ENVIRONMENTAL & RISK ASSESSMENT FOR AN APPLICATION FOR A RIGHT TO ENGAGE IN AN ABALONE RANCHING PILOT PROJECT APPLICANT: DORING BAY ABALONE (PTY) LTD

September 2019

Anchor Environmental Consultants (Pty) Ltd Project Number 1857/1

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Report Prepared for:
Doring Bay Abalone (Pty) Ltd.

Report Prepared by:
Anchor Environmental Consultants (Pty) Ltd.
8 Steenberg House, Silverwood Close, Tokai 7945, South Africa
https://anchorenvironmental.co.za

Authors: Ken Hutchings, Vera Massie and Barry Clark

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1 INTRODUCTION

Doring Bay Abalone (Pty) Ltd. (DBA) has been undertaking on-shore mariculture of abalone *Haliotis midae* at Doring Bay since 2014. The company has received support from TRONOX mining and the Matzikama municipality but is now totally reliant on its own income from sale of its farmed Abalone to cover all its running expenses. The sustainability of this project is critical to the survival of the community of Doring Bay and surrounding areas. DBA employs over 50 staff from the local community of Doring Bay. DBA considers abalone ranching as an important diversified activity which would complement the land based facility; and in so doing could assist in meeting social upliftment objectives via the creation of lasting direct and indirect job opportunities, and improve marketing prospects and economic returns due to the preference for larger abalone that can only be economically produced via ranching.

The Spatial Development Framework for the Matzikama Municipality, 2014 read together with the Amendment thereof in 2019 supports this proposal as follows: “Further development of the aquaculture sector e.g. abalone farms as well as associated facilities and development possibilities.”

DBA has been successful in Phase 1 of the abalone ranching application process (Government Gazette 21 April 2011, No. 352 & 353) and intends submitting an application for Phase 2 of the application process. This document comprises the Environmental Assessment (EA) required by the Department of Agriculture, Forestry and Fisheries in terms of their Marine Ranching Guidelines (GN 729, Government Gazette 20 August 2010).

H. midae is no longer listed as a protected species in the Threatened or Protected Species Regulations, 14 December 2007 (TOPS). Furthermore, the translocation of indigenous species into an area outside of its natural range (described as extra-limital species) is now exempt in terms of the Alien and Invasive Species Regulations, 2014. This means that a Risk Assessment is not legally required in terms of NEMBA for the application of a Ranching Right. However, considering that abalone ranching involves the introduction of this species outside of its natural range, a best practice approach was followed, and a Risk Assessment was conducted as specified in the TOPS Regulations. These two components are included as separate sections of this document.

A public participation process must be undertaken as part of Phase 2 of the application process. Registered Interested and Affected Parties (I&APs) will be provided with an opportunity to comment on this Draft Environmental and Risk Assessment Report. Comments provided by stakeholders will be considered when finalising this report for submission to the Department of Agriculture, Forestry and Fisheries and the Department of Environmental Affairs. A comment and response report will be compiled following the completion of the public participation period and will be submitted to the decision-making authority.

This document was prepared by Anchor Environmental Consultants (Pty) Ltd. (Anchor) for, and on behalf of Doring Bay Abalone (Pty) Ltd. Anchor forms part of the Anchor Environmental Group, an independent consulting firm based in Cape Town, South Africa, offering ecological and economic expertise to inform management and decision making regarding the use and conservation of natural resources.

2 LEGISLATIVE FRAMEWORK

The "Guidelines and Potential Areas for Marine Ranching and Stock Enhancement of Abalone *Haliotis midae* in South Africa" (Government Notice 2010, No. 729) indicate that ranching applicants should address potential risks of the proposed activity under the general headings of Environmental Interactions, including the following:

1. Assessment of carrying capacity
2. Trophic and ecological impacts
3. Potential genetic impacts
4. Diseases, pests and parasites

The increasing pressure on *H. midae* by both legal and illegal harvesting had led to the banning of abalone harvesting (CITES in Appendix 3) and listing as a protected species in the Threatened or Protected Species Regulations, 23 February 2007 (TOPS) promulgated in terms of the National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEMBA). However, soon thereafter, pressure from the fishing industry led to the removal of *H. midae* from both CITES Appendix 3 and NEMBA TOPS Regulations (Raemaekers *et al.* 2011).

As the area for which the Ranching Right is being applied falls outside of the natural distribution range of *H. midae,* this species would be translocated into a region where it does not naturally occur. As such, abalone are classed as an "alien" species in this context. The Alien and Invasive Species List (Government Gazette Number 37886, 2014) promulgated in terms of the NEMBA defines such species as *extra-limital*. These Regulations classify *extra-limital* species as exempt, which means that a permit is not required in terms of NEMBA Section 65 for conducting restricted activities involving alien species.

Notwithstanding the above, abalone ranching involves the introduction of this species outside of its natural range and it is considered best practice to conduct a Risk Assessment (RA) as per Regulation 15 of the Threatened or Protected Species Regulations (2007, as amended), which includes the following information:

(1) Information regarding the relevant listed threatened or protected species, including:

- i) the taxonomy of the species, including the class, order, family, scientific name, scientific synonyms and common names of the species;
- ii) the national and provincial conservation status of the species, including IUCN Red List Status;
- iii) the population status and trends of the species, including:
  - aa. its national population status;
  - bb. the size of its local population which will be affected by the restricted activity in respect of which application is made; and
  - cc. its current national and local population trends;
- iv) the geographic distribution and trends of the species, including:
  - aa. the distribution of the natural population;
  - bb. the distribution of any translocated and introduced populations; and
  - cc. the geographic distribution trends;

v) the requirements of the species with respect to habitat and climate;

vi) the role **of** the species in its ecosystem, taking into account -

aa. whether the species is a keystone or indicator species;

bb. the species' level in the food chain; and

cc. the functions which the species performs in its ecosystem; and

vii) the major threats affecting the species nationally and locally;

(a) information regarding the restricted activity in respect of which application is made, including -

i) the nature of the restricted activity;

ii) the reason for the restricted activity;

iii) where the restricted activity is to be carried out;

iv) the gender, age and number of the specimens of the species involved; and

v) the intended destination of the specimens, if they are to be translocated;

(b) any regulations, policies, norms and standards or international agreements binding on the Republic which may be applicable to the application;

(c) the potential risks associated with the restricted activity to the particular listed threatened or protected species and a specific population of such threatened or protected species or to any other species or ecosystems, including -

i) degradation and fragmentation of a species' habitat;

ii) creation of a significant change in an ecosystem caused by the removal or addition of keystone species;

iii) over-exploitation of a species; and

iv) hybridisation of species;

(d) evaluation of the risk identified under paragraph (d) in terms of:

i) the likelihood of the risk being realised;

ii) the severity of the risk and consequences of the realisation of the risk for the particular species as well as for other species, habitats and ecosystems;

iii) options for minimising potential risks;

iv) management of potential risks; and

v) any other information as the issuing authority may determine.

3 DESCRIPTION OF PROPOSED PROJECT

Doring Bay Abalone (Pty) Ltd. (DBA) undertakes onshore mariculture of abalone *Haliotis midae* at Doringbaai . DBA has a fully functional hatchery on site and are now over-producing for the land-based facility's needs. The hatchery currently produces in the range of 80 000 spat per month and only requires 55 000 per month for the existing shore-based grow-out facility. It is envisioned that the excess spat production will be used for Experimental Ranching in the sea adjacent to the existing land-based facility.

DBA is therefore investigating the feasibility of establishing an abalone ranching operation in the same area. DBA applied for a concession to establish an abalone ranching pilot project in the vicinity of Doring Bay extending from a point just south of Doringbaai (31°49'17.70"S, 18°13'50.77"E), to a point near Strandfontein 7km to the north (31°45'26.34"S; 18°13'15.35"E) (Figure 1). DBA have been successful in Phase 1 of this application process and are in the process of compiling a submission for Phase 2 of the application process. This Environmental and Risk Assessment will form part of that submission.

Figure 1. Location of the applied for concession area for abalone ranching by Doring Bay Abalone (Pty) Ltd.

DBA's proposal for the establishment of the pilot abalone ranching operation is set to start as soon as the application process has been finalised, assuming they are successful in this process. The DBA land-based facility can supply the proposed ranching operation with approximately 300 000 juvenile spat per year that are currently in excess of their requirements. They also have a supply agreement with I & J for the supply of 15mm spat as required. Each batch of spat to be seeded will have a valid Health Certificate issued by Amanzi Biosecurity.

