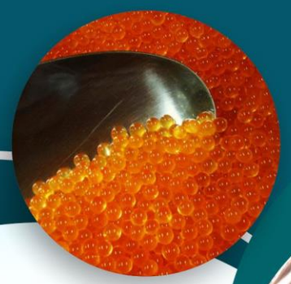
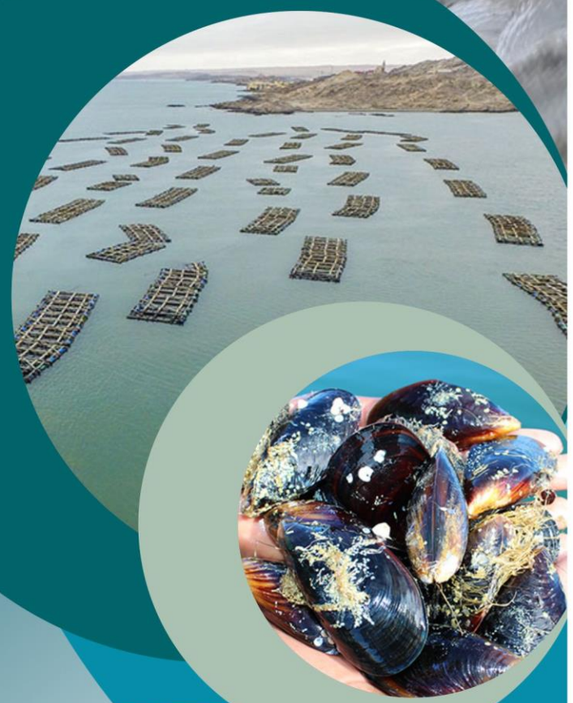
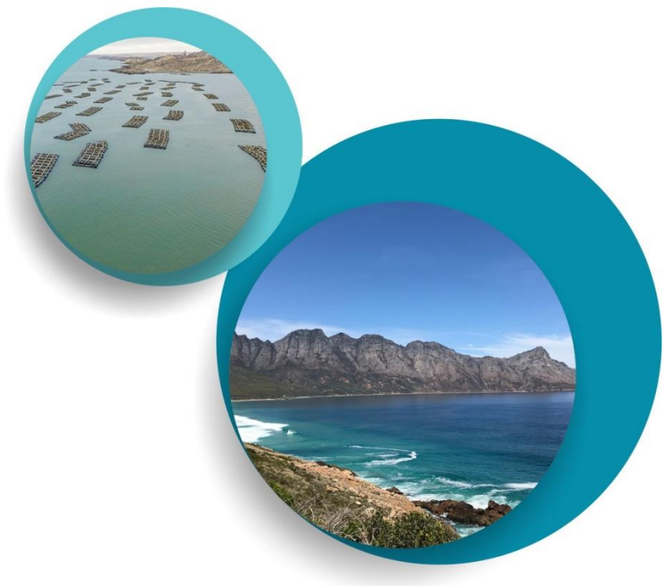
PART 2

IDENTIFICATION OF THE AQUACULTURE FOCUS AREAS





CONTENTS



TABLES

FIGURES

PART 2. IDENTIFICATION OF THE AQUACULTURE DEVELOPMENT ZONES

Introduction

This part of the report describes the approach followed to strategically identify eight marine and nine freshwater focus areas or aquaculture development zones (ADZs) during Phase 2 of the SEA process. The approach was developed in line with the context and study objectives described in the previous part of the report and is broadly based on an integrated multi-variate spatial analysis of the best available data at the time. The first step during Phase 2 involved the identification of strategic focus areas in South Africa that would have the highest potential for aquaculture development considering environmental and technical suitability. Following iterative consultation with government, industry and specialists, 17 study areas were prioritised and identified as eight marine and nine freshwater draft ADZs that were further assessed as part of the SEA process.

Section 2.1 Identification of Study Areas

National government continues to work towards creating an enabling environment to facilitate the development and growth of the South African aquaculture sector through the establishment of aquaculture development zones (ADZ's). The location of these ADZs are motivated based on the environmental and technical suitability of an area to sustain aquaculture activities, the extent of existing marine and freshwater aquaculture operations, the availability of state-owned land earmarked for future development, as well as suitable sea-space conducive for farming of various aquaculture species, in and along coastal provinces.

A key objective of the SEA process constituted Phase 2, a screening phase for which the main outcome was the identification of strategic focus areas or draft aquaculture development zones for marine and freshwater aquaculture (Figure 2-1). The strategic aquaculture focus areas served as study areas for specialist investigation and pre-assessment during Phase 3, the scientific assessment phase of the SEA process.

