to, economic opportunities associated with a new project.

Project-induced in-migration is not anticipated to realise during the operational phase of the ADZ related process. This conclusion is underpinned by the same factors as identified for the construction period. These are:

- The extraordinarily high employment levels in the Seychelles will preclude any in-migration to a specific area due to the availability of jobs.
- Significant labour imports are unlikely.
- Being an island, a large movement of unofficial in-migration will be difficult.

It is unlikely that any of the side effects of large-scale immigration, with the associated drawbacks would realise.

The impact is rated as a negative **low** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

No further mitigation or management measures are proposed, over and above the ones made previously.

Skills Requirements

Impact

The implementation of the Seychelles MMP in order to establish a new aquaculture sector is a diverse process and will require a multitude of expert skills. A national science skills survey was undertaken in 2009 and updated in 2013. The purpose was to determine the number of diplomonads and graduates with qualifications applicable to marine aquaculture (SFA, 2013). Please refer to Table 34 for the results.

Table 34: Science graduates in the Seychelles by employment sector

Qualification	Government	Private sector	International programme	NGO and other	Total
Higher Diploma	2	3	1	0	6
BSc	25	2	3	6	36
BSc Honours	1	0	0	0	0
MSc	2	2	0	0	0
PHD	1	0	0	2	3
BVS	6	0	0	0	6
Total	**37**	**7**	**4**	**12**	**60**
Percent	**61.7**	**11.7**	**6.7**	**20**	**100**

Source: (SFA, 2013)

The results show an impressive list of people with the relevant qualifications. Most of these skilled people worked for the government, with NGOs a distant second, followed by the private sector. There is however a need for more people with tactical and scientific qualifications in the mariculture field. Indications are that this process is being urgently addressed by the SFA.

On the short-medium term, it is anticipated that a number of appropriately qualified people will be required during the operational phase of this Seychelles mariculture process. If these people cannot be sourced locally or nationally, they will be imported from outside.

When considering the project employee numbers in table Table 33, and one makes the conservative assumption that 50% of those require specialised scientific and technical skills, the number of skills to be imported would still be low.

UniSey, however, has started offering courses in environmental science. If current and future students are made aware of the opportunities and skills requirements for the mariculture field, the bulk of the required skills could be developed in the Seychelles over time. It is therefore anticipated that the need for an external specialist will decrease over time. This will become a reality if there is a policy approach that necessitates operators and investors to employing, and where necessary mentor, appropriately qualified Seychellois people for the mariculture projects.

The impact is rated as a negative **moderate** impact before and **positive moderate** impact after mitigation measures have been applied.

Mitigation Measures

- Identify the skills required for the operations of the mariculture projects .
- Implement and coordinate a process to educate and train current and future students in the relevant scientific and technical aspects – ensure close linkages with UniSey and its international partners'.
- Develop an approach or policy whereby operators and investors must appoint as many local specialists as feasible, possibly as an investment or corporate social responsibility criteria.
- Appoint a scientific training coordinator to manage and coordinate this process.

Change in Employment Equity of Vulnerable Groups

As indicated in previous sections, changes in employment equity of vulnerable groups are interpreted as the degree to which job opportunities match employment of vulnerable groupings living at or close to the development, including women and the youth.

The motivation and mitigation measures proposed for the construction periods, is the same as for the operational period. The mitigation measures are therefore repeated here, for ease of access.

Due to the much larger number of people involved in the operational phase this impact may affect a significantly more people than during the construction phase. The benefit is assessed as a positive impact.

The impact is rated as a negative **low** impact before and positive **moderate** impact after mitigation measures have been applied.

Mitigation Measures

- Implement the recommendations made to focus on involving women and the youth in the operations process.
- Implement the skills training and capacity building focus as indicated above.

Impacts on Daily Living and Movement Patterns

Impacts on daily living and movement patterns relate to the individual fish farm related traffic and access related impacts on residents, road users and boat traffic. These individual fish farm related vehicular and marine traffic movements might interfere adversely with current land and marine traffic patterns. Indications are that the projected growth will be incremental, as new fish farms are implemented in the various ADZs. This will ensure that the increase in daily living and movement patterns will also increase incrementally.

The impact is rated as a negative **moderate** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

- Communicate information regarding the operational routes (land and sea), operational times and associated information to the local district as well as the relevant community representatives.

- Operational land traffic past community infrastructures such as schools, crèches, and sporting facilities must be strictly managed.
- Marine traffic must consider tourism locations and activities to minimise adverse tourism and quality of life impacts.
- Maintain the formal grievance mechanism.

Introduction of New Social Classes and Related Socio-Cultural Impacts

Indications are that initially, a number of outsiders with different values, beliefs and practices may migrate to the Seychelles during the operational phases. These would typically be the technical and scientific personnel needed to for the operational phase of the projects. The intensity of such an impact would be more prominent if these outsiders are mostly single males and if no adequate housing facilities are available. The conduct of these outsiders, due to different values, beliefs and practices could lead to social tension and conflict between the locals and the outsiders.

As mentioned, there was feedback from local stakeholders that some foreign cultures have a negative impact on the Seychellois culture and may become a nuisance factor. It was also stated that the ways and norms of these foreign workers are very different to the way of the Seychellois and there is a fear that the Seychellois culture will deteriorate and eventually disappear due to the foreign influence in the Seychelles.

It is foreseen, however, that the adverse impact of the outsiders will decrease over time, if the capacity building drive and local sourcing emphasis are driven strongly. Based on this assumption, it is not foreseen that predicted that new social classes would be introduced to any significant extent during the operational phases of the projects.

The impact is rated as a negative **low** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

- Implement a comprehensive stakeholder engagement process.
- Continue with the community liaison process recommended earlier.
- Implement the mitigation measures proposed above.
- Develop appropriate exit strategy for the outside employees.

Quality of life Impacts

Impact

As indicated before, the quality of life relates to the measure of a person's satisfaction or dissatisfaction with the cultural or intellectual conditions under which they live. This is a concept based on people's perceptions, but it has the potential to disrupt projects depending on how well it is addressed and mitigated.

In this case, the quality of life impacts refers to the potential for noise, visual, photic (light pollution) or physical intrusion at sensitive social receptors such as houses, tourism sites, hotels, cultural venues and so forth. The distance from the potentially intrusive aspect is also a key consideration.

Due to the nature and long-term duration of the operational activities, some quality of life impacts are anticipated. The impact is rated as a negative **moderate** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

- Continue with the community liaison process recommended earlier.
- Ensure that the operational activities are planned to minimise intrusion impacts.

- Consider the location and distance from hotels and tourism sites, diving or sport fishing sites or any other culturally or sensitive sites to minims the potential for intrusion impacts during the site selection and operational phases of the ADZ projects.
- Consider photic intrusion when selecting the type and placement of light sources.
- It is recommended that the measures identified in the EMP be followed to reduce the occurrence of any intrusion impacts.
- Address issues and aspects identified using the proposed grievance mechanism in a timely and thorough fashion. Records of any such incidents should be kept and prompt feedback provided to the relevant stakeholders.

Potential for Conflict between Mariculture and Other Users of the Sea

Impact

The small-scale fishing in the Seychelles, which includes the artisanal and semi-industrial subsectors, contributes between 1% and 2% of the GDP annually, while the fisheries sector, as a whole, contributed 7.7% in 2008, an increase of 1.3% from 2004. In the Seychelles 17% of the total population is employed in the fishing industry, 30% of which are active in the small-scale sector, while 10% of the population is directly dependent on the small-scale fishing sector. The Seychelles has very limited land-based opportunities, thus, fishing is a vital source of income, employment, food security and foreign exchange in the country (Hilmi, N., Allemand 2015). Competition for any diminishing resource (or perceived as such) will increase the conflict potential among those stakeholders.

Local stakeholder raised a number of aspect during the consultation process, including the following:

- Concerns that the proposed mariculture industry could destroy their fishing livelihoods.
- The need to ensure local fishermen benefit from the mariculture industry.
- The requirement that farmed fish not be sold in the local markets, but should be exported.
- The SFA should consult with the fishermen's associations when planning the ADZ sites.
- Government and the SFA should assist with the local fishermen with funding and capacity building to get involved in the mariculture fishing industry. The importance for local fishermen to be able to invest into such projects and participate in the blue economy was stated.
- The proposed mariculture industry needs to be symbiotic to the local and commercial fishing industry.
- Concerns that the proposed ADZ sites will limit the fishermen's access to favoured fishing grounds.

The impact is rated as a negative **moderate** impact before and negative **moderate** impact after mitigation measures have been applied.

Mitigation Measures

- On-going stakeholder engagement and a grievance mechanism are needed.
- Develop mechanisms to allow entrance or joint ventures with maricuture project operators and investors.
- ADZ investors must comply with all new MMP regulations, standards and licence conditions to guarantee sustainable healthy fishing practices.
- All opportunities to benefit the artisanal fishing industry should be considered and implemented where feasible.
- SFA will need to set up a Mariculture Monitoring Committee to manage the new sector, to monitor the price of fish and various conflicts between operators and local fishermen (Stead, 2016).

- Improve capacity building on the Mariculture industry.

Impacts on Social Infrastructure

Impact

A sizeable number of migrants have already settled in the Seychelles due to other industry developments (such as tuna canning). It is predicted that there will still be a foreseeable growth in the local population of approximately 2 500 people (as 'high-road' industry modelling) which will result in added pressure on the existing social amenities in the inner islands, Seychelles.

This increasing population will put pressure on local infrastructure and services, including the availability of land for building purposes and subsistence agriculture and access to potable water, access to education, health care and social security services. Indications are that some of the MMP workforce will be housed either within the current available housing in the area or placed in designated expatriate contractor housing, which will alleviate some pressure on local infrastructure and services. It is important to note that the planned expatriate contractor housing has not yet been developed and is part of the Seychelles Strategic Development Planning for the near future.

Consultations with the acting Principal Secretary of the Ministry of Land Use and Housing emphasized the issue of the growing population and the need for additional residential units. The principal secretary noted that there was insufficient development space in the Seychelles but the MLUH have made provision to expand the current number of residential units (see section 4.5 of the Social Impact Assessment under APPENDIX H) The MLUH have noted this is a major concern knowing there are large developmental projects starting in the area and nowhere for new migrants to live.

Respondents from social focus group meetings from all three large islands (Mahé, Praslin and La Digue) stated that there is adequate access to primary school educational institutions. Access to tertiary institutions is a problem as most tertiary institutions are located on Mahé and people who are wanting to further their education have to relocate then to the main island to do so. The predicted population growth for the operational phase may lead to increased pressure on the existing educational infrastructure.

It is estimated that there are currently approximately 522 people per doctor. With the perceived local population growth this ratio is expected to increase, but the there is space to grow the doctor patient ratio quite significantly. The Seychelles National Care is centralised in Victoria (Mahé). Access to health care in general is not anticipated to become too constrained, due to the relatively low number of expacts initiaqlly expected.

Regarding social security the current ration of policemen to civilians is 1:1000. This ratio is still acceptable and shows potential for growth. It is not anticipated that the initial influx of the scientific and technical expats will strain this service to any extent. The impact is rated as a negative **low** impact before and negative **low** impact after mitigation measures have been applied.

Mitigation Measures

- The development areas highlighted in the Seychelles Strategic Land Use and Development Plan must be implemented to reduce the predicted pressure on social infrastructure.
- Operating contractors/investors must comply with all MMP rules and regulations.
- The involvement and capacity building of local stakeholders to participate in the projects must be driven robustly.
- The sourcing of local skills and employees must be driven as a priority.

7.4.7.3 Decommissioning

The eventual termination of fish farm sites within ADZs is unavoidable and the decommissioning activities are expected to give rise initially to impacts similar to those mentioned under the construction phase (associated with the dismantling of infrastructure). Rehabilitation follows demolishing or removal of existing ADZ infrastructure and specific onshore infrastructure. This phase is not described in detail in this ESIA, as

imminent closure and decommissioning of the aquaculture sector is not anticipated. However, this phase would involve the removal of infrastructure such as the cages, moorings and boats from the waters, with the land-based facilities being utilised for alternate purposes. This would require removal of aquaculture equipment and infrastructure activities.

The decommissioning phase of the MMP is expected to give rise to the loss of employment and associated economic impacts.

Impacts

Potential impacts related to the Decommissioning Phase may include the following:

- A temporary increase in employment opportunities followed by a significant decrease after decommissioning;
- Noise and impacts linked to offshore decommissioning activities; and
- Noise and dust impacts linked to specific onshore decommissioning activities.
- Loss of employment for approximately 1850 workers;
- The loss in economic benefits from mariculture.

The impact regarding loss of employment is rated as a negative **moderate** impact before and negative **moderate** impact after mitigation measures have been applied.

The impact regarding loss of economic benefits is rated as a negative **moderate** impact before and negative **moderate** impact after mitigation measures have been applied.

Mitigation and Management Measures

Potential mitigation measures may include:

- Provide employees with clear, transparent information on planned activities and closure dates for relevant fish farms / ADZs;
- A employment to current employees at alternative fish farms;
- Implement and initiate planned exit strategies.

7.4.7.4 Cumulative Impacts

Cumulative impacts are defined as impacts resulting from the combined effects of two or more projects or actions. Cumulative impacts usually relate to large scale rather than site-specific impacts and have a tendency to increase the intensity of impacts already predicted for the proposed project.

Cumulative impacts are expected to arise because of the combined effects of the larger MMP project and other, existing and planned MMP operations in and around the inner islands. These cumulative impacts relate to large scale rather than site-specific impacts associated with a concentration of projects, and their tendency to dominate the local economy, thereby causing the local economy to become increasingly dependent on mariculture that inevitably has a finite lifespan, and their tendency to alter the local Seychellois image and quality of life. Cumulative impacts that have been identified are:

The inshore zone (aquaculture within 2km of the land) and offshore zone aquaculture developments (cage culture beyond 5kms of the land) of the MMP have not been included in the scope of this SIA. It is important to note that these additional aspects of the larger MMP will have significant cumulative impacts if all four aquaculture zones are operational concurrently.

Description of Impacts

Possible cumulative impacts to consider are as follows:

- Local population change.

- Increased socio-cultural tension.
- Maximised economic benefits.
- Economies of scale is an issue.
- Harbour and airport capacities becoming stretched.

Mitigation and Management Measures

- It was recommended that a large single concentrated land based aquaculture zone would be more feasible than having land based sites scattered across the inner islands.

7.4.8 Cultural Heritage

7.4.8.1 Construction

Impacts

Impacts to cultural heritage, if present, during the construction and implementation phase will vary according to type of equipment and depth of subsurface disturbance (into ground or seabed). Generally, impacts may be expected on land and inter-tidal areas from excavations for pipes, and services and foundations related to the building construction. In the sub-tidal areas impacts may be expected to cultural heritage, if present, from excavations (if required for pipes offshore), the placement of structure (intake pipes), and the placement of anchors and ground tackle for vessel engaged in constructing of intake pipes and the cages.

The potential impact of construction for the offshore components (intake pipes) of the proposed BQAF and Aquaculture R&D Facility sites, the pilot project Cage Site was assessed as being of ***moderate (SP = 60)*** significance (Table 3). The following mitigation measures are recommended to reduce the impact assessment to ***moderate (SP = 36)*** significance reflecting no change in probability but a magnitude reduced to low:

- A diver survey by a qualified archaeologist to determine the presence/absence of a submerged archaeological site within the project areas/cage sites;
- If an archaeological site is observed, this assessment assumes it will be small enough that construction impacts may be avoided through Project redesign; and,
- Even with Project redesign there remains some potential (probability to reduce to improbable [1]) for impacts to an unrecorded archaeological site, to be addressed with chance find procedures.

The potential impact of construction for the ADZ components was assessed as being of ***moderate (SP = 40)*** significance. The following mitigation measure is recommended to reduce the impact assessment to ***low (SP = 24)*** significance, reflecting no change in probability but magnitude reduced to low:

- The possibility of encountering archaeological materials may be addressed with implementation of chance find procedures with the chance find document tailored to ship and aircraft wreck remains.

The potential impact of construction at the R&D Facility where archaeological potential has been determined (where the intake pipe extends from the sea and where the water pipe parallels the stream/canal) was assessed as being of ***moderate (SP = 40)*** significance. The following mitigation measure is recommended to reduce the impact assessment to ***low (SP = 24)*** significance, reflecting no change in probability but magnitude reduced to low:

- The possibility of encountering archaeological materials may be addressed with implementation of chance find procedures with the chance find document tailored to buried archaeological materials and structural foundations.

7.4.8.2 Operation

Impacts

Potential impacts to cultural heritage, if present, during the operation phase will be limited to ADZs and pilot project location. These impacts may occur as a result of anchors and ground tackle associated with the cages and work boats servicing the cages. Mobility of the sandy seabed as well as on-going penetration and scouring of the seabed by the anchors and tackle may lead to the exposure of wreck materials previously buried or unnoticed.

The potential impact of operation at the proposed ADZ and pilot project Cage locations was assessed as being of ***moderate (SP = 40)*** significance. The following mitigation measure is recommended to reduce the impact to one of ***low (SP = 24)*** significance, reflecting no change in probability but magnitude reduced to low:

- The possibility of encountering archaeological materials may be addressed with implementation of chance find procedures with the chance find document tailored to ship and aircraft wreck remains.