Juvenile abalone for the ranching operation will initially be held in tanks on the existing farm at Doringbaai for a period of 2-6 months to allow the animals to acclimatise to the site, and to develop and grow further (up to a size of 25-30 mm). After this acclimatisation period, the juvenile abalone will be seeded by divers into identified suitable habitat (kelp beds) in the identified concession area. The abalone will be left to grow to a desired harvestable size *in situ* (150-250 g) where they will subsist on local seaweed. Harvesting of adult abalone will be undertaken by divers. Seeding of spat and harvesting of market size adults by divers will be ongoing to ensure continuity of supply for markets.

Although abalone ranching is a relatively new industry in South Africa, the proof of concept has been established, particularly in concession area NC2 in the vicinity of Kleinzee, Northern Cape. There is still some uncertainty regarding the growth rates, survival, time to harvest, and financial returns that can be expected from the ranching project, owing to the fact that these are all influenced by area specific factors (physical and biological environment). This information can only be gained through practical experience which is why the initial operation has been categorised as a pilot project. Monitoring of the growth and survival rates of abalone in this study as well as their impacts on the environment will be undertaken as part of this operation (see Section 7 for details on this). This will inform aspects such as optimal stocking rates and densities, growth rates under different conditions, and optimum time to harvest.

4 DESCRIPTION OF THE CONCESSION AREA

4.1 Regional oceanography

The physical oceanography of an area, particularly water temperature, nutrients, oxygen levels, and wave exposure are the principal driving forces that shape the marine communities. The marine ecosystems off the west coast of Africa are influenced by the Benguela Current System (BCS), which extends along the eastern edge of the southern Atlantic Ocean between Cape Agulhas in South Africa, and Southern Angola (Figure 2). The BCS is one of four major eastern-boundary current systems which is characterised by the wind-driven upwelling of cold, nutrient rich water (Shannon & O'Toole 1998). This cold current originates from the South Atlantic Circulation, which circles just north of the Arctic Circumpolar Current. The system is bounded by two warm currents; the Agulhas Current in the south and the Angola Current in the north.

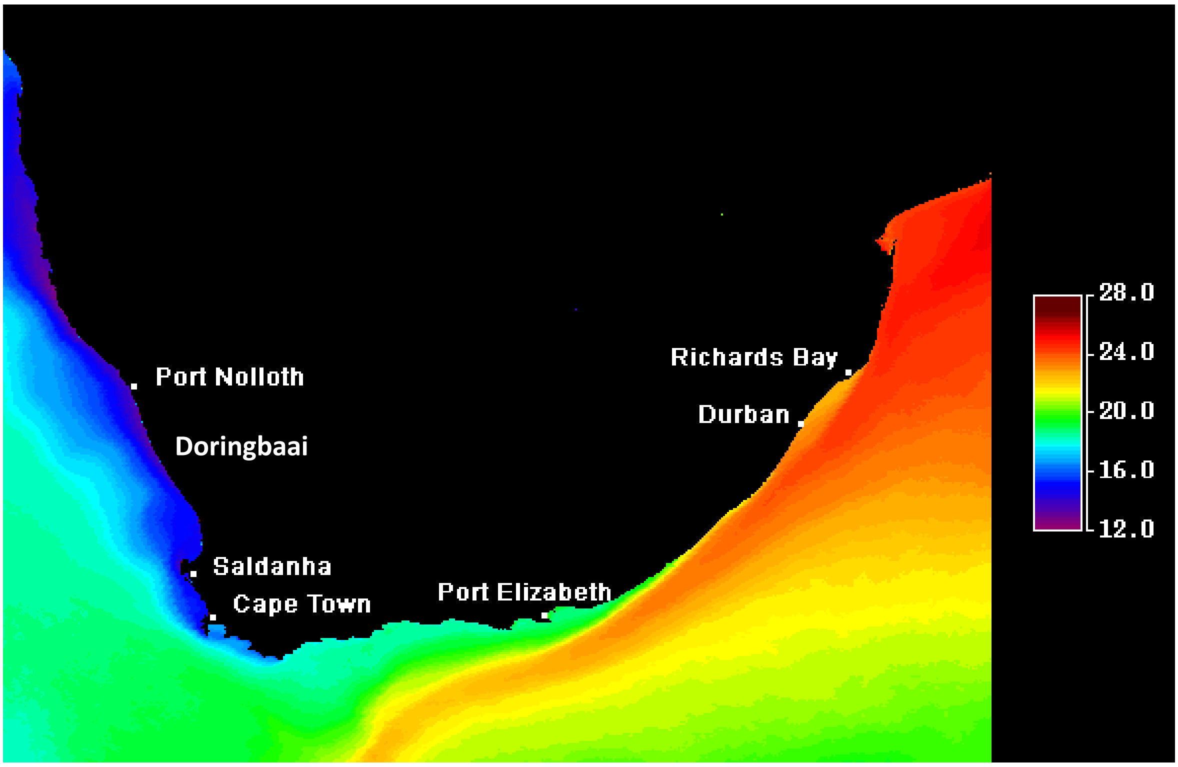

Figure 2. Average sea surface temperature (°C) showing the warm-water Agulhas Current moving south westerly along the east coast and the cool Benguela Current System (blue) moving north westerly along the west coast (AquaMODIS 4km-resolution, nine-year time composite image).

The naturally cool temperature of the Benguela current (average temperature 10 - 14°C) is enhanced by the upwelling of colder, nutrient-rich deep water (Branch & Branch 1981). The area experiences strong southerly and south-easterly winds. These prevailing conditions deflect the surface waters offshore and cause cold, nutrient rich water to upwell and replace them. This water is the nutrient rich life force of the west coast. Phytoplankton bloom when the nutrients reach the surface waters where plenty of light is available for photosynthesis. Phytoplankton are preyed upon by zooplankton, which are in turn eaten by filter feeding fish such as anchovy or sardine. This makes the west coast one of the richest fishing grounds in the world and also attracts large colonies of birds and seals (Branch & Branch 1981). The areas that experience the most intense upwelling activity in the southern Benguela system are off Cape Columbine, approximately 100 km south of Doring Bay, and the Cape Peninsula (approximately 100 km south of Saldanha). The water temperature and nutrient levels are strongly influenced by wind with minimum temperatures and maximum nutrient levels occurring in conjunction with upwelling events (Branch & Griffiths 1988).

4.2 Regional biogeography

Doring Bay falls within the Southern Benguela bioregion or ecoregion, one of four inshore bioregions spanning the coast of South Africa identified in the 2011 National Biodiversity Assessment (NBA) (Sink *et al* 2011). This bioregion extends from Cape Agulhas northwards into Namibia (Figure 3). At a finer spatial scale, the Doringbaai falls within the Namaqua Inshore Ecozone (Cape Columbine to Orange River). The Namaqua eco-zone is characterized by cooler waters, higher productivity and lower diversity than the adjacent SW Cape inshore eco-zone. For most groups, marine species diversity decreases from east to west, whilst biomass increases.

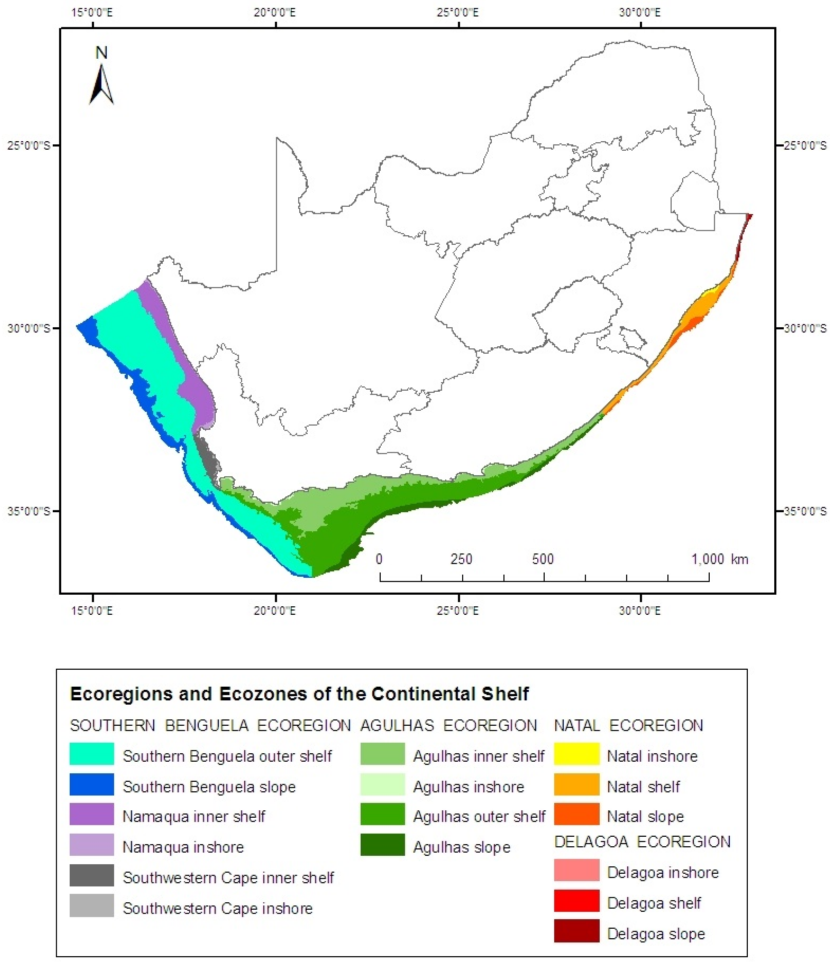

Figure 3 **Inshore and offshore bioregions in South Africa as defined by Sink *et al.* (2011).**

4.3 Local oceanography

The study site is subject to semi-diurnal tides, with each successive high (and low) tide separated by 12 hours. Each high tide occurs approximately 25 minutes later every day, which is due to the 28-day rotational cycle of the moon around the earth. Spring tides occur once a fortnight during full and new moons. Tidal activity greatly influences the biological cycles (feeding, breeding and movement) of intertidal marine organisms, and influences when people visit the coastline to partake in various activities (e.g. relax, bathe, harvest marine resources). The tidal variation in the vicinity of Doringbaai usually ranges between 0.24m (relative to the chart datum) at mean low water springs to 1.75m at mean high water springs.

