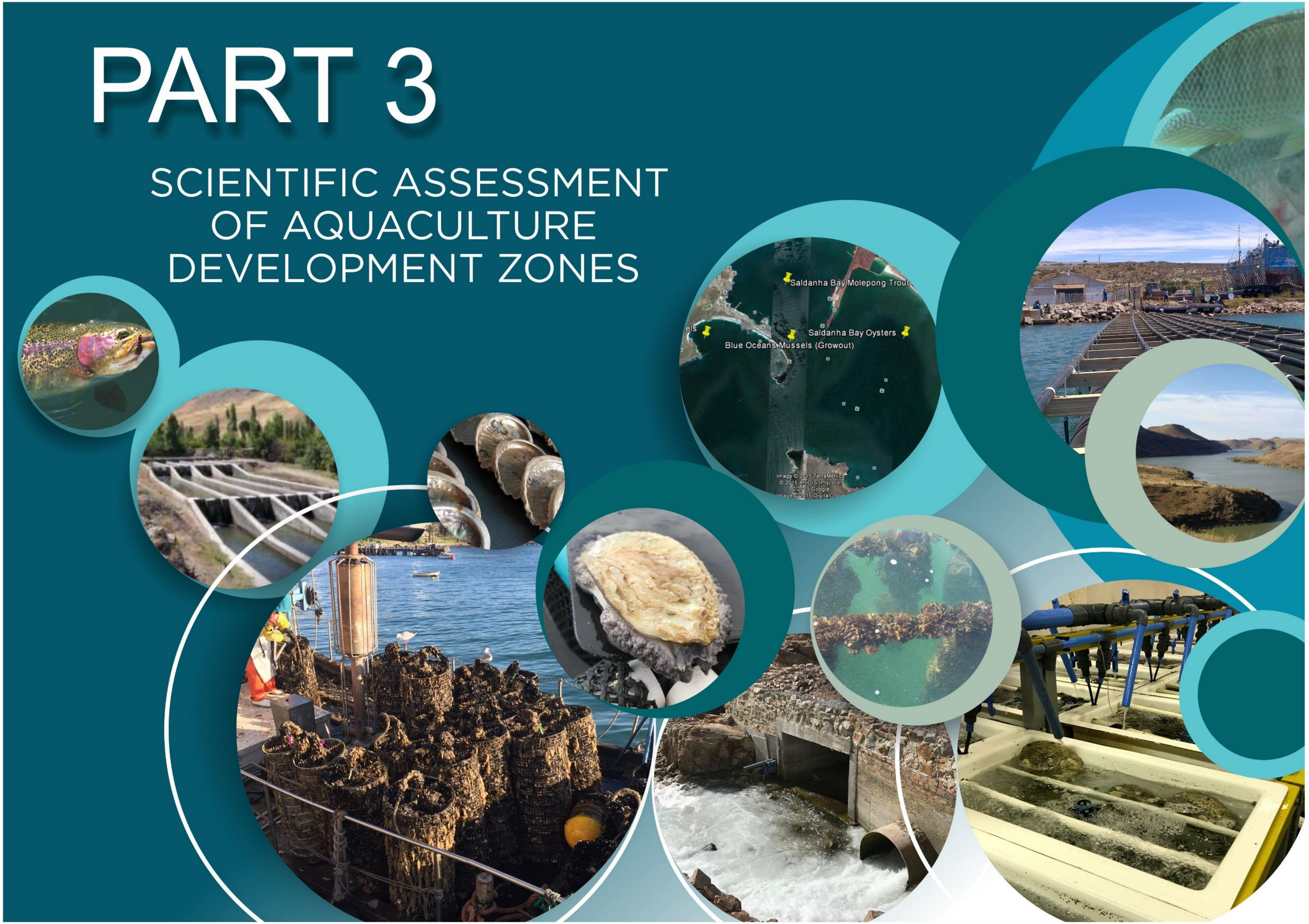
PART 3

SCIENTIFIC ASSESSMENT OF AQUACULTURE DEVELOPMENT ZONES



PART 3.1

Marine Biodiversity and Ecology

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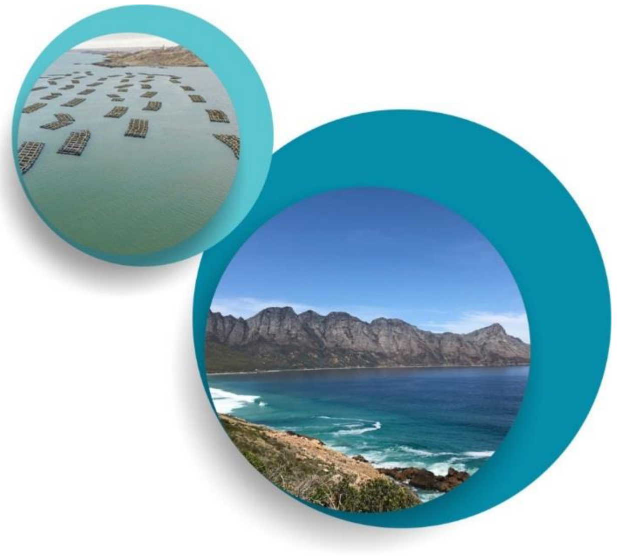

PART 3. SCIENTIFIC ASSESSMENT OF AQUACULTURE DEVELOPMENT ZONES

Section 3.1 Marine Biodiversity and Ecology

Fisheries and aquaculture are important sources of food (protein), income generation and livelihoods for millions of people throughout the world. In South Africa, aquaculture production has increased significantly during the last two decades and marine operations are currently the main contributor to total aquaculture production.

Marine aquaculture (mariculture) relies on conducive environmental and technical conditions to ensure efficient production, health of stocks and product quality. However, if not properly designed and operated, mariculture activities can detrimentally impact coastal environments and affect the value that other users derive from coastal resources.

Finfish and shellfish farming in marine environments pose a wide range of potential environmental impacts and risks to marine biodiversity and ecology. These impacts/risks merited strategic-level investigation in considering the sustainability of marine aquaculture (mariculture) in eight identified marine aquaculture development zones (ADZs) along the South African coast.

3.1.1 Environmental Attributes

Generically important, spatially explicit (mappable) ecological features and socio-economic uses typified of coastal and marine environments were identified and included the following:

- **Ecological:** Formally protected areas; estuaries (specifically marine environments adjacent to estuaries); fluvially-derived banks; aggregation areas for important marine species (e.g. seal, penguin colonies, islands); important fishery nurseries; critically endangered habitats; endangered habitats; vulnerable habitats; least threatened habitats; and
- **Socio-economic:** Important recreational areas (Blue Flag beaches and popular diving sites); high density urbanised areas; cultivated lands; commercial ports; small ports and fishing harbours.

These features and uses were rated in terms of their sensitivity to anthropogenic, specifically mariculture pressures. This enabled the identification of ecological and socio-economic sensitivities across each of the eight study areas, and representing these spatially in zones categorised as being of very high, high, moderate and low sensitivity. This allowed the development of geo-referenced ecological and socio-economic attribute and environmental sensitivity maps for each of the mariculture study areas.

3.1.2 Sensitivity Mapping

Available information was used to describe key environmental (e.g. physical processes and biotic habitat) and socio-economic attributes within each of the marine study areas. Considering the large spatial scale of this assessment, a generic suite of environmental and socio-economic indicators, mappable using existing knowledge and available datasets, and which were suitable for assessing potential risks associated with mariculture, were selected (Table 3.1-1).

Based on available information, in addition to the authors' knowledge of estuarine and coastal ecosystem sensitivities to anthropogenic effects (such as those posed by mariculture), each of these indicators was allocated a sensitivity rating (Table 3.1-1). Sensitivity maps were produced for each study area demarcating the presence and locations of socially, economically and ecologically sensitive areas. Areas of significance located within the study areas, other than those described by the generic indicators and which could potentially pose site-specific risks to mariculture, were also highlighted.

Table 3.1-1. Selected ecological and socio-economic sensitivity indicators and associated sensitivity ratings used in this assessment

Sensitivity Indicator		Brief description	Sensitivity Rating
Ecological sensitivity	Formally protected areas	Marine, estuarine and terrestrial areas within the study area boundaries that are under formal protection.	Very High
	Estuaries (specifically marine environments adjacent to estuaries)	Although this assessment does not consider mariculture activities in estuaries, impacts on the marine environment adjacent to these systems can result in detrimental effects through their connectivity with the sea. Estuaries (as demarcated by estuarine functional zones) are included as a sensitivity category in this assessment to caution against development in marine areas immediately adjacent to estuary mouths (i.e. development buffer zones).	High
	Fluvially-derived banks	Fluvially-derived banks and plumes typically develop in the marine environment where large rivers deliver high sediment loads to the coast. These banks and plumes fulfil an important ecological role as unique habitats in South African marine areas, as refugia for estuarine biota during times of high flow, and in providing cues for estuarine recruitment. These areas are characterised by fine sediments and are therefore prone to sediment quality impacts. Because plumes are important habitats (e.g. turbid, nutrient rich areas) for certain biota, they are also included here.	High
	Aggregation areas for important marine species	Areas where important marine fauna aggregate include significant breeding, nursery and feeding sites for marine biota (e.g. seals, penguins, Cape gannets), cetaceans (dolphins, whales), sharks, or rare and over-exploited species. For this assessment large seal and penguin colonies, as well as islands are used as key indicators of aggregation areas.	High
	Important fishery nurseries	Estuaries and adjacent marine areas that are important nursery areas for fish and shellfish populations, and which support fisheries.	Very High
	Critically endangered habitats	Natural habitats identified in the National Biodiversity Assessment (2011) as being critically endangered, and coastal forest and dune habitat as identified in SANBI (2012).	Very High
	Endangered habitats	Natural habitats identified in the National Biodiversity Assessment (2011) as being endangered.	High
	Vulnerable habitats	Natural habitats identified in the National Biodiversity Assessment (2011) as being vulnerable.	Moderate
	Least threatened habitats	Natural habitats identified in the National Biodiversity Assessment (2011) as being least threatened.	Low
Socio-economic sensitivity	Important recreational areas	Areas where direct use is made of coastal waters for recreational purposes. These include Blue Flag beaches which are places designated and valued as safe and clean swimming areas and popular diving sites. These areas generate (either directly or indirectly) tourism income for local municipalities and mariculture impacts may result in loss of revenue. Issues relate to aesthetics, water quality and competition for space.	High
	High density urbanised areas	Urbanised areas and cultivated lands where (especially) land-based mariculture may result in competition for terrestrial space with other users. Highly urbanised areas and cultivated lands (as per the 2014 Land Cover) are included as a sensitivity category.	High
	Cultivated lands		Low
	Commercial ports	Ports and harbours provide opportunity for mariculture (e.g. sheltered waters and proximity of land and infrastructure for processing and dispatching of products), but mariculture development can result in competition for space with port and harbour activities, as well as other industrial and commercial activities linked to ports and harbours.	High
	Small ports and fishing harbours		Moderate