The identification of the strategic aquaculture focus areas for the purposes of the SEA constituted three main stages:

1) Variable and threshold identification;
2) A multi-criteria analysis using Geographic Information Systems;
3) Area selection and refinement. Iterative stakeholder engagement formed an integral part of identifying the strategic aquaculture areas.

In order to identify strategic freshwater and marine aquaculture focus areas, a multi-criteria analysis using geographical information systems (GIS) was undertaken using variables that considered existing conditions, uses- and users of the environment and water resources in particular, as well as high-level requirements of aquaculture facilities employing specific operational systems for farming different species. GIS analysis have increasingly become a crucial tool for planning and managing natural resources, and have been implemented around the world for identifying suitable, sustainable and optimal areas for aquaculture development using a range of environmental, economic, and social parameters.

The identification and investigation of strategic aquaculture focus areas aims to:

1) facilitate the development of aquaculture in an environmentally responsible manner;
2) assist and guide potential aquaculture developers by acting as a high-level development siting tool;
3) maximize the sustainability of new aquaculture development; and
4) stimulate the industry by reducing regulatory complexity and incentivizing development within the identified strategic focus aquaculture areas.

First, spatially explicit key siting variables, which would act as the input for the GIS analysis, were identified and selected in a workshop setting with stakeholders. The variables constituted push- and pull-factors which broadly represented environmental conditions and sensitivities; uses and users of the environment; as well as requirements of aquaculture facilities employing specific operational systems for breeding different species.

An initial list of key variables was compiled and workshopped with key stakeholders to determine key siting criteria for identifying suitable strategic aquaculture areas, per species. Workshop participants were also asked to rank the variables from one ("1" = most important / non-negotiable) to five ("5" = least important). Final selection of variables depended on the importance of the variable (as ranked by stakeholders) and the availability of adequate spatial data.

2.1.1 Positive Mapping

Various siting criteria considered as **pull factors** or opportunities were identified and ranked by stakeholders, after which a number of key variables were selected depending on its level of importance and availability of adequate data. These were then used as input to conduct a GIS analysis to identify the areas of significance for aquaculture development in South Africa.

2.1.1.1 Water Resource

Key environmental variables used that relate to water resources included dams, perennial rivers, irrigated crops (presence of irrigation schemes and water boards), mean annual runoff, sea surface temperature, and water quality and salinity.

2.1.1.2 Technical Suitability

Key environmental variables used that relate to technical suitability for aquaculture included topography, coastal and inland slope, sedimentation, turbidity and marine water depth.

2.1.1.3 Species-Specific Thresholds

Sufficient spatial data for sea surface temperature and marine water depth were available; therefore, species-specific thresholds with regards to these two variables were identified for mariculture species. Optimal and tolerable ranges for these thresholds were established with stakeholder input (Table 2-1).

Table 2-1. Optimal and tolerable marine water depth and sea surface temperature ranges for mariculture species considered in the SEA process.

			MARINE WATER DEPTH (m)		SEA SURFACE TEMPERATURE (°C)	
			Optimal	Tolerable	Optimal	Tolerable
OFFSHORE	Dusky kob		40	25 – 100	18 – 21	12 – 30
	Atlantic salmon		40	25 – 100	12 – 16	6 – 20
NEARSHORE	Dusky kob		35	25 – 70	22 – 25	12 – 30
	Atlantic salmon		35	25 – 70	12 – 16	6 – 20
	Bivalves (Mediterranean mussel & Pacific oyster)	Rafts	10	< 10	10 – 20	7 – 30
		Long-lines	15 – 20	< 10	10 – 20	7 – 30
ONSHORE	Abalone (incl. micro and macro algae)		-	1 – 50	14 - 18	< 25

Freshwater temperature was not considered in the GIS analysis as no reliable water temperature data was available for the entire country's freshwater bodies. Furthermore, air temperature was not deemed to be a reliable proxy for water temperature. Suitable temperature ranges for the different freshwater aquaculture candidate species considered in the SEA (i.e. African sharptooth catfish, Marron crayfish, Mozambique tilapia, Nile tilapia, Brown trout and Rainbow trout) were derived from general climatic suitability based on stakeholder input in refining the study areas.

2.1.1.4 Infrastructure Support

Key variables used that relate to ready access and infrastructure support included the proximity to launch harbours, major city / town centres, airports, electrical grid supply, markets, road infrastructure, and support services such aquaculture feed suppliers, laboratory facilities, technical skills base and veterinary services.