Another factor that greatly influences marine ecology and human activities along the coastline is wave energy. Wave size is determined by wind strength and fetch (or distance over which it blows) and determines the degree to which breaking waves at the shore will shift sand and erode rock. The Cape west coast typically experiences high wave energy and is dominated by south-westerly swells with a long fetch and a period of 10-15 seconds (Branch and Griffiths 1988).

4.4 Ecology

4.4.1 Rocky shores

Rocky shores can be divided into distinct bands according to the amount of time each is exposed to the air, which in turn influences the organisms which inhabit each section of the shore. Species that are more tolerant to desiccation (drying out) are found near the high-water mark, while those that cannot stand long periods of water recession are found near the low-water mark. A further influencing factor on the distribution of organisms on the rocky shore is the degree of exposure to wave action, with significant differences noted between sheltered and exposed areas (Bustamante *et al.* 1997). Five distinct zones are typically found on rocky shores South Africa's west coast. These zones (moving in a landward direction) are named the Infratidal zone, the Cochlear zone, the Lower Balanoid zone, the Upper Balanoid zone and the Littorina zone

Rcoky shore communities are fairly ubiquitous within a biogeographical zone and tend to vary in response to wave exposure. A general description of species likely to be found in the different zones on west coast rocky shores follows. The Infratidal zone is inhabited by species that cannot withstand long periods of exposure and include algal beds of kelp, *Gigartina* spp., *Champia lumbricalis* and articulated corallines. These are usually interspersed with sea urchins (*Parechinus angulosus*) and the invasive black mussel, *Mytilis galloprovincialis*. The large limpets, *Scutellastra argenvillei* and *Cymbula granatina*, form dense stands that extend up into the cochlear zone, effectively replacing *Scutellastra cochlear,* which are somewhat rare in the region. Above the Cochlear zone is the Lower Balanoid, with thick beds of seaweed *Gigartina polycarpa*, *Sarcothalia striata, Gymnogongrus complicatus*, *Aeodes orbitosa* and *Ulva* sp, limpets, winkles *Oxystele* species and welks *Burnupena* species. Mussels *Choromytilus meridionalis* and the invasive *Mytilus galloprovincialis* often dominate this zone on exposed shores. The upper Balanoid is dominated by animals, in particular limpets, e.g. *S. granularis* and barnacles. Little seaweed occurs within this zone, however some sea lettuce *Ulva* is present. The harshest of all is the *Littorina* zone, which is dominated by the snail *Afrilittorina africana*. The shore crab *Cyclograpsus punctatus* and the flat-bladed algae *Porphyra* also occur in this zone (Branch 1981). Starfish *Marthasterias glacialis,* octopus *Octopus vulgaris,* and various species of fish from the Clinidae, Gobiidae, Blenniidae families, some termed klipvis in South Africa, live in subtidal rock pools and gullies.

4.4.2 Rocky reefs and kelp forests

Temperate rocky reefs are found below the low water mark (i.e. are always completely submerged) and are known to support diverse assemblages of life. Stresses from wave action and sedimentation result in a high turnover of competitors in these habitats. Many large predators such as fish and sharks are attracted to rocky reefs, and thus form an important component of these ecosystems (Barros *et al.* 2001). Many of the reef-associated fish and crustaceans not only forage directly on the reef but also on the adjacent sandy bottom areas. Rocky reef community structure is thus also known to influence macrobenthic distribution and abundance in the adjacent soft bottom habitats, and it has been found that more benthic species occur close to rocky reefs (Barros *et al.* 2001).

Rocky reefs provide substratum to which kelp (*Ecklonia maxima* and *Laminaria pallida*) can attach (Figure 4). These large kelp forests provide food and shelter for many organisms. As light is the limiting factor for plant growth, kelp beds only extend down to approximately 10 m depth (Branch *et al.* 2010). Encrusting coralline is the dominant algae below the kelp canopy. Growing epiphytically on kelp are the algae *Carradoria virgata*, *Suhria vittata* and *Carpoblepharis flaccida*. Representative under-storey algae include *Botyrocarpa prolifera*, *Neuroglossum binderianum*, *Botryoglossum platycarpum*, *Hymena venosa* and *Epymenia obtuse* (Meyer and Clark 1999). Filter feeders such as mussels, red bait and sea cucumbers comprise a large part of the faunal community on subtidal rocky reefs (Branch *et al.* 2010). The dominant grazer is the sea urchin *Parechinus angulosus*, with lesser grazing pressure from limpets, the isopod *Paridotea reticulata* and the amphipod *Ampithoe humeralis* (Branch 1981). It is important to note that abalone *Haliotis midae,* which are the dominant gastropod grazers in kelp beds elsewhere in the South-western Cape, do not naturally occur north of Elands Baai, some 30 km south of Doringbaai . West coast rock lobster, *Jasus lalandii*, and octopus *Octopus vulgaris* are two of the most important carnivores that occur within kelp forests. Other kelp forest predators include the starfish *Henricia ornata*, various feather and brittle stars (Crinoidea & Ophiuroidea), and the whelks *Nucella* and *Burnupena* spp.

Fish species likely to be found swimming within the kelp beds include hottentot (*Pachymetopon blochii*), galjoen (*Dichistius capensis*), milk fish (*Parascorpis typus*), rock suckers (*Chorisochismus dentex*) and the catshark *Haploblepharus pictus* (Branch *et al.* 2010).

Figure 4 ***Ecklonia maxima*** **kelp forest with** ***Laminaria pallida*** **sub-canopy and Hottentot** ***Pachymetopon blochii*** **(left) with sandy anemones (*****Bunodactis reynaudi*****), below (right).**

Kelp washed ashore forms an important food source for scavengers and provides shelter for numerous amphipods and isopods (sea lice and sand hoppers), which are in turn are preyed upon by birds (Figure 5). Kelp thus forms an integral part of the rocky shore and sandy beach ecosystems. Filter feeders such as mussels, red bait and sea cucumbers comprise 70-90% of the faunal community on rocky shores and their principal food source is kelp (Branch *et al* 1994). Kelp also produces large quantities of mucus, which encourages bacterial growth upon which protozoa feed. Microorganisms, kelp spores and phytoplankton and fragments of organic matter form an important food sources for filter feeders (Branch *et al.* 1994).

Figure 5 **Horned isopods** ***Deto echinata*** **feeding on drift cast kelp** ***Ecklonia maxima.***

4.4.3 Sandy beaches

The sandy beaches of the southern Benguela system are exposed to high energy waves with the exception of a few small sheltered bays (Bally 1987). The main inputs of food to the sandy beaches in this system are upwelling-related coastal phytoplankton and kelp detritus (Bally 1987; Stenton-Dozey and Griffiths 1983). The biomass values reported for beaches along the southern Benguela coast are some of the highest in the world (Bally 1987).

Five groups of organisms are typically found on sandy beaches: aquatic scavengers, aquatic particle feeders, air breathing scavengers, meiofauna (smaller than 1 mm in size), and higher predators (Branch 1981):

Aquatic scavengers feed on dead or dying animals that wash up on the beach and their activity is largely regulated by tides. This group includes species such as *Bullia* (the plough snail), that emerge from the sand as the tide rises and are deposited in the same area in which the wave drops the debris and decaying matter. Later they follow the tide down the shore as it recedes to avoid be eaten by terrestrial predators. **Aquatic particle feeders**, such as the sand hopper, occur mostly on the low-shore and feed on small organic particles. The majority of these species migrate up and down the beach with each tidal cycle, such that they remain in the surf zone and can escape avian and terrestrial predators. Sand hoppers are important for the breakdown of sea weeds and are also a major food source for sanderlings and other birds. **Air breathing scavengers** live high on the shore and feed on kelp and other seaweeds that have been washed up, as well as dead and decaying animal matter. These species complete their life cycles out of water, emerge from the sand during low tide when there is less risk of being washed away, and are almost strictly nocturnal to avoid desiccation and predation. **Meiofauna** (organisms < 1mm in size) are by far the most abundant of the animals found on sandy beaches, as their small size enables them to live between sand grains. The two most common groups are nematode worms and harpacticoid copepods. Meiofauna play an important role in breaking down organic matter that is then colonised by bacteria. **Higher predators** that feed on sandy beach organisms include birds, such as African black oystercatchers, White fronted plovers and Sanderlings, and fish such as galjoen and west coast steenbras (Branch 1981).