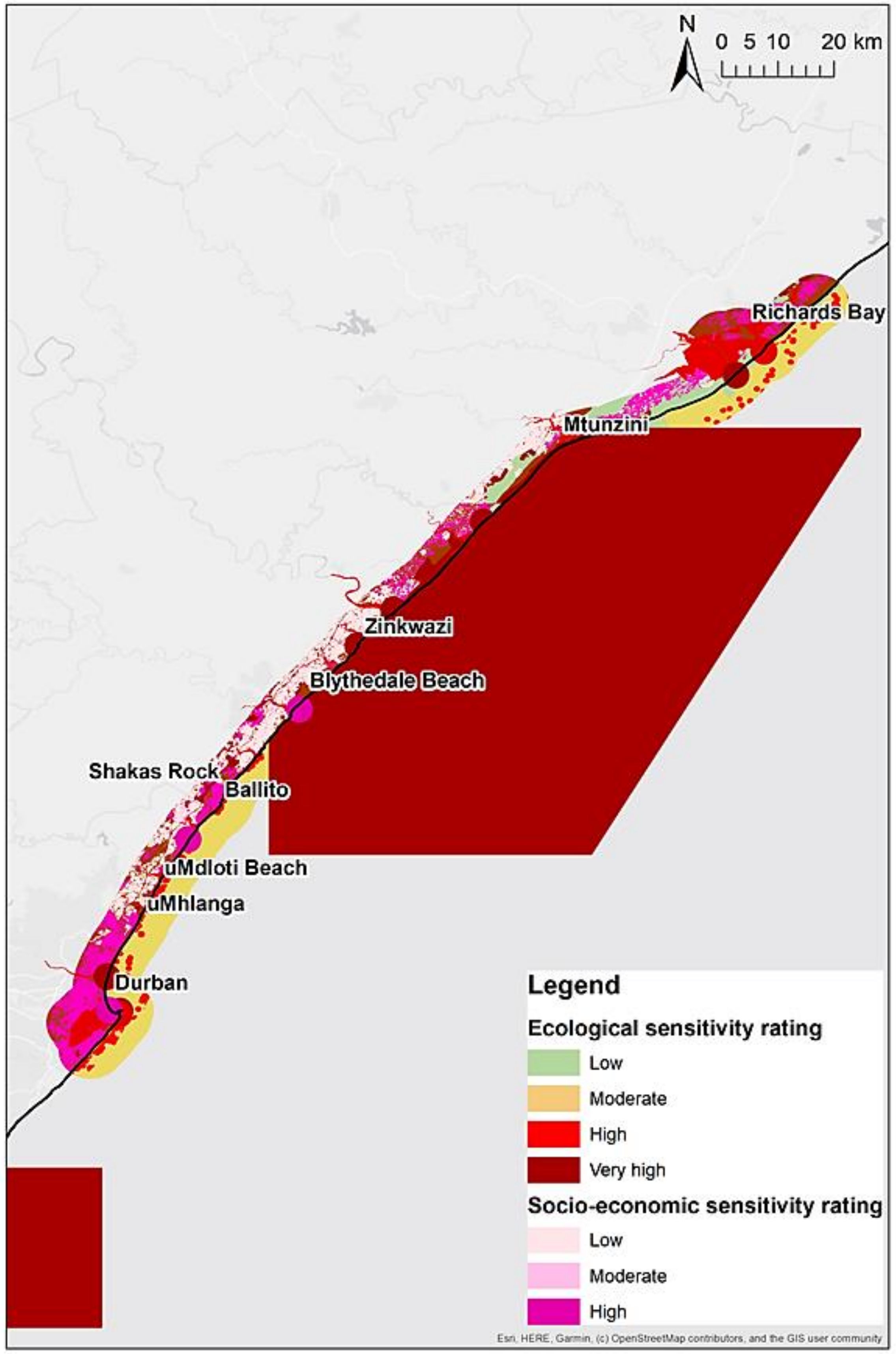

Figure 3.1-1: Ecological and socio-economic sensitivity of the Durban – Richards Bay Study Area

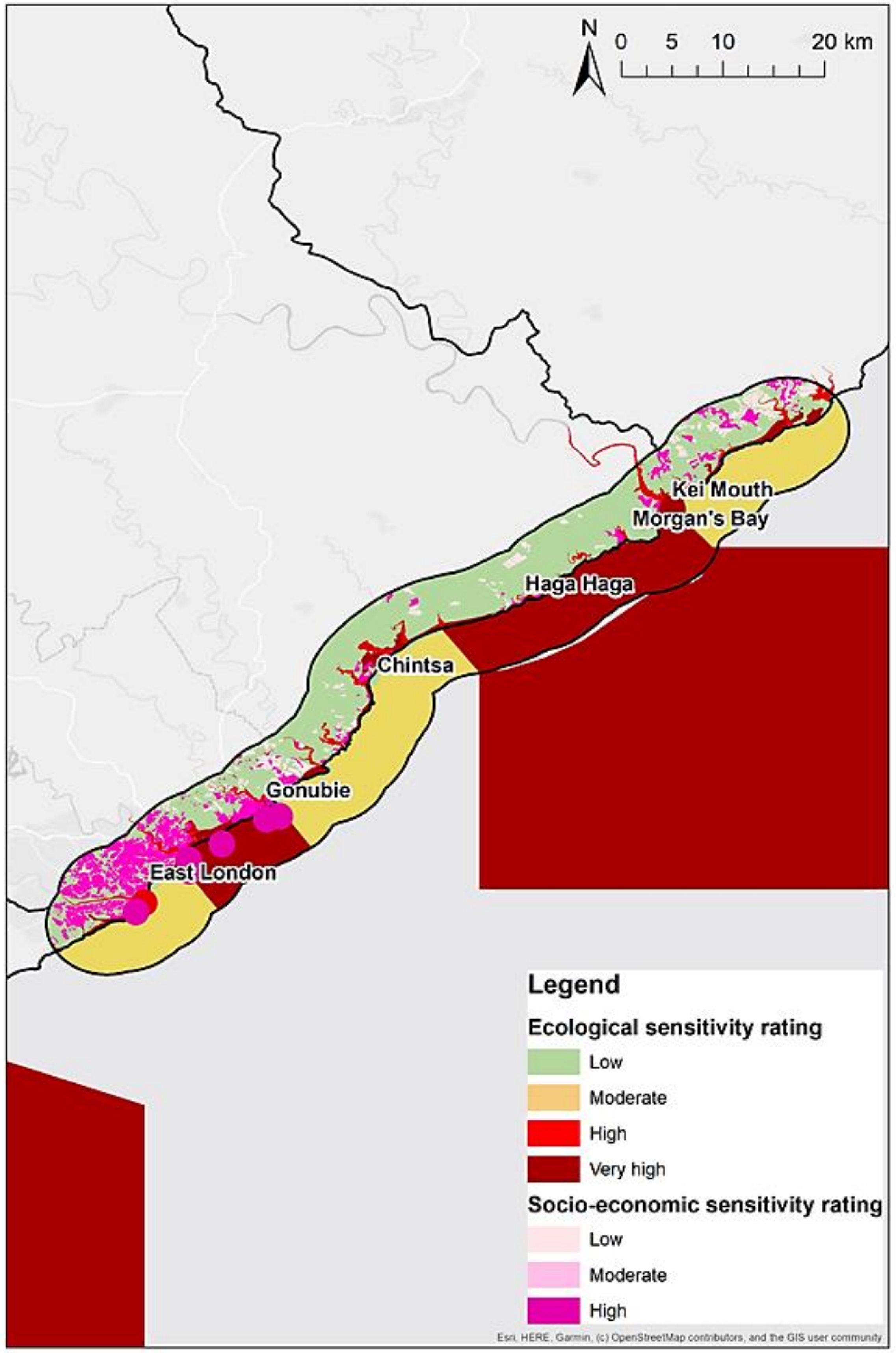

Figure 3.1-2: Ecological and socio-economic sensitivity of the East London-Kei Study Area

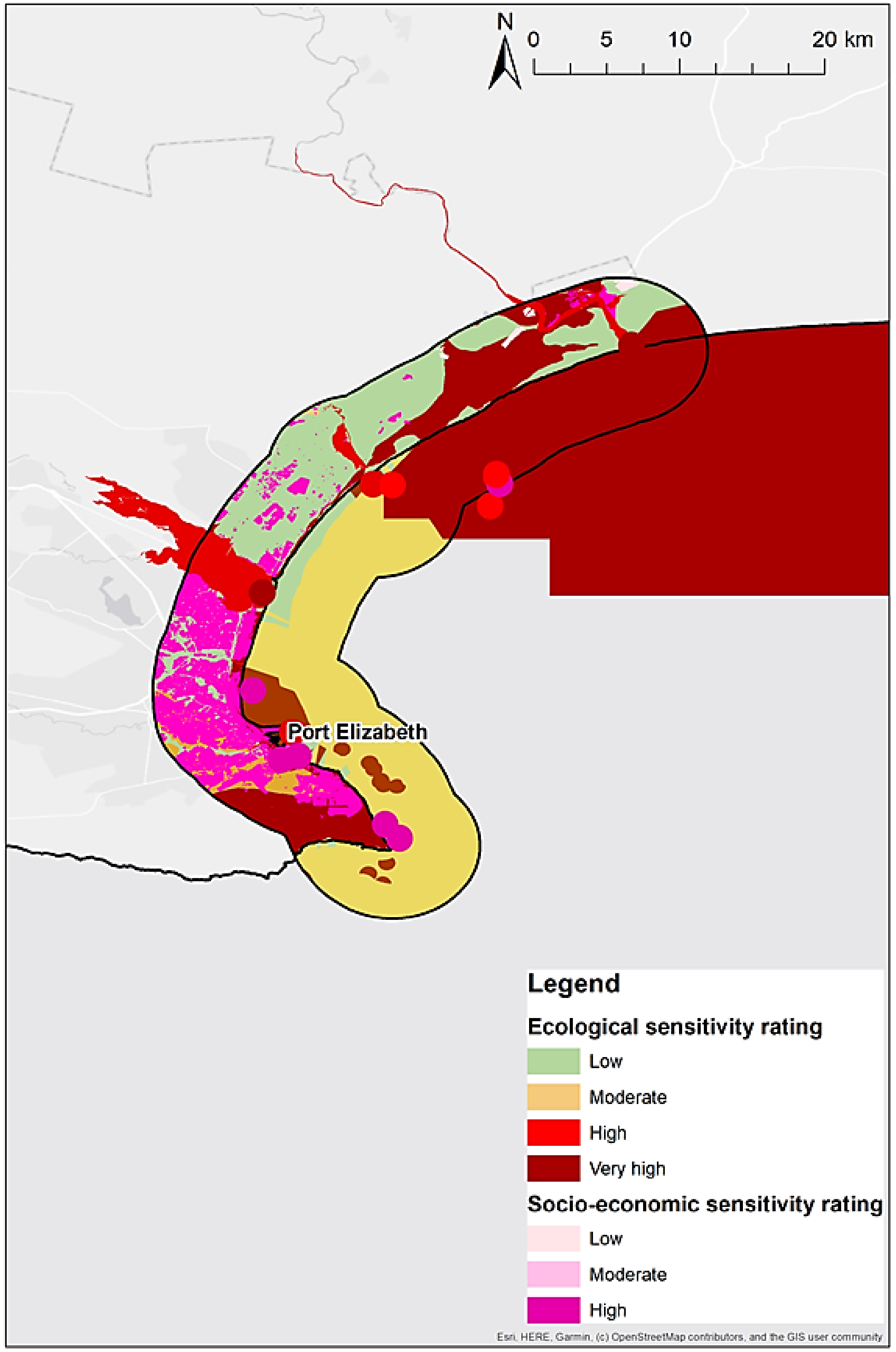

Figure 3.1-3: Ecological and socio-economic sensitivity of the Port Elizabeth Study Area