2.1.2 Negative Mapping

Various siting criteria considered as **push factors** or constraints were identified and ranked by stakeholders, after which a number of key variables were selected depending on its level of importance and availability of adequate data. These were then used as input to conduct a GIS analysis to identify the areas of significance where aquaculture development should not be promoted in South Africa.

Key high-level environmental and technical criteria deemed as constraints to aquaculture development included, amongst other, protected areas, critical biodiversity areas, sensitive aquatic, marine and terrestrial biodiversity areas (habitats), archaeological and cultural heritage sites, military areas, mining areas, fish sanctuaries, steep coastal and inland slope, stressed water catchments, extreme wave height, high risk areas for harmful algal blooms, sea space subject to major river plumes, waste outfalls, as well as existing water resource users and uses.

2.1.3 Study Areas

The GIS analysis to delineate strategic aquaculture areas has consisted of four steps: a) data preparation; b) reclassification; c) Weighted Overlay Analysis; and d) area extraction. This process was conducted separately for freshwater aquaculture and marine aquaculture.

2.1.3.1 Data preparation and reclassification

Most recent and available spatial data for the selected key environmental, social and economic variables were collated and vector data was converted to raster format. Each raster dataset was reclassified into a gradient of classes, from 'Restricted' (0) to 'Most Suitable' (5). For example: In the South African Protected Areas Database (SAPAD) spatial dataset, a formal protected area was scaled as 'Restricted' as it is assumed no regulatory streamlining may be proposed for areas that are formally protected by law, whilst an area that is not a protected environment was scaled as 'Most Suitable' as it is assumed that, at a strategic level, there would be a smaller risk of aquaculture activities being in conflict with priority conservation areas.

2.1.3.2 Weighted Overlay Analysis

Weighted Overlay Analysis is a GIS spatial analysis tool that enables the analysis of multiple criteria to solve problems like site selection and suitability models using intra-variable scaling and inter-variable influence. Scale and influence were broadly derived from the variable ranking input from stakeholders.

The output of the Weighted Overlay Analysis consisted of a mosaic of 'suitability' classes ranging from least suitable / restricted to most suitable. A single output was generated for freshwater aquaculture. Marine aquaculture species were distinguishable based on data availability for sea surface temperature and marine water depth, therefore an output for each candidate species considered in the SEA process (i.e. abalone, Atlantic salmon, Dusky kob, Mediterranean mussel and Pacific oyster) was generated.

Metadata, including data sources for the key environmental and technical variables are provided in Table 2-2.

Table 2-2: Key selected environmental and technical variable metadata used to identify strategic aquaculture areas

FEATURE	DESCRIPTION	SPATIAL RESOLUTION	SOURCE	DATE
Dams	Dams of South Africa. Department of Water and Sanitation (DWS) dams use/purpose obtained from http://www.dwa.gov.za/Documents/DWS_DAMS%20LIST%20INTERNET.pdf. Dataset contains a total of 473 dams, for which the use/purpose of only 168 is recorded.	1: 250 000	Department of Water and Sanitation (DWS) (Url: http://www.dwaf.gov.za/iwqs/gis_data/river/rivs500k.aspx) and as updated by the National Freshwater Ecosystem Priority Area (NFEPA) study.	2005
Marine water depth	Raster dataset containing marine water depth along the coast of South Africa	30 arc second	The GEBCO_2014 Grid, version 20150318, www.gebco.net	2014
Irrigated lands	Crop field boundaries digitized from satellite imagery. Irrigated land extracted.	1:20 000	Department of Agriculture, Forestry and Fisheries (DAFF)	2013
	Irrigated crop boundaries were augmented with the latest 2013-2014 National Land Cover Data set.	30 m	GEOTERRAIMAGE (DEA Open Access)	2015
Slope	Steep slopes exceeding 10 % derived from Digital Elevation Model.	30 m	United States Geological Survey (USGS)	2015
National Parks	National Parks extracted from the South African Protected Areas Database (SAPAD) as well as National Protected Areas Expansion Strategy Focus Areas.	1: 5 000	Department of Environmental Affairs (DEA) (Url: https://egis.environment.gov.za/data_egis)	2017
Mean annual Sea Surface Temperature	Mean sea surface temperature globally from 2009 to 2013. The dataset was created using remotely-sensed MODIS Aqua data from NASA's (National Aeronautics and Space Administration) Ocean Color database.	0.08333 dd	NASA Ocean Biology (OB.DAAC). (2014). Mean annual sea surface temperature for the period 2009-2013 (composite dataset created by UNEP-WCMC). Data obtained from the Moderate Resolution Imaging Spectro-radiometer (MODIS) Aqua Ocean Colour website (NASA OB.DAAC, Greenbelt, MD, USA). Accessed 28/11/2014. URL: http://oceancolor.gsfc.nasa.gov/cgi/l3. Cambridge (UK): UNEP World Conservation Monitoring Centre. URL: http://data.unep-wcmc.org/datasets/36.	2014
Launch harbours	Important launch harbours identified by stakeholders, digitised as points.	1: 5 000	Council for Scientific and Industrial Research (CSIR)	2017
Major centres	Major centres identified by stakeholders, digitised as points.	1: 5 000	CSIR	2017
Extreme waves	Mean height of 1:1 year extreme waves at 15 m depth contour. Digitised as sections along the coast.	1: 5 000	CSIR coastal vulnerability study	2014
Stressed catchments	Highly stressed / over-exploited catchments	1: 500 000	Water Resources 2005	2002
Perennial rivers	Perennial rivers	1: 500 000	DWS (Url: http://www.dwaf.gov.za/iwqs/gis_data/river/rivs500k.aspx) and as updated by the National Freshwater Ecosystem Priority Area (NFEPA) study.	2004
	Present Ecological State (PES)		DWS (Url: http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx)	2014
Fish sanctuaries	Sub-quaternary catchments identified as important for protecting threatened or near-threatened indigenous fish species – National Freshwater Ecosystem Priority Areas	1: 500 000	CSIR	2011