Beaches typically comprise three functional zones, namely the surf zone, the beach (intertidal and backshore zones) and the dunes. The diversity and abundance of species has been shown to increase with depth in the **surf zone** of beaches along the Benguela system. A rich outer turbulent zone (10m-33m from the shore) supports delicate cnidarians (anemones), tube building polychaetes and amphipods, while the less diverse offshore turbulent zone (3m-5m from the shore) is typified by deep burrowing polychates and crustaceans. The poor species diversity and abundance, as well as the presence of the cumacean *Cumopsis robusta* (a small crustacean), characterise the inner turbulent zone (0m-1m from the shore) of the surf zone. Surf zone habitats, particularly medium to low energy beaches, are in fact widely recognised as important nursery areas for fish and is even thought to rival that of estuaries in some areas (Clark *et al.* 1996, Lenanton *et al.* 1982, Bennett 1989, Potter *et al.* 1990). The **intertidal zone** of sandy beaches along the coast of the Benguela system can be divided into three zones; the zone of saturation (or the sublittoral fringe), the midshore and the upper drift line (or supralittoral zone). The sublittoral fringe is typified by mysids (*Gastrosaccus* spp.) and scavenging gastropods (*Bullia* spp.), while the midshore region is characterised by isopods (*Eurydice longicornis* and *Pontogeloides latipes*) and a polychaete (*Scolelepis squamata*). The upper drift line is typified by air-breathing amphipods (*Talorchestia*) and giant isopods (*Tylos* spp.), as well as a rich diversity of Coleoptera and Diptera where large quantities of kelp have been deposited on the drift line (Stenton-Dozey and Griffiths 1983).

4.5 Fisheries and mariculture activities

There is little data on shore based recreational angling in South Africa. Although several recent surveys have assessed catch and effort in this fishery along the KZN coast and several discrete localities along the Eastern and Western Cape coasts, the last time the Namaqualand coast was surveyed was between 1994 and 1996 as part of the National Marine Linefish Survey (Brouwer *et al.* 1997). Even at this time, little survey effort was expended north of Doringbaai (C. Erasmus Department of Agriculture, Forestry and Fisheries. pers. comm.). Data from this survey were reported for the West Coast (Cape Point to Namibian border) as a whole, and revealed that this region had the lowest estimated number of shore anglers nationally (average of just 0.12 anglers per km), who expended approximately 200 000 angler days.year^{-1} effort and caught fish at an average catch-per-unit-effort of 0.94 fish.angler.day^{-1} (Brouwer *et al.* 1997). The main species targeted by shore anglers along the west coast were galjoen, white stumpnose, hottentot, kob and steenbras. There is no recent data available on ashore angler catch and effort in the vicinity of Doringbaai specifically.

Clark *et al.* (2002) identified 458 subsistence/small scale commercial marine fishers in the region between the Orange River and Doringbaai. Thirty percent of these fishes were estuarine gill net fishers from the villages of Ebenhaeser and Papendorp at the Olifants River Mouth. Assuming that the remaining 330 fishers were more or less evenly distributed between the three identified fishing communities (Port Nolloth, Hondeklip Baai and Doringbaai) approximately 100 subsistence or small-scale fishers operate out of the Doringbaai area. In this region as a whole, these fishers mainly harvested rocky intertidal invertebrates (58%), rock lobster (69 %) and finfish (100%), predominately snoek and hottentot (Clark *et al.* 2002). The increase in the number of artisanal fishers in Doringbaai in the 18 years since Clark *et al.* (2002) completed their survey is unknown, in the interim, many of these fishers have received official recognition and have been granted small scale commercial or “interim relief” rights to valuable resources such as linefish and rock lobster (caught with hoopnets set from small vessels).

A land-based abalone mariculture facility, Doring Bay Abalone (DBA) was established in the old rock lobster factory at Doringbaai in 2013 with support from Tronox mining, the Matzikama Municipality and the IDC. DBA has a fully functional hatchery on site that currently produces in the range of 80 000 spat per month, about two thirds of which are used in the onsite grow out facility (currently expanding). DBA is a stand-alone functioning abalone farm that is now totally reliant on sales for its income and employing over 50 staff. Abalone produced at the DBA facility is currently sold to AbaGold and HIK Abalone. DBA has the full support of National and local government that seeks to grow the aquaculture sector nationally and in this region as a sustainable economic activity in a region where job opportunities are scarce (partially due to the collapse of the rock lobster resource).

5 ENVIRONMENTAL ASSESSMENT

This section of the document provides details on the Environmental Assessment undertaken for the proposed ranching operation required in terms of the Marine Ranching Guidelines published by Department of Agriculture, Forestry and Fisheries (DAFF) (Government Notice 2010, No. 729). Note that there is a certain amount of overlap in terms of the relevant information required for the Environmental Assessment and the Risk Assessment in terms of the National Environmental Management: Biodiversity Act (NEMBA, Act 10 of 2004) for a "restricted activity" such as the ranching of a species that does not occur naturally in the proposed area (see Chapter 6). Therefore, where information is common to both (i.e. the Environmental Assessment and the Risk Assessment), it has been included only in the Environmental Assessment section of this report, rather than repeated in both.

5.1 Assessment of carrying capacity

It is important that stocking densities are adhered to and that they do not exceed the environmental carrying capacity of the area where the proposed ranching is to take place. Carrying capacity among different areas of the coast can vary and is difficult to determine. On the relatively mesotrophic Eastern Cape Coast, abalone densities have been shown to vary from 0.03 to 2.23 abalone per m^2 at several sites (Proudfoot *et al.* 2006). A similar density of 1.5 abalone per m^2 was found by Wood (1993) in the same area, although both studies are likely to reflect reduced densities owing to poaching.

During the pilot ranching phase, seeding of spat in Doringbaai Concession Area will be undertaken with the aim of achieving an average density of no more than three harvest size (12 cm shell diameter) abalone per m^2. This guideline is based on the average density of abalone recorded in the Betty's Bay Marine Protected Area during pristine levels before the escalation of poaching and subsequent encroachment of west coast rock lobster (Government Gazette, 2010, No. 729; Blamey and Branch 2010).

A study conducted by Hutchings and Clark (2008) further north along the Namaqualand coast in the vicinity of Kleinzee (Concession area NC 3) recorded a similar density of 2.53 abalone per m^2 at a successful ranching site with similar habitat. Regular monitoring of abalone densities and ecosystem health status will be conducted to determine if stocking densities need to be adjusted to bring them in line with the assumed carrying capacity of the proposed area.

5.2 Trophic and ecological impacts

5.2.1 Habitat degradation and fragmentation

Provided reasonable stocking densities are followed, *Haliotis midae* itself is not expected to have a significant impact on its habitat in terms of degradation and fragmentation (but see 5.2.1 below). Furthermore, the habitat and resident species where abalone will be introduced are very similar and within the same biogeographic region (i.e. the Cool Temperate Namaqua Province) as abalone found further south on the West Coast. There may, however, be an increase in competition for space among other resident benthic species in areas where abalone are introduced. Space is often the most limiting factor on rocky reefs (Dayton 1971).

The potential impacts from the ranching activities themselves, including for example, impacts from the seeding and harvesting operations will be minimised. Although early abalone ranching operations used specially designed release structures (Sweijd *et al.* 1998), the industry has moved away from the use of release structures and abalone are typically seeded by hand. A similar method (divers seeding by hand) will be followed in this instance. In addition, care will be taken by divers during seeding and harvesting activities to avoid damage to other benthos.