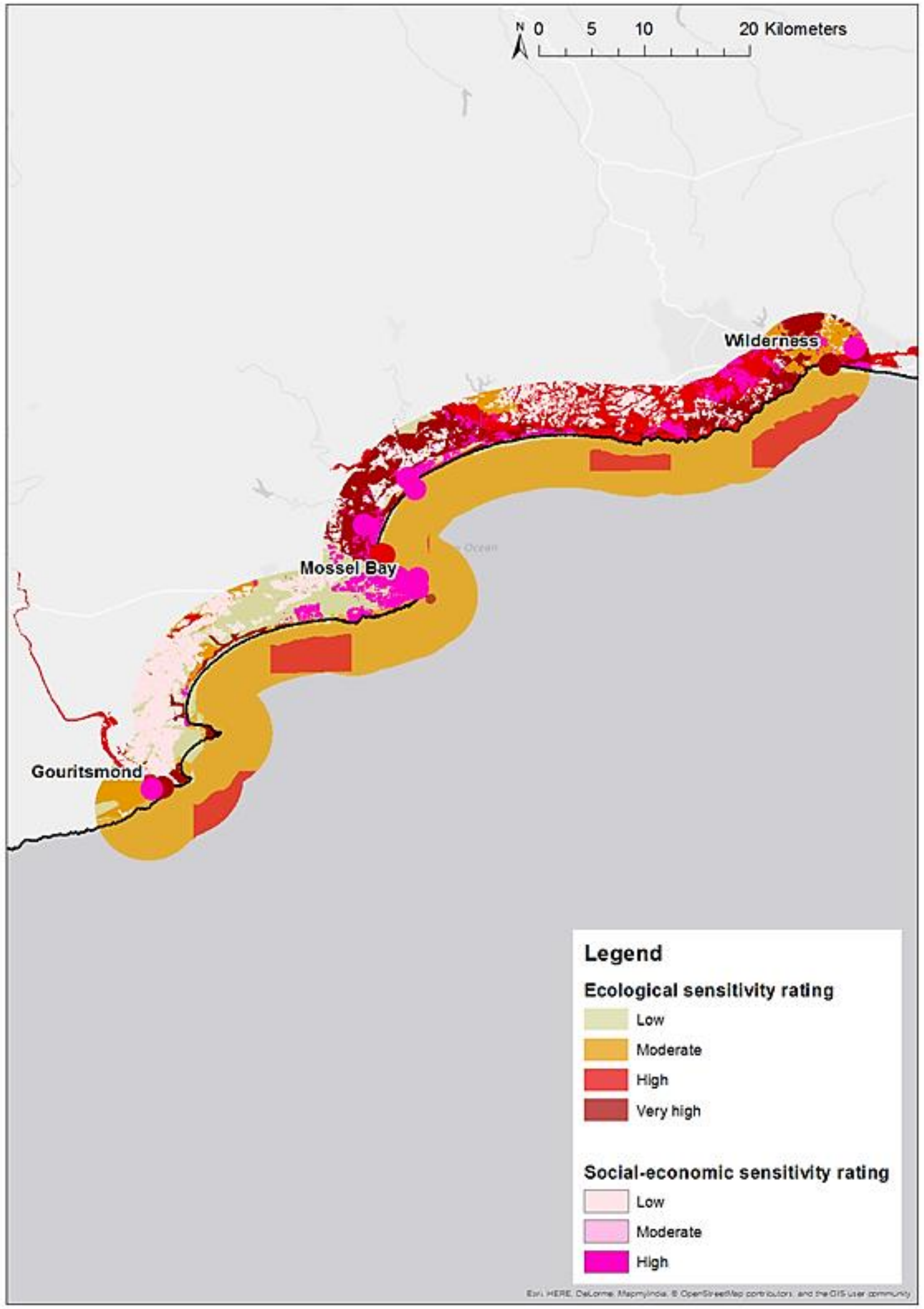

Figure 3.1-4: Ecological and socio-economic sensitivity of the Gouritz – George Study Area

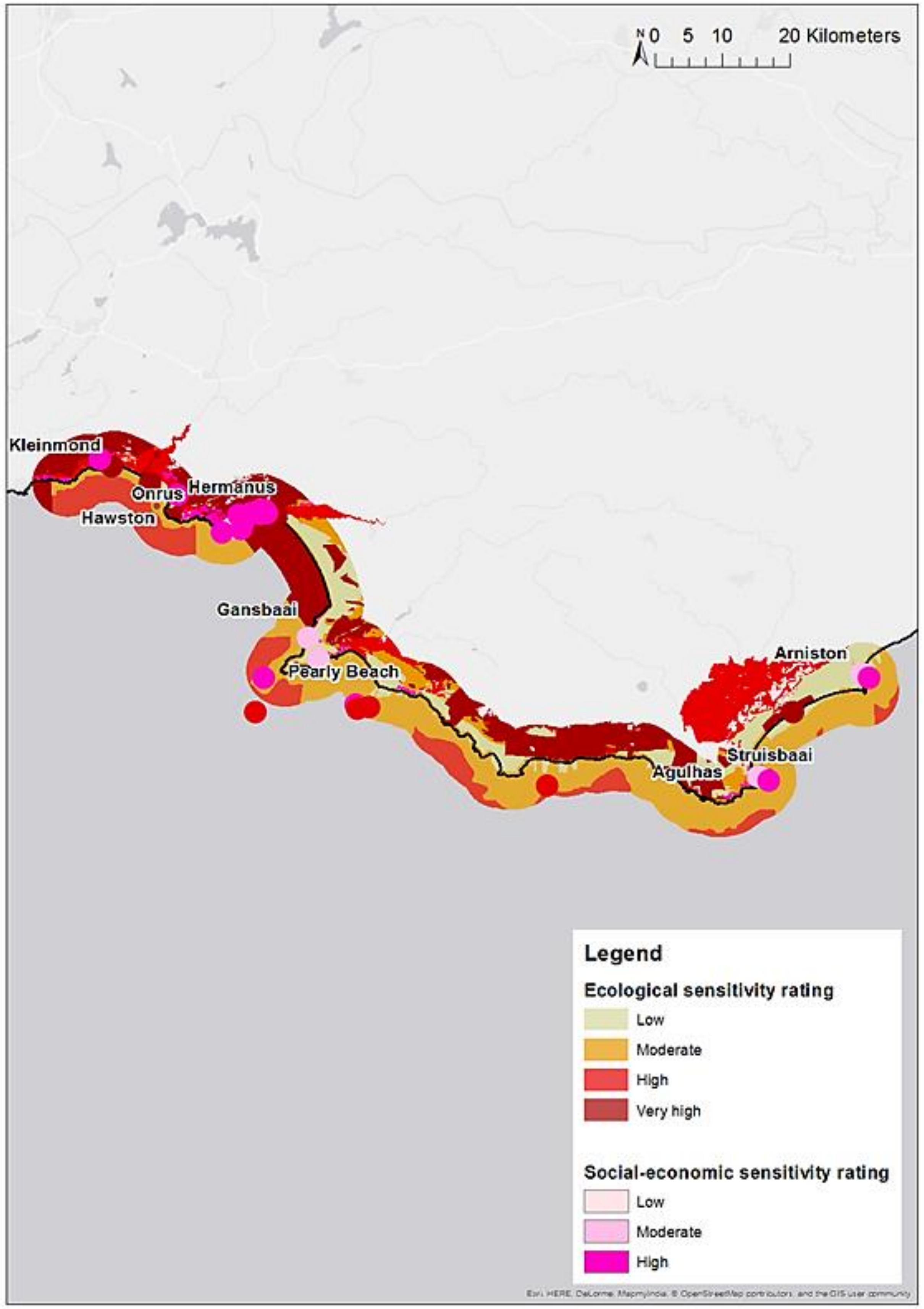

Figure 3.1-5: Ecological and socio-economic sensitivity of the Hermanus – Arniston Study Area

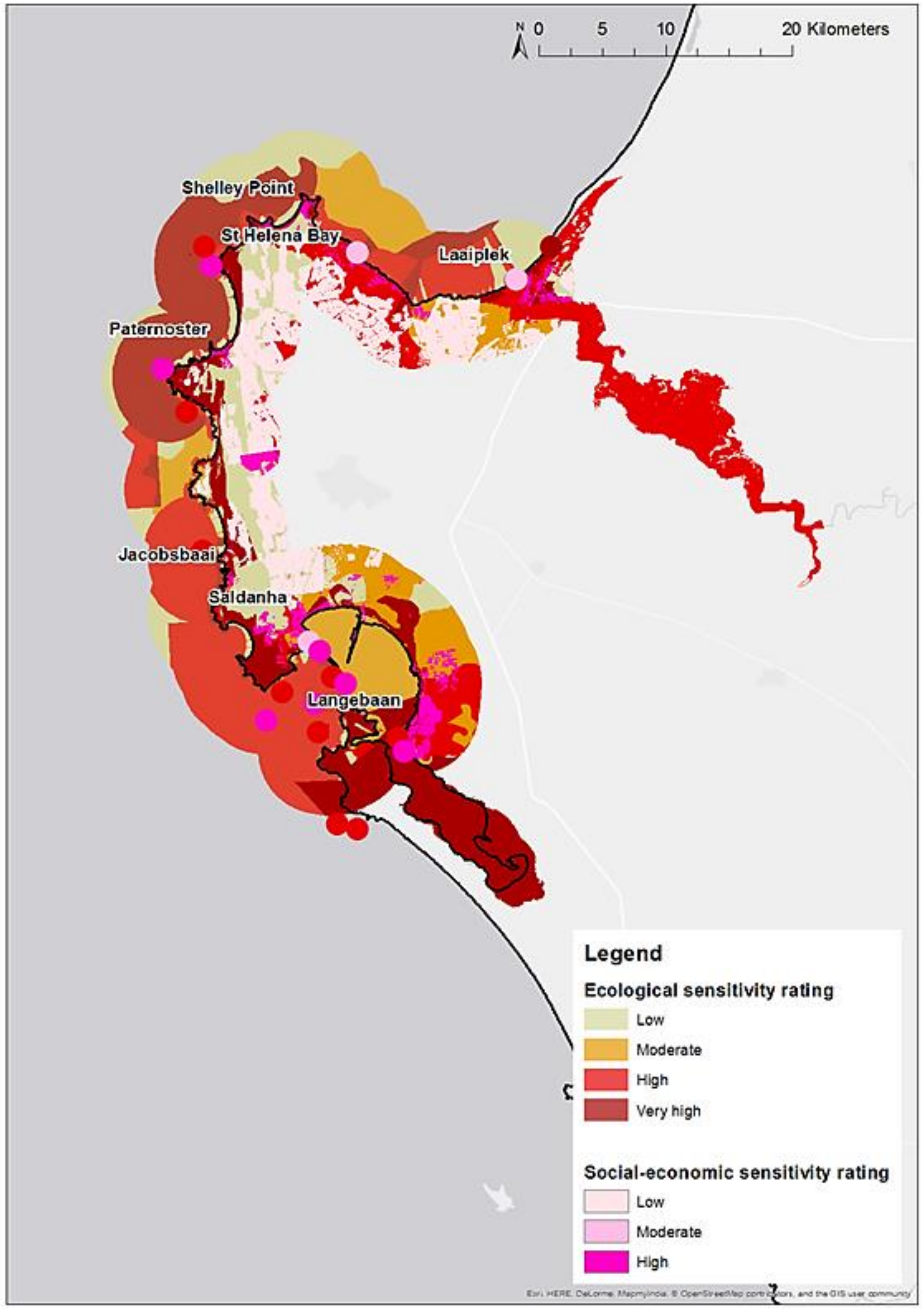

Figure 3.1-6: Ecological and socio-economic sensitivity of the Velddrif – Saldanha Study Area