Consider a range of key environmental, social and economic variables ranked as opportunities versus constraints based on stakeholder input and determine resulting potential for aquaculture development

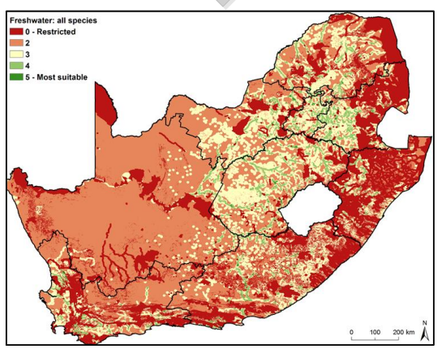
Apply an environmental and technical constraints mask to extract the most suitable aquaculture areas

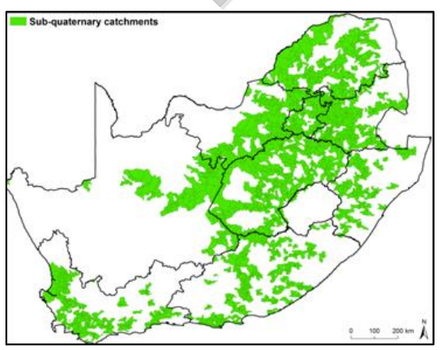
Obtain inputs from stakeholders and identify strategic study areas that have the highest aquaculture development potential and lowest environmental sensitivity

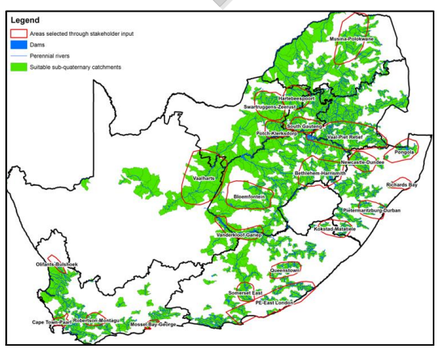
Obtain inputs from stakeholders to refine the identified study areas and delineate draft strategic aquaculture development zones

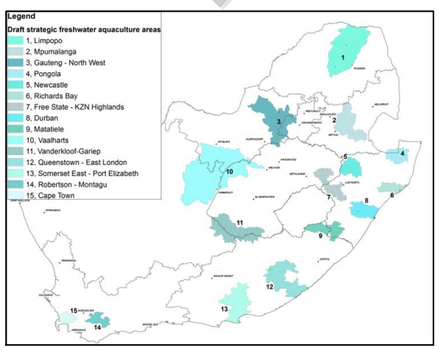
Obtain inputs from stakeholders to refine and select the final strategic aquaculture development zones for further assessment