5.2.2 Impacts on ecosystem functioning

The risk of causing a significant change ecosystem functioning as a result of the introduction of abalone into the Doringbaai subtidal kelp habitat is regarded as moderate, as although *H. midae* is not considered a keystone species in its native environment, it will constitute the largest gastropod in the area and could potentially dominate available suitable habitat and outcompete other grazers at high population densities. It is, however, not a ferocious predator, and feeds mainly on floating seaweed fragments that are abundant on the West Coast. It is also not known to transform its habitat, swarm or to reach unsustainably high population densities (Wood and Buxton 1996a, b). In addition, as mentioned previously, *H. midae* is not being introduced into a foreign biogeographic province, as it occurs further south on the West Coast in the Cool Temperate Namaqua Province, and therefore the risk of a significant ecosystem change is considered low. Furthermore, available evidence suggests that *H. midae* is not able to recruit successfully in the proposed ranching area and is thus unlikely to become invasive. Should monitoring show that ranching is having a significant negative effect on the ecosystem, introduction of juveniles will be halted, and the system should in all likelihood, eventually return to baseline conditions after the life span of the last batch of introduced juvenile abalones has elapsed.

Natural mortality of juvenile abalone is expected to be high in the initial period following their introduction (mortality in ranching operations is variable, but estimates as high as 70% in the time taken to reach harvest size are reported), either from the stress of being introduced (seeded) or from natural causes (most likely predation). Regular seeding of juveniles may thus create an environment where predators hone in on the area as they associate it with higher densities of prey, which may ultimately have unpredictable consequences for the trophic dynamics at large. This will be mitigated to some extent by seeding healthy, acclimatized spat in once off seeding events in areas and at times (e.g. avoiding dawn and dusk) where potential predators are less likely to be active thereby giving the spat time to find shelter on the reef itself.

Subtle (probably not resulting in a significant ecosystem shift) ecosystem changes are envisaged to occur, although how they will manifest is impossible to say with certainty and may be difficult to separate statistically from natural factors in an environment characterised by high variance. The fact that ongoing abalone ranching operations at Kleinzee in NC3 has in ecological monitoring undertaken to date not detected significant trophic and ecological differences between ranched and control sites, suggests that the risk of significant ecosystem change is low (Hutchings and Clark 2008, 2016,2018).

5.3 Potential genetic impacts

5.3.1 Hybridisation of a species

The risk of *H. midae* hybridising with another species in the Doring Bay Concession Area is considered to be very low. Hybridisation with native populations of *H. midae* is not possible in this area, as *H. midae* does not occur locally this far north on the West Coast (Branch *et al.* 2010). Secondly, the risk of hybridizing with other congenerics is also not likely as they too do not occur in the area and are distributed east of Cape Point (Branch *et al.* 2010). Furthermore, evidence suggests that *H. midae* cannot recruit successfully due to cold ambient conditions and severe upwelling events, a characteristic of the West Coast that is likely to be the dominant factor excluding all five species of South African *Haliotis* from the area where ranching is proposed.

Therefore, most genetic factors suggested for consideration by the guidelines on ranching of abalone (Government Gazette 2010, No, 33470) are not relevant to the DBA Concession Area. However, provision is made in the guidelines (Government Gazette 2010, No, 33470) for some selection process to improve broodstock when introducing abalone into new areas such as Doringbaai to optimize fitness and improve survival, which will be considered.

5.4 Diseases, pests and parasites

Diseases, pests and parasites affecting abalone have been reviewed by Bower (2000, 2011). Some of the parasites which affect abalone are also known to affect other molluscs including snails, limpets, oysters, mussels, clams, and cockles (Bower *et al.* 1994; Kuris and Culver 1999; Bower 2004; Bower and McGladdery 2004) as well as sea urchins (Bower 1996). Risks associated with introduction of diseases and parasites to native species in the area under consideration is thus not insignificant. At least eight different diseases or parasite have been found to infect *Haliotis midae* (Table **1**).

Table 1 Diseases reported to occur specifically in *H. midae* (from Bower 2011).

Category	Disease/parasite	Known distribution
1. Cause severe disease and mortality	*Vibrio* spp.	Global
	Sabellid polychate	Southern Africa; California, Baja, Mexico, USA.
	Withering foot syndrome	South Africa; California, USA
2. Parasites of lesser concern	Ciliates	Global-specific studies from southern Africa
	Margolisiella haliotis	South African; California USA
	Trematode parasitism	Global
3. Detrimental under adverse conditions	Ubiquitous opportunistic organisms	Global
	Shell-boring organisms	Global

The high stocking densities commonly found in hatcheries can lead to outbreaks of parasites and diseases, if the hatchery design and management is not maintained at a high standard (Oakes and Fields 1996). The movement of juvenile abalone from land-based culture facilities to the open ocean for ranching has the potential to spread disease and pests into areas where they are not naturally present and hence where there may be no natural resistance. Although *H. midae* do not naturally occur in the vicinity of the proposed ranching operation, parasites or pathogens not specific to *H. midae* may infect a variety of other mollusc species and urchins (Bower 2011). The susceptibility of co-occurring organisms in the DBA concession area to any of the diseases and/or parasites carried by abalone is not known, and there is a reasonable chance that introduced abalone could act as a host for unwanted species. Best management practices will thus be followed to minimize the risk of disease outbreaks within the hatchery at Doringbaai , and farm and ranched animals will need to be regularly inspected for parasites and diseases.

5.5 Social impacts

Aquaculture and the ranching of *Haliotis midae* has been identified as a viable and sustainable economic activity that is well aligned with the objectives of the national Phakisa- unlocking the blue economy programme. This project is thus important for Doringbaai area as it will create employment and provide empowerment opportunities and social upliftment for coastal communities who have been hard hit by the closure of fishing industry activities in the area (particularly rock lobster and small pelagic sectors).

Specifically, 8 to 12 people will be employed for the initial ranching operation (licensed divers and skippers) and previously disadvantaged individuals will have preferential opportunities for employment. The granting of a commercial ranching right in this area will later increase direct and indirect employment opportunities, creating further employment opportunities. Communities benefiting most from the employment opportunities generated by this project will include Doringbaai and Papendorp.

5.6 Enforcement risks

Poaching of the farmed and ranched abalone is a potential threat. Doring Bay has several inherent advantages that reduce the risk of poaching due to its remote location and the exposed nature of the shoreline:

(1) The exposed nature of the shoreline (rough seas and few sheltered bays) limits the number of sea days where abalone could be poached. DBA is likely to take advantage of the few calm days for seeding, maintenance and harvesting and the presence of the ranching right holder on site during diving days would act as a deterrent to poachers.
(2) Doring Bay has one slipway and any boats launching from this location will be easily identified. Launching from the beach is risky.
(3) Only parts of the concession area will be suitable for abalone ranching and these small areas will be difficult to locate by poachers. With limited sea days available the presence of poachers would be easily detected.

Notwithstanding, poaching constitutes a serious risk and mitigation measures to reduce this can include maintaining secrecy on the location of seeding sites, seeding abalone in inaccessible areas and the employment of security guards or observers. An enforcement risk assessment plan is required by the guidelines on marine ranching (Government Gazette 2010, No. 33470). DBA will, in consultation with the Department of Agriculture, Forestry and Fisheries (now DEFF) enforcement division, compile such a compliance enforcement plan, prior to initiating ranching activities.

5.7 Risk mitigation

Risk mitigation will be undertaken using adaptive management guided by regular monitoring and best practice guidelines. This is dealt with in detail below (see Scope for and approach to managing and minimising potential risks) in the Environmental Risk Assessment. In short, risks can be minimised with appropriate stocking densities, strict sterilization and quarantine protocols, verification of no native abalone and adequate security.

6 ENVIRONMENTAL RISK ASSESSMENT

The following section provides information required in terms of Gazette Notice R. 152 (as amended) promulgated in terms of the National Environmental Management: Biodiversity Act (NEMBA) (Act 10 of 2004) for an Environmental Risk Assessment for a species that is listed threatened or protected or for undertaking a restricted activity (in this case a translocation). Note, however, that *H. midae* is currently not listed in terms of the Threatened or Protected Species Regulations (2007, as amended).

6.1 Taxonomic details of the species

Class: Gastropoda

Order: Vetigastropoda

Family: Haliotidae

Scientific name: *Haliotis midae* (Linnaeus, 1758)

Scientific synonyms: *Haliotis modesta, Haliotis capensis*

Common names: perlemoen, (South Africa); ear shells, sea ears, muttonshells (Australia); paua (New Zealand); ormer (Europe).

6.2 Conservation status

The increasing pressure on *H. midae* by both legal and illegal harvesting had led to the banning of abalone harvesting (CITES in Appendix 3) and listing as a protected species in the Threatened or Protected Species Regulations, 23 February 2007 (TOPS) promulgated in terms of the National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEMBA). However, soon thereafter, pressure from the fishing industry led to the removal of *H. midae* from both CITES Appendix 3 and NEMBA TOPS Regulations (Raemaekers *et al.* 2011).