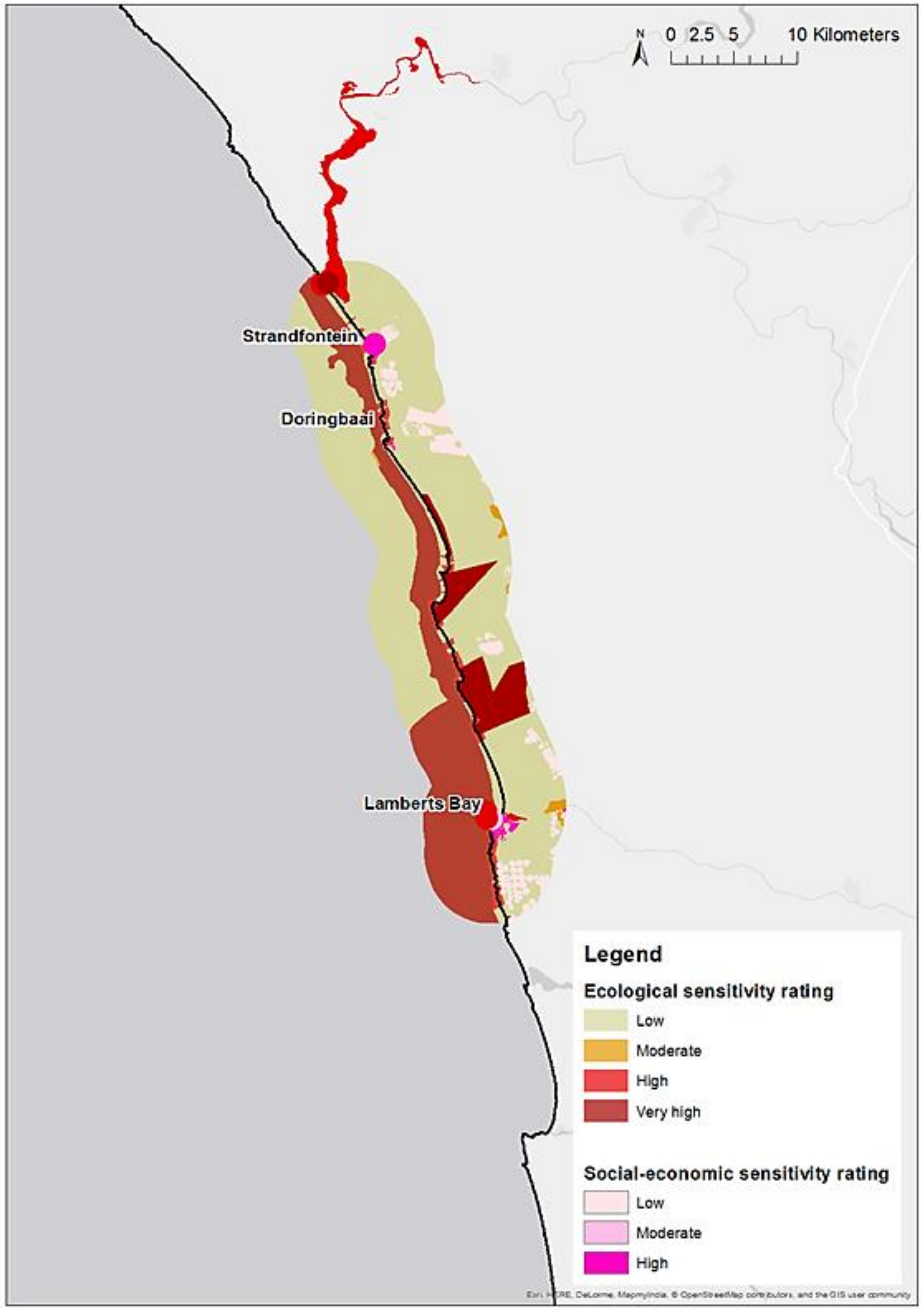

Figure 3.1-7: Ecological and socio-economic sensitivity of the Strandfontein – Lamberts Bay Study Area

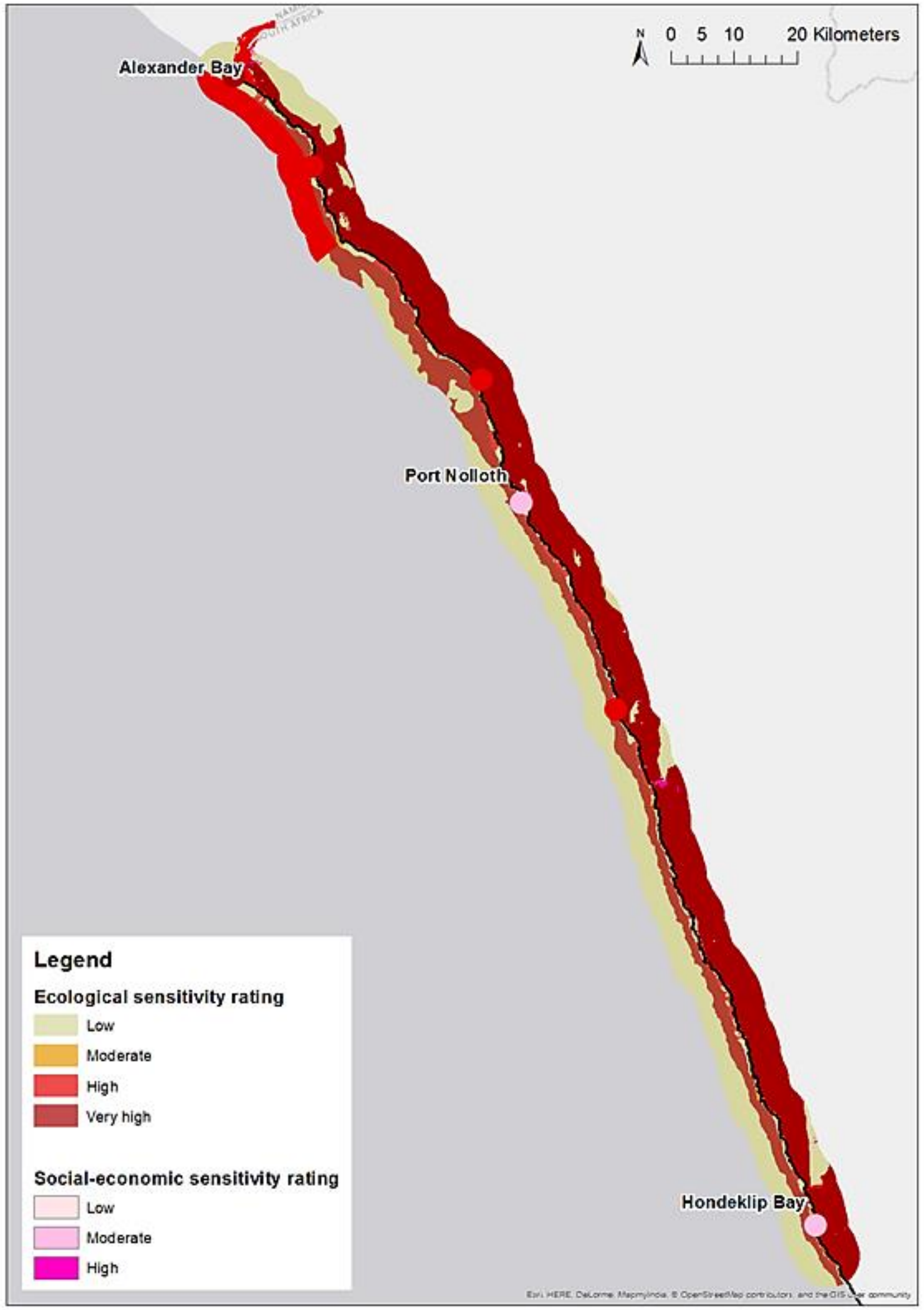

Figure 3.1-8: Ecological and socio-economic sensitivity of the Orange – Hondeklip Bay Study Area

3.1.3 Key Potential Impacts

In South Africa, several national-level assessments and feasibility studies on mariculture activities have highlighted key impacts that could adversely affect the receiving marine environment. Within civil society, general opposition to mariculture operations from local and national interest groups has played a role in limiting its development to date.

Drawing from the literature and industry inputs, key potential biodiversity and ecological impacts of mariculture have been identified. These impacts are largely generic and are not universally applicable to all mariculture species and production systems. The nature and severity of these impacts varies considerably depending on the species being farmed, the nature of the production systems, the scale and duration of farming, as well as the oceanographic and biological setting in which the mariculture activity takes place.

Key potential marine biodiversity and ecological impacts assessed in this SEA include:

- Alteration in water circulation patterns, wave and sediment regimes;
- Alteration in benthic habitat;
- Alteration of genetic structure of wild populations;
- Introduction of invasive alien species;
- Transmission of diseases and parasites to wild populations;
- Interactions with- and entanglement of marine biota;
- Destruction of terrestrial vegetation;
- Deterioration in water quality (pollution and eutrophication); and
- Socio-economic impacts (conflict of use).

3.1.4 Risk Assessment[1]

3.1.4.1 Abalone

The greatest risk posed by abalone cultivation is the **destruction of coastal terrestrial vegetation** for the establishment of the land-based pump ashore flow-through system (Figure 3.1-9). **New abalone facilities should be sited as to avoid sensitive coastal environments.**

Other concerns include deterioration in **water quality and diseases and parasites.** These are, however, generally **effectively mitigated**, especially since abalone require good water quality to thrive.