7.4.8.3 Decommissioning

Impacts

Potential impacts to cultural heritage, if present, during the decommissioning phase are considered the same as operations. This assumes the decommissioning the terrestrial components and pipes will not impact a greater area than was disturbed during construction. Decommissioning of the ADZs and pilot project cage location will continue the potential impacts (as previously noted for operation) may occur as a result of anchors and ground tackle associated with the cages and work boats servicing the cages. Mobility of the sandy seabed as well as on-going penetration and scouring of the seabed by the anchors and tackle may lead to the exposure of wreck materials previously buried or unnoticed.

The potential impact of decommissioning at the proposed ADZ and pilot project cage locations was assessed as being of ***moderate (SP = 40)*** significance. The following mitigation measure is recommended to reduce the impact to one of ***low (SP = 24)*** significance, reflecting no change in probability but magnitude reduced to low:

- The possibility of encountering archaeological materials may be addressed with implementation of chance find procedures with the chance find document tailored to ship and aircraft wreck remains.

Mitigation Measures

Mitigation measures which may be employed to address the possibility of Project-related impacts to cultural heritage are detailed below.

Dive Survey

The CHOA (Golder 2016) which can be found under APPENDIX I, recommended that a dive survey be conducted by a qualified archaeologist in marine areas of the proposed project/cage siteswhere the potential for cultural heritage was identified. The dive survey may consist of divers operating with snorkel on the surface and/or SCUBA underwater, depending on water depth and visibility, while conducting systematic traverses of the Project area where the potential for an underwater archaeological site was identified. Traverses would be recorded via GPS mounted to a surface float towed by a diver. The location of confirmed and suspected archaeological material would be recorded via GPS. Confirmed cultural heritage encountered underwater would be photographed and if considered necessary by the archaeologist, mapped.

In the event that underwater archaeological site is encountered during the dive survey, it is anticipated that a project relocation of cages would be recommended to avoid project-related impacts to the site. If Project-related impacts cannot be avoided, appropriate mitigation recommendations would be provided.

Chance Find Procedure

Project-related activity within areas that were determined during the CHOA to not require further inspection may proceed under a project-specific chance find procedure. The chance find procedure is laid out in a

document that will be distributed to the SFA, project developers and their subcontractors. This document will provide the following to help people in the field recognize a possible archaeological site or materials:

- An illustrated description of what a ship or aircraft wreck might look like in an environment like the Seychelles;
- A brief description with illustrations of a variety of artefacts which might be associated with a shipwreck or other archaeological site in the region;
- An illustrated description of structures such as building foundations which might be found buried within the Project area.

In the event that archaeological materials are encountered, the chance find document will outline the next steps, including who to notify, (i.e., a qualified archaeologist and the appropriate local authorities) depending on the nature of the find, including whether human remains are discovered or considered potentially present.

7.4.8.4 Cumulative Impacts

As there are no known cultural heritage resources or archaeological features in or adjacent to the Project area, no cumulative impacts are considered.

7.5 Summary of Environmental Impacts

7.5.1 Construction Phase

Table 35 below summarises those impacts directly related to the Construction Phase of the proposed project, and provides a significance rating for each impact before and after mitigation. The construction period will be approximately 12 months for the BQAF and R&D facility. The construction and assembly of the pilot project cages and grow out cages for individual farms will be a couple of weeks at most and may occur at different times as new operators enter the aquaculture sector and begin setting up fish farms.

Table 35: Environmental Impact Assessment Matrix for the Construction Phase of the proposed Seychelles MMP

POTENTIAL ENVIRONMENTAL IMPACT: CONSTRUCTION PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
Physical Oceanography												
N/A	-	-	-	-	-	-	-	-	-	-	-	-
Waste												
N/A	-	-	-	-	-	-	-	-	-	-	-	-
Coral Reef and Benthos												
Importation of genetically distinct fingerlings - Disease Impact	10	2	4	5	80	High	10	2	4	4	64	Moderate
Importation of genetically distinct fingerlings -Genetic Impact	8	5	4	5	85	High	8	5	4	4	68	Moderate
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - Disease impact	8	4	4	4	64	Moderate	6	4	4	3	42	Moderate
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - genetic impact	6	5	3	4	56	Moderate	6	5	3	2	28	Low
Cage installation - ADZs	2	2	1	5	25	Low	2	2	1	5	25	Low

POTENTIAL ENVIRONMENTAL IMPACT: CONSTRUCTION PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
Pilot-project cage construction	2	1	1	5	20	Low	2	1	1	5	20	Low
Broodstock facility water intake pipeline construction	2	1	1	3	12	Low	2	1	1	1	4	Low
R & D facility water intake pipeline construction	6	4	1	5	55	Moderate	4	4	1	2	18	Low
Technical Aquaculture Aspects												
Importation of genetically distinct fingerlings - Disease Impact	10	2	4	5	80	High	10	2	4	4	64	Moderate
Importation of genetically distinct fingerlings -Genetic Impact	8	5	4	5	85	High	8	5	4	4	68	Moderate
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - Disease impact	8	4	4	4	64	Moderate	6	4	4	3	42	Moderate
Importation broodstock fish that are not sourced from the Seychelles Inner Islands - genetic impact	6	5	3	4	56	Moderate	6	5	3	2	28	Low
Cage installation	2	2	1	1	5	Low	2	1	1	0	0	Low
Visual												
Reduction in visual resource value due to increased shipping/boat traffic	6	4	2	5	60	Moderate	2	4	2	3	24	Low
Light pollution at night	6	4	2	5	60	Moderate	4	4	2	3	30	Moderate
Noise												
Construction of the BQAF and R&D Facility: Site preparation, earthworks, clearing, transport, construction of the facilities and installation of the pumps, tanks etc.	8	2	2	4	48	Moderate	6	2	2	4	40	Moderate
Construction of the pilot project cage site and ADZ cages	6	1	2	3	27	Low	4	2	2	3	24	Low
Social												
Job Opportunities and Local Employment	2	2	3	4	28	Low	4	2	3	4	36	Moderate
Population Influx	4	2	3	2	18	Low	2	2	2	2	12	Low
Project-Induced In-Migration	2	2	3	1	7	Low	2	2	3	1	7	Low
Skills Requirement	2	2	3	3	21	Low	4	2	3	4	36	Moderate
Change in Employment Equity of Vulnerable Groups	2	2	2	2	12	Low	4	2	3	3	27	Low
Impacts on Daily Living and Movement Patterns	6	2	2	4	40	Moderate	4	2	2	2	16	Low

POTENTIAL ENVIRONMENTAL IMPACT: CONSTRUCTION PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
Introduction of New Social Classes and Related Socio-Cultural Impacts	4	2	3	3	24	**Low**	2	2	3	3	21	**Low**
Impacts on Quality of Life	4	2	1	2	14	**Low**	2	2	1	2	14	**Low**
Cultural Heritage												
Offshore impacts from excavations, pipe placement, and anchoring for Project construction and pilot project cage place placement.	10	5	5	3	60	**Moderate**	2	5	5	3	36	**Moderate**
Impacts from anchoring for Project construction/ placement of cages in ADZs.	10	5	5	2	40	**Moderate**	2	5	5	2	24	**Low**
Subsurface impacts in the close to the shore at the proposed R&D Facility	10	5	5	2	40	**Moderate**	2	5	5	2	24	**Low**

7.5.2 Operational Phase

Table 29 below summarises those impacts directly related to the Operational Phase of the proposed project, and provides a significance rating for each impact before and after mitigation. The operational period will be a minimum of 25 years, possibly much longer, although it is anticipated that the overall growth of the aquaculture sector and associated operations of fish farms will grow gradually over this period.

Table 36: Environmental Impact Assessment Matrix for the Operation Phase of the proposed Seychelles MMP

POTENTIAL ENVIRONMENTAL IMPACT: OPERATIONAL PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
Physical Oceanography												
Implementation of aquaculture cages in ADZs will generate solid organic waste releases in the marine environment that could adversely impact diverse physical and biological components of the marine ecosystem, both locally and remotely through advection.	4	2	2	4	32	**Moderate**	2	2	2	4	24	**Low**
Waste												
Undercage benthic effects from faeces and fish waste can impact seabed under cage and down-current	8	2	2	3	36	**Moderate**	4	2	2	3	24	**Low**
Waterborne nutrient loss can contribute to local and cub-regional nutrient concentrations in coastal	6	1	2	2	18	**Low**	6	1	2	2	18	**Low**

POTENTIAL ENVIRONMENTAL IMPACT: OPERATIONAL PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
waters with potential effects on phytoplankton growth												
Sediment contaminant accumulation can occur through antifouling and from trace elements in feed	6	4	1	3	33	**Moderate**	4	3	1	3	24	**Low**
Sediment debris accumulation can occur from the loss of cage fouling during on site cleaning	4	2	1	4	28	**Low**	4	2	1	3	21	**Low**
Rubbish loss can occur through poor on-site management (introduction of recalcitrant rubbish, especially plastics)	2	1	3	3	18	**Low**	2	1	2	3	15	**Low**
Coral Reef and Benthos												
Potential Genetic Contamination	8	5	3	4	64	**Moderate**	6	5	3	2	28	**Low**
Disease and parasite transmission to wild fish stocks	10	2	3	5	75	**Moderate**	8	2	2	3	36	**Moderate**
Degraded water quality as a result of organic wastes	8	4	2	4	56	**Moderate**	4	4	2	2	20	**Low**
Particulate organic build-up beneath cages	6	4	1	5	55	**Moderate**	4	4	1	4	36	**Moderate**
Chemical pollution arising from finfish cages	8	4	2	4	56	**Moderate**	4	4	2	2	20	**Low**
Entanglement of cetaceans	2	1	1	2	8	**Low**	2	1	1	1	4	**Low**
Entanglement of turtles and sharks	2	4	1	2	14	**Low**	2	5	1	1	8	**Low**
Interactions with piscivorous marine animals	2	4	1	5	35	**Moderate**	2	4	1	2	14	**Low**
Impacts on fishing, yachting and recreational vessels	2	1	1	4	16	**Low**	2	1	1	2	8	**Low**
Interactions with piscivores-pilot cages	4	4	1	2	18	**Low**	4	4	1	1	9	**Low**
Entanglement of turtles and sharks - pilot cages	2	4	1	1	7	**Low**	2	4	1	1	7	**Low**
R & D facility water intake pipeline maintenance	2	2	1	5	25	**Low**	2	2	1	5	25	**Low**
Technical Aquaculture Aspects												
Potential Genetic Contamination	8	5	3	4	64	**Moderate**	6	5	3	2	28	**Low**
Disease and parasite transmission to wild fish stocks	10	2	3	5	75	**Moderate**	8	2	2	3	36	**Moderate**
Degraded water quality as a result of organic wastes	4	2	2	2	16	**Low**	4	2	1	1	7	**Low**

POTENTIAL ENVIRONMENTAL IMPACT: OPERATIONAL PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
Chemical pollution arising from finfish cages	6	4	2	2	24	**Moderate**	4	2	1	3	21	**Low**
Entanglement of cetaceans	2	1	1	2	8	**Low**	2	1	1	1	4	**Low**
Interactions with piscivorous marine animals	2	1	1	5	20	**Low**	2	1	1	2	8	**Low**
Impacts on fishing, yachting, recreational and other vessels	2	1	1	4	16	**Low**	2	1	1	2	8	**Low**
Visual												
Reduction in visual resource value due to increased shipping/boat traffic	6	4	2	5	60	**Moderate**	2	4	2	3	24	**Low**
Reduction in visual resource value due to presence of floating cages and associated infrastructure (feed barges and work/well boats)	6	4	2	5	60	**Moderate**	2	4	2	3	24	**Low**
Light pollution at night	6	4	2	5	60	**Moderate**	4	4	2	3	30	**Moderate**
Noise												
Stock transport vehicles /vessels servicing the pilot project and ADZ	6	2	2	3	30	**Moderate**	4	2	2	3	24	**Low**
Life support systems at the BQAF and Research & Development Facilities	4	4	1	4	36	**Moderate**	4	4	1	3	27	**Low**
Social												
Job Opportunities and Local Employment	8	3	4	3	45	**Moderate**	8	3	4	4	60	**Moderate**
Continued Population Influx	4	3	4	2	22	**Low**	2	3	4	2	18	**Low**
Project-Induced In-Migration	2	2	3	1	7	**Low**	2	2	3	1	7	**Low**
Skills Requirement	6	2	4	3	36	**Moderate**	6	4	4	3	42	**Moderate**
Change in Employment Equity of Vulnerable Groups	2	2	4	2	16	**Low**	6	2	4	3	36	**Moderate**
Impacts on Daily Living and Movement Patterns	6	2	2	4	40	**Moderate**	4	2	2	2	16	**Low**
Introduction of New Social Classes and Related Socio-Cultural Impacts	4	2	3	3	24	**Low**	2	2	3	3	21	**Low**
Impacts on Quality of Life	4	3	4	3	33	**Moderate**	4	2	3	3	24	**Low**
Conflict Potential	8	3	4	4	60	**Moderate**	4	3	4	4	44	**Low**
Impacts ion Social Infrastructure: ability to accommodate influx of skilled labour	4	3	4	3	33	**Moderate**	6	3	4	3	39	**Moderate**
Impacts on Social Infrastructure: pressure on existing social amenities	4	3	3	2	20	**Low**	4	3	2	2	18	**Low**
Cultural Heritage												

POTENTIAL ENVIRONMENTAL IMPACT: OPERATIONAL PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
Impacts from anchoring of cages and service vessels.	10	5	5	2	40	Moderate	2	5	5	2	24	Low

Table 37 below summarises those impacts directly related to the Decommissioning Phase of the proposed project, and provides a significance rating for each impact before and after mitigation. The closure and decommission of the infrastructure will take approximately 12 months (same as for construction phase).

Table 37: Environmental Impact Assessment Matrix for the Decommissioning Phase of the proposed Seychelles MMP

POTENTIAL ENVIRONMENTAL IMPACT: DECOMMISSIONING PHASE	ENVIRONMENTAL SIGNIFICANCE											
	Before mitigation						After mitigation					
	M	D	S	P	SP	Rating	M	D	S	P	SP	Rating
Physical Oceanography												
N/A	-	-	-	-	-	-	-	-	-	-	-	-
Waste												
N/A	-	-	-	-	-	-	-	-	-	-	-	-
Coral Reef and Benthos												
Farm operations cease	6	3	2	4	44	Moderate	2	2	1	1	5	Low
General decommissioning - ADZ cages	6	4	1	5	55	Moderate	6	2	1	1	9	Low
General decommissioning - pilot-project cages	6	4	1	5	55	Moderate	6	2	1	1	9	Low
Brood stock pipeline	4	4	1	5	45	Moderate	4	1	1	1	6	Low
R & D facility water intake pipeline	6	4	2	4	48	Moderate	2	1	1	1	4	Low
Technical Aquaculture Aspects												
Farm operations cease	6	3	2	4	44	Moderate	2	2	1	1	5	Low
Visual												
Reduction in visual resource value due to increased shipping/boat traffic	6	4	2	5	60	Moderate	2	4	2	3	24	Low
Light pollution at night	6	4	2	5	60	Moderate	4	4	2	3	30	Moderate
Noise												
Decommissioning of the BQAF and R&D Facility: Demolition, clearing and transport of waste offsite	6	2	2	4	40	Moderate	4	2	2	4	32	Moderate
Disassembly of the pilot project and ADZ cages and transport back to the island	6	2	2	3	30	Moderate	4	2	2	3	24	Low
Social												
Loss of employment	8	2	4	4	56	Moderate	6	2	4	4	48	Moderate
Loss of economic benefits	8	2	4	4	56	Moderate	6	2	4	4	48	Moderate
Cultural Heritage												
Impacts from anchoring of cages and service vessels.	10	5	5	2	40	Moderate	2	5	5	2	24	Low

7.6 Impact Management Objectives and Outcomes for Inclusion in the ESMP

The impact management objectives and outcomes for the proposed Seychelles MMP are as follows:

- To maximise the positive and minimise the negative socio-economic impacts from the proposed new aquaculture sector;
- To mitigate and reduce the negative impacts to acceptable levels by staging development of the aquaculture sector in such a way that integral monitoring informs the expansion of the new aquaculture sector, provided monitoring results are satisfactory and in line with the ESMP;
- To maintain cordial relationships with local residents, authorities and other stakeholders *via* sustained open communication at all times.

7.7 Assumptions, Uncertainties and Gaps in Knowledge

The ESIA was limited to the scope of the assessment described in detail in the scoping report and in the specialist studies appended to this ESIA & ESMP report.

The baseline information received was a combination of data collected in field, data sourced from third parties, as well as various desktop literature sources.

The ESIA does not address Occupational Health and Safety as required by IFC Performance Standard 2. It will be required that SFA establishes a suitable Occupational Health and Safety framework whereby individual operators of fish farms or aquaculture related facilities are able to establish their own appropriate environmental, health, safety, security and quality control procedures or policies in this regard.

Although all efforts were made by the ESIA project team to identify all pertinent environmental and social aspects, impacts and mitigation measures, errors and omissions may have occurred.

Every effort was made to engage stakeholders to the extent possible, however not every stakeholder may have been consulted, or their comments may not have been recorded accurately. It is recommended that a grievance mechanism be put in place at the commencement of construction through which stakeholders are able to raise grievances and continue to contribute their concerns and issues with SFA as the regulating authority. A grievance mechanism may be considered for implementation by individual fish farm operators.