6.3 Population status

The national population of *H. midae* has been drastically reduced in size over the past two decades due to illegal exploitation (Hauck and Sweijd 1999; Tarr 2000). Before 1996, *H. midae* supported a successful fishery for almost 50 years and produced annual catches of approximately 615 tonnes. However, poaching has forced dramatic cuts in allowable catch by as much as 90% (Hauck and Sweijd 1999). Recreational harvesting was suspended in 2003, and the commercial abalone fishery was closed in February 2008, but reopened in 2011 (Government Gazette 2010, No. 33470, Schedule 2; Raemaekers *et al.* 2011).

At a local scale *H. midae* is thought to be absent from the Doringbaai area where the proposed ranching is to take place. The area of coastline under assessment lies beyond the northernmost distribution limits of *H. midae* on the west coast (Government Gazette 2010, No. 33470, Schedule 2) by approximately 30 km (Branch 2010). There is thus no local population of abalone that could be affected by the ranching activity.

Empirical data on which to derive current national trends in *H. midae* population status are not available as nationwide surveys have not been conducted over a consistent period. However, analysis of data from Fishery Independent Abalone Surveys collected in the commercial fishing area of the south-western Cape between 1996 and 2014 has shown a declining trend in abalone densities (Raemaekers *et al.* 2011, DAFF 2016). In addition, the average size of abalone collected from confiscated catches in the Western Cape has sharply declined (Raemaekers *et al.* 2011). Spatial and age-structured production assessment models show that spawner biomass in the south Western Cape will continue to decline should poaching proceed at current levels. However, substantial declines in illegal catches are required (49-98%), simply to maintain spawner biomass at the current collapsed levels (DAFF 2016). Under the unrealistic scenario that illegal fishing is halted completely, and the TAC only is harvested, simulation models predict resource recovery in some management zones (DAFF 2016).

As management and anti-crime responses have not been successful to date (Raemaekers *et al.* 2011, DAFF 2016), the national population trend of *H. midae* is therefore likely to continue to decline as poaching intensity is unlikely to be reduced sufficiently in the foreseeable future to allow for an increase in spawner biomass and population recovery.

6.4 Distribution

The natural population distribution of *H. midae* extends along the coast easterly from St Helena Bay in the Western Cape to Port St. Johns in the Eastern Cape covering a coastline distance of approximately 1 500 km (Newman 1969; Branch *et al.* 2010; Raemaekers *et al.* 2011) but is most abundant between St Helena Bay and Cape Agulhas. It is endemic to South Africa. At a local scale, *H. midae* is found on intertidal and shallow subtidal rocky reefs and attains highest densities in kelp forest habitats (Branch *et al.* 2010). Animals are usually found aggregated on certain areas of reef rather than evenly distributed (Newman 1969).

Translocation of *H. midae* has occurred on the Namaqualand coast in the Northern Cape for purposes of experimental ranching. *Haliotis midae* has been introduced by Port Nolloth Sea Farms in the vicinity of Port Nolloth and near Kleinzee (Sweijd *et al* 1998; de Waal 2002). No translocation has occurred outside of its eastern-most distribution limit for a number of ecological and socio-economic reasons. No historical distributional trends or shifts have been reported.

6.5 Habitat requirements

Haliotis midae is a temperate saltwater species restricted to intertidal and subtidal rocky reefs (Branch *et al.* 2010). Highest densities have been recorded in shallow subtidal kelp forests (Branch *et al.* 2010) although individuals have been recorded as deep as 35 m (Newman 1969; Barkai and Griffiths 1986). As abalone grow their habitat preferences and behaviour changes (Shepherd and Turner 1985; Prince *et al.* 1988; Tutschulte and Connell 1988). Larvae prefer to settle on encrusting coralline substrata (Morse *et al.*1980, Saito 1981, Shepherd and Turner 1985) where they feed on benthic diatoms and bacteria (Kawamura *et al.* 1995). They remain cryptic at this size, preferring habitats that offer concealment (Tegner and Butler 1989, McCormick *et al.* 1994).

Juveniles are commonly found on the undersides of boulders or beneath sea urchins, and studies have shown that these aspects of their habitat are critical for their survival (Tarr 1989; Wood 1993; Tarr 1995; Tarr *et al.* 1996; Day and Branch 2000; Branch *et al.* 2010). Tarr *et al.* (1996) showed that juvenile abalone have virtually disappeared from areas where urchins are depleted. A detailed study by Day and Branch (2000) found that of all the juvenile abalone they sampled, more than 98% were found beneath sea urchins. All small (3-10 mm) and medium-sized (11-20 mm) juvenile abalone were under urchins, whether on flat or vertical reef, or in crevices. A small proportion (~10%) of larger juveniles (21-35 mm) was not found under urchins, and in these instances, they occupied crevices instead (Day and Branch 2000). Adults occupy crevices or exposed positions on reefs (Branch *et al.* 2010) and feed mainly on kelp fronds and red algae.

6.6 Role of *Haliotis midae* in the ecosystem

Although *H. midae* is the largest invertebrate herbivore found in kelp forests it is not considered a keystone species as it does not have a disproportionately large effect on its environment relative to its abundance. Abalone feed primarily on drift algae and probably have little impact on attached plants (Lowry and Pearse, 1973). Although juveniles provide a food source for many species of predator, other molluscan food sources in this size range are also available and there are no reports of any species being exclusively dependent on abalone.

As *H. midae* juveniles are highly reliant on urchins for their survival (Tarr 1989; Wood 1993; Tarr 1995; Tarr *et al.* 1996; Day and Branch 2000; Branch *et al.* 2010), and urchin abundance can be influenced by predatory rock lobster (Blamey and Branch 2010), abalone can be considered an indicator species. Low numbers or juvenile *H. midae* are indicative of the presence of high numbers of rock lobster for example, and of an ecosystem undergoing top-down regulation. A reduction in *H. midae* abundance may also be an indicator of climate change and ocean acidification, as the growth of coralline algae, on which the juveniles depend for settlement, is retarded; a possibility tentatively suggested by Rogers-Bennett (2007) for abalone species occurring in California.

Abalones are herbivores that feed either by trapping drift seaweed under their muscular foot or by grazing on attached algae (Cox 1962; Barkai and Griffiths 1986; Wells and Keesing 1989). Juveniles that have recently settled, however, are known to feed on diatomaceous films that cover rocks particularly where encrusting coralline algae are present (Tomita and Tazawa 1971). Abalone therefore occupy the level of primary consumer in the food chain.

In terms of the role abalone play in ecosystem functioning, juveniles (< 12cm) provide a food source for animals at higher trophic levels such as rock lobster, octopus, fish, crabs, other molluscs and starfish (Shepperd 1973). As they feed on drift seaweed they also help to breakdown and recycle nutrients back into the water.

6.7 Threats affecting the species nationally and locally

Haliotis midae is a highly sought-after delicacy and is in high demand in the Far East (Raemaekers *et al.* 2011). Since the 1990s, the historical traditional abalone fishery transformed overnight into a highly mechanised illegal fishery with syndicates exporting the product to Hong Kong (Hauck and Sweijd 1999; Raemaekers *et al.* 2011). The population has been decreasing since the 1960s, initially due to overharvesting under open access but more recently due to poaching (Raemaekers *et al.* 2011, DAFF 2016). Poaching therefore appears to be the most important threat to the sustainability of abalone at a national scale.

In addition to the poaching, an unprecedented rock lobster invasion in the mid-1990s, that happened to correspond with the surge in illegal fishing for them, has been a significant threat too, albeit at a local scale (Raemaekers *et al.* 2011). As previously mentioned, there is a complex dynamic among juvenile abalone, urchins and rock lobster (Tarr *et al.* 1996; Day and Branch 2000; Branch *et al.* 2010; Blamey and Branch 2010). Juvenile abalone are critically dependent on urchins for cover (Day and Branch 2000; Branch *et al.* 2010). The eastward invasion of rock lobster into the abalones core distribution resulted in a dramatic decline in urchin abundance due to predation that in turn resulted in a significant decline in the numbers of juvenile abalone reaching adolescence (Blamey and Branch 2010). Rock lobsters also have a dietary preference for abalone over urchins (van Zyl *et al.* 2005), and this is likely to intensify when their preferred prey of mussels is limited.

Climate change, in the form of increasing temperatures and ocean acidification, is also a potentially important additional threat to abalone populations in this country. Increasing water temperatures have the potential to disrupt the physiology and spawning potential of abalone (Newman 1967), while ocean acidification has the potential to hinder the development of encrusting coralline algae that juveniles rely on during settlement. The impacts from this source remain highly speculative at this stage though (Rogers-Bennett 2007).

6.8 Information regarding the restricted activity

6.8.1 Nature of the restricted activity

The proposed activity involves the introduction of juvenile *Haliotis midae* into the marine environment for purposes of ranching. Marine ranching (reseeding) is defined by Bannister (1991) as “Identifiable stock released with the intension of being harvested by the releasing agency.” A land-based hatchery within the existing farm provides excess juvenile abalone (spat) and can support the ranching of abalone in the adjacent sea. Spat will be released into the sea and grown for approximately 4-5 years to a harvestable size *in situ* and will subsist on local seaweed and acquire all resources from the area of ocean they have been introduced to.