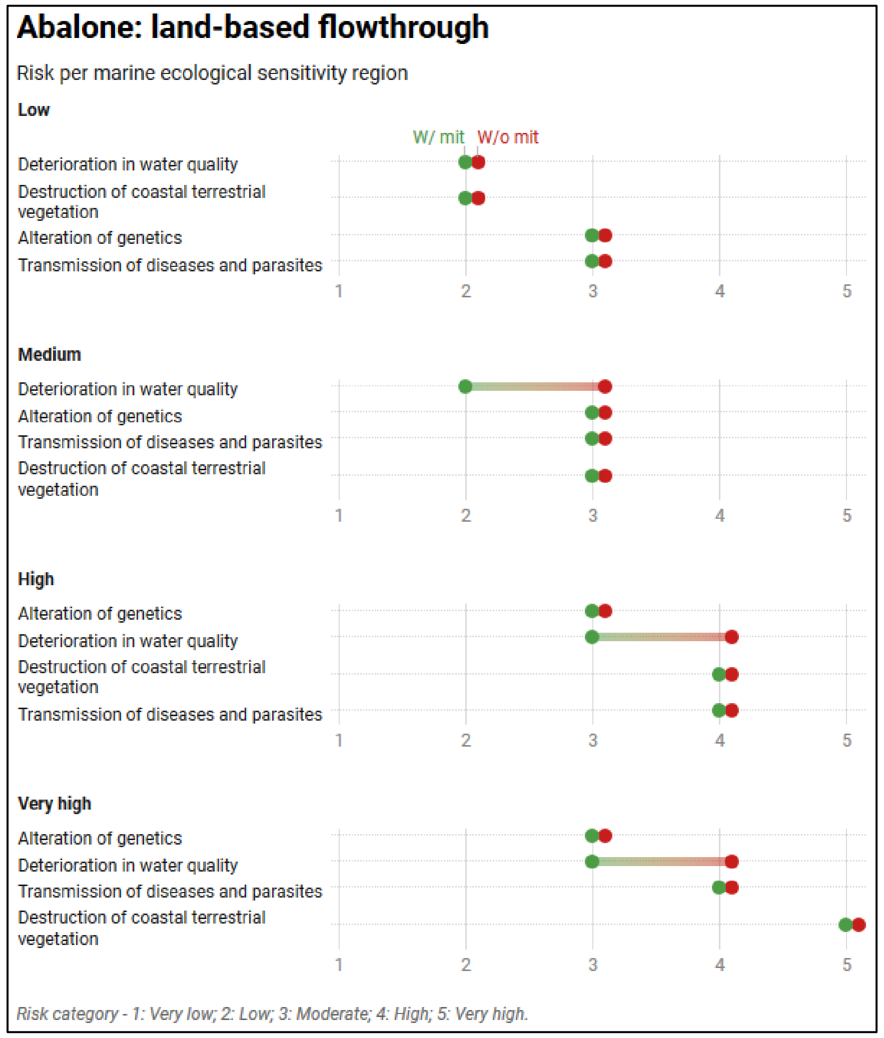

Figure 3.1-9: Risk summary for mariculture of abalone using a land-based pump ashore flow-through systems. Risks are presented per ecological sensitivity region, without mitigation ("W/o mit") and with best practice management and mitigation ("W/ mit").

3.1.4.2 Bivalves (mussels and oysters)

The risk of **wildlife interaction and entanglement with physical raft and longline infrastructure** is high and very high in most sensitive marine ecological regions (Figure 3.1-10).

Other key risks **include alteration of benthic habitat, disease and parasites**, especially **in sheltered areas which don't flush well, causing build-up of organic matter.**

Cultivation of **exotic bivalve species presents a risk of alien invasive species establishing in local ecosystems.**

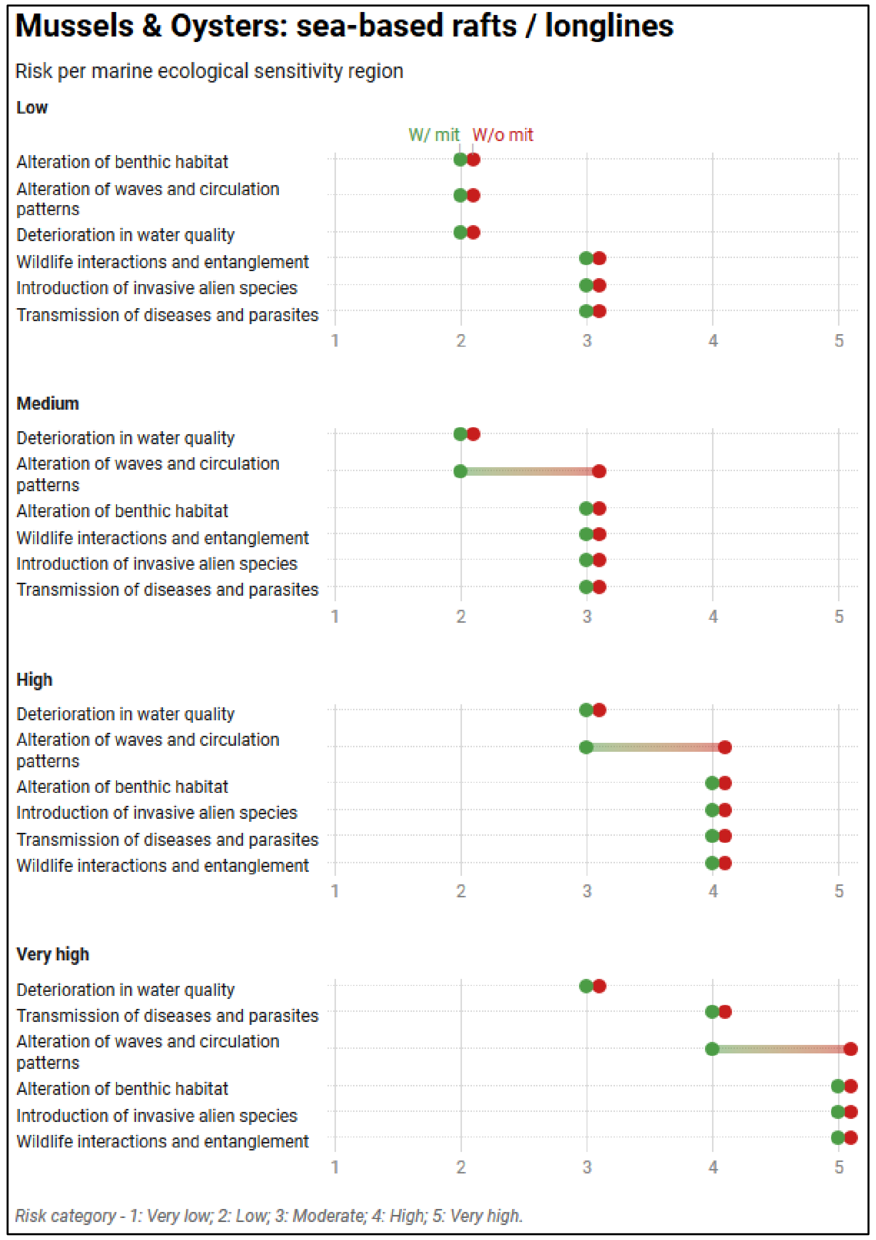

Figure 3.1-10: Risk summary for mariculture of mussels and oysters using sea-based rafts / longlines. Risks are presented per ecological sensitivity region, without mitigation ("W/o mit") and with best practice management and mitigation ("W/ mit").

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[1] The green dots indicate risk after mitigation, but does not imply that risk has been mitigated to acceptable levels. The position of the green dot indicates the risk class after mitigation, which may be high, even with mitigation.

The greatest risk posed by land-based oyster nurseries is the **destruction of coastal terrestrial vegetation** for the establishment of the land-based pump ashore flow-through system (Figure 3.1-11). **New nurseries should be sited as to avoid sensitive coastal environments.**

Risks of **disease, parasites and introduction of exotic species** are also of concern in more sensitive marine ecological regions.

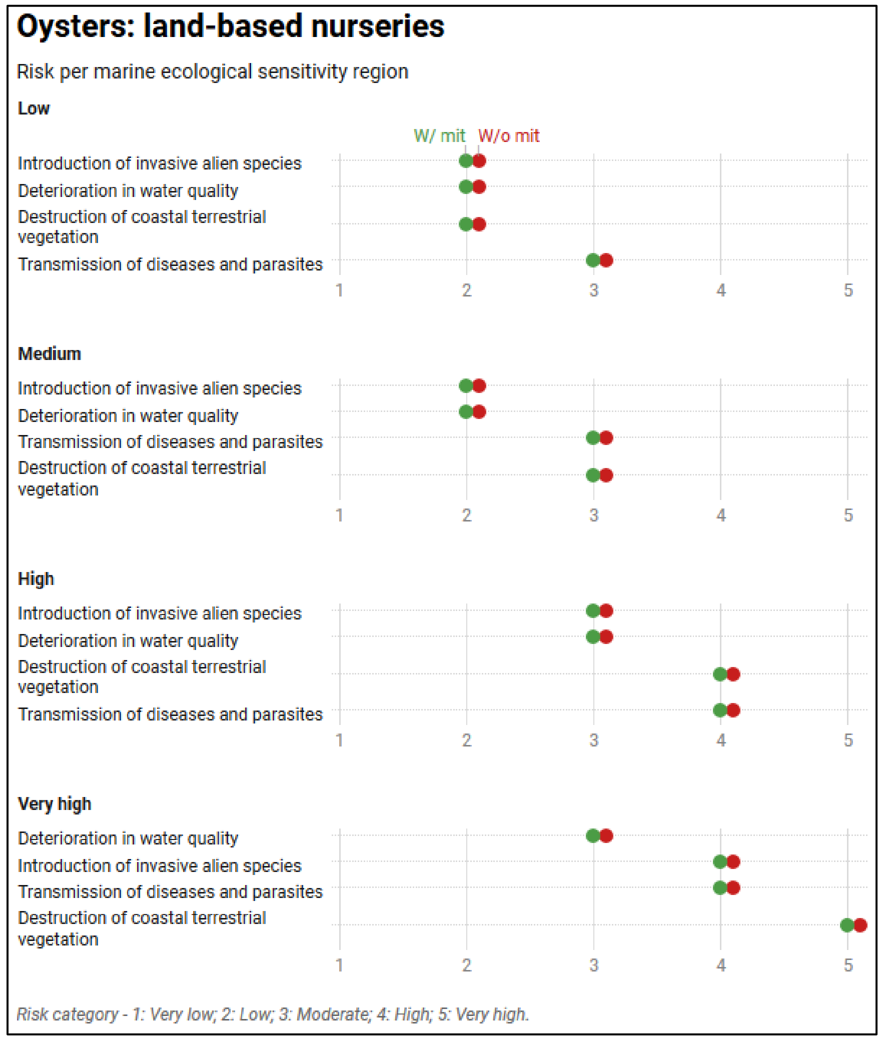

Figure 3.1-11: Risk summary for mariculture of mussels and oysters using land-based oyster nurseries. Risks are presented per ecological sensitivity region, without mitigation ("W/o mit") and with best practice management and mitigation ("W/ mit").

3.1.4.3 Dusky kob

Sea--based cage culture and land-based ponds pose overall greatest risk to marine ecology and biodiversity in terms of **genetic alteration and transmission of disease and parasites**, which remains high and very high after mitigation (Figure 3.1-12 and 3.1-13).