7.8 Opinion of the EAP

In accordance with legislative requirements and generally accepted ESIA best practice, the Environmental Assessment Practitioner (EAP) must provide an opinion as to whether the activity or activities being assessed should or should not be authorised, and if the opinion is that it should be authorised, any conditions that should be made in respect of that authorisation must be stated.

An environmental impact assessment has been undertaken, which has incorporated consultation with and participation of the interested and affected parties. It is the EAP's opinion that due process has been followed. Where impacts have been found to be potentially significant, various mitigation measures to manage and monitor the impacts of the project have been proposed.

It has been found that the construction and implementation of the MMP would:

- Not give rise to any adverse biophysical impacts that cannot be adequately mitigated;
- Result in significant positive impacts such as the sustainable diversification of the Seychelles National economy, increased contribution to GDP, secondary economic benefits, and skills development, employment (targeted at women and youth).

It is the opinion of the EAP that, subject to compliance with the recommended mitigation measures, which are detailed in the ESMP, the project has significant positive aspects and acceptably low negative biophysical

impacts which can be managed by suitable monitoring and management interventions. It is the opinion of the EAP that it should be approved on the basis that overall the positive impacts outweigh the negative impacts.

8.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (ESMP)

8.1 Impact Management Objectives and Statements

The overall objective of this Environmental and Social Management Plan (ESMP) is to provide SFA, fish farm operators and its contractors with practical guidance for environmentally and socially responsible construction, operation and eventual closure and decommissioning of individual fish farms, and aquaculture related facilities which in this case includes the pilot project cage site, BQAF and R&D facility. The ESMP lists National Seychellois and international guidelines and standards which are required to be adhered to as well as describing the actions to be taken to achieve them.

The SFA will have an obligation to ensure that fish farm operators comply with the ESMP and their aquaculture license conditions and to ensure compliance by its contractors and agents, where relevant.

This ESMP describes mitigation measures designed to minimise or eliminate the significant adverse impacts that may be caused as a result of the implementation of the proposed aquaculture sector. Mitigation will be achieved by:

- Applying preventative measures during the construction, operation and decommissioning phases; and
- Applying management measures during the construction and operational and decommissioning phase.

The primary objectives of the ESMP are to:

- Devise measures to mitigate the impacts that have been identified during the ESIA;
- Define organisational and administrative arrangements for environmental management and monitoring of the activities associated with the new aquaculture sector, including defining the responsibilities of staff and co-ordination, liaison and reporting procedures between SFA and individual fish farm operators and license holders;
- Ensure awareness amongst site supervision staff so that potential problems can be identified and mitigation measures adopted to prevent or minimise environmental impacts and to optimise the monitoring programmes where appropriate; and
- Define actions for environmental control, in the event of pollution or similar events requiring immediate action.

This ESMP will form the basis for environmental management across the new aquaculture sector related to the activities within the ADZs, pilot project cage site, BQAF and R&D facilities. This ESMP is viewed as a live document in the sense that it will be amended when circumstances change or more information becomes available, and it requires that environmental management must be integrated with health and safety and general management of the aquaculture sector, individual fish farms or related aquaculture facilities. The management measures described in this section have been formulated by the independent environmental assessment practitioner and specialist team. These measures have been proposed to mitigate negative impacts and enhance the positive benefits of the new aquaculture sector.

It should be kept in mind that the monitoring results and operational experience gained from the operation of the pilot project cages will be important to re-integrate back into this ESMP and update and/or refine mitigation measures and monitoring programmes proposed. Any material changes to the ESMP will need to be approved by the MEECC in writing.

8.2 Implementation of the ESMP

A number of activities must take place before commencement of construction. Certain of these activities are not directly related to physical work on site, but are presented below, as they must be addressed before

commencement of, or during the early phases of, construction. Please refer to section 7.4 and 8.0 of this document for details of the potential impacts, mitigation measures and monitoring actions.

8.2.1 Responsibility for Implementation

Responsibility for implementation of the overall ESMP rests with SFA. The General Manager of each fish farm operator or aquaculture facility will be required to ensure compliance of the ESMP as it relates to that operation or facility.

SFA should appoint an Environmental Control Officer (ECO), who will monitor construction activity related to the BQAF (including pilot project cage site) and R&D facilities. Furthermore, each fish farm should have a designated ECO who is responsible for adhering to the conditions of the ESMP. These responsibilities will be to:

- Ensure that all SFA and fish farm operator personnel members and all contractors are aware of the requirements of the ESMP and their responsibilities with regards to implementation thereof;
- Ensure that all conditions of the ESMP are implemented;
- Ensure that all environmental activities delegated to operators or contractors operating on-site are implemented;
- Resolve any conflicts that may arise between SFA, operators and contracting parties regarding implementation of the ESMP;
- Each operator will be required to monitor the results of the mitigation measures and keep the description of the environmental baseline status of the individual fish farms and operating environment up to date;
- Provide regular reports on the environmental performance of the construction or operation of the fish farm or aquaculture facility to the SFA;
- Evaluate and report on material and reputational risks to the fish farm operator / aquaculture facility or SFA arising from environmental performance, or lack thereof; and
- Amend the ESMP as and when necessary to improve environmental performance and/or to accommodate changes in legislation, guidelines, standards and current best practice as it relates to each individual fish farm or aquaculture facility.
- SFA will ensure that all contracting companies tendering for work that may have an environmental impact, will be made aware of the relevant conditions in the ESMP and understand their responsibility to operate within the framework of the measures defined in the ESMP. When adjudicating tenders, SFA will ensure that contractors have made appropriate allowance for management of environmental and social matters where relevant.
- SFA will ensure that, on appointment, all permanent contracting companies operating on-site receive a copy of the ESMP and understand their responsibility to operate within the framework of the measures defined in the ESMP.
- SFA will ensure that, all license holders (fish farm operators or aquaculture facility operators) operating within the new aquaculture sector receive a copy of the ESMP and understand their responsibility to operate within the framework of the measures defined in the ESMP.
- SFA will ensure that all employees' and contractors' Safety, Health and Environment inductions to site (on land or at sea) include environmental and social issues and awareness training to build capacity of staff and contract staff regarding management of the environment.
- The fish farm operator will appoint a responsible person to audit the implementation of, and adherence to the ESMP. This party will be an independent environmental practitioner. SFA as the regulating authority will ensure this practice is employed in terms of policy.

- Fish farm operators should implement an Environmental Awareness Plan regarding their operations in the context of the surrounding environment in which they operate.
- Fish farm staff and contract workers will be included in the target audience of the awareness plan. Any environmental incident or breach of the conditions of the ESMP should be reported to the Environmental Manager / General Manager responsible at each fish farm immediately in order for corrective action to be undertaken.
- The Environmental Manager / General Manager will notify the controlling authority (SFA) of such an incident, if the environmental incident constitutes a breach of any permit or license condition then reporting is required by the applicable license holder.

8.2.2 Contractors' Responsibilities

All contracting companies will be made aware of applicable environmental commitments that will incur cost on their part. When adjudicating tenders, SFA or fish farm operators will ensure that contractors have made appropriate allowance for management of environmental matters where required. It is the responsibility of the contractor to ensure that all of their staff are aware of the measures applicable to their area of work onsite; and

It is the responsibility of the operator to bring to the attention of the SFA, any environmental incident or breach of the conditions of the ESMP.

8.2.3 Complaints Management

Complaints received regarding activities associated with the new aquaculture sector pertaining to the environment will be recorded in a register and the responses will be noted with the dates and actions taken. Construction contractors will be required to keep a log or register. This record will be submitted with the monthly reports and a verbal report will be given at regular site meetings.

For operational aspects, the relevant Ministry (or responsible regulatory authority) and individual fish farm operators should also maintain a complaints log or grievance mechanism whereby stakeholders or anyone else is able to report a complaint or grievance. Appropriate follow up will be required on behalf of the contractor or operator.

8.3 Monitoring, Evaluation and Reporting

8.3.1 Auditing/Inspections

During the construction phase of the project, the ECO (or relevant authority) will be responsible for undertaking audits and inspections to verify compliance with the ESMP, and any conditions of the environmental authorisation. These audits will be undertaken on a regular basis (fortnightly) and also *ad hoc* and any non-compliance will be recorded.

Weekly or monthly tracking records of compliance will be produced and discussed during meetings between the contractor and the SFA. Since construction activities related to the BQAF and R&D facility will be of relatively short duration, the frequency of audits may occur monthly.

8.3.2 Mariculture Liaison and Advisory Committees

The need for a Mariculture Liaison and an Advisory Committee (Steering Committee) was identified during the development of the MMP. The specific functions of the two committees have been defined and have and will function as follows:

- The Liaison Committee has operated during the formulation phase of the MMP; and
- The Advisory Committee will only be constituted at the start of the implementation phase.

The Advisory Committee will then become a standing Committee of the Ministry of Fisheries and Agriculture (or whichever other Ministry or Department will in future be responsible for Mariculture). Therefore, the

Liaison Committee has a finite existence, while the Advisory Committee will ultimately be a permanent Committee.

The establishment of the Liaison Committee has ensured that all key stakeholders can play an active role during the formulation of the MMP. This has ensured “buy-in” from all stakeholders and will allow Mariculture to develop side by side with the other economic pillars of the country. The Liaison Committee has overseen the formulation of the MMP, by reviewing and signing off Progress Reports, thereby ensuring that the TOR and all project goals have been met. The name of the Liaison Committee has been changed to the Mariculture Steering Committee (MSC).

On the other hand, the Mariculture Advisory Committee (MAC) plays a pivotal role during implementation and roll-out of the sector. The Department of Natural Resources is currently responsible for aquaculture development and the SFA would therefore be the promoter and the regulator. This conflict is resolved by the MAC fulfilling the function to advise SFA on the suitability of proposals and matters of policy etc. SFA scientists, as a matter of course, will evaluate the feasibility of Mariculture proposals and will prepare a report for the MAC but it is the MAC that takes the final decision whether a particular proposal is a “go” or a “no go”. Hence SFA is protected and can freely carry out its regulatory and monitoring function. The composition of the MAC may for example comprise representatives from SFA (but not chaired by the CEO of SFA), SIB, IDC, Chamber of Commerce, Department of Finance, Conservation and at least two members from civil society.

8.4 ESMP for the Various Project Phases

The ESMP and specific mitigation measures and monitoring actions for the identified impacts in Sections 7.4 are presented in the section below. The mitigation measures associated with each of the construction, operational and decommissioning phases are described. The designated person responsible for implementing each individual mitigation measure as part of the ESMP is stated.

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
CONSTRUCTION PHASE								
7.4.3.1 Coral Reef and Benthos	Benthic environment (ADZs)	Mortality and disturbance to benthic macrofauna	To minimise footprint of mooring infrastructure and disturbance caused by movement of mooring infrastructure of ADZ cages	N/A	Essential mitigation measures: ■ Consolidated (hard/reef) areas of seafloor should be excluded from M1 and SN2 (and from any other proposed ADZs)	Specialist appointed by SFA	During ADZ zonation/ delineation	N/A
7.4.3.1 Coral Reef and Benthos				Ensuring that any shifting mooring equipment is prevented from doing so again within 6 months	Optional mitigation measures: ■ Ensure mooring system is designed to limit movement of anchors and cables over the seafloor; ■ Position mooring anchors/blocks strategically so that when undertaking maintenance or fallowing of sites moorings do not have to be moved.	Engineering contractors, Fish farm manager and independent ECO/auditor	Duration of Construction Activities	Quarterly for the first year after mooring cages within an ADZ, thereafter at periodic intervals after severe storm events. Quarterly and ad hoc reporting
7.4.3.1 Coral Reef and Benthos	Benthic environment and adjacent coral reef (pilot project cages)	Disturbance and mortality	Minimise disturbance and impact at adjacent coral reef of pilot project cages	NA	Essential mitigation measures: ■ Nearby reef to the north-east must be a designated “no-go” area to construction vessels, workmen and mooring blocks/anchors.	Contractor, independent ECO auditor	Duration of construction activities	Continuous supervision. Weekly reporting
7.4.3.1 Coral Reef and Benthos	Benthic organisms including adjacent coral reef (BQAF pipeline)	Mortality and disturbance to benthic organisms	Limit disturbance of the benthic environment to within the pipeline footprint	NA	Essential mitigation measures: ■ Sensitive coral reef habitat exists in close proximity (<50 m) to the north-west of the proposed pipeline. This area must be a designated “no-go” area during construction and maintenance phases.	Contractor. Independent ECO auditor	Duration of Construction Activities	Weekly
7.4.3.1 Coral Reef and Benthos	Coral reef organisms (BQAF pipeline)	Mortality to coral reef organisms due to trampling	Minimise disturbance and mortality from trampling	No deviation outside of 1 m either side of the pipeline footprint by construction workers or machinery.	Essential mitigation measures: ■ Limit trampling to within the development footprint. The development footprint should be set at 1 m either side of the location of the proposed pipeline so that a swath of approximately 2 m wide is affected. ■ Construct the pipeline from within the development footprint and not from outside of the development footprint.	Contractor, Independent ECO auditor	Duration of construction phase	Continuous supervision/ monitoring monthly reporting
7.4.3.1 Coral Reef and Benthos	Coral reef organisms	Mortality to coral reef organisms due to trampling (R&D facility pipeline)	Minimise disturbance and mortality from trampling	No deviation outside of 1 m either side of the pipeline footprint by construction workers or machinery.	Essential mitigation measures: ■ Limit trampling to within the development footprint. The development footprint should be set at 1 m either side of the location of the proposed pipeline so that a swath of approximately 2 m wide is affected. Construct the pipeline from within the development footprint and not from outside of the development footprint.	Contractor, Independent ECO auditor	Duration of construction phase	Continuous supervision/ monitoring monthly reporting
7.4.3.1 Coral Reef and Benthos			Minimise pipeline footprint on reef	NA	Essential mitigation measures: ■ The pipeline must be re-routed so that it overlies less coral reef, and in particular, does not traverse the reef edge and slope where fragile corals typically grow. The new proposed route for the pipeline is indicated in APPENDIX D by the solid red line and reduces the impact by ~85%.	SFA, Engineer and contractor, independent ECO auditor	Design stage and construction phase	NA
7.4.4.1 Technical Aquaculture	Importation of genetically distinct fingerlings	Introduction of new diseases and parasites	To prevent infection of wild stocks with a new disease or	Imported fish free from parasites and disease vectors	■ Prior to the commencement of any aquaculture activities, use of the target species must be authorised by the regulator ■ Health certificate from exporting country	State Veterinarian and contracted	During implementation phase of MMP	Monthly report on health and disease status of

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
Aspects			parasite		■ Prophylactic treatment of imported fish for parasites ■ Quarantine and monitoring for parasites and diseases ■ Follow ICES Code of Practise on the Transfer and Introduction of Marine Species	veterinary service providers		imported fingerlings
7.4.4.1 Technical Aquaculture Aspects		Escapees from cages contaminate wild fish genetic profile	No alteration of wild fish genetic profile	No escapees	Operational measures to minimise escapement according to Seychelles Aquaculture Standard for Responsible Finfish Cage Aquaculture	Farm management under supervision of Seychelles Fishing Authority	During implementation phase of MMP (pilot project)	Incident reporting of any escapees. Annual summary report to Seychelles Fishing Authority
7.4.4.1 Technical Aquaculture Aspects	Importation of genetically distinct broodstock fish that are not sourced from the Seychelles Inner Islands	Introduction of new diseases and parasites	To prevent infection of wild stocks with a new disease or parasite	Broodstock fish and offspring free from parasites and disease vectors	■ Prior to the commencement of any aquaculture activities, use of the target species must be authorised by the regulator ■ Native species should not be introduced to an area where they do not already occur ■ Prophylactic treatment of imported fish for parasites ■ Quarantine and monitoring for parasites and diseases	Veterinarian	During implementation phase of MMP	Initial treatment of fish for parasites followed by six monthly health screening
7.4.4.1 Technical Aquaculture Aspects		Escapees from cage farms contaminate wild fish genetic profile	No alteration of wild fish genetic profile	No escapees	■ Adequate steps must be taken to prevent the escape of production organisms, especially from the hatchery environment where individual organisms may be very small. ■ Escape barriers may include netting, grids, sand and other filters, predator ponds, chemical treatment areas, soak away systems, etc. ■ Barriers should be adequate to prevent escape during flooding, overflows and during other unforeseen circumstances	Farm management	During implementation phase of MMP	Incident logging and annual reporting to Seychelles Fishing Authority.
7.4.4.1 Technical Aquaculture Aspects	Cage installation	Impact to sensitive benthic habitats	No damage to sensitive benthic habitats such as coral reefs and sea grass beds	No impact on sensitive benthic habitats	Pre-installation site survey to verify benthic habitat type and select sandy/muddy bottom	Independent service provider	During implementation phase of MMP and establishment of farms	ADZ Site survey at least six months prior to cage installation
7.4.5.1 Visual	Visual Resource	Reduction in visual resource value due to increased shipping/boat traffic (construction, operational and decommissioning activities)	To remain at least 2 km from the shoreline where sensitive receptors are present	No complaints from sensitive receptors	The SFA should limit placement and/or siting of fish farms within ADZs to a minimum of 2km form the direct line of sight of sensitive receptors should they occur. This can be achieved by refining the size and delineation of each ADZs, as well as the movement of ADZs by up to 1 nautical mile in certain instances. These measures should specifically apply with regards to sites PLD4 and SN2 in order to limit the visual intrusion towards sensitive receptors, which in these two instances are high value tourism establishments. Lastly, in order to reduce the visual intrusion that may be experienced by additional boat/shipping traffic, it is recommended that operators of fish farms try and schedule trips from main port to the fish farms at times of the day when receptors are least active. This may be during first light (early morning) or late afternoon before sunset. By scheduling boat and ship traffic, it may have the effect of reducing visual degradation experienced by sensitive receptors with views towards ADZs.	SFA	Duration of Construction Activities	SFA to monitor complaints received and logged by Operators in monthly monitoring report
7.4.5.1 Visual	Visual Resource and Light Pollution	Light pollution at night (construction, operations and decommissioning)	To reduce excessive lighting or illumination at cage sites	No complaints from sensitive receptors	In addition, operators should limit the amount of lighting / illumination and/or the intensity of such lighting on board of the floating cages. For safety reasons, navigational lighting has specific standards that need to be implemented, however lighting for on-board crew can be adjusted to an absolute minimum required in order reduce any excess light pollution that may be visible form shore. Utilise security lighting (if feasible) that is movement activated rather than permanently switched on, to prevent unnecessary constant illumination. Avoid up-lighting of structures by rather directing lighting downwards and focused on the area to be illuminated.	Fish Farm Operators	Duration of Construction Activities	Complaints should be logged and reported weekly.
7.4.6.1 Noise	Noise	Excessive noise at the BQAF and R&D Facility sites causing annoyance or disturbance	To remain within national standards at site perimeter and at sensitive receptors	No exceedances of standards in APPENDIX G attributable to project	■ Notify neighbours prior to commencing activities that will generate significant noise. ■ A complaints reporting procedure should be established and all complaints logged. Investigations into the cause of the complaints should be initiated and appropriate mitigation measures applied timeously.	ECO appointed by Contractors	Duration of Construction Activities	Complaints should be logged and reported weekly.