6.8.2 Reason for the restricted activity

The project is important for the Doringbaai area and West Coast region as it will create employment and provide empowerment opportunities and social upliftment for the surrounding communities, and ultimately stakeholder opportunities for employees. Ranching specifically, as opposed to land-based culture methods, allows for the economically viable production of larger abalone that fetch premium prices that are preferred by the market.

6.8.3 Where the restricted activity is to be carried out

Ranching is to be conducted in kelp beds in the inshore zone below the high-water mark in the Western Cape between the coastal towns of Doringbaai and Strandfontein.

Geographic boundaries of the concession area are indicated in the table below:

	Boundaries	Latitude	Longitude
North	Point at south of Strandfontein	31°45'26.34"S	18°13'15.35"E
South	Point at south of Doringbaai	31°49'17.70"S	18°13'50.77"E

6.8.4 Gender, age and number of *Haliotis midae* involved

Haliotis midae is dioecious and juvenile abalone can only be sexed histologically requiring them to be euthanized prior to analysis (Wood & Buxton 1996a). Both sexes will therefore be used for ranching and a 1:1 sex ratio of males to females is assumed. Note that anecdotal evidence suggests that ambient conditions dictate that they cannot successfully reproduce due to low water temperatures required for spawning and larval settlement.

It is proposed that 15 mm juvenile abalone (spat) will be acquired from the established DBA hatchery in Doringbaai or from Abagold in Hermanus. These will be grown in the existing farm tanks on site for a period of approximately 6-8 months to a size of 3-40 mm before being released into the nearby ocean for ranching purposes. At the stage of release, abalone would be approximately 15 months old assuming it takes 6 months for an abalone to reach 12.7 mm and a further 9 months to reach 30 mm (see Dlaza 2006). Abalone will then be grown *in situ* for a further 4-5 years until they reach a harvestable size of approximately 150 mm shell width. Approximately one million 15 mm spat are to be acquired per annum that are assumed to have a mortality rate of 2% per annum during the initial land-based rearing phase, resulting in approximately 977 500 animals being introduced initially per annum for ranching. Available data suggests that mortality rates will increase sharply after the animals are released into the sea in the initial phases of seeding but will decline again with time. A conservative average ranching mortality rate of 70% has been assumed by Sustainable Environmental Aquaculture Services (Pty) Ltd (SEAS) for the period between release and harvest. This means that for the most part approximately 293 250 abalone of harvestable size will remain after a 4-5 year period. There is insufficient evidence available at this stage to refine this estimate. However, intensive monitoring of sites where seeding is to take place during the pilot phase of the project will be used to refine this estimate in future.

6.8.5 Intended destination

DBA has existing sales agreements with Abagold and HIK Abalone at present. These companies have well established processing and canning factories for abalone products and have good connections with established Asian market channels. The majority of abalone harvested is therefore destined for Asia and for the most part it appears that the product will be sold live or in canned and dried forms.

6.9 Regulations, policies, norms and standards or international agreements binding the Republic that are applicable.

Relevant legislation and policies include the Marine Living Resources Act: Policy for a Sustainable Marine Aquaculture Sector in South Africa (2007), the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004), and the FAO Code of Conduct for Responsible Fisheries, FAO: 1995.

6.10 Potential risks associated with the restricted activity

Potential risks associated with ranching and/or stock enhancement activities have been identified as follows (Guidelines for Marine Ranching GN 29657):

i) Degradation and fragmentation of a species' habitat (see section 5.2 on Trophic and ecological impacts)
ii) Creation of a significant change in the ecosystem (see sections on Trophic and ecological impacts and Diseases, pests and parasites above)
iii) Over-exploitation of a species
iv) Hybridisation of a species (see Potential genetic impacts above)

Potential impacts of the project associated with each of these risks categories have been identified and are elaborated in Sections 5 of the Environmental Assessment above as indicated next to each of the identified risks and are not repeated here.

Note also that no over-exploitation of a species is likely to occur directly from the proposed ranching activities. Brood-stock to supply juveniles for seeding purposes has already been acquired by DBA and Abagold facilities.

6.11 Evaluation of the risks associated with the project

The significance of impacts associated with any particular risks are a function of the likelihood of the risk being realised and the consequences for the species in question as well as for other species, habitats and ecosystems. These aspects are elaborated separately below.

6.11.1 Likelihood of risk being realised

The degradation or species' habitat fragmentation and/or the creation of a significant change in the ecosystem (including hybridisation) for most potential agents of risk (including disease and pathogens) are unlikely to occur in this situation as *H. midae*:

- is not a keystone species and therefore does not exert a disproportionately large influence on its environment relative to its abundance;
- is not from a different biogeographic province therefore unlikely to disrupt current ecological interactions;
- occurs in very similar habitat with many of the same species a few tens of kilometres south of the proposed ranching area and is thus unlikely to significantly disrupt current ecological interactions in the Doringbaai area;
- is not a ferocious predator but feeds mainly on drift algae (kelp), which is not considered a limiting resource on the west coast due to the high nutrient levels and high levels of productivity (Bustamante *et al.* 1995);
- is unlikely to disrupt predator-prey dynamics in a top-down manner owing to its preferred diet (kelp);
- has not ever recorded to swarm, transform its habitat or reach unsustainable levels naturally, and is thus not likely to do so in the future in the area in question, especially considering that the proposed area for ranching lies adjacent to its natural distribution where it has never immigrated, assumed to be related to larval thermal tolerance levels being exceeded in this area;
- will be certified disease free by suitably qualified veterinarians before being introduced and will be tested periodically for infections and parasites;
- is not able to successfully recruit in the proposed area where ranching will take place and thus there is no risk of hybridizing with indigenous *H. midae* or for the population to reach unsustainable levels; and
- is not at risk of hybridizing with other congeneric species as these only occur west of Cape Point (Branch *et al.* 2010).

However, there is a reasonable likelihood that:

- Predator-prey interactions in the concession will be affected due to relatively high levels of post-release mortality of *H. midae* and the high number of juvenile *H. midae* that will need to be introduced into the area to make ranching a viable prospect. This could potentially attract higher numbers of predators to the area than would naturally occur, making other co-occurring prey species more vulnerable to predation.
- Introduced abalone will compete with other species for space on the reef in the study area. Note that available substratum is considered to be one of the chief limiting abiotic variables in intertidal and shallow subtidal reef systems (Dayton 1971). In addition, *H. midae's* morphology is such that it has a large footprint to height ratio, meaning proportionally more of itself is distributed directly on the reef than in the water column above the reef. Hence it is more likely to have an effect on competition for space than many other benthic organisms that do not have these morphological characteristics. It is also one of the largest benthic invertebrates occurring in kelp forest habitats, growing up 190 mm in diameter (Branch *et al.* 2010).

6.11.2 Severity of the risk and consequences of the realisation of the risk for the particular species as well as for other species, habitats and ecosystems

According to Borg (2004), who outlines biological levels of risk that are used in the Department of Environmental Affairs and Tourism's (Government Gazette, 13 June 2008, No. 31143) guidelines on marine ranching, the ranching of abalone in the proposed Kleinzee area is at a risk Level of 3, Level 5 being the highest. The following provides a description of the five biological-risk levels (Borg 2004) and provides context to the Level 3 risk associated with the proposed ranching of *H. midae* at Doringbaai :

Level 1: Lowest level risk is the introduction of naturally occurring species into areas within their range but where they are no longer found.

Level 2: A higher level is introduction of stock within its range where it is already found, to restore abundance to levels of productivity of naturally occurring stock.

Level 3: The next level is when a species whose reproductive biology is well understood is introduced into an area outside its natural range where it is known that successful reproduction cannot occur.

Level 4: An even higher level is translocation of an indigenous species' outside its natural range, where neither its reproductive biology is known nor conditions for successful reproduction are known to exist.

Level 5: The highest level of risk is introduction of alien species that has the potential to be invasive in that particular environment.

In the context of the risk levels outlined above, the severity of the risk of habitat degradation and fragmentation or the creation of a significant change in the ecosystem is regarded as low in this situation. As *H. midae* naturally occurs in the same type of habitat and in the same biogeographic province it is anticipated that changes will be subtle and unlikely to have a significant impact on ecological functioning and species composition. Studies by Hutchings and Clark (2008, 2016, 2018) that monitored the effects of ranching abalone at Kleinzee corroborates this view as they tentatively concluded that no significant impact was detectable on the subtidal biota at this site following introduction of large numbers of juvenile abalone over a period of several years. However, if the risk was realised then a worse case consequence would be a decline in the overall fishery production of the area (Mustafa 2003). However, the expected response is much more likely to manifest as small shifts in abundances of some taxa. These may be hard to detect with any certainty and are unlikely to significantly affect overall fishery production in the area.