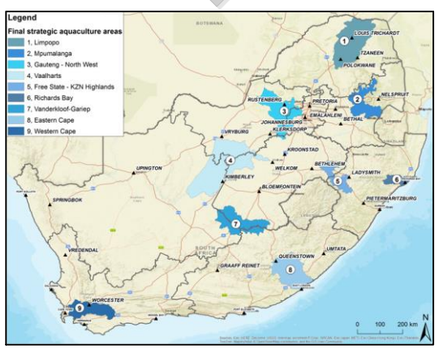
FRESHWATER AQUACULTURE



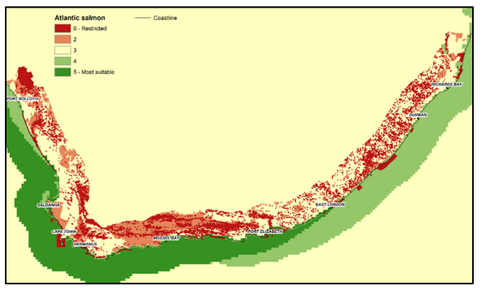


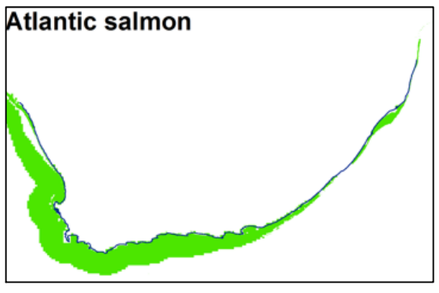


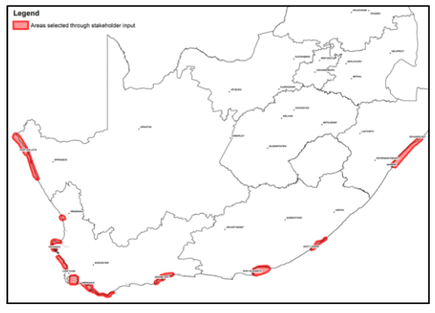




MARINE AQUACULTURE







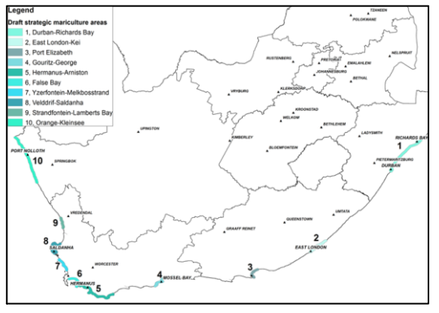


Figure 2-1: Illustration of the Freshwater and Marine Aquaculture Development Zones identification process

Section 2.2 Identification of Strategic Aquaculture Development Zones

The identification of the strategic aquaculture development zones for the purposes of the SEA constituted three main stages (Figure 2-2). Key components of this process included iterative consultation with key stakeholders and a spatial analysis using geographic information systems (GIS) techniques.

2.2.1 Stakeholder Consultation

Stakeholders were engaged at key points throughout the strategic aquaculture area identification process, and mainly consisted of (but not limited to) members of the Aquaculture SEA Project Steering Committee (PSC) and Expert Reference Group (ERG) which includes relevant national and provincial authorities, conservation agencies, research institutions, and industry representatives. The purpose of these workshops was to inform the stakeholders of the screening process and obtain their input into extracting and delineating the most suitable study areas that would be further assessed in the SEA process. Details of the outcomes of these workshops are provided in Appendix C-2.

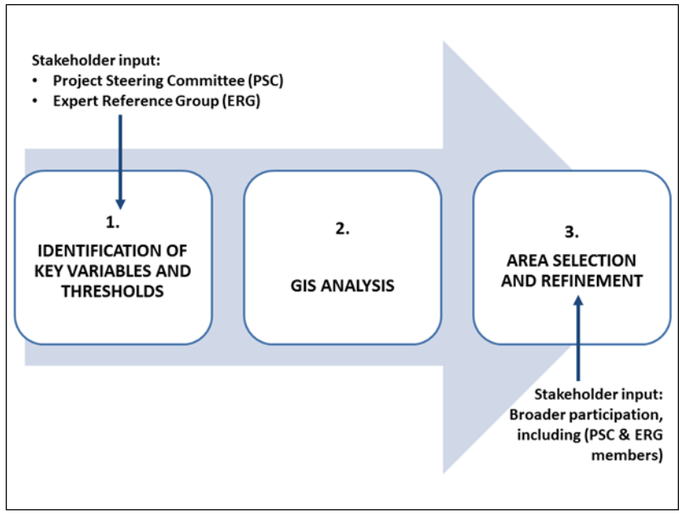


Figure 2-2. The three main stages in the process of identifying strategic areas for aquaculture development, with key points of stakeholder involvement.