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
					■ Construct noise barriers between noisy activities and noise-sensitive receptors. ■ Reroute truck traffic away from residential streets where possible. ■ Site noise generating equipment such as generators and air compressors on the construction lot as far away from noise sensitive receptors as possible. ■ Shut down or throttle down equipment (such as backhoes, cranes, bobcats, loaders and generators) whenever they are not in actual use. ■ Combine noisy operations to occur in the same time period. ■ Avoid night-time construction activities. ■ Select quieter equipment where possible. ■ Use newer equipment where possible. ■ Ensure equipment is well maintained. ■ Construct temporary walled enclosures around especially noisy activities or clusters of noisy equipment. ■ Ensure personel are trained to carry out their respective tasks.			
7.4.6.1 Noise	Noise	Excessive noise at the pilot project and ADZ sites causing annoyance or disturbance	To remain within national standards at site perimeter and at sensitive receptors	No exceedances of standards in APPENDIX G attributable to project	■ Plan routes to avoid known dive sites and/ or tourism routes and use existing transport routes where possible; ■ Ensure boats and engines are well maintained; and ■ Avoid night-time activities. Sensitivity to noise increased during the night-time hours.	ECO/ SHEQ officer (from SFA)	Duration of the Operation	Complaints should be logged and reported monthly.
7.4.7.1 Social	Social Change	Job Opportunities and Local Employment	To enhance local employment opportunities	Compliance with national labour regulations. HR requirements are in place and maintained.	■ A multi-level governance approach should be adopted to ensure all those with an interest in mariculture is given the opportunity to learn more about this sector and be involved in decision-making on its future development (Stead, 2016). ■ Introduce contractual obligations for contractors to use local labour as far as possible. ■ Establish community liaison officers to manage the local MMP public interface, specifically during the construction phase. ■ ADZ developers must comply with all MMP regulations, standards and licence conditions. ■ ADZ developers must source local labour as far as possible with an emphasis on employing youth and women. ■ If specific skilled positions cannot be sourced within the local districts, they should be sourced at a national level first before looking at international workers. ■ Any contractors working on this project should be encouraged to utilise the local labour pool and local businesses where possible. ■ Implementation of recruitment and procurement policies for all contractors which include maximising the usage of local service providers and utilisation of local labour should be a key requirement in the tender documentation.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Construction Activities – approximately 12 months	Weekly
7.4.7.1 Social	Social Change	Population influx	Manage potential population influx for MMP vacancies.	Developers to comply with national and MMP job criteria requirements.	■ Reiterate communications on the limited available job opportunities in order to deter influx to the area. Utilise existing communication strategies to inform the surrounding communities. ■ Monitor potential influx through observations of the community liaison officers (CLOs). ■ Maximise the usage of local service providers, including contractors. ■ The use of Seychelles labour should be specified in the tender documentation. ■ Before construction commences, representatives from the local authority and community-based organisations, as well as neighbouring residents should be informed of the details of the construction company, size of the workforce and construction schedules. ■ Continue restrictive access to the MMP onshore and offshore sites. ■ Implement spatial plans for existing and new residential units within the Seychelles, through controlled and regulated development. ■ Criminal incidents should be communicated to the workforce and employees to ensure a general awareness of the safety situation in the area.	The SFA and relevant government department (MLUH)	Duration of Construction Activities – approximately 12 months	Weekly

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
7.4.7.1 Social	Social Change	Project induced in-migration	Manage population in-migration into the MMP project areas.	Recruitment centre in place and utilised.	■ Continue restrictive access to the MMP onshore and offshore sites. ■ Recruitment through a formal employment office or info centre at Victoria, Mahe. ■ Monitor potential in-migration through observations of the community liaison officers (CLOs). ■ Implement an effective stakeholder engagement process regarding the construction process in particular, and the larger Seychelles MPP as well. ■ Ensure adherence to land use zoning, occupation and land use rights. ■ Before construction commences, representatives from the District Authority, the District Social Committee and the District Team, and community-based organisations, as well as neighbouring residents should be informed of the details of the construction process, contractor (if any), the size of the workforce and construction schedules. ■ Prevent the development of roadside/informal dwellings, shops and so forth. ■ Implement spatial plans for existing and new residential units within the Seychelles, through controlled and regulated development.	The SFA and relevant government department (MLUH)	Pre-construction and for the duration of Construction Activities – approximately 12 months	Weekly
7.4.7.1 Social	Social Change	Skills Requirements	Enhance local skills development to address the current shortage of industry relevant skills	The Ministry of Fisheries and Agriculture (MoFA) to fill scholarship, bursary and capacity building positions.	■ Finalise the details of the construction activities, specific job requirements and associates skills as well as the schedules. This should take place before the construction starts, to enable the process of capacity building if required. ■ Develop the capacity requirements and associated budgets. ■ Develop a list of potential candidates, focusing firstly on the unemployed youth and women before construction commences. Representatives from the District Authority, the District Social Committee and the District Team, as well as neighbouring residents should be consulted should be consulted in this regard. ■ Appoint a training coordinator to manage and coordinate this process. This function can be combined not only why with those of the proposed community liaison officers. ■ Provide skills related capacity building and support, particularly aimed at women and the youth. ■ Formalise skills development through a process of developing a strategic community skills development programme inclusive of stakeholder engagement input and monitoring and adaptation mechanisms. ■ Establish a community liaison committee to consult on human resource and social issues and develop joint solutions where feasible.	The Ministry of Fisheries and Agriculture (MoFA) and relevant government department (Department of Education)	Pre-construction and for the duration of Construction Activities – approximately 12 months	Weekly
7.4.7.1 Social	Social Change	Change in employment equity of vulnerable groups	To enhance the employment of women and youth.	Developers to comply with national and MMP job criteria requirements.	■ Implement the recommendations made to focus on involving women and the youth in the construction process. ■ Implement the skills training and capacity building focus as indicated in Sections 5.1.1 and 5.1.4 of the SIA - APPENDIX H.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Construction Activities – approximately 12 months	Monthly
7.4.7.1 Social	Social Change	Impacts on daily living and movement patterns	Increase awareness on road access and safety	Comply with the necessary national health and safety regulations.	■ Communicate information regarding the construction routes, peak operational times, hazards associated and precautionary measures to the Ward councillor as well as the relevant community organisations. ■ Notify the public of construction progress, when and where new construction will start and what routes will be affected. ■ Construction traffic past community infrastructures such as schools, crèches, sporting facilities, etc. must be strictly managed. ■ Ensure construction activities avoid peak traffic hours and particular social usage requirements. ■ General road rules should be enforced, and specific provision should be made for management of construction related complaints. ■ Ensure safe and secure public transport access points.	ADZ Developer (Policed by the SFA and relevant government department)	Pre-construction and for the duration of Construction Activities – approximately 12 months	Monthly

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
					■ The development of a strategy to address community safety and security would be needed. This can be achieved by expanding on existing health and safety procedures to reduce risk to communities and employees. ■ Implement a community safety and security plan.			
7.4.7.1 Social	Social Change	Introduction of New Social Classes and Related Socio-Cultural Impacts	To limit the number of outsiders with different values, beliefs and practices.	Developers to comply with national and MMP job criteria requirements.	■ Implement a comprehensive stakeholder engagement process. ■ Maximise the use of local service providers, including contractors. ■ The use of local labour should be a key requirement in the tender documentation. ■ Provide skills related capacity building and support, particularly aimed at women and the youth. ■ An appropriate exit strategy should be developed for the temporary construction related employees.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Construction Activities – approximately 12 months	Weekly
7.4.7.1 Social	Social Change	Quality of life impacts	To manage the potential for adverse intrusions.	Comply with the necessary national health and safety regulations and EIA recommendation.	■ Manage construction times to minimise noise intrusion during night time. ■ Ensure effective dust management. ■ Minimise on site lighting during the night times. ■ It is recommended that the measures identified in the EMP be followed to reduce the occurrence of any intrusion impacts. ■ Operating contractors/investors must comply with all MMP rules and regulations. ■ Address issues and aspects identified using the proposed grievance mechanism in a timely and thorough fashion. Records of any such incidents should be kept and prompt feedback provided to the relevant stakeholders.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Operational Activities.	Monthly
7.4.8.1 Cultural Heritage	Cultural Heritage (Archaeological site, if present)	Offshore impacts from excavations, pipe placement, and anchoring for Project construction and pilot project cage place placement.	To avoid impacts to unidentified archaeological resources.	The *National Monuments Act*, applicable international law, and, international conventions to guide internationally recognized practices (section 5.1 of CHIA)	■ Conduct a dive survey in identified Project areas (section 5.6.1.1 of CHIA - APPENDIX I). ■ If an archaeological site is observed, this assessment assumes it will be of small enough size that construction impacts may be avoided through Project redesign; and, ■ Even with Project redesign there will remain some potential for impacts to an unrecorded archaeological site, to be addressed with chance find procedures.	Qualified Archaeologist	Prior to Construction Activities	Field survey followed by report with recommendations for Heritage Resource Management.
7.4.8.1 Cultural Heritage	Cultural Heritage (Archaeological site, if present)	Impacts from anchoring for Project construction/ placement of cages in ADZs.	To observe and avoid further impacts to unidentified archaeological resources.	The *National Monuments Act*, applicable international law, and, international conventions to guide internationally recognized practices (section 5.1 of CHIA)	■ Implement chance find procedure (section 5.6.1.1 of CHIA - APPENDIX I).	SFA, Developers and their sub-contractors, and a qualified consulting archaeologist	Duration of Construction Activities	Chance find.
7.4.8.1 Cultural Heritage	Cultural Heritage (Archaeological site, if present)	Subsurface impacts on land close to the shore at the proposed R&D Facility	To observe and avoid further impacts to unidentified archaeological resources.	The *National Monuments Act*, applicable international law, and, international conventions to guide internationally recognized practices (section 5.1 of CHIA)	■ Implement chance find procedure (section 5.6.1.1 of CHIA - APPENDIX I).	SFA, Developers and their sub-contractors, and a qualified consulting archaeologist	Duration of Construction Activities	Chance find.
OPERATIONAL PHASE								
7.4.1.2 Physical Oceanography	Marine Environment	Organic solid waste releases from culture cages	Minimization of waste releases as a result of fish feeding; and Minimization of	No exceedance from effluent quality standards for aquaculture facilities	■ Restrict cage operations to open water conditions depths >25 m; typical minimum current speeds >0.1 m/s; no coastal restrictions on circulation ■ Locate downdrift from sensitive habitats (corals, seagrass, dive sites)	Fish Farm Operators	Duration of Operational phase	Monthly (first year) and quarterly thereafter

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
			organic solid accumulation on the seafloor		■ Rotate cage use and implement fallow intervals as part of production cycle			
7.4.2.2 Waste	Undercage benthic effects from faeces and fish waste can impact seabed under cage and down-current	Particulate organic build-up under cages and down current, resulting in habitat smothering and mortality of macrofauna	Reduce the quantity of particulate organic matter build-up and its impact on below cage and/or adjacent sensitive habitats	FAO Code of Conduct for Responsible Fisheries/ Specialist advice	■ Site selection must exclude consolidated (hard/reef) areas of seafloor ■ ADZs should be moved to avoid overlying benthic macro-algae patches, fish spawning aggregation sites, any coral reef and seagrass habitats or rocky reef dive sites ■ Feeding regimes and feed selection (e.g. appropriate size for fish) must be managed as per Aquaculture Standard 18 and manufacturers instructions	Farm manager, specialists, SFA, independent ECO auditor	Duration of operational phase	Recorded daily feed rates and biannual surveys
7.4.2.2 Waste	Nutrient enrichment	Waterborne nutrient loss can contribute to local and sub-regional nutrient concentrations in coastal waters with potential effects on phytoplankton growth	Minimise concentrations of dissolved nutrients (nitrate and phosphate) sufficiently before they come into contact with sensitive habitats	Mean ambient water column nitrogen and phosphorus concentrations must not exceed 5% of seasonal background levels at sensitive receptors (e.g. coral reef and seagrass beds).	■ Prior to establishment of any farms within a ADZ, onsite monitoring to obtain of site specific data will allow for the accurate modelling of waste plumes, to ensure that they will have dissipated sufficiently before coming into contact with sensitive habitats	Independent specialist	During ADZ zonation/ delineation. Acoustic Doppler Current Profiler (ADCP) data to be collected at key positions close to ADZs for at least a year for input into hydro-dynamic models	N/A
7.4.2.2 Waste	Sediment	Sediment contaminant accumulation can occur through antifouling and from trace elements in feed	Minimise concentrations of chemicals and trace elements before they come into contact with the receiving environment	FAO Code of Conduct for Responsible Fisheries/ Specialist advice	■ Prior to establishment of any farms within a ADZ, onsite monitoring of site current data and baseline concentrations will allow for the accurate modelling of dispersion plumes, to ensure that chemical concentrations have dissipated to acceptable levels before coming into contact with sensitive habitats ■ Use of therapeutics and disinfectants must be regulated as per the Seychelles Aquaculture Standards	Independent specialist	Prior to any development	N/A
7.4.2.2 Waste	Sediment	Sediment debris accumulation can occur from the loss of cage fouling during on site cleaning	Reduce the quantity of debris discharged at one time so that the risk to sensitive habitats is reduced		■ Cages must be maintained regularly so that there is no extensive cleaning required at one time. ■ Cleaning must take place in stages. ■ No gear may be abandoned or ‘dropped’ as per the Seychelles Aquaculture Standard for ‘Responsible Finfish cage culture” ■ Dropped cages must be GPS tagged with a float buoy and reported to the Regulator	Farm manager, independent ECO auditor	Duration of operational phase	ECO audits
7.4.2.2 Waste	Solid Waste	Rubbish loss can occur through poor on-site management (introduction of recalcitrant rubbish, especially plastics)	Ensure zero discharge of rubbish into the marine environment		■ Sealed rubbish bins must be located on all platforms ■ Training of staff	Farm manager, independent ECO auditor	Duration of operational phase	N/A
7.4.2.2 Waste	Processed Fish Waste	With the development of the ADZs, fish production increases over time will result in increases in both liquid and solid waste	Reduce the amount of waste that goes to landfill by producing byproducts from processed waste Reduce Liquid waste (blood, fish washing, cleaning) that is discharged into sewerage system and stop anyl discharge to coastal waters.	Solid waste management within the ADZs is governed by Section 7 of the Seychelles Aquaculture Standard 18 Finfish Cage Culture (S18)	With the development of the ADZs, fish production increases over time will result in increases in both liquid and solid waste. It is important that the predicted production increases are matched to: ■ The capacity of fish processing facilities to receive the production. ■ The capacity of wastewater treatment systems to receive increased volumes of liquid waste. ■ The ability of secondary processing industries to receive fish waste to produce added value fish products. ■ Ice production required to support the industry.	SFA / Seychelles Government	Before the start of operations	N/A