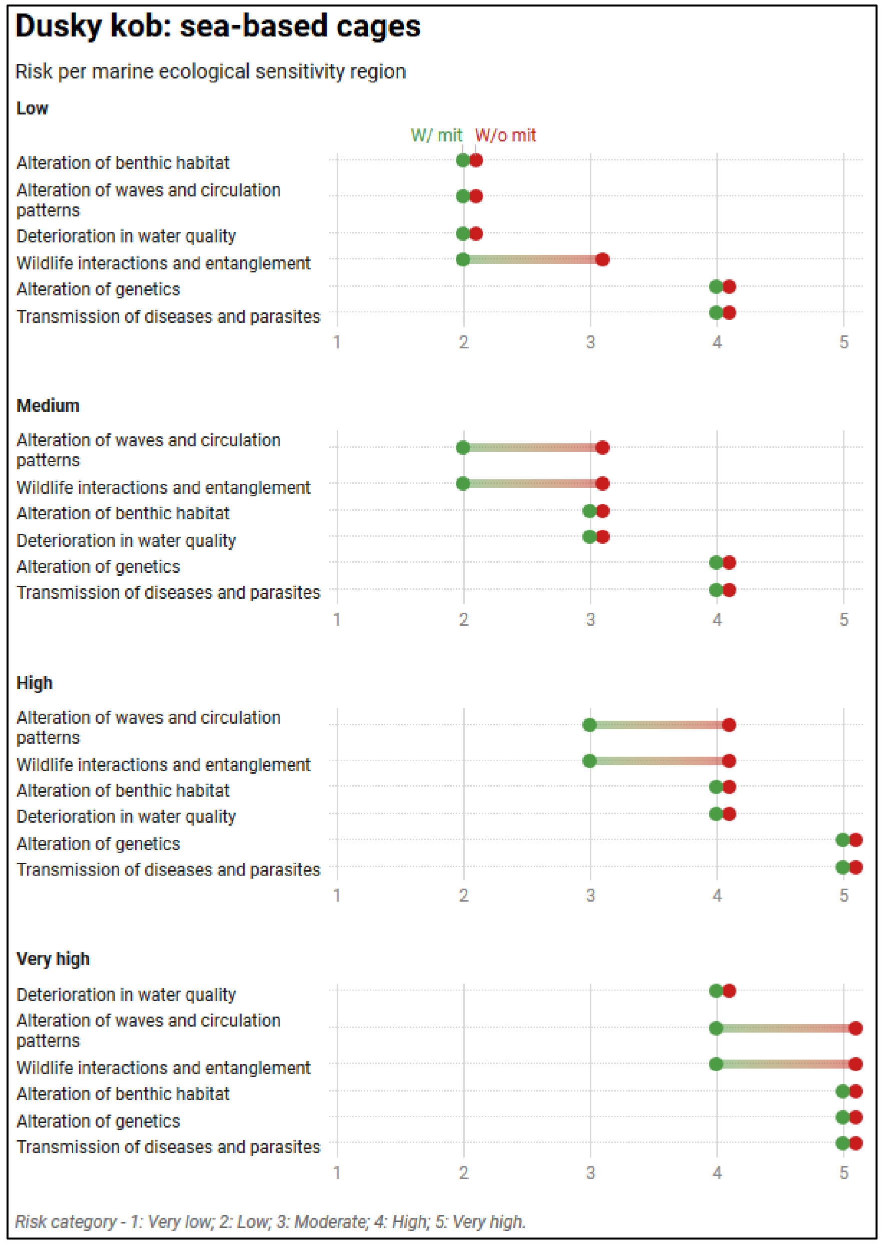

Figure 3.1-12: Risk summary for mariculture of dusky kob species using sea-based cages. Risks are presented per ecological sensitivity region, without mitigation ("W/o mit") and with best practice management and mitigation ("W/ mit").

In Very high sensitivity regions risk of **altered waves and circulation patterns, and wildlife interaction and entanglement with cages** may also be a concern (Figure 3.1-12).

Since **dusky kob is indigenous** to South Africa, it does not pose invasive alien species risks.

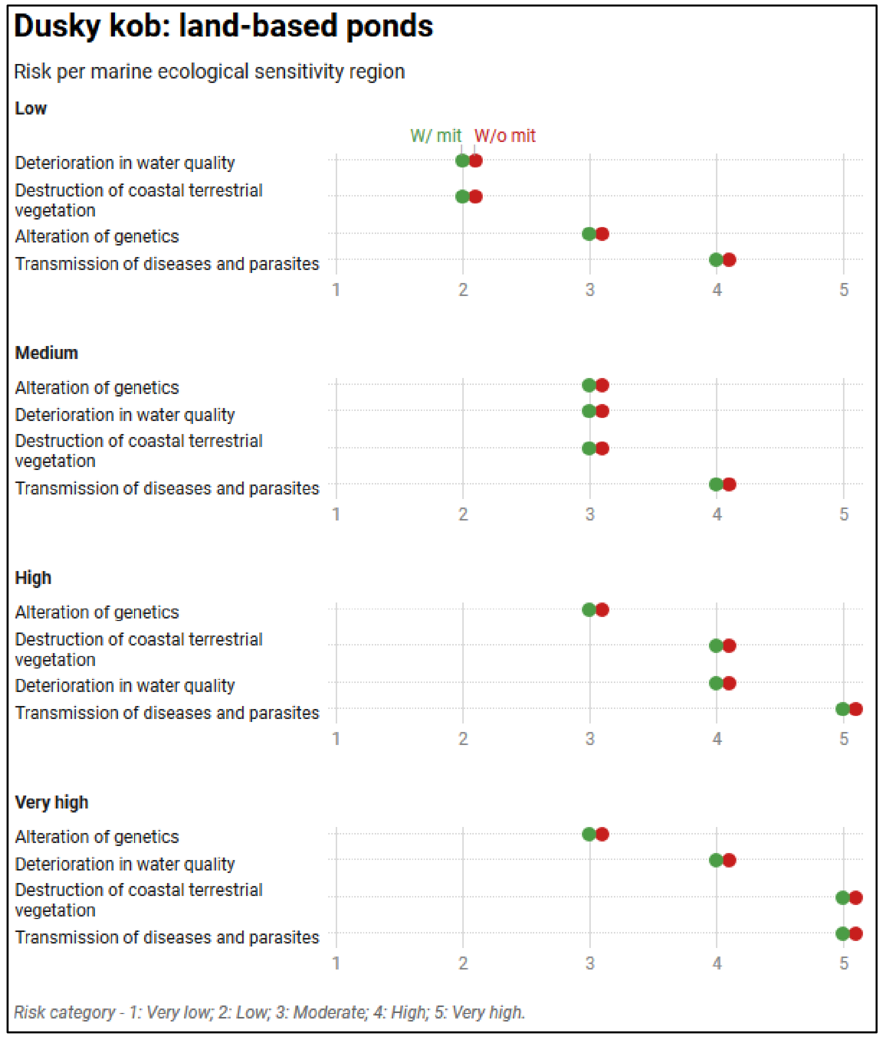

Figure 3.1-13: Risk summary for mariculture of dusky kob species using land-based ponds. Risks are presented per ecological sensitivity region, without mitigation ("W/o mit") and with best practice management and mitigation ("W/ mit").

Land-based RAS systems reduces biological risks associated with dusky kob mariculture, but needs to be **sited in a manner which reduces the risk of destruction of coastal terrestrial vegetation** (Figure 3.1-14).

Where possible and feasible, **RAS systems should be considered a preferred alternative** and be sited as to avoid sensitive coastal terrestrial environments.

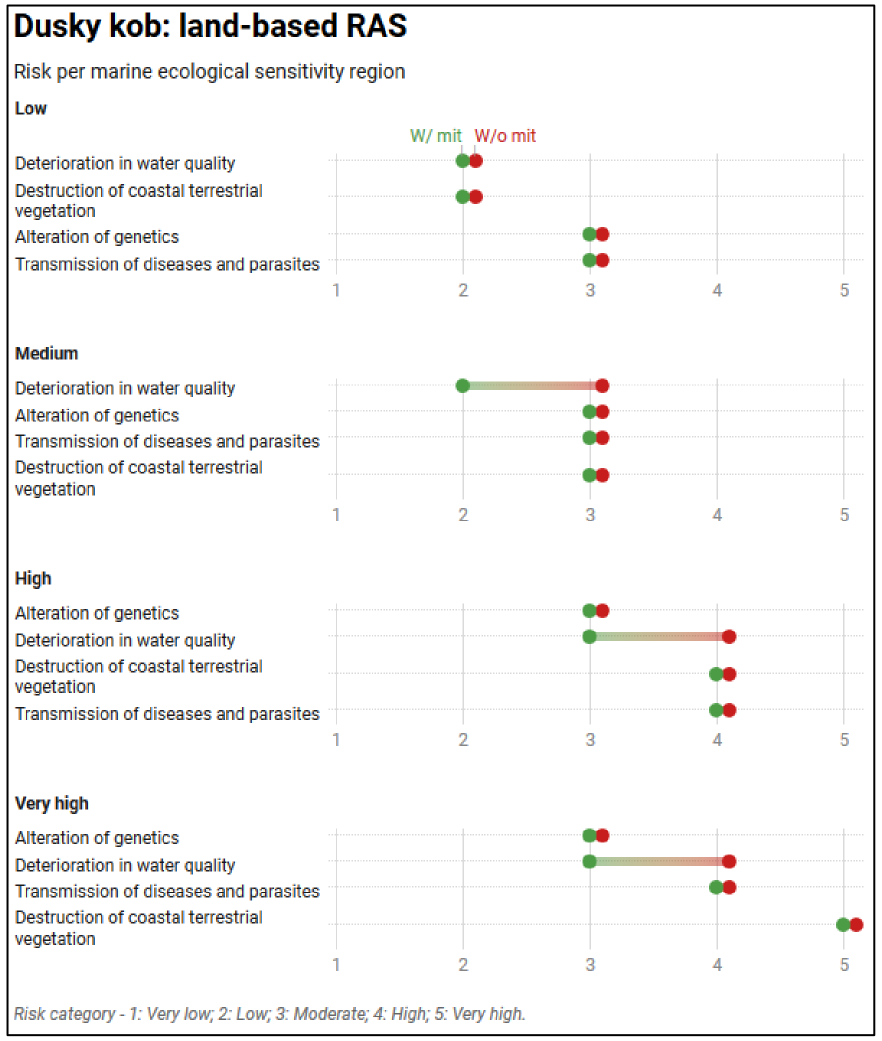

Figure 3.1-14: Risk summary for mariculture of dusky kob species using land-based RAS. Risks are presented per ecological sensitivity region, without mitigation (“W/o mit”) and with best practice management and mitigation (“W/ mit”).

3.1.4.4 Salmon

The greatest concerns with salmon farming are around **escapees from sea-based cages that establish and invade** local ecosystems. This risk is **greatly reduced by employing land-based RAS** (Figure 3.1-15 and 3.1-16).