Potential indirect effects on predator-prey interactions could be more severe than those outlined above for degradation and fragmentation and can potentially have wider ecological consequences in the area, including for example an overall decline in fishery production (Mufasa 2003). However, should the scenario of a disruption in predator-prey interactions take place, it is predicted to occur at a relatively small scale and be limited to the vicinity of the proposed ranching area. In contrast, outbreaks of disease and parasitic infections could have much more severe consequences to the ecosystem at a large scale, potentially affecting many other species (not restricted to only molluscs) and would not be restricted to the ranching area. The consequence of this in extreme cases could be mass mortality to co-occurring affected species and a concomitant decline in overall fishery production (Mufasa 2003).

Hypothetically, if hybridisation were to take place this could result in a breakdown of adapted gene complexes and the deletion of some genotypes (Mufasa 2003) resulting in decreased fitness and lower resilience to environmental changes and threats. Note though that the risk of this occurring is considered extremely low.

6.12 Scope for and approach to managing and minimising potential risks

Key risks that have been identified through the Environmental and Risk Assessments that require mitigation include the following:

- Competition with other co-occurring benthic organisms for space
- Degradation and fragmentation of a species habitat
- Introduction of diseases and parasites
- Hybridization
- Poaching

An adaptive plan to risk management will need to be followed due to the experimental nature of the project and the paucity of data relating to ranching of abalone in South Africa at present. There are a range of management protocols being utilised around the world to minimise risk associated with marine aquaculture and ranching operations. These include the Codes of Practice and Manual of Procedures for the Consideration of Introductions and Transfers (Turner 1988, ICES 1995), the Code of Conduct for Responsible Fisheries (FAO 1995), and the corresponding guidelines for aquaculture development (FAO 1997). Sea ranching is referred to as a “culture-based fishery” under the FAO’s Code of Conduct for Responsible Fisheries (FAO 1995), provided that the operations therein ensure ecologically sustainable development of marine resources and respect the provisions of the Convention on Biological Diversity, Rio de Janeiro 1992 (Mokhtar and Awaluddin 2003). In addition, when assessing and managing the environmental impacts incurred by ranching it is advised that this be done at the coastal zone level (Lorenzen *et al.* 2000).

DBA (Pty) Ltd will ensure that appropriate mitigation measures are implemented that address potential risks on an ongoing basis using an adaptive management strategy informed by regular monitoring (see Section 7 below). A phased approach will be used to determine optimal stocking densities and to assess any environmental changes due to ranching as well as risks associated with the development of diseases and parasite infections.

The potential risks associated with disruptions in ecological functioning (i.e. from competition with other co-occurring benthic organisms for space, degradation and fragmentation of a species habitat) will be mitigated by seeding at modest stocking densities such that introduced abalone do not exert excessive pressure on the habitat via ecological interactions and excessive and unsustainable requirements for resources.

Transfer of parasites, diseases and viruses into the ranching area could take place via the cultured juvenile abalone. To avoid this risk being realised, the DBA land-based facilities will be maintained at the highest standards of water quality and hygiene, and at reasonable stocking densities (following the existing biosecurity protocols). Important quarantine procedures will be followed for this project including those described by the ICES Code of Practice on the Introductions and Transfers of Marine Organisms 2004 (ICES 2004). In addition, prescripts included in the World Organisation for Animal Health (OIE) Code of Practice will be followed when translocating abalone to ensure containment of potentially new diseases. Other considerations to be addressed will include:

- All disinfectants will be neutralized before being released into the surrounding medium. Juveniles on land-based facilities will be isolated from disease agents, birds and animals as well as from unauthorised personnel.
- Regular inspections for reportable diseases and pathogens will be done on land-based juveniles as well as on ranched abalone.
- Detailed records will be kept of mortalities, effluent/influent treatments and veterinary reports.
- A suitable time period will be allowed for detection of all non-target species (including non-pathogenic parasites and diseases) between acquisition of spat from the in-house hatchery and Abagold and introduction to the sea.

All abalone spat acquired from the Abagold facility will be accompanied by a valid Health Certificate from Amanzi Biosecurity or government veterinarian. In addition, immediately prior to releasing the juvenile abalone into the sea, all ranch seed will be certified as disease free before introduction into the environment. This will be done at the DBA land-holding facility and at Abagold where disease-free spat will be acquired. The reason for this is that abalone will be accommodated at the Doringbaai land-based facility for approximately six months before being introduced to the sea, and there are risks that infections could be acquired or could develop as a result of the stress of relocation from the Abagold Abalone facility, difficulties in acclimatising to the new Doringbaai holding facilities, and as a result of being weaned onto a diet of local seaweeds. In addition, monitoring of introduced abalone for diseases will be undertaken regularly during the experimental project phase.

Should diseases be detected in ranched abalone, a contingency plan entailing the immediate harvesting of all abalone would be undertaken to ensure containment of the disease as far as practically possible.

The risk of abalone hybridizing will be verified as being negligible during baseline surveys which are expected to find no wild abalone present at the ranching area.

Poaching of abalone will be mitigated with physical security barriers (fences) at the land-based facility and security guards. This will be adapted on an ongoing basis to align with current threat status. Should the threat increase security will be enhanced with more guards and surveillance technology.

7 PROPOSED MONITORING PROGRAMME FOR THE DBA ABALONE RANCHING OPERATION

The objectives of the monitoring programme as stipulated by the DAFF Ranching Guidelines are to evaluate the costs and benefits of the proposed ranching operation. Success of the project (both the pilot and commercial phases) should be evaluated in terms social, ecological and economic considerations. The monitoring program will be undertaken by Anchor Environmental and will address only the pilot phase of the ranching operation (specifically the first three years thereof where after it will most likely need to be revised and updated) and will be focused on assessing ecological impacts of the project only. It will nonetheless generate data that will be useful for assessing social and economic impacts as well.

The area to be ranched is approximately 7 km in length. The monitoring approach will follow a classic BACI (Before-After-Control-impact) design. The environmental monitoring program to be conducted by Anchor involves the undertaking of a baseline ecological survey of two "impact" sites where abalone is to be seeded and two "control" sites which will not be seeded with abalone for the duration of the monitoring program. Three bi-annual (every 2 years) monitoring surveys of these sites over a production cycle (i.e. from seeding to harvest – expected to be approximately 6 years) will be undertaken. There are still active mining concessions along the coast of the Matzikama Municipality, and this must be taken into account for the ranching site selection and placement of control sites within the ranching concession area. Sites likely to be impacted by mining activities over the duration of the monitoring must be avoided.

These diving surveys will include quantitative assessments of the substratum type and the abundance of key habitat and indicator species, namely kelp, coralline algae, other foliose algae, urchins, herbivorous molluscs, rock lobster, whelks, crabs etc. Mobile species will be counted while percentage cover will be recorded for sedentary species by qualified scientific divers using SCUBA. This will be conducted at each site using 0.25 m^2 quadrats placed at 10 m intervals along three 50 m long transects aligned perpendicular to the shore. A total of six quadrats will be surveyed on each transect, totalling 18 quadrats per site. The three transects will be placed 10-20 m apart from one another within an area that is demarcated using anchors and buoys. GPS coordinates will be taken at each corner demarcating the sites. Two sites will be designated as impact sites to be seeded with abalone at commercial densities (approximately 7 abalone per m^2); whilst 2 control sites will remain unseeded for the duration of the monitoring program.

The data collected at control and impact sites will be compared, using univariate and multivariate statistics in order to assess potential impacts of abalone ranching at impact sites over a full grow-out production cycle. During monitoring surveys at impact sites, the abundance of abalone within sampled quadrats will be recorded, and a statistically reasonable sample (up to 100) will be measured to enable estimation of survival and growth rates. Doring Bay Abalone would need to select four sites where they are sure they would like to seed abalone. These "sites" should be at least 30m by 30m in area to allow us to conduct three transects as per the survey methodology. In the vicinity of the two selected impact sites, abalone should only be seeded within the designated impact areas only, and none should be seeded within a minimum distance of 300 m of the border of each impact site (to allow for measurements of movement rates outside of the seeded areas). At the very least a buffer of at least 300m should be left to the one side (north or south) of each impact site so estimates of movement rates can be made. No abalone should be seeded within 300m of the selected control sites.

A random selection of at least 20 abalone from different areas within the Concession Area will also be collected during each of the surveys and these will be submitted to a qualified aquatic veterinary service e.g. Amanzi Biosecurity where the animals will be assessed for known diseases and pathogens.

Findings and recommendations from these surveys will be communicated in the form of detailed written reports which will include recommendations on aspects such as site selection, seeding rates and strategies, and optimal stocking densities.

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