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
					■ Further information on current disposal practices is required to inform wastewater management and capacity at waste water treatment plants in the future. It is recommended that an industry wide waste management strategy/plan be developed that will review the Seychelles capacity for handling liquid and solid waste from fish processing, especially given the potential large increases in volume associated with the new aquaculture sector.			
7.4.3.2 Coral Reef and Benthos	Particulate organic loading/pollution of benthic environment beneath cages	Particulate organic build-up beneath cages and mortality of macrofauna	Minimisation of particulate organic build-up and its impact on sensitive habitats	Seychellois Legislation governing MPAs FAO Code of Conduct for Responsible Fisheries/ Specialist advice	Essential mitigation measures: ■ Sensible site selection. This has been partly achieved but consolidated (hard/reef) areas of seafloor must be excluded from M1 and SN2 (and any other proposed ADZs) ■ ADZs should be moved to avoid overlying benthic macro-algae patches (See SFA, 2016c) ■ ADZs must be sited at least 500 m from fish spawning aggregation sites ■ ADZs must be located at least 500 m away from any coral reef and seagrass habitats ■ ADZs must be located at least 500 m away from rocky reef dive sites. M2 and M4 appear to be too close. ■ ADZs must be located at least 1000 m away from marine protected areas (MPAs)	Specialist appointed by SFA	During ADZ zonation/ delineation	NA
7.4.3.2 Coral Reef and Benthos				Sediment type and colour, erosional and depositional areas, relative abundance of flora and fauna, presence of feed pellets and manmade debris (See Seychelles Aquaculture Standard: Finfish cage culture)	■ Undertake benthic monitoring, including baseline surveys at control and ADZs sites to determine scale of impacts and decrease ADZ production levels should the impact exceed the accepted sacrificial footprint. ■ Rotate cages (fallowing) within each ADZ to allow for recovery of soft sediment benthos, as stipulated by the regulator ■ Use species and system-specific feed to maximise food conversion ratios and minimise waste ■ No cleaning of fouling organisms from nets at sea ■ Quantitative surveys should be conducted prior to development to obtain baseline data and repeated thereafter every year. Monitoring may be reduced after three years of annual monitoring, provided production rates are stable and benthic environmental health is acceptable. Annual reporting	Farm manager, SFA, independent ECO auditor	Duration of operational phase	Qualitative surveys biannually in January and in July as per Seychelles Aquaculture Standard: Finfish cage culture. Biannual reporting
7.4.3.2 Coral Reef and Benthos				Maximum of 1% of feed quantity uneaten and settling below cages	Monitor feeding behaviour and particulate deposition beneath cages and adapt feeding strategy to maximise feeding efficiency and minimise particulate matter fallout	Farm manager	Duration of operational phase	Feeding rates recorded daily and pellet deposition bi-annually in qualitative survey. Monthly reporting
7.4.3.2 Coral Reef and Benthos					Optional mitigation measures: ■ Near-field modelling exercise of particulate organic matter for each proposed ADZ would add more confidence in assessing the scale of the fallout of particulates and thus its impact	Independent specialist	During ADZ zonation/ delineation	Once off
7.4.3.2 Coral Reef and Benthos	Nutrient enrichment in the form of dissolved organic nutrients. Effects on adjacent sensitive habitats (e.g. coral reefs and seagrass beds)	Increased epiphyte load on seagrasses leading to competition and mortality. Decrease in skeletal density, higher infestation of boring organism and decreased reproductive effort in corals. Increased shading of corals due to increase in macro-algal abundance.	Minimise concentrations of dissolved nutrients (nitrate and phosphate) sufficiently before they come into contact with sensitive habitats	European Union recommendations (Huntingdon 2006). Mean ambient water column nitrogen and phosphorus concentrations must not exceed 5% of background levels at coral reef and seagrass beds	Essential mitigation measures: In the year prior to operating at a particular ADZ, the operator should conduct a minimum of 6 months' worth of monitoring (typically 2 months during each monsoon season and a month each for inter-monsoon periods). The operator should then continue to monitor throughout their operational period and conduct MOM modelling with the monitoring data on an annual basis. By applying the minimum buffer distances between fish farms and sensitive receptors, as stated above, and by conducting the continuous monitoring and MOM modelling impacts should be detected allowing for proactive management, It is recommended that SFA or the regulator of the Aquaculture sector monitors the currents of the ADZs in order to build up monitoring data that can be used to conduct further hydrodynamic modelling exercises. The tier 1 sites have been located over areas identified for sand mining and where sufficient current data exists. Subsequent ADZs should be monitored by the SFA/regulator for atleast 12 months and a far field hydrodynamic modelling exercise	Fish farm operator SFA or Regulator Independent specialist	Collect 6 months monitoring data in the year prior to fish in water. Undertake continuous monitoring and MOM modelling on an annual basis during operations	NA

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
		Mortality			should be undertaken in order to rule out areas of low/insufficient current flow or areas with circular current movement which are unsuitable for fish farming. The far-field hydrodynamic modelling exercise should also include dissolved nutrient dispersal for each ADZ using the detailed current profiling data (and other relevant data i.e. bathymetry, wind, cage drag, Coriolis Force). as well as including themodelling of different intensities of ADZ development and predict dissolved nutrient diffusion (nitrate and phosphate) from each ADZ and ensure that waste plumes have dissipated sufficiently before coming into contact with sensitive habitats such as coral reefs and seagrass beds.			
7.4.3.2 Coral Reef and Benthos					■ Use species specific formulations designed to enhance nitrogen and phosphorus retention efficiency, and reduce metabolic waste output. ■ Monitor feeding behaviour and adapt feeding strategy to ensure minimal wastage (excess) of feed.	Farmer managers, SFA	Duration of operation phase	Feeding rates recorded daily. Monthly reporting
7.4.3.2 Coral Reef and Benthos					Undertake monitoring of water quality (Nitrate & phosphate in particular) and adjacent coral reef and seagrass habitats, including baseline surveys at control and ADZs sites to determine baseline concentrations and scale of impacts. Decrease ADZ carrying capacity should the levels of dissolved organics exceed performance criteria.	Independent specialist	Prior to any development for at least a 6 month period (baseline). Then for the duration of the operational phase	6 Months water sampling (monsoon and inter-monsoon periods) for baseline in year prior to fish farming and monthly thereafter first three years thereafter. If no increase in stocking, sampling can be done quarterly at coastal sites overlying sensitive habitats and at Control Sites. Quarterly and annual reporting
7.4.3.2 Coral Reef and Benthos	Water quality: Chemical pollution especially copper, veterinary therapeutics etc. in water column and trace metals in sediments	Mortality to corals and other lower life forms	Minimise concentrations to levels that are on par with background copper levels. Levels of therapeutics and disinfectant s etc. below toxic levels for lower life forms. Trace metals in sediments below toxic levels	FAO Code of Conduct for Responsible Fisheries/ Specialist advice	Essential mitigation measures: In the year prior to operating at a particular ADZ, the operator should conduct a minimum of 6 months' worth of monitoring (typically 2 months during each monsoon season and a month each for inter-monsoon periods). The operator should then continue to monitor throughout their operational period and conduct MOM modelling with the monitoring data on an annual basis. By applying the minimum buffer distances between fish farms and sensitive receptors, as stated above, and by conducting the continuous monitoring and MOM modelling impacts should be detected allowing for proactive management, It is recommended that SFA or the regulator of the Aquaculture sector monitors the currents of the ADZs in order to build up monitoring data that can be used to conduct further hydrodynamic modelling exercises. The tier 1 sites have been located over areas identified for sand mining and where sufficient current data exists. Subsequent ADZs should be monitored by the SFA/regulator for atleast 12 months and a far field hydrodynamic modelling exercise should be undertaken in order to rule out areas of low/insufficient current flow or areas with circular current movement which are unsuitable for fish farming. The far-field hydrodynamic modelling exercise should also include dissolved nutrient dispersal for each ADZ using the detailed current profiling data (and other relevant data i.e. bathymetry, wind, cage drag, Coriolis Force). as well as including themodelling of different intensities of ADZ development and predict dissolved nutrient diffusion (nitrate and phosphate) from each ADZ and ensure that waste plumes have dissipated sufficiently before coming into contact with sensitive habitats such as coral reefs and seagrass beds.	Fish farm operator SFA or Regulator Independent specialist Independent ECO auditor	Collect 6 months monitoring data in the year prior to fish in water. Undertake continuous monitoring and MOM modelling on an annual basis during operations	NA

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
7.4.3.2 Coral Reef and Benthos					■ Use only approved veterinary chemicals and antifoulants ■ Where possible use environmentally friendly alternatives ■ Use the lowest effective dose of therapeutics ■ Do not clean cages on site/in the sea. Clean cages on land but ensure that any effluent resulting from this process reaching the sea contains acceptable levels of copper and antifoulants.	Farm managers, independent ECO auditor	Duration of the operational phase	Detailed records must be taken every time chemicals are used. Quarterly reporting
7.4.3.2 Coral Reef and Benthos				US: EPA (2016) Total dissolved water column copper not to exceed 1.3 ppb / 1.3 µg.L^{-1} at sensitive habitats (see also Young 2003; Beilmyer et al. 2010). For veterinary products chronic toxicity thresholds must not be exceeded as per instructions and MSDS. For sediment trace metals within ADZs: BCLME (2006) Guidelines (mg/kg dry weight) Copper < 18.7; Lead < 30.2; Zinc < 124; Chromium < 52.3; Arsenic < 7.24; Mercury < 0.13; Cadmium < 0.68; Nickel < 15.9; Silver < 0.78; Tin as Tributylin-Sn < 0.0005.	Monitoring	Independent specialist, independent ECO auditor	Prior to any development for at least a year (baseline). Then for the duration of the operational phase	Monthly water sampling and yearly sediment sampling. Annual reporting
7.4.3.2 Coral Reef and Benthos	Disease and parasites	Transfer to wild stocks leading to increased mortality rates, reduced fecundity, delayed maturity and reduced productivity of wild stocks	Minimise disease and parasitic infections on wild stocks	Target = Zero infections and pathogens of farmed species. No increase in disease and pathogens above baseline levels in wild stocks should be acceptable.	Essential mitigation measures: ■ Maintain strict bio-security measures within hatchery, holding tanks and sea cages ■ Ensure all fry undergo a health examination before stocking in cages ■ Regularly inspect stock for disease and parasites as part of a formalised stock health monitoring programme and take necessary actions to eliminate pathogens through the use of therapeutic chemicals or improved farm management. This will require focused research effort into the identification, pathology and treatment of diseases and parasites infecting farmed species, both in culture and in wild stocks. ■ Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the efficacy of treatments applied. These records should be made publically available to facilitate rapid responses by other operators to future outbreaks. ■ Locate cages stocked with different cohorts of the same species as far apart as possible, if possible stock different species in cages successively. ■ Treat adjacent cages simultaneously even if infections have not yet been detected. ■ Keep nets clean and allow sufficient fallowing time on sites to ensure low environmental levels of intermediate hosts and or pathogens	Farm managers, SFA, independent veterinarians, independent ECO auditors, Specialists	Duration of operational phase	Daily/weekly checks of cultured stock (or at frequencies determined by a formal stock health monitoring programme). Reporting routinely at monthly intervals and within 24 hrs of outbreaks. Wild-stock health to monitored and reported on annually
7.4.3.2 Coral Reef and Benthos	Genetic integrity of wild stocks	Reduced genetic diversity and fitness in wild stocks	Avoid reductions in fitness of wild stocks due to genetic	Genetic homogeneity of cultured and wild stocks	Essential mitigation measures:	SFA	Duration of operational phase	At initiation when each species are first stocked and

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
			contamination		■ Maintain genetic compatibility between cultured and wild stocks by developing a genetic best-practice management guideline for finfish mariculture and ensure adequate genetic monitoring is undertaken routinely.			thereafter every five years. Reporting every five years
7.4.3.2 Coral Reef and Benthos				Target = zero escapees	■ Minimise the number of escapes by maintaining cage integrity through regular maintenance inspections and replacement of compromised or old infrastructure. ■ Cages should have jump nets installed ■ Develop and implement stock recovery procedures should escapes happen. ■ During fish transfers or harvest, operations must be conducted in appropriate weather conditions and under constant visual supervision. Equipment appropriate to the weather and cage design must be used. Where necessary or appropriate, additional netting must be used to prevent escapes during transfer. ■ Record all escapees and cage failures	Farm managers, independent ECO auditors	Duration of operational phase	Continuous monitoring and Monthly reporting. Escapes must be reported to the regulator within 24 hours
7.4.3.2 Coral Reef and Benthos					Maintain robust and healthy populations of wild stocks.	SFA and Seychelles National Parks Authority	Duration of operational phase	Whenever routine stock assessments are done
7.4.3.2 Coral Reef and Benthos					Optional mitigation measures: ■ The use of anti-predator netting should be investigated.	Farmer mangers	Duration of operational phase	NA
7.4.3.2 Coral Reef and Benthos					Develop the technology to mass produce sterile fry for cage culture.	SFA	Duration of operational phase	NA
7.4.3.2 Coral Reef and Benthos	Interactions with Piscivores	Behaviour changes in piscivores	Reduce interactions with piscivores and human animal conflicts	Target = Zero mortality of piscivores	Essential mitigation measures: ■ Develop a protocol to deal with problematic piscivores with experts and officials ■ Maintain a record of all interactions with piscivores as per EMP ■ During harvesting ensure that minimal blood enters the water	SFA, independent scientists, farm managers, independent ECO auditors	Duration of operational phase	Daily monitoring. Monthly reporting
7.4.3.2 Coral Reef and Benthos		Escape of cultured stocks	Minimise escapees	Target = Zero cage failures	■ Remove any injured or dead fish from cages promptly ■ Install and maintain suitable anti-predator nets	Farm managers, independent ECO auditors	Duration of operational phase	Daily monitoring. Monthly reporting
7.4.3.2 Coral Reef and Benthos	Entanglements in cage infrastructure	Mortality of turtles and sharks	Minimise risk of entanglements	Target = Zero entanglements	Essential mitigation measures: ■ Ensure all mooring lines and nets are highly visible. Use thick visible lines. ■ Keep all lines and nets as tight as possible and conduct regular inspections to ensure this ■ Do not have any hanging lines or unnecessary lines from cages ■ Maintain adequate separation between primary and secondary nets even during strong currents and rough seas ■ Use square mesh and ensure that net mesh-size does not exceed 16 cm whilst stretched	Farm managers, independent ECO auditors, Seychelles National Parks Authority	Duration of the operational phase	Daily monitoring. Monthly reporting
7.4.3.2 Coral Reef and Benthos	Particulate organic loading/pollution of benthic environment beneath cages	Particulate organic build-up beneath cages and mortality of macrofauna	Minimisation of particulate organic build-up and its impact on sensitive habitats	Local Seychellois Legislation regarding MPAs FAO Code of Conduct for Responsible Fisheries/ Specialist advice	Essential mitigation measures: ■ Sensible site selection. This has been partly achieved but consolidated (hard/reef) areas of seafloor must be excluded from M1 and SN2 (and any other proposed ADZs) ■ ADZs should be moved to avoid overlying benthic macro-algae patches (See SFA, 2016c) ■ ADZs must be sited at least 500 m from fish spawning aggregation sites ■ ADZs must be located at least 500 m away from any coral reef and seagrass habitats ■ ADZs must be located at least 500 m away from rocky reef dive sites. M2 and M4 appear to be too close. ■ ADZs must be located at least 1000 m away from marine protected areas	Specialist appointed by SFA	During ADZ zonation/ delineation	NA

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
7.4.3.2 Coral Reef and Benthos				Sediment type and colour, erosional and depositional areas, relative abundance of flora and fauna, presence of feed pellets and manmade debris (See Seychelles Aquaculture Standard: Finfish cage culture)	■ Undertake benthic monitoring, including baseline surveys at control and ADZs sites to determine scale of impacts and decrease ADZ production levels should the impact exceed the accepted sacrificial footprint. ■ Rotate cages (fallowing) within each ADZ to allow for recovery of soft sediment benthos ■ Use species and system-specific feed to maximise food conversion ratios and minimise waste ■ No cleaning of fouling organisms from nets at sea	Farm manager, SFA, independent ECO auditor	Duration of operational phase	Qualitative surveys biannually in January and in July as per Seychelles Aquaculture Standard: Finfish cage culture. Biannual reporting Quantitative surveys should be conducted prior to development to obtain baseline data and repeated thereafter every year. Monitoring may be reduced after three years of annual monitoring, provided production rates are stable and benthic environmental health is acceptable. Annual reporting
7.4.3.2 Coral Reef and Benthos				Maximum of 1% of feed quantity uneaten and settling below cages	Monitor feeding behaviour and particulate deposition beneath cages and adapt feeding strategy to maximise feeding efficiency and minimise particulate matter fallout	Farm manager	Duration of operational phase	Feeding rates recorded daily and pellet deposition bi-annually in qualitative survey. Monthly reporting
7.4.3.2 Coral Reef and Benthos					Optional mitigation measures: Near-field modelling exercise of particulate organic matter for each proposed ADZ would add more confidence in assessing the scale of the fallout of particulates and thus its impact	Independent specialist	During ADZ zonation/ delineation	Once off
7.4.3.2 Coral Reef and Benthos	Nutrient enrichment in the form of dissolved organic nutrients. Effects on adjacent sensitive habitats (e.g. coral reefs and seagrass beds)	Increased epiphyte load on seagrasses leading to competition and mortality. Decrease in skeletal density, higher infestation of boring organism and decreased reproductive effort in corals. Increased shading of corals due to increase in macro-algal abundance. Mortality	Minimise concentrations of dissolved nutrients (nitrate and phosphate) sufficiently before they come into contact with sensitive habitats	European Union recommendations (Huntingdon 2006). Mean ambient water column nitrogen and phosphorus concentrations must not exceed 5% of background levels at coral reef and seagrass beds	Essential mitigation measures: In the year prior to operating at a particular ADZ, the operator should conduct a minimum of 6 months' worth of monitoring (typically 2 months during each monsoon season and a month each for inter-monsoon periods). The operator should then continue to monitor throughout their operational period and conduct MOM modelling with the monitoring data on an annual basis. By applying the minimum buffer distances between fish farms and sensitive receptors, as stated above, and by conducting the continuous monitoring and MOM modelling, impacts should be detected allowing for proactive management, It is recommended that SFA or the regulator of the Aquaculture sector monitors the currents of the ADZs in order to build up monitoring data that can be used to conduct further hydrodynamic modelling exercises. The tier 1 sites have been located over areas identified for sand mining and where sufficient current data exists. Subsequent ADZs should be monitored by the SFA/regulator for atleast 12 months and a far field hydrodynamic modelling exercise should be undertaken in order to rule out areas of low/insufficient current flow or areas with circular current movement which are unsuitable for fish farming. The far-field hydrodynamic modelling exercise should also include dissolved nutrient dispersal for each ADZ using the	Fish farm operator SFA or Regulator Independent specialist	Collect 6 months monitoring data in the year prior to fish in water. Undertake continuous monitoring and MOM modelling on an annual basis during operations	NA