2.2.2 Aquaculture Development Zones

A combination of GIS analysis and iterative stakeholder engagement processes (as described in Section 2.1 above) has produced a final 17 strategic aquaculture development zones (ADZs), eight marine ADZs (Figure 2-3) and nine freshwater ADZs (Figure 2-4) which served as study areas for specialist investigation in Phase 3, the scientific assessment phase of the SEA process. Existing aquaculture facilities, based on available information sourced from DEFF dated 2019 (work-in-progress), are shown in relation to the final ADZs. The existing aquaculture facilities database is a separate output from the SEA process and is based on information received from multiple stakeholders, including national and provincial authorities, conservation agencies, and industry associations (Appendix C-7).

2.2.2.1 Marine

A total of eight strategic aquaculture development zones were identified and selected for marine aquaculture. These areas are representative of all four coastal provinces of South Africa (Table 2-3).

Table 2-3: Final strategic marine aquaculture development zones, with the candidate species and production systems proposed for each area

	Name of strategic ADZ	Candidate Species	Production system	Province
1	Durban-Richards Bay	- Dusky kob	- Cage-culture - Land-based RAS - Land-based ponds	KwaZulu-Natal
2	East London-Kei	- Dusky kob	- Cage-culture - Land-based RAS - Land-based ponds	Eastern Cape
		- Abalone*	- Land-based flow-through tanks	
3	Port Elizabeth	- Dusky kob	- Cage-culture - Land-based RAS - Land-based ponds	Eastern Cape
		- Abalone*	- Land-based flow-through tanks	
		- Mediterranean mussel	- Longlines/rafts	
		- Pacific oyster	- Longlines/rafts	
4	Gouritz-George	- Abalone*	- Land-based flow-through tanks	Western Cape
		- Mediterranean mussel	- Longlines	
		- Pacific oyster	- Longlines	
5	Hermanus-Arniston	- Abalone*	- Land-based flow-through tanks	Western Cape
		- Atlantic salmon	- Cage-culture - Land-based RAS	
		- Mediterranean mussel	- Long-lines	
		- Pacific oyster	- Long-lines	
6	Velddrif-Saldanha	- Abalone*	- Land-based flow-through tanks	Western Cape
		- Atlantic salmon	- Cage-culture - Land-based RAS	
		- Mediterranean mussel	- Longlines/rafts	
		- Pacific oyster	- Longlines/rafts - Land-based nurseries	
7	Strandfontein-Lamberts Bay	- Abalone*	- Land-based flow-through tanks	Western Cape
		- Atlantic salmon	- Land-based RAS	
		- Mediterranean mussel	- Longlines/rafts	
		- Pacific oyster	- Longlines - Land-based nurseries	
8	Orange-Hondeklip Bay	- Abalone*	- Land-based flow-through tanks	Northern Cape
		- Atlantic salmon	- Land-based RAS	
		- Pacific oyster	- Land-based nurseries	

**Abalone includes micro- and macro algae often associated with abalone farms.*

2.2.2.2 Freshwater

A total of nine final strategic aquaculture development zones were identified and selected for freshwater aquaculture. These areas are representative of all nine South African provinces (Table 2-4).

Table 2-4: Final strategic freshwater aquaculture development zones, with the candidate species and production systems proposed for each area

	Name of strategic ADZ	Candidate Species	Production system	Province
1	Limpopo	- African sharptooth catfish	- Dam cage-culture - Ponds - Recirculating aquaculture system (RAS)	Limpopo
		- Mozambique tilapia	- RAS - Ponds	
		- Nile tilapia	- RAS	
2	Mpumalanga	- Mozambique tilapia	- RAS - Ponds	Mpumalanga
		- Nile tilapia	- RAS	
		- Rainbow and Brown trout	- Dam cage-culture - Ponds - Flow-through (raceways & tanks) - RAS	
3	Gauteng - North West	- African sharptooth catfish	- Dam cage-culture - Ponds - Flow-through (tanks) - RAS	Gauteng North West
		- Mozambique tilapia	- RAS - Ponds	
		- Nile tilapia	- RAS	
4	Vaalharts	- African sharptooth catfish	- Dam cage-culture - Ponds - RAS	Free State North West Northern Cape
5	Free State - KZN Highlands	- Rainbow and Brown trout	- Flow-through (raceways & tanks) - Dam cage-culture - Ponds - RAS	Free State KwaZulu-Natal
6	Richards Bay	- African sharptooth catfish	- Dam cage-culture - Ponds - RAS	KwaZulu-Natal
		- Mozambique tilapia	- RAS - Ponds	
		- Nile tilapia	- RAS	
7	Vanderkloof-	- African	- Dam cage-culture	Eastern Cape