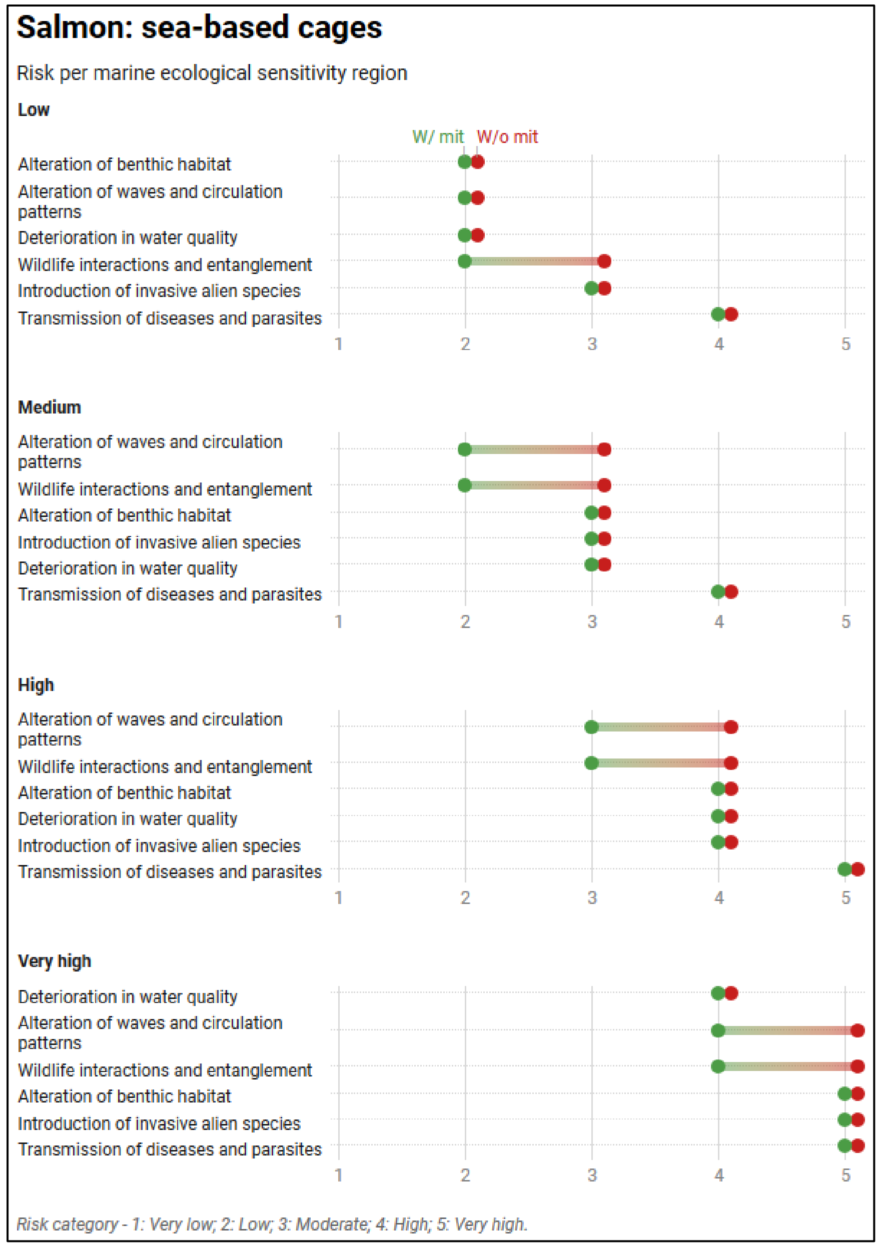

Figure 3.1-15: Risk summary for mariculture of salmon species using sea-based cages. Risks are presented per ecological sensitivity region, without mitigation (“W/o mit”) and with best practice management and mitigation (“W/ mit”).

Other key risks include **alteration of benthic habitat, disease and parasites**, especially in **sheltered areas which don’t flush well, causing build-up of organic matter** (Figure 3.1-15).

Land-based RAS systems reduces biological risks associated with salmon mariculture, but needs to be **sited in a manner which reduces the risk of destruction of coastal terrestrial vegetation** (Figure 3.1-16).

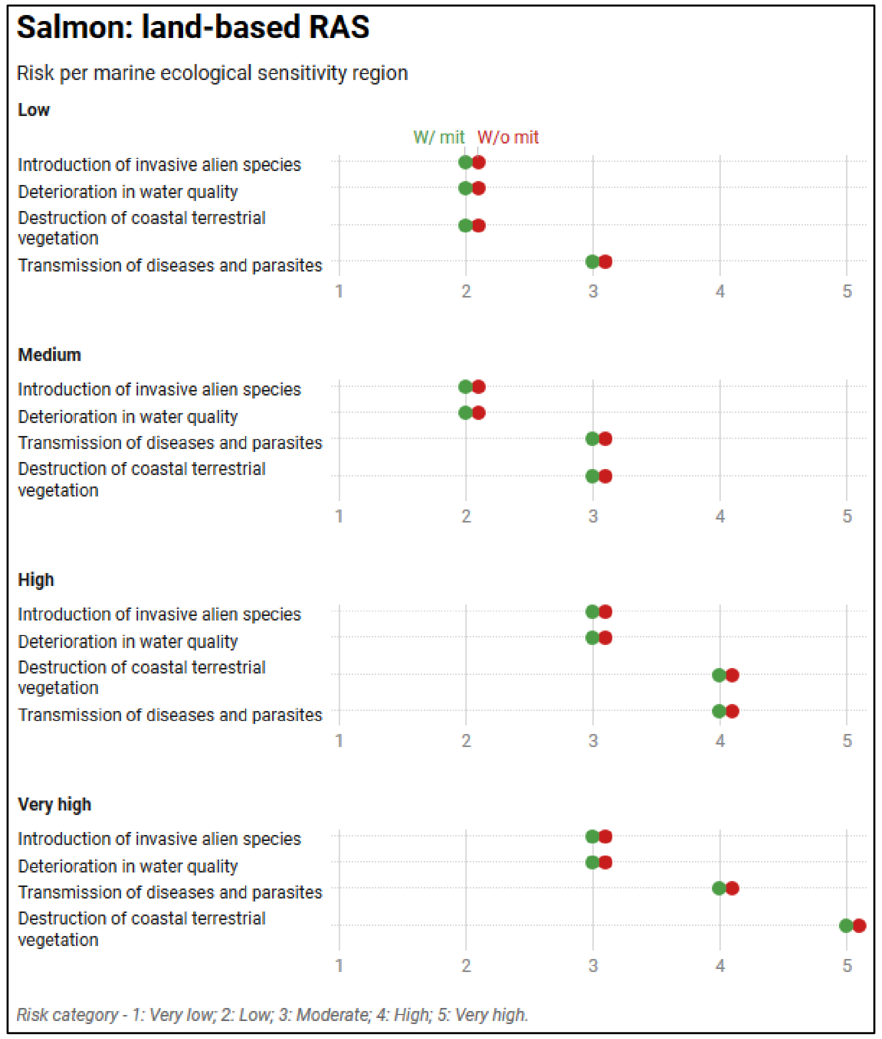

Figure 3.1-16: Risk summary for mariculture of salmon species using land-based RAS. Risks are presented per ecological sensitivity region, without mitigation (“W/o mit”) and with best practice management and mitigation (“W/ mit”).

3.1.4.5 Risk assessment implications for environmental assessment

High and Very High risks after mitigation indicates key issues specific to mariculture that needs to be addressed in environmental assessment to indicate whether the risks may be reduced to acceptable levels.

Species & production system	Key issue	Assessment implication
Abalone – Land-based flow-though	Terrestrial coastal ecosystems	Environmental assessment needs to establish that the siting of a new land-based flow-through abalone facility does not lead to the unacceptable loss of sensitive terrestrial ecosystems / ecosystems of conservation concern.
	Disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.
Mussels and oysters – Sea-based rafts / longlines	Alteration of waves and circulation patterns	Bathymetric and hydrodynamic study establishes that physical infrastructure will not alter waves, circulation and flushing ability.
	Alteration of benthic habitat	Bathymetric and hydrodynamic study establishes that physical infrastructure will not alter waves, circulation and flushing ability.
	Introduction of invasive alien species	Site-specific biodiversity risk and benefit assessment is required.
	Transmission of disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.
	Wildlife interaction and entanglement	An entanglement monitoring and response plan needs to be in place.
Oysters – Land-based nurseries	Terrestrial coastal ecosystems	Environmental assessment needs to establish that the siting of new land-based flow-through abalone facility does not lead to the unacceptable loss of sensitive terrestrial ecosystems / ecosystems of conservation concern.
	Introduction of invasive alien species	Site-specific biodiversity risk and benefit assessment is required.
	Transmission of disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.
Dusky kob – Sea-based cages	Wildlife interaction and entanglement	An entanglement monitoring and response plan needs to be in place.
	Alteration of waves and circulation patterns	Bathymetric and hydrodynamic study establishes that physical infrastructure will not alter waves, circulation and flushing ability.
	Alteration of benthic habitat	Bathymetric and hydrodynamic study establishes that physical infrastructure will not alter waves, circulation and flushing ability.
	Alteration of genetics	Genetic monitoring plan needs to be in place.
	Deterioration of water quality	A water quality monitoring plan needs to be in place.
	Transmission of disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.
Dusky kob – Land-based ponds	Terrestrial coastal ecosystems	Environmental assessment needs to establish that the siting of new land-based flow-through abalone facility does not lead to the unacceptable loss of sensitive terrestrial ecosystems / ecosystems of conservation concern.
	Deterioration of water quality	A water quality monitoring plan needs to be in place.
	Transmission of disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.
Dusky kob – Land-based RAS	Terrestrial coastal ecosystems	Environmental assessment needs to establish that the siting of new land-based flow-through abalone facility does not lead to the unacceptable loss of sensitive terrestrial ecosystems / ecosystems of conservation concern.
	Transmission of disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.
Salmon – Sea-based cages	Transmission of disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.
	Alteration of benthic habitat	Bathymetric and hydrodynamic study establishes that physical infrastructure will not alter waves, circulation and flushing ability.
	Deterioration of water quality	A water quality monitoring plan needs to be in place.
	Introduction of invasive alien species	Site-specific biodiversity risk and benefit assessment is required.
	Wildlife interaction and entanglement	An entanglement monitoring and response plan needs to be in place.
Salmon – Land-based RAS	Terrestrial coastal ecosystems	Environmental assessment needs to establish that the siting of new land-based flow-through abalone facility does not lead to the unacceptable loss of sensitive terrestrial ecosystems / ecosystems of conservation concern.
	Transmission of disease and parasites	A molluscan shellfish monitoring and biosecurity control programme including a response plan needs to be in place.