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
					detailed current profiling data (and other relevant data i.e. bathymetry, wind, cage drag, Coriolis Force). as well as including themodelling of different intensities of ADZ development and predict dissolved nutrient diffusion (nitrate and phosphate) from each ADZ and ensure that waste plumes have dissipated sufficiently before coming into contact with sensitive habitats such as coral reefs and seagrass beds.			
7.4.3.2 Coral Reef and Benthos					■ Use species specific formulations designed to enhance nitrogen and phosphorus retention efficiency, and reduce metabolic waste output. ■ Monitor feeding behaviour and adapt feeding strategy to ensure minimal wastage (excess) of feed.	Farmer managers, SFA	Duration of operation phase	Feeding rates recorded daily. Monthly reporting
7.4.3.2 Coral Reef and Benthos	Benthic environment beneath pilot project cages	Smothering, disturbance and mortality	Minimise severity of impact	Maximum of 1% of feed quantity uneaten and settling below cages. Sediment type and colour, erosional and depositional areas, relative abundance of flora and fauna, presence of feed pellets and manmade debris (See Seychelles Aquaculture Standard: Finfish cage culture)	Essential mitigation measures: ■ Sensible site selection. This has been achieved buy zoning the cages over previously disturbed unconsolidated habitat however the depth is shallow ■ Rotate cages (fallowing) to allow for recovery of soft sediment benthos ■ Use species and system-specific feed to maximise food conversion ratios and minimise waste ■ No cleaning of fouling organisms from nets at sea ■ Monitor feeding behaviour and particulate deposition beneath cages and adapt feeding strategy to maximise feeding efficiency and minimise particulate matter fallout ■ Undertake benthic monitoring, including baseline surveys to determine scale of impacts and decrease stocking densities should the impact exceed the accepted sacrificial footprint. ■ Optional mitigation measures: ■ Move pilot cages offshore and in deeper water	Farm manager, specialists, SFA, independent ECO auditor	Duration of operational activities	Daily monitoring of feeding behaviour, biannual visual surveys of benthos. Annual quantitative monitoring. Monthly, biannual and annual reporting
7.4.3.2 Coral Reef and Benthos	Water quality: dissolved nutrients (pilot project cages)	Eutrophication of adjacent coral reef and seagrass beds leading to stress and mortality	Minimise nitrates and phosphates	European Union recommendations (Huntingdon 2006). Mean ambient water column nitrogen and phosphorus concentrations must not exceed 5% of background levels at coral reef and seagrass beds	Essential mitigation measures: ■ Use species specific formulations designed to enhance nitrogen and phosphorus retention efficiency, and reduce metabolic waste output. ■ Monitor feeding behaviour and adapt feeding strategy to ensure minimal wastage (excess) of feed ■ Undertake monitoring of water quality and adjacent coral reef and seagrass habitats, including baseline surveys at control and cage sites to determine scale of impacts and decrease stocking density should the impact start effecting sensitive habitats.	Pilot-cage site manager, independent specialist, independent ECO auditor	Prior to any development measure baseline levels for at least a year (baseline). Then for the duration of the operational phase.	Monthly water sampling and quarterly reporting Daily monitoring of feeding behaviour, monthly reporting
7.4.3.2 Coral Reef and Benthos	Water quality: Chemical pollution especially copper, veterinary therapeutics etc. in water column and trace metals in sediments (pilot project cages)	Toxicity from copper and veterinary therapeutics	Minimise concentrations to levels that are on par with background copper levels. Levels of therapeutics and disinfectant s etc. below toxic levels for lower life forms	US: EPA (2016) Total dissolved water column copper not to exceed 1.3 ppb / 1.3 µg.L^{-1} at sensitive habitats (see also Young 2003; Beilmyer et al. 2010). For veterinary products chronic toxicity thresholds must not be exceeded as per instructions and MSDS. For sediment trace metals below cages:	Essential mitigation measures: ■ Use only approved veterinary chemicals and antifoulants ■ Where possible use environmentally friendly alternatives ■ Use the lowest effective dose of therapeutics ■ Do not clean cages on site/in the sea. Clean cages on land but ensure that any effluent resulting from this process reaching the sea contains acceptable levels of copper and antifoulants. ■ Monitoring: Total dissolved water column copper over reefs and seagrass beds not to exceed 1.3 ppb / 1.3 µg L^{-1}. Sediment monitoring ■ Optional mitigation measures: ■ Shift pilot cages further offshore.	Farm manager, SFA, independent specialist, independent ECO auditor	Duration of the operational phase	Monthly monitoring and record keeping of dissolved copper and therapeutics etc. Annual sediment monitoring. Monthly reporting

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
				BCLME (2006) Guidelines (mg/kg dry weight) Copper < 18.7; Lead < 30.2; Zinc < 124; Chromium < 52.3; Arsenic < 7.24; Mercury < 0.13; Cadmium < 0.68; Nickel < 15.9; Silver < 0.78; Tin as Tributylin-Sn < 0.0005.				
7.4.3.2 Coral Reef and Benthos	Disease and parasites (pilot project cages)	Transfer of disease and parasites to wild stocks	Reduce the risk of disease and parasitic transmissions	Target = Zero infections and pathogens of farmed species. No increase in disease and pathogens above baseline levels in wild stocks should be acceptable.	Essential mitigation measures: ■ Maintain strict bio-security measures within hatchery, holding tanks and sea cages ■ Ensure all fry undergo a health examination before stocking in cages ■ Regularly inspect stock for disease and parasites as part of a formalised stock health monitoring programme and take necessary actions to eliminate pathogens through the use of therapeutic chemicals or improved management. This will require focused research effort into the identification, pathology and treatment of diseases and parasites infecting farmed species, both in culture and in wild stocks. ■ Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the efficacy of treatments applied. These records should be made publically available to facilitate rapid responses by other operators to future outbreaks. ■ If possible stock different species in cages successively. ■ Treat adjacent cages simultaneously even if infections have not yet been detected. ■ Keep nets clean and allow sufficient fallowing time on site to ensure low environmental levels of intermediate hosts and or pathogens	Farm manager, veterinarian, independent ECO auditor, SFA	Duration of the operational phase	Daily/weekly checks of stock (or at frequencies determined by a formal stock health monitoring programme). Reporting routinely at monthly intervals and within a week of outbreaks.
7.4.3.2 Coral Reef and Benthos	Genetic integrity of wild stocks (pilot project cages)	Heterogeneity between cultured and wild stocks and reduced fitness of wild stocks	Maintain genetic homogeneity between cultured and wild stocks. Minimise risk of genetic contamination to wild stocks Maintain diverse and healthy populations of wild stocks		Essential mitigation measures: ■ Maintain genetic compatibility between cultured and wild stocks by developing a genetic best-practice management guideline for finfish mariculture and ensure adequate genetic monitoring is undertaken routinely. ■ Minimise the number of escapes by maintaining cage integrity through regular maintenance inspections and replacement of compromised or old infrastructure. ■ Cages should have jump nets installed ■ Develop and implement stock recovery procedures should escapes happen. ■ During fish transfers, operations must be conducted in appropriate weather conditions and under constant visual supervision. Equipment appropriate to the weather and cage design must be used. Where necessary or appropriate, additional netting must be used to prevent escapes during transfer. ■ Maintain robust and healthy populations of wild stocks ■ Optional mitigation measures: ■ The use of anti-predator netting should be investigated ■ Develop the technology to mass produce sterile fry for cage culture	Farm manager, SFA, Seychelles Nature Conservation Authority, Independent ECO auditor, specialists	Duration of the operational phase	At the initiation of when each species are first stocked and thereafter every five years. Reporting every five years
7.4.3.2 Coral Reef and Benthos	Interactions with piscivores (pilot project cages)	Behavioural changes in piscivores	Reduce interactions with piscivores and human animal conflicts	Target = Zero mortality of piscivores	Essential mitigation measures: ■ Develop a protocol to deal with problematic piscivores with experts and officials (Independent scientists and SFA) ■ Maintain a record of all interactions with piscivores as per EMP ■ Remove any injured or dead fish from cages promptly ■ Install and maintain suitable anti-predator nets	SFA, independent scientists, farm managers, independent ECO auditors	Duration of operational phase	Daily monitoring. Monthly reporting

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
7.4.3.2 Coral Reef and Benthos	Entanglements in pilot project cage infrastructure	Mortality of turtles and sharks	Minimise risk of entanglements	Target = Zero entanglements	Essential mitigation measures: ■ Ensure all mooring lines and nets are highly visible. Use thick visible lines. ■ Keep all lines and nets as tight as possible and conduct regular inspections to ensure this ■ Do not have any hanging lines or unnecessary lines from cages ■ Use square mesh and ensure that net mesh-size does not exceed 16 cm whilst stretched ■ Report entanglements to authorities immediately. Attempt to remove animals as quickly and safely as possible. ■ Rehabilitate any injured turtles and other endangered species	Farm managers, independent ECO auditors, Seychelles National Parks Authority	Duration of the operational phase	Daily monitoring. Monthly reporting
7.4.3.2 Coral Reef and Benthos	Benthic environment beneath pilot project cages	Smothering, disturbance and mortality	Minimise severity of impact	Maximum of 1% of feed quantity uneaten and settling below cages. Sediment type and colour, erosional and depositional areas, relative abundance of flora and fauna, presence of feed pellets and manmade debris (See Seychelles Aquaculture Standard: Finfish cage culture)	Essential mitigation measures: ■ Sensible site selection. This has been achieved buy zoning the cages over previously disturbed unconsolidated habitat however the depth is shallow ■ Rotate cages (fallowing) to allow for recovery of soft sediment benthos ■ Use species and system-specific feed to maximise food conversion ratios and minimise waste ■ Limit cleaning of fouling organisms from nets at sea ■ Monitor feeding behaviour and particulate deposition beneath cages and adapt feeding strategy to maximise feeding efficiency and minimise particulate matter fallout ■ Undertake benthic monitoring, including baseline surveys to determine scale of impacts and decrease stocking densities should the impact exceed the accepted sacrificial footprint. ■ Optional mitigation measures: ■ Move pilot cages offshore and in deeper water	Farm manager, specialists, SFA, independent ECO auditor	Duration of operational activities	Daily monitoring of feeding behaviour, biannual visual surveys of benthos. Annual quantitative monitoring. Monthly, biannual and annual reporting
7.4.3.2 Coral Reef and Benthos	Benthic organisms including adjacent coral reef	Mortality and disturbance to benthic organisms	Limit disturbance of the benthic environment to within the pipeline footprint	NA	■ Essential mitigation measures: ■ Sensitive coral reef habitat exists in close proximity (<50 m) to the north-west of the proposed pipeline. This area must be a designated “no-go” area during maintenance and inspection activities.	Contractor. Independent ECO auditor	Duration of Operational Activities	During maintenance
7.4.3.2 Coral Reef and Benthos	Coral reef organisms (R&D facility pipeline)	Mortality to coral reef organisms as a result of trampling during routine pipeline inspections	Minimise disturbance and mortality from trampling	No deviation outside of 1 m either side of the pipeline footprint by inspectors	Essential mitigation measures: ■ Limit trampling to within the development footprint. The development footprint should be set at 1 m either side of the location of the pipeline so that a swath of approximately 2 m wide is affected. ■ Any maintenance to the pipeline must be undertaken from within the development footprint and not from outside of the development footprint.	SFA, engineer, contractor	Duration of the operational phase	Monitor annually and after significantly large seas. Yearly reporting
7.4.4.2 Technical Aquaculture Aspects	Cage Aquaculture of Finfish	Genetic Contamination of wild populations	No measurable genetic contamination of wild stocks	Minimise farm fish escapees	■ Adequate steps must be taken to prevent the escape of production organisms, especially from the hatchery environment where individual organisms may be very small. ■ Escape barriers may include netting, grids, sand and other filters, predator ponds, chemical treatment areas, soak away systems, etc. ■ Barriers should be adequate to prevent escape during flooding, overflows and during other unforeseen circumstances	Farm management	Duration of operational phase	Daily inspection.
7.4.4.2 Technical Aquaculture Aspects	Hatchery and Cage Aquaculture of Finfish	Disease and parasite transmission to wild fish stocks	To maintain health fish within the farm and protect wild stocks	No breakout or spread of disease	■ Staff trained in fish health management and disease recognition ■ Implement a Fish Health Management Programme ■ Apply aquaculture best management practices ■ Maintain strict bio-security measures within hatchery, holding tanks and sea cages. ■ Ensure all fry undergo a health examination prior to stocking in sea cages. ■ Regularly inspect stock for disease and/parasites as part of a formalised stock health monitoring programme. ■ Take necessary action to eliminate pathogens through the use of therapeutic chemicals or improved farm management.	Farm management under veterinary oversight	Duration of operational phase	Six monthly veterinary health assessment Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
					■ Research into the identification, pathology and treatment of diseases and parasites infecting farmed species. ■ Treat adjacent cages simultaneously even if infections have not yet been detected in these cages.			efficacy of treatments applied Annual health management programme report to Seychelles Fishing Authority
7.4.4.2 Technical Aquaculture Aspects	Hatchery and Cage Aquaculture of Finfish	Organic Pollution from fish faecal and feed waste	To prevent the build-up of nutrients within the water column	Dissolved and particulate organic nutrients below specified levels in the vicinity of the fish farm and hatchery and R&D facility	■ Biofiltration of shore based hatchery effluent ■ Set production carrying capacity limits for cage sites ■ Cage location in areas with current >0.2m/s ■ Effluent monitoring at BQAF and R&D discharge points (canal or drains) as well as marine environment closest to discharge point ■ Ongoing MOM modelling and feedback into management measures	Independent service provider	Duration of operational phase	Sampling and reporting every six months
7.4.4.2 Technical Aquaculture Aspects	Cage Aquaculture of Finfish	Chemical pollution arising from finfish cages	No chemical pollution of the environment	No measurable chemical pollution in the environment	■ Utilise professional fish health services and/or veterinary expertise to diagnose disease prior to initiating any disease treatment ■ No veterinary therapeutic-products and medicinal premixes for inclusion in fish feeds may be applied to fish unless they are approved for use ■ Follow manufacturer's/veterinarian's instructions regarding dosage, frequency and duration ■ Keep a current copy of the veterinarian's written recommendation ■ Use environmentally-friendly detergents ■ Ensure all chemicals and drugs are secured to prevent unauthorised use ■ Dispose of unutilised therapeutic agents and medicines according to conventional hazardous waste disposal practices	Farm management and veterinarian	Duration of operational phase	Incident logging if any chemicals are released to the environment. Annual incident log summary report to Seychelles Fishing Authority Annually
7.4.4.2 Technical Aquaculture Aspects	Cage Aquaculture of Finfish	Entanglement of cetaceans in finfish cage infrastructure	No entanglement of cetaceans	No cetacean entanglement incidents	■ Do not locate ADZs in important cetacean habitats and migration routes. ■ Ensure all mooring lines and nets are highly visual. ■ Keep all lines and nets tight through regular inspections and maintenance. ■ Ensure that mesh size on primary and secondary nets does not exceed 16 cm stretched mesh.	Farm Management	Duration of operational phase	Incident logging if any entanglement events occur. Annual incident log summary report to Seychelles Fishing Authority Annually
7.4.4.2 Technical Aquaculture Aspects	Cage Aquaculture of Finfish	Piscivorous marine animals interacting with finfish cage culture operations	Minimal interaction between piscivores and cage fish	Minimal interaction between piscivores and cage fish	■ Install and maintain suitable predator nets (sufficient strength, visibility and mesh size, above and below water line). ■ Install visual deterrents (e.g. tori line type deterrents for birds). ■ Store feed so piscivores cannot access it, and implement efficient feeding strategy. ■ Remove any injured or dead fish from cages promptly. ■ During harvesting of stock, ensure that minimal blood or offal enters the water. ■ Implement mitigation measures as for entanglement impacts (see above). ■ Develop a protocol for dealing with problem piscivores in conjunction with experts and officials.	Farm Management	Duration of operational phase	Incident logging interactions with piscivoros animals. Annual incident log summary report to Seychelles Fishing Authority Annually.
7.4.4.2 Technical Aquaculture Aspects	Cage Aquaculture of Finfish	Impacts on fishing, yachting and recreational vessels	No impact on other vessels and activities	No incidents or activities which impact negatively on other vessels	■ Install navigational markers and lights as required by SAMSA regulations ■ Include position of ADZs on navigational charts ■ Ongoing consultation with user groups to keep them informed of the ADZ developments	Farm management	Duration of operational phase	Incident logging of incidents with other sea users. Annual incident log summary report to Seychelles Fishing Authority Annually.