	Name of strategic ADZ	Candidate Species	Production system	Province
	Gariep	sharptooth catfish	- Ponds - RAS	Free State
		- Rainbow and Brown trout	- Flow-through - Dam cage-culture - Ponds - RAS	Northern Cape
8	**Eastern Cape**	- Marron	- RAS	Eastern Cape
		- Mozambique tilapia	- RAS - Ponds	
		- Nile tilapia	- RAS	
		- Rainbow and Brown trout	- Flow-through (tanks) - Dam cage-culture - Ponds - RAS	
9	**Western Cape**	- Rainbow and Brown trout	- Flow-through (tanks) - Dam cage-culture - Ponds - RAS	Western Cape
		- Mozambique tilapia*	- RAS - Ponds	
		- Nile tilapia*	- RAS	
		- African sharptooth catfish*	- RAS	

**Note that although these three species can also be farmed in the Western Cape ADZ preferably within the indicated production systems, this focus area was only pre-assessed in terms of its sensitivity to farming with Brown and Rainbow trout during this SEA. The addition of these species to the Western Cape ADZ is based on comments received from CapeNature.*

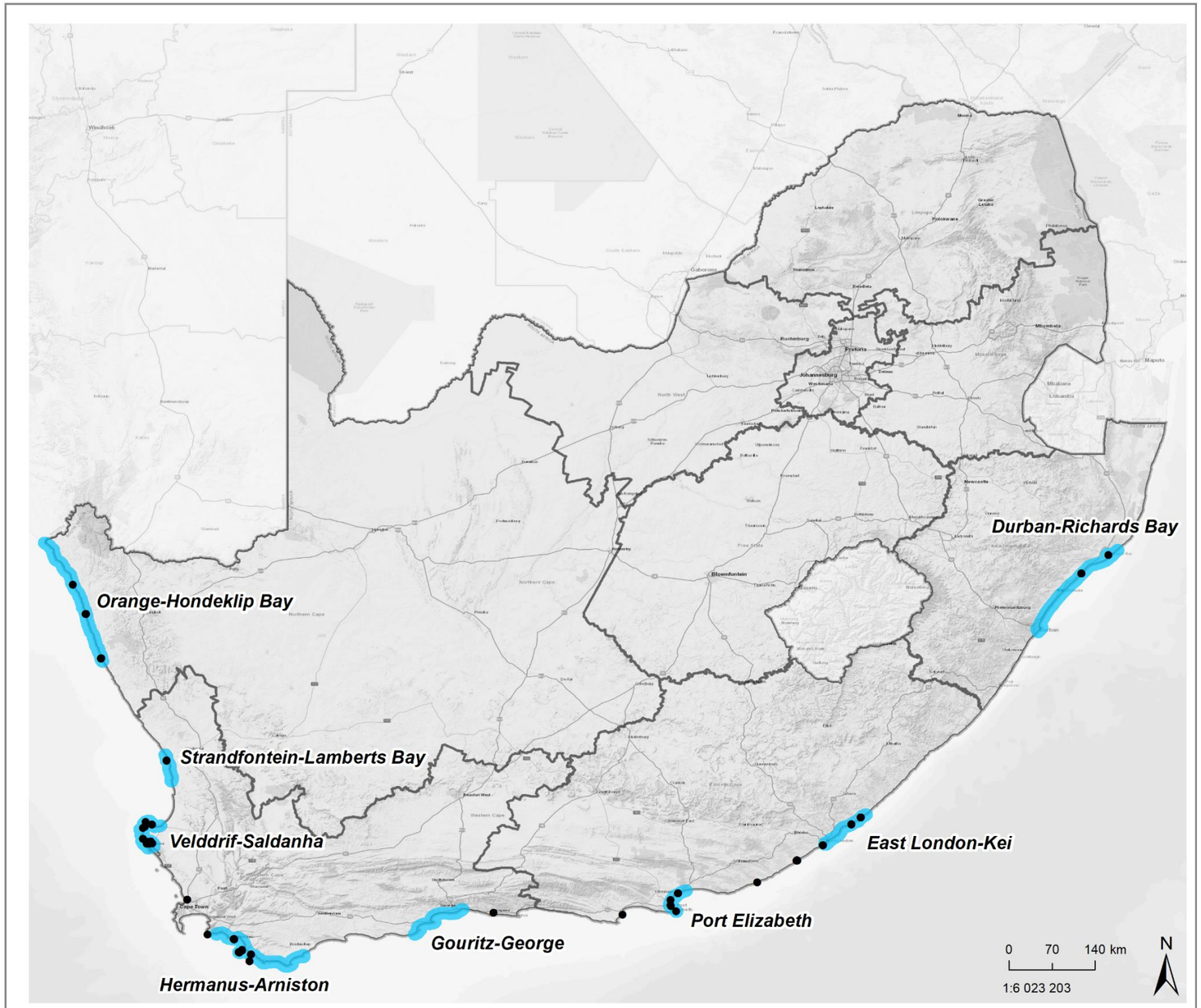


Figure 2-3: Final strategic marine aquaculture development zones that were further assessed in Phase 3 of the SEA process.