3.1.5 Management Actions and Best Practice Guidelines

Developmental Stage	Best Practice Guidelines for the Management of Marine Impact
Design / Planning / Construction phase	Siting of farms (including key environmental considerations) • Sites favoured for mariculture development should be well-flushed and deep, and located to avoid overlap with potentially sensitive and valuable habitats such as conservation areas, biogenic habitats and reefs. • Buffer zones should be established around sensitive and valuable habitats, and other ecosystem features used by other users. These could be established on a case-by-case basis using tools such as numerical modelling). A 500 m buffer zone in which no shellfish mariculture development is permitted and a 1 000 m buffer in which no finfish culture is permitted, is recommended around MPAs. Furthermore, a minimum 100 m buffer is recommended around reefs and blinders. Literature has shown that depositional footprints of >250 m were suitable for shellfish farm sites in more energetic environments or greater water depth, whereas nutrient effects in the water column could extend several kilometres from commercial-scale finfish farms. • Predictive analytical and numerical modelling should be taken into consideration before authorisation for mariculture operations is granted. This is particularly important where proposed shellfish and finfish farms are proposed adjacent to MPAs. This would include for example, predicting the effects of shellfish farming on local currents, stratification and wave climates and using the results to develop alternative farm designs to minimise possible localised hydrodynamic changes. Such models could also provide an indication of the extent of waste plumes and depositional footprints of biological and feed wastes generated by farms, effects on water column nutrient parameters (dissolved carbon, nitrogen and phosphorous) and seston depletion shadows (particulate organic carbon, phytoplankton abundance and species composition) in response to the farm structures and stock. Model outputs should inform suitability, location and design of the proposed mariculture works to ensure that these do not impact on sensitive habitats such as the shoreline, important reefs and MPAs. This is particularly important in sheltered bays such as Saldanha Bay, where hydrodynamics have been compromised by other developments and where proposed precincts are in the immediate vicinity of potentially sensitive and valuable habitats. Cognizance is taken of the fact that these modelling studies are very costly and the requirement for such an assessment should be determined on a case-by case basis depending on the potential risk associated with each proposed development. • Fish cages should be located at sites of suitable depth and the configuration of finfish cages be such so as to limit coverage of area under cage farming, both within individual licensed areas and within Aquaculture Development Zones. Unfarmed area should be used on a rotational basis for fallowing. Depth and area limitations may be site specifically derived, although industry specifications suggest that cages be held at least 5 m off the seabed. Assessment of potential ecological impacts in the Saldanha Bay ADZ recommended that finfish cages should not exceed a total coverage of 30% of the total surface area allocated for finfish farming. • Ensure mooring systems are well designed and placed to prevent/limit movement of anchors and chains across the sea floor.
Operational phase	Farming operations • In sea-based shellfish farming, avoid high density culture and overcrowding of mussel rafts, oyster longlines and stacks, and other production structures and reduce the discard rate of over-settlement. • In sea-based farming, implement recommended monitoring of biodeposition and physico-chemical changes in seabed properties, infaunal and epifaunal macrobenthic communities, at shellfish and finfish farming sites relative to undisturbed control sites. For finfish farms, adopt the MOM management system (Modelling-Ongrowing fish farms-Monitoring) or similar to monitor infaunal and epifaunal macrobenthic communities at farming sites. • In finfish cage farming, manage fish stocking densities to ensure the marine environment and stock health is maintained. Optimum stocking densities and feeding rates, during each season and for different species of fish of different size classes, can only be determined after several seasons of rearing have taken place at each site. • Monitor and manage feeding regimes in finfish farms to minimise feed wastage and chemical usage, and use species and system-specific highly digestible, high energy and low phosphorus fish feeds to maximize food conversion ratios and minimize waste. • Rotate cages within suspended cage sites to allow recovery of benthos, and destock or fallow a site after a growing cycle prior to restocking. • Install visual deterrents for birds (e.g. tori line type deterrents) on finfish cage superstructure. • Ensure debris and waste material do not enter the water to minimise the risk of attraction and entanglement by seabirds, marine mammals and large predators. • Monitoring by farm personnel of presence of marine mammal species in the vicinity or general region of the farm sites (and potentially also monitor the absence of important marine mammals), as well as observations of any time spent under or around the farm structures. A log of all cetaceans, as well as seabirds and predators recorded in the vicinity of farms, and notes on behavioural observations, should be kept regularly. These data should be periodically compiled and analyzed by experts. • Use predator exclusion nets for finfish farming as necessary; enclose nets at the bottom to minimise entanglement; keep nets taut; use mesh sizes of <6 cm; and keep nets well maintained (e.g. repairing holes). • Remove any injured or dead fish from finfish cages promptly and ensure that minimal blood and offal enters the water during harvesting of cultured finfish. • Minimise the potential for domestic waste to enter the marine environment (particularly plastic wastes). • Use only approved anti-foulants and environmentally friendly alternatives where effective. Do not apply anti-foulants in sea-based sites. • Leave mooring anchors or blocks in place when undertaking maintenance of mariculture structures (e.g. cages, rafts and longlines) or fallowing sites to avoid repetitive impacts of the same activity at each site. Biosecurity, genetics and disease control • Ensure a high level of biosecurity management and planning is in place within hatcheries, holding tanks and sea cages to limit the introduction of pests and diseases and to be able to respond quickly and effectively should biosecurity risks be identified. • Have good house-keeping practices in place at all times i.e. in finfish cage farming keep nets clean and allow sufficient fallowing time on sites to ensure low environmental levels of intermediate hosts and or pathogens. • Farm operators should undertake routine surveillance on and around marine farm structures and associated vessels and infrastructure for indications of non-native fouling species. • Maintain effective antifouling coatings and regularly inspect farm structures and vessels for pests; clean structures and hulls regularly to ensure eradication of pests before they become established. • Fouling organisms removed from oyster stacks, abalone barrels and finfish cages should not be discharged back into the marine environment thereby ensuring that any introduced non-native fouling species undetected previously, are not released into the wild.

	• Develop and/or use South African bivalve hatcheries to reduce the reliance on spat import, and hence the risk of non-intentional introduction of associated alien species and diseases. • If spat import cannot be avoided, culture facilities should only be permitted to use spat sourced from biosecure certified hatcheries. • Ensure that veterinary protocols to eliminate any pests, parasites and diseases are strictly adhered to. • Ensure suitable management and planning measures are in place to limit the possibility of genetic interactions between farmed stock and wild populations. • Ensure good physical and biological containment to limit the effects of escaped stocks. • Use sterile triploid shellfish spat to minimise the potential of reproduction in shellfish farms and releases of eggs and larvae within farmed areas allowing possible recruitment to natural shellfish habitat and competition with wild populations. • Implement the “Genetic Best Practice Management Guidelines for Marine Finfish Hatcheries” developed by then DAFF (undated) and ensure adequate genetic monitoring of broodstock rotation. • When farming endemic species, use offspring from wild-sourced fish broodstock, as they will be genetically similar to wild fish. • Use appropriate spawning regimes in the hatchery to maintain genetic diversity in the offspring. • Use only female fish in farm cages. • Control breeding in the stock and develop the technology to create sterile fry for stocking of cages. • Use robust, well-maintained containment systems to reduce the likelihood of escape. • Develop and implement recovery procedures should escapes from finfish farms occur. • Ensure as far as possible that all spat and fry undergo a health examination prior to stocking in sea cages. • Take necessary action to eliminate pathogens through the use of therapeutic chemicals or improved farm management. • Restrict stocking densities to below 15 - 20 fish per m^3 to limit the spread of diseases and parasitic infections (DAFF, 2013). • Regularly inspect stock for disease and parasites as part of a formalised stock health monitoring programme. • Maintain comprehensive records of all pathogens and parasites detected as well as logs detailing the efficacy of treatments applied. • Locate cages stocked with different cohorts of the same species as far apart as possible; if possible stock different species in cages successively. • Have good house-keeping practices in place at all times i.e. keep nets clean and allow sufficient fallowing time on sites to ensure low environmental levels of intermediate hosts and or pathogens. • Treat adjacent cages simultaneously even if infections have not yet been detected. • Use only approved veterinary chemicals. • Reduce levels of nutritional therapeutants and trace contaminants in fish feed using only the lowest effective doses. • Use the most efficient drug delivery mechanisms that minimise the concentrations of biologically active ingredients entering the environment. • Consider the use of seaweeds as a co-culture species for use in Integrated Multi-Trophic Aquaculture (IMTA). General • Conduct monitoring as per the terms and conditions of the coastal waters discharge permit (NEM: ICMA, 2008) where effluent are being discharged to coastal waters (specified per species farmed). This should include monitoring of the immediate water quality around the precincts or specific farms for nutrient parameters (i.e. dissolved carbon, nitrogen and phosphorus) and for key plankton parameters (i.e. chlorophyll-a, phytoplankton abundance and species composition). *Reference documents: (i) Republic of South Africa, Department of Environmental Affairs (2018). South African Water Quality Guidelines for Coastal Marine Waters - Natural Environment and Mariculture Use. Cape Town; (ii) Republic of South Africa, Department of Environmental Affairs (2014). National Guideline for the Discharge of Effluent from Land-based Sources into the Coastal Environment. Pretoria, South Africa. RP101/2014.* • In shellfish farming, adhere to the requirements and monitoring schedules for the management of food safety risks set forth in the South African molluscan shellfish monitoring and control programme. • Ensure that minimal non-navigational lighting occurs at night and use downward-pointing and shaded lights. • Develop and enforce strict maintenance and operational guidelines and standards in relation to potential entanglement risks on the farm including loose ropes, lines, buoys or floats. • Ensure all mooring lines and rafts are highly visible (use thick lines and bright antifouling coatings). • Keep all lines taught through regular inspections and maintenance. • In sea-based farming, develop disentanglement protocols in collaboration with DEFF and the South African Whale Disentanglement Network, and establish a rapid response unit to deal with entanglements. • Adopt appropriate maintenance and operational guidelines and standards for minimizing noise in noise-generating equipment. • Establish and adhere to guidelines around the use of anti-fouling products in the mariculture industry.

3.1.6 Monitoring Requirements

Environmental monitoring is required to ensure that mariculture farms are compliant and sustainable in the long term, taking only a proportionate share of the marine resource with respect to other users and without adversely affecting marine ecosystem function and productivity, or leading to the deterioration of rare or sensitive habitats. As a generic requirement this should include monitoring of effluent quality (e.g. land-based systems with discharge flows back to the sea) and monitoring of the physical, chemical and biological conditions of the receiving environment (water and sediments) in the vicinity of effluent outflows, as well as around sea-based systems.

The overall objective of monitoring the receiving environment should be to assess the degree of impact that mariculture operations have on the environment, to evaluate trends in the impact occurring, to elucidate causality and to inform appropriate management response. Environmental monitoring requirements vary amongst different mariculture species and production systems, and site-specific conditions need to be considered in the design of monitoring programmes. Marine monitoring programmes should also consider spatial (e.g. number and location of sampling points) and temporal (e.g. frequency of sampling) requirements, a recent example of which are monitoring and sampling plans that have been developed for the newly declared Saldanha Bay Aquaculture Development Zone.

Environmental variables that commonly constitute a mariculture monitoring programme include the following:

Physical	Chemical	Biological
• Bathymetry • Currents, waves, tides • Wind • Precipitation • Substrate type • Sediment movement • Erosion/accretion • Temperature	• pH, alkalinity • Redox • Salinity • Dissolved Oxygen • Nutrients • Particulate/dissolved organic matter • Suspended solids • Specific chemicals (depending on the operation	• Species abundance and diversity: plankton, benthos, nekton, birds (qualitative, i.e. species list, or quantitative, i.e. full abundance) • Biomass • Productivity • Population structure • Trophic interactions • Habitat mapping • Rare and endangered species/habitats

In both baseline surveys and on-going monitoring it is important that background variability in environmental parameters being measured is assessed and accounted for. This generally demands high replication of sampling both temporally and spatially, which can result in monitoring becoming a costly exercise. Adopting an adaptive strategy in monitoring by reducing the scope and scale of sampling as results emerge, can lessen the financial burden on a mariculture operation. Apart from showing other users that the marine environment being utilised is protected and safeguarded from mariculture impacts, monitoring can have direct value for the mariculture industry as mariculture farmers are focused on ensuring their products are grown in clean and safe conditions.