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
7.4.5.2 Visual	Visual Resource	Reduction in visual resource value due to increased shipping/boat traffic (construction, operational and decommissioning activities)	To remain at least 2 km from the shoreline where sensitive receptors are present	No complaints from sensitive receptors	The SFA should limit placement and/or siting of fish farms within ADZs to a minimum of 2km from the direct line of sight of sensitive receptors should they occur. This can be achieved by refining the size and delineation of each ADZs, as well as the movement of ADZs by up to 1 nautical mile in certain instances. These measures should specifically apply with regards to sites PLD4 and SN2 in order to limit the visual intrusion towards sensitive receptors, which in these two instances are high value tourism establishments. Lastly, in order to reduce the visual intrusion that may be experienced by additional boat/shipping traffic, it is recommended that operators of fish farms try and schedule trips from main port to the fish farms at times of the day when receptors are least active. This may be during first light (early morning) or late afternoon before sunset. By scheduling boat and ship traffic, it may have the effect of reducing visual degradation experienced by sensitive receptors with views towards ADZs.	SFA	Duration of Construction Activities	SFA to monitor complaints received and logged by Operators in monthly monitoring report
7.4.5.2 Visual	Visual Resource	Reduction in visual resource value due to presence of floating cages and associated infrastructure (feed barges and work/well boats)	To remain at least 2 km from the shoreline where sensitive receptors are present	No complaints from sensitive receptors	The SFA should limit placement and/or siting of fish farms within ADZs to a minimum of 2km from the direct line of sight of sensitive receptors should they occur. This can be achieved by refining the size and delineation of each ADZs, as well as the movement of ADZs by up to 1 nautical mile in certain instances. These measures should specifically apply with regards to sites PLD4 and SN2 in order to limit the visual intrusion towards sensitive receptors, which in these two instances are high value tourism establishments. Lastly, in order to reduce the visual intrusion that may be experienced by additional boat/shipping traffic, it is recommended that operators of fish farms try and schedule trips from main port to the fish farms at times of the day when receptors are least active. This may be during first light (early morning) or late afternoon before sunset. By scheduling boat and ship traffic, it may have the effect of reducing visual degradation experienced by sensitive receptors with views towards ADZs.	SFA	Duration of Construction Activities	SFA to monitor complaints received and logged by Operators in monthly monitoring report
7.4.5.2 Visual	Visual Resource and Light Pollution	Light pollution at night (construction, operations and decommissioning)	To reduce excessive lighting or illumination at cage sites	No complaints from sensitive receptors	In addition, operators should limit the amount of lighting / illumination and/or the intensity of such lighting on board of the floating cages. For safety reasons, navigational lighting has specific standards that need to be implemented, however lighting for on-board crew can be adjusted to an absolute minimum required in order reduce any excess light pollution that may be visible from shore. Utilise security lighting (if feasible) that is movement activated rather than permanently switched on, to prevent unnecessary constant illumination. Avoid up-lighting of structures by rather directing lighting downwards and focused on the area to be illuminated.	Fish Farm Operators	Duration of Construction Activities	Complaints should be logged and reported weekly.
7.4.6.2 Noise	Noise	Excessive noise at the BQAF and R&D Facility sites causing annoyance or disturbance	To remain within national standards at site perimeter and at sensitive receptors	No exceedances of standards in Section APPENDIX G attributable to project	■ Noise mitigation measures should be implemented at all noise sources radiating **noise in excess of 85.0 dB(A).** Such measures may include: ▪ Installing suitable mufflers on engine exhausts and compressor components; ▪ Installing acoustic enclosures for equipment such as pumps and generators causing radiating noise; ▪ Installing vibration isolation for mechanical equipment; ■ Equipment/ technology with lower sound power levels should be prioritised in the procurement process ■ All equipment should be well maintained and frequently inspected to ensure optimum operation; ■ The use of the generators should be limited to when electrical supply is interrupted; and ■ A complaints reporting procedure should be established and all complaints logged. Investigations into the cause of the complaints should be initiated and appropriate mitigation measures applied timeously.	ECO/ SHEQ officer (from SFA)	Duration of the Operation	Complaints should be logged and reported monthly.

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
7.4.6.2 Noise	Noise	Excessive noise at the pilot project and ADZ sites causing annoyance or disturbance	To remain within national standards at site perimeter and at sensitive receptors	No exceedances of standards in Section APPENDIX G attributable to project	■ Plan routes to avoid known dive sites and/ or tourism routes and use existing transport routes where possible; ■ Ensure boats and engines are well maintained; and Avoid night-time activities. Sensitivity to noise increased during the night-time hours.	ECO/ SHEQ officer (from SFA)	Duration of the Operation	Complaints should be logged and reported monthly.
7.4.7.2 Social	Social change	Job opportunities and local employment	Maximise local employment	Developers to comply with national and MMP job criteria requirements	■ Recruit locally as a priority (from among those that are unemployed, poor or under income stress). ■ Contractors (if any) must be contractually obliged to use local labour as far as possible. ■ There should be an emphasis on employing the youth and women. ■ If specific skilled positions cannot be sourced within the local districts, they should be sourced at the national level first before looking at international workers. ■ Continue using the proposed community liaison officers to manage the local MMP public interface, specifically during the construction phase. ■ Maximise the usage of local service providers, including contractors. ■ A multi-level governance approach should be adopted to ensure all those with interest in mariculture is given the opportunity to learn more about this sector and be involved in decision-making on its future development (Stead 2016).	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Operational Activities.	Monthly
7.4.7.2 Social	Social change	Population influx	Manage population growth in the inner islands.	Developers to comply with national and MMP job criteria requirements	■ The use of local labour should be a key requirement in the tender documentation. ■ The operators must maximise the usage of local service providers. These requirements should be captured in a contractual agreement. ■ The SFA must ensure that all operators source the bulk of their employees from the local labour market. The focus on creating employment opportunities for the youth and women should continue. ■ The operators/investors should implement formal mentorship and skills development programmes to build the capacity of local candidates to fill the required skilled positions. ■ There should be a concerted effort, monitored by the SFA, by operators/investors to make provision to replace expatriates with local people over time. A twinning programme[16] could be a mechanism to achieve this. ■ The development areas highlighted in the Seychelles Strategic Land Use and Development Plan must be implemented to reduce the predicted pressure on social infrastructure. As per the IFC performance standards requirements, the development of an Influx Management Plan may be required if the population influx is high for the local area.	ADZ Developer (Policed by the SFA and relevant government department- MLUH)	Duration of Operational Activities.	Monthly
7.4.7.2 Social	Social change	Project-Induced In-Migration	Manage population in-migration into the MMP project areas.	Recruitment centre in place and utilised.	■ Recruitment through a formal employment office or info centre at Victoria, Mahe. ■ Monitor potential in-migration through observations of the community liaison officers (CLOs). ■ The extraordinarily high employment levels in the Seychelles will preclude any in-migration to a specific area due to the availability of jobs. ■ Significant labour imports are unlikely. ■ Being an island, a large movement of unofficial in-migration will be difficult. ■ It unlikely that any of the side effects of large scale immigration, with the associated drawbacks would realise.	The SFA and relevant government department (MLUH)	For the Duration of Operational Activities	Quarterly

[16] A twinning programme is one where the expat specialist works with a local understudy for a set number of years, after which the understudy becomes the lead. The expat will then continue for another year to provide advice and support to the local specialist.

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
7.4.7.2 Social	Social change	Skills Requirements	Enhance local skills development to address the current shortage of industry relevant skills	The SFA to fill scholarship, bursary and capacity building positions.	■ Identify the skills required for the operations of the mariculture projects . ■ Implement and coordinate a process to educate and train current and future students in the relevant scientific and technical aspects – ensure close linkages with UniSey and its international partners'. ■ Develop an approach or policy whereby operators and investors must appoint as many local specialists as feasible, possibly as an investment or corporate social responsibility criteria. ■ Appoint a scientific training coordinator to manage and coordinate this process.	The SFA and relevant government department (Department of Education)	Duration of operational activities.	Monthly
7.4.7.2 Social	Social change	Change in employment equity of vulnerable groups	To enhance the employment of women and youth.	Developers to comply with national and MMP job criteria requirements.	■ Implement the recommendations made to focus on involving women and the youth in the operations process. ■ Implement the skills training and capacity building focus as indicated in Sections 5.1.1 and 5.1.4.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Operational Activities	Monthly
7.4.7.2 Social	Social change	Impacts on daily living and movement patterns	Increase awareness on road access and safety	Comply with the necessary national health and safety regulations.	■ Communicate information regarding the operational routes (land and sea), operational times and associated information to the local district as well as the relevant community representatives. ■ Operational land traffic past community infrastructures such as schools, crèches, and sporting facilities must be strictly managed. ■ Sea traffic must consider tourism locations and activities to minimise adverse tourism and quality of life impacts. ■ Maintain the formal grievance mechanism.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Operational Activities	Monthly
7.4.7.2 Social	Social change	Introduction of New Social Classes and Related Socio-Cultural Impacts	To limit the number of outsiders with different values, beliefs and practices.	Developers to comply with national and MMP job criteria requirements.	■ Implement a comprehensive stakeholder engagement process. ■ Continue with the community liaison process recommended earlier. ■ Implement the mitigation measures proposed in section 5.2.4. ■ Develop appropriate exit strategy for the outside employees.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Operational Activities	Monthly
7.4.7.2 Social	Social change	Quality of life impacts	To manage the potential for adverse intrusions.	Comply with the necessary national health and safety regulations and EIA recommendation.	■ Continue with the community liaison process recommended earlier. ■ Ensure that the operational activities are planned to minimise intrusion impacts. ■ Consider the location and distance from hotels and tourism sites, diving or sport fishing sites or any other culturally or sensitive sites to minims the potential for intrusion impacts during the site selection and operational phases of the ADZ projects. ■ Consider photic intrusion when selecting the type and placement of light sources. ■ It is recommended that the measures identified in the EMP be followed to reduce the occurrence of any intrusion impacts. ■ Address issues and aspects identified using the proposed grievance mechanism in a timely and thorough fashion. Records of any such incidents should be kept and prompt feedback provided to the relevant stakeholders.	ADZ Developer (Policed by the SFA and relevant government department)	Duration of Operational Activities	Monthly
7.4.7.2 Social	Social change	Potential for Conflict between Mariculture and Other Users of the Sea	To manage the predicted conflicts between the artisanal and semi-industrial fishing subsectors	Adhere to signed agreements and grievance mechanisms.	■ On-going stakeholder engagement and a grievance mechanism are needed. ■ Develop mechanisms to allow entrance or joint ventures with maricuture project operators and investors. ■ ADZ investors must comply with all new MMP regulations, standards and licence conditions to guarantee sustainable healthy fishing practices. ■ All opportunities to benefit the artisanal fishing industry should be considered and implemented where feasible.	This can be the ADZ Developer (Policed by the SFA and relevant government department)	Duration of Operational Activities	Monthly

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
					■ SFA will need to set up a Mariculture Monitoring Committee to manage the new sector, to monitor the price of fish and various conflicts between operators and local fishermen (Stead, 2016). ■ Improve capacity building on the Mariculture industry.			
7.4.7.2 Social	Social change	Impacts on Social Infrastructure	To manage the predicted pressure on the existing social amenities.	Comply with national infrastructure development plans	■ The development areas highlighted in the Seychelles Strategic Land Use and Development Plan must be implemented to reduce the predicted pressure on social infrastructure. ■ Operating contractors/investors must comply with all MMP rules and regulations. ■ The involvement and capacity building of local stakeholders to participate in the projects must be driven robustly. ■ The sourcing of local skills and employees must be driven as a priority.	ADZ Developer (Policed by the SFA and relevant government department- MLUH)	Duration of Operational Activities	Monthly
7.4.8.2 Cultural Heritage	Cultural Heritage (Archaeological site, if present)	Impacts from anchoring of cages and service vessels.	To observe and avoid further impacts to unidentified archaeological resources.	*The National Monuments Act*, applicable international law, and, international conventions to guide internationally recognized practices (section 5.1 of CHIA)	Implement chance find procedure (section 5.6.1.1 of CHIA - APPENDIX I).	SFA, Developers and their sub-contractors, and a qualified consulting archaeologist	Duration of the Operation	Chance find.
DECOMMISSIOING PHASE								
7.4.3.4 Coral Reef and Benthos	Pollution and entanglement hazard	Disturbance and mortality to benthic organisms, sharks and turtles	Remove risk	Removal of all infrastructure	Essential mitigation measures: ■ Ensure that all infrastructure associated with the development of ADZs are removed from the sea and seafloor within 3 months of decommissioning a farm or ADZ ■ Rehabilitate site in terms of the Seychelles Marine Aquaculture and Sea-Ranching Regulations 2014.	Farm managers, SFA, independent ECO auditors	Within 3 months of decommissioning	Reporting at the end of the project
7.4.3.4 Coral Reef and Benthos	Pollution and entanglement hazard (pilot project cages)	Disturbance and mortality to benthic organisms, sharks and turtles	Remove risk	Removal of all infrastructure	Essential mitigation measures: ■ Ensure that all infrastructure associated with the development of ADZs are removed from the sea and seafloor within 3 months of decommissioning a farm or ADZ ■ Rehabilitate site in terms of the Seychelles Marine Aquaculture and Sea-Ranching Regulations 2014.	Farm managers, SFA, independent ECO auditors	Within 3 months of decommissioning	Reporting at the end of the project
7.4.3.4 Coral Reef and Benthos	Benthic organisms including adjacent coral reef (BQAF pipeline)	Disturbance and mortality	Limit disturbance and mortality of benthic environment and adjacent reef	NA	Essential mitigation measures: ■ Remove all pipeline infrastructure ■ Sensitive coral reef habitat exists in close proximity (<50 m) to the north-west of the proposed pipeline. This area must be a designated “no-go” area during the removal of all infrastructure	SFA, Contractor, Independent ECO auditor	Within 3 months of decommissioning broodstock facility	After 3 months have expired from the date of decommission. Report 4 months after the date of decommission
7.4.3.4 Coral Reef and Benthos	Coral reef organisms (R&D facility pipeline)	Mortality to coral reef organisms as a result of trampling and physical damage	Minimise disturbance and mortality from trampling and ageing infrastructure	No deviation outside of 1 m either side of the pipeline footprint by inspectors. All infrastructure removed within one year of decommissioning	Essential mitigation measures: ■ Remove all pipeline infrastructure within a year of it being decommissioned ■ Work only within a 2-m swath to reduce damage to adjacent reef	SFA, engineer, contractor	Within one year of the R & D facility being decommissioned	At the end of the project
7.4.5.3 Visual	Visual Resource	Reduction in visual resource value due to increased	To remain at least 2 km from the shoreline where sensitive receptors are present	No complaints from sensitive receptors	The SFA should limit placement and/or siting of fish farms within ADZs to a minimum of 2km from the direct line of sight of sensitive receptors should they occur. This can be achieved by refining the size and delineation of each ADZs, as well as the movement of ADZs by up to 1 nautical mile in certain instances. These measures should specifically apply with regards to sites PLD4 and	SFA	Duration of Construction Activities	SFA to monitor complaints received and logged by

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
		shipping/boat traffic (construction, operational and decommissioning activities)			SN2 in order to limit the visual intrusion towards sensitive receptors, which in these two instances are high value tourism establishments. Lastly, in order to reduce the visual intrusion that may be experienced by additional boat/shipping traffic, it is recommended that operators of fish farms try and schedule trips from main port to the fish farms at times of the day when receptors are least active. This may be during first light (early morning) or late afternoon before sunset. By scheduling boat and ship traffic, it may have the effect of reducing visual degradation experienced by sensitive receptors with views towards ADZs.			Operators in monthly monitoring report
7.4.5.3 Visual	Visual Resource and Light Pollution	Light pollution at night (construction, operations and decommissioning)	To reduce excessive lighting or illumination at cage sites	No complaints from sensitive receptors	In addition, operators should limit the amount of lighting / illumination and/or the intensity of such lighting on board of the floating cages. For safety reasons, navigational lighting has specific standards that need to be implemented, however lighting for on-board crew can be adjusted to an absolute minimum required in order reduce any excess light pollution that may be visible from shore. Utilise security lighting (if feasible) that is movement activated rather than permanently switched on, to prevent unnecessary constant illumination. Avoid up-lighting of structures by rather directing lighting downwards and focused on the area to be illuminated.	Fish Farm Operators	Duration of Construction Activities	Complaints should be logged and reported weekly.
7.4.6.3 Noise	Noise	Excessive noise at the BQAF and R&D Facility sites causing annoyance or disturbance	To remain within national standards at site perimeter and at sensitive receptors	No exceedances of standards in Section APPENDIX G attributable to project	■ Notify neighbours prior to commencing activities that will generate significant noise. ■ A complaints reporting procedure should be established and all complaints logged. Investigations into the cause of the complaints should be initiated and appropriate mitigation measures applied timeously. ■ Construct noise barriers between noisy activities and noise-sensitive receptors. ■ Reroute truck traffic away from residential streets where possible. ■ Site noise generating equipment such as generators as far away from noise sensitive receptors as possible. ■ Shut down or throttle down equipment (such as backhoes, cranes, bobcats, loaders and generators) whenever they are not in actual use. ■ Combine noisy operations to occur in the same time period. ■ Avoid night-time activities. ■ Select quieter equipment where possible. ■ Use newer equipment where possible. ■ Ensure equipment is well maintained. ■ Construct temporary walled enclosures around especially noisy activities or clusters of noisy equipment. Ensure personel are trained to carry out their respective tasks.	ECO appointed by Contractors	Duration of decommissioning Activities	Complaints should be logged and reported weekly.
7.4.6.3 Noise	Noise	Excessive noise at the pilot project and ADZ sites causing annoyance or disturbance	To remain within national standards at site perimeter and at sensitive receptors	No exceedances of standards stated in Noise Impact Assessment Report attributable to project	■ Plan routes to avoid known dive sites and/ or tourism routes; ■ Ensure boats and engines are well maintained; and ■ Avoid night-time activities. Sensitivity to noise increased during the night-time hours.	ECO appointed by Contractors	Duration of decommissioning Activities	Complaints should be logged and reported weekly.
7.4.7.3 Social	Social Change	Loss of Employment	To manage the decrease in employment positions.	Comply with local labour regulations.	■ Provide employees with clear, transparent information on planned activities and closure dates for relevant ADZ sites. ■ Offer employment to current employees at alternative ADZ sites.	ADZ Developer (Policed by the SFA and relevant government department)	Pre-closure and decommissioning and for the duration of the closure phase.	Weekly
7.4.7.3 Social	Social Change	Loss of economic benefits	To manage the reduced national	Maintain GDP contribution.	■ Provide stakeholders with clear, transparent information on planned activities and closure dates for relevant ADZ sites. ■ ADZ investors must comply with MMP regulations, standards and licence conditions.	The SFA and relevant	Pre-closure and decommissioning and for the	Monthly

Section No	Aspect (of Activity Service or Product)	Potential impact	Objectives	Performance Criteria	Mitigation measure(s)	Responsible person / party	Time-frame	Monitoring and Reporting Frequency
			economic contributions.		■ Implement adequate exit strategy.	government department.	duration of the closure phase.	
7.4.8.3 Cultural Heritage	Cultural Heritage (Archaeological site, if present)	Impacts from anchoring of cages and service vessels.	To observe and avoid further impacts to unidentified archaeological resources.	The *National Monuments Act*, applicable international law, and international conventions to guide internationally recognized practices (section 5.1 of CHIA)	Implement chance find procedure (section 5.6.1.1 of CHIA - APPENDIX I).	SFA, Developers and their sub-contractors, and a qualified consulting archaeologist	Duration of decommissioning activities	Chance find.