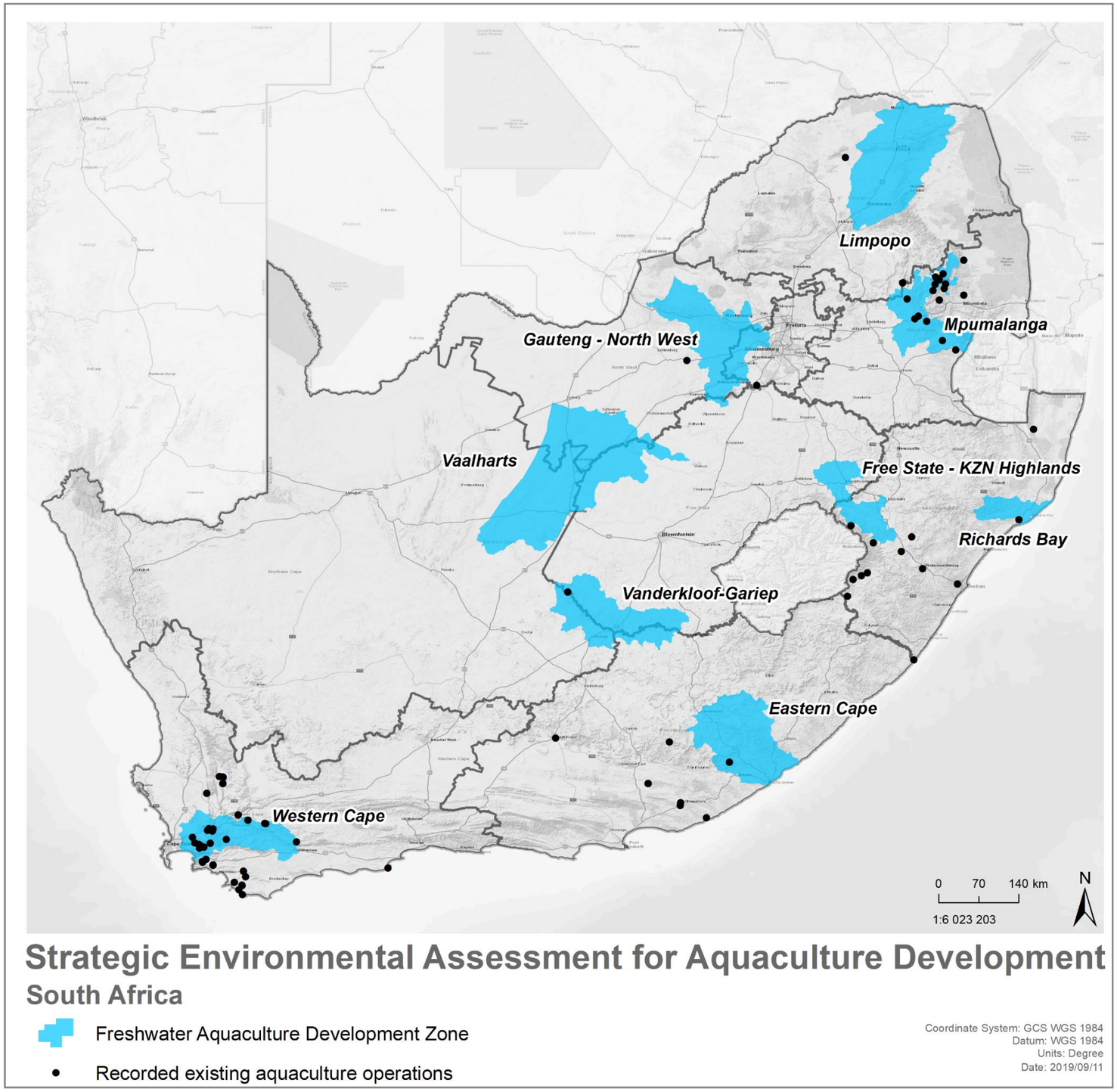


Figure 2-4: Final strategic freshwater aquaculture development zones that were further assessed in Phase 3 of the SEA process.