8.5 Environmental Awareness Plan

As stipulated in section 8.2.1 above, environmental conditions will be included in any operational contracts or licenses, thereby making contractors or operators aware of the potential environmental risks associated with the project and the necessity of implementing good environmental and housekeeping practices.

The following principles and training will apply to the Environmental Awareness Plan and the Environmental Management System (EMS), should operators implement one:

- All personnel, including contractors, will as a minimum undergo general safety, health and environmental (SHE) induction and environmental management system (EMS) training, if the latter is implemented;
- The General Manager / Environmental Manager or Safety, Health, Environmental and Quality (SHE) Manager of individual fish farms or aquaculture facilities will identify the SHE training requirements for all personnel and contractors. The training requirements will be recorded in a training needs matrix indicating particular training that must be undertaken by identified personnel and contractors. The training matrix will be administered by the relevant operators Human Resources Department (HRD); and
- Development of the training programme, which will be based on the ESMP and will include:
  - Job specific training – training for personnel performing tasks which could cause potentially significant environmental impacts;
  - Assessment of extent to which personnel are equipped to manage environmental impacts;
  - Basic environmental training;
  - EMS training (if one is implemented by an individual fish farm or facility);
  - Comprehensive training – on emergency response or other pertinent topics;
  - Specialised skills;
  - Training verification and record keeping; and
  - Periodic re-assessment of training needs, with specific reference to new developments, new technologies, newly identified issues and impacts and associated mitigation measures.

8.6 General Awareness Training

The Human Resources Development (HRD) Manager, together with the General Manager / Environmental Manager / SHE Manager, will be responsible for the development of, or facilitating the development of, the required general SHE induction and awareness training. A general environmental awareness training module should be developed and integrated into the general induction programme for each fish farm operator or aquaculture facility.

The general awareness training must include the Environmental Policy, a description of the environmental impacts and aspects and the importance of conformance to requirements, general responsibilities of the operator's personnel and contractors with regard to the environmental requirements and a review of the emergency procedures and corrective actions.

8.7 Specific Environmental Training

- Specific environmental training will be in line with the requirements identified in the training matrix; and
- Personnel whose work tasks can impact on the environment will be made aware of the requirements of appropriate procedures/work instructions. The General Manager / SHE Manager of fish farms will communicate training requirements to responsible supervisors to ensure that personnel and contractors are trained accordingly.

8.8 Training Evaluation and Re-training

- The effectiveness of the environmental training will be reflected by the degree of conformance to the ESMP requirements, the result of internal audits and the general environmental performance achieved by the individual fish farms or aquaculture facilities;
- Incidents and non-conformances will be assessed through the Internal Incident Investigation and Reporting System, to determine the root cause, including the possible lack of awareness/training;
- Should it be evident that re-training is required, the General Manager / SHE Manager will inform the designated person of the need and take the appropriate actions;
- General awareness training of all personnel shall be repeated annually; and
- The re-induction shall take into consideration changes made in the ESMP, changes in legislation, current levels of environmental performance and areas of improvement.

8.9 Emergency Procedures

The following emergency procedures are relevant to the project:

- The SHE Manager shall define emergency reporting procedures for that particular fish farm or aquaculture facility;
- All personnel shall be made aware of emergency reporting procedures and their responsibilities;
- Any environmental incidents will be dealt with immediately and rectified in accordance with relevant legislation or standards (major incidents will require notifying SFA/regulator immediately); and
- Telephone numbers of emergency services, the local fire-fighting and medical services, shall be conspicuously displayed.

In addition, any major incidents should be reported to SFA/regulator of aquaculture sector as soon as possible.

8.10 Monitoring

8.10.1 Physical Oceanography

The suitability of Seychelles' maritime zone is the basic fundamental that determines whether it is possible to farm fish in cages in the region. The review of MMP products and literature studies presented above provides a certain level of confidence with respect to the met-ocean conditions that appear to be suited to aquaculture development. **However, the vast majority of studies and findings of the data review presented herein underscored that more site-specific and long-term data should be collected to establish baseline conditions.** Such a conclusion appears to be a recurrent statement within studies targeting the Seychelles metocean conditions, in particular throughout the various MMP reports. As well, the impact of climate change including any potential shifts in the cyclone belt variability in the Indian Ocean should be taken into account when developing further strategy to strengthen metocean forecast and assessing aquaculture capacity for the Seychelles. Long-term current and wave data are needed for baseline monitoring purposes but also for operational modelling validation. It has therefore been proposed that SFA/Regulator employs an ongoing current monitoring programme, whereby 12 month monitoring data at each ADZ is acquired, and prior to development. This excludes the initial sites targeted for development as they have been sited over areas which have been approved for sand mining and where sufficient current data exists. Going forward, current data colelctiona and far field hydrodynamic modelling is required in order to confirm the movement and dilution of various constituents and which can be used as a management tool by the SFA.

The potential water quality impacts of effluents from aquaculture facilities was identified as a key factor to determine an achievable maximum fish production up to 42.92 tpa/ha. Monitoring of the marine environment and water quality in the vicinity of fish farms is a pre-requisite for successful growth given the risks associated with eutrophication, sedimentation, increased oxygen and carbon demand, and ecological regime

shifts (e.g. change in the structure and make-up of benthic communities). A precautionary principle of 10 tpa/ha was suggested as a starting point. Using an annual maximum production of 47.1 tons of fish production per culture cage in the Seychelles, modelling results show that on a weekly time scale this would result into limited solid waste accumulation on the seabed and negligible increases in suspended organic matter in the water column. Results show that a maximum potential flux of 30 mg C m-2 d-1 would be reached within the worst-case scenario due to solid waste releases.

In order to validate the results of our idealized model runs, further sensitivity analysis should be conducted using a greater range of scenarios of fish production, waste production and environmental conditions than those used in the modelling exercise presented above. Also, in order to validate any model results, monitoring of actual fish farm effluents and their impacts on baseline conditions would be needed during the project, for example through the deployment of sediment traps below selected culture cages to estimate the settling flux and through seawater collection for the analysis of dissolved organic carbon and nutrients. This could be done at least initially as part of the pilot project cage site at Providence.

So far the impact assessment conducted has been limited in scope and has focused on solid waste dispersion of faeces and uneaten feed. The outcomes of our idealized modelling approach remains thus limited, in particular with respect to re-entrainment of deposited waste, trajectory of the dissolved fraction and impact on the ecological systems. The paucity of in situ oceanographic data and the lack of information on the theoretical fish production per culture cage in the Seychelles MMP hindered the development of a site-specific dispersion model. A second phase of predicting modelling for the sinking and resuspension flux of particulate waste material from fish farms and the benthic community impact of that flux could be undertaken, for example through NewDEPOMOD[17] modelling that has a focus on post-depositional particle behaviour.

Finally, the development of a more sophisticated regional hydrodynamic model coupled to a biogeochemical and particle tracking model would be needed to study the actual dispersion of fish farm waste from a given ADZ, including the dissolved fraction and influence on the biology. More complex “waste products” such as fish parasites should also be targeted as part of any future modelling exercise.

8.10.2 Waste

8.10.2.1 Aquaculture Standard 18

Monitoring is an important component of ADZ management as it informs adaptive management. Section 6 of the *Aquaculture Standard 18: Effluent and Waste*, sets out minimum monitoring requirements for operators. The monitoring is based on seabed video and seabed photography capturing the nature and condition of the seabed. Information is recorded via transects and quadrats. The Standard indicates that the images are to be of sufficient detail and clarity to allow for the accurate assessment of benthic conditions. A brief written narrative with the tape or photographs describing current speed and direction and reference points are to be prepared.

8.10.2.2 Environmental monitoring

A range of environmental monitoring can be undertaken during the adaptive management phase of early ADZ farm development. In particular emphasis in monitoring should be given to benthic enrichment monitoring (as identified above in relation to *Aquaculture Standard 18: Effluent and Waste*). Monitoring needs to be adapted for each site specific ADZ depending on farm layout and local physical conditions (especially currents).

8.10.3 Coral Reef and Benthos

It is recommended that ESMPs are developed for each ADZ in their entirety, for each individual fish farm within a particular ADZ and for each ancillary development (i.e. pilot-project cage site, broodstock facility, and research and development facility. The ESMP for ADZ’s will allow for the management of the cumulative effects of all farms within it holistically. Such an ESMP should include all recommendations listed in the Environmental Impact Assessment Report and conditions outlined in the

[17] http://www.sams.ac.uk/kenny-black/newdepomod

Environmental Authorisation. ESMP's for farms within ADZs however, will allow for more efficient and precise management at the scale of individual concessions. This will in turn provide fish farmers with the opportunity to custom manage their facilities and allow designated authorities to more efficiently manage compliance. EMP's for farms should be formulated so that they are compatible, supportive and facilitative of the ESMP for the ADZ within the limits of the Environmental Authorisation.

A critical component of the proposed project and its associated ESMP is the management and monitoring of potential impacts on the environment. As discussed section 2.3.5, **it is recommended that the proposed development be phased in; this will allow for an adaptive management strategy that can be formulated and adjusted based on real-time environmental monitoring data as the project evolves and production increases in accordance with acceptable environmental thresholds and Republic of Seychelles Marine Aquaculture and Sea-ranching Regulations contained in the Fisheries Act 2014.**

An efficient and detailed monitoring programme that will guide and inform an adaptive management strategy is therefore an essential requirement. In order to manage the programme, a Monitoring Forum that comprises stakeholders from SFA, the mariculture industry, Seychelles National Parks Authority, independent scientists and community members should be established. An independent company(s) should then be managed and tasked by the Monitoring Forum to conduct environmental monitoring at each individual fish farm within ADZs and for the ADZs and Inner Island area at large. This will ensure objectivity and transparency, and facilitate the requirements and goals of the ESMP.

The Republic of Seychelles Marine Aquaculture and Sea-ranching Regulations is particularly relevant in highlighting specific aspects that need to be incorporated into a monitoring programme. These emphasise sustainability and the maintenance of ecosystem integrity informed by the FAO Code of Conduct for Responsible Fisheries and the associated Technical Guidelines for Aquaculture, in particular Supplement 4, "Ecosystem approach to aquaculture". They specifically mention fallowing, the maintenance of genetic diversity and biodiversity, pollution, disease, water quality and sediment monitoring and management. Furthermore, the Fisheries Act (2014) requires that an ecological baseline survey be conducted prior to any sea ranching activities to provide a benchmark for monitoring. This has not been undertaken in the detail required to allow for appropriate monitoring of potential impacts of the ADZs on benthic habitats and needs to form part of the monitoring programme of the ESMP.

As such, operations must be conducted within sustainable production capacities to prevent environmental degradation. Monitoring data may therefore be collected:

- as part of an EIA generated environmental and social management plan (ESMP);
- in compliance with some form of code of practice;
- for the information of the farmer in support of husbandry;
- by regulatory authorities as part of compliance; and
- by regulatory authorities as part of monitoring in the wider environment

It is recognised that components of a monitoring programme for each ESMP (ADZ, farm, pilot-cage project etc.) may vary and overlap to differing degrees, depending on whether the ESMP is for an individual farm or for an entire ADZ, or depending on the individual characteristics and requirements of each individual farm/development. Essentially, each fish farm within an ADZ should have its own monitoring programme for their respective EMP that is project specific and is compiled as and when it is developed. This should include for example farm specific monitoring and record keeping of animal husbandry, stock health, feeding programmes, water quality within and adjacent to cages, sediment sampling in the immediate vicinity of the farm cages and plans to deal with escapees and predators.

Components of a monitoring programme for an ADZ ESMP, however, would include monitoring for wider spatial and cumulative impacts of farms including monitoring further afield outside of zoned ADZs and at control sites so that the overall footprint of each ADZ can be determined. Furthermore, monitoring for the ADZ EMP would include studies of disease and parasites and genetic variability within wild

stocks, and status of ecosystem indicators further afield (e.g. coral reefs, habitat use by fish, cetaceans and sharks via telemetry studies). All farmers should contribute to an ADZ monitoring trust that provides funding for the monitoring component of the ADZ ESMP, with assistance from the state (SFA etc.).

In view of the guidelines provided by the Seychelles Aquaculture Standard: Responsible Finfish Cage Culture, studies undertaken in South Africa (CCA Environmental 2008; DAFF 2013), and the impacts highlighted in Section 4 of APPENDIX D, components for monitoring and management with particular reference to coral reef and benthic habitats are provided for in that report.

8.10.4 Social

The monitoring and reporting phase involves the collection, analysis, and dissemination of information overtime. This phase can assist in refining assessments, track the progress of social impact management approaches and identify changes needed, report to communities on impacts and activities, and facilitate an informed dialogue around these issues. Complaints handling processes (also known as grievance mechanisms) and participatory monitoring processes are essential activities during this phase (Franks 2011, 2012).

The monitoring programme outlines preliminary performance indicators and an approach to monitoring and reporting for the mitigation strategies. A more detailed monitoring program can be developed in consultation with the key stakeholders during the finalisation of the SMP. The principal objectives of the monitoring program will be to:

- Demonstrate compliance with the EIA and EMP commitments;
- Track the identified impacts and the delivery of their mitigation strategies;
- Identify new impacts arising from changing conditions and develop responses; and
- Enable regular stakeholder contact and feedback.

9.0 CONCLUSION

The Seychelles provides an attractive location for cage aquaculture due to the constant tropical environmental conditions, shallow water (20-50m depth) with generally soft/sandy sediments, low average wind and swell regimes, and no cyclones.

The site selection of ADZs was undertaken by the SFA and included an analysis of various hydrographic and oceanographic data available and benchmarking these findings against international standards and applying a rigorous process to the identification and subsequent refinement of aquaculture development zones.

Sixteen sites were originally selected, of which 25% did not fully meet the selection criteria and were rejected. The species that have been selected to launch the aquaculture sector, have been selected as a result of being naturally distributed in the Seychelles waters and the fact that the aquaculture production techniques are well established. Furthermore, they are economically viable due to their marketability and price. The technologies and carrying capacities calculated for the MMP ensure that any adverse environmental impacts and diseases are minimised by adopting a precautionary approach. Standards for responsible aquaculture and fish health further ensure that the industry will be operated according to international best practises to ensure sustainability.

The approach taken by the specialist team for the impact assessment presents a robust and pragmatic approach to assessing the pertinent potential impacts that were identified for the potential new aquaculture sector and relevant components covered under this ESIA. The predicted impacts that were evaluated and assessed included devising mitigation measures in order to reduce negative impacts and enhance positive impacts. These impacts and mitigation measures are contained in the ESMP.

Due to the comprehensive Seychelles Mariculture Masterplan process these impacts were anticipated and planned for with appropriate mitigation and management strategies, including the identification of sustainable ADZ sites, the setting of aquaculture production carrying capacities, Aquaculture Standards and Regulations and institutions and Government capacity to support industry development.

It is the opinion of the Environmental Assessment Practitioner (EAP) that, subject to compliance with the recommended mitigation measures, which are detailed in the ESMP, the proposed new aquaculture sector has significant positive aspects and acceptably low negative biophysical and socio-cultural impacts which can be managed by suitable monitoring and management interventions. It is the opinion of the EAP that it should be approved on the basis that overall the positive impacts outweigh the negative impacts